Sharing benefits and costs of integrated offshore grid structures

NorthSeaGrid Policy Brief

Key messages

- The conventional approach for allocating cost of offshore grid investments in short:
  - Attribution of costs of connecting an offshore wind farm to the home country transmission grid and the definition of home country transmission grid is country-specific.
  - Equal shares for the hosting countries in grid project costs and congestion income through their respective TSOs.
- Alternative cross-border cost allocation (CBCA) methods considered in the NorthSeaGrid project are:
  - Positive Net Benefit Differential: cost allocation among countries in line with differential net benefit compared to the base case and compensation of negative/low net benefit differentials
  - Louderback : allocating to countries the directly attributable costs, adding the indirect – i.e. common – costs proportionate to the difference between stand-alone and direct cost.
- The cost and benefit impacts of the distinct cross-border cost allocation methods should not only be considered at country level, but also at stakeholder level. The NSG project has pioneered an approach to do so.
- The CBCA method to be adopted should yield an acceptable net benefit distribution among, at least, hosting countries. For this purpose, the NSG project has assessed the Positive Net Benefit Differential method.
- Countries involved need to agree ex ante on a transparent and robust approach for net benefit determination and the cost compensation rule among affected/hosting countries.

Date: 9 March 2015
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Acknowledgements:
Status of document: Final Draft

1 Introduction

Scenario studies indicate that offshore wind has a prominent role to play in contributing to the EU's medium and long term electricity supply. This holds notably if EU and, where applicable, MS self-determined longer-term renewable energy targets are to be achieved in the most cost effective way.[1] A crucial facilitating factor for the take-off of offshore wind is the realization of offshore grid infrastructures. However, upon take-off of offshore wind in the Northern Seas, dedicated near-shore locations that can command sufficient public acceptance will become in short supply. Therefore, upon the availability of advanced transmission technology, foreseen early in the 2020s, offshore grid infrastructure will increasingly have to encompass 'hybrid components', i.e. components combining the transmission of electricity traded cross-border and the evacuation of electricity from offshore wind farms. This poses huge regulatory challenges. These challenges have to be tackled. Hence, **the case of offshore wind is a potent driver for the accelerated transition of European electricity markets towards the aspired Internal Energy Market for electricity**.

The realization of the required offshore grid infrastructure implies high investment costs. Rolling it out in a cost-effective way from a global (cross-border regional or rather EU) perspective would seem to be a political must. In this respect, four key issues need to be addressed:

1. **Offshore transmission grid planning**: how should it be undertaken efficiently?
2. **Approval/rejection of proposed offshore grid investment projects**: what investment decision methodology to apply, with due allowance for cross-border effects?
3. **Offshore grid governance**: who should be in charge of investing in, operating, and supervising the offshore grid?
4. **Investment financing**: who should pay for offshore grid projects, i.e. what cross-border cost allocation (CBCA) mechanism to apply, ensuring full cost recovery?

This Policy Brief focuses on the fourth issue. In doing so, this central issue will first be put in context of the other intertwining issues (Section 2). Next the cross-border cost allocation issue will be set out, selecting three cross-border cost allocation methods for further consideration (Section 3). They are tested in one of three numerical Case Study examples (Section 4). The Policy Brief concludes with some pragmatic suggestions for the way forward.[2]

2 The contextual framework

Given the innovative features of the envisaged future offshore grid in especially a technological and a regulatory sense, the optimal way to deal with cross-border cost allocation highly depends on how the EU and its Member States will address the other key issues concerned as enumerated in the previous section. In the remainder of this section we will sketch the broad outlines of the envisaged contextual framework.

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[1] See for example (European Commission, 2011; Rohrig et al, 2014: p.25, Table 3).

[2] This Policy Brief builds on (van der Welle, 2014). While the usual disclaimer for remaining errors applies, this Policy Brief has benefitted from valuable feedback given by participants of the NorthSeaGrid (NSG) project stakeholder consultation events at CEPS, Brussels, on 13 and 14 January 2015.

Within the EU, national transmission networks are poised to expand to become increasingly interconnected. This renders necessary a regional and preferably **an EU-wide indicative planning approach** with a gradually stronger role for ACER (Zachmann, 2013). Initially, an oversight role might be implemented by regional groupings of national regulatory agencies (NRAs) and notably by reinforcing ACER's mandate, as foreseen in EU Regulation No 347/2013. In pursuing the complex global planning assignments, stochastic network flows modelling is to be applied, **consistent with rolling updates of Energy Roadmap 2050 scenarios** (Meeus et al, 2013). This will yield on a periodic basis long lists of competing transmission network projects and, notably, cross-border transmission network projects.[3] ACER, based on inter alia (Meeus *et al.*, 2013), has convincingly determined that **ranking and appraisal of, notably cross-border, transmission network expansion projects** is to be mainly based on **net benefit** to be established by EU-wide consistent cost-benefit analysis (CBA) methodology, based on the same supply/demand scenarios, values of crucial parameters such as the discount rate as well as fuel and CO_2 prices.

