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Ocean Energy in Germany

Executive Summary

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Issues and background

Germany intends to increase the share of renewable energy (RE) in the country's electricity supply to a minimum of 30 percent by the year 2020. Thereafter, this share is to rise continually. Onshore and offshore wind energy will account for the largest proportion of future power generation from RE sources. Further contributions will be made by biomass, water power, solar energy and geothermal energy.

Up until today, the use of ocean energy[1] plays no part in the RE mix; at present, no ocean power plants are being operated in Germany. Hence, with a view to the 30 per cent target for the year 2020 and the subsequent continuous increase of the RE share in the country's electricity supply, the potential in the German North Sea and Baltic Sea has been considered to be so low as to forestall any extensive private or publicly-subsidised research and development programmes (R&D) or energy policy promotion measures in respect of ocean power generation.

Given the significant progress made in plant design and the testing of prototypes in countries outside Germany in the past few years, this status quo should be reassessed. Comprehensive maps based on long term reliable research that indicate the theoretical potential of wave and ocean current energy in the German North and Baltic Seas have not been published up until now.

Research regarding the technical potential of ocean power generation is still hampered by the fact that, in contrast to wind energy[2], ocean power generation is largely still at the research stage worldwide. This is reflected, inter alia, by the large number of different ocean energy concepts and a lack of convergence on a few promising technologies[3]. Furthermore, the concepts, which are predominantly being developed abroad, are not optimised for the wave and current regimes dominating in the German North and Baltic Seas. As a consequence, they cannot be applied efficiently in Germany. Without exact knowledge of the technical characteristics of potentially suitable technologies, it is not possible to make reliable calculations of the technical potential on the basis of Germany's theoretical potential.

Nevertheless, several German energy plant construction companies as well as a few power supply companies are interested in the issue of ocean power generation or have announced future activities in this field. This involvement is almost exclusively located outside Germany; the companies in question are interested in the global ocean energy potential, which is considered to be vast.

Given this commitment, the question arises whether local trials of test plants involving prototypes at individual locations in the German North or Baltic Sea are possible, and if so, expedient. The hope is to create the necessary basis to open up presumably vast export potentials, similar to the field of onshore wind energy - a field in which Germany has assumed the technological leadership.

Potential use of ocean energy in Germany

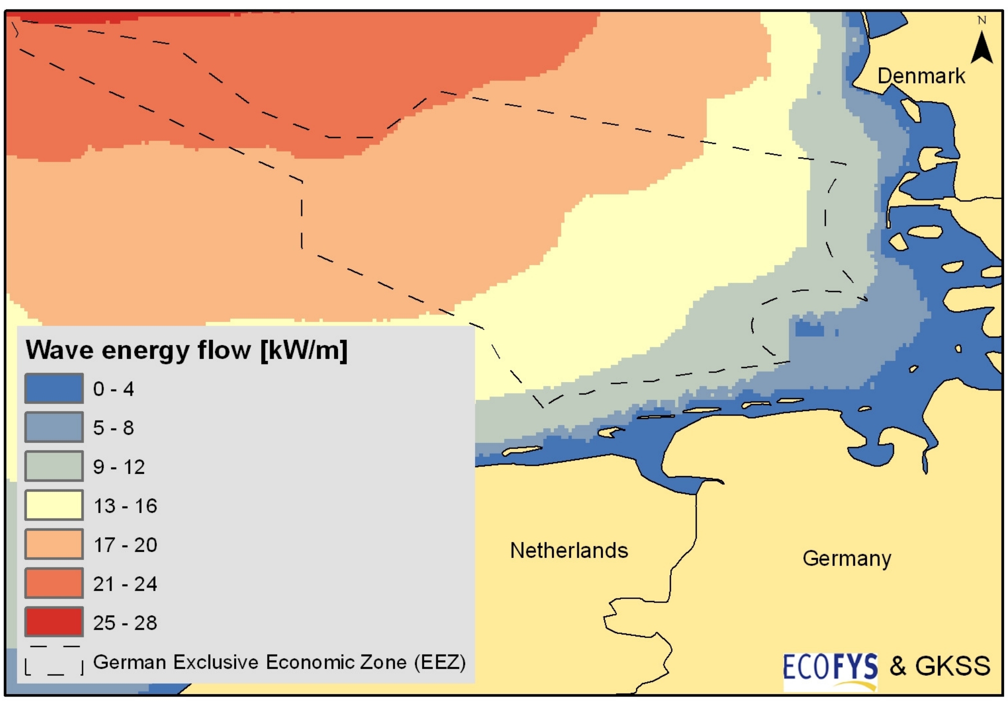
In response to the question for suitable locations, the theoretical potential in the North and Baltic Sea was initially determined with respect to the following types of ocean power: tidal range, waves, current, salt gradient and temperature gradient.

