

# POLICY *brief*

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## Offshore Grids: Towards a Least Regret EU Policy<sup>1</sup>

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### Highlights

- The objective of the 5<sup>th</sup> report of THINK has been to formulate policy recommendations to the European Commission (DG Energy) on offshore grids, and this brief is derived from that report.
- The development of an offshore grid is able to play a significant role in the accomplishment of the EU energy and climate objectives. The total installed capacity of offshore wind farms is expected to increase from the existing 3 GW to about 40 GW by 2020. The number one priority project in the recently proposed EU infrastructure package is the Northern Seas offshore grid.
- There are two possible offshore grid developments (Figure 1): there could be a multiplication of standalone lines, which already exists today; or there could also be a transition towards combined solutions, which requires more advanced grid technology than what is currently on the shelf. The first would correspond to an increase of shore to shore investments to exchange energy across borders or to relieve congestion within an onshore grid, and an increase in farm to shore investments to connect offshore wind farms to the existing onshore grid. The second instead would imply mixed investments, combining the connection of offshore wind farms with the creation of interconnection capacity.
- The potential for EU added value depends on which of these alternative offshore grid developments will prevail. The economic case for combined solutions is still uncertain, but regulation needs to be proactive to avoid compromising this possible offshore grid development. It means that we have to address the fact that the currently mainly national regulatory frames for farm to shore and shore to shore investments are unsound, and the difficulties to design and develop combined solutions are tremendous.
- We recommend the European Commission to take initiatives to: 1// harmonize into economically sound regulatory frames for offshore transmission investments; 2// harmonize the renewable support schemes for offshore wind farms; 3// facilitate the ex-ante allocation of costs and benefits of offshore transmission investments; 4// speed-up offshore grid technology development; 5// adapt the Community-wide transmission planning to offshore grids, while also allowing regionalized solutions for the implementation of some of these remedies.
- A least regret EU policy on offshore grids indeed also implies giving a chance to regional initiatives, such as the North Seas Countries' Offshore Grid Initiative.



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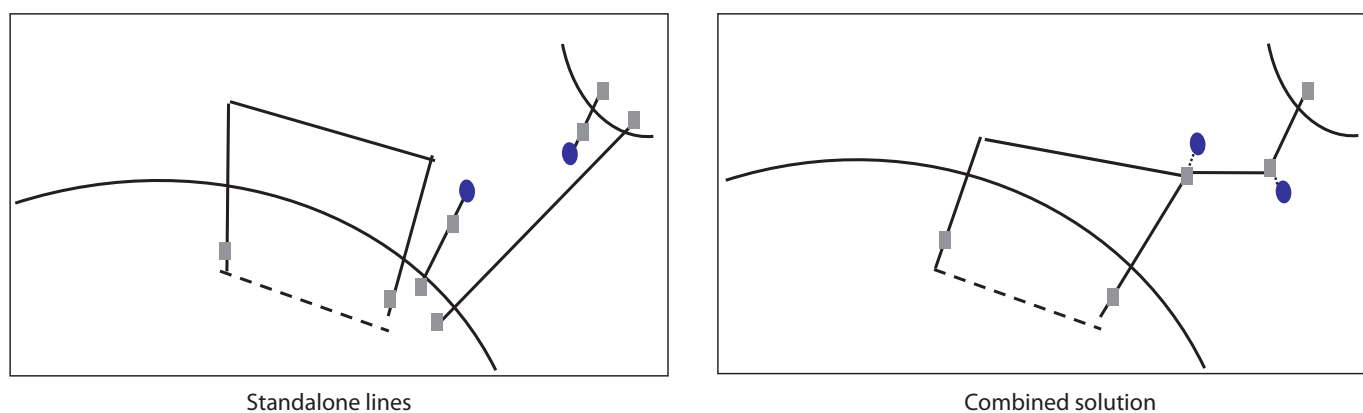
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1. Topic 5 of the EU's FP7 funded project THINK. The project report is available at: <http://think.eui.eu>



**Figure 1 – alternative offshore grid developments**  
 (Legend: ○ wind farm; ■ converter station; – HVDC cable; -- HVAC)

### Standalone lines

There are two types of standalone lines, i.e. shore to shore to exchange energy across borders (with a so-called interconnector) or to relieve congestion within an onshore grid (with a so-called bootstrap), and farm to shore to connect offshore wind farms to the existing onshore grid.

