Baltic LINes

Coherent Linear Infrastructures in Baltic Maritime Spatial Plans

A PRACTICAL GUIDE TO THE DESIGNATION OF ENERGY INFRASTRUCTURE IN MARITIME SPATIAL PLANNING

Work Package 4.4

Interreg Baltic Sea Region

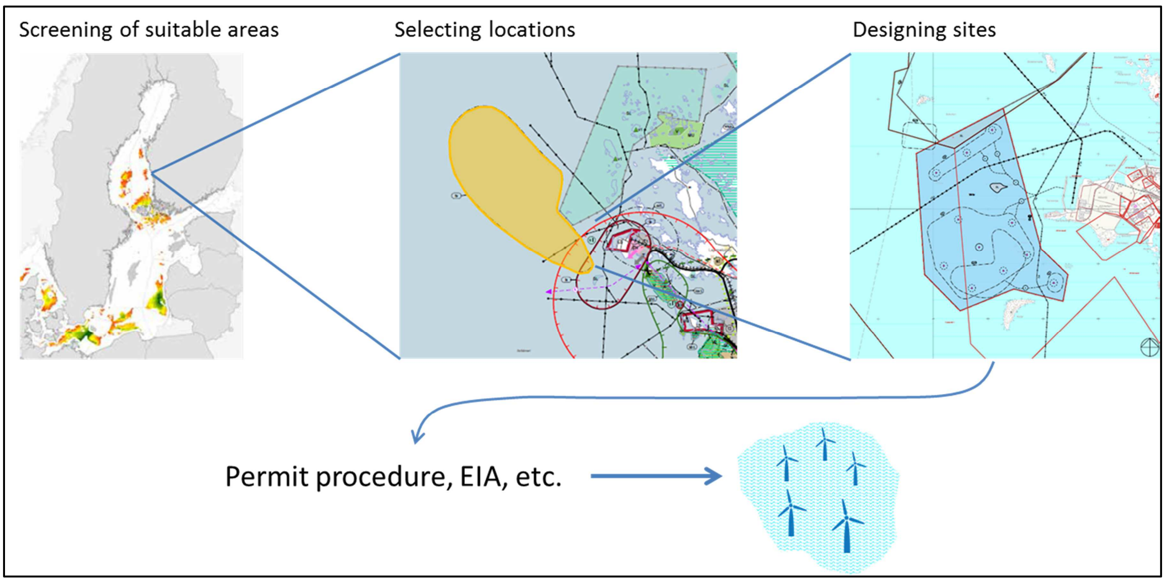
EUROPEAN UNION EUROPEAN REGIONAL DEVELOPMENT FUND

Foreword

This practical guide has been developed by the partnership of several planning authorities in course of the Interreg project Baltic LINes. The guide is strongly related and therefore also added as annex to the Baltic LINes report "Identification of transnational planning criteria in the Baltic Sea". However, the guide can also be used independently as a source for those maritime spatial planners that are looking for practical advices for the designation of energy infrastructure at sea. In best case the guide will be used by many countries that have common borders. We are convinced that using comparable planning approaches in MSP will increase mutual understanding and eventually lead to greater coherence in transnational maritime spatial planning.

This guide presents a step-wise approach summarizing the considerations taken when assessing, deciding on and designating the suitable areas for offshore wind energy and grid development. It also points out the most commonly used planning criteria and gives examples from different BSR countries on more detailed ones.

This guide should not be seen as the one-and-only way to develop and designate OWFs as part of the maritime spatial planning (MSP) process as national planning systems vary greatly and other options may be preferable. Writers of this guidance document also acknowledge that the role of MSP process in the designation of areas suitable for OWFs varies greatly, and it might not have a big role in the process. However, energy as a sector and possible installations at sea need to be discussed and taken into account in the MSP process. Planning of energy installations is an iterative process starting from more general considerations of suitability of areas and corridors to more detailed construction planning, which is followed by permitting procedures before the actual construction.



MSP typically focusses on designating suitable areas and corridors for energy installations, while more detailed planning of how to locate the turbines and electricity transmission infrastructure within the designated areas is usually left for the private operators.

