Technical University of Denmark

Off Shore wind energy – Case study of cooperation mechanisms design

Cost-Efficient and sustainable deployment of renewable energy sources towards the 20% target by 2020, and beyond: D3.3

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PERFACE/ACKNOWLEDGEMENTS

This document reports activities and results of Task 3.3 of the Intelligent Energy Europe supported project RES4Less. This work is the initial analyses and survey of barriers for implementing cooperation mechanisms in the EU countries. This work builds on earlier Intelligent Energy Europe projects and is the result of literature surveys and discussions in the project group. Furthermore, fruitful inputs have been obtained in the stakeholder workshops carried out within the RES4Less project. Additionally, the topic has been presented and debated at two international conferences.

The preliminary results were also shared and enriched by comments from other members of the RES4Less Team during internal meetings of the project.

EXECUTIVE SUMMARY

According to the projections presented in (Dalla Longa et al., 2011), offshore wind energy constitutes a large potential in the medium cost range that can be exploited using cooperation mechanisms. A large fraction of this potential is found in the North Sea area, where wind conditions are good and the water is relatively shallow. Denmark is projected to have by 2020 a large excess potential for offshore wind capacity in the North Sea at shallow and near to the coast locations. The Netherlands on the other hand has low and expensive RES potentials for its 2020 RES target obligations. Therefore offshore wind potentials in Denmark constitute a possible cost reduction for the Netherlands in meeting its 2020 RES target.

This case study examines a large amount of 2 GW offshore wind capacity in the Danish North Sea area. Cooperation unfolds in a joint project type with state to state negotiation and settlement. Different timing and implementation options are described with the possibility to implement a series of 200 MW joint projects with negotiation for each separate phase. The case study is focusing on the area around Horns Rev, where wind conditions are good, the distance to shore is 20-30 km and water depth is around 25 m. With these conditions the cost level will be around 12 c€/kWh and that is at least a 3c€/kWh cost advantage to the expansion with offshore wind in the Netherlands.

Joint project cooperation is a simple form of cooperation that does not involve a restructuring of national support schemes and legislator changes that can take a long time to implement and affect a lot of entities in the host country. Projects are negotiated between the host and the user country, with the major task to settle a transfer price for the credits transferred in 2020. The design of cooperation assigns the entire project risk to the host country as the host is the party that enters into the contract with the investors in renewable energy capacity.

For offshore wind it is natural to proceed with the Danish national tendering procedure based on the Danish planning for future expansion of offshore wind, which is already there. When the tenders are held and a winning bid (price) for the actual wind farm is known, the two governments have to make a binding agreement on the transfer volume and transfer price for credits in 2020. The host country (Denmark) at the same time enters into a contract with the investor country about the support it will receive for the generation for a specified time period (in this case 15 years). In this way the host (Denmark) determines all the conditions and influence the risk vis a vis the investor (project developer) but has a certain knowledge about the contribution that Denmark will receive from the user country (the Netherlands).

This case study identifies the main barriers for the joint project cooperation and concludes that the main barriers to cooperation between Denmark and the Netherlands is the missing detailed knowledge on the penalty for non-compliance with the 2020 targets, and the lack of post 2020 targets in the EU policy. The missing knowledge on the penalty may on the overall terms prevent cooperation. Only the issue of the lack of post 2020 targets is expected to constitute a challenge to the actual design of the cooperation and will be handled in the negotiations of the RES transfer price.

In the actual negotiations over the transfer price in 2020 there are two very different options. One option is to transfer the generated RES credits from the additional capacity for the whole lifetime of this capacity. This will involve a large amount of support from the user country which will be a very high price if the credits are only measured in comparison to the 2020 obligations that the Netherlands have to meet.

Another option is only to acquire the RES credits generated in the year 2020, if the host country have a national (domestic) value for the post 2020 RES generation or expect that EU targets will be increased post 2020 and credit prices will have another level after 2020. This is a special situation that might be especially relevant for the cooperation between Denmark and the Netherlands as Denmark has national targets for RES beyond 2020 that are considerably higher than the EU target for 2020. In the case study sensitivity regarding this critical assumption about future credit prices (national value of RES) reveals that the single year price for credits heavily depends on this expectation. Apart from national targets it depends on the policy actions expected from the EU on setting future targets. Reducing the uncertainty can be established by having EU policy determining that the RES targets after 2020 will be at least slightly increased for all countries, and that the target level for 2020 is also binding for later years.

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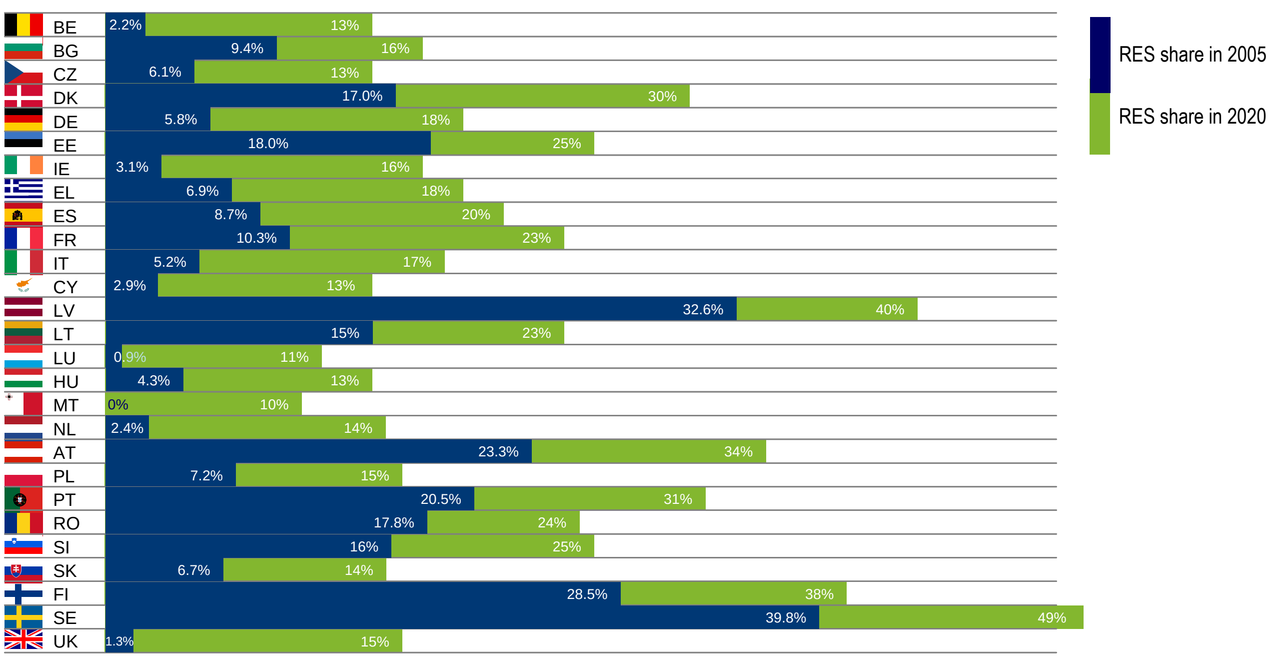
1 INTRODUCTION

The EU Directive on the promotion of the use of renewable energy sources (RES) was adopted in April 2009 (2009/28/EC) and sets binding targets for all EU Member States to reach the European target of a 20% RES share in EU gross final energy consumption by 2020. Such targets are based on a flat rate approach -same additional share for each country- adjusted to the member state´s GDP. This target allocation approach does not correlate with the Member States' RES potentials since the available resources, biomass, wind, hydro, tidal, wave and solar, vary significantly across the different Member States (Klessmann et al. 2009).

Figure 1-1 National Res targets according to the Directive 2009/28/EC



Source: EU 2009

Given such variability of renewable energy resource potentials and generation costs across Europe, articles 6-9 of the Directive introduce the possible use of "cooperation"1 mechanisms so that countries with limited or expensive RES potential can partially fulfil their RES target by purchasing or jointly develop RES energy produced in other countries, which has a higher RES potential or lower production costs. Consequently, their objective is twofold: On the one side they aim at providing Member States greater flexibility and, on the other side, they aim at achieving the overall 20% target in a cost-effective way.

There exists three different types of intra-European2 cooperation mechanisms:

[1] They are named "cooperation" mechanisms in order to differentiate them from the "flexibility" mechanisms in the Kyoto protocol.

[2] Despite from not being analyzed in this paper, there also exist the option to physically import RES electricity from third countries outside the EU (known as "joint projects between member status and third countries")

(i) Statistical transfers: Renewable energy that has been produced in one Member State is ex-post and virtually transferred to the RES statistics of another Member State, counting towards the national RES target of the latter.

(ii) Joint projects: RES electricity or heating/cooling projects that are developed under framework conditions, jointly set by two or more Member States (for example: one Member State provide financial support for a RES project in another Member State and count part of the project's energy production towards its own target).

(iii) Joint harmonization of support schemes: Member States combine part of their RES electricity or heating/cooling support schemes to achieve their national RES targets jointly. Under this mechanism, the produced RES energy can be allocated to the Member States via statistical transfer or a distribution rule agreed by the participating Member States.

In June 2010, in accordance with the RES directive, all Member States had to submit a National Renewable Energy Action Plan (NREAP) that contained (i) estimation of gross energy consumption by 2020, (ii) sectorial targets by 2020, (iii) support actions in place, as well as (iv) contribution of the energy efficiency and saving measures. According to a recent analysis of Member States´ National Renewable Energy Action Plans (NREAPs) conducted by Beurskens and Hekkenberg (2011) 13 countries, out of 27 Member States, reported information on an anticipated excess or deficit of renewable energy by 2020. Only two countries (Italy and Luxemburg) reported a deficit while eleven countries (Bulgaria, Denmark, Germany, Greece, Spain, Lithuania, Luxembourg, Hungary, Malta, Slovakia and Sweden) reported an excess of renewable energy. Overall, NREAPs reported an estimated European renewable energy production excess of about 0.7% over the 20% 2020 target.

The above mentioned summary indicates that there might be some scope for utilization of the cooperation mechanisms. However, so far, only few countries (Italy, Luxembourg, UK) have expressed their intention to use them. One possible explanation is that the practical implementation of the cooperation mechanisms is not straight forward and that further guidance of where the cooperation opportunities are and how to make use of them is needed. The Directive defines general accounting rules for using the mechanisms but does not give any specification of their design. It is up to the Member States to design and practically implement such mechanisms. Moreover, and as it will be discussed in a later section, there are various indirect costs (barriers) which may have detracted some potential users of the cooperation mechanisms.

In this context, the EU funded research project RES4LESS (www.res4less.eu) aims at demonstrating that, in comparison to isolated national energy strategies, the use of cooperation mechanisms can contribute to achieve the national and European renewable energy targets at a lower cost.