[1] i.e. energy from tidal ranges, waves, current, salt gradients and temperature gradients
[2] As regards onshore wind energy generation, experience has been gained over many years and initial research is currently carried out on the offshore test field "alpha ventus" with respect to its offshore use in Germany.
[3] Some concepts that were originally considered promising, e.g. the Portuguese PELAMIS wave power plant and its three prototypes located offshore in front of the Portuguese coast have run into unexpected problems; the challenges associated with ocean energy technologies are still immense.

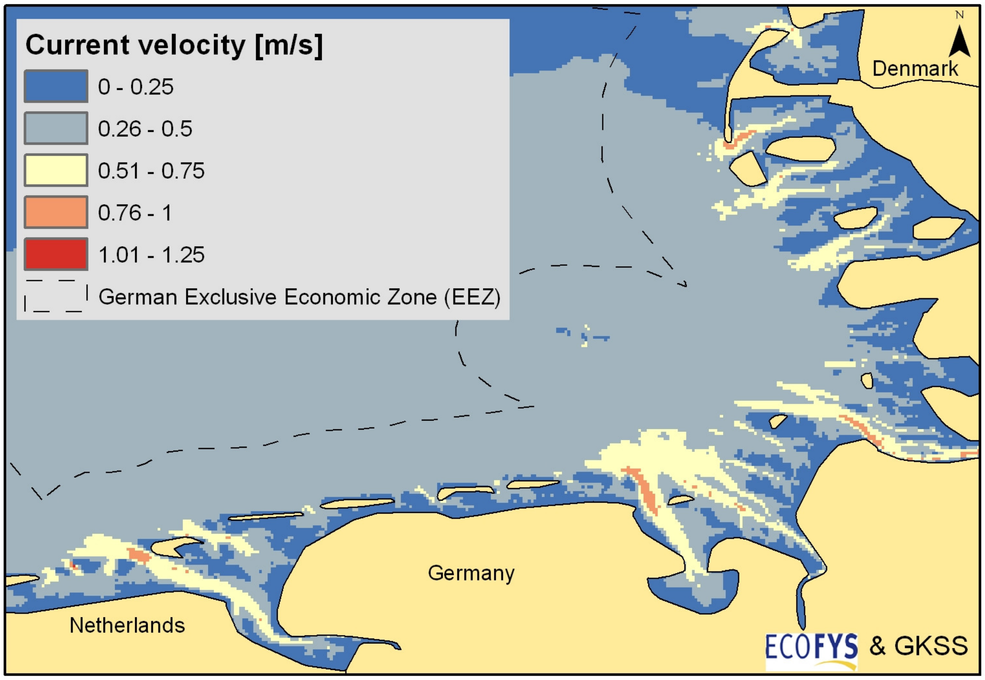
In the study, the theoretical potential use of tidal ranges and wave and ocean current power was determined on the basis of long-term time series supplied by the coastDat database of the GKSS Institut für Küstenforschung (institute for coastal research) (for database see table). The theoretical potential use of salt gradients and temperature gradients was assessed on the basis of publicly accessible sources.