For marine electricity generating technologies, foremost offshore wind, propitious development of cross-border offshore grids is of existential importance. One of the key issues for getting this grid development moving is the **governance issue**. Recent research indicates that a well-conceived strategic and co-ordinated, long-term approach towards offshore grid development by littoral states in close coordination as against a national incremental approach is the most cost-effective way forward (Skillings and Gaventa, 2014; Strbac et al, 2014). To that effect, the most effective cooperation model to implement strategic long-term grid development would seem to be the so-called TSO model (Meeus, 2014). [4] The TSO model, currently implemented in most countries participating in NSCOGI, extends the responsibility of TSOs to connect offshore generators offshore through onshore-offshore transmission network extension or by interconnecting offshore wind farms or offshore hubs to offshore interconnectors. Moreover, offshore integrated infrastructure projects would then be regulated rather than allowed to be merchant projects.

However, the take-off of cross-country offshore network development is hampered by **regulatory uncertainty and especially regulatory 'white spots'**. In this respect, one of the key regulatory issues that need to be urgently addressed is the **allocation of cross-border offshore investment cost, i.e. the CBCA issue**. Anticipating on the installation of hybrid assets, the offshore grid CBCA issue can only be dealt with in a globally cost-effective way when addressed concurrently with convergence and ultimate harmonization of **other relevant regulatory issues**. **These include coordinated support schemes, integrated cross-border electricity markets, notably in the balancing market and intraday timeframes, as well as similar use of system charging and harmonized congestion management regimes.** A bottom-up coordinated approach of like-minded littoral states might well initiate such a process of concurrent regulatory convergence and ultimate harmonization at regional and EU-wide levels, supported by concurrent less stringent top-down convergence fostered by the EU. Based on the foregoing, the main general framework assumptions that have been applied, will be explained hereafter.

Our analysis is performed mainly from a social welfare perspective as reflected by the applied assumptions such as the social discount rate of 4%. We assume that the efficiency gain achieved in case of the integrated case is not significantly affected by effects that are not taken into account in this analysis (e.g. network reliability or other

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3 As explained by Meeus et al. (2013), competing projects should be excluded from the project baseline against which alternative project proposals should be assessed, whilst projects with a (strongly) positive interdependency should be lumped.

4 Recently, the use of system charges imposed by OFTOs have to meet TSO-type requirements, as set by OFGEM.

effects discussed in: van der Welle, 2014). All amounts of money mentioned below are at constant prices, expressed in million euros of 2014 i.e. M€$_{2014}$.

Network users will ultimately pay for the network cost, made by the TSOs concerned and approved by the competent national regulatory agencies (NRAs). Generation Use of System (GUoS) charges as percentage of total (transmission) system charges in accordance with ENTSO-E [13] i.e.

- Belgium 7%
- Denmark 4%
- Germany 0%
- Great Britain/UK 27%
- Netherlands 0%
- Norway 38%

The Consumer Use of (Transmission) System charges are the complement of GUoS charges (both adding to 100%).

Typically, in the so-called TSO model (Meeus, 2014) congestion rents are accruing, at least initially, to the TSOs.[5] Here, it is assumed indeed that the TSOs receive the congestion rents due to them under prevailing interconnection agreements. They will hold these inflows under a separate account. The NRAs concerned are assumed to decide on the ultimate destination of the congestion rent inflows.

Production support benefits for OWF operators for hosting countries in the case studies with offshore wind farms in their respective exclusive economic zones, defined as projected average support level in excess of the average ex post commodity price (€/MWh), normalised in an approximate way over 20 years:[6]

- Belgium 70
- Denmark 60
- Germany 60
- Great Britain 90
- Netherlands 90

Support cash flows to the operators of offshore wind farms (OWFs) located in the exclusive economic zone (EEZ) of country A will be ultimately passed on to electricity consumers of country A.

In case (part of) the electricity produced by an offshore wind farm in the EEZ of interconnected country A is physically evacuated to the shore of interconnected country B, the competent authority on support payments in

5 As per EU regulation on the use of congestion rents, the competent national regulatory agencies (NRAs) mandate TSOs under their supervision to pass on a residual part of congestion rents in use of system charges, when this income cannot be spent on, notably, approved investments in interconnectors .