The purpose of this report (Deliverable 3.3 of the RES4 Less project) is to present a case study illustrating a potential cooperation between Denmark and the Netherland with respect to 2 GW offshore wind in the North Sea. This particular case study is chosen based mainly on the outcome of the work package 2: Valley of Opportunity and primarily on the Deliverable 2.3: VoO and surplus potential of wind energy in EU27+. Furthermore, Deliverable 3.1: Report on barriers for coordination and cooperation mechanisms to overcome these barriers (Pade and Jacobsen, 2012), also provide input to the present report.

In the present report we make a thorough introduction to the technical details behind the case study and briefly present the arguments for choosing this specific case study (Chapter 2). In Chapter 3 we consider the case study with respect to the two cooperation mechanisms Joint Project and Joint Support Scheme. We address the barriers introduced in Deliverable 3.1 (Pade and Jacobsen, 2012) and assess which of the barriers are relevant to the present case study (Chapter 4). Some of these barriers relate to the compensatory challenges arising when engaging in cooperation. Therefore Chapter 5 is dealing with the quantification of the relevant effects that is important for engaging in cooperation. Chapter 6 provides recommendations and conclusions.

2 THE CASE STUDY

In this chapter we focus on providing the argumentation for the chosen case study. We look into the overall potentials for wind energy and the surpluses and Valleys of Opportunity (VoO) identified in Jacobsen et.al. (2012) in order to clarify the reasons for this specific case study. Furthermore, we provide a thorough description of the technology and the assumptions behind the projects originating from cooperation and finally, we provide the expected output.

2.1 Background and scope

This case study analyse cooperation between Denmark as a host country and the Netherlands as a user country of RES credits. The host country is defined as the country where the development of RES physically takes place and the user country is defined as the country acquiring the credits for the developed RES. In the case study we analyse offshore wind installations of 2 GW of wind capacity in the North Sea area of Horns Rev. We assume that the development will take place stepwise such that tenders for each 1 GW will be at a three year interval. The size should be possible to accommodate in a range of depth between 20m and 25m and relatively close to shore implying installation costs between 11 and 12 c€/kWh.

This case study is based on offshore wind in the Danish sea basin for the following reasons:

- Suitable sites (shallow waters, close to shore) that could host surplus offshore wind developments have been identified in the Horns Rev area
- Grid-related barriers are limited, in particular due to a expected future connection between Denmark and the Netherlands.
- The relatively large offshore surpluses in Denmark are in line with the concrete plans for offshore development
- As Denmark has RES targets post 2020 the RES development has an actual value for Denmark which reduces the necessary financial contribution from the Netherlands
- The wind offshore development offers the opportunity to stepwise development for example 200MW at a time
- For the Netherlands, this might involve a considerable option for cost reduction relative to expanding its own RES resources or supporting entirely RES expansion in other countries

2.1.1 Denmark as Host country

The Valley of Opportunity (VoO) for offshore wind is one of the largest among the technologies in the total VoO reported in Jacobsen et.al. (2012), Tantareanu et.al. (2012) and Santamaria et.al. (2012). The VoOs are defined as the subset of surplus potential that is readily exploitable (Dalla Longa, 2011). Relative to onshore wind, offshore wind is more expensive, but the onshore potential is limited and is most likely reserved for meeting future national RES obligations. Furthermore, onshore wind is associated with implementation issues and public acceptance barriers, which are less pronounced for offshore wind.

Among the VoO for offshore wind, France was identified to have the largest surplus followed by Denmark with a little less. There is however a large uncertainty regarding the French eligible surplus and the respective costs, furthermore France has not specifically indicated interest to engage in the cooperation mechanisms (Jacobsen et.al., 2012).

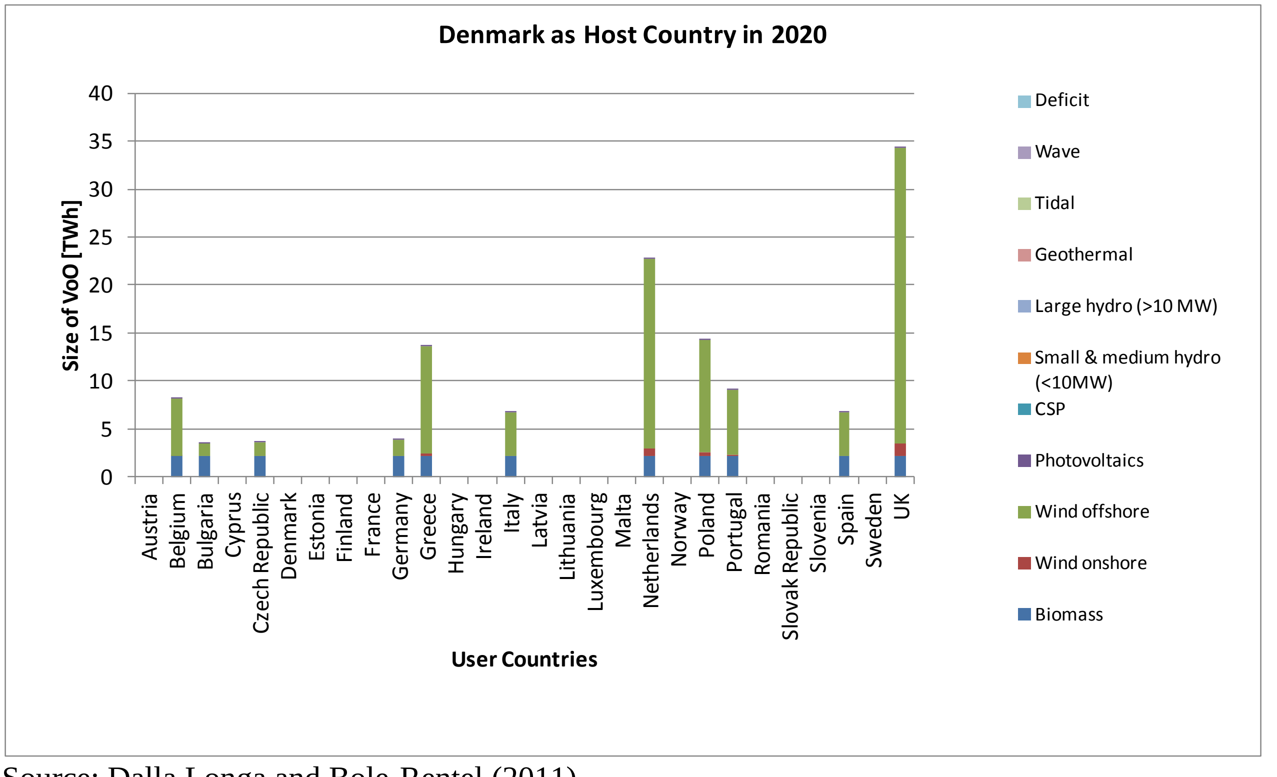
Table 2-1 Offshore wind eligible surpluses for 2015-2020 sorted by size (TWh)

Country	2015	2020
France	3.2	39.5
Denmark	14.9	30.9
Sweden	6.2	17.2
Germany	0	15.7
Ireland	4.6	8.1

Source: Reproduced from Jacobsen et.al. (2012)

For Denmark the offshore wind as a Valley of Opportunity is the most dominating technology for cooperation with all possible user countries. This is illustrated in Figure 2-1 showing the size of Valley opportunity of offshore wind energy for Denmark relative to the potential user countries. The Figure shows that the possible users of Danish surplus offshore wind are numerous, e.g. Belgium, Greece, the Netherlands, Poland and the UK, which makes it a consistent and competitive source for Denmark as a host in cooperation projects. The Netherlands and UK appears as obvious user countries for Danish offshore wind.

Figure 2-1 Wind offshore is the dominating option for Denmark as a host country



Source: Dalla Longa and Bole-Rentel (2011)

In the Danish NREAP only 1340MW offshore wind are identified as contributing to the total RES target of 30% in 2020 (Beurskens et. al. 2011). The main contribution towards Danish 2020 targets is seen from solid biomass based CHP. Therefore Denmark has a considerable surplus potential based on offshore wind as identified in this case study and also included in the site planning of future wind parks by Danish authorities (DEA, 2011). There are not yet any agreements or funding for the planned offshore wind extensions and the offshore wind expansion is assumed only to take place in areas where large scale wind parks will open.

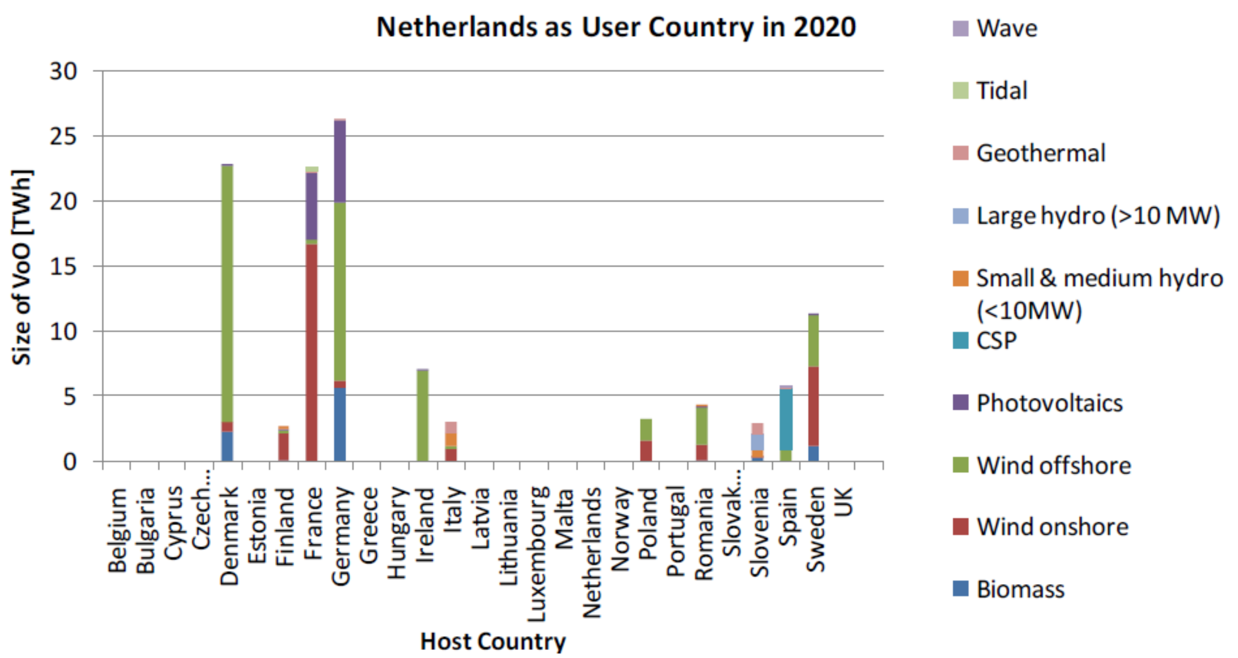
Compared to the geographical North Sea area the offshore target specified in the NREAP of 1340 MW is very little and no additional North Sea wind parks – relative to the existing – have to be built to meet this target. The other North Sea countries have considerable higher targets compared to their area with Germany 10GW and the Netherlands 5GW (L.W.M. Beurskens et. al., 2011). It is therefore more likely to find lower cost options in offshore locations in Denmark than in the two other countries

The conclusion is therefore that the Danish VoO for offshore wind is realistic, in the low to medium cost part of offshore wind costs in Europe. Furthermore the wind parks presently politically agreed on already exceed the 2020 targets. Network extension is partly in place and further extension underway to accommodate the specifically sited Danish plans for further wind expansion that amounts to more than 50% of the identified VoO. By 2020 the transmission system will be able to handle this amount of additional wind without congestion and probably the entire VoO without serious congestion problems. The case study capacity is well below a size that can be handled within the network extensions underway today.