More and more countries in the Baltic Sea area are taking a proactive role in finding and screening of suitable areas as part of their MSP processes. In many countries this has been done until now by the wind farm or transmission system operators. This guidance document describes the steps that would be taken in a proactive approach as depicted in the following figure:

Hanna Nieminen, Riku Varjopuro (Finnish Environment Institute) and Annika Koch (BSH)

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Planning Guidance for Offshore Renewable Energy Installations


Source:BSH

STEP 1

Defining the need for development - political goals for offshore renewable energy installations

- ☑ Clarify what are the political goals for the development of offshore wind energy (e.g. how much wind energy and offshore wind energy is aimed to be developed, and by which year)
    - o Transfer more general objectives into more detailed ones – how much marine space is needed to meet the targets?
- ☑ Clarify what is the priority of the development (e.g. what energy sources are prioritized)
- ☑ Check also the priorities of your neighbouring countries
- ☑ Be aware of the future trends and technological developments
    - o Economic drivers and preconditions must be part of the trend analysis

International, EU-level, national and regional political goals and targets steer the development of renewable energy in general. Development of offshore renewable energy installations – such as offshore wind farms – as part of the maritime spatial planning process should also be seen as part of this context. Based on the Baltic LINes Energy scenarios report ("Baltic LINes Energy Scenarios for the Baltic Sea 2030 and 2050" developed under WP 2.4), literature reviewed and interviews of national experts done as part of the Baltic LINes project, it seems that only few countries have specific targets for the development of offshore energy – but targets for the development of renewable energy and the expected share of wind energy in general do exist.

As all countries have a need to increase production of renewable energy all countries in the Baltic Sea Region are seeking possibilities to increase energy production in sea areas. It is, therefore, important to consult and be aware of plans of the neighbouring countries and inform them about your national plans.

Renewable energy technology is currently developing very rapidly. For instance, the price of producing energy offshore is decreasing because of the technological development. Investments in R&D in ocean energy (e.g. wave and tidal) is expected to produce new innovations. Combinations of wind energy and ocean energy productions are tested which would increase the capacity to produce more energy per km^2. Currently, however, prospects for other offshore renewable energy production technologies than wind energy are not very high.

STEP 2

Mapping the existing designations and installations

- ☑ Find out areas already designated for offshore wind energy
  - o Licensed areas (existing/approved/in the process)
  - o Sectoral development plans (national/regional priority areas)
  - o Other spatial plans (e.g. regional/municipal spatial plans stretching to the sea areas)
- ☑ Find out areas designated for other uses and activities
- ☑ Check your neighbouring countries' area designations for wind energy and other uses
- ☑ Take into account in the plan the previously mentioned, and incorporate them into the planning process (e.g. use them for example as background information)

Existing wind farms and the projects in the pipeline in 2018.

Country	Current situation	In the pipeline
Denmark	13 offshore wind farms (516 turbines)	3 under preparations
Estonia	None existing	8 projects in the pipeline or expressed interest
Finland	1 offshore wind farm (11 turbines)	10 projects in different phases
Germany	3 offshore wind farms ▪ 2 in EEZ (150 turbines) ▪ 1 in Mecklenburg-Vorpommern (21 turbines)	1 under construction (60 turbines), 1 approved
Latvia	None existing	Several expressions of interest
Lithuania	None existing	3 finished EIAs for OWE projects
Poland	None existing	1 project has received a permit, 1 project has finalized EIA
Sweden	5 offshore wind farms (77 turbines)	7 offshore wind farms approved + several projects in preparation

Infobox: Country example

Sweden took the existing national energy targets that included priority areas for offshore wind production as a starting point for the national MSP process. They conducted new studies on the suitability of the existing wind energy areas and identified new potential areas. This was done in close collaboration with sector authorities and companies. The result presented in the MSP is an updated plan of offshore wind priority areas.

STEP 3

Mapping suitable areas (general planning criteria)

- ☑ Natural and technical conditions
  - Wind
  - Water depth
  - Geology
- ☑ Demand for energy in the coastal area
- ☑ Possibility for grid connection (also transnationally)
  - Lowest expenses for grid connection – distance from the coast, possible corridors for cables etc.

Step 3 is about mapping the preconditions relevant for this specific sector, offshore wind energy development.

