CONDITIONS FOR DEPLOYMENT OF WIND POWER IN THE BALTIC SEA REGION

Analysis part II
Strategic Outline offshore wind promotion

BASREC

In 1998, the intergovernmental Baltic Sea Region Energy Co-operation (BASREC) was initiated by the Baltic Sea countries and the European Commission.
BASREC[1] is part of the Council of the Baltic Sea States (CBSS).

BASREC's main objective is to promote sustainable growth, security and prosperity in the region and supports therefore the creation of competitive, efficient and well-functioning energy markets. BASREC is pursuing energy efficiency and renewable energy measures, along with measures to develop and use new, low-carbon and energy-efficient technologies and Carbon Capture and Storage (CCS) in order to ensure sustained economic growth in the short and the long run. The participation in the work programme 2009-2011 - in addition to BASREC member countries and the European Commission - also involves the Nordic Council of Ministers (NCM) and the Council of Baltic States (CBS).

[1]Governments of Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Russia and Sweden. The European Commission is represented by DG ENER, the Directorate General for Energy.

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Preface

In the Communiqué adopted at the 5th BASREC Conference of Energy Ministers in Copenhagen in February 2009, the Parties addressed the coherence of energy and climate policy issues. Stable, secure and affordable energy supplies are important for economic growth and welfare in the region, which can be achieved in harmony with climate change requirements.

The Parties confirmed their will to continue to strengthen energy co-operation in the next three-year period (2009-2011), in order to sustain the integration of the energy markets and the energy infrastructure as well as to ensure competitive, stable and secure energy supply in the region.

They also stated that the use of renewable energies is essential to meet the challenges of energy and climate policy issues and confirmed that their co-operation in the upcoming three-year period will, among other, concentrate on increased use of renewable sources with specific focus on the forms of energy potentially dominant in the region.

Their commitment is, among other, to engage in activities carried out within best practices for deployment of renewables in the energy sector, integration of fluctuating wind power into the electricity system and legal and financial frameworks to promote the objectives for increased use of renewables.

Consequently this study has been commissioned to serve as a key input for strategic actions to promote offshore wind power in the Baltic Sea Region during the coming years, i.e. through regional co-operation within BASREC with the ambition expressed above, hereby also optimising the contribution of wind power to fulfil the EU 20-20-20 targets (20% less CO2 emissions, 20% more energy efficiency and 20% of energy from renewable sources in 2020) and other energy policy targets in the Baltic Sea Region.

This project has been conducted along a firm timeline with numerous people contributing. It would be exploding at this place to list all of you by name, who fed us with appreciated thoughts. However, we would like to thank the interviewees for sharing their knowledge and insights with us, the Mirror Group and HELCOM for being critical in a constructive and operational dialog, the team from GL Garrad Hassan and Deloitte for their straight forward and skilled action to conduct this complex task, the BASREC Group of Senior Energy Officials for their guidance, Susan Brockett from Plan & Process for her joyful lead at the pre-project workshop, Granath for their creative repro work floating on a steady stream of changes and last but not least the Swedish Energy Agency purchasing department for their competent advices.

Finally we do hope that the result of this study may serve as an important step stone in the acceleration of development of offshore wind power in the Baltic Sea Region. We are also looking forward to meet many of you again, together leaving climate friendly foot prints in strong winds ahead.

Berlin & Stockholm April 2012

Wolfdieter Böhler
Acting Chairman BASREC, German presidency
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Introduction

This report forms part of a study of issues related to the deployment of substantial offshore and onshore wind in the Baltic Sea Region in 2020. The work was carried out on behalf of the Baltic Sea Region Energy Co-operation (BASREC). The results of the study are aimed to serve as a key input for strategic actions to promote wind power, particularly offshore wind power, in the Baltic Sea Region (BSR).

The study provides an outline strategy for the integrated economic promotion of wind power in the BSR through regional co-operation within BASREC based on evaluation of potential production sites, grid integration possibilities and appropriate supporting regulatory frameworks. The work has been undertaken in two phases. Phase 1 consisted of three related tasks termed “enabling studies” as they provide the factual informative basis upon which strategic review work can proceed.

These three tasks are:

- *Task 1 Spatial Analysis*
- *Task 2 Grid and Interconnection Study*
- *Task 3 Regulatory Review*

Phase 2 of the study was a Strategic Review based on the results from Phase 1. This review delivers an Outline Strategic Plan for the promotion of wind power in the Baltic Sea Region. The plan also provides a clear roadmap for addressing identified barriers to deployment and accelerating the efficient roll-out of this technology in the region.

The implementation framework of this study:

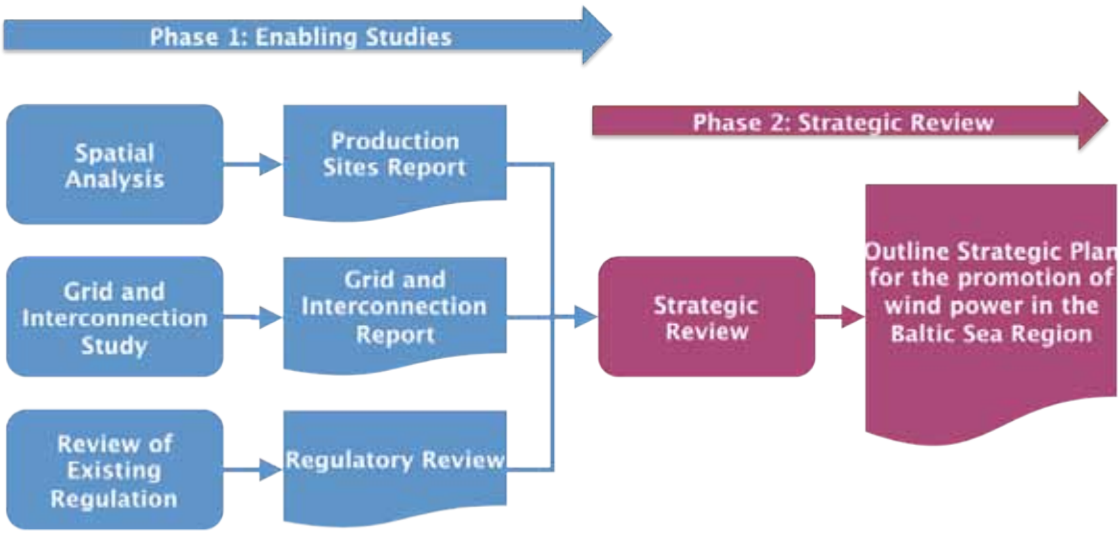


Photo: Danish Energy Agency

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EXECUTIVE SUMMARY

The Baltic Sea Region (BSR) joins countries with very different economies and starting points in terms of energy. For example hydro power is an important source of electricity generation in Norway, Sweden, Finland and Latvia. Sweden and Finland stands out with respect to their use of nuclear energy, and wind power already contributes considerably to electricity generation in countries like Denmark and Germany.

In terms of the demand for energy, a number of challenges exist for example in relation to climate change, increasing import dependence and higher energy prices. Moreover, the interdependence of Baltic Sea Region countries for energy, as for many other areas, is increasing[1] – a power failure in one country has immediate effects in others.

The key to meet energy challenges in terms of for example increasing interdependence is cooperation and hereby turning the countries' different energy starting points into a competitive advantage for the BSR. As a strategic, domestic and largely untapped resource, offshore wind is one of the key technologies for meeting the BSR energy challenges of the future.

The following section summarizes the attractive offshore wind areas in the BSR on the basis of the enabling studies and Deloitte's further analyses[2]. The analysis shows that enough attractive offshore wind capacity is present to make the countries fulfill their NREAP targets and even to become world-leading in terms of offshore wind energy deployment in case that would be the political ambition. These two scenarios are further described in the two last sections, and strategic initiatives available for the BSR decision makers in regard to each scenario are described.[3]

1. For example the NordBalt project which is a submarine power cable between Lithuania and Sweden under construction. The aim of the project is to promote trading between Baltic and Nordic electricity markets, and also to increase the security of power supply in both markets.
2. For further description of methodology etc. see enabling studies and the strategic outline.
3. See the strategic outline for a thorough discussion of the strategic initiatives and a description of how they have been developed.

1 Attractive offshore wind areas in the BSR

A central question with respect to the future strategy for offshore wind development in the BSR is where to locate the new offshore capacity that would lead to the fulfillment of at least the NREAP objectives or perhaps even further towards a leading status for the BSR with respect to wind energy deployment as a share of total electricity supply.

Since there is no supranational authority to decide in which areas and countries within the BSR the offshore wind capacity should be located, the recommendations in the strategy outline is limited to suggesting the most attractive areas for offshore wind energy deployment in the BSR based on further analysis of the findings in the spatial analysis and the grid and interconnection analysis which are both part of the enabling studies.

Methodology: Identifying attractive future offshore wind areas in the BSR

To decide on the most attractive sites for offshore wind deployment in the BSR, a number of criteria have been applied such as cost of energy (including wind speed, distance to shore and water depth), hard constraints (e.g. other wind farms in operation) and soft constraints (e.g. shipping and fishery).

These criteria are the ones used in scoring the 10*10 km offshore grids in the spatial analysis. The spatial analysis score enables initial selection of areas with attractive properties with respect to costs of energy and the specific hard and soft constraints applying to the sea areas where the offshore wind farms will be placed (so called 'golden sites'). However, the spatial analysis score does not give a full account of the factors that contribute to the overall attractiveness of a certain potential offshore wind area. Deloitte has therefore applied a funnel perspective in further selecting the most attractive areas.

Turning some of the soft constraints into hard constraints establishes a second-level selection where only some of the very high and high score areas form the spatial analysis are selected for further consideration. A third-level selection is accomplished by focusing only on sites with sufficient electricity demand or reasonable grid cost for long-distance transmission. Finally, some of these areas are selected for development due to their growth potentials (forth-level selection).

The table below shows the total constrained capacity for areas with very high and high score capacity, that is, after excluding areas with hard constraints and reducing the scores for areas with soft constraints.

The table indicates that the highest capacity of attractive offshore wind sites can be found in Finland followed by Denmark, Sweden and Estonia. Table 1.1 also shows that even if all environmentally protected areas and important bird areas (including wintering sea birds) are disregarded, and the amount of golden sites is therefore reduced in most countries, there is still a substantial capacity left within the high score band in most countries.

It can be deducted that, except for Lithuania and Norway, there are still plenty of 'silver sites' available, even in those countries which have few or no sites left within the very high score band. However, at the same time, it is also clear that some countries, especially Estonia, Lithuania, Russia (Kaliningrad), lose most of their attractive offshore wind locations if all environmentally protected areas are disregarded.[4]

The conclusion is therefore that a second-level selection of sites with focus on environmental issues will realistically limit the available amount of attractive sites, especially in the Baltic States. Yet, enough attractive capacity remains to make the countries fulfill their NREAP targets and even to become world-leading in terms of offshore wind energy deployment in case that would be the political ambition.

Taking into account the electricity demand and grid costs (third-level selection), to deploy offshore wind on some of the most attractive areas measured by criteria 1-3 – such as the central and northern group in Finland and areas in Estonia, Latvia, Germany and Denmark – new transmission capacity must be constructed over very long distances in order to enable export of the electricity to areas where there is sufficient demand. This will entail significant addition capital costs.

A central conclusion of the grid and interconnection study is, however, that including the already planned transmission reinforcements and cross-country grid interconnections within the BSR, there will be sufficient trans-

Table 1.1 – Total capacity in the very high and high score bands before and after excluding all environmentally protected areas

Country	Constrained capacity [MW] – very high score areas (+40)		Constrained capacity [MW] – high score areas (35-39)	
	Capacity after hard constraints	Capacity after excl. protected areas	Capacity after hard constraints	Capacity after excl. protected areas
Denmark	1,607	201	44,345	21,430
Estonia	966	83	14,500	1,346
Finland	17,883	16,651	73,483	67,989
Germany	87	–	5,718	2,774
Latvia	–	–	5,839	2,542
Lithuania	–	–	1,830	107
Norway	–	–	–	–
Poland	–	–	4,698	2,003
Russia (Kaliningrad) + Leninggrad prov.	–	–	3,059	1,160
Sweden	203	–	22,441	14,507
Total (MW)	**20,746**	**16,935**	**159,911**	**113,857**

4. It should be noted that a number of other soft constraints than those which it has been possible to take into account in the spatial analysis might also play a role in limiting the number of available sites – such as for example marine habitats and benthic (seabed) communities, fish migration patterns and nursery areas, archaeological heritage (e.g. ship wrecks etc.), visual impact, etc.

mission capacity for all countries to reach their NREAP targets in 2020. Reaching those targets will require a total additional capacity of merely 3 GW when it is considered that most of the German gap will be covered by offshore wind deployment in the North Sea.

However, if the capacity is going to be developed beyond the NREAP targets, transmission reinforcements and new interconnections will be needed in most power regions. This would have implications for the attractiveness of potential offshore wind sites as some of the golden and silver areas will require higher additional grid costs than others.

Conclusions on where the growth effects (forth-level selection) can be expected to be strongest and most beneficial from a social perspective would require detailed analysis far beyond the scope of this study. However, it can be foreseen that similar concerns – as have been raised in Denmark on the particular social need for generating growth in the outer urban areas far away from the metropolitan areas – will be raised in other countries as well.

2 Scenario 1: Fulfilling the 2020 NREAP targets

The table below shows the expected offshore wind capacity in each country in accordance with the NREAPs, and similar estimates for Norway and Russia.

Table 2.1 – The BSR countries' progress towards 2020 targets for deployment of offshore wind

Country	Electricity demand 2020 [TWh/a]	Offshore [MW] 2020 targets NREAP/similar	Offshore MW installed or C/C* 2010	Offshore MW yet to be installed
Denmark	37.7	1,339	1,268 (incl. 400 C/C*)	71
Estonia	10.9	250	0	250
Finland	101.6	900	0	900
Germany	561.9	10,000	3,007 (incl. 2,887 C/C*)	6,993 (699 in the BSR**)
Latvia	13.9	180	0	180
Lithuania	8.7	0	0	0
Norway	115	Assumed small	2	0
Poland	169.8	500	0	500
Russia (Kalingrad)	n/a	Assumed small	0	0
Sweden	154.6	182	133	49
Total BSR	**1,174**	**13,351**	**4,410**	**8,943**

Source: NREAP – 'additional energy efficiency' scenario, and similar assumptions for Norway and Russia
* C/C = contracted or under construction
** Assuming that 10% (699 MW) will be built in the BSR.

In general, the BSR countries are well underway fulfilling their 2020 targets considering as mentioned above that Germany's feed-in tariff will take the country most of the way towards its 2020 trajectory. However, it is important to note that the BSR countries have put forward different levels of ambition when setting up these targets. Furthermore, the BSR countries are very different not only in terms of ambitions but also in terms of experience within offshore wind deployment which is summarized in the figure 5.1.

The BSR countries can be divided into three groups in terms of their experience and ambitions within deployment of offshore wind:

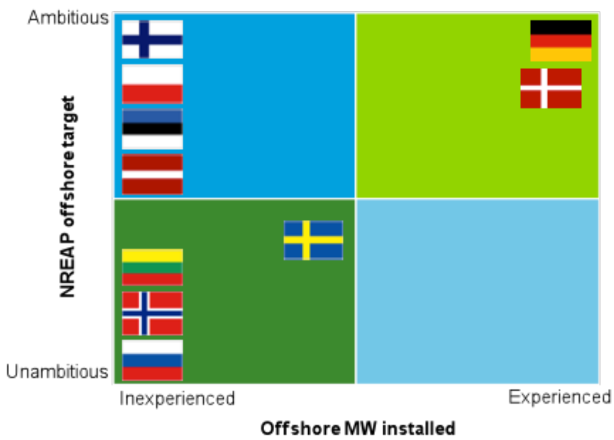
1) *Ambitious and experienced*: Denmark and Germany are both very ambitious in terms of the NREAP targets but the countries are also experienced in terms of offshore wind deployment (e.g. table 2.1)
2) *Ambitious but inexperienced*: Finland, Poland, Estonia and Latvia are ambitious in terms of NREAP targets (900 MW for Finland, 500 MW for Poland, 250 MW for Estonia and 180 MW for Latvia), but the four countries have not yet developed the first offshore wind farms.
3) *Unambitious and inexperienced*: Russia, Norway and Lithuania have no 2020 target and none of the countries have deployed offshore wind power of any significance. Sweden, however, has a 2020 target of 182 MW and has deployed 133 MW of offshore wind which is why Sweden is leaning more towards the experienced and ambitious countries. However, Sweden has so far focused almost entirely on creating favourable conditions for onshore wind development.

In many ways, the BSR is in a unique position. The BSR is a region that can benefit from the strategic location between the EU and Russia and within the BSR 'wind pioneers' such as Denmark and Germany can lead the way in terms of exchange of experience and cross-country cooperation for deployment of wind energy throughout the BSR.

On the basis of the problems and opportunities identified in the enabling studies, a number of strategic initiatives have been identified. They are divided into four main themes:

1. Policy and regulation
2. Research, technological development and demonstration
3. Grid development and integration
4. Environmental planning and permits

Figure 5.1 – The BSR countries' offshore wind ambitions and experience



Policy and regulation

To guarantee investor confidence, and develop offshore wind farms on a sufficient scale, the offshore wind sector needs a stable political framework. However, in the BSR, a number of countries have different political frameworks thus presenting developers with a more complex policy landscape. Hence, from a macro-regional point of view, harmonization of policy and regulation across the BSR into a favourable regime for offshore wind would be best way forward to strengthen investor confidence. This could happen through the development of a common BSR action plan with quantification of the expected offshore wind power. Furthermore, Finland, Poland, Estonia and Latvia will have to undertake strategic initiatives in relation to policy and regulation since they still need to deploy offshore wind in order to meet their NREAP target.