2.1.2 The Netherlands as User country

For the Netherlands there are several options for purchasing RES credits in 2020, but as can be seen from Figure 2-2 three countries, Denmark, France and Germany, are dominating as cooperation counterparts.

Figure 2-2 Composition of options for Netherlands as a user in 2020

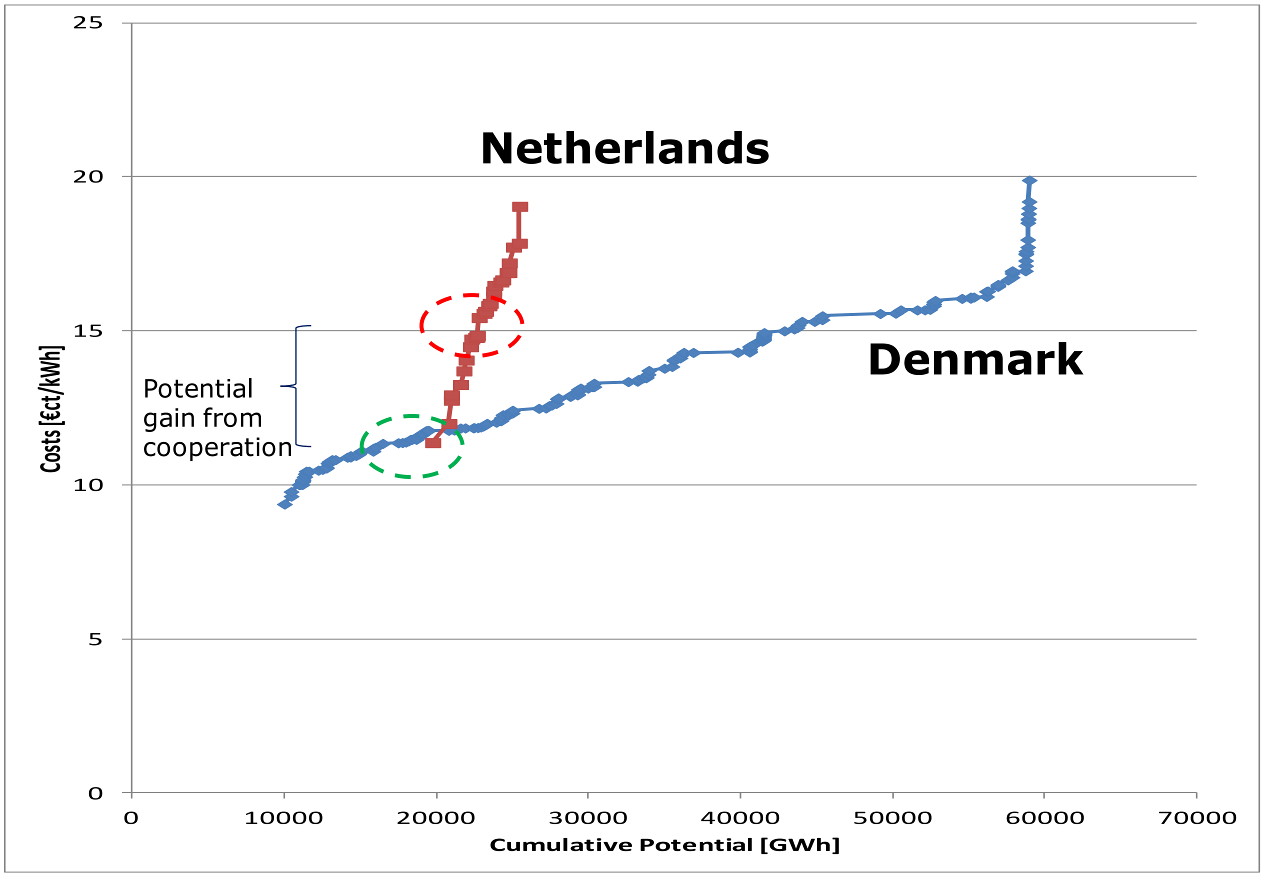


Source: Dalla Longa and Bole-Rentel (2011)

Jacobsen et.al. (2012) examined the potential for both Denmark and Germany as neighbouring host countries and the Netherlands as a user country. While Denmark has a realistic exploitable VoO for offshore the case for Germany is that there are considerable delays in the implementation of capacity in the national RES target. Furthermore, grid constraints and limited maritime space availability on shallow waters close to shore and consequently higher costs makes the role of Germany as a host country less realistic (Dalla Longa, 2012). For these reasons the joint support scheme case with local joint support for offshore wind in Danish and German North Sea areas seams less relevant.

There are large cost differences between offshore wind parks developed in Denmark and the Netherlands towards 2020 (Figure 2-3). The main cost drivers per generated unit are: wind speed condition, sea depth and distance to shore. One of the potential benefits of cooperation originates from the cost differences of offshore wind energy in the two cooperating countries. For Denmark and the Netherlands this difference roughly amounts to 3c€ per kWh in long term levelised generation costs.

Figure 2-3 Marginal cost and potentials for offshore wind, Denmark and the Netherlands, 2020



Source: Jacobsen et al (2012)

The actual benefits from cooperation may differentiate from this amount for several reasons:

- Indirect costs and benefits related to offshore wind development. The indirect costs and benefits relate to employment effects, environmental effects and public acceptance.
- Costs related to grid expansion and reinforcement
- Effects on the power market, such as electricity price level and volatility as well as investment incentives
- The fact that the target is only one separate year, namely 2020, also affects the value of the RES in both the host and user country.
- The lack of a well-defined non-compliance penalty makes the upper limit for the willingness to pay for RES credits unknown

In the following chapters we address these issues and illustrate the potential effects on the net benefit.

2.2 Technology choice and description

In this case study we analyse the development of 2 GW offshore capacity in the North Sea area of Horns Rev. It is assumed that the wind farms are installed in 200MW groups and the turbine size is 5-7 MW. Based on this, up to 10 wind farms would have to be built in the suggested area to accommodate a 2 GW expansion. We assume that the development will take place stepwise such that tenders for each 1 GW will be at a three year interval. Alternatively a smaller scale of 200 MW tendering at a time could be used, and the same design of the cooperation could apply. In this case however the negotiation process could exclude some of the indirect effects that will be very marginal if a 200 MW project is examined isolated. If a 200 MW project is a part of a in total 2 GW project, the indirect effects as for example through market prices will still apply. Further details are given in Chapter 5.

The planning in Denmark has focused on the least cost offshore areas taking into account all the alternative use and regulatory restrictions. Figure 2-4 shows the wind farm development plans regarding the Horns Rev (HR). The sites closest to shore, HR3, HR4 and HR5, represents a potential cost range that are not necessarily available for cooperation as they are situated on shallow waters and therefore below the marginal cost level of the Danish target for RES-E in 2020. Locations similar to HR6 and HR7 are on deeper waters, around 20m, and further ashore are limited. The potential sites for cooperation should mostly be found in areas of depth around 25m on average. In the figure the northerly located wind farms in the Ringkøbing area, RK3, is at depth of approximately 25m and approximately 20km from the shore. RK3 thus represents a typical location for potential cooperation.

A conservative guess based on planned sites and some extension in the North-South direction for nearby sites to marginally deeper locations is that these areas can accommodate up to 3000 MW (Jacobsen et.al, 2012) in this cost range given by water depths and distance from shore. 2000 MW can be accommodated with the following parameters:

- 20-25m depth
- 20-25km from shore

This corresponds to production costs of: 10.7 c€/kWh (Resolve model data, 20-50km, 20-30 m depth, 10-11 m/s) The most recent Danish bidding in spring 2010, the Anholt offshore wind farm East of Jutland, resulted in around 13.4 c€/kWh - 25% higher (DEA, 2011b). With present day turbine prices and the expectation of more competition on the offshore market the necessary revenue level is assumed to be in the middle of this range. Hence, for our calculations we assume a revenue to attract investment of 12 c€/kWh. This corresponds to an investment of around 3.75 M€ per MW capacity.

This cost is then compared to the power market prices (value) in Denmark and the Netherlands, which should ideally be for the entire lifetime of the parks. With the expected profile of the Netherlands as a user country their power prices will not decline due to installation of zero marginal costs generation. If Denmark continues expanding its zero marginal cost wind then there will be a price reducing impact on the Nordic power market even though there is also some interconnection capacity expansion. However, as the European power market integration continues, development in power prices will be moderate and affect Denmark as well as the rest of Europe and hence the Netherlands.