#### *Shore to shore*

The economic features (i.e. the network externalities, cost and technology uncertainties, and economies of scale) of shore to shore investments are similar to onshore transmission expansions so that the regulatory frame offshore can be the same as onshore. The currently mainly national regulatory frames that apply to these investments are however economically unsound, i.e. they do not follow the three guiding principles to minimize the total investment cost of transmission and generation.

1. **Planning principle:** Planning is about coordinating transmission expansions with the demand for transmission, taking into account the strong economies of scale and network externalities of transmission investments. The most common procedure is that the Transmission System Operator (TSO) presents the costs and benefits of the proposed investments to the regulator who then decides which projects to approve. Despite the strong interdependencies between national grid investments, planning is currently done mainly at the national level, except for an indicative Community-

wide planning procedure that has recently been introduced.

2. **Competition principle:** Tendering can be used to introduce competition, which is especially opportune when there are cost and technology uncertainties. Tendering for the participation of third parties in part of the investment decisions incentivizes innovation and reduces the problem of information asymmetry between the TSO doing the planning and the regulator. Note that transmission expansions onshore, contrary to offshore, are typically incremental investments in an existing grid, which can be many small investments that are more difficult to delegate. The coordination cost of tendering could therefore be higher than the potential gain from adding competition, but an element of competition can also be added by allowing third parties to propose projects to the regulator so that the TSO can be contested. This is currently only possible for merchant projects, while it is also being considered for regulated projects in the UK.
3. **Beneficiaries pay principle:** Making the beneficiaries pay is important to signal the costs of their demand for transmission services. A combination of transmission access rights (making users of a line pay) and transmission tariffs (sharing costs among grid users) need to be used to allocate costs to beneficiaries. Transmission tariffs are however national, while these types of projects create winners and losers beyond national borders. The ex-ante allocation of costs and benefits of offshore transmission investments is currently

not facilitated at EU level, while it is clearly needed. The infrastructure package that has recently been proposed by the European Commission is a step in this direction.

### *Farm to shore*

The national regulatory frames to connect a generator are economically unsound. This was already a problem onshore, but is especially problematic offshore because the economic features of the investment to connect a generator can be stronger offshore than onshore, especially for the most recent development of farm-to-shore connections (Box 1).

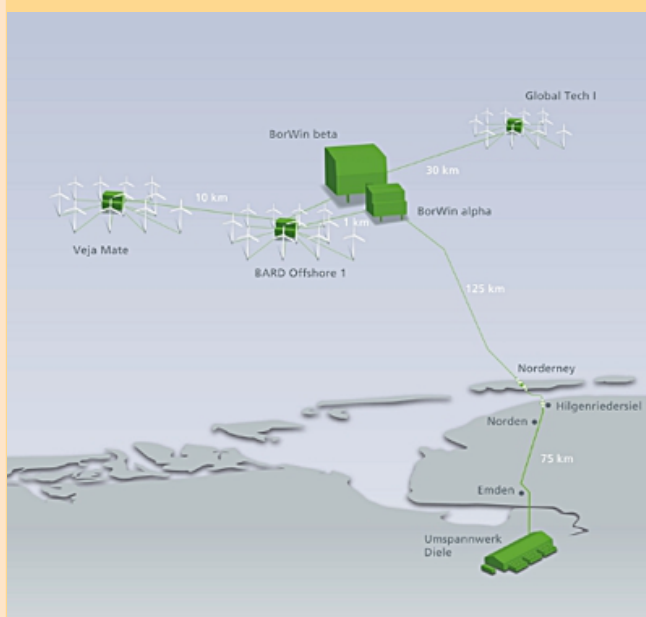
1. **Planning principle:** The commonly used first-come-first-serve procedure to connect generators is not in line with this principle. The potential negative impacts offshore are stronger than onshore due to the significant economies of scale that can be achieved when clustering offshore wind-farms to shore, i.e. to use a single line to connect several wind-farms to shore, and the strong impact that such projects might have on the existing grid (because of their larger scale compared to onshore investments).