Strategic initiatives in relation to policy and regulation

- Development of the BSR action plan with quantification of the expected contribution of offshore wind power similar to the NREAP targets but more binding, long-term (e.g. till 2030) and manifested in a strong political mandate.
- Finland, Poland, Estonia and Latvia to develop financial incentives through regulation making it sufficiently attractive for developers to construct offshore wind farms. The design of new regulation might be facilitated through cooperation projects with wind pioneer countries (e.g. Denmark) targeting a feed-in tariff approach with differentiated subsidies for onshore and offshore wind, perhaps in combination with temporary incentives such as a sprinter bonus etc.

Research, technological development and demonstration

Offshore wind energy technology is evolving towards larger scale and towards offshore systems being developed in a wider range of water depths and across wider geographical areas. Today, a number of large wind turbine types primarily designed for offshore use are available. It is important that research is further strengthened to support a cost-effective large scale deployment of the technology and strengthen the offshore wind supply chain in general. Further development of port infrastructure, vessels, electrical infrastructure, substructures, turbines, and operation and maintenance infrastructure and techniques is therefore necessary. However, since the BSR is very close to fulfilling the 2020 target, the scenario can probably be realized without further investment.

It is important to note, however, that increased R&D may turn the BSR into a more attractive region for offshore investments specifically benefitting the BSR countries that need to build offshore wind farms towards 2020 such as Finland, Poland, Latvia and Estonia. These countries can benefit from cross-country demonstration projects. As well as countries such as Sweden and Finland can benefit from specific demonstration projects targeting problems related to sea ice loading. Furthermore, 'virtual demonstration projects' presents a fruitful way of engaging in cross country research and development.

Strategic initiatives: Research and technological development

- Estonia, Latvia (and perhaps Poland) to engage in cross-country demonstration projects that will support the deployment of the remaining offshore wind energy to realize their 2020 targets. The demonstrations projects may include physical demonstration projects, for example in the Gulf of Riga, testing for both technical and environmental issues.
- Finland and Sweden to engage in cross-country offshore wind demonstration projects in the northern part of the Gulf of Bothnia testing for foundation and rotor problems related to sea ice loading, and how the harsh conditions in general affect installation and operation of the wind turbines and the grid connection.
- 'Virtual demonstration projects' to be carried out as a supplement to the above in for example Gulf of Riga, the upper or middle parts of the Gulf of Bothnia between Sweden and Finland, and The Middle Bank area between Poland and Sweden. The purpose of the virtual demonstration projects would be to model cross-country consenting complications and alignments and to model the effect on electricity flow and market prices in cases where offshore wind farms have substantial cross-border implications.

Grid development and integration

The availability, cost allocation and processing time of grid connection possibilities frequently represent a key barrier to wind power development. This is particularly true for offshore wind farms where the substantial distance to shore and further onshore distance from national/international electricity grids can make cabling procurement and installation one of the largest cost items in the construction of a wind farm.

Since Finland, Estonia, Latvia and Poland have to deploy more offshore wind to fulfil their 2020 targets, it is important that these countries initiate strategic initiatives as summarized in the box below.[5] Furthermore, Poland and Sweden will have to tackle the back-log problem with large number of applications to the TSO for wind farm connection.

Strategic initiatives: Grid development and integration

- Poland and Sweden to tackle back-log problem with large number of applications to the TSO for wind farm connection, for example. through upfront application fees.
- Finland, Poland, Estonia and Latvia to decide on a cost structure such as a shared cost structure that to a greater extent divides cost and risk between developer and authority.

Environmental planning and permits

Even before wind farms are constructed in terms of environmental planning there are a considerable number of issues to be resolved over site selection, including legal rights and coastal zoning. With respect to environmental planning, it is important that authorities have conducted an initial screening of the economic exclusive zones and the coastal zoning thereby informing developers on which areas that are suitable for offshore wind projects seen from an environmental point of view

Furthermore, the one-stop-shop permitting process as known from for example Denmark can be beneficial to other BSR countries without this permitting process. Especially for the four countries which (according to their NREAPs) still have to deploy offshore wind towards 2020, it is important that they all put in place an efficient process for planning in order for them to generate developer interest and drive down the cost of developing the wind farms. The four countries should put in place an initial screening process and a structured model for consenting (for example an open-door model or a tender model) to create an attractive landscape for offshore wind farm developers.

Strategic initiatives: Environmental planning and permits

- Finland, Estonia, Latvia and Poland to conduct an initial screening of the economic exclusive zones and the coastal zoning thereby informing developers of which areas that are suitable for offshore wind projects seen from an environmental point of view.
- Further and more detailed environmental screening of potentially attractive areas and sites to be carried out by all the BSR countries that plan additional offshore wind energy capacity.
- One-stop-shop approach to permitting to be adopted in all the BSR countries.

5. In scenario 1, it is not seen as realistic that a future transnational offshore grid incorporating all the BSR countries can be established. This is however described in more detail in scenario 2: The BSR to become world leading

Photo: Johnér Bildbyrå

3 Scenario 2: World leading in 2050

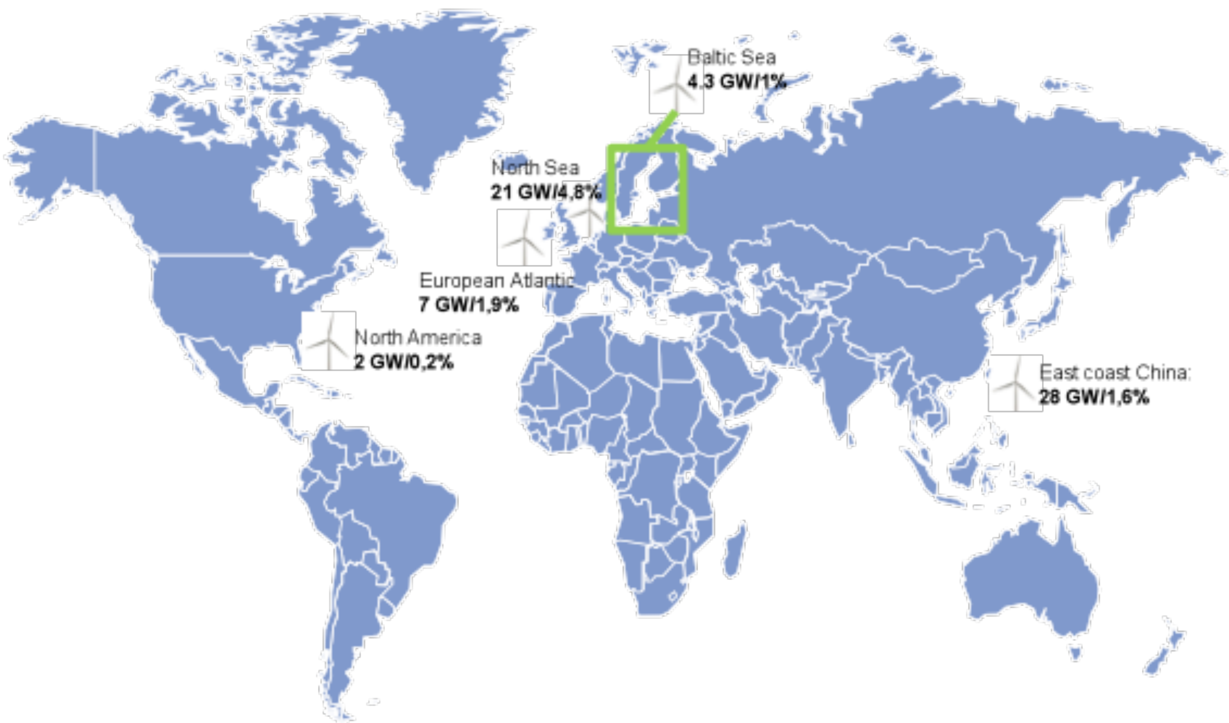
As stressed by scenario 1, only four countries have to further deploy offshore wind in order for them to fulfill the BSR countries 2020 targets, and in general the BSR is well underway fulfilling their 2020 targets. However, if the time horizon is extended to 2050, a number of new possibilities become available for the BSR decision makers among which; the BSR to become world leading in terms of deployment of offshore wind, is a realistic scenario. It requires, however, that the BSR countries from now on prioritize offshore wind deployment and put in place a number of strategic initiatives to support the development of the scenario.

The spatial analysis identified a number of locations for deployment of offshore wind. In total, a capacity of more than 100 GW of spatially attractive sites has been identified in the BSR. Hence, there is enough offshore wind potential for the BSR to become world leading. The figure below shows the 2020 projections for the leading regions in terms of deployment of offshore wind.

The figure illustrates that even though the BSR fulfills the NREAP 2020 targets of 4.3 GW, the Baltic Sea will be very far from leading in terms of deployment of offshore wind. Instead, the east coast of China and the North Sea will be the leading regions. Furthermore, other projections show that from 2020, North America will possibly see massive growth in offshore wind with up to 54 GW although this is highly uncertain (cf. GL Garrad Hassan, Bridging note).

The recommendations for strategic initiatives that were given on these issues on the NREAP scenario also apply to the world leading scenario. Yet, there are additional requirements for strategic initiatives for this second scenario and they are summarized below.

Figure 3.1 – Offshore wind power projections 2020 for leading regions in GW and as a % of 2020 electricity consumption



Note: The percentage of 2020 electricity consumption - assumes a 35% capacity factor for each region. Source. GLGH, IEA and NREAP

Policy and regulation

If the BSR is to become world leading in terms of deployment of offshore wind, policy and regulation has to be the most efficient and trustworthy in the world. Hence, offshore targets have to be strong and a macro-regional harmonization of policy and regulation across the BSR into a favourable regime for offshore wind will have to be undertaken.

Strategic initiatives: Policy and regulation

- Development of a binding target of offshore wind deployment to 2050 for the BSR.
- Setting up of a BSR policy framework that harmonizes rules and legislation within offshore wind including a joint or similar financial incentive scheme for all the BSR countries. The rules should be formulated in accordance with the EU and in close cooperation with other regions with wind ambitions.

Research, technological development and demonstration

If the BSR is to become world leading in terms of deployment of offshore wind, the BSR has to be a leading region in research, technological development and demonstration. First and foremost, the BSR governments' R&D support for offshore wind energy has to be strengthened but also cross-country funds, such as Interreg IVB, present a good opportunity to further strengthen R&D. Furthermore, a fund for innovation and research across the BSR is a necessary step.

Strategic initiatives: Research and technological development

- Strengthening of government R&D support for offshore wind energy.
- Development of a *Baltic offshore fund raising body* consisting of authorities and research institutions across the BSR countries focusing on the utilisation of EU funds such as the Interreg Baltic IVB and national funds for development of offshore wind technology projects.
- Development of a Baltic Sea Fund for innovation and research

Grid development and integration

Grid development is a key issue if the BSR is to become world leading. Today, electrical grids are seen as national infrastructure, but if the BSR is to become world leading, electrical grids - onshore and offshore - have to become corridors for electricity trade, and hence an integrated grid connecting all the BSR countries with both the rest of the EU, and obviously Russia, has to be developed. Furthermore, grid connection costs have to be socialized throughout the BSR so that the state carries the burden of grid costs. Furthermore, an integrated grid system should include the development of a smart grid.

Strategic initiatives: Grid development and integration

- Establishment of integrated grid connecting the BSR, EU and Russia.
- Socialization of grid connection costs throughout the entire BSR so that the state rather than the developers carry the major burden.
- The BSR cross-country implementation body to lead the development of an integrated grid system including development of a smart grid. The purpose of the body would be planning and managing of further grid investments including coordination with other countries and institutions.

Environmental planning and permits

Environmental planning and permits have to be smooth and efficient and the best in the world if the BSR is to become world leading. A coordinated effort to screen the Baltic Sea for possible offshore areas has to take place and the BSR authorities have to conduct an initial screening of the economic exclusive zones and the coastal zoning.

Furthermore, the BSR countries should adopt a common consenting approach all through the BSR possibly open-door in order to ensure investor confidence. Potentially, HELCOM might play a central role as an interregional body promoting cross-border coordination with respect to both environmental screening and consenting.

Strategic initiatives: Environmental planning and permits

- The BSR countries to adopt a common consenting approach e.g. open-door.
- The BSR decision makers to establish a BSR cross-border screening body that will identify relevant sites in the BSR and handle constraints not considered with the relevant national authorities.
- Establishment of cross-country permitting body to coordinate all the BSR countries one-stop-shop permitting approach.
- Potentially, HELCOM might play a central role as a body promoting the above-mentioned cross-border coordination.

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STRATEGIC OUTLINE
4 Objectives and approach

The enabling studies present a thorough mapping of the Baltic Sea Region (BSR) in regard to important factors for the deployment of offshore wind, including a mapping of wind power potentials in different areas, national regulatory frameworks, grid and interconnection issues etc.

On the basis of this mapping, the strategic outline presented in this report explores two different strategic scenarios for developing offshore wind power in the region and come up with proposals for strategic actions and policies in order to realize the respective scenarios.

The objective of the strategic review is to analyze barriers and potential strategic actions in relation to three key scenarios

- *Scenario 0: Business as usual.* Describes the deployment of wind energy according to strategic actions and policy support throughout the region today. The non-action strategy for making scenario 0 happen will be denoted strategy option 0.
- *Scenario 1: The BSR to fulfil the 2020 NREAP targets.* Describes the strategic actions and policies needed for the BSR to optimize the contribution of wind power to fulfil the EU 20-20-20 target as specified in the national reallocation plan (NREAP) framework. The strategic actions and policies for realizing scenario 1 will be denoted strategy option I.
- *Scenario 2: The BSR to progress towards a world leading status in offshore wind energy.* Describes the strategic actions and policies needed to turn the BSR into one of the world-leading regions in terms of deployment of wind energy. The strategic actions and policies for realizing scenario 2 will be denoted strategy option II.

Scenario 0 describes the ”as is” situation whereas scenario 1 and 2 are the potential “to-be” situations that will only happen if strategy option I or II are implemented.

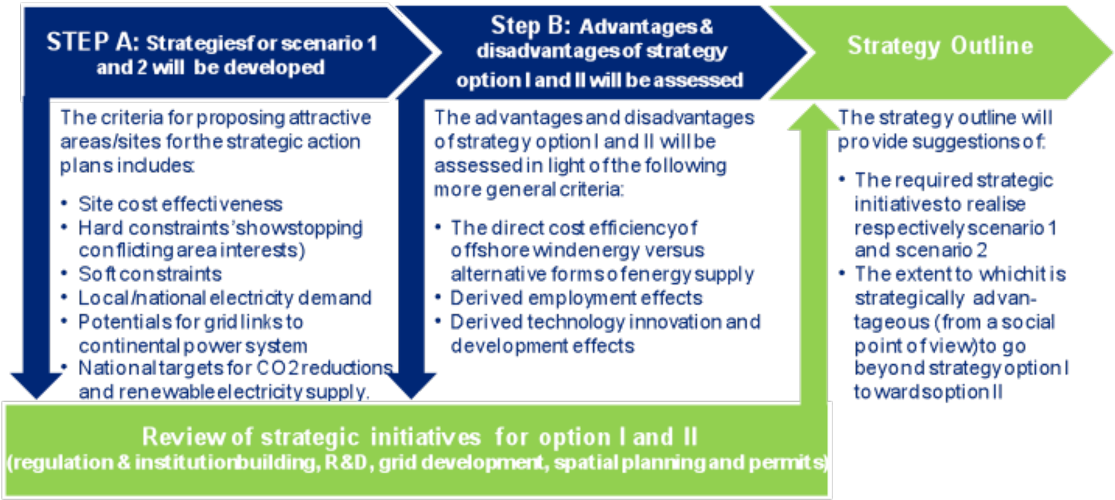
The strategic review will focus on:

- How to get from scenario 0 to scenario 1, and from scenario 1 and possibly further on to scenario 2
- A weighting of strategic pros and cons in moving from scenario 1 towards scenario 2

In order to answer these questions, a two-step approach has been followed as specified in the figure below.

The report is structured so that the analyses and results of step A are reported in section 5 on energy challenges and offshore wind potentials in the BSR and in section 6 on the strategic initiatives. The analyses and results of step B are mainly reported in section 4 on the benefits and costs of offshore wind power vs. alternative electricity supply in the BSR. The review of the strategic initiatives for option I and II is mainly reported in section 6. The final conclusions of the strategic outline are reported in section 8.

Figure 4.1 – The strategic outline within the structure of work packages:



5 Energy challenges and offshore wind potentials in the BSR

The energy challenge of the Baltic Sea Region (BSR) is similar to that of the European Union. The European Wind Energy Association has in its report *Delivering offshore wind power in Europe* underlined the fact that a number of challenges exist in relation to climate change, increasing import dependence and higher energy prices. Moreover, the interdependence of Baltic Sea Region countries for energy, as for many other areas, is increasing[6] – a power failure in one country has immediate effects in others.

The interdependence of energy is very strong for the BSR. Energy in the BSR is at the heart of EU-Russia relations and has become a central element of Russia's engagement in the BSR, especially since the formal beginning of the Nord Stream project in 2005.[7] It is within this context that the Baltic countries face the complicated challenge of balancing national, macro-regional and European interests in their energy policy choices.

The Baltic Sea Region joins countries with very different economies and starting points. Hydro power is an important source of electricity generation in Norway, Sweden, Finland and Latvia. In Norway, Sweden and Finland, biomass energy resources also play an important role, deriving from both agricultural residues and from the large areas covered by forests. Sweden and Finland moreover stands out with respect to their use of nuclear energy. Wind power already contributes considerably to electricity generation in countries like Denmark and Germany, and is likely to play a much greater role in the region in the years to come, both onshore and offshore.