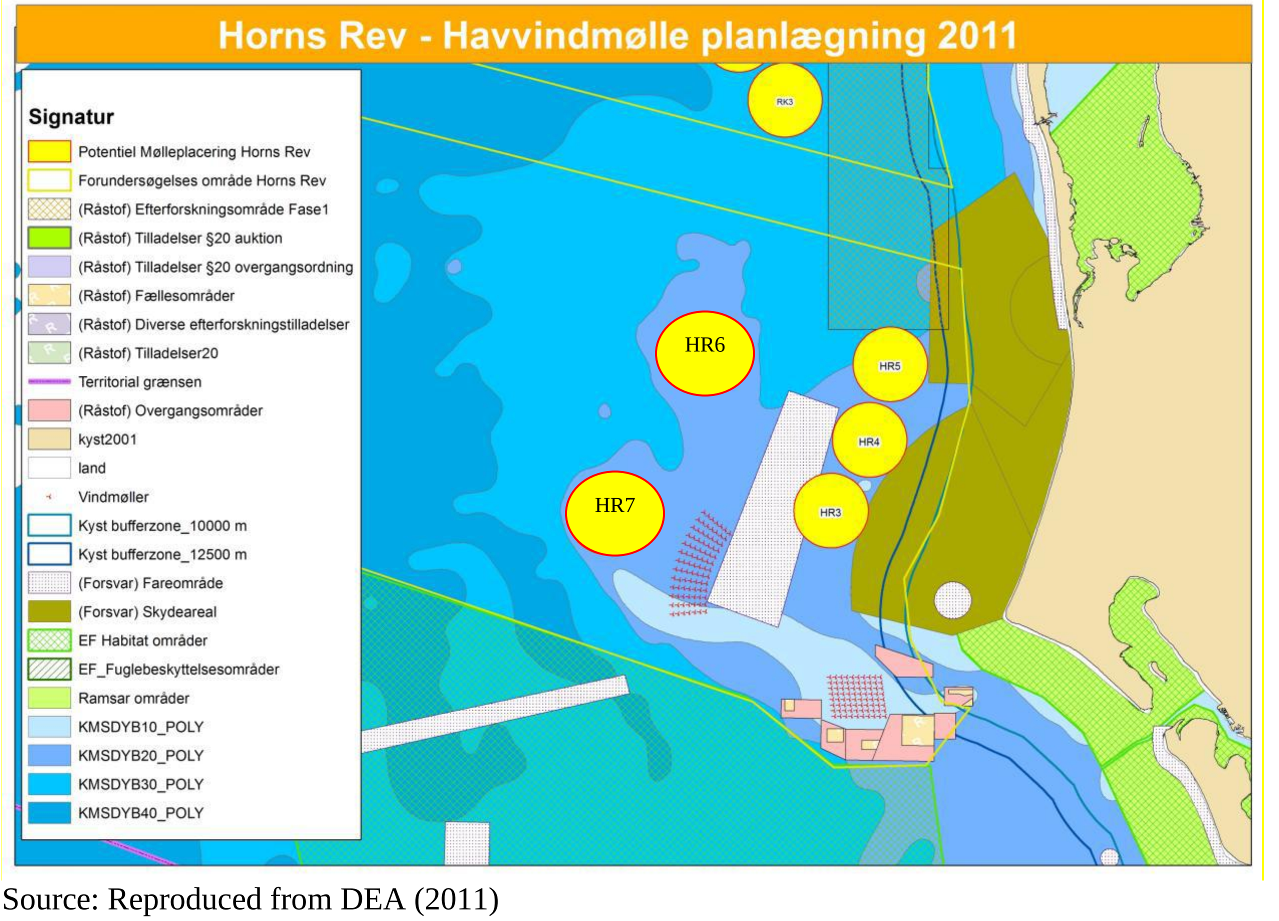
In our case we are operating with an expected future connection between Denmark and the Netherlands as an additional feature of the joint cooperation. Thus in this case we examine two different connection options:

- Connection to shore – (no connection between Denmark and the Netherlands is established)
- Connection to the expected interconnection between Denmark and the Netherlands

The first option without interconnection between Denmark and the Netherlands seems to be the most realistic at the time being. Negotiations are slow and the TenneT TSO involved on the Dutch side is very reluctant to invest in new capacity extensions as the regulation of its activities and revenue caps are seen as very tight especially in its North Germany operations.

With the second option it is assumed, that it is possible to physically transfer the majority of the generation from the additional offshore wind farms through a cable to the Netherlands.

Figure 2-4 Localisation of planned wind farms in the Horns Rev area

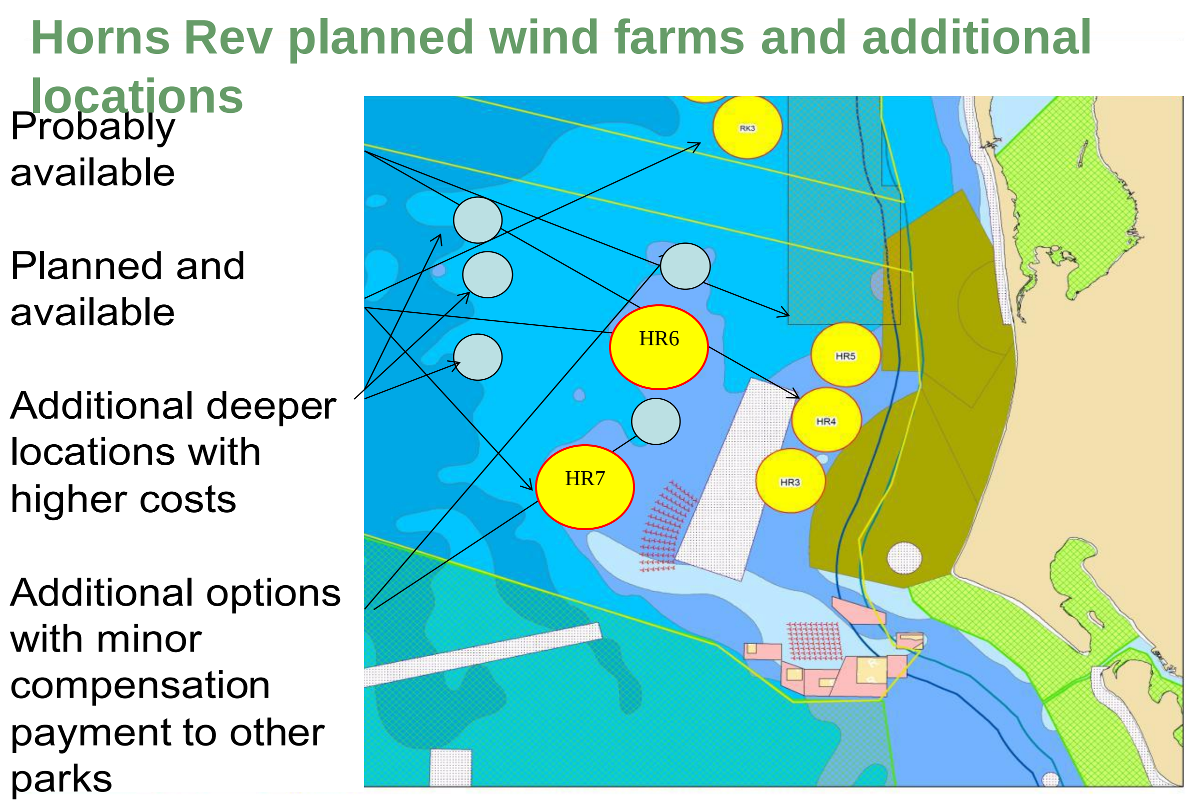


Source: Reproduced from DEA (2011)

Figure 2-5 illustrates that the five locations in Horns Rev area are included in the Danish planning. Maybe all and at least two further ashore sites are available for cooperation. 2 GW offshore wind can be accommodated in the area if locations to the north (Ringkøbing) are included and possibly a denser siting of parks is used. A denser siting will result in a minor reduction of output, which is why 4100 hours annually are used in the calculations (see Section 5.1.3).

In the case study the 10 wind parks will be assumed located at average conditions similar to HR6 and HR7 even though the three parks closer to shore might be included in the cooperation.

Figure 2-5 Additional wind farms located in the Horns Rev area up to 2000MW



Source: Original from DEA (2011) with own additions

The specific location of wind farms in the Horns Rev area as illustrated in Figure 2-5 may involve some conflict with each other and the already existing two wind farms with respect to wake effects and allocation of service corridors (service ships etc.). These possible effects will have to be identified and the issue of some marginal compensation to existing generators would have to be solved. Alternatively the specific sites can be chosen further ashore or further north.

2.3 Expected output

The benefits from cooperation are first of all connected to the cost differential between offshore wind development in Denmark and Netherlands illustrated in Figure 2-3. The actual benefit obtained is modified primarily by the different value of the generated electricity in the two markets. As the electricity in Denmark historically has been cheaper compared to the Netherlands, the benefit for the investor from developing RES in Denmark is lower. When the future connection between Denmark and the Netherlands is included and therefore some share of the generation can be supplied directly to the Netherlands the disadvantage to the investor of lower electricity prices (value) from electricity generation in Denmark may be reduced.

For the case study of 2000MW the support payments will amount to quite large sums, i.e. an accumulated support payment of €7011 million in Option I, where the Netherlands keeps the RES credits for the whole period, and a single payment in 2020 of €1271 million for Option II, where the RES belongs to Denmark post 2020.

3 ASSESMENT OF COOPERATION MECHANISMS FROM A SPECIFIC TECHNOLOGY POINT OF VIEW

In the RES Directive 2009/28/EC (European Commission 2009) setting binding RES targets for 2020 for the 27 EU countries also defines three cooperation mechanisms. The purpose of the cooperation mechanisms is to introduce the necessary flexibility to achieve Europe's renewable energy targets in the most cost efficient way. The three cooperation mechanisms are:

- Statistical transfer
- Joint project
- Joint support scheme

The statistical transfer is an ex-post transfer of virtual RES certificates that can be used for target compliance. **In joint projects** the member states lacking sufficient low-cost RES potential have the possibility to develop RES projects with other member states. And finally, **joint support scheme** is a broad cooperation on the support of renewable energy of member states. In the RES4Less project we only analyse the joint project and joint support scheme (Pade and Jacobsen, 2012). In a **joint project** the member states can either work together on a project to project basis, for larger isolated project, or agree on a special support framework for a number of projects. In a **joint support scheme** the member states either agree on a common support scheme that covers all technologies and areas or only covers specific technologies, or to specific areas. Generally the joint support scheme provides the best chance to exploit the RES potentials the most cost efficient way (Pade and Jacobsen, 2012).

In the following we regard the options of designing the cooperation mechanism as a Joint Project as well as a Joint Support Scheme and assess which of the two is the most suitable for the case study.

3.1 Joint project support arrangements

The described project has the potential of being rather large, up to 2 GW. The wind farms are installed in groups of 200 MW groups and therefore there is a potential up to 10 wind farms. The project is assumed to be developed as tenders for each 200 MW over 1-2 years with a construction time of 2 years. In this way, the project will attract competition but also to allow reasonable efficiency in continuous capacity use of installation equipment, manpower etc. The case is a joint project because it involves upfront commitment to additional RES investment and is basically a state to state cooperation.

To illustrate a possible timeline for the cooperation development we have divided the 2000 MW in two phases to allow a more smooth procedure and construction time. A possible timeline is illustrated in Figure 3-1 showing the stepwise implementation of the 200 MW wind farms. Dividing such a large project into two project owners would reduce the risk to both host and user country.

Figure 3-1 Timeline example for joint project cooperation option II

2012/13	2013	2013/14	2014	2014-16	2016	2017-19	2020	2020-32
Sites and conditions for tenders defined – negotiation on transfer price and volume	Negotiation phase concluded – tender material prepared	Tender for offshore wind parks of 1000MW	Contract with investor/-developer signed Signed DK-NL transfer agreement	Construction phase I	Construction finalised New tender for additional 1000MW New signed agreements	Construction phase II	Transfer of RES credits DK-NL settlement payments	Continued DK support payment to RES investor

The joint projects could be divided in more continuous tenders with similar conditions if that is found more beneficial for achieving competition in bidding. For example 200 MW in a continuous procedure each year is possible.