2. **Competition principle:** Contrary to this principle, TSOs design and develop the connection of a generator in most member states. Onshore, the disadvantage is limited due to the relatively limited cost level and limited cost and technology uncertainties of an onshore connection, but this is not the case offshore where connections tend to be more costly and based on less known technologies.

3. **Beneficiaries pay principle:** Regulatory practices in allocating these investment costs differ widely between member states, but so-called super shallow charging whereby the generator almost does not pay for its connection is not uncommon, while the generator is the main beneficiary. Generators that do not pay for their connection, do not have an incentive to proactively participate in connection planning, which is especially a problem offshore because offshore there are more opportunities to reduce the cost of connecting generators with planning.

Offshore wind pioneering member states have recognized the stronger economic features that farm to shore investments can have, and started to adapt their regulatory frames for these in-

### **Box 1: Borwin project** (Source: Tennet)



**Cost and technology uncertainties:** Because of the large distance from shore, the traditional High Voltage Alternating Current (HVAC) transmission system cannot be used, instead, the lesser known High Voltage Direct Current Voltage Source Converter (HVDC VSC) systems need to be used.

**Network externalities:** There is a strong impact on the existing grid because 1200 MW in total needs to be connected close to shore where the existing grid is weak and often already congested. Note that Borwin will cost about 1200 m Euros, i.e. 400 MW in phase 1 in 2009 and 800 MW in phase 2 in 2012

**Economies of scale:** HVDC systems consist of a DC cable with two converter stations, one to convert the AC output of the wind turbine into DC, and one to reconvert the DC output of the cable into the AC of the existing onshore grid. By coordinating the connection of three wind farms in Borwin in two phases, only 3 converter stations and one cable to shore need to be used, instead of 6 stations and 3 cables.

vestments. The models of Germany, the UK and Sweden are good examples of how the first, second and third guiding principles can be implemented, respectively, but they are economically unsound from the perspective of at least one of the other principles.

1. **German model:** This is a good example of how advanced connection planning can be implemented. Planning for the impact of offshore wind on the existing grid has been initiated in Germany by the so-called DENA studies, and clustering of offshore wind farms has for instance already been proactively implemented in the Borwin project (Box 1). The model is however far from being perfect because offshore wind farms do not pay for their connection and there is no competitive tendering for the design and/or development of connections.
2. **UK model:** This is a good example of how the competitive tendering can be implemented. Tenders have already been organized in the UK for the ownership and operation of connections developed by offshore wind generators, and they are envisaged to also include the design and development of future connections. The model is also sound from

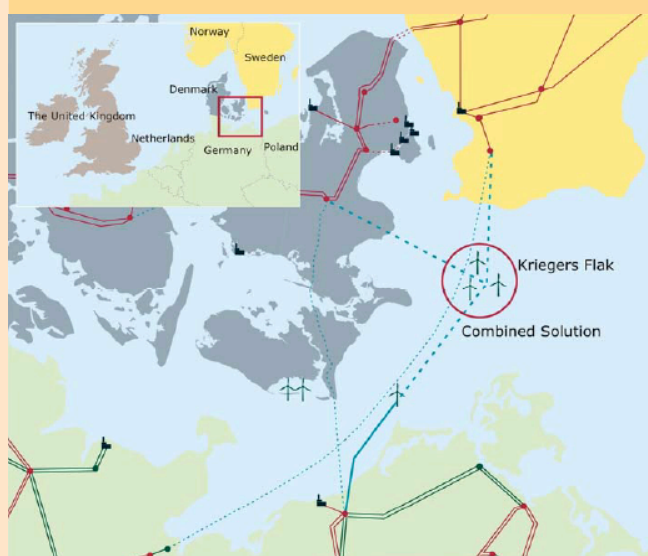
the perspective of the third principle because generators pay for their connection. The inclusion of advanced connection planning in this model is ongoing.

3. **Swedish model:** This is a good example of how the beneficiaries pay principle can be implemented. Generators in Sweden pay for their connection; they are even responsible for designing and developing their connection so that the Swedish model is also sound from the perspective of the second principle. The model is however misbalanced because connection planning is missing.