Type	Region	Period	Breakdown, spatial	Breakdown, temporal
Tidal range	North Sea	1958-2003	Variable, up to 100 m in the coastal area	Hourly
Waves	North Sea	1958-2007	5.5 x 5.5 km	Hourly
	Baltic Sea	1958-2002	5.5 x 5.5 km	Hourly
Current	North Sea	1958-2003	Variable, up to 100 m in the coastal area	Hourly

As regards currents and waves, the following illustrations present the comprehensive theoretical potential in the German North Sea.

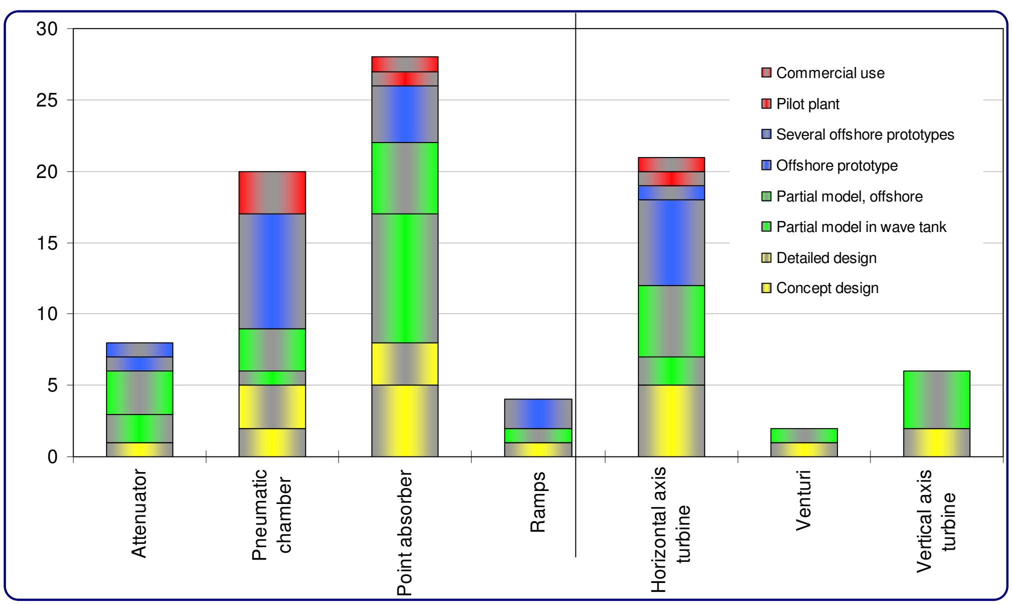


Long-term mean values of the wave energy flow [kW/m] in the German Bight region, determined on the basis of the coastDat database.