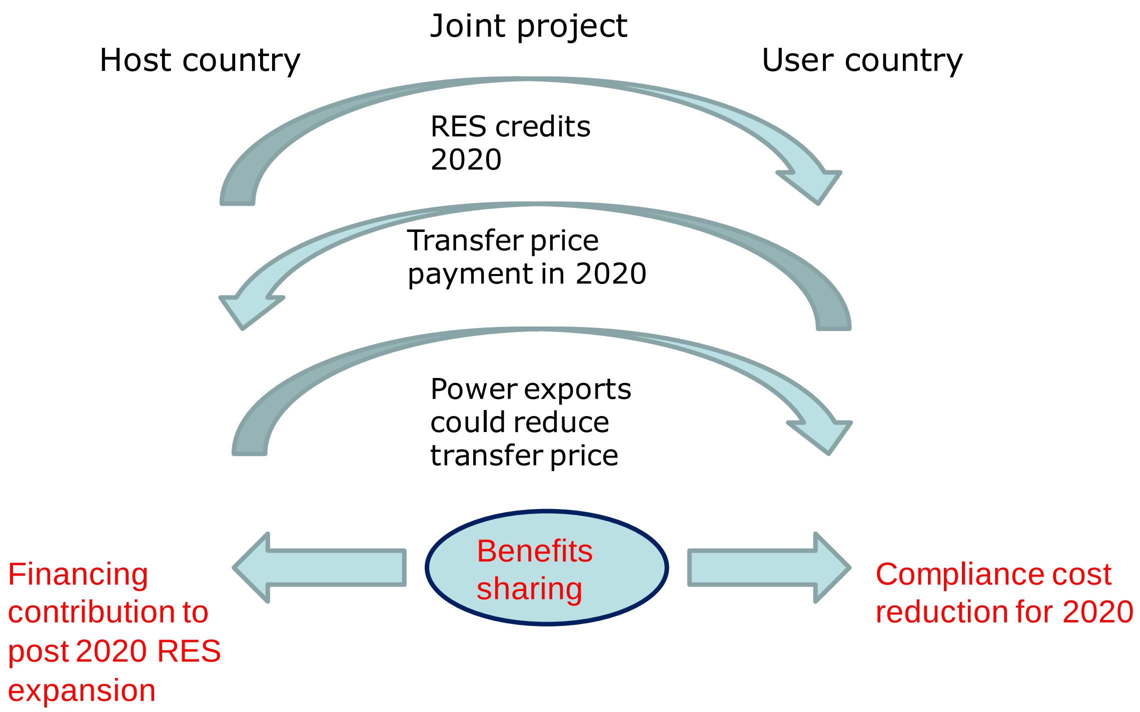
The investors will be the usual bidders for international offshore wind projects including individual utilities, developers and often grouped in consortiums. Investors will face the normal Danish conditions in tenders, the specific details will not be specified in this case study (for example, financial penalties for delays etc.).

The wind technology as a project-based cooperation has its advantages in the relatively low project implementation risk with a well-established technology and known cost efficiency. The project assumptions do not involve anticipated technological progress that depends on global development. For the direct generation there is well proved generation forecast (wind maps, measurements, etc.) from specific sites and reliability of existing turbine design. However, as the annual generation varies quite a bit ±10-15% from this fluctuating source the cooperation agreement has to assign the risk of this to one of the parties or define how to share the risk.

The Danish offshore wind farms have been supported in tendering procedures so far. Specific conditions and outcome in terms of support level have varied greatly. The tendency have been towards higher prices rather than lower prices (see Section 4.1) as the last tender resulted in guaranteed prices 25% higher than those in the previous two tenders. The connection costs have been borne by the TSO, which also applies for any necessary transmission extensions.

Figure 5-4 illustrates the main transfers in a joint project. It shows that the overall target is a transfer of RES credits in 2020 from the host country to the user country. In order for this to happen the countries have to agree on a transfer price payment from the user country to the host country. Dependent on the electricity prices in the two countries a physical transfer of electricity between the two countries may alter the necessary transfer price. Furthermore, indirect benefits and costs affect the necessary transfer price.

Figure 3-2 Transfer principles between host and user country



In this case study we assume that the total support costs are guaranteed by the host country, Denmark, which also conducts the tendering procedure. The user country, The Netherlands, buys the 2020 credits when the contract between the winning bidder and the host country is settled. Settling the price for the credits will thus only take place when the total support costs from the tendering process are known. The host country is assumed to carry the implementation risk and therefore the final payment cannot take place before 2020, after the actual generation from the project has been verified. The terms on which to share the administrative costs related to the tender procedure between host and user country is assumed to be agreed on.

3.1.1 Specific design options

Cooperation between the **Netherlands and Denmark** includes two options**:**

I. Acquire the full RES capacity credits necessary for 2020 compliance but not the power generation: Cost example, support cost for 15 years: **80 Euro/MWh annually corresponding to 1200 Euro/MWh for 2020 credits**
Capacity counts towards the Netherlands post 2020 targets (reduced risk)

II. Acquire only the credits necessary for 2020 compliance: Cost example, **350 Euro/MWh in 2020**
The Netherlands has the full risk on post 2020 compliance

Details on the calculation of the numbers given for the two options above can be found in Section 5.1.3. Comparing the costs of acquiring credits for the year 2020 reveals that option II (350€/MWh) is considerably cheaper for Netherlands than option I (1200€/MWh). But this cost advantage comes with a considerably higher risk on complying with possible future RES obligations set by the EU.

Based on the two different options covered by this case study the support arrangement for investors will be different:

Option I will cover the lifetime of the project, for example 15 years with annual payments from Netherlands to investors in Denmark of the agreed support amount. In return Netherlands get the RES credits generated in each year. The investors get additionally the market price in either Denmark or the Netherlands.

In Option II only the RES credits for 2020 are traded. There is therefore only a single payment to the Danish government, which guarantees the total support payment for the entire lifetime (support period) towards investors. The project implementation risk is assumed to be borne by the Danish part. The benefit of Denmark taking the full risk is that it simplifies the procedures and reduces the risk of conflicting incentives. Denmark will have to be strict on the investor contract compliance and domestic procedures (TSO, environmental planning) that may otherwise delay the implementation. In case the risk was shared between Denmark and the Netherlands, it would require a more direct involvement in tendering procedures and contract negotiation for the Netherlands.

The different options have very different risk profiles with regard to the post 2020 RES obligations. Option I provides the Netherlands with the ability to count this wind generation towards maintained or increased RES targets post 2020 for the lifetime of the wind farms. Option II leaves the Netherlands with the challenge to comply with possible future RES targets from the EU. The higher risk associated with Option II is balanced by cost that is less than 20% of the costs from acquiring the lifetime RES credits from the capacity (Option I) (see Section 5.1.3).

In order to take the option of physical transfer into account and avoid the interference of the host country in the electricity market of the user country we assume that support is organized as a premium added to the market price. This is not the case for the existing offshore wind parks in Denmark that are supported by a fixed feed-in price. For the market price the simple assumption is that the generation is sold at the market price in Netherlands or Denmark respectively, dependent on whether the wind farm is connected to shore or not. However, in practise it will be sold in the market where it is generated and the price here will be affected by the available capacity/congestion at the interconnections.

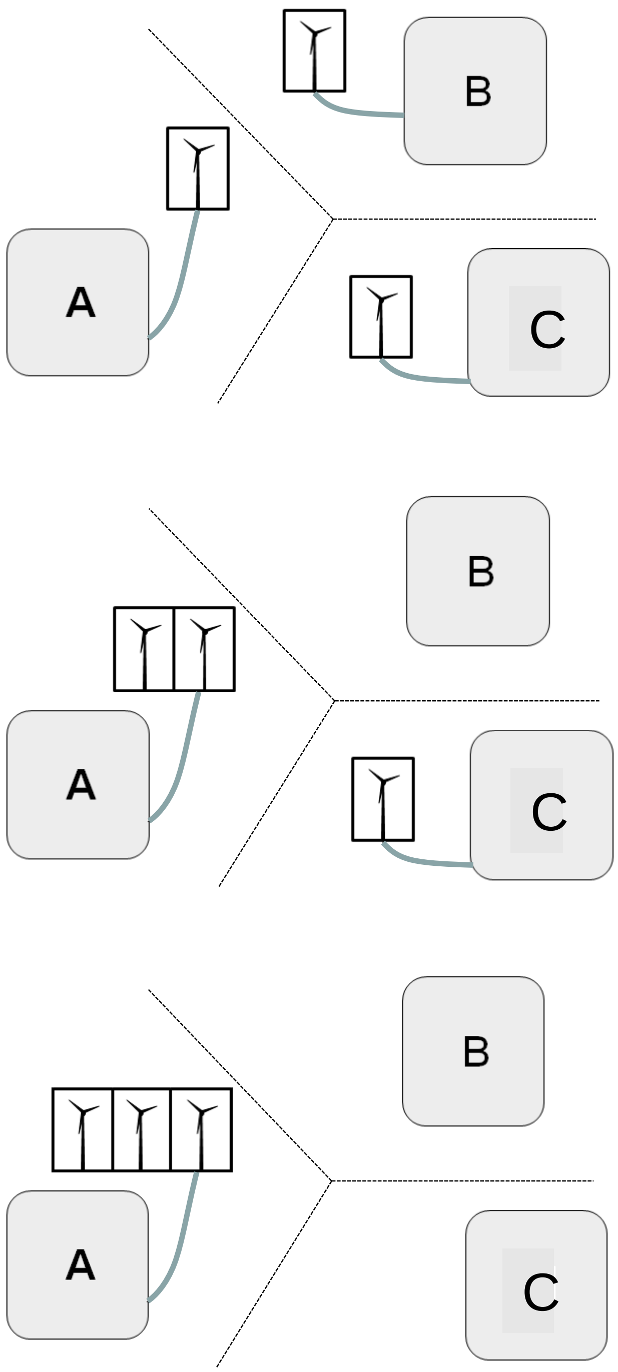
3.2 Joint support scheme cooperation

Alternatively a joint support scheme cooperation model can be used. When considering the option of going into cooperation based on a joint support scheme there are two extreme situations:

- The general solution with just one support scheme for the participating countries covering all regions of the participating countries and all technologies or
- The situation where two or more countries agree on a joint support scheme for a specific region, for a specific technology or the combination of the two, i.e. a specific technology in a specific region.

In the latter situation the region can both be defined within the borders of one country as well as being cross border.

For the present case study the latter situation would be most relevant, e.g. offshore wind in the North Sea covering Denmark, the Netherlands and possibly Germany. When several countries cooperate in a joint support scheme covering a cross border region, RES development may take place in only one country or in several countries. This is illustrated in Figure 3-3 where there are two different solutions to a joint support scheme between three countries.



Solution 1: National solution.

Solution 2: JSS with wind development in two countries.

Solution 3: JSS with wind development in one country.

Figure 3-3 National solution (top), JSS with wind development in two countries (middle) and JSS with wind development in one country (bottom)

One important issue with respect to a joint support scheme is that the country with the cheapest RES potentials on average will experience higher costs associated with reaching their RES target, as they would otherwise have been able to use the cheapest RES potentials first for their own target. As the cooperation is defined for a specific area a way to get around this for the country with the cheapest potentials is to omit the most favourable locations from the cooperation and keep them for their own target compliance.