Criteria	Description	Examples from MSPs
Wind speed	Sufficient wind speed is a precondition for suitability of locations. Current practice and studies do not have one specific amount for wind. Typically the wind speed is expressed as an annual mean in specific height.	▪ In Uusimaa regional plan in Finland areas with wind speed less than 6m/s at the height of 100m were ruled out ▪ In Latvian MSP, limit for wind speed is more than 8m/s in the height of 100m ▪ In Sweden the limit is more than 9m/s
Water depth	The depth of water influences the costs of building turbines. Therefore, a maximum depth is determined. There are differences in what is conceived still as a feasible depth. Rapid development of offshore technologies affects the feasibility.	▪ In Latvia depth up to 60m (thought earlier 30m, but new technology was taken into account) ▪ In Sweden depth up to 40m ▪ In Lithuania a suitable depth is 20–50 m. The minimum depth of 20 m protects high nature values of shallow waters.
Geology	Wind turbines require a solid ground to build on. Different types of turbine constructions have different requirements, though. The current tendency is to build ever higher turbines that underlines the importance of geology even more.	▪ In Germany detailed seabed assessments are conducted as part of the determination of site suitability by the competent authority ▪ In Sweden studies to identify priority areas for offshore seabed should be stable, flat and homogenous ▪ In Poland geomorphology is studied in more detailed technical plans

Infobox: In the search of suitable areas for offshore wind energy

BASREC (2012) report: Site selection model

- Criteria based scoring (10x10km offshore grid spatial analysis) → initial selection of attractive areas, so called 'golden sites'. Then, funnel perspective was used to further select the most attractive areas:
  1) only some 'very high' and 'high' score areas are selected for further consideration,
  2) focussing only on areas with sufficient electricity demand or reasonable grid cost for long-distance transmission, and
  3) some of these areas are selected for development due to their growth potentials
- Considered criteria:
  - Cost of energy (i.e. wind speed, distance to shore and water depth)
  - Hard constraints (e.g. other wind farms in operation or in construction etc.)
  - Soft constraints (e.g. shipping and fishery)
  - Regional electricity demand
  - Potentials grid links to the continental power system
  - Local employment and growth stimulation
  - National targets for CO_2 reduction and renewable energy deployment

Keivanpour et al. (2017): have listed several different methods

- GIS models (aim to analyze, organize and present spatial data); for instance including wind speed, water depth and distance to shore
- Statistical methods (climatological data, on-site measurements)
- Optimization methods (multi-criteria decision making; 1) definition of the criteria, 2) defining alternatives, 3) evaluation of alternatives based on the criteria)

Exclusionary method (Uusimaa Regional Council, Finland):

Possible areas were found via spatial data analysis; putting first 'no-go' areas and then 'maybe' areas on the map, and then to see what was left for more detailed analysis.

Infobox: Study on capacity density of offshore wind energy

To ensure efficient and sustainable use of space, one question to solve is the extent of sea space that is required to install a certain capacity of offshore wind energy. Within Baltic LINes a study was compiled to address this issue of the so-called capacity density of offshore wind farms (OWF) and the main influencing factors. Both technical-economic issues and regulatory frameworks influence the capacity density. The study has been conducted by Deutsche WindGuard GmbH. Although no detailed recommendations have been developed, the report provides some key analytical insights which are relevant for planners working or starting to work on zoning for offshore wind in their MSPs.

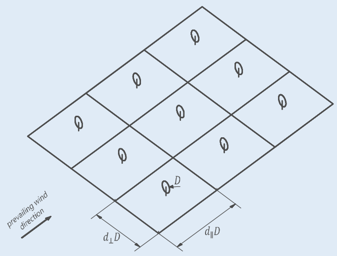
The study covers three levels: A. Theoretical background and literature review, B. Analysis of national planning approaches and standards and C. Analysis of capacity densities and layout of realized OWF in the Baltic and North Sea region.