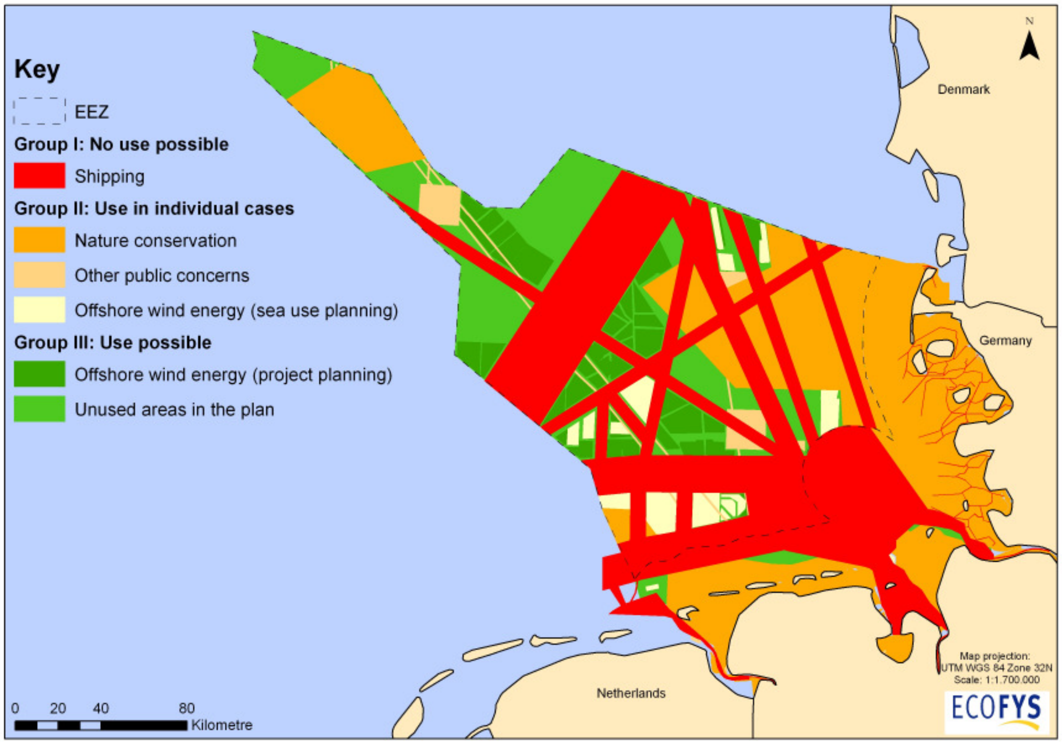
Long-term mean values of the depth-averaged current velocities [m/s] in the German Bight region, determined on the basis of hourly coastDat values.

Extensive research into the state-of-the-art technology relating to all ocean power plants was carried out to assess the degree to which the theoretical ocean energy potential can be used on a technical basis. The following diagram presents a synopsis of the relevant types of wave and current power plants.



Overview of the state of technical development regarding the use of wave and current power: Own diagram

GIS-based, large-scale research of the area was carried out to assess the extent to which competing uses in the German North and Baltic Seas and nature conservation concerns may restrict certain locations at which the technical conditions for ocean power generation are present. The following illustration presents the spatial distribution of the three derived area groups (I to III).



Spatial representation and grouping of types of use as well as nature conversation concerns competing with use for ocean power generation:

As regards the individual energy types, the results of the study can be summarised as follows.

Tidal range

Taking into account competing uses and the concerns of nature conservation, the potential associated with tidal ranges in Germany is zero. Shipping and nature conservation in particular preclude any exploitation of the already low theoretical and technical potential. Compared to other countries, the technical potential is so low that the implementation of projects in Germany does not seem justified given the substantial number of competitive uses.

Waves

Analysis of the theoretical potential and state-of-the-art technology indicates that the German Exclusive Economic Zone (EEZ) in the North Sea offers little technical potential in respect of wave power generation. As regards the potential, taking into account competing uses and the concerns of nature conservation, some promising locations exist were wave power generation is possible (group III) or should be considered following individual case assessments and consideration of the competing uses (group II). However, these sites are located at a long distance (approximately 80 to 350 km) from the shore in the northwestern parts of the EEZ.

A few sites with comparably low potential (400 to 500 full load hours if WaveDragon technology is used) are located in the coastal waters off the East Frisian Islands.

Current

The technical potential associated with ocean power generation in Germany is exclusively located in areas near to the coast involving uses in groups I or II. Consequently, a large part of the potential cannot be exploited due to competitive use and, specifically, nature conservation concerns. Individual case assessment as to whether, and under which conditions, ocean current power plants may be approved is necessary for all locations where ocean current power generation appears possible.

Salt gradient

The river Elbe possesses the largest and presumably only noteworthy theoretical potential for use of salt gradients in Germany. However, due to the wide, approximately 80 km brackwater zone, technical exploitation of this potential is limited. What is more, a huge volume of water would have to be taken out of the river to guarantee energetically relevant use of the salt gradient. Due to the predominantly onshore use of space, offshore use conflicts are unlikely in the case of osmotic power plants. Furthermore, the selective discharge of brackwater is not expected to have any ecological effects on the dynamic coastal waters system. However, ultimately the ecologically sound potential of osmotic power plants is as low as their technical potential. As result, osmotic power generation does not appear expedient in Germany.