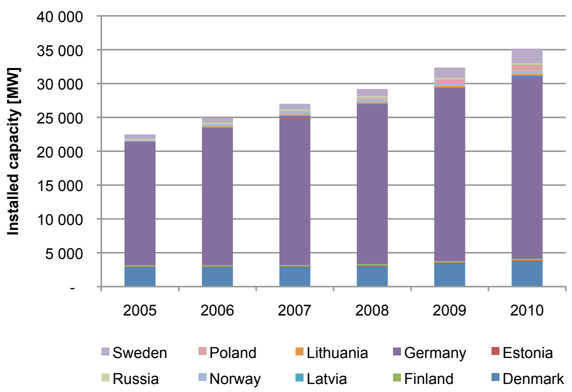
The key to meet challenges in terms of for example increasing interdependence is cooperation and hereby turning the countries' different economies and starting points into a competitive advantage for the BSR.

5.1 Existing deployment of wind energy in the BSR

The BSR includes countries which have widely differing degrees of experience in the deployment of wind power, ranging from wind energy's 'spiritual home' of Denmark through to the 'sleeping giant' of Russia. The reasons for such different levels of progress are many and varied encompassing the political strength of environmental policy, international directives, natural resources of both wind and competitive fuels, electricity market structures and markets, framework conditions and industrial policy.

Figure 5.1 presents the growth in wind power for the BSR (onshore and offshore) over the last 5 years. As illustrated in this graph, Denmark and Germany dominate onshore and offshore deployment to date while Sweden and Poland have begun to make considerable contribution with respect to development of onshore wind energy in the last few years.

Figure 5.1 – Growth in cumulative wind energy capacity of the nations of the BSR 2005 to 2010



6. For example the NordBalt project which is a submarine power cable between Lithuania and Sweden under construction. The aim of the project is to promote trading between Baltic and Nordic electricity markets, and also to increase the security of power supply in both markets.
7. Nord Stream is a twin pipeline system project through the Baltic Sea which is going to transport natural gas from Russia to Western Europe.

The region can be divided into six sub-groups of nations:

1. The pioneers of Denmark and Germany with already high wind energy penetrations in their electricity mix and for whom future growth in the sector is increasingly focused on offshore possibilities.

2. The hydro and nuclear power based electricity producers of Sweden and Finland which until a few years ago had only very low levels of wind deployment but for which recent/impending changes to support mechanisms are accelerating wind energy development activities, especially onshore wind.

3. Norway which is also a hydro power based electricity producer and, like Finland and Sweden, has plenty of wood biomass resources, but makes no use of nuclear power. Norway is moreover special because of its massive oil resources and its relatively small Baltic Sea coast line south of the country.

4. Poland which is similarly a current hotbed of European onshore wind development but rather than being blessed with strong hydro resources instead is heavily dependent on carbon intensive domestic coal reserves.

5. The comparatively small electricity systems of Estonia, Latvia and Lithuania where market liberalization is ongoing and further integration of their grids and markets with Europe is a key priority. However, wind power has only seen very limited deployment to date.

6. Russia which is not bound by any European treaties for renewable energy targets but nevertheless has drafted its own wind energy plans. The country has a huge untapped potential for both onshore and offshore wind power, but only a very small part of the potential lies in the Baltic Sea.

To sum up, the BSR has ensured continuous growth in cumulative wind capacity. However, additional offshore wind power is likely still needed if all the BSR countries are to fulfill the 2020 targets.

5.2 Strategic selection of attractive future offshore wind areas in the BSR

A central question with respect to the future strategy for offshore wind development in the BSR is where to locate the new offshore capacity that would lead to the fulfillment of at least the NREAP objectives or perhaps even further towards a leading status for the BSR with respect to wind energy deployment as a share of total electricity supply.

Since there is no supranational authority to decide in which areas and countries within the BSR the offshore wind capacity should be located, the recommendations in our strategy outline will be limited to suggesting the most attractive areas for offshore wind energy deployment in the BSR based on further analysis of the findings in the spatial analysis and the grid and interconnection analysis which are both part of the enabling studies.

5.2.1 Suggested criteria for deciding the attractiveness of offshore areas/sites

To decide on the most attractive sites for offshore wind deployment in the BSR, we suggest that the following criteria are applied:

1. *Cost of energy.* Conditions that determine the basic cost effectiveness of offshore wind sites (including wind speed, distance to shore, and water depth)

2. *Hard constraints* ("show-stopping" conflicting area interests) such as other wind farms in operation or under construction, cables and pipelines, oil platforms, monitoring of radioactive substances or combine monitoring stations, and chemical munitions dumping grounds

3. *Soft constraints* in the form of shipping (ship transits) and fishery (kilo-tons landed), protected bird areas and other environmental protected areas such as Ramsar, Natura 2000 and special Baltic Sea Protected Areas. Under certain circumstances some of these soft constraints may turn into hard constraints.

4. *Regional electricity demand.* While some offshore sites may be highly cost-effective measured by the cost of energy and be relatively free of constraints, the demand for electricity may not be sufficient within the region served by available grid connections. In other words, the more excess demand for electricity within the grid interconnected region, the more attractive the site will be – everything else being equal.

5. *Potentials for grid links to the continental power system.* Even if there are no grid interconnections at present to transmit electricity to areas with sufficient demand, it is always possible to reinforce the existing transmission system and build new interconnections. Yet, reinforcing and building long-distance transmission systems are costly and those costs need to be taken into account when deciding about the attractiveness of the potential offshore wind sites.

6. *Local employment and growth stimulation.* Finally, construction and operation of huge offshore wind sites may generate significant employment and growth effects, especially in the populated coast areas surrounding the offshore sites. Such growth stimulation might be economically and socially more valuable in some places than in others, which is why this is also a relevant criterion in deciding about the relative attractiveness of offshore wind sites.

Apart from these criteria relating to the attractiveness of specific areas/sites for offshore development, the national targets for CO_2 reductions and renewable energy deployment also plays an important role in making it more attractive to policy-makers to develop sites in some BSR countries than in others. However, as opposed to the above-mentioned criteria, the national targets are more subjective and may turn with the political tides.

Criteria 1-3 above are the ones used in scoring the 10*10 km offshore grids in the spatial analysis. The spatial analysis score enables initial selection of areas with attractive properties with respect to costs of energy and the specific hard and soft constraints applying to the sea areas where the offshore wind farms will be placed.

However, as indicated by the other criteria above, the spatial analysis score does not give a full account of the factors that contribute to the overall attractiveness of a certain potential offshore wind area. Deloitte therefore suggests using a funnel perspective in further selecting the most attractive areas for offshore wind development.

As shown by the figure 5.2, turning some of the soft constraints into hard constraints establishes a second-level selection where only some of the very high and high score areas form the spatial analysis are selected for further consideration.

A third-level selection is accomplished by focusing only on sites with sufficient electricity demand or reasonable grid cost for long-distance transmission (criteria 4 and 5). Finally, some of these areas are selected for development due to their growth potentials (criterion 6).

Figure 5.2 – Site selection model

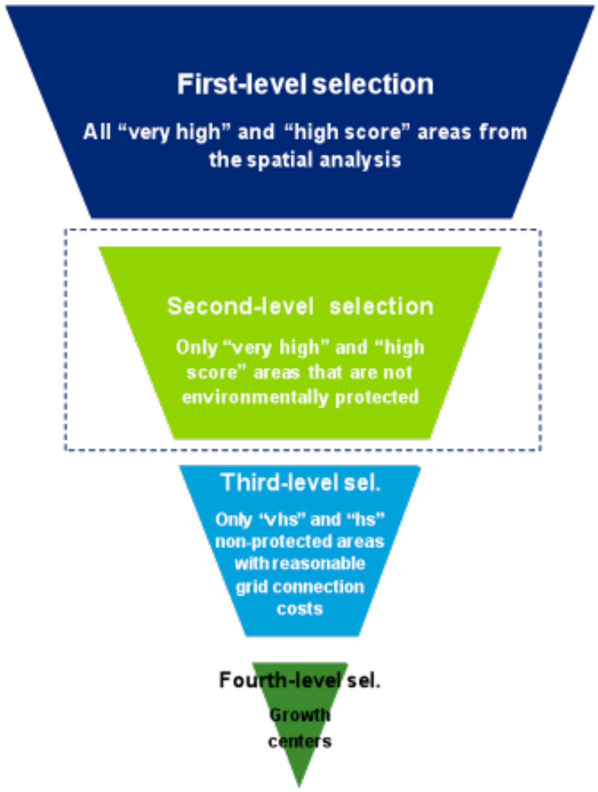
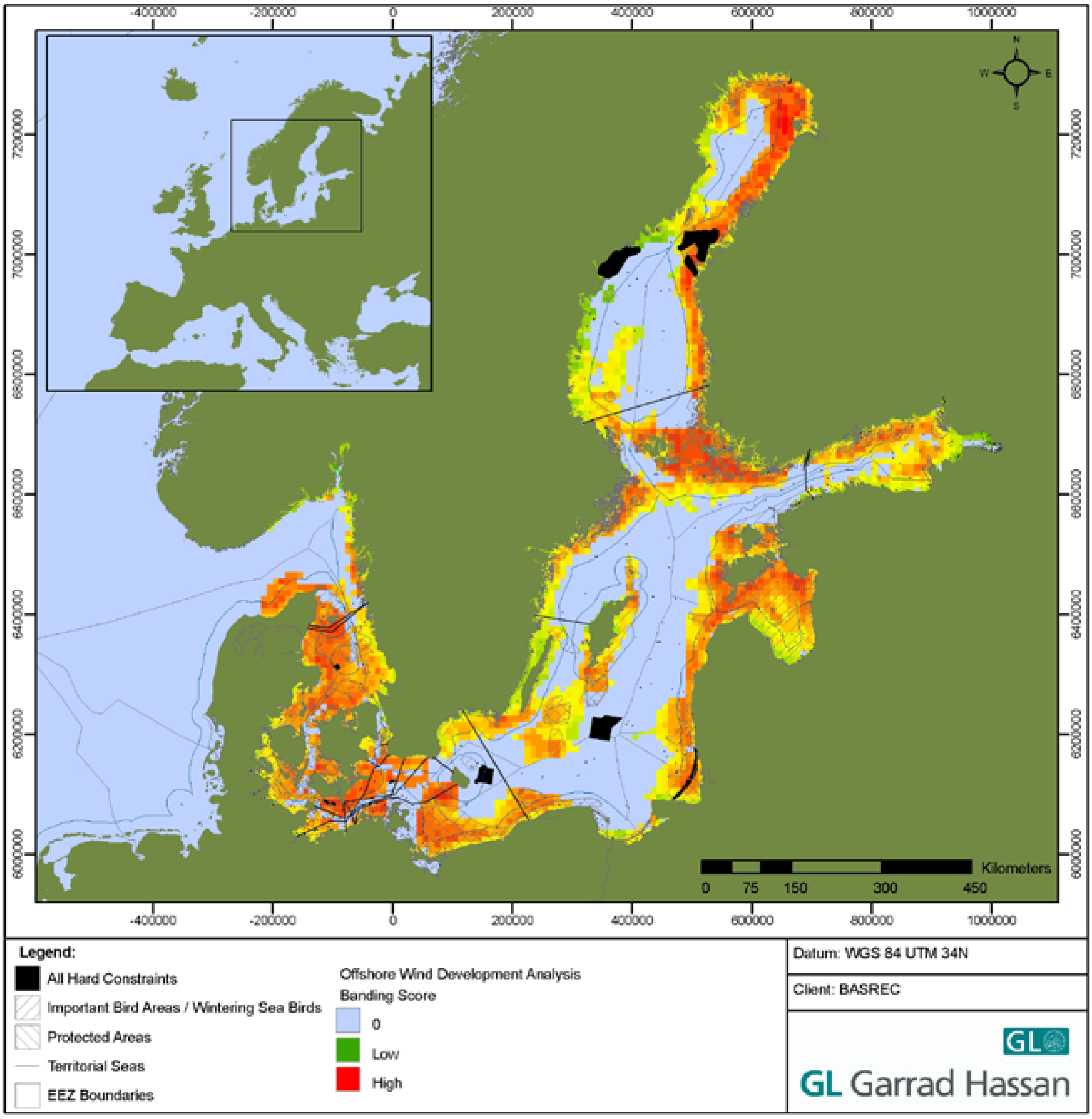


Figure 5.3 – Offshore wind potentials according to the spatial analysis

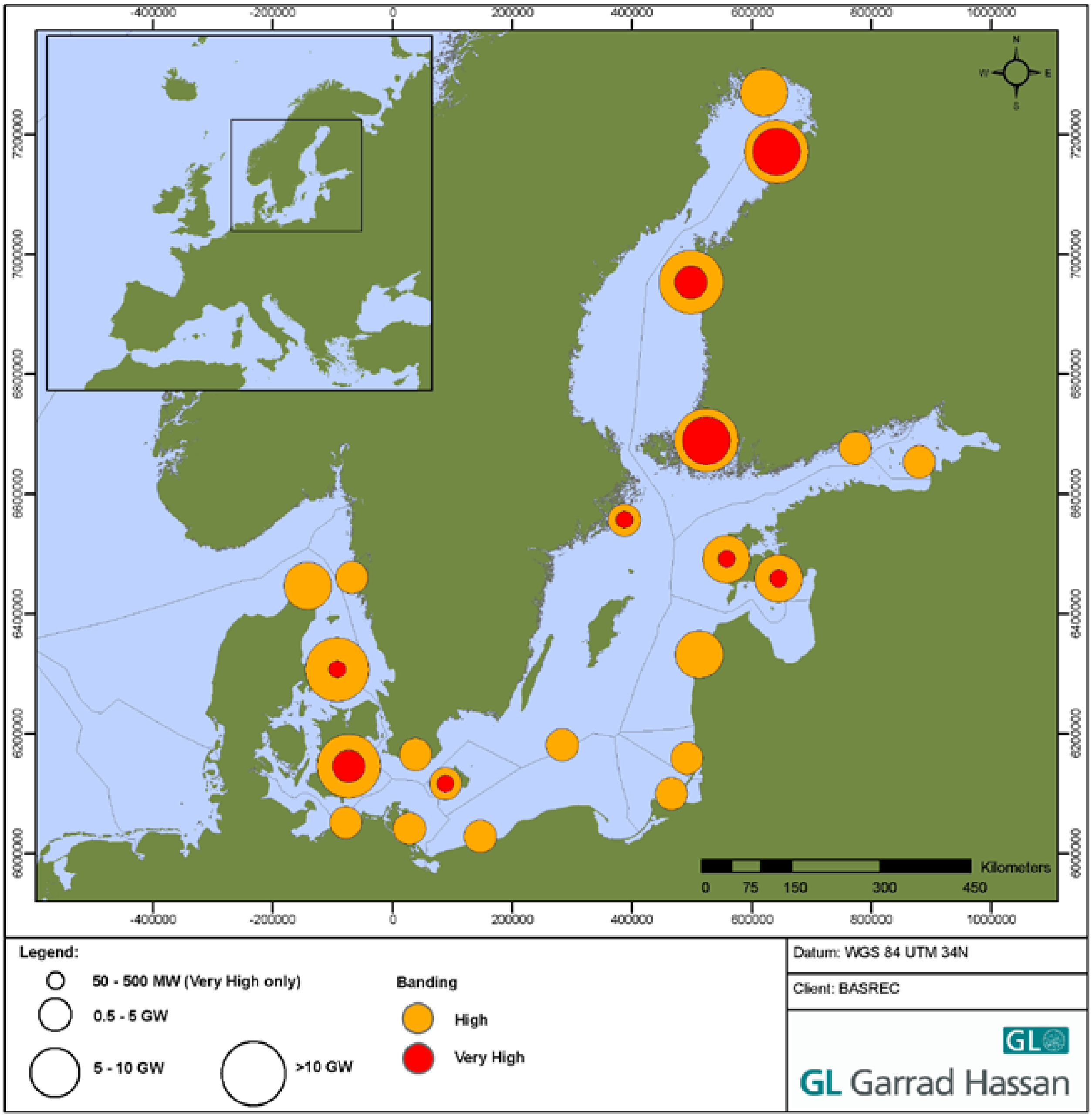


5.2.2 First-level selection of attractive sites: applying the spatial analysis score to the BSR

Using the scores for the spatial analysis based on criteria 1-3 listed above, it is possible to identify 'golden sites' in the BSR. The golden sites are to be found among those areas that scored either very high (+40) or high (35-39) in the spatial analysis. All potential areas and a gross representation of the major constraints are illustrated in figure 5.3. The colors illustrate the score level; the warmer the colors, the higher the score. Figure 5.4 illustrates the aggregated potential capacity of the golden sites in each region indicating areas of significant size which registered very high or high scores. The size of the circles illustrates the size of the potential offshore wind capacity (MW) within each score band.

Accordingly, the golden sites from the perspective of criteria 1-3 are to be found in the following areas:

Figure 5.4 – Golden offshore wind sites in the BSR, condensed view



- Finland, Baltic Sea, east coast:
  - Gulf of Bothnia, Northern part
  - Gulf of Bothnia, Middle part
  - Archipelago Sea between Åland Islands and Finland
- Estonia and Latvia, Baltic Sea
  - East coast of Estonia and Latvia
  - Gulf of Riga
- Denmark, Baltic Sea and the seas between Baltic Sea and North Sea
  - Baltic Sea, South of Bornholm Island
  - Baltic Sea, North and South of the Lolland-Falster Islands
  - Kattegat, South of Læsø Island
  - Skagerak, west coast of North Jutland

Moreover, there is a substantial number of high score sites in Sweden (northern part of Gulf of Bothnia, west of the Stockholm Archipelago and a part of the south coast), Lithuania, Germany (north coast towards Denmark) and Russia (Kaliningrad).

Table 5.1 shows the total constrained capacity for areas with very high and high score capacity on the same basis as for the figures 5.3 and 5.4, that is, after excluding areas with hard constraints and reducing the scores for areas with soft constraints (see the spatial analysis report for a more detailed account of how the constraints are applied).

The table indicates that the highest capacity of attractive offshore wind sites can be found in Finland followed by Denmark, Sweden and Estonia (when electricity demand, grid connection costs and growth potentials are not yet taken into account).