### Combined solutions

Combined solutions are mixed farm to shore (connection of offshore wind farms) and shore to shore (creation of inter-connection capacity) investments. This type of offshore grid development is an alternative to standalone solutions and implies different recommendations in terms of regulation and EU involvement. Therefore, we first discuss the rationale for combined solutions and then provide recommendations for combined solutions.

#### Box 2: Kriegers Flak project



**Project:** the Danish TSO (Energinet.dk), a German TSO (50-Hertz), and the Swedish TSO (Svenska Kraftnätt) studied a combined solution, involving the connection of up to 1600 MW of offshore wind farms in an area that crosses the waters of their countries (Energinet.dk, 2009; E-Bridge, 2010; Jørgensen, 2011).

**Economic case:** The feasibility study argues that in this specific case, there is a net gain, but the study did not demonstrate that the net gain of this combined solution is superior to the net gain of a multiplication of standalone lines: "It is not within the scope of this pre-feasibility study to make detailed comparisons between a combined solution at Kriegers Flak and other ways of providing additional transmission capacity across the Baltic Sea."

*Rationale*

The rationale to combine is the same as to cluster, i.e. the possible reduction in the volume of assets, like in the Borwin project (Box 1). Contrary to clustering, the economic case for combined solutions is however uncertain because this alternative to standalone solutions requires more advanced grid technology than what is currently on the shelves.

In existing HVDC systems, the whole infrastructure stops working if a fault occurs in one of its components. A more sophisticated operation of HVDC systems would require more advanced grid technology that has not yet been tested in practice, i.e. including hardware (e.g. HVDC circuit breakers) and software (e.g. HVDC control systems).

In relatively small offshore grids, like Kriegers Flak (Box 2), it would still be manageable to shut down the entire grid to isolate a fault before reactivating part of it, so that combined solutions might already be opportune today. They may also become opportune on a wider scale in the future, depending on how the advanced grid technology develops.

*Remedies for the key difficulties*

There are five key difficulties to develop combined solutions under the current regulatory frame, which we will illustrate by referring to the Kriegers Flak project (Box 2). For each of these difficulties, we have also identified a remedy:

**1 // Harmonizing into economically sound regulatory frames for offshore transmission investments**

Non aligned national frames for transmission investments make it difficult for stakeholders to cooperate in the development of combined solutions. For instance in the case of Kriegers Flak, the Danish and German TSOs are responsible for the interconnectors as well as for the connection of offshore wind farms in their waters, while the Swedish TSO is only responsible for interconnectors. A promising remedy would therefore be to harmonize the national frames towards the guiding principles of an economically sound regulatory frame for transmission investments (see above), which would include more harmonized planning responsibilities.

**2 // Harmonizing the renewable support schemes for offshore wind farms**

Non aligned national renewable support schemes for offshore wind farms also make it difficult for stakeholders to cooperate in the development of combined solutions. For instance in the case of Kriegers Flak, this is not necessarily an issue, but the current project design only integrates three national solutions, whereby each country continues to import the offshore wind produced in its waters, which is not necessarily the best design. Therefore, a promising remedy would be to harmonize renewable support schemes for offshore wind farms, or at least to improve their compatibility.

**3 // Facilitating the ex-ante allocation of costs and benefits of offshore transmission investments**

Even if the regulatory frames and renewable support schemes were harmonized, the development of combined solutions still requires cooperation between several stakeholders that do not necessarily benefit from this solution. For instance in the case of Kriegers Flak, three TSOs, three wind developers and three national regulatory authorities are involved. This multi-stakeholder setting is problematic because the distribution of benefits of offshore infrastructure is dispersed between many countries and between generators and consumers, with winners and losers that might need to be compensated. A promising remedy would therefore be the facilitation of the ex-ante allocation of the costs and benefits of the investment, which could prompt the implementation of the beneficiaries pay principle for combined solutions.