Temperature gradient

Today, ocean thermal energy conversion (OTEC) plants are feasible at the technical level. However, their efficiency is very low. In the German North and Baltic Sea, temperature gradients are far below 20 Kelvin, making OTEC plants infeasible. Consequently, considering competitive uses and natural conservation concerns, their potential is also negligible.

All in all, this analysis shows that the theoretical potential associated with the use of ocean energy in Germany is low both in comparison to other locations worldwide and with a view to the German objectives relating to the expansion of renewable energies in the country’s power generation system. The potential associated with tidal ranges and ocean wave and ocean current power appears to facilitate smaller-scale applications for technology testing purposes at individual locations.

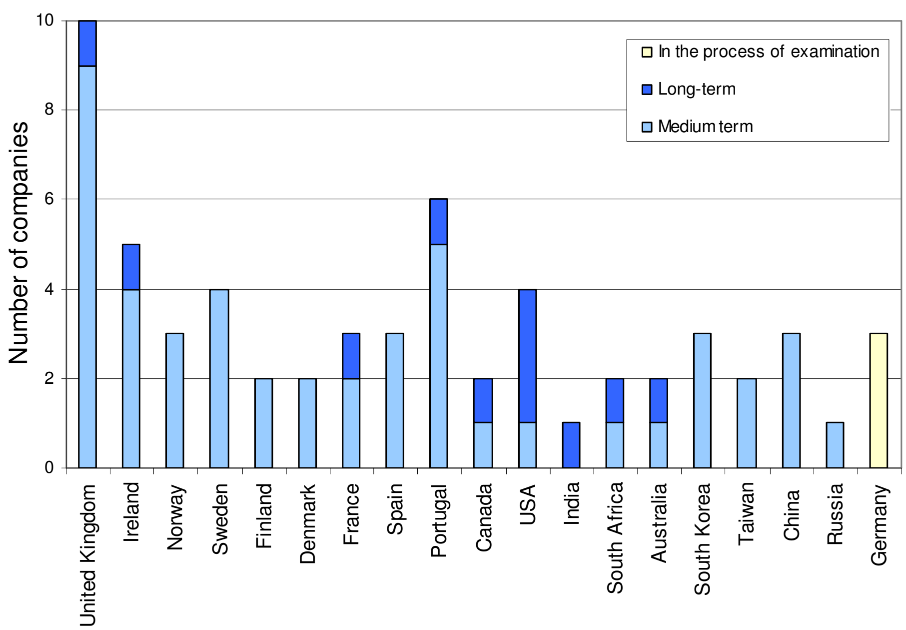
The methodology applied in the study did not allow for a quantitative calculation of the technical potential relating to the use of future wave and ocean current power plants that have been adjusted to German waters. The following table presents a quantitative assessment of the use potential of the various types of ocean power.

	Theoretical potential	Technical potential	Potential after consideration of competitive uses
Tidal range	Low	Low	Almost impossible
Wave	Low: far offshore	Very low	Very low
Current	Low: inlets, estuaries	Very low	Almost impossible
Salt gradient	extremely low	Non-existent	Non-existent
Temperature gradient	Non-existent	Non-existent	Non-existent

Opportunities abroad for German industry

Having concluded that low potential at best exists in the German North and Baltic Seas, the sub-issue of the export potential of German technologies gains relevance. In methodological terms, research of the literature and, in particular, an industry survey was carried out to answer this question. The following graph presents an overview of the export orientation of German companies in the field of ocean power, based on the study that took the form of a company survey.

Export orientation of German companies in the field of ocean energy



The study found that technologies tested in German waters would have limited exportability. The following sections will set out the reasons.

In international comparison, the extent of research and development relating to ocean power plants in Germany in the last few decades was negligible; an exception are a few very successful projects abroad that received German research funding. All things considered, a significant development gap to countries such as the UK, USA, Canada and Portugal is stated. This certainly does not preclude the significant developments made by selected German companies.