It should be noted that the areas which are considered potentially attractive on the basis of the first-level selection is the result of rough techno-economic assessment of 10*10 km squares. It does not take into account specific site opportunities within those squares. Moreover, it does not take into account the location of the squares within a broader context including the political and economic interests in these locations. Therefore, further selection will be needed in order to locate sites that would also be considered attractive from a social point of view.

Table 5.1 – Total capacity in the very high and high score band

Country	Constrained capacity [MW] – very high score areas (+40)	Constrained capacity [MW] – high score areas (35-39)
Denmark	1,607	44,345
Estonia	966	14,500
Finland	17,883	73,483
Germany	87	5,718
Latvia	–	5,839
Lithuania	–	1,830
Norway	–	–
Poland	–	4,698
Russia (Kaliningrad)	–	3,059
Sweden	203	22,441
Total (MW)	**20,746**	**159,911**

5.2.3 Second-level selection: considering environmentally protected areas

Some of the attractive sites included above are actually important bird areas which had their deployment capacity reduced by 20 per cent because of the protected status.[8] This is because general experience shows that it is often possible to find solutions for constructing offshore wind farms even in important bird areas. The offshore wind farms can often be situated, designed and constructed in such way that harmful impacts on the bird environment are considerably reduced. This is more difficult (although not always impossible) with respect to protected areas with more general environmental interests such as Ramsar, Natura 2000 and special Baltic Sea Protected Areas which therefore had their deployment capacity reduced by 90 per cent in the spatial analysis because of the protected status.

However, the BSR countries, especially the Scandinavian countries and Germany, generally apply very high environmental standards, and it is therefore likely that precautionary principles will be applied when potential offshore wind farm sites overlap with protected areas with general environmental interests and also in the case of overlap with protected bird areas.[9] In other words, environmentally protected areas will often be a hard constraint for the construction of offshore wind farms, especially when many other (nearly as good) sites are available.

8. It means that out of the total MW capacity within very high and high score protected bird areas, only 90 per cent of the capacity/areas are included in the golden sites shown in table 5.1 and figure 5.4. For other types of environmentally protected areas, only 20 per cent are included.
9. For example, an area south of the Læsø Island, which is probably the most attractive offshore wind site in the whole Danish Kattegat Sea, was dropped solely for the reason that it might have caused problems for the protected black duck.

Photo: Danish Energy Agency

Figure 5.5 – Golden sites after excluding protected and bird areas

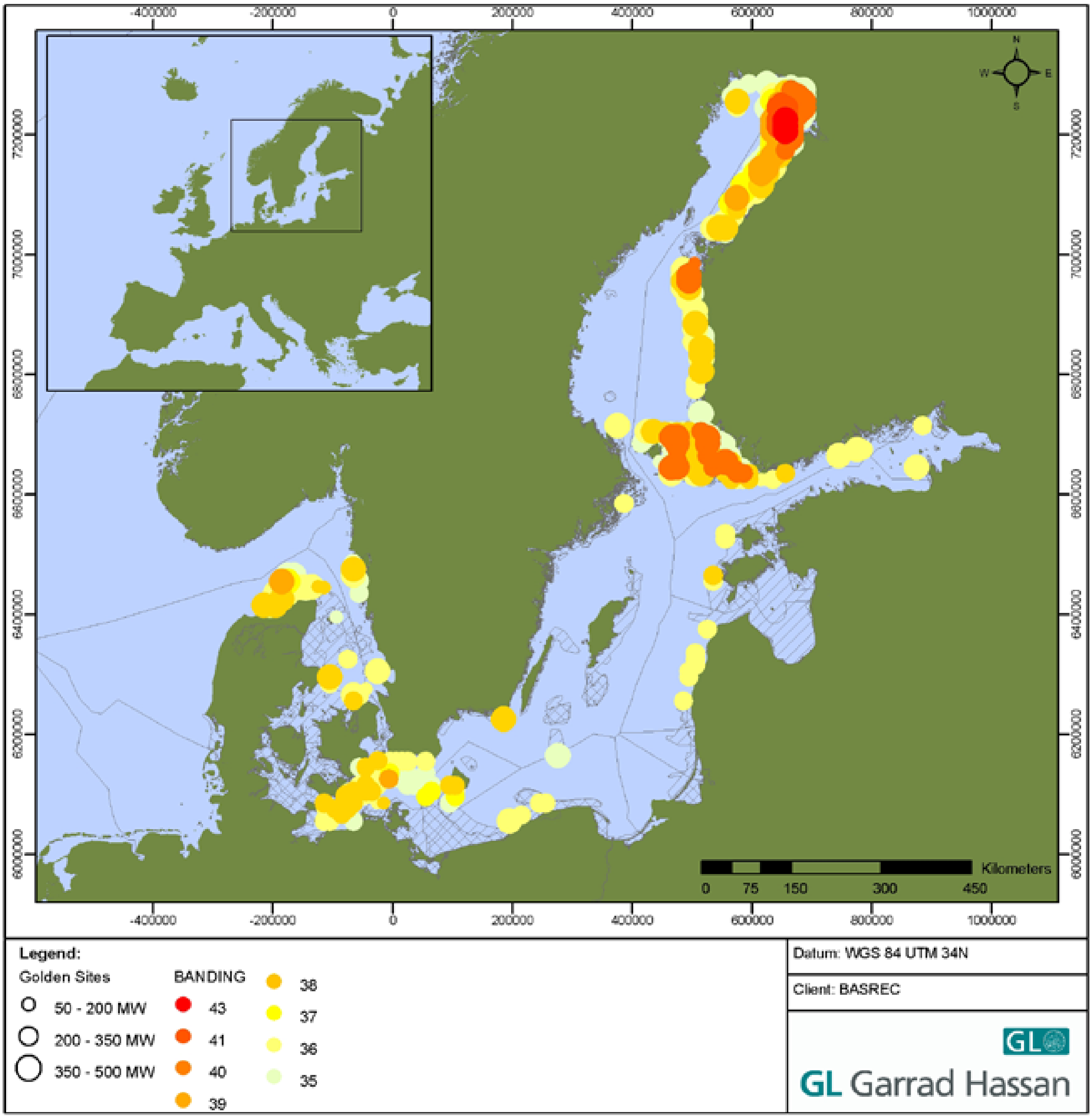


Figure 5.5 and table 5.2 show that even if all environmentally protected areas and important bird areas (including wintering sea birds) are disregarded, and the amount of golden sites are therefore reduced in most countries, there is still a substantial capacity left within the high score band in most countries.

It can be concluded that, except for Lithuania and Norway, there are still plenty of 'silver sites' available, even in those countries which have few or no sites left within the very high score band. However, at the same time it is also clear that some countries, especially Estonia, Lithuania, Russia (Kaliningrad), lose most of their attractive offshore wind locations if all environmentally protected areas are disregarded.

Table 5.2 – Total capacity in the very high and high score bands before and after excluding all environmentally protected areas

Country	Constrained capacity [MW] – very high score areas (+40)		Constrained capacity [MW] – high score areas (35-39)	
	Capacity after hard constraints	Capacity after excl. protected areas	Capacity after hard constraints	Capacity after excl. protected areas
Denmark	1,607	201	44,345	21,430
Estonia	966	83	14,500	1,346
Finland	17,883	16,651	73,483	67,989
Germany	87	–	5,718	2,774
Latvia	–	–	5,839	2,542
Lithuania	–	–	1,830	107
Norway	–	–	–	–
Poland	–	–	4,698	2,003
Russia (Kaliningrad) + Leninggrad prov.	–	–	3,059	1,160
Sweden	203	–	22,441	14,507
Total (MW)	**20,746**	**16,935**	**159,911**	**113,857**

In these countries, it may therefore be relevant not to rule out beforehand the construction of offshore wind farms in areas which are only protected for the reason of bird interests, but instead try to find solutions for establishing the offshore wind farms in less critical parts of the protected areas plus organizing and designing the wind turbines in ways that cause minimal harm to the birds. For Estonia and Kaliningrad in particular, it is noted that some of these protected bird areas are designated as Wintering Grounds of Sea Birds rather than Important Bird Areas; a designation which may prove less onerous when applying for environmental permits. Indeed some planned offshore wind farms in Estonian waters are located in these areas for example Hiiumaa offshore wind farm.

From the table it appears that most of the attractive sites are still left in Finland after disregarding all environmentally protected areas. Yet, although only minor parts of the golden area in South Finland within the Archipelago between Åland Islands and the coast of Finland have the status as officially protected areas, environmental interest weigh heavily in that part of Finland (for example it is a great concern to conserve the best possible conditions for sea eagles) and there are also considerable leisure interests associated with the many summer houses in the area.

According to the Finnish Wind Power Association, it is therefore doubtful whether it will be feasible and desirable to exploit any of the theoretical potentials in the Turku Archipelago.

Also in Denmark, Sweden and other countries, where much of the capacity is left after disregarding officially protected areas, there will still be a number of areas where offshore wind farms will be ruled out because of more specific environmental concerns. Moreover, it should be recalled that a number of other soft constraints than those which it has been possible to take into account in the spatial analysis might also play a role in limiting the number of available sites – such as for example marine habitats and benthic (seabed) communities, fish migration patterns and nursery areas, archaeological heritage (e.g. ship wrecks etc.), visual impact, etc.

The conclusion is therefore that a second-level selection of sites with focus on environmental issues will realistically limit the available amount of attractive sites, especially in the Baltic States. Yet, enough attractive capacity remains to make the countries fulfill their NREAP targets and even to become world-leading in terms of offshore wind energy deployment in case that would be the political ambition.

The strategic recommendation following from this section is that the potential environmental consequences should be considered very carefully before designating out areas for future offshore wind development in the BSR as it may be both costly and in the end prove infeasible to develop sites that conflict with environmental interests. On the other hand, the recommendation is not that all environmentally protected areas should be ruled out on beforehand since in some cases there may be practical and technical solutions available to deploy offshore wind farms in small parts of such areas at lower costs than the alternatives means for energy supply. In that sense, it is correct not to consider environmental protection status as a hard constraint per se.

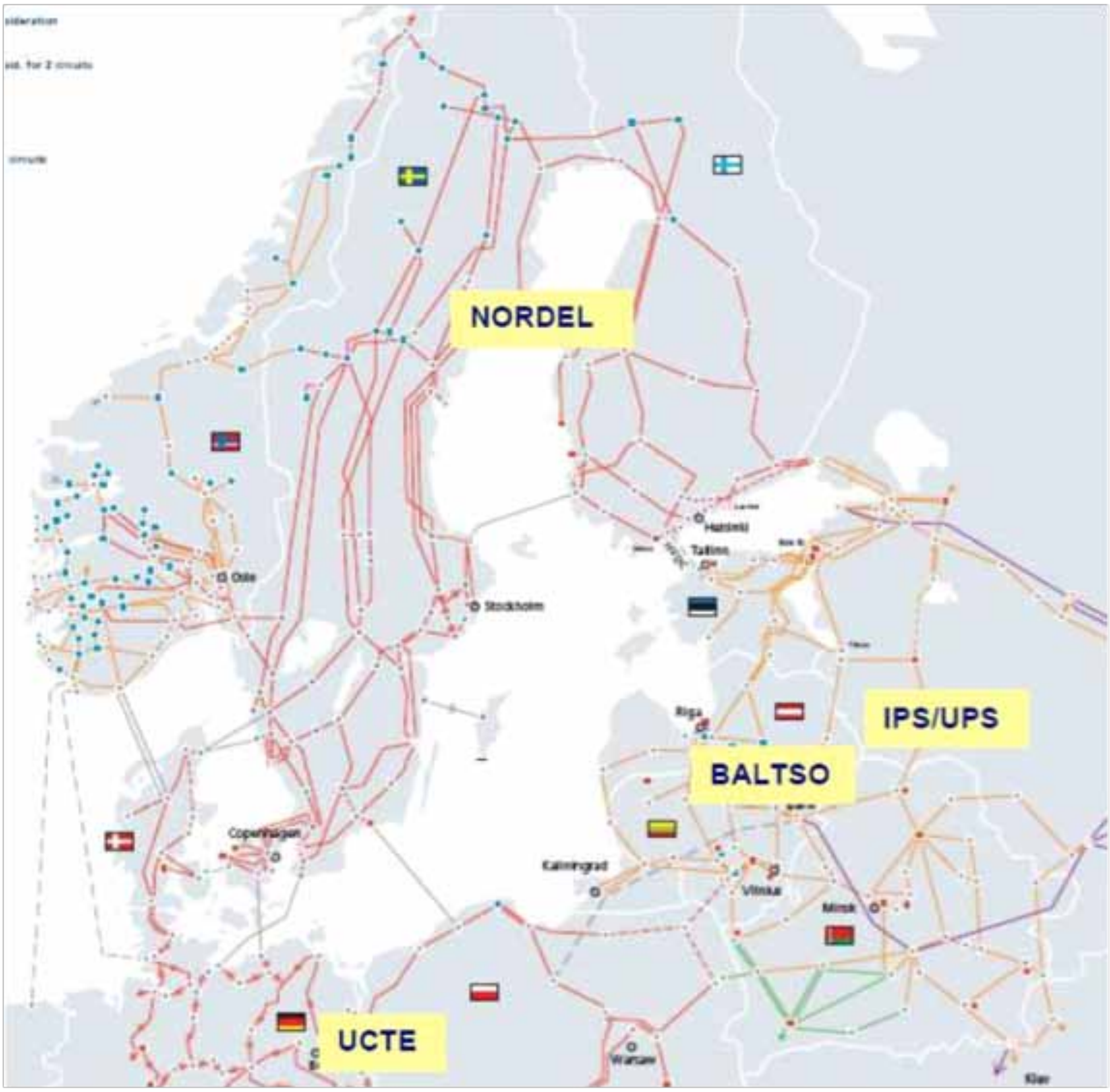
5.2.4 Third-level selection: taking into account electricity demand and grid costs

The areas identified as the most attractive from considerations on site cost effectiveness and local hard and soft constraints may not necessarily be the most attractive seen in the larger perspective. It depends crucially on the extent to which the produced electricity from the offshore sites can be transmitted, at reasonable costs, from the shore points to regions where there is sufficient demand for the electricity given the variability and relative instability of wind energy supply.

It is therefore relevant to consider the existing electricity grid interconnections within and between the countries in the BSR, and the further interconnections to Continental Europe, Russia, Belarus and the British Islands. These interconnections have been studied more carefully in the *Grid and Interconnection Study* which constitutes one of the three enabling studies of the strategic outline.

The central issue is whether the existing high voltage transmission system that transfers large amounts of electrical power over long distances, from large power stations to the main centres of electricity demand such as cities, is sufficient for supporting wind energy production, or whether it needs to be reinforced and at what costs.

Figure 5.6 – Synchronous transmission systems in the BSR (2009)



Source: CESI report June 2009 nr. A9017214

A central conclusion of the grid and interconnection study is that, including the already planned transmission reinforcements and cross-country grid interconnections within the BSR, there will be sufficient transmission capacity for all countries to reach their NREAP targets in 2020. Reaching those targets will require a total additional capacity of merely 3 GW when it is considered that most of the German gap will be covered by offshore wind deployment in the North Sea, cf. table 5.3.

However, if the capacity is going to be developed beyond the NREAP targets, transmission reinforcements and new interconnections will be needed in most power regions. This would have implications for the attractiveness of potential offshore wind sites as some of the golden and silver areas will require higher additional grid costs than others.

A rough estimation of the additional transmission costs is provided in the Appendix 5 of the Grid and Interconnection study. The results are reproduced in table 5.4.

The table shows that, for some of the most attractive areas measured by criteria 1-3 – such as the central and northern group in Finland and areas in Estonia, Latvia, Germany and Denmark – new transmission capacity must be constructed over very long distances in order to enable export of the electricity to areas where there is sufficient demand. This will entail significant addition capital costs.

For example, exploiting the huge offshore wind potentials in the central and northern group in Finland will require that new transmission capacity is established connecting the region with power centres in Germany and Poland over a distance of at least 1600 kilometers. This is because

Table 5.3 – The BSR countries' progress towards 2020 targets for deployment of offshore wind

Country	Electricity demand 2020 [TWh/a]	Offshore [MW] 2020 targets NREAP/similar	Offshore MW installed or C/C* 2010	Offshore MW yet to be installed
Denmark	37.7	1,339	1,268 (incl. 400 C/C*)	71
Estonia	10.9	250	0	250
Finland	101.6	900	0	900
Germany	561.9	10,000	3,007 (incl. 2,887 C/C*)	6,993 (699 in the BSR**)
Latvia	13.9	180	0	180
Lithuania	8.7	0	0	0
Norway	115	Assumed small	2	0
Poland	169.8	500	0	500
Russia (Kalingrad)	n/a	Assumed small	0	0
Sweden	154.6	182	133	49
Total BSR	**1,174**	**13,351**	**4,410**	**8,943**

Source: NREAP – 'additional energy efficiency' scenario, and similar assumptions for Norway and Russia
* C/C = contracted or under construction
** Assuming that 10% (699 MW) will be built in the BSR.

within Scandinavia, there is little fossil generation for this large amount of additional offshore wind to displace, and offshore wind is not very likely to be able to compete against biomass and onshore wind in that area. However, the power flows will doubtlessly be moderated by the storage effect of Norwegian and Swedish hydro, and possibly also demand-side management in Finland, so the transmission capacity required will be less than the wind capacity. Yet, it is estimated that it would still increase the total capital costs of the developing sites in this area with some 40 per cent compared to areas where no transmission reinforcement is required.

Since in the southern Finnish group there are better transmission potentials to the power centres in Finland and Russia (and Sweden), this calls for a reconsideration of which areas in Finland that are most relevant for offshore wind deployment. Even if there are more environmental concerns in the southern Finnish group – and even if some reinforcement will also be required in case of a substantial increase in offshore wind deployment in that area – the sites will probably be more cost-effective overall than the sites in the central and northern group.[10]

For the Baltic countries, new transmission capacity will have to be built, both between the countries and towards Russia, Belarus, Poland and Finland for every additional offshore wind capacity that is installed beyond the NREAP targets. However, in Denmark and Germany, additional transmission costs of similar size per MW are expected. By contrast, it is not assumed that additional transmission capacity will be required in Sweden, hence making the golden and silver areas in Sweden appear rather attractive when total costs are considered.