Main results

A. Theoretical background and reviews of international assumptions

The capacity density of a wind farm is defined as the ratio of the wind farm's rated capacity to its ground area (expressed in megawatts per square kilometre). Therefore the definition of the wind farm area (nominal vs. corrected area) is relevant for the interpretation of its capacity density. A wind farm's capacity density alone does not lead to conclusions on its energy production. This requires the wind farm's capacity factor to be taken into account, which is usually calculated as the yearly averaged power production divided by the rated power production. Specific power defines a turbine's specific rated power capacity per rotor area. It depends on the power capacity of the wind turbine and the rotor diameter.

$$\text{capacity density} = \frac{\text{rated power capacity of wind farm}}{\text{wind farm area}}$$



Idealized wind farm layout and turbine spacing

$$p_{A_{WF}} = \frac{P_{rated,T}}{d_\parallel d_\perp D^2}$$

$$D^2 = \frac{4}{\pi} \cdot A_{rotor,T}$$

$$p_{A_{WF}} = \frac{\pi}{4} \cdot \frac{1}{d_\parallel d_\perp} \cdot \frac{P_{rated,T}}{A_{rotor,T}}$$

$$p_{A_{WF}} = \frac{\pi}{4} \cdot \frac{1}{d_\parallel d_\perp} \cdot p_{A_{rotor}}$$

$p_{A_{WF}}$	Capacity density of a wind farm $[\mathrm{MW/km^2}]$
$P_{rated,WF}$	Rated power capacity of a wind farm $[\mathrm{MW}]$
A_{WF}	Wind farm area $[\mathrm{km^2}]$
$p_{A_{rotor}}$	Specific power of a wind turbine $[\mathrm{W/m^2}]$
$P_{rated,T}$	Rated power capacity of a wind turbine $[\mathrm{MW}]$
$A_{rotor,T}$	Rotor area of a wind turbine $[\mathrm{m^2}]$
D	Rotor diameter of a wind turbine $[\mathrm{m}]$
$d_\parallel$	Relative turbine distance in prevailing wind direction $[-]$
$D_\parallel$	Turbine distance in prevailing wind direction $[\mathrm{m}]$
$d_\perp$	Relative turbine distance perpendicular to prevailing wind direction $[-]$
$D_\perp$	Turbine distance perpendicular to prevailing wind direction $[\mathrm{m}]$

Capacity density is a function of specific turbine power and turbine spacing. The distances between neighbouring turbines in a wind farm usually depend on the prevailing wind direction. Turbine spacing is a critical issue because of the wake effect. Wind turbines that are placed within the wake of a neighbouring turbine will produce less power than under free-stream conditions.

Different studies aiming at assessment of energy potential for European sea basins conclude that the capacity density is in the range of 5 MW/km^2 to 5.4 MW/km^2.

B. Analysis of national planning framework

Capacity density is not purely techno-economical driven. Instead, it also depends on the regulatory framework defined by the national authorities. Wind farm capacity densities show high variances and significant differences exist between national averages.

The difference in the average capacity densities of the North Sea region and the Baltic Sea region can be partly explained by the strong influence of national regulatory frameworks (e.g. Denmark requires a certain capacity density for a certain area as a criterion for a successful bid in a tender). Another reason might be lower specific power ratings as a consequence of the slightly lower wind speeds in the Baltic Sea.

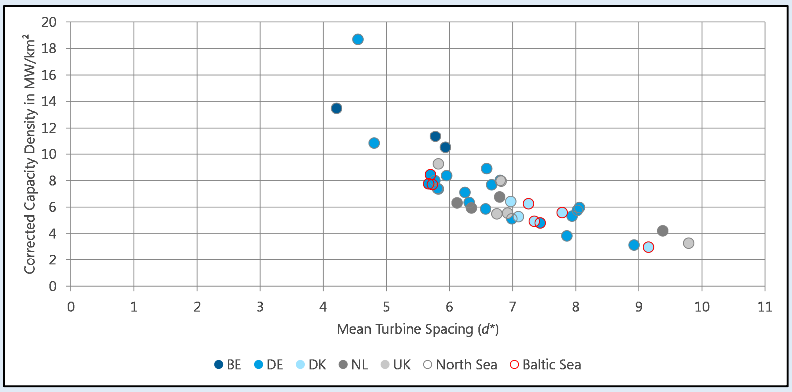
Mean values of capacity density (weighted by area)