**4 // Speeding-up offshore grid technology development**

The dependency on offshore grid technology development further complicates combined solution projects because this development is hampered by the typical market failures that apply to RD&D. For instance, the technology to use in combined solutions would typically be HVDC VSC, which is relatively new technology that has already been used for standalone lines, but not yet in a combined solution. As mentioned previously, the combined solution systems require more advanced hardware and software that still need to be developed and test-

ed. Therefore, a promising remedy for the required offshore grid technology development would then be to coordinate and speed-up their development.

### 5 // Adapting the Community-wide transmission planning to offshore grids

A final complication is that all the above difficulties have to be overcome in a context of uncertainty and irreversibility (e.g. dimensions of the offshore platform, cost of combining HVDC technologies that operate at a different voltage, etc.), while combined solutions are typically phased grid developments. For instance in the case of Kriegers Flak, the complete international solution with all offshore wind turbines spinning, all modules of the grid connection in operation, and electricity being traded, is still some years in the future, while the first building blocks and the most important decisions to enable a combined solution are not that far away. Therefore, a promising remedy could be to do more than only include offshore grid development in a Community-wide connection and transmission plan. We also need to develop new transmission planning methods, for instance to capture the value of investing today to create more options for possible incremental offshore grid investments.

## Recommendations

Our analysis shows that the added value of additional EU policy actions for offshore grids depends on whether the offshore grid will develop as a multiplication of standalone lines or whether there will be a transition towards combined solutions. Therefore, we provide recommendations for standalone lines and combined solutions separately in what follows.

### *Standalone lines*

Even though there is no need for a specific EU intervention for standalone lines, it is important to continue the following policy actions that are ongoing for grids, onshore as well as offshore:

1. It is important to continue the implementation of the third package, comprising a Community-wide transmission planning that already includes shore to shore invest-

ments. Additionally, it is worth mentioning that this still needs to be backed-up by an EU level facilitation of the ex-ante investment cost and benefit allocation, as proposed by the infrastructure package.

2. It is important to continue the experimentation with novel regulatory frames (e.g. Germany, the UK and Sweden) that have been fine-tuned for the connection of offshore wind farms. Note that, even if the currently imperfect fine tuning is not a problem from the EU perspective, the EU could add value by supporting this learning process, for instance, by benchmarking existing practices.

### *Combined solutions*

The least regret EU policy strategy would be to implement remedies for the tremendous difficulties faced by combined solutions (see above), while also giving a chance to the ongoing regional initiatives. So, where opportune, the EU should opt for a soft intervention, guiding and supporting the national and/or regional policy implementation of the remedies; and, where a regional solution is not viable, a stronger EU involvement is already recommended today. In the report we consider both options for each of the remedies, but here we only list the resulting recommendations for initiatives to be taken by the European Commission, in addition to the third package and the infrastructure package proposal:

1. **Harmonizing into economically sound regulatory frames for offshore transmission investments:** By providing indicative guidelines that encourage member states to follow the guiding principles of an economically sound regulatory frame (i.e. planning principle, competition principle, and beneficiaries pay principle) to reduce the distortions coming from the national frames (i.e., soft type of EU involvement, supporting regionalized solutions).
2. **Harmonizing the renewable support schemes for offshore wind farms:** By promoting the use of the renewable support scheme flexibility mechanisms for offshore wind farms (i.e. joint project and joint support scheme mechanisms) to reduce the distortions coming from the national schemes (i.e., soft type of EU involvement, supporting re-

gionalized solutions).

3. **Facilitating the ex-ante allocation of costs and benefits of offshore transmission investments:** By organizing the approval of transmission investment project packages, complemented with a new mechanism to implement the beneficiaries pay principle for combined solutions (i.e., strong type of EU involvement that could be complemented by partly regionalized solutions).
4. **Speeding-up offshore grid technology development:** Through the inclusion of an offshore grid technology roadmap in the SET-Plan, within an industrial initiative driven by HVDC manufacturers, focused on the speed-up of offshore grid technology development required for large scale combined solutions (larger than projects like Kriegers Flak). (i.e., strong type of EU involvement).
5. **Adapting the Community-wide transmission planning to offshore grids:** By developing improved transmission planning methodologies and applying them to elaborate on a twenty or thirty year network development plan that considers combined solutions (i.e., strong type of EU involvement).