Table 5.4 – Assessment of additional transmission costs

Country	Additional transmission capacity assumed [% of additional offshore wind capacity]	Assumed distance [km]	Transmission cost estimate [€/MW]	Fractional increase in offshore wind capital cost
Denmark	50%	800	0.68 M	20%
Estonia	100%	400	0.68 M	20%
Finland (southern and south-eastern groups)	Assume offshore wind capacity in this area is not large enough to require export	0	0	0
Finland (central and northern groups)	50%	1,600	1.36 M	40%
Germany	50%	800	0.68 M	20%
Latvia	100%	400	0.68 M	20%
Lithuania	100%	200	0.34 M	10%
Poland	100%	200	0.34 M	10%
Russia	Assume limited offshore wind development for local consumption	0	0	0
Sweden	0	0	0	0

10. The potential increase in operating costs because of wing icing problems in the northern group may contribute further to this differential until low cost solutions to that problem have been found.

5.2.5 Fourth-level selection: employment and growth considerations

Employment and growth considerations will be important in finally deciding between potential candidates for offshore wind sites that appear attractive on the other dimensions, i.e. which are cost effective from the local site perspective; not bound by spatial constraints that cannot be overcome; and do not entail additional transmission costs beyond acceptable levels.

For example, it has been estimated that the construction of the upcoming 600 MW offshore wind farm in Denmark, which is expected to be sited either at Kriegers Flak in the Baltic Sea or Horns Rev in the North Sea will generate up to 16,000 additional jobs in the construction phase when multiplier effects are included plus hundreds of permanent jobs in the operation phase. Facing these prospects, there are ongoing lobbying efforts and a political discussion on whether the Danish government should grant the next 600 MW concession for the Krieger Flak site or the Horns Rev site. While Krieger Flak is close to the metropolitan Copenhagen area, and will primarily generate jobs in that area, Horns Rev is situated at the Danish west coast where there is more stagnation and arguably more need for the extra economic stimulus generated by the huge construction project.

Other sources have estimated that 16 new jobs are created in wind power related industries for every MW installed which means that for each 200 MW offshore site, at least 3,200 new jobs are created.[11] Employment and growth will therefore be important factors in deciding about the most attractive sites for offshore wind deployment in the BSR.

Conclusions on where the growth effects can be expected to be strongest and most beneficial from a social perspective would require detailed analysis far beyond the scope of this study. However, it can be foreseen that similar concerns – as have been raised in Denmark on the particular social need for generating growth in the outer urban areas far away from the metropolitan areas – will be raised in other countries as well. This might for example strengthen the case for developing offshore wind power in the northern and central group of Finland and certain places along the shores of the Baltic countries and Poland.

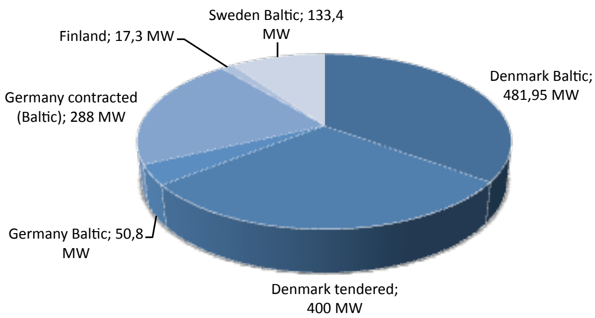
11. EWEA (2009), *Wind at Work: Wind energy and job creation in the EU.*

5.3 Lessons learned from forerunners: Denmark and Germany

This section will highlight the most central lessons that can be learned from Denmark and Germany which are the forerunner BSR countries in terms of offshore wind energy deployment.

Figure 5.7 below presents the operational, contracted, committed and under construction offshore wind capacity by country in the BSR as of mid-2011.

Figure 5.7 – Offshore wind in operation, contracted/ committed or under construction in the BSR[12]



As illustrated in the figure, Germany and Denmark are the forerunners when considering built and contracted offshore wind farms. Both these countries also have a substantial amount of offshore wind capacity deployed in the North Sea, and their position as frontrunners has been ensured by setting up framework conditions that have guaranteed investor and developer confidence. The countries' more than 20 years of experience in setting up framework conditions may provide guidance and be an important asset to the rest of the BSR countries. Some of the important lessons are summarized below in regard to four key themes:[13]

Policy and regulation: Over time Denmark and Germany have had varying success in ensuring a policy and regulation framework that represents an attractive landscape for potential investors. For example, Denmark tendered the offshore wind farm Anholt back in 2009, but only one utility chose to bid in spite of the fact that Anholt presents a large amount of offshore wind capacity (400 MW).

Through an evaluation of the Anholt tender process, potential investors emphasized the importance of determining a political action plan for the coming years' expansion of offshore wind farms. When developers choose sites and countries for their offshore investments, they are particularly concerned with the synergy effects that may be realized in the tender, construction and operating phase in order to optimize the value chain. Furthermore, they are very concerned about the national support models. Among the potential investors there was a broad recognition of the Danish support model with a fixed settlement price for a given amount of electricity which gives the developers security for income. Hence, two important learning points can be derived:

- In order to stimulate investments, it is important to set ambitious long-term political targets and publish specific action plans regarding the future national capacity-building offshore wind energy.[14]
- It is also very important that the financial incentives are sufficient and stable which is best achieved by relatively fixed feed-in-tariffs[15] including sufficient public subsidies

Research and technological development: Many leading global wind turbine component manufacturers and developers are entering the offshore sector as part of their transformation processes. Denmark has been able to create a framework for these developers through specific

12. Denmark and Germany also have installations in the North Sea (Denmark 386 MW and Germany 2,668.2 MW) while Sweden has installation in the inland lake Vanern (48.6 MW) all of which are not included in this graph.
13. Lessons learned are developed by Deloitte based on our general experience and in particular a comprehensive analysis carried out by Deloitte and GLGH for the Danish government: *Analysis of the furthering of competition in relation to establishment of large offshore wind farms in Denmark*. Among other key activities Deloitte analyzed framework conditions in key EU countries and interviewed numerous European utilities and potential financial investors.

demonstration projects and R&D centres. For example, the former Odense Steel Shipyard, Lindø, is developing a Maersk ship yard which is becoming a significant research and development site for offshore wind power turbine foundations and wave energy plants. Hence, one important learning point can be derived:

- Specific initiatives should be taken to promote offshore wind farms for demonstration and technology testing

Grid development and integration: Grid development and integration are very important to developers. If grid connection is performed, paid and guaranteed by a state-owned TSO (transmission system operator) – as is the case in Denmark – it helps reducing the risk for the investors. In Germany, the state also helps financing grid costs. However, the German TSO is not owned by the state. It acts as the contract counter-party to the generator rather than a supplier. Two learning points can be derived:

- The vesting of responsibility for grid development within one central, state-owned TSO stimulates fast and well-structured development of offshore wind integration into the grid
- Full or partly state-financing of grid development costs stimulates investments and fast development (as opposed to the private developer bearing all costs)

However, an important difference between Denmark and Germany may be noted in this respect as there are currently substantial delays with respect to the offshore grid development in Germany which cause great problems to the investors and threaten to stall new investments. Similar problems are so far not encountered in Denmark. It has yet to be analyzed whether that difference is related to differences in the structure and organization of the Danish and German TSO.

Environmental planning and permits: Effective environmental planning and consenting makes it more attractive for developers to invest. For example, Germany has been particularly proactive in spatial planning conducted in the Exclusive Economic Zone (EEZ) by the Maritime and Hydrographic authority (BSH) who have identified areas suitable for offshore wind energy. The purpose has been to ensure a higher realization rate of offshore development projects. In Germany, developers are free to apply for sites in an open-door procedure, and by way of thorough initial spatial screening and planning, the realization prospects of potential offshore wind farms are improved.

In regard to the permitting process, Denmark has set-up a one-stop-shop for licenses applying to offshore wind farms that ensures coordination with other relevant authorities on conflicting area interests, for example environmental protection or demarcation. This process is unbureaucratic and effective and hence an important asset for developers. Hence, two learning points can be derived:

- Thorough spatial-environmental planning, and sponsoring of environmental impacts assessments prior to consenting for offshore wind farm concessions ensures a higher realization rate of offshore development projects
- The Danish one-stop-shop is an example of efficient and fast coordination of the different permit requirements and a best practice example for other countries to follow.

The lessons learned will be important for other BSR countries that wish to establish stable framework conditions to ensure developer confidence and hereby deploy more offshore wind energy. However, what kind of lessons other BSR countries will be inspired by - and to what extent - depends on what the specific country aspire to achieve and hence what scenario the BSR decision markers envisage.

14. UK is a good example of a country that has created an attractive landscape for developers through ambitious targets. Allocations for tender round 3 were launched in 2008 with high hopes of producing an additional massive 25GW of offshore wind energy. Along with the ambitious targets offshore energy is subsidized by attractive financial subsidy schemes creating an even more attractive landscape for developers.
15. Fixed feed-in tariffs (uniform fixed tariffs) represent a price adjustment model by which the price subsidy for electricity production from offshore wind farm has been stated, and where the project developers focus on determining the offshore turbine capacity that maximizes their profit.

Photo: Johnér Bildbyrå

6 Analysis of strategic initiatives to accomplish the two scenarios for offshore wind in the BSR

The overall objective of the outline strategic plan is to provide a summary of the range of strategic and policy options available to Baltic Sea Region decision makers for the effective realization of the identified wind power potential. However, the range of strategic and policy options varies with the target that the BSR decision makers wish to achieve. If for example the deployment of offshore wind today is seen as sufficient, the range of strategic and policy options will be much more narrow than if the BSR decision makers wish to turn the BSR into a world leading region in terms of deployment of wind energy.

Hence, Deloitte has on the basis of the enabling studies analyzed three different scenarios in terms of deployment of offshore wind power:

- *Scenario 0: Business as usual.* Describes the deployment of wind energy according to strategic actions and policy support throughout the region today. The non-action strategy for making scenario 0 happen will be denoted strategy option 0.
- *Scenario 1: The BSR to fulfil the 2020 NREAP targets.* Describes the strategic actions and policies needed for the BSR to optimize the contribution of wind power to fulfil the EU 20-20-20 target as specified in the national reallocation plan (NREAP) framework. The strategic actions and policies for realizing scenario 1 will be denoted strategy option I.
- *Scenario 2: The BSR to progress towards a world leading status in offshore wind energy.* Describes the strategic actions and policies needed to turn the BSR into one of the world-leading regions in terms of deployment of wind energy. The strategic actions and policies for realizing scenario 2 will be denoted strategy option II.

Scenario 0 describes the "as is" situation whereas scenario 1 and 2 are the potential "to-be" situations.[16] How to get from scenario 0 to scenario 1 and possibly further on to scenario 2 is the focus of the present section 6. Section 6.2 will follow up by a weighting of strategic pros and cons to assess whether there are net benefits in moving from scenario 1 towards scenario 2 (compared to alternative electricity supply in the BSR).

16. All three scenarios are important and are taken into account through the enabling studies, but the strategic outline will focus on how to get from scenario 0 to scenario 1 and 2.

6.1 Scenario 1: Fulfilling the 2020 NREAP targets

While none of the BSR countries set legally binding targets for wind energy, all EU countries (including the EU member states within the BSR) submitted expected trajectories both in terms of sector (i.e. electricity, heat and transport) and by technology as part of their National Renewable Energy Action Plans (NREAPs).[17] Similar technology level trajectories can be estimated for Norway via its certificate obligation levels and Russia using research by the Russian Institute of Energy Strategy.

These trajectories are the basis for an analysis of scenario 1 (BSR to fulfill the NREAP 2020 target) and hereby to describe the strategic initiatives needed for the BSR to optimize the contribution of offshore wind power to fulfill these targets.

Figure 6.1 presents the level of progress for the deployment of offshore wind power towards the trajectories laid out for 2020 in national NREAPs or similar for non-EU countries. The solid shaded areas of the green dials represent the proportion of the 2020 offshore wind trajectory fulfilled as of end 2010. Light green shaded areas represent projects which are either contracted/under construction (in the case of Germany) or have won a tender (in the case of Denmark).

Not included in the figure are a number of offshore wind farms where developers have received or submitted for permitting rights. For some countries, such as Finland and Sweden, additional financial support of some form is probably necessary to enable these projects to proceed and receiving consent to build. For Germany, relatively strong financial support is available via the country's offshore wind feed-in tariff system and thus a significant proportion of the 5 GW of permitted projects in addition to those included in the figure 6.1 may be realized, taking Germany most of the way towards its 2020 trajectory.

Figure 6.1 – Progress of offshore wind power deployment to 2020

Note: Offshore contribution in Russia and Norway expected to be negligible by 2020. Lithuania's NREAP does not include any offshore contribution for 2020.

One further complication surrounds the surplus margin of renewable energy included in NREAP in some of the countries. While this in itself is based upon a projection for demand in the NREAPs, there is clearly the potential for some countries to deploy at lower rates than their NREAP trajectories and yet still meet their overall renewable energy targets.

17. Some countries have national binding targets but this is then also reflected in the NREAP.

Photo: Mirco Kaiser, GL Garrad Hassan

Table 6.1 – The BSR countries' progress towards 2020 targets for deployment of offshore wind

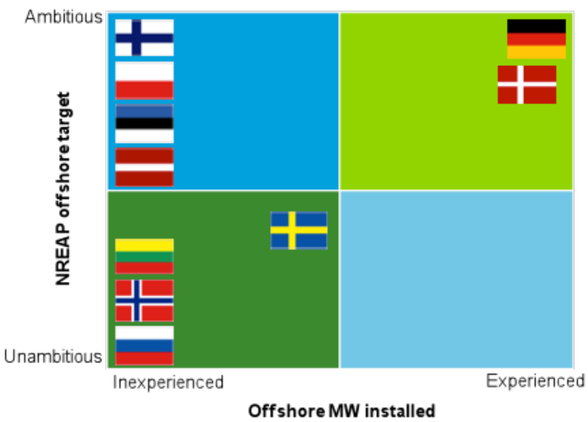
Country	Electricity demand 2020 [TWh/a]	Offshore [MW] 2020 targets NREAP/similar	Offshore MW installed or C/C* 2010	Offshore MW yet to be installed
Denmark	37.7	1,339	1,268 (incl. 400 C/C*)	71
Estonia	10.9	250	0	250
Finland	101.6	900	0	900
Germany	561.9	10,000	3,007 (incl. 2,887 C/C*)	6,993 (699 in the BSR**)
Latvia	13.9	180	0	180
Lithuania	8.7	0	0	0
Norway	115	Assumed small	2	0
Poland	169.8	500	0	500
Russia (Kalingrad)	n/a	Assumed small	0	0
Sweden	154.6	182	133	49
Total BSR	**1,174**	**13,351**	**4,410**	**8,943**

Source: NREAP – 'additional energy efficiency' scenario, and similar assumptions for Norway and Russia
* C/C = contracted or under construction
** Assuming that 10% (699 MW) will be built in the BSR.

Table 6.1, which is presented once again above, shows the expected offshore wind capacity in each country in accordance with the NREAPs, and similar estimates for Norway and Russia.

In general, the BSR countries are well underway fulfilling their 2020 targets considering as mentioned above that Germany's feed-in tariff will take the country most of the way towards its 2020 trajectory. However, it is important to note that the BSR countries have put forward different levels of ambition when setting up these targets. Furthermore, the BSR countries are very different not only in terms of ambitions but also in terms of experience within offshore wind deployment which is summarized in the figure below.

Figure 6.2 – The BSR countries' offshore wind ambitions and experience



The BSR countries can be divided into three groups in terms of their experience and ambitions within deployment of offshore wind:

1) *Ambitious and experienced:* Denmark and Germany are both very ambitious in terms of the NREAP targets but the countries are also experienced in terms of offshore wind deployment (e.g. table 6.1)

2) *Ambitious but inexperienced:* Finland, Poland, Estonia and Latvia are ambitious in terms of NREAP targets (900 MW for Finland, 500 MW for Poland, 250 MW for Estonia and 180 MW for Latvia), but the four countries have not yet developed the first offshore wind farms.

3) *Unambitious and inexperienced:* Russia, Norway and Lithuania have no 2020 target and none of the countries have deployed offshore wind power of any significance. Sweden however, has a 2020 target of 182 MW and has deployed 133 MW of offshore wind which is why Sweden is leaning more towards the experienced and ambitious countries. However, so far Sweden has focused almost entirely on creating favourable conditions for onshore wind development.

Obviously, one of the strongest barriers to the development of wind power in the BSR is the presence of electricity supply alternatives (especially hydro power and biomass in Norway, Sweden, Finland and Latvia). Hence, countries unambitious in terms of offshore wind targets may still very well be ambitious in terms of renewable energy.

However, as mentioned in section 5.3, the countries' varying energy assets experience can be an important stronghold of the Baltic Sea Region. This is especially important for countries that still need to deploy offshore wind before 2020 (Finland, Poland, Estonia and Latvia). Having in mind the lessons learned in Denmark and Germany, exchange of experience can be converted into tangible strategic initiatives for these four countries.

In many ways, the BSR is in a unique position. The BSR is a region that can benefit from the strategic location between the EU and Russia and within the BSR 'wind pioneers' such as Denmark and Germany can lead the way in terms of exchange of experience and cross-country cooperation for deployment of wind energy throughout the BSR region.

6.2 Strategic initiatives to support the development of scenario 1

The role of the BSR decision makers and national authorities in general is to provide a stable, predictable market framework which gives the industry the confidence to innovate and invest in the required manufacturing capacity. For this to happen, a Baltic Sea framework closely connected to a European framework for offshore wind power focusing on removing barriers, reducing investment risks, planning interconnectors and grid infrastructure and strongly coordinating the national policies of the BSR countries is needed.