Country / Sea Basin	Total Area in km^2	$\overline{p_{A_{WF}}}$ in MW/km^2	$\overline{p_{A_{WF}}^{*}}$ in MW/km^2
BE	43	16.5	11.9
DE	751	8.4	6.3
DK	195	5.7	4.1
NL	121	8.1	6.2
UK	285	5.5	4.6
North Sea	1145	7.3	5.7
Baltic Sea	249	6.8	5.0

C. Analysis of capacity densities and layout of realized OWF in the Baltic and North Sea region

Due to wake effects the layout of a wind farm and the positioning of the wind turbines are important factors for the capacity density and the final energy production. The layout takes into consideration several factors, such as the wind direction and changes in the wind direction, the size of the turbines (as explained above) and connection to the grid.

Corrected capacity density as function of mean turbine spacing



Capacity density of European OWF varies considerably (compare graphic above). Potential reasons might be limited sea space (e.g. in Belgium), the specific OWF layout and the national regulatory framework. The national regulatory framework shows a strong impact on the mean capacity densities of OWF per country. Policy frameworks and offshore regulations, on for example subsidies per MW or energy production objectives for a certain area influence future developments. Therefore capacity density can also be seen as an effective political control parameter.

For further information please find the full report here: https://www.msp-platform.eu/practices/capacity-densities-european-offshore-wind-farms.

Source: Borrmann, R., Rehfeldt, K., Wallasch, A.-K., Luers, S. (2018): Capacity densities of European Offshore Wind Farms. Report conducted as part of Interreg project Baltic LINes.

STEP 4

Mapping the conflicts and synergies with other uses and activities

- ☑ Detect areas/locations with conflicts
  - o Do not forget to look beyond national border
- ☑ Find solutions for the conflicts
  - o Find synergies – can activities exist in the area?
  - o Exclude areas – possible no-go areas for energy installations
  - o Discuss safety issues and determine buffer zones
- ☑ Discuss with other sectors and stakeholders

After the possible locations (based on natural and technical conditions) have been detected, other activities and uses at sea should be incorporated into the analysis. This discussion is essential to engage various actors from other sectors administrations, organisations, companies and groups of citizen.

Infobox: Examples of consideration of conflicts and solutions

In Satakunta region on the west coast of Finland the regional planning authority identified together with a range of stakeholders sea uses that might conflict with offshore energy production. These areas were determined as not possible for offshore energy installations. The process also identified buffer zones:

- Recreational housing, distance 2000m
- Shipping lane (depth 5m or over), distance 350m
- Shipping lane (depth less than 5m) , distance 50m
- Light house, distance 1000m
- Ship wreck, distance 1000m
- Recreational areas, distance 3000m
- Valuable areas for cultural history , distance 3000m
- Natura 2000 areas , distance 3000m
- Other protected areas / natural protection, distance 3000m
- Bird protection areas, distance 500m

The Lithuanian MSP process identified the least conflicting areas. The practical solution was to direct offshore energy installations away from areas already used for other purposes such as:

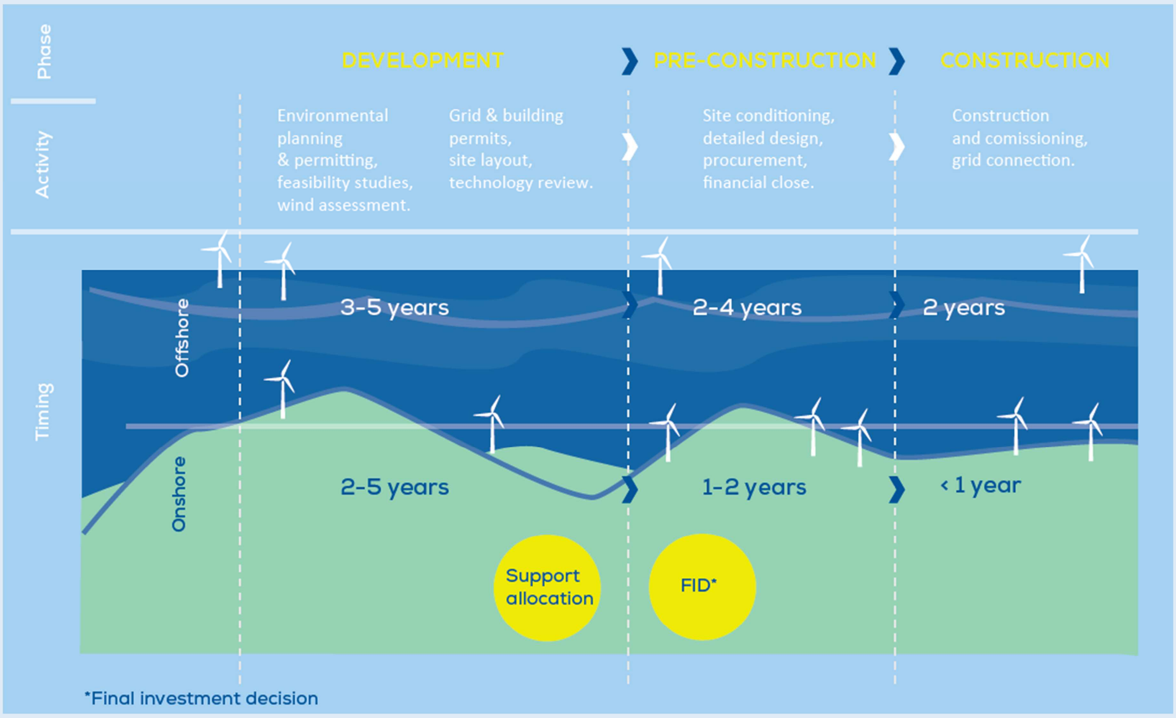
- shipping lines and port roadstead/anchorage sites
- military areas (training and radar zones)
- Natura 2000 sites (existing and potential/under research)
- main fishing grounds
- away from coastal zone (= deeper than 20m)
- wrecks, potential underwater cultural heritage sites.

STEP 5

Defining of the priority areas for offshore wind energy

- ☑ Consider again national targets for renewable energy production – do planned sizes for offshore wind energy development match the targets?
  - o Use calculations, e.g. capacity density to assess cumulative energy production
  - o Take into account timing of the wind energy projects (see infobox below)
- ☑ Based on the above analysis identify the priority areas
- ☑ Discuss with other sectors and stakeholders
  - o Inform your neighbouring countries
- ☑ Define specifications for the priority areas
  - o Conditions for the use of the area
  - o Where to start the development and when
  - o Point out areas that need to be further investigated

Infobox: Offshore wind project planning and implementation times



Source: Hundleby, G., Freeman, K., Barlow, M., Blanch, M., Tardieu, P., & Walsh, C. (June 2017). Unleashing Europe's offshore wind potential. Brussels: WindEurope & BVG Associates.

Planning Guidance for Offshore Energy Cables

In addition to the practical guide for the designation of areas for offshore renewables energy installations this guide also covers some practical advice with regard to the designation of corridors for offshore renewable energy cables in MSP.


Source: TenneT Offshore

In general, compared with wind turbine structures electricity cables seem less conflictual with other interests. Therefore identification of planning criteria for subsurface linear infrastructure seems simpler than for offshore wind energy installations.

STEP 1

Political framework/ targets

- ☑ Clarify what are the political energy or climate protection targets and figure out what is the planned offshore wind capacity.
- ☑ From transnational perspective interconnectors have a special relevance, as these are cross-border in nature. Therefore it is worth to see the “big picture”, especially to consider a potential future Baltic Grid and to take the Ten-Year Network Development Plan into account.

Infobox: TYNDP

The future demand for transnational cables from the energy market perspective is identified by all European transmission system operators in the Ten-Year Network Development Plan (TYNDP, published every two years) based on the ENTSO-E System Needs Report. The TYNDP includes trans-regional and international grid development measures, which are of international importance for the European cross-border electricity transmission.

https://tyndp.entsoe.eu/tyndp2018/

- ☑ In addition it is also necessary to consult neighbours as early as possible to identify further need for cables that are not included in TYNDP.

Future demand

- ☑ Define future need for offshore energy cables and interconnectors based on political and market-driven framework/ criteria.

STEP 2

Suitability of areas

After considering the future demand it is important to look at which areas are suitable for cables from natural and technical conditions.