6 Note that support levels contractually promised to new offshore wind projects are often revised, e.g. because of revised regulatory framework conditions. E.g. in the Netherlands the Dutch TSO will become responsible for offshore transmission of wind power, whilst currently wind farm operators have to make offshore grid arrangements themselves to eject their generated energy to the Dutch shore. Furthermore, so far no OWFs have been realised in the exclusive economic zone of Norway.

country A remains responsible for support over the volume of exported electricity concerned. In other words, country A is responsible for support over the total offshore wind energy production in its EEZ, irrespective of to which jurisdiction the electrons concerned flow.[7] The other side of the medal is that country A enjoys the benefits of hosting offshore wind farms (employment, value added, green sunrise industry development, etc.) and is entitled, in principle, to the target accounting benefits over the offshore wind energy, produced in its jurisdiction.[7]

OWFs in the EEZ of a certain country have to bid into the applicable bidding zone of that country, even if the anticipated commodity price in (one of) the other hosting country (countries) is higher and/or the physical flow is into another direction than towards aforementioned zone.[8]

In the case of hybrid assets, OWFs are assumed to have to pay merely for the connection to the interconnector or to the offshore hub that is part of an integrated infrastructure concerned. Note that, to the extent that already regulations exist on this issue in national jurisdictions, this assumption might not be fully consistent with current national regulation. However, for realising integrated investments, the hosting countries concerned need to align their respective regulation frameworks facing investors in offshore wind farms.

In case of congestion on offshore interconnector structures OWFs have access priority for the notified power injection capacity at the intraday gate closure time. In line with current regulations in most NSCOGI countries, OWFs are given a waiver to pay for access to the transmission network; even in the event of congestion.

The NorthSeaGrid project has also assessed within-country stakeholder welfare impacts of distinct cross-border allocation methods. To that effect, the following stakeholder categories have been distinguished:

- Consumers
- Offshore wind farm operators (WFOs)
- Other producers
- TSOs.

The sketch of the contextual framework above sets the stage for addressing the focal CBCA issue in the remainder of this Policy Brief.

3 CBCA methods to be considered

Focal issue of this Policy Brief is the impact of applying selected methods for cross-border cost allocation of global (total) costs of an integrated infrastructure project to the distribution of global project benefits. The global

[7] This assumption has been made to facilitate an unambiguous allocation of the support benefits when more than two countries are interconnected. Upon introduction of a joint support scheme for offshore wind covering (at least) the hosting countries and comprehensive cross-border electricity markets (in all time frames), this assumption can be relaxed.

[8] This assumption was made as this arrangement is the easiest to implement, obviating the need to validate to which country what part of the produce of a wind farm connected to the integrated grid infrastructure concerned has been ejected. This issue can become more complex the more hosting countries are involved. Evidently, the interconnected countries concerned may agree otherwise ex ante as per bilateral/multilateral/regional offshore wind cooperation agreement, i.e. on the transfer of a defined part of the target accounting units.

cost and benefit levels as such and how to determine these levels are addressed elsewhere.[9] Two conventional 'rules' for cross-border cost allocation of interconnecting infrastructures across countries and within countries across stakeholders are:

1. *Equal Share* ('the 50-50 rule') in absorbing the cost and congestion rents of an interconnector between the (TSOs[10] of the) hosting, i.e. interconnected, countries. This is a politically convenient, readily understandable and implementable approach.
2. *Postage Stamp* spreading of cost allocated to (the TSO of) hosting countries and within a hosting country among network users. The Postage Stamp principle can be applied lump sum, capacity-dependent or energy-dependent. The Postage Stamp principle is, again, a politically convenient, readily understandable and implementable approach. Moreover, it avoids the contestable and less easy understandable exercise of benefit attribution, and recognizes the public good character of reliability benefits of power supply provided by the public grid to all network users.

ACER[11] and NSCOGI[12] are pivotal institutions, investigating the cross-border cost allocation issue. ACER focuses on the more generic case of power and gas interconnectors against the backdrop of overseeing the progress towards reaching the so-called Target Model (for the electricity and gas market respectively). According to ACER cross-border cost allocation can best be arranged on the basis the *Beneficiaries Pay* principle. To be more specific, ACER (2013) favours the project-specific application of cost-benefit analysis to assess the projected net benefit incidence among affected countries in establishing cross-border cost allocations (CBCA) for projects of common interests (PCIs).

NSCOGI has made an extensive review of a range of CBCA methods for application to a hybrid asset combining renewable generation and cross-border trade (NSCOGI, 2014a). A key necessary pre-condition before proceeding to cross-border cost allocation, that is assumed to hold indeed in NSCOGI's review, is that the global net benefit of the hybrid asset case is positive. Moreover, when it is considered that the investment proposal concerned is competing with corresponding (potential) stand-alone investments, the total hybrid asset costs should, in principle, be lower or rather, its total net benefit should be higher than in the stand-alone case. NSCOGI made a valuable assessment of the respective strengths and weaknesses of each allocation method considered without revealing a preference for a single one.