On the basis of the problems and opportunities identified in the enabling studies, a number of strategic initiatives to support the development of scenario 1 have been identified. They are divided into four main themes:

1. Policy and regulation
2. Research, technological development and demonstration
3. Grid development and integration
4. Environmental planning and permits

6.2.1 Policy and regulation

To guarantee investor confidence, and develop offshore wind farms on a sufficient scale, the offshore wind sector needs a stable political framework. However, in the BSR, a number of countries have different political frameworks presenting developers with a more complex policy landscape. Hence, from a macro-regional point of view, harmonization of policy and regulation across the BSR into a favourable regime for offshore wind would be best way forward to strengthen investor confidence.

Yet, the situation today is much like the situation in the rest of the EU: member states are competing against each other in regard to creating attractive framework conditions and support schemes for developers. If the BSR is to fulfill its 2020 targets, it is important that the BSR countries exchange the best policy practices.

A strategic initiative to strengthen the exchange of policy and policy harmonization could be more binding targets and concrete legislation. Legislation could be preceded by a European Commission Offshore Action Plan as EWEA suggests in its report: *Delivering offshore wind power in Europe* and this could further be supported by a BSR specific action plan.

The BSR action plan should be based on themes such as legislation, policy measures and specific payment mechanisms. The action plan should encourage the BSR countries to develop national action plans containing sector targets and a quantification of the expected contribution of offshore wind power similar to the NREAP targets but more binding.

The action plan should integrate conclusions on how to develop offshore wind power effectively. The conclusions could be derived from the experience of wind pioneers such as Denmark and Germany. It is important to note that the policy and regulation for deployment of offshore wind in the two countries are not perfect, but it has been possible to create an attractive environment for project developers and their investments in offshore wind.

Especially those BSR countries that still have to deploy a substantial amount of offshore MW in order to reach the NREAP targets (Finland, Poland, Estonia and Latvia) should improve the policy framework in relation to two key points:

- Long-term targets for offshore wind development manifested in a strong political mandate
- Attractive financial incentives

For example through the German Government's *'Energy Concept' a roadmap to an 'environmentally sound, reliable and affordable energy supply'*, Germany has succeeded in ensuring a political stable framework attractive for developers. The 'concept' incorporates Germany's commitment under EU Directive 2009/28/EC to produce 18% of gross energy consumption from renewable sources in 2020 and extrapolates this target to a vision for 2050 where 60% of energy demand is met by renewable energies. Furthermore, since the Bundestag passed law changes to the Atomic Energy Act that require the closure of all nuclear generation capacity by 2022, investor confidence has been further strengthened.

In relation to financial incentives for wind energy development, the BSR countries are as mentioned very different from each other. For example, in *Poland and Sweden*, the current renewable energy support mechanism is 'technology blind' providing the same level of support regardless of renewable technology type. The principal support mechanism is a tradable certificate mechanism linked to annual obligations concerning the percentage of electricity from renewable sources. In both countries, the tradable certificate support mechanism is technology blind, hence resulting in more mature technologies such as for example hydro power and onshore wind being further developed at the expense of technologies where significant development and learning remains such as for example offshore wind.

Finland has recently introduced a specific feed-in-tariff incentive for wind power that has stimulated activity among developers and is expected to accelerate wind energy deployment in Finland. Support is available for up to 2,500 MW cumulative capacity of wind. Furthermore, the mechanism includes a sprinter bonus for early movers. Yet, as in the Swedish case, the support levels do not differentiate between onshore and offshore wind as the tariff is the same in both case. This also applies to the premium tariffs in Estonia.

By contrast, the tariffs in Denmark and Germany are differentiated for onshore and offshore wind power, and the resulting "infant industry" premium for offshore wind power is an important reason why development of the latter is more advanced in these two countries than in the other BSR countries.

Poland, Estonia and Latvia have to put in place similar financial initiatives to promote offshore wind if they still intend to realize the 2020 targets they have indicated for offshore wind power in their respective NREAPs (cf. table 6.1).

No harmonization of financial incentives is planned at EU level [18] and hence a more relevant strategic initiative for the BSR countries would be to engage with wind pioneer countries in cooperation projects to exchange best practice with respect to financial framework conditions for offshore wind energy.

The cooperation project should target a fixed feed-in tariff system with subsidies that would move the BSR countries which have not yet deployed offshore wind closer to the Danish and Finnish financial incentive scheme.

The strategic initiatives in relation to the policy and regulation theme are summarized below.

Strategic initiatives in relation to policy and regulation

- Development of the BSR action plan with quantification of the expected contribution of offshore wind power similar to the NREAP targets but more binding, long-term (e.g. till 2030) and manifested in a strong political mandate.
- Finland, Poland, Estonia and Latvia to develop financial incentives through regulation that makes it sufficiently attractive for developers to construct offshore wind farms. The design of new regulation might be facilitated through cooperation projects with wind pioneer countries targeting a feed-in tariff approach with differentiated subsidies for onshore and offshore wind, perhaps in combination with temporary incentives such as a sprinter bonus etc.

18. Harmonization of tax and subsidies across the EU is specifically difficult since direct taxation is effectively the EU countries' responsibility. EU members are largely free to organize their system of direct taxation in a manner consistent with domestic policy objectives and needs – as long as member states respect the free movement of goods, persons, services and capital and the principle of non discrimination.

6.2.2 Research, technological development and demonstration

Offshore wind energy technology is evolving towards larger scale and towards offshore systems being developed in a wider range of water depths and across wider geographical areas. Today, a number of large wind turbine types primarily designed for offshore use are available. It is important that research is further strengthened to support a cost-effective large scale deployment of the technology and strengthen the offshore wind supply chain in general. Further development of port infrastructure, vessels, electrical infrastructure, substructures, turbines, and operation and maintenance infrastructure and techniques is therefore necessary. However, since the BSR is very close to fulfilling the 2020 target, the scenario can probably be realized without further investment.

It is important to note, however, that increased R&D may turn the BSR into a more attractive region for offshore investments benefitting the BSR countries that need to build offshore wind farms towards 2020 such as Finland, Poland, Latvia and Estonia. Research and technological development is a driver for innovation and job creation. Hence there is a massive potential for industrial development in the BSR in terms of macro-regional value from the development of key elements of the industrial supply chain. Yet, it is especially important that research and technological development enable a more cost-effective large scale deployment of the technology so that the countries which intend to deploy new offshore wind power to fulfil the 2020 targets can do so at reasonable costs.

A tangible approach to achieve this is by initiating new cross-country demonstration projects that possibly could initiate the four countries' offshore deployment, but also strengthen cooperation between countries in terms of research and development of offshore wind technology.

Today, in terms of offshore wind technology most countries with shorelines prioritize research to support offshore wind technology: Denmark, Finland, Germany, Norway and Sweden. Below some of these demonstration projects are described.

- *Denmark*: Green Lab DK is a new support scheme for the construction of large-scale test facilities. With 600 million DKK (80.4 million euro) from the government's Business Climate Strategy, a better framework will be created for Danish enterprises to exploit opportunities that arise in the wake of climate challenges. Also in Denmark, the Linda Offshore Renewable Centre (LORC) was established as a European centre for 1:1 testing, demonstrations, and research into offshore renewable energy. Facilities for testing wind turbine drive train components of 10 MW to 20 MW rated peak power are being established.

- *Germany*: A unique full-scale onshore test of an offshore gravity foundation in Germany will provide fundamental knowledge on the long-term stability of such foundations and perhaps pave the way for offshore wind farms on greater water depths. A 7-m-deep hole near the coast holds the foundation of water-saturated sediment similar to the open sea bottom. Wave forces are simulated by hydraulic devices, and up to 170 sensors measure the displacements of the foundation and sediment as well as other physical parameters. Also, the German rotor blade test centre at Frauenhofer IWES began testing blades up to 70 meter using cyclic biaxial fatigue test methods. Developed in the InnoBlade-TeC project, the method will simulate 20 years of operation in four months. In 2010, construction began of a second 90-m test rig at IWES to begin operation in 2011.

- *Norway*: The Research Council of Norway has founded eight Centres for Environment-friendly Energy Research (CEER) to lead the world in their respective areas of energy research and to make environmentally friendly energy profitable. Each CEER will receive up to 20 million NOK (2.4 million euro) annually. Two of the CEERs focus on offshore wind energy.

- *Sweden*: The new Swedish Wind Power Technology Centre focuses on complete design of an optimal wind turbine which takes into account the interaction among all components. Moreover, the *Vindforsk* (wind research) cooperation between the Gotland high school and Risø in Denmark supports offshore wind research projects focusing on e.g. farm–to–farm interactions.

- On EU level also R&D projects focusing on offshore wind technology are prioritized. In the EU, around 20 R&D projects were running in 2010 with the support of the Sixth (FP6) and Seventh (FP7) Framework Programs of the EU (the Framework Programs are the main EU-wide tool to support strategic research areas). The TPWind platform produced strategies for strategic research and market deployment of wind energy and a longterm strategy for R&D in wind energy.[19]

19. IEA's *WIND* Annual Report, 2010

The BSR countries such as Estonia, Finland, Latvia, and Poland, which have no or little experience with offshore wind, have particularly good reasons for engaging in cross-country demonstration projects.

One way to realize that would be through two or more of the aforementioned countries going together in jointly applying for EU funds that could fund a cross-country offshore wind demonstration project in the eastern part of the Baltic Sea. For example, Estonia and Latvia could go together and apply for physical demonstration projects in the Gulf of Riga or along their outer Baltic coastline where there are also good potentials for offshore wind development. The development projects could have several objectives including a testing of the consequences for birds of deploying offshore wind power under certain conditions in the Gulf of Riga.

A second potential issue for offshore demonstration projects would be testing of foundation and rotor problems related to sea ice loading and other harsh winter conditions – including the technical means to overcome these problems. The most obvious place for this kind of demonstration project would be in the northern part of the Gulf of Bothnia, either in Finland or Sweden, or as a joint project between the two countries. If successful solutions can be devised, it would remove an important barrier to offshore wind development in this part of the BSR where potentials are high. Moreover, the Gulf of Riga has also been suggested as a test ground as it can have very hard ice winters with several meters of ice thickness.

As a supplement, or alternative, to the above, 'virtual demonstration projects' should be considered. Their aim would be to model consenting complications and alignments between two or more nations for offshore projects connecting either into interconnections or directly to another country, and to model the effect on electricity flow and market price in these cases. The virtual demonstration projects will have two major phases:

1. A trial exercise concerning an already planned project (or a potential project in one of the golden areas) agreed between two governments involving all respective permitting agencies and TSOs. A virtual developer team (perhaps drawn from a real developer or consultant) is contracted to conduct the exercise seeking respective permits from both governments. Process could be run for 3 or 4 teams in parallel with differing cooperation arrangements between governments, that is, a base case using current structures followed by other cases where some kind of collaboration work is initiated.

2. Electricity market modelling to estimate the effect on price and electricity flow of the set-up

Suggested "virtual" locations for such projects would be the Gulf of Riga, the upper or middle parts of the Gulf of Bothnia between Sweden and Finland, and The Middle Bank area between Poland and Sweden.

The three above-mentioned types of strategic demonstration initiatives would be good in view of reaching the NREAP targets (scenario 1) and probably mandatory if the BSR is to become world leading (scenario 2).

Strategic initiatives: Research and technological development

- Estonia, Latvia (and perhaps Poland) to engage in cross-country demonstration projects that will support the deployment of the remaining offshore wind energy to realize their 2020 targets. The demonstration projects may include physical demonstration projects, for example in the Gulf of Riga, testing for both technical and environmental issues.
- Finland and Sweden to engage in cross-country offshore wind demonstration projects in the northern part of the Gulf of Bothnia testing for foundation and rotor problems related to sea ice loading, and how the harsh conditions in general affect installation and operation of the wind turbines and the grid connection.
- 'Virtual demonstration projects' to be carried out as a supplement to the above in for example Gulf of Riga, the upper or middle parts of the Gulf of Bothnia between Sweden and Finland, and The Middle Bank area between Poland and Sweden. The purpose of the virtual demonstration projects would be to model cross-country consenting complications and alignments and to model the effect on electricity flow and market prices in cases where offshore wind farms have substantial cross-border implications.

6.2.3 Grid development and integration

The availability, cost allocation and processing time of grid connection possibilities frequently represent a key barrier to wind power development. This is particularly true for offshore wind farms where the substantial distance to shore and further onshore distance from national/international electricity grids can make cabling procurement and installation one of the largest cost items in the construction of a wind farm. There are two principle steps for consideration; (a) whether the TSO is obliged (provided certain technical requirements are met) to make a connection offer; and (b) how costs both for the connection and deep grid reinforcements are distributed between the TSO and generator.

Obligatory connection offers are in place in a number of countries although processing time can be substantial creating substantial risk with respect to other investment commitments. This was raised as a particular issue in Poland and Sweden and is threatening to become a problem in Norway. In Sweden there are a large number of applications to the TSO for wind farm connection creating a back-log which makes it difficult for the TSO to identify the serious applicants and prioritize areas for strengthening the grid. Poland is attempting to deal with it via requiring upfront application fees to discourage speculative applications. Obligatory connection offers are yet to be made a legal requirement in the Baltic States.

Only Germany and Denmark offer socialization/support of the cost of export cables from offshore wind farms to onshore connection point. Sweden and Lithuania currently offer cost sharing between the TSO and generators for deep (i.e. line reinforcement) costs while Finland and Latvia are considering adopting shared cost structures. In Norway, the TSO currently pays for all deep reinforcement costs although connection offers are not mandatory. Both these aspects are expected to change whereby connection offers to renewable generators become mandatory and deep costs are shared. In Poland and Estonia all costs are borne by the generator.

Since Finland, Estonia, Latvia and Poland have to deploy more offshore wind to fulfil their 2020 targets, it is important that these countries initiate strategic initiatives as summarized in the box below.[20]

Strategic initiatives: Grid development and integration

- Poland and Sweden to tackle back-log problem with large number of applications to the TSO for wind farm connection, for example. through upfront application fees.
- Finland, Poland, Estonia and Latvia to decide on a cost structure such as a shared cost structure that to a greater extent divides cost and risk between developer and authority.

For small Baltic States such as Estonia and Latvia, it may not be sufficient to stimulate a gradual development of the grid infrastructure. In order to realize the offshore wind NREAP targets, it might be necessary that the state makes upfront investments in cross-country grid interconnections so that the electricity production can be better utilized.

20. In scenario 1, it is not seen as realistic that a future transnational offshore grid incorporating all the BSR countries can be established. This is, however, described in more detail in scenario 2: *The BSR to become world leading*

6.2.4 Environmental planning and permits

Even before wind farms are constructed in terms of environmental planning, there are a considerable number of issues to be resolved over site selection, including legal rights and coastal zoning. Up to the traditional 12 mile (22.2 km) distance from a particular country's shore, approval for and negotiation over offshore development rights rest with the national authorities. Beyond this, although most countries have declared a further area as an EEZ (Economic Exclusive Zone), there is still some uncertainty as to exactly what this jurisdiction covers.

With respect to environmental planning, it is important that authorities have conducted an initial screening of the economic exclusive zones and the coastal zoning thereby informing developers on which areas that are suitable for offshore wind projects seen from an environmental point of view. This would help to avoid situations where developers claim rights for the exploitation of a particular sea area and initiate development activities only to find out later that progressing with the project is not possible.

The problem is illustrated by the case in Germany. In Germany, developers are free to apply for sites in an open-door approach. For many years, developers in Germany claimed areas without developing offshore wind farms. Since then Germany has been particularly pro-active in spatial planning conducted in the EEZ by the Maritime and Hydrographic authority (BSH) who have identified areas suitable for offshore wind energy.

For the countries which (according to their NREAPs) still have to deploy offshore wind towards 2020 – Finland, Poland, Estonia and Latvia – it is important that they all four put in place an efficient process for planning in order for them to generate developer interest and drive down the cost of developing the wind farms. The four countries should put in place an initial screening process and a structured model for consenting (for example an open-door model or a tender model) to create an attractive landscape for offshore wind farm developers.

Poland should perhaps once again review whether the general prohibition of coast-near offshore wind farms (all areas within12 nautical miles from coast are forbidden) can be justified for the entire national coastline.

In relation to permits: simple is better. As mentioned in regard to lessons learned, the Danish one-stop-shop is an example of efficient and fast coordination of the different permit requirements. The Energy Agency in Denmark has implemented a one-stop-shop approach for licenses for offshore wind turbines and coordinates with other relevant authorities about conflicting area interests and requirements of, for example, natural protection or demarcation. This process is effective and unbureaucratic and hence an important asset for developers.

It is important that the countries still to deploy offshore wind before 2020 put in place an efficient process for permitting. Finland and Estonia have not constructed offshore wind farms and thus little experience exists of the consenting process. In Latvia, the current consenting process for offshore wind farms is unclear with developers and researchers citing a lack of a central coordinating body for dealing with permitting issues. In Poland, installation of wind turbines in the internal waters and territorial sea is forbidden, so no turbine can be placed closer than 12 nautical miles (over 20 km) from the coast. Deployment of turbines in the exclusive economic zone will also be regulated. Further concerns include the period of building permit validity or permitted time from construction to operation.

Strategic initiatives: Environmental planning and permits

- Finland, Estonia, Latvia and Poland to conduct an initial screening of the economic exclusive zones and the coastal zoning thereby informing developers on which areas that are suitable for offshore wind projects seen from an environmental point of view.
- Further and more detailed environmental screening of potentially attractive areas and sites to be carried out by all the BSR countries that plan additional offshore wind energy capacity.
- One-stop-shop approach to permitting to be adopted in all the BSR countries.

6.3 Scenario 2: World leading in 2050

As the above described scenario stressed, only four countries have to further deploy offshore wind in order for them to fulfill the BSR countries' 2020 targets, and in general the BSR is well underway fulfilling their 2020 targets. However, if the time horizon is extended to 2050, a number of new possibilities are available for the BSR decision makers that can turn the region into a world leading region in terms of deployment of offshore wind. It requires, however, that the BSR countries from now on prioritize offshore wind deployment and put in place a number of strategic initiatives to support the development of the scenario.