It is unlikely that Germany will catch up significantly on these countries' lead. One of the prerequisites for this would consist of the local implementation of test facilities and prototypes. However, in this context, one comes up against the following fundamental inconsistency: Ocean power plants designed for and tested in the wave and current regime in German waters are not suitable for immediate export to countries with higher wave or ocean current potential[4]. Ocean power plants tested in Germany can neither efficiently exploit energy potentials at other international locations, nor could their safe operation be guaranteed.

Consequently, the support of research and development into projects in German waters would not make a noteworthy contribution towards the development of export potentials.

Instead, specific assistance for individual projects abroad that involve German companies with sufficient experience appears to be the better strategy. Typically, the high investment costs associated with ocean power generation represent an entry barrier for smaller companies pursuing potential innovative approaches. However, public funds can only be used efficiently and responsibly for R&D purposes if the risk associated with ocean power plant testing is minimised.

In addition to this individual assistance, collaborations with existing test fields associated with the testing of ocean power plants abroad are recommended (e.g. UK, Portugal, Denmark and Ireland). Intergovernmental agreements could open doors for German companies in this field. Furthermore, support of national standards and the active involvement of German experts in setting international standards relating to ocean power technology should be assessed. Without this support, especially German small and medium-sized enterprises with potentially innovative concepts may not have the means to represent their interests in this strategically important field of standardisation; this might result in additional barriers to the future entry into foreign markets.

Irrespective of the comparably low potential in Germany and the limited technology export possibilities, the study also analysed aspects relating to the adaptation of the German legal framework. Where required, the results give an indication of the adaptations that may be necessary for the small-scale development of ocean power generation projects in Germany.

Irrespective of the above results, both project developers in the field of German offshore wind parks and co-operation partners should be free to test ocean power plants in the vicinity of offshore wind parks on their own authority and thus reduce costs associated with the grid connection of ocean power plants.

With respect to the resulting necessary avoidance of competing uses in the German EEZ, the study states that the Marine Facilities Ordinance represents a sufficient legal framework that does not require any adaptations. Applicable law also places no obstacles in the way of the planning and construction of ocean energy plants in the coastal region. However, a few exemptions and clarifications favouring the construction of ocean power plants may give some positive impulses and, at least in legal terms, prevent a further curtailing of the low potential associated with ocean power plants as set out in the study.

The designation of "ocean power" pilot areas could act as a political signal as well as having a positive steering effect. Such pilot areas would not necessarily have to consist of areas with particularly high theoretical potential since their main benefit would consist of their research and demonstration character. However, it shall be pointed out once again that knowledge gained in German areas with low potential is

[4] This represents a decisive difference compared to wind energy where a manageable number of wind power plant types are sufficient to supply the global mass market with large volumes.

not directly transferable to the development of ocean power plants in locations with substantially higher natural parameters. Consequently, detailed regulations, for example the development of BSH standards (German Federal Maritime and Hydrographic Agency, BSH) would be recommended in the case of greater demand only.

In any case, the issue of grid connection would have to be clarified before any locations are designated as “ocean power” pilot areas. In the medium term, the amount of energy generated by ocean power plants will remain so small that the use of voltage transmission systems as employed in offshore wind energy generation would make no economic sense. Nevertheless, it is technically possible to connect ocean power plant prototypes and demonstration plants to offshore substations without having to raise capacities to a large extent. The associated costs would have to be borne by the project developers.

As regards the frequently discussed synergy effects relating to optimised utilisation of grid connections by using both offshore wind energy and ocean power, the study states with regard to the German EEZ that the time lag between the occurrence of the energy forms and the spatial correlation between one energy form at different locations does not lead to significant synergy effects. However, the study did not focus on these investigations and more detailed analysis of such effects is recommended.

Further investigations should also be carried out into the calculation of the technical potential relating to the use of wave and ocean current power plants that were adapted to German waters. The methodology of the study did not allow for such calculations.