For a joint support scheme under such a setup there are a number of opportunities regarding the choice of support scheme: feed-in tariff and premium, tenders and tradable green certificates (TGC). In the following tenders and TGC are considered.

3.2.1 Tendering

The tenders for offshore wind could be designed such that they were covering the North Sea area with joint tenders for several pre-defined locations in the North Sea covering Denmark, Germany and the Netherlands. A tender design would be agreed upon and investors from all the countries would be able to bid. The support costs as well as the RES credits should be shared among the participating countries based on predefined rules.

3.2.2 Tradable green Certificates

The concept of several countries cooperating on a TGC scheme was addressed in Grenaa Jensen and Morthorst (2007) putting forward that expectedly a common TGC market functions best if the power market is already integrated. As we consider a case for offshore wind energy this condition is not naturally fulfilled as countries with neighbouring offshore areas do not necessarily share onshore borders as well, normally being the prerequisite for integrated power markets.

In order to assure that the TGC system contributes sufficiently to the RES target, the amount of quotas in the common TGC system should correspond to the total needed RES development within the technology for the three countries.

3.3 Choice of cooperation mechanism

The present case study deals with an offshore wind farm defined to be located in Denmark with the purpose of fulfilling the Dutch RES targets in 2020. As these prerequisite basically by definition fulfill the terms of a joint project the most obvious design to use is a joint project.

4 IDENTIFICATION OF BARRIERS

In order to determine which barriers are relevant for the offshore case study considering Denmark and Netherlands the relevant factors for each of the identified barriers is analysed for each country. With the point of departure in the barriers identified in Pade and Jacobsen (2012) we analyse which barriers are relevant for this specific case study. Furthermore, we address the critical success factors to overcome these barriers as well as assess which will be the largest obstacles to overcome.

4.1 RES support systems

As described in Pade and Jacobsen (2012) the differences in RES support schemes in the cooperating countries may lead to barriers to cooperation. The application of different support schemes can create barriers due to the administration of additional support mechanisms and may mirror different industrial strategies for the countries. Furthermore, different kinds of support schemes tend to have similar or different characteristics. For example, feed-in tariffs and feed-in premiums have rather similar characteristics and are often used in combination with tender schemes. All support mechanisms tend to be targeted towards a specific technology with the purpose of promoting this specific technology or to promote the technology in one specific area. Green certificates are designed to encourage competition between the RES technologies and all technologies are provided with the same support. In that sense green certificates and tenders by nature have different characteristics (see Pade and Jacobsen (2012) for more details and discussions).

Both The Netherlands and Denmark have historically applied several different support schemes ranging from tax incentives, production incentives, investment subsidies, feed-in premiums and tariffs and tendering (RESolve-E, *DK source*). Currently, the dominant support schemes in the Netherlands are feed-in premiums (biomass, hydro, solar PV and onshore wind), tendering (offshore wind) and netmetering for PV (Lensink et al. 2011, Netherlands Ministry of Economic Affairs 2007, Netherlands Ministry of Economic Affairs 2009).
In Denmark the dominant support schemes are feed-in tariffs (onshore wind), net-metering, tax incentives (small scale RES in general) and tendering (offshore wind). In that regard, it does not seem to be a problem for Denmark (the host country) to administer the support scheme for this specific cooperation between Denmark and the Netherlands where tenders are in mind. Furthermore, as tendering already is the dominant support scheme for offshore wind in both the Netherlands and Denmark it is not such that the tenders for the joint project collide with the existing support schemes for offshore wind in Denmark.

Another barrier to cooperation described in Pade and Jacobsen (2012) is the obstacles that may arise in the case where support is granted on the basis of being indirect support for a specific industry. If this is the case for the user country, the country may be reluctant to engage in cooperation as the payment for the RES credits possibly will support a RES industry in the host country and not in the user country. However, as this case study is dealing with a tender, that is open to international competition, Dutch companies have the same opportunity to win the tender as companies from any other country and hence the support might as well go to Dutch industries.

Finally, a barrier may arise as a consequence of different levels of support. In the case of the three latest offshore wind farms established in Danish territory was supported from 8.5 c€/kWh to 13.4 c€/kWh (Table 4-1). In the Netherlands the range was 9.7c€/kWh to 18 c€/kWh. Even though the levels are different; we are dealing with a tender and in such case the support levels are bound to be different from project to project and thus it does not constitute a barrier.

Table 4-1 Latest offshore wind projects, Denmark and the Netherlands, support levels, c€/kWh

Denmark		Netherland	
Anholt	13.4[b] c€/kWh	OWEZ en Amalia	9.7 c€/kWh[a]
Horns rev II	6.97 c€/kWh[a]	The Bard-parks	17-18 c€/kWh[a]
Rødsand II	8.5 c€/kWh[a]		

Sources: DEA (2011b)
Note: For the Bard-parks the exact amount is not yet public
[a]: Feed-in tariff
[b]: Feed-in premium

4.2 Power markets

The effects on the power market as a result of cooperation constitute possible barriers due to four possible effects (Pade and Jacobsen, 2012):

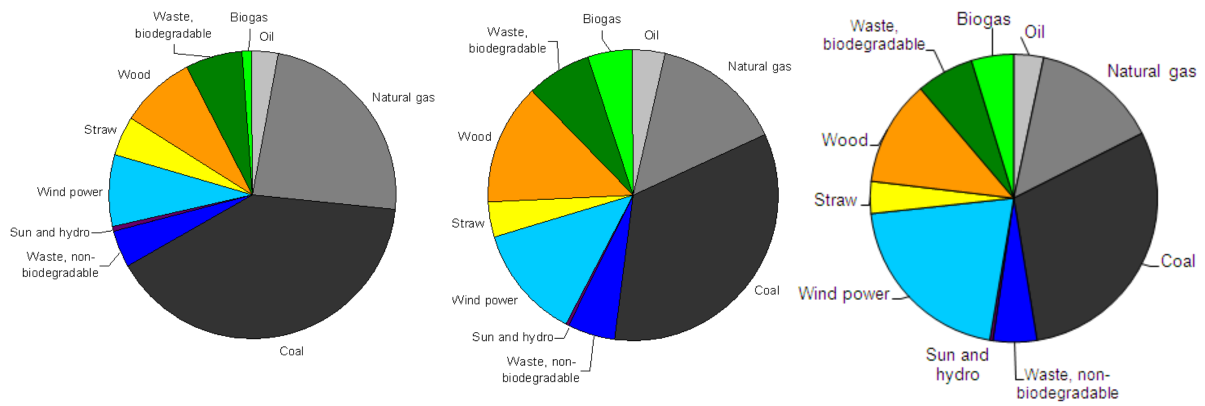
- Changes in price volatility, which enhances the profitability of some plants and decreases it for others
- Expected power price decrease, reducing the profitability of existing capacity
- Expected power price decrease, reducing the incentive to invest in new capacity
- Risk of less diversified energy mix and consequently less security of supply for power

The effect of cooperation depends on the design of the electricity market in the host country, in this case Denmark. In the following we assess the extent to which these effects actually constitute barriers in the specific case.

4.2.1 Denmark

Below the generation mix of the Danish electricity and heat production is illustrated (Figure 4-1). In 2010 the wind energy accounted for 8% of the whole energy system and 20% of the electricity production (DEA 2011c) corresponding to almost 8 TWh. The Danish Energy Authority predicts that wind energy in 2020 account for 12.5% of the total energy production in 2020, which corresponds to 12 TWh. If we include the 2 GW installed capacity corresponding to 8.2 TWh the share of wind increases to 20% of the entire energy system in Denmark, corresponding to 20 TWh.

Figure 4-1 Generation mix in the Danish energy system, 2010 (left), 2020 BAU (middle) and 2020 with cooperation (right)



Source: DEA (2011)
Note: *2020 with cooperation* (right) is modified with respect to the increased share of wind

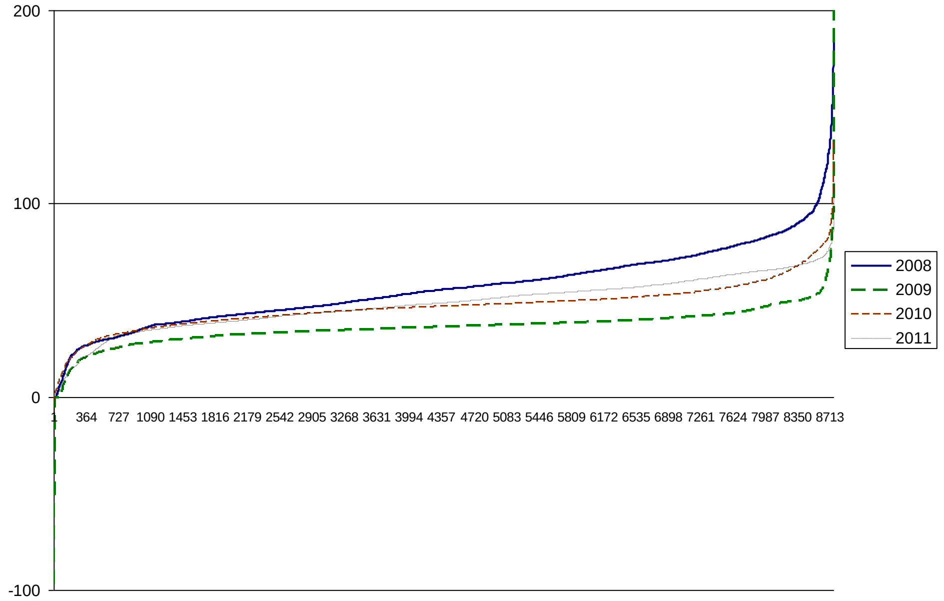
The newest political energy agreement (Danish Ministry of Climate, Energy and Building 2012) includes additionally 1.5 GW offshore wind and 500 MW onshore wind towards 2020. Furthermore, the energy agreement specifies an increased use of biomass in cogeneration.
We assume that the RES development resulting from cooperation will not replace otherwise planned capacity in combination with the initiatives within biomass in the energy agreement. To a large extent the decrease in the consumption of coal is replaced by biomass having the same characteristics when it comes to balancing and reserve capacity. Furthermore, we assume that a substantial share of the extra wind energy will be exported. Therefore, we do not expect the increased share of wind energy in the energy system will cause balancing issues.

As the increased share of wind energy in the energy system resulting from cooperation between Denmark and the Netherlands is not expected to cause balancing and reserve issues this is not expected to constitute a barrier to cooperation.

In the long run, a larger share of renewable energy, such as wind, solar, tidal and wave, in the energy system is expected to cause a downward pressure on the whole sale electricity price. As of today the electricity price is determined by the marginal plant supplying energy at any given time. Denmark is linked to Norway and Sweden with large capacities of hydro power, which has a large opportunity of storing and hence smoothen the electricity price. As 2 GW is not a dominant share in the Nordic market, the expectation is that the long run effect on the electricity price of an additional 2 GW wind energy in the Nordic energy system will only be limited. As the effect of an additional 2 GW wind energy in the energy system on the electricity price in the Nordic system is expected to be limited this is not expected to constitute a barrier to cooperation.