In the NorthSeaGrid project *three CBCA methods* are being considered, applied to cross-border cost allocation of integrated offshore grid structures. Integrated infrastructures facilitate both the transmission of renewable generation and cross-border trade. The CBCA methods considered are:

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9 In Work Package 4 of the NSG project the cost-benefit methodology was determined and, consequently global costs and benefits for the three NSG Case Studies. See (Jafar *et al*, 2014). Work Package 5 focuses on the allocation of costs and benefits, that were determined in Work Package 4.

10 Transmission system operators.

11 The Agency for the Cooperation of (EU) Energy Regulators, headquartered in Llubjana, Slovenia.

12 The North Seas Countries' Offshore Grid Initiative.

1. *Conventional*: The conventional method stands for CBCA practices prevailing to date. It assumes
   - An allocation for financing an interconnector on a 50/50 basis by the national TSOs of the two hosting countries (and a 1/3 : 1/3 :1/3 basis for three hosting countries, etc.)[13]
   - The same allocation rule for interconnector congestion rents among the national TSOs
   - Cost allocation within countries is based on national regulations regarding, notably, support schemes, responsibility for connecting offshore wind farms, internal congestion rents, market integration and network tariffs.

2. *Louderback*: Allocate to the entity concerned its directly attributable costs (direct costs) and its part in the total non-directly attributable costs (common costs) proportionally to one variable, i.e. its share in the difference between stand-alone cost minus direct costs. The allocation of the direct costs can be regarded as an application of the *Beneficiaries Pay* principle, whilst the *Louderback* allocation of the common costs can be regarded as an application of the *Postage Stamp* principle.

3. *Positive Net Benefit Differential (PNBD)*: Establish the Net Present Value of differential costs and benefits of the Integrated Infrastructure investment proposal compared to the Base Case. To ensure consistency with Work Package 4 of the NorthSeaGrid project, the Base Case defined in Work Package 4 has been retained, i.e. a situation including the stand-alone investments[14]. The net benefit differential of the Integrated Case results from discounting annual differential cash flows of benefits minus costs of the Integrated Case minus the corresponding Base Case cash flows for each distinct country. Contingent on the compensation rule to be agreed upon, allocation of the total investment and operating costs of the Integrated Case will be broadly in line with the respective net benefits (NPVs) of the affected countries. The crux is which pre-set compensation rules to apply.

   The first compensation variant applied by NorthSeaGrid follows ACER (2013) stipulates that **hosting and third countries** with a 'significant' positive net benefit (default 10% of the sum of positive net benefits) provide compensation to **hosting countries**[15] with a negative net benefit proportionate to their share in **the sum of positive net benefits above the threshold**. This variant should at best be 'minimum Pareto-optimal', i.e. ending up with some countries 'winning' and leaving the other (pre-compensation 'losing') countries at most with a zero net benefit position.

   To reduce lingering negotiations between Member States, the *second compensation variant* **negates the net benefit impacts on third countries altogether**, recognizing that this may imply free-riding issues when significant negative or positive net welfare effects upon third countries are induced by implementation of the Integrated Case. But under the given level of European integration it would appear to be hardly politically feasible to realize compensation transfers between integrated infrastructures hosting countries and third countries. **Moreover, the second compensation variant pays tribute to the political reality that in a joint project there should be 'something in it' for every hosting country.** This variant will

[13] Alternatively, a division based on the cost of the infrastructure on the territory of each of the hosting countries might be chosen by the national regulatory authorities concerned.

[14] The method as such does not change when another Base Case is chosen.

[15] The restriction of compensation-receiving countries to hosting countries only may not be fully in line with the spirit of Regulation (EU) No 347/2013 (EU, 2013): see e.g. Annex V, principle (10) of this Regulation. Presumably ACER has opted so for practical reasons, i.e. to reduce the complexity of negotiations that have to lead to a final investment decision.

assume that hosting countries with a net benefit 'return' below a pre-set positive value (default threshold: 10% of the sum of positive net benefits) will be compensated up to this threshold as a maximum. The compensation will be up to a lower level than the threshold value across-the-board for all compensation-eligible countries to the extent that the sum of surplus positive net benefits exceeding the threshold falls short of providing compensation up to the threshold. **Hosting countries** with a 'significant' positive net benefit contribute compensation proportionate to their share in the sum of positive net benefits above the threshold. Hence, under this variant the less well-off hosting countries in terms of induced welfare effect are compensated beyond minimum Pareto optimality in principle: contingent on available surplus positive net benefit, the compensation transfers to 'the losers' will more than offset the negative net benefit in a project situation without compensation. In practice, national regulatory agencies may request the Connecting Europe Facility to make up for any shortfall of the sum of surplus positive net benefits for all hosting countries.