6.4 Strategic initiatives to support the development of scenario 2

The spatial analysis identified a number of locations for deployment of offshore wind. In total, a capacity of more than 100 GW of spatially attractive sites has been identified in the BSR; cf. table 5.2 earlier on in section 5. Hence, there is enough offshore wind potential for the BSR to become world leading. The figure below shows the 2020 projections for the leading regions in terms of deployment of offshore wind.

The figure illustrates that even though the BSR fulfills the NREAP 2020 targets of 4.3 GW, the Baltic Sea will be very far from leading in terms of deployment of offshore wind. Instead, the east coast of China and the North Sea will be the leading regions. Furthermore, other projections show that from 2020, North America will possibly see a massive growth in offshore wind with off up to 54 GW although this is highly uncertain (cf. GL Garrad Hassan, Bridging note).

Obviously, the deployment of offshore wind energy depends on the energy demand in the specific region, but if the BSR is to be close to world leading in terms of deployment of offshore wind energy, the conditions applying to policy and regulation, R&D, grid connections, and spatial planning must offer a much more attractive landscape for developers than the case is today.

The recommendations for strategic initiatives that were given on these issues in section 6.1 on the NREAP scenario also apply to the world leading scenario. Yet, there are additional requirements for strategic initiatives for this second scenario and these are presented below.

Figure 6.4 – Offshore wind power 2020 projections for leading regions in GW and as a % of 2020 electricity consumption

Note: The percentage of 2020 electricity consumption - assumes a 35% capacity factor for each region. Source. GLGH, IEA and NREAP

6.4.1 Policy and regulation

If the BSR is to become world leading in terms of deployment of offshore wind, policy and regulation have to be the most efficient and trustworthy in the world. Hence three key characteristics of this framework have to be achieved:

1. Ambitious binding targets for offshore wind across the BSR,
2. Harmonization of policy and regulation across the BSR and cooperation with other regions.

A first key step to be taken in order to ensure a stable political framework is a binding ambitious target rooted in a broad political mandate. For example, the BSR decision makers could decide to set up binding targets for offshore wind deployment of a specific size before 2050. This would strengthen developer confidence and they would be much more likely to be interested in the BSR and possibly begin to set up initial project organizations etc. for the general benefit of the BSR.

Another key to ensure a stable political framework is the harmonization of rules and legislation across the BSR. The BSR decision makers should establish a common BSR policy framework for offshore wind power in regard to four key pillars:

- *Harmonization of legislation and policy measures* including a joint or similar financial incentive scheme for all the BSR countries. This could be either in the form of harmonized feed-in tariffs throughout the region that are sufficiently generous to offshore wind or, alternatively, one single renewable certificate trading system applying to the entire region including some kind of technology banding that provide extra incentives to offshore wind until it has reached maturity.[21]

- *Grid reinforcement measures.* Reinforcement of the grid to enable trade with electricity between the BSR countries and other regions. Possibly connecting this with a smart grid system (see section 6.2.1.3)

- *Environmental measures.* For example setting up cross-country marine spatial planning instruments that will identify any environmental issues threatening a prospective offshore wind farm site. Environmental issues are handled quickly and smoothly with national authorities hereby making way for developers (see section 6.2.1.4)

- *R&D measures.* Enforced and strategic use of R&D setting up a workforce and supply chain that will constitute the backbone in the BSR's push to become world leading in terms of deployment of offshore wind energy (see section 6.2.1.2)

This policy framework should be developed in accordance with the European policy framework that might be developed in parallel.[22] Furthermore, it is important that any harmonization of policy framework is implemented in close cooperation with other regions with wind ambitions e.g. the North Sea, the Atlantic Ocean and/or the Mediterranean. The cooperation between regions would focus on identifying potential barriers, limitations and suggest measures to remove those barriers within key areas such as energy trade and grid reinforcement measures.

Strategic initiatives: Policy and regulation

- Development of a binding target of offshore wind deployment in 2050 for the BSR.
- Setting up of a BSR policy framework that harmonizes rules and legislation within offshore wind including a joint or similar financial incentive scheme for all the BSR countries. The rules should be formulated in accordance with the EU and in close cooperation with other regions with wind ambitions.

21. The major source of inspiration for the latter solution would be the UK certificate trading model where offshore wind is currently favored on a 2-1 basis compared to onshore wind.
22. The above-mentioned four key pillars are the same as EWEA suggests for the EU in their *Delivering Offshore Wind Power in Europe* report, 2007.

6.4.2 Research, technological development and demonstration

If the BSR is to become world leading in terms of deployment of offshore wind, the BSR has to be a leading region in research, technological development and demonstration.

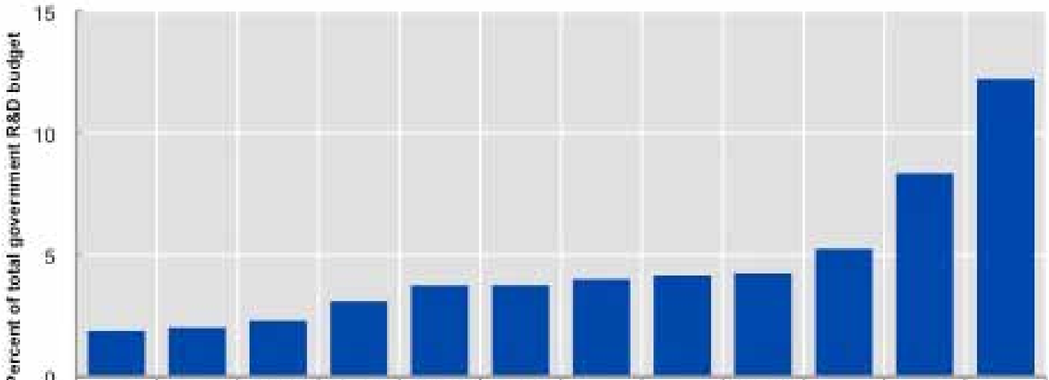
It is difficult to count the total research funds supporting offshore wind energy technology today. R&D is performed both at the local, regional and national level and cross country. Moreover, it is financed both by the government, the private sector and public-private partnerships, and it is difficult to narrow the R&D activities to specific industries. For instance, R&D within turbine technology can benefit both the offshore industry and the onshore. However, a rough indication of the differences between the countries is given in the figure below.

In terms of government R&D budgets for energy, Finland is leading in the Baltic Sea but is far behind the lead country of Japan. The BSR can be divided into two groups in terms of if their energy R&D:

1. Countries above the OECD average "technology leaders": Finland, Denmark, Sweden, Germany and Norway
2. Countries below OECD average R&D catch-uppers: Poland, Russia, Estonia, Latvia and Lithuania [23]

If the BSR is to become a world leading region in terms of deployment of offshore wind energy, the R&D catch-up countries need to devote more of their GDP for R&D specifically targeting offshore wind. The technology leaders however also still need to strengthen their R&D

Figure 6.4 – Selected countries' government R&D budgets for energy, as a percentage of the total government R&D budget, 2010



	USA (2009)	Russia (2009)	Poland (2008)	Estonia (2009)	OECD (2008)	EU27 (2008)	Germany	Norway	Sweden (2009)	Denmark	Finland	Japan
Energy	1,90	2,02	2,31	3,10	3,75	3,76	4,02	4,15	4,25	5,25	8,35	12,22

Source: OECD, Research and Development Database, May 2011
Note: R&D includes basic research, applied research and experimental development. R&D budgets include research on the production, storage, transport, distribution and rational use of all forms of energy, but exclude research on prospecting and on vehicle and engine propulsion, an important area for energy efficiency. Estimates not available for Latvia and Lithuania as they are not members of the OECD.

23. Considering that Lithuania and Latvia share a lot of the same background factors (e.g. geographic location, historical development etc.) with Estonia. Furthermore, in 2008, Estonia devoted the greatest proportion of GDP to R&D with 1.29%, Latvia 0.61% and Lithuania 0.8 % which indicates that both Latvia and Lithuania are not above Estonia in regard to energy R&D.

support in order to keep up with Asian countries that prioritize R&D. Failure to provide sufficient support for R&D in offshore wind energy would risk the loss of one of the key energy technology growth areas in Europe and in the BSR today.

A competitive advantage of the BSR and the EU compared to Japan is the possible exchange of experience through R&D projects involving research institutes, universities, wind industry, consultancy firms and utilities from a number of EU countries. EU funds are crucial for advancing technology development, and the BSR can maximize the new possibilities that have opened in terms of EU funds.

The funding for renewable energy under the EU's cohesion policy is to double from 2014-2020 and the new framework research program Horizon 2020 – a flagship initiative aimed at securing Europe's global competitiveness with an € 80 billion budget – presents a multitude of opportunities for the BSR decision makers to strengthen and further focus R&D efforts. Specifically by utilizing EU programs such as Interreg Baltic IVB, the BSR authorities can exchange experience and develop common cooperation projects on key issues in relation to the further strengthening of offshore wind (permitting, environmental planning, policy etc.) The Interrreg Baltic IVB program could also be used to finance the establishment of a Baltic offshore fund raising body consisting of authorities and research institutions across the BSR countries focusing on the utilization of EU and national funds for development of offshore wind technology projects.

To further support the above, the BSR decision makers can create a Baltic Sea Fund for Innovation and Research as mentioned in the Baltic Sea Strategy and hereby further strengthen demonstration of technology as proposed in relations to scenario 1. An example of a specific key theme for cross country R&D projects is the development of a smart grid system in the BSR possibly in the realm of The European Technology Platform for Electricity Networks of the Future, also called SmartGrids ETP, the key European forum for the crystallization of policy and technology research and development pathways for the smart grids sector.

Strategic initiatives: Research and technological development

- Strengthening of government R&D support for offshore wind energy.
- Development of a Baltic offshore fund raising body consisting of authorities and research institutions across the BSR countries focusing on the utilization of EU funds such as the Interreg Baltic IVB and national funds for development of offshore wind technology projects.
- Development of a Baltic Sea Fund for innovation and research.

6.4.3 Grid development and integration

Grid development is a key issue if the BSR is to become world leading. Today, electrical grids are seen as national infrastructure, but if the BSR is to become world leading, electrical grids - onshore and offshore - have to become corridors for electricity trade, and hence an integrated grid connecting all the BSR countries with both the rest of the EU and obviously Russia has to be developed.

The future offshore grid should contribute to building a well-functioning single European/BSR/Russia electricity market that will benefit all consumers, with the North Sea, the Baltic Sea and the Mediterranean Sea leading the way. The future transnational offshore grid will have many functions, each benefitting Europe in different ways. It will provide grid access to offshore wind farms, smooth the variability of their output on the markets and improve the ability to trade electricity within Europe, thereby contributing dramatically to Europe's energy security.

Providing sufficient grid development in order for the BSR region to become world-leading in offshore wind will probably require that grid connection costs are socialized throughout the entire BSR region. Hence, the major burden must be carried by the government and thus the society as a whole.

Moreover, the establishment of a future offshore grid has to go hand in hand with the development of a smart grid system. A smart grid system is an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies. A smart grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies in order to:

- Better facilitate the connection and operation of generators of all sizes and technologies,
- Significantly reduce the environmental impact of the whole electricity supply system.

The smart grid system can better utilize the fluctuating wind energy and hence there are strong synergy effects between a future offshore grid and smart grid. By focusing R&D (see section 6.2.1.2) and politically prioritizing the development of a smart grid in the BSR, the BSR could become first mover and capitalize strongly on the technologies' implementation. For example through the integration of electrical vehicles which due to the smart grid is easier since they can charge at times with energy overload.

Denmark has already serious plans to establish a smart grid before 2020 and by exchanging experience between the BSR countries this could be further extended to the BSR within a 20 years period. In order to initiate the future offshore grid and smart grid a BSR cross country implementation body has to further attract investments and coordinate with central authorities (e.g. Smart Grid European Technology Platform) and countries in the BSR.

Strategic initiatives: Grid development and integration

- Establishment of integrated grid connecting the BSR, EU and Russia.
- Socialization of grid connection costs throughout the entire BSR so that the government rather than the developers carry the major burden.
- The BSR cross country implementation body to lead the development of an integrated grid system including development of a smart grid. The purpose of the body would be planning and managing of further grid investments including coordination with other countries and institutions.

6.4.4 Environmental planning and permits

Environmental planning and permits have to be smooth and efficient and the best in the world if the BSR is to become world leading.

A coordinated effort to screen the Baltic Sea for possible offshore areas has to take place and the BSR authorities have to conduct an initial screening of the economic exclusive zones and the coastal zoning. Furthermore, the BSR countries should adopt a common consenting approach all through the BSR possibly open-door in order to ensure investor confidence. Potentially, HELCOM might play a central role as an interregional body promoting cross-border coordination with respect to both environmental screening and consenting.

As shown in section 5.2 there are a number of areas with high and very high potential, and a total of 50 GW raw potential is identified. However, it is emphasized that while there are many areas illustrated as being attractive for offshore wind development, there are numerous constraints not considered in the spatial analysis. Such constraints include:

- Martine habitats and benthic (seabed) communities
- Sediment marine habitats and benthic (seabed) communities
- Sediment transport paths, bed forms, scouring, mixing, turbidity, changes in wave or tidal current characteristics
- Water quality and pollution incidents during construction and maintenance
- Fish migration patterns, nursery areas
- Birds – disturbance, mortality
- Archaeological heritage (e.g. ship wrecks etc)
- Visual impact
- Marine mammals – distribution, disturbance, displacement, impacts of noise and vibration
- Noise, vibration, lighting and turbine installation

GL Garrad Hassan notes that there is a risk that as much as 80% of the 50GW potential offshore capacity could be prevented due to such other constraints. This fact emphasizes the importance of cross-border cooperation between the BSR countries with respect to the identification of prospective sites for offshore wind development.

First of all, the relevant authorities in the BSR should work together to expand the offshore area potential by initially screening the most attractive sites hereby ensuring that constraints will not lead to the cancellation of 80% of the prospective offshore projects. This could happen by setting up a cross-border screening body that can identify relevant sites in the Baltic Sea and furthermore handle any constraints with the responsible national authority.

In terms of permits, the BSR countries have to establish a one-stop-shop permitting approach possible being coordinated by a cross-country BSR permitting body.

Strategic initiatives: Environmental planning and permits

- The BSR countries to adopt a common consenting approach e.g. open-door.
- The BSR decision makers to establish a BSR cross-border screening body that will identify relevant sites in the BSR and handle constraints not considered with the relevant national authorities.
- Establishment of cross-country permitting body to coordinate all the BSR countries one-stop-shop permitting approach.
- Potentially, HELCOM might play a central role as a body promoting the above-mentioned cross-border coordination.

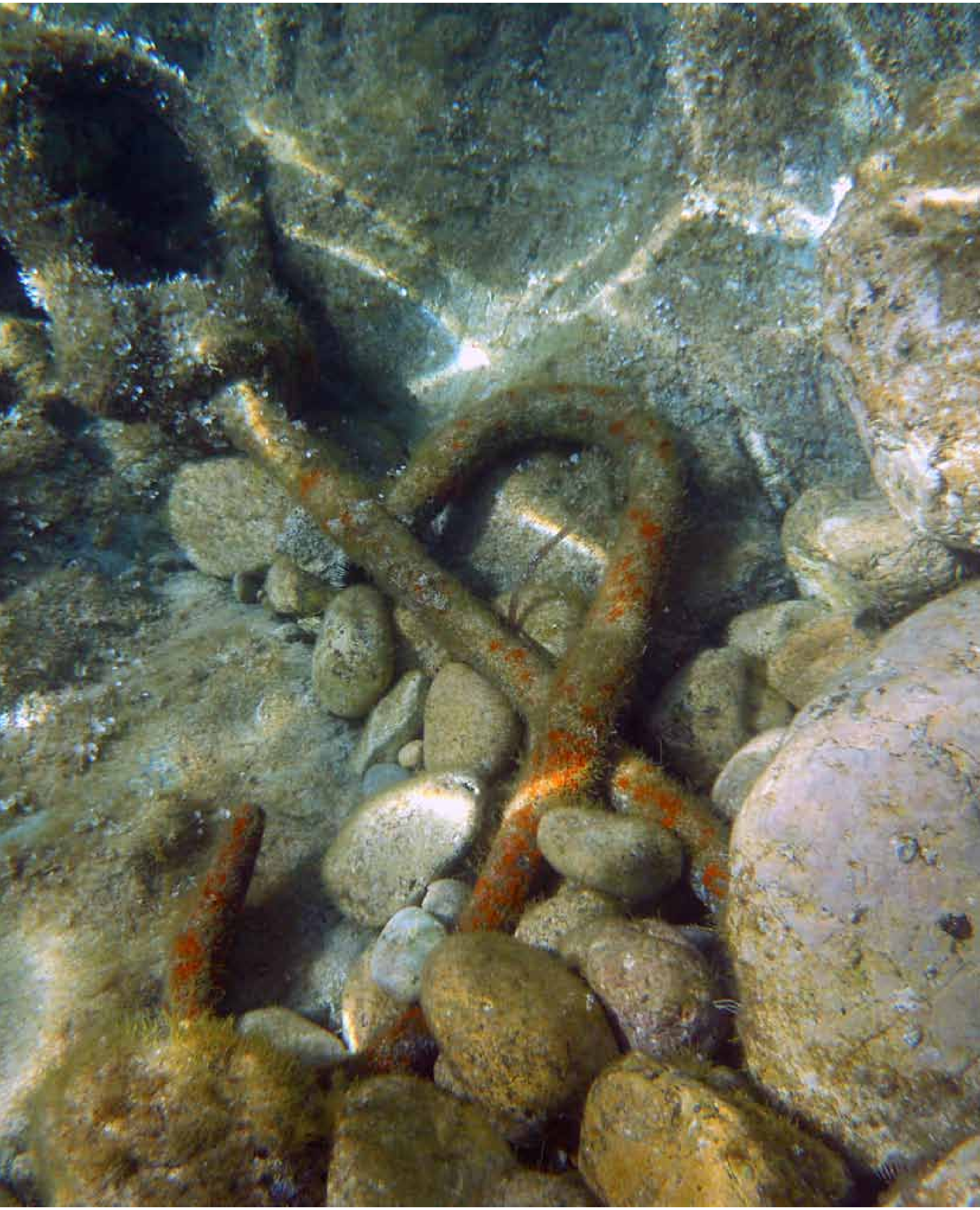


Photo: Johnér Bildbyrå

7 Benefits and costs of offshore wind power vs. alternative electricity supply in the BSR

As a strategic, domestic and largely untapped resource, offshore wind is one of the key technologies for achieving energy and climate goals. Offshore wind encompasses a number of benefits such as:

- Emission-free electricity generation: Wind power is a means of achieving future carbon reductions. This also applies to other renewable energies. However, whereas biomass energy is only CO_2 neutral in a long-run perspective as it gives rise to CO_2 emissions in the short run during incineration or gasification, wind energy is genuinely carbon free. Moreover, in contrast to bio mass energy, wind energy does not give rise to emissions of any other pollutants.
- Export and regional development: As a cutting-edge technology, offshore wind can strengthen the export position. Furthermore, offshore wind gives a strong impulse to job creation.
- Cost-efficient in the long-run: Onshore wind energy already has a lower cost of energy than any other form of electricity supply when externality costs are taken into account. Towards 2020 and beyond, research and development in offshore technology will improve the cost-efficiency of offshore wind energy compared to onshore wind energy and, at the same time, fossil fuels are expected to become more expensive due to scarcity and more accurate pricing of their CO_2 and other externality costs (see documentation further below in this section).
- Security of supply: Offshore wind power reduces fossil fuel imports. However, this is also the case with onshore wind, other renewable energies and nuclear energy, so offshore wind is not exceptional in that respect. Yet, offshore wind may contribute to increased energy diversification and in this way increase security of supply.[24]

Even though offshore wind energy may seem as the obvious energy choice, decision makers constantly have to evaluate and assess alternative technologies to ensure a sustainable and cost-effective energy mix. Changes in the relative energy prices and the cost of energy from different sources may occur as new energy technologies are developed and as market demand and the amount of known resources change. It would therefore be risky to be overly politically committed to develop one particular source of energy supply as opposed to others.