In the past four years the electricity price has fluctuated a great deal independent of the share of wind energy. Below (Figure 4-2) the price duration curve for 2008, 2009, 2010 and 2011 is illustrated. The Figure shows that the prices in general were higher in 2008, with an average price of 56.4 €/MWh, compared to the other years and especially 2009, with an average price of 36 €/MWh. In 2010 and 2011 the average prices were 46.49 €/MWh and 47.96 €/MWh. The share of wind energy in 2008, 2009 and 2010 varied from 18.5 % in 2009 to 20.1 % in 2010. The Figure also shows that 2009 was the year with both the lowest and highest prices of -120 €/MWh and 200 €/MWh. In 2008 there were no incidences of negative prices. On this basis we cannot conclude if additional 2 GW wind offshore capacity will affect the electricity prices. Further analyses are carried out in Section 5.1.1.

Figure 4-2 Price duration curve, Denmark West, €/MWh



Source: Energinet.dk

Increased share of offshore wind in the energy system may also affect the volatility of the electricity price. If there are very volatile prices base load and intermediate load plants will have higher revenue and therefore higher profitability. We expect the prices to become less volatile in the short run as the short run difference between peak and off peak prices decrease when the existing capacity is maintained and not replaced by new, renewable fluctuating resources.
In the longer run we expect the electricity price to become more volatile, due to existing "medium load" plants may become less profitable in time and thus they may shut down. In this case only the peak load plants and the renewable fluctuating resources are available resulting in higher peak prices and more often price peaks.

In the relevant time period the volatility of the electricity price is not expected to be affected, either the time period within the cooperation mechanisms – i.e. up to 2020, or the entire lifetime of the project. Hence it does not constitute a barrier to cooperation between Denmark and the Netherlands.

4.2.2 The Netherlands

In contrast to the Danish energy system, the Dutch electricity production is largely dominated by natural gas while coal is also playing a significant role (Figure 4-3). The share of renewable energy in the electricity consumption has increased from 3.2 % in 2000 to 9.5 % in 2010, mainly due to an increase in biomass, renewable wastes and wind energy.

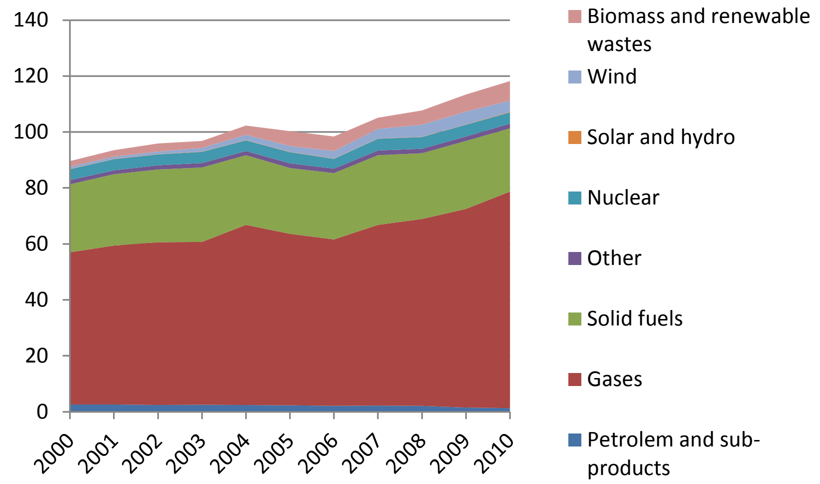


Figure 4-3 Electricity generation mix, TWh, 2000-2010

Source: Eurostat (2012)

The expectation is that the dominance of gas continues in the future (Figure 4-4). In generation, coal still plays a significant role in 2020. The share of renewable energy sources are expected to increase to 12 % of the electricity generation in 2020.

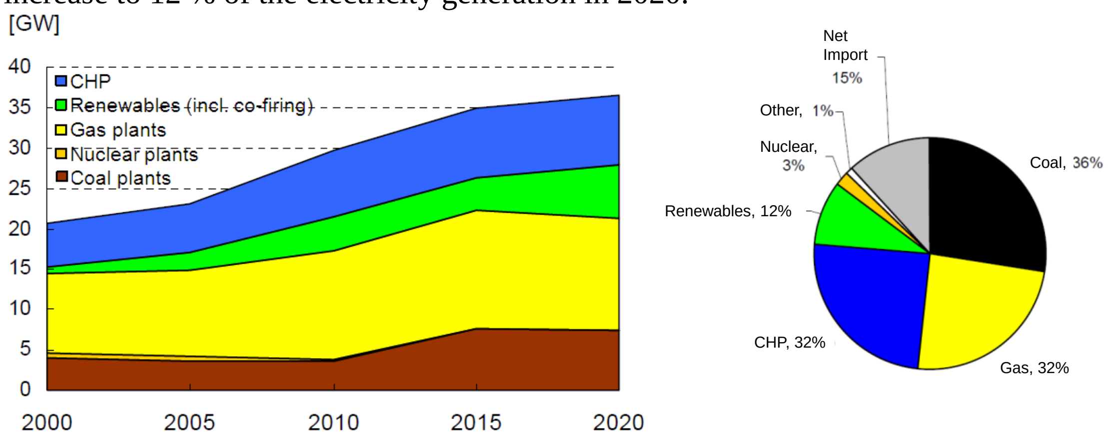


Figure 4-4 Capacity (left) (GW) 2000-2030 and generation mix (right) in 2020

Source: Seebregts et al (2009)

Examining the composition of renewable energy in the Netherlands (Figure 4-5) it shows that up until 2010 onshore wind, waste and other biomass play a dominant role whereas the future scenario points in the direction of more onshore wind and a large expansion of the offshore wind capacity.

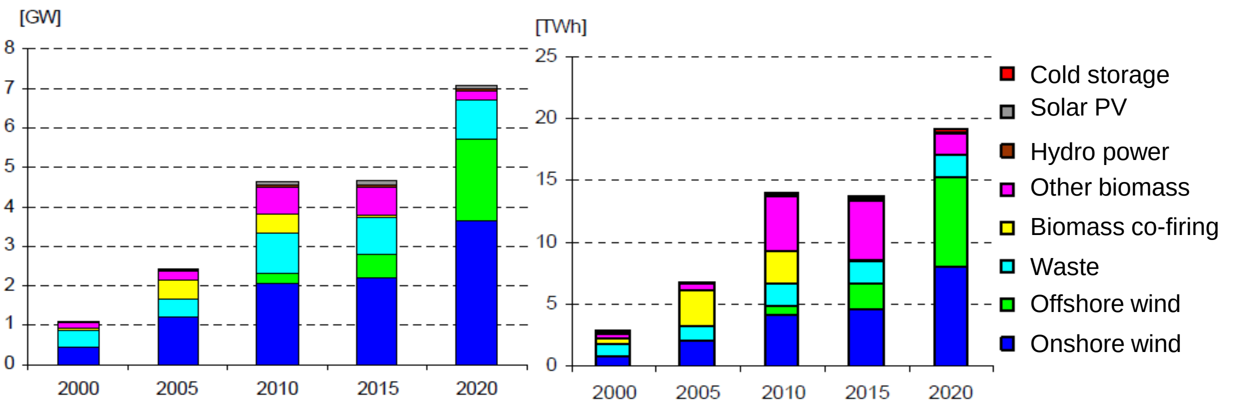


Figure 4-5 Capacities (GW) and generation mix (TWh), 2000-2020

Source: Seebregts et al (2009)

Relating these projections to the targets listed in the NREAPS for the Netherlands these are quite modest. The target for RES production in electricity generation in the NREAPS is 50 TWh in 2020 (Beurskens et al, 2011), which is more than twice as much as reported above. The total electricity production is assumed to increase to approximately 180 TWh in 2020 (Seebregts et al, 2009), which gives a total share of RES out of the electricity consumption on 28 %. Assuming that the Netherlands chose to cooperate with Denmark regarding the 2 GW wind, the total share of RES of the electricity consumption would decrease (as a share of their RES target is now produced in Denmark) and now amount to 23.5 %. As the 2 GW wind energy would constitute a rather modest share of the entire electricity system in the Netherlands we assume that the effect on the power price will be modest as well. Hence, the possible barriers related to the effects on the energy mix, investment incentives and profitability of existing producers are assumed to be negligible.

In 2008, 2009 and 2010 the electricity generation from renewable energy was approximately identical, 8.8 % in 2008 and 9.5 % in both 2009 and 2010. The share of renewable energy as such does not give rise to differences in the electricity price in these three years. The price duration curve in the Dutch electricity market is illustrated in Figure 4-6 and shows that the prices in general were higher in 2008 and the lowest in 2009.

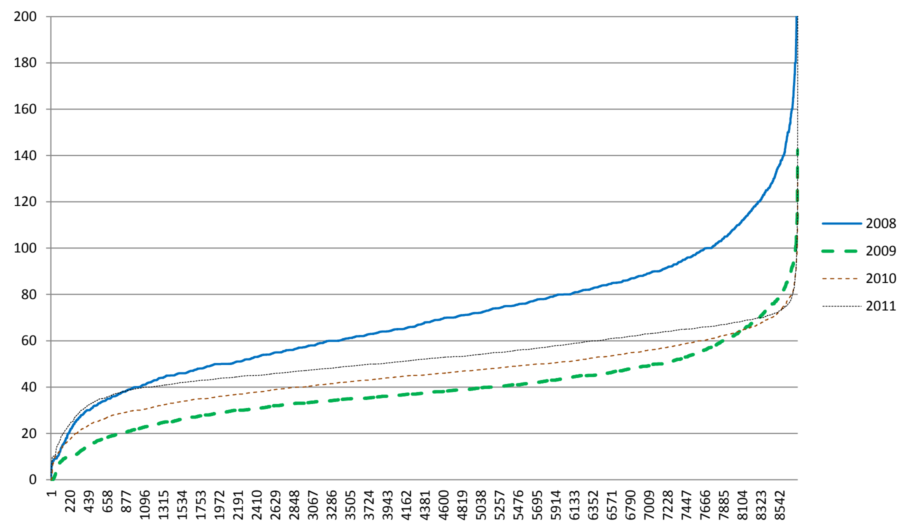


Figure 4-6 Price duration curve, Netherlands, 2008, 2008, 2010 and 2011, €/MWh

Source: APX-ENDEX
Note: In 2008 prices above 200 €/MWh were recorded for 16 hours. The maximum price in 2008 was 500 €/MWh

Comparing the average power prices of the Dutch market with the power prices in the Danish market in these four years you will observe that the price levels are not significantly different (Table 4-2).