In a second step, the net benefit impact for stakeholders within countries is determined, when applying the CBCA methods above. The information on intra-country distributive impacts of a certain CBCA method, agreed upon between hosting countries, may inform negotiating national regulatory agencies and the political debate in the countries concerned on the intra-country distributive impacts. In turn, these impacts might be one of the drivers prompting one or more of the country governments concerned to consider redistributive measures (e.g. through adjustment in network tariffs). Evidently, analysis of such measures goes beyond the scope of the NorthSeaGrid project.

4 Cost and benefit allocation: the German Bight case study

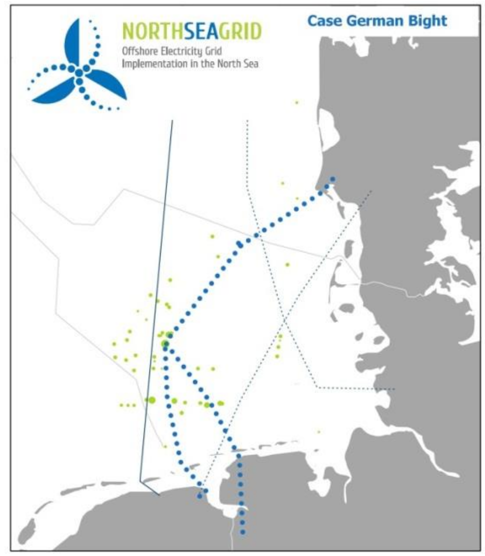
The NorthSeaGrid project analyses three case studies, i.e. German Bight, UK-Benelux and UK-Norway (DeDecker *et al.* 2013). This Policy Brief confines itself to explaining the resulting cost and benefit allocation from application of the cross-border cost allocation methods for the German Bight case study only.[16] These projected results have been calculated with a spreadsheet tool developed by ECN based on inputs on projected offshore grid costs from DNVGL and projected electricity market results generated by ICON's European electricity market model.

This case study involves hosting countries Germany, Denmark and the Netherlands. Given the shape of the German EEZ in the North Sea which boasts most potential for German offshore wind, the German Bight case illustrates the strategic importance of integrated infrastructures for notably, *but not only*, German offshore wind development. This case study envisages two wind farm hubs in the German EEZ: one near Sylt (and the borderline with the Danish EEZ) and the other near Austerngrund (and the borderline with the Dutch EEZ).

In the stand-alone case the two aforementioned hubs are each radially interconnected with the German onshore transmission network, whilst a stand-alone DK-NL interconnector for facilitation of DK-NL trade energy exchanges is foreseen. The integrated infrastructure case envisions one integrated structure as follows:

[16] For a more detailed explanation of allocation results for all three case studies, the reader is referred to the NorthSeaGrid Work Package 5 final report which can be downloaded from the NorthSeaGrid website: http://www.northseagrid.info/

- The hub near Sylt is interconnected with the Danish onshore transmission grid.
- The hub near Austerngrund is interconnected through one cable with the German onshore grid and with another cable with the Dutch onshore grid.
- The interconnector between these two German hubs completes the jigsaw to render the whole set of interconnector parts into one single DE-DK-NL integrated infrastructure project, facilitating the transmission of offshore-wind energy to - and exchanges of trade energy between - Germany, Denmark and the Netherlands.



Applying the CBCA methods explained in Section 3 above, outcomes in terms of net benefit (NPV) have been projected at country level and, for the three hosting countries, at intra-country stakeholder level.

4.1 Country level results

The results in terms of net benefit differentials, i.e. net benefit of the Integrated Case minus net benefit of the Base Case, expressed in million euros of year 2014 purchasing power, are shown in Table 1. The amounts in bold italics denote net benefit differentials (in M€2014), i.e. the net benefit value of the Integrated Case minus the net benefit value of the Base Case (which is the situation including the stand-alone solution). The global (differential) net benefit of the proposed Integrated Project considered in Case Study 1 is projected to show a high positive value, i.e. 1382 M€. Hence, when deciding in favour of the proposed integrated project instead of the stand-alone project solution, the stated amount in net socio-economic welfare (SEW) gain can be generated. On aggregate, non-hosting countries are hardly affected (-3M€, applying the Conventional CBCA method). When applying Conventional, Germany is the projected big winner (6746 M€), Denmark the big loser (-5333 M€) and the Netherlands experiencing on balance an almost neutral SEW effect (-28 M€). In the next sub-section the major undercurrents, leading to these projected results will be explained.