- ☑ Geology / seabed conditions
  With regard to technical suitability seabed conditions are the most important issue to consider and these are very heterogeneous in the Baltic Sea. On the other hand ground conditions do not cause a real obstacle to the laying of cables. It is more a question of the technique of cable laying and safety/ insurance reasons with regard to shipping or bottom trawling. From the shipping sector perspective it is for example necessary that cables are buried as deep as possible or secured by rock dumping.

  When planning cables the consideration of other uses has even more significance (step 3).

STEP 3

Stocktake: Analysing/ Mapping conflicts and synergies with other uses

Before designating corridors for cables it is most important to

- ☑ consider existing and planned energy and data cables/ cable corridors
  - including the ones in neighbouring countries
- ☑ Include all other relevant planned and existing uses/ rights of use and protected areas. Uses particularly to consider:
  - Shipping (consideration of safety and insurance reasons)
  - Natura2000 areas and sensitive biotopes/ habitats (Routing outside these areas is desirable.)
  - Pipelines
  - Military exercise areas, esp. exercise areas for submarines
  - Cultural heritage sites, for example wrecks
  - Sand and gravel extraction
  - Offshore Wind Farms
  - Fishing grounds (The interests of fisheries should also be taken into account at an early stage.)
  - Dumping grounds
  - Munition
- ☑ The above mentioned stocktake and analysis also apply for the transnational level.

STEP 4

Consider land-sea interaction

- ☑ Consider connection to onshore power grid

Special attention has to be given the grid connection to the terrestrial grid with regard to available grid connection points and suitable cable corridors onshore. Since cables for the transport of power generated at sea have to be connected to the onshore power grid, it is necessary to ensure that the cables are routed to suitable grid connection points into the onshore high voltage/extra high voltage power supply.

STEP 5

Define cable corridors based on the analysis and application of planning criteria / planning principles

Based on the previous steps priority or reservation areas for cables/ cable corridors can be designated by the application of certain planning principles. For the definition of cable corridors the following areas need to be considered:

- ☑ space needed for the cable itself and its laying,
- ☑ a safety zone around it to ensure sufficient space for potential repairs
- ☑ space at cable crossing areas (secured by dumped rocks) and/or
- ☑ specific distances in case of parallel routing with other uses.

Necessary distances between cables and other uses depend on the water depth, site-specific ground conditions and technical required distances for cable laying and cable repairs. Regarding the question of appropriate distances guidelines of the International Cable Protection Committee (ICPC) and the European Subsea Cables Association (ESCA) can give helpful advice. As for offshore energy cables, the International Cable Protection Committee (ICPC) recommends that existing cables in shallower waters (up to a depth of 75m) are given a default 500m exclusion zone on either side. The actual distance varies between single countries.

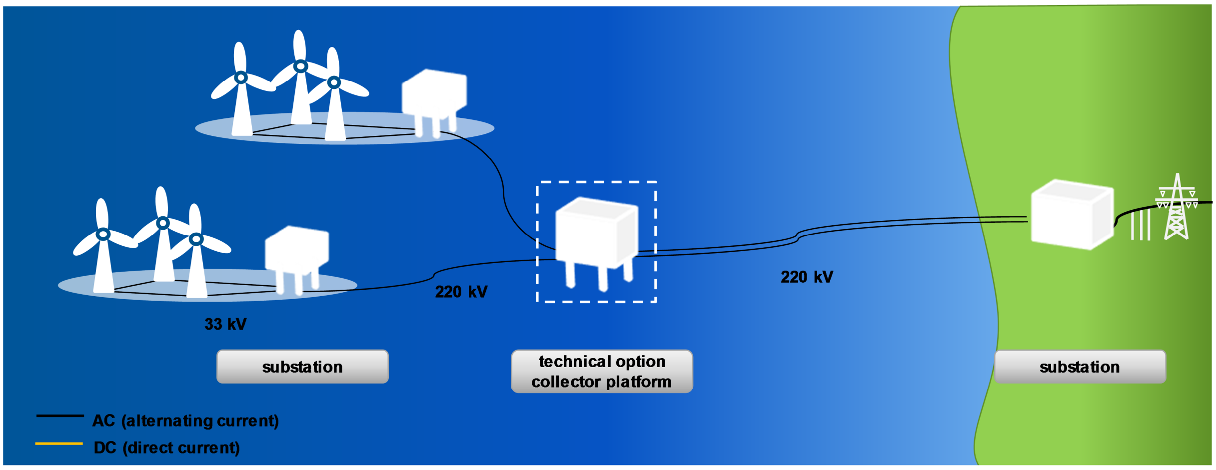
Source: *http://transition.fcc.gov/pshs/advisory/csric4/CSRIC_IV_WG8_Report1_3Dec2014.pdf*