On the other hand, offshore wind energy requires huge private capital investments and thus needs firm, long-term political commitments and stable support conditions in order to attract investors. Further reductions in the capital and operating costs of offshore wind farms are therefore dependent on politically stimulated growth of the business.

For the BSR region, the political decision-makers therefore need to decide on whether to embark on a strategy that set more ambitious targets for offshore wind energy development than the present NREAP targets.

24. However, as long as wind energy cannot be stored, moving wind power beyond a certain critical level will not increase security of supply as it would make the national electricity generation too reliant on the weather (i.e. wind conditions).

The most ambitious strategy option would be to turn the BSR into a world leading region for offshore wind development. The enabling studies and the foregoing sections of the strategy outline have shown that it is indeed possible to strive in that direction. But something in between world leading and merely reaching the NREAP targets might be sufficient and perhaps the optimal strategy for the BASREC countries if they were able the make joint decisions on the issue.

This section will, on a rather general level, compare the costs and benefits of offshore wind energy to its alternatives. The purpose is to support informed decisions in relation to the strategic ambitions of the individual BSR countries as well as in relation to joint decisions on the strategic ambitions of the region as a whole in international settings such as BASREC.

7.1 Comparing the cost efficiency of wind energy vs. the alternatives

While there are electricity generation sources with cheaper capital and operating costs, no other energy source matches wind energy with respect to the cost of energy when all externality costs are taken into account including the full life-cycle pollution costs of traditional fuels.

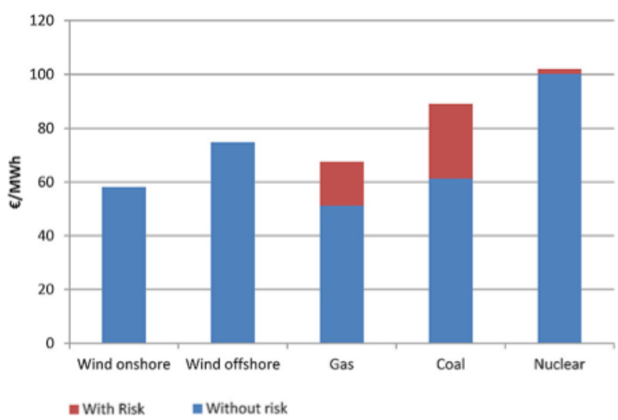
Yet, even if only externality costs valued at market prices are included, that is, only tradable CO_2 permits, wind energy is expected to become the most cost-efficient electricity generation technology shortly after 2020.

The levilized cost of electricity (LCOE) is an important metric to compare the generation technologies. It is defined as the actualized MWh cost over the complete lifetime of the project, taking into account the present value of all the cost components valued at market prices:

- Capital costs, including planning and site work
- Operation and maintenance costs
- Fuel costs
- CO_2 emission costs, as given by the European Trading System for CO_2 credits.

It appears from the figure 7.1 that wind energy is expected to become clearly the most cost-efficient alternative for electricity generation by 2050.

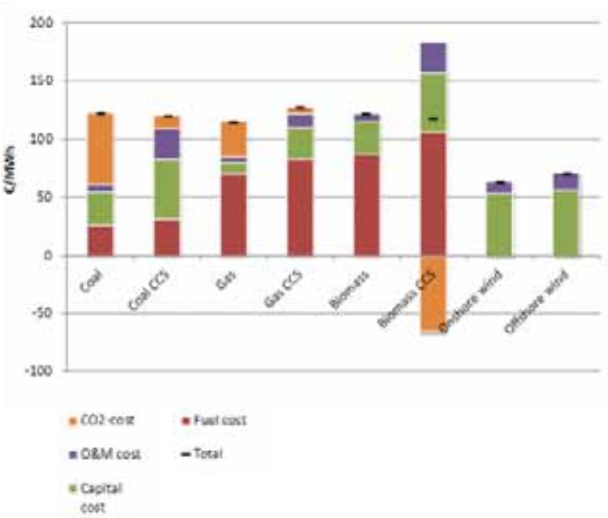
Figure 7.1. Expected levilized cost of electricity – 2020



Source: EWEA, Cost of Wind Power compared to Other Technologies, http://www.ewea.org/index.php?id=1643
See also EEA Energy Analyses, Energy Policy Strategies of the Baltic Sea Region for the Post-Kyoto Period, Draft version Prepared for BASREC, 18.12.2011.

Figure 7.2 below shows the expected levilized cost of electricity from the main generation sources in 2050 when the cost of CO_2 emissions has risen substantially compared to the present level and technology development has driven down the costs of renewable energy sources, especially offshore wind.

Figure 7.2. Expected levilized cost of electricity – 2050



Source: EEA Energy Analyses, *Energy Policy Strategies of the Baltic Sea Region for the Post-Kyoto Period*, Draft version Prepared for BASREC, 18.12.2011.
Fuel price assumption: Coal: 3.7 €/GJ, Natural gas: 12 €/GJ, Wood-pellets: 12 €/GJ. The calculations 20 year depreciation time, 10% IRR (Internal Rate of Return), a carbon price 95 €/ton CO_2 and 4000 full load hours for thermal power plants.

It appears from the figure that wind energy is expected to become clearly the most cost-efficient alternative for electricity generation by 2050. However, The International Energy Agency projects that solar PV will rise to become the most cost-efficient renewable energy source by 2050 followed by wind power.[25] In any case, there seems to be strong economic reasons for pursuing a strategy for wind energy development in the BSR which goes much further than the NREAP targets.

Although it may be tempting in this light to opt for a world leading strategy, it should be recalled that there are limits to the amount of variable wind energy that can be absorbed into the electricity system. As long as wind energy cannot be stored, its variable nature necessitates balancing with storage energy forms like hydro power, biomass and other fuels. Hydro power together with high amounts of district heating that can be fed by storage energy provides for good balancing potentials in the Nordic energy system. Therefore wind energy penetration levels could be much higher than present levels without causing major problems. But still there are limits. Developing the Baltic region into a world leading region would require major reinforcement and expansion of the transmission system along with the development of smart grid solutions that provide for a better utilization of the wind energy in periods where conventional demand is low.

Reinforcing the transmission system and developing smart grids are also costly and that needs to be taken into account in setting the ambitions for wind energy development in the BSR. A rough estimate of the total transmission costs for making the BSR one of the world leading regions (with a total capacity of let's say 25 GW) after 2020 is that it would cost more than € 21 billion.[26] That cost can probably be reduced by investing in substantial electricity demand management and hydro storage capacity within the BSR as it would reduce the need for transmission reinforcement. Nevertheless, the extra development costs would be high for such high levels of wind energy penetration.

While there will also be additional grid development costs etc. for the alternative energies over and above those presented in figure 7.2, it will be on a lower level for the traditional energy forms. A more careful assessment of the total costs of developing the electricity system therefore needs to be carried out before concluding on how ambitious the offshore wind strategy might be in the BSR, before the costs starts to outweigh the benefits.

25. International Energy Agency (2010), *Energy Technology Perspectives 2010: Scenarios & Strategies to 2050*, p. 134. Moreover, IEA does not share the view of EWEA and EEA that offshore wind will become nearly as inexpensive as onshore wind in 2050. Accordingly, the assumptions and projections still differ on this matter.
26. Following the logic of Appendix 5 in the Grid and Interconnection Study, we can assume that for this very high level of offshore wind capacity, very substantial transmission capacity out of the BSR to other markets would be necessary. As a rough calculation, we can assume transmission capacity equal to 75% of the wind capacity. Detailed studies would be necessary to reach a more accurate figure, and the studies would need to make assumptions about demand management, reservoir hydro and pumped storage within the BSR. Yet, following the arguments of Appendix 5, we can assume an average distance for transmission reinforcement of 800 km. This is sufficient to reach major demand centres further south in Europe. The cost of transmission reinforcement is assumed to be € 1700 per MW.km. Therefore, 1 GW of offshore wind requires 750 MW x 800 km of transmission reinforcement, at a cost of € 1,020M, or approximately € 1 billion. Hence, the transmission reinforcement required to take the BSR from the NREAP offshore wind capacity of 4 GW to the 'world-leading' figure of 25 GW would cost something in the order of € 21 billion.

7.2 Onshore vs. offshore wind energy development in the BSR

Even though there is a strong case for developing the BSR much beyond the NREAP targets for wind energy deployment, it needs not necessarily be in the form of offshore wind, as onshore wind provides for a more cost-efficient alternative measured by the levilized cost of energy all the way up to 2050, cf. figure 7.2.

However, over time the cost differential between onshore and offshore wind is expected to be substantially reduced. In addition offshore wind has a number of advantages over onshore wind:

- First, in the more populated regions/countries within the BSR, the area conflicts with neighbours are much less outspoken in the case of offshore wind than onshore wind which often faces considerable public opposition. One example is Denmark where the complaints against noise, visibility and other nuisance from onshore wind farms have substantially reduced the political willingness of further onshore development. Similar opposition to onshore wind could be (or has already been) mobilized in other relatively populated the BSR countries such as Germany, Poland and the Baltic States.
- On the other hand, there is more free space for onshore development in the cold-climate BSR countries such as for example Sweden, Finland and Norway, thereby making onshore wind relatively more attractive compared to offshore wind in these countries when the remaining cost differentials are taken into account. Yet, concerns may also be raised in the latter countries as the presence of onshore wind farms in protected waste lands or wood areas is further increased.
- Second, very high levels of wind energy penetration will not be possible solely by the means of onshore wind energy as the total power potentials are substantially less than for offshore wind. This is because higher wind speeds and better space improve the offshore potentials for concentrated deployment of mega-size wind turbines. Hence if the BSR is going to be among the world leading regions in terms of overall wind energy deployment, a significant contribution will have to come from offshore wind.

Yet, finding a cost effective and environmentally acceptable balance between offshore and onshore wind deployment will be one of the important challenges in deciding about the future wind energy strategies for the individual BSR countries and for the region as a whole.

7.3 Wind energy deployment in the BSR vs. the North Sea

In the case of Norway, Denmark and Germany offshore wind deployment in the North Sea (and further up the Atlantic Coast in Norway) provides a strong alternative to offshore wind deployment in the BSR.

Germany has already had more focus on developing the North Sea where the potentials are higher than in the Baltic Sea north of Germany. This will also be the case in the future, although the Baltic Sea north of Germany indeed offers attractive opportunities closer to the shore as shown in the Spatial Study.

Denmark has so far had a mixed strategy of developing offshore wind projects both in the North Sea and the BSR. The existing analyses have shown that further potentials are good, and almost equally cost effective, in both areas. Yet, the greatest absolute offshore wind potentials for Denmark are in the North Sea where wind speeds are generally higher and where there is still enough shallow water areas left to make development cost effective. Yet, the projected wind energy development in the Danish part of the BSR is so high that Denmark does not need to develop the potentials in the North Sea, except for a situation where Denmark decides to do this mainly for export reasons.

For Norway, the greatest potentials are clearly in the North Sea and Norway will therefore only contribute little to offshore wind development in the BSR.

For the remaining countries, the offshore wind potentials are solely in the BSR and hence there are no offshore alternatives to developments in the Baltic Sea. Yet, these countries are so far not as advanced with respect to offshore wind development as Germany and Denmark which, at the same time, face the North Sea opportunity. Hence, in order for the BSR to move from the NREAP targets in the direction of becoming world leading in wind energy deployment, countries like Finland, Sweden and Estonia must eventually lead the way.

8 Conclusion

As a strategic, domestic and largely untapped resource, offshore wind is one of the key technologies for achieving energy and climate goals. Offshore wind encompasses a number of benefits but as mentioned above, decision makers constantly have to evaluate and assess alternative technologies to ensure a sustainable and cost-effective energy mix.

However, the analysis of strategic selection of attractive future offshore wind areas in the BSR has shown that enough attractive offshore wind capacity exists to make the BSR countries fulfill their NREAP targets and even to become world leading in terms of offshore wind energy deployment in case that would be the political ambition.

Furthermore, the fact that the BSR countries have different experience within the deployment of offshore wind should be turned into a macro-regional competitive advantage by strengthening the cooperation between the countries. The scenario analysis above has set forth a number of strategic initiatives to further strengthen the deployment of offshore wind and hereby strengthening offshore wind development cooperation in the BSR. The strategic initiatives show how the two scenarios will require a different level of political ambition and will.

As described in scenario 1, the BSR countries are well underway fulfilling their 2020 NREAP targets considering that Germany's feed-in tariff will take the country most of the way towards its 2020 trajectory. The countries that still need to deploy offshore wind till 2020, Finland, Poland, Estonia and Latvia, can benefit highly from the strategic initiatives set forth such as for example the development of financial incentives through regulation that makes it sufficiently attractive for developers to construct wind farms or conducting an initial screening of the economic exclusive zones.

In regard to scenario 2, the BSR needs to a much higher degree to harmonize policy and regulation, strengthen R&D dramatically, establish a common consenting approach e.g. open-door and permitting process (one-stop-shop) and electrical grids - onshore and offshore - have to become corridors for electricity trade and hence an integrated grid (including development of a smart grid) connecting all the BSR countries with both the rest of the EU and Russia has to be developed in order for the BSR to become world leading in terms of deployment of offshore wind.

List of Abbreviations*

ABBREVIATION	MEANING
BASREC	Baltic Sea Region Energy Cooperation
BSR	Baltic Sea Region
CapEx	Capital Expenditure
CHP	Combined Heat and Power
CoE	Cost of Energy
DSO	Distribution System Operator
EEA	European Economic Area
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EU	European Union
FIT	Feed-In Tariff
FIT CfD	Feed-In Tariff Contract for Difference
GBS	Gravity Base Structure
GDP	Gross Domestic Product
GIS	Geographical Information System
GLGH	GL Garrad Hassan
GW	Gigawatt
HVDC	High-Voltage Direct Current
kWh	Kilowatt-hour
MW	Megawatt
MWh	Megawatt-hour
NPV	Net Present Value
NREAP	National Renewable Energy Action Plan
OpEx	Operational Expenditure
PPA	Power Purchase Agreement
PSO	Public Service Obligation
RE	Renewable Energy
RES	Renewable Energy Sources
TSO	Transmission System Operator
TWh	Terawatt-hour

* Only general terms used through the report are included here. Abbreviations and Acronyms for individual country entities and mechanisms are introduced as they are met in each country chapter.

Project key facts

Original title: Analysis of conditions for deployment of wind power in the Baltic Sea Region (BASREC-wind)

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Lead country: Sweden

Project manager: Jörg Neubauer, Swedish Energy Agency

Conductors: Deloitte & GL Garrad Hassan, Martin Korch Enevoldsen, Frank Rosengreen Lorenzen, David Williams

Layout: Granath Euro RSCG

Frontcover photo: Johnér Bildbyrå

April 2012

In the Communiqué adopted at the 5th BASREC Conference of Energy Ministers in Copenhagen in February 2009, the Parties addressed the coherence of energy and climate policy issues and stated that the use of renewable energies, in particular those potentially dominant in the region, is essential to meet the challenges.

This report uncovers and locates the potential for deployment of offshore and onshore wind in the Baltic Sea Region in order to optimise the contribution of wind power to fulfil the EU 20-20-20 targets and other energy policy targets in the region.

Barriers and potential strategic initiatives for the acceleration of development of offshore wind are identified (Report II) based on evaluation of potential production sites, grid integration possibilities and appropriate supporting regulatory frameworks (Report I). Additional reflections can be obtained from the supplementing note condensing discussions on the results of the study at the open seminar held in Stockholm 27 April 2012.

Baltic Sea Region BASREC Energy Co-operation

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