Table 1: German Bight: Summary table: breakdown of differential global net benefit among countries (million €2014)

	Country				
CBCA method (Net Benefit IC minus net benefit BC)	**DE**	**DK**	**NL**	**Third countries**	**Total**
Conventional	***6746***	***-5333***	***-28***	***-3***	***1382***
Louderback	***5981***	***-4950***	***355***	***-3***	***1382***
PNBDvar1	***1385***	***0***	***0***	***-3***	***1382***
PNBDvar1: required transfers among countries *)	-5361	5333	28	0	0
PNBDvar2: required transfers among countries *)	***675***	***355***	***355***	***-3***	***1382***
PNBDvar2: required transfers among countries *)	-6072	5688	383	0	0

*) A negative (positive) amount is an outgoing (incoming) transfer.
Source: ECN based on data from ICON model and DNV GL.

Applying the Louderback CBCA method, the rather unbalanced distribution of global (differential) net benefit across countries is slightly mitigated. Still the resulting (projected) aggregate net benefit outcome for Denmark (-5333 M€) would seem to be a non-starter for Danish official project negotiators. The PNBD CBCA method seeks to redress the projected disparate country-distributional SEW outcomes. We have applied two compensation rules leading to Pareto optimal results. Applying the rule recommended by ACER (2013) leads to neutral overall SEW impacts for Denmark and the Netherlands. As 'there should be something in it' for all hosting countries, we have applied a second compensation variant leading to significant SEW gains for all three hosting countries. Should the negotiators of all hosting countries have faith in the project selection and SEW projection methodology applied and its results, this variant might be a useful starting point for negotiating a final investment decision on the German Bight integrated project.

The German Bight case study confirms that notably, but not only, Germany has a lot to gain from the take-off of integrated, meshed offshore transmission grid; the more so the more importance offshore wind assumes in the overall German and European power supply portfolio. A graphical representation of the projected differential SEW impacts of the CBCA Conventional, Louderback, PNBDvar1 and PNBDvar2 methods is shown in Figure 1.

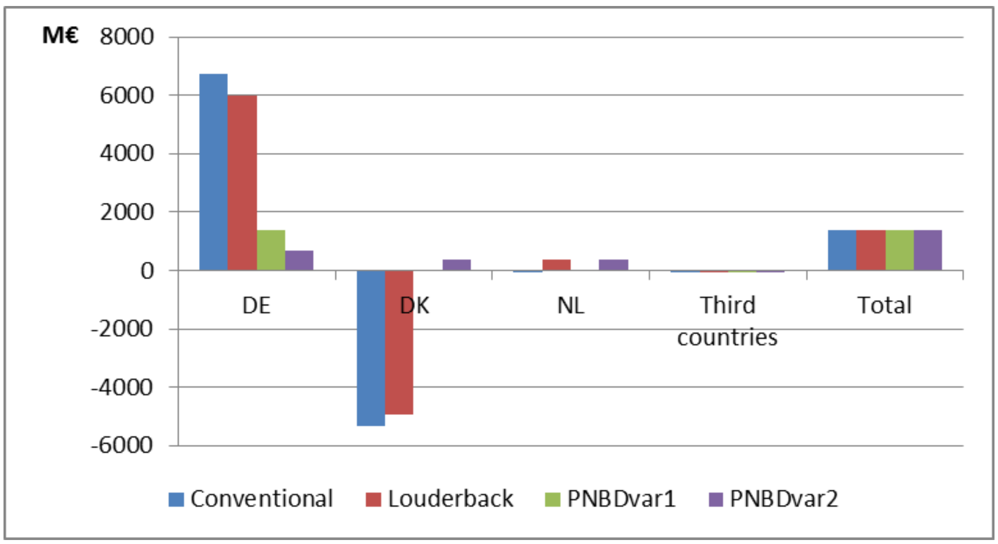


Figure 1: Case 1: German Bight - Alternative allocations over countries of net benefits

4.2 Intra-country distributive impacts

The intra-country distributive impacts in terms of net benefit (differentials) are visually summarized in Figure 2 below. These outcomes are explained successively for each of the hosting countries in the remainder of this Sub-section. As for impacts on third countries and associated stakeholders, brings out that these are rather small.