Infobox: Planning Criteria/ Planning Principles to take into account (based on experiences with German Site Development Plan)

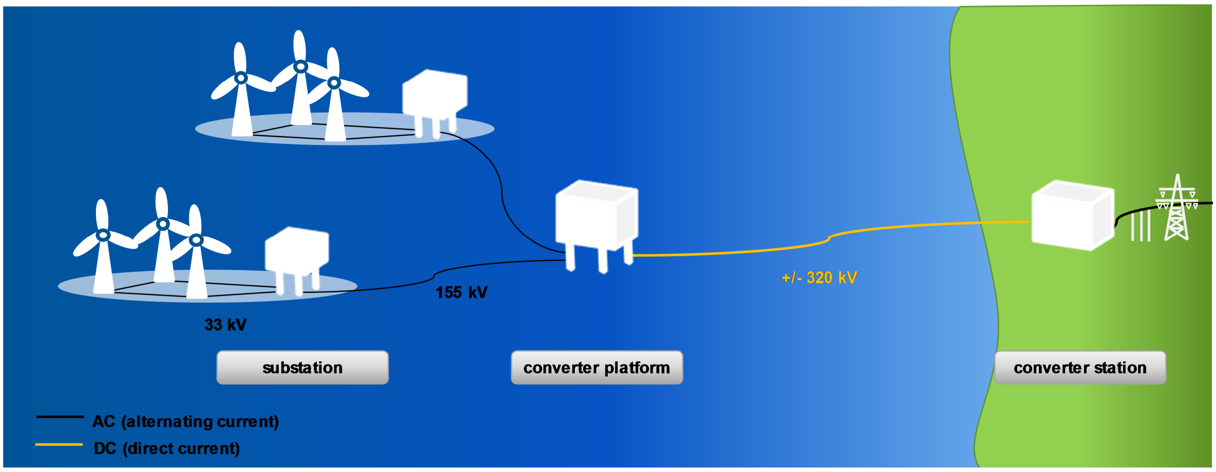
- Maximum bundling possible by parallel routing: cables and other offshore infrastructure should be integrated whenever possible to maximize concentration of sea uses and reduce use of space
- Consideration of all existing and approved uses and adequate safety distances to constructions and shipping routes
- Crossing of priority and reservation areas for shipping by the shortest route possible/ as right-angled as possible (for safety reasons, covered by the provisions of UNCLOS)
- Routing as far outside of Natura2000 areas/protected biotopes
- Consideration of cultural heritage sites, esp. wrecks and other underwater obstacles
- special consideration of sites where munitions have been discovered
- Shortest route possible (relevant from economic perspective), under consideration of conflict minimisation with other uses and nature protection issues
- Coverage, which ensures a permanent safety of subsea cables
- Avoiding cable crossings (Crossings increase the risk of malfunctions, leading to higher maintenance requirements and, consequently, to increased traffic of maintenance/repair vessels, which should be avoided.)
- Routing of interconnectors through transfer gates at EEZ borders

Infobox: Definition of technical specifications for cables

Apart from spatial regulation or planning principles it is also to recommend to define some technical specifications in MSP, as these are often also of spatial relevance. For example the implementation of the cable system as direct current or alternating current is relevant for the capacity of the cable and therefore determines also the number of cables required to transmit a certain capacity. The technical specification of the grid connection systems of offshore wind farms often depends on the distance to shore. Whereas shorter cables are often implemented as alternating current, longer cables (over 100 km) are usually implemented as direct current cable system. Interconnectors are usually implemented as direct current cable systems with a supply and return conductor as a bundled cable system in order to minimize negative effects from magnetic fields on sensitive species.



Example of technical grid connection concept using alternating current technology.



Example of technical grid connection concept using direct current technology.

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