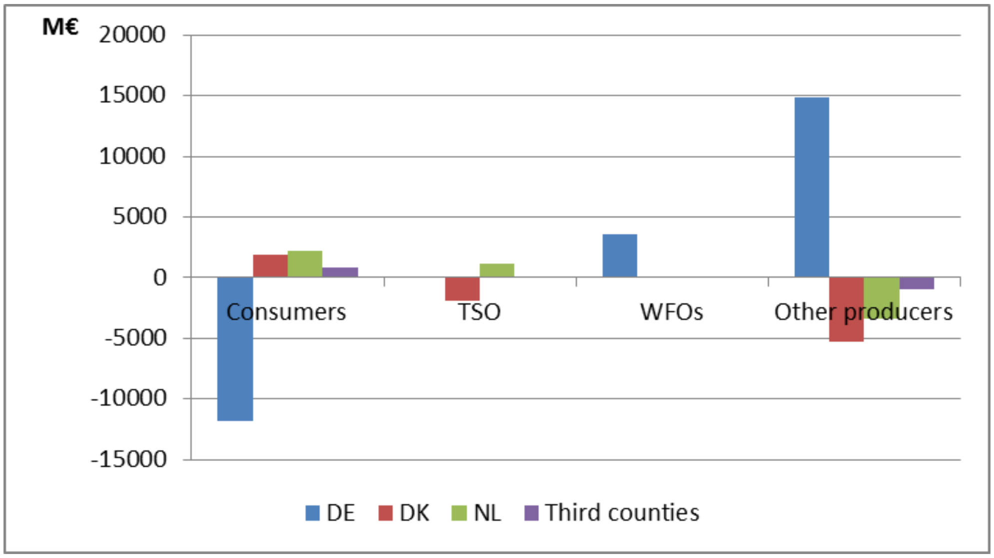


Figure 2: German Bight: impact of applying the Conventional Method for CBCA on within-country total differential net benefit for stakeholders

Let us consider - for Germany, Denmark and the Netherlands respectively - the underlying factors of the distributive impacts among distinct stakeholders, when applying the Conventional cross-border cost allocation method. Based on a detailed analysis presented in (Jansen et al., 2015) the following trends emerge.

4.2.1 Germany

The big winners in **Germany** of an integrated grid solution instead of a stand-alone solution are the **power generators**. Both (German) 'other producers' and offshore wind farm operators feeding into the proposed integrated project, generate a producer surplus. This relates to an upward price effect as German offshore-wind power is causing less congestion in Germany: in the Integrated Case part of this power is directly injected into the Danish and Dutch onshore transmission grids. The transmission redundancy created by the integrated solution relieves the intra-German transmission network and mitigates in Germany the so-called merit order effect from variable wind power with a consequential reduced downward pressure on average wholesale power prices in Germany. **Offshore wind power operators** receive a triple dividend from the integrated infrastructure solution: as their production can be injected into the grid more readily, they are facing less curtailment events. Hence, annual production volumes are positively affected. Therefore, offshore wind power operators gain from higher volumes, higher average prices, and higher production-related support benefits. **Other producers** also gain from a volume effect in terms of higher exports, resulting from less congested German transmission networks. The gain in total producer surplus is offset to a large extent – but not completely due to higher German power exports – by a loss in German consumer surplus. **German consumers** lose twice: they are facing on average higher power process than is the case of the stand-alone solution. Moreover, the higher offshore wind power production gives rise to higher RES support charges to be paid for by German power consumers. In contrast, a positive factor for German consumers is that under the Conventional CBCA method, the project costs of the proposed integrated project for Germany is lower than the stand-alone project solution. As a result, transmission cost of system charges to be borne by German power consumers are lower. On aggregate, **German TSOs** are hardly affected in terms of congestion rent receipts: against high gains in congestion rent receipts from the integrated offshore transmission infrastructure, TSOs are facing lower receipts of congestion rents from other German onshore interconnections. In order to allow for full TSO cost recovery, this difference would have to be compensated by levying higher network charges on network users.

In the case of Germany, being a significant winner when the integrated solution will be implemented, application of one of the PNBD variants implies that a higher share of the total project cost bill has to be paid by Germany, after allowance for compensation transfers. This will ultimately be passed on to the **German power consumers** through higher use of transmission system charges. Applying the PNBD method, German consumers face higher aggregate network charges. In contrast, applying Conventional and implementing the integrated solution instead of the stand-alone solution would give German consumers an aggregate advantage in terms of reduced network charges. Applying the Louderback method yields results for Germany only marginally different from Conventional.

4.2.2 Denmark

As already stated, **Denmark** as a whole is projected to lose a substantial amount of SEW (-5333 M€: see Table 1) from an integrated solution when the Conventional CBCA method is to be applied. **Danish generators** are the most important losing stakeholder category: increased volumes of German offshore wind power directly feeding into the Danish onshore transmission network in combination with an already quite high share of wind power in the Danish electricity supply portfolio makes for a sharply increased merit-order effect, pushing Danish wholesale power prices down on average. Moreover, they have to sustain a downward volume effect because of increased competition from German wind power. This induces that the loss in producer surplus cannot be fully offset by a gain in Danish consumer surplus. Nonetheless, **Danish consumers** are well off when the integrated solution is chosen. A minus point for them (and to a minor extent for Danish generators as well) is the higher use of transmission system charges as under the Conventional method Denmark has to pay a higher part of the bill for project cost. As according to ICON model results, the integrated project reduces congestion within the Danish transmission system compared to the Base Case, the Danish TSOs are projected to cash in less congestion rent income. Compared to the Conventional method, especially **Danish consumers** and to some extent **Danish generators** are better off when Denmark would receive compensations by either one of the two variants of the PNBD method. This goes to a minor extent as well when the Louderback method is applied.

4.2.3 The Netherlands

The overall SEW result for **the Netherlands** of a choice pro Integrated Project is almost break-even (-28 M€, see Table 1 first row). **Dutch generators** loose out from on average lower prices and lower production volumes as a result from more competition posed by German offshore-wind power. This is incompletely offset by a gain in Dutch consumer surplus, because **Dutch power consumers** are enjoying on average lower power prices. A less dominant countervailing effect for Dutch consumers is that they have to pay higher use of transmission system charges as the Netherlands has to spend more on offshore grid costs when the integrated project is chosen. German wind power will cause more congestion in the Dutch transmission system and interconnectors, should the integrated project be realized. This pushes up congestion rent income to be cashed in by **the Dutch TSO**.

Compared to the Conventional method, **Dutch consumers** are better off when the Netherlands would receive compensations by either one of the two variants of the PNBD method. Unlike their Danish counterparts, **Dutch generators** would not gain. This relates to the fact that in the Netherlands generators are fully exempted from use of transmission system charges. Again, this goes to a minor extent as well when the Louderback method is applied.

5 Conclusions on the way forward

For meeting *cost-effectively* 2030 EU climate and energy headline targets and even more so for 2050 EU carbon reduction targets, offshore wind has a substantive role to play. For making this happen, the best sites will soon be taken and gradually less shallower sites further away from shore sites have to be used. Hence, for implementing the EU climate and energy policy agenda in the most cost-effective way, the implementation of a properly planned, meshed offshore grid consisting of integrated infrastructures needs to take off early in the next decade.

One of the key pre-conditions to be fulfilled is the adoption of socio-economically sound and well-balanced cross-border cost and benefit allocation by at least littoral states (potentially) hosting meshed offshore grid structures. Our main recommendation is to apply a CBCA method that yields a non-negative or rather a significant positive net benefit for each hosting country of an integrated offshore infrastructure project as pivotal point of departure for negotiations between the national regulatory agencies concerned aimed to arrive at financial closure. In the NorthSeaGrid project the *Positive Net Benefit Differential* (PNBD) method has been applied to that effect. This method is consistent with the *Beneficiaries Pay* principle; it mitigates free riding.

Moreover, it is recommended to also assess the welfare impacts of the integrated project under consideration to stakeholders within each of the hosting countries. The NorthSeaGrid has pioneered such an assessment for each of the three NorthSeaGrid case studies, such as for German Bight case study as explained in this policy brief.

The Louderback method and, often even more so, the Conventional method give rise to less balanced to sometimes highly unbalanced outcomes. Therefore, in the absence of compensation these methods are considered less suited to provide guidance for sharing costs and benefits of integrated offshore infrastructure projects.

When applying the PNBD method, issues meriting due further attention include the choice of Base Case assumptions. For instance, should it be a situation including the relevant stand-alone projects or should the cost-benefit analysis be a 'stand alone' CBA[17]? Also the rule for compensation between countries should be investigated further; it is to strike a delicate balance between theory and political feasibility. Besides, the robustness of net benefit projections at country level should be tested under several plausible scenarios.

To conclude, the right regulatory framework conditions need to be in place; to start with at least in the (potential) hosting countries of integrated infrastructures. The relevant regulations should, i.a., level the playing field among (hosting) countries for investors in offshore wind farms. Not only support schemes in the hosting countries need to be aligned, also their congestion management and use of system charging approach to offshore wind farm operators. Their electricity markets need to be virtually fully integrated, also in the intra-day and balancing time frames, whilst their planning and oversight of offshore wind and grid infrastructure needs to be closely coordinated. Properly filling the legal voids for implementing integrated offshore infrastructures would appear to be a matter of high urgency.

[17] See ACER (2013), page 8. This refers to a cost-benefit analysis of a proposed project (e.g. an integrated offshore infrastructure project) , where the counterfactual base case is an entirely stand-alone situation, i.e. without other projects. See also footnote 3 of this Policy Brief.

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