Table 4-2 Average power market prices in Denmark and the Netherlands, 2008-2011, €/MWh

	2008	2009	2010	2011
Denmark	56.4	36	46.5	48
Netherlands	70	39.4	45.4	52

Source: Energinet.dk, APX-ENDEX

As the price difference between Denmark and the Netherlands on average is rather limited we do not assume the marginally lower prices in Denmark to constitute a barrier to cooperation.

4.3 Network regulation

As described in Pade and Jacobsen (2012) network regulation may cause barriers due to two characteristics:

- Incentives for networks to facilitate efficient connection of new technologies are determined by the national network regulation
- National network regulation determines who holds the costs connected to necessary network reinforcement
- Curtailment of RES-E and the risk of non-compliance

In these two respects the network regulation in Denmark and the Netherlands are fairly similar. The regulation for the two countries is briefly described below.

4.3.1 Denmark

The laws on network regulation in Denmark assures that new RES technologies always are connected to the grid, as the grid operator, whether it is the DSO or the TSO, is obliged to connect the technologies to the grid (RES-INTEGRATION, 2011b). Concerning on shore technologies the regulatory regime in Denmark is referred to as shallow as the RES developer bears the costs of connecting to the next suitable grid point whereas the DSO/TSO is obliged to reinforce the grid if necessary when connecting RES-E plants.

So for RES technologies onshore, such as wind and solar, the RES developer pays for the connection to the grid (shallow costs). Regarding offshore wind though the farms are connected directly to the transmission grid and the TSO pays for the connection. The regulation allows networks to include reinforcement investments caused by renewable generation in their capital base and thereby revenue cap. Furthermore, the TSO has the obligation to reinforce the grid when necessary (Heinemann et al, 2012a).

The rules for curtailment in Denmark assures that the non-renewables are curtailed first followed by offshore wind (Zane et al, 2011).

4.3.2 The Netherlands

Similar to Denmark the grid operator is obliged to connect energy technologies to the grid and the RES developer only bears the costs of connecting to the nearest suitable grid point. However, in the Netherlands grid operators are not allowed to pre-invest in grid capacity anticipating future RES development and are only obliged to expand the grid in relation to the existing demand (RES-INTEGRATION, 2011c). Moreover Dutch network companies have to submit network development plans and will be allowed to recover “reasonable” forward-looking investments in their allowable rates. Support to Dutch wind offshore projects has to include the cost for connection to the nearest point of the onshore transmission network (Lensink et al. 2011, Netherlands Ministry of Economic Affairs 2007, Netherlands Ministry of Economic Affairs 2009).

As in Denmark, grid development costs are financed through a transmission fee and therefore distributed to the end consumers in the Netherlands.

The rules for curtailment in the Netherlands assures that non-renewables are curtailed first followed by RES, dependent on their degree of adjustability.

4.3.3 Summary

A barrier may arise if the cooperating countries are not able to agree on which of the countries’ network regulation should count in the cooperation. The network regulation in Denmark and Netherlands do not differ significantly, except for when it comes to grid reinforcement obligations. As the development takes places in Denmark, we assume for the case study that the Danish network regulation will count for the cooperation.

Another barrier may then arise relating to public acceptance, as the result of Danish network regulation is that only the Danish TSO pays for network costs.I I.e. the Danish consumers pay for network costs and then may oppose to cooperation as the electricity price for the end consumer will increase as a consequence of the offshore wind development in favour of the Netherlands.

In order to overcome the latter barrier, the connection costs and grid reinforcement costs borne by the Danish TSO should be quantified and included as a part of the transfer payment. It could be argued that in case of several offshore wind farms in the same area the Netherlands should only pay a share of the connection costs. Therefore, the size of the share of the grid reinforcement costs included in the transfer payment should be a part of the negotiation between the two countries.

Finally, the issue of curtailment may constitute a barrier as curtailment constitutes a risk of not achieving the expected RES production in case the offshore wind is being curtailed. We assume that the host country, Denmark, bears the risk of curtailment and thus guarantee a certain amount of RES-E for the user country, the Netherlands. This makes it the responsibility of the host country to assure the necessary grid reinforcement and pricing structure that will minimise the amount of curtailment of RES.

4.4 Institutional barriers

The institutional barriers described in Pade and Jacobsen (2012) relate to regulation, public acceptance and EU policy. In the following we relate these barriers to this specific case study

4.4.1 Legislation

The barriers related to legislation cover four issues:

- How to structure the agreements legally?
- How legal agreements are traditionally designed?
- Resources used on lawyers
- Allocation of costs of support: public service obligations or provided by the government

The issues of how to structure a legal agreement is not expected to constitute a serious barrier to cooperation in the EU in general. EU countries handle legal agreements regarding common issues continuously and a legal agreement between two countries regarding cooperation will easily be handled. Relative to the cost of the project and resources used on research with respect to the project development the resources used on lawyers are expected to be minor and therefore of no importance relative to the whole project.

In Denmark the cost of the support is covered by the public service obligations, i.e. paid by the electricity consumers through the electricity price. In the Netherlands, for eligible projects up to 2013 support is paid for by the central government budget, as from 2013 support is paid for by a flat annual rate surcharge on the electricity customers power bills, which works out quite regressively: the customers with the lowest annual consumption paying the most on a per energy unit basis (Lensink et al. 2011, Netherlands Ministry of Economic Affairs 2007, Netherlands Ministry of Economic Affairs 2009).

4.4.2 Public acceptance

Public acceptance of RES technologies normally relate to the issues of “not in my backyard” reflecting the attitude that “renewable energy is a good thing as long as I do not have to look at it”. In case of cooperation between two countries the issue is somewhat expanded as the renewable energy “in my backyard” is in favour of another country. As the case study is dealing with offshore wind farms the “not in my backyard” is not expected to be an issue in relation to public acceptance (Pade and Jacobsen, 2012).

Another issue is related to location problems. When engaging in cooperation regarding offshore wind possible/cheap locations for offshore wind will be used for another country's target compliance. This is not an issue in this case study. First of all, there are no official targets post 2020 for EU and the Danish targets set by the government are for 2050. As the lifetime of the wind turbines is shorter than 38 years the wind farms developed with respect to the 2020 targets would have to be replaced by then. In case there is no EU target post 2020 the capacity established in favour of the 2020 target of the Netherlands can be included in the Danish national targets for e.g. 2030.

4.4.3 EU policy

The current EU policy with respect to the cooperation mechanisms may give rise to barriers for two reasons:

- No penalty for non-compliance has been specified
- No targets for post 2020 have been specified

As described in Pade and Jacobsen (2012) the extreme consequence of the lack of a well-defined penalty is that the user country does not attribute any value to reaching the target and the willingness to pay for the RES credits is zero. This is obviously the extreme case, and in the case study we assume that the lack of a penalty will not affect the negotiations between Denmark and Netherland.

The lack of targets for post 2020 affect the perceived value of RES post 2020. In case there is no target post 2020 the RES basically does not have a value after 2020 (Pade and Jacobsen, 2012). This basically means that neither the user country nor the host country puts any value on the RES after 2020 and a barrier arise as the participating countries have to agree on who should pay for the RES.

In this case study where we are dealing with offshore wind in Denmark, the case is that Denmark has set its own target for 2030 and 2050 and does – independent of the EU policy – attribute value to RES after 2020. This means that Denmark to a certain extent attributes a value to the RES after 2020 and this should be a part of the negotiation of the RES transfer price.

4.4.4 Risk sharing

Another barrier to cooperation may arise as there is an actual risk that the RES project may not be developed or the expected electricity outcome may not be achieved as we are dealing with fluctuating energy sources.

In this case study we assume that the entire risk is borne by the host country, Denmark, and it will therefore not constitute a barrier for the user country, the Netherlands. For Denmark we assume that the risk will be implemented in the tender contract in order to reduce the risk for Denmark.

4.5 Compensatory challenges

Entering a cooperation such as a joint project based on tenders for offshore wind will inevitable involve both costs and benefits for the participating countries. As described in Pade and Jacobsen (2012) the presence of especially indirect costs and benefits may constitute a barrier as the indirect costs and benefits are difficult to measure and value, and therefore will be a matter of negotiation between the participating countries.

The costs and the benefits can be divided into two groups: the direct costs and benefits relating to the establishment of the offshore wind, grid connection, expansion etc., and the indirect costs and benefits relating to the derived effects from establishing the offshore wind. In many cases, what are costs for the host country will appear as benefits for the user country and vice versa. In the following we attempt to assess which of the costs and benefits – direct as well as indirect – are relevant to the present case study.

The relevant indirect costs and benefits for the two participating countries, Denmark as a host country and the Netherlands as user country, are listed in Table 4-3. For Denmark the direct costs are related to the establishment of the renewable energy including grid related costs.

Table 4-3 Relevant costs and benefits for the participating countries

	Denmark	Netherlands
Direct costs	- RES development costs - Grid related costs	
Direct benefits		- Decreased compliance costs - Saved grid related costs
Indirect costs		- Employment effects - Not obtained increased economic activity - Not obtained energy security - Not obtained technological change - Lack of decrease in local emissions - Lack of positive effect on CO2 emissions
Indirect benefits	- Employment effects - Increased economic activity - Technological change - Local emissions decrease - CO2-effects	
Ambiguous	- Power market effects - Energy security	- Power market effects

On the benefit side for Denmark are the employment effects, increased economic activity and increased technological change. The magnitude as well as the value of these effects are very insecure and will only play a role as tool for negotiations. Furthermore, there is expected to be health effects from reduced energy production on conventional fossil fuel plants, which therefore affects on the CO2-emissions. The effect on the power market is ambiguous as an additional 2 GW wind power will have a smaller effect on the Nordic energy market in the direction of less volatile but lower prices. This in general is not a benefit for the conventional producers as they earn more money during peak load when the electricity is expensive and will in general suffer from lower prices. However, the consumers will earn correspondingly on lower electricity prices and the net-effect is unknown. Similar, if the new capacity is needed the additional 2 GW wind power will improve the security of supply. However, in the same time wind energy is a resource of limited predictability and at some points in time the wind resource is not available worsening the security of supply.

For the Netherlands the overall direct benefit is the savings related to the compliance costs. Installing wind in Denmark relative to the Netherlands provide the Netherlands with a direct gain.

In addition to this, the Netherlands also avoid expanding the grid and avoid other grid related costs, which also counts on the side of the direct benefits. On the other hand, the Netherlands actually misses the positive effects from technological progress, increased economic activity and positive employment effects, which then counts on the side of indirect costs. Furthermore, the environmental effects in terms of decreased local emissions as well as CO_2 emissions are also not achieved in the Netherlands. As for Denmark, the net-effect on the power market is ambiguous in terms of being positive or negative.

4.6 Assessment of barriers: relevance and constraints

Above we have been discussing the following barriers in relation to cooperation between Denmark and the Netherlands regarding 2 GW offshore wind capacity installed in Danish waters in favour of Dutch RES target compliance:

- RES support schemes
- Power market effects
- Network regulation
- Institutional barriers
- Compensation scheme

We saw that both Denmark and the Netherlands have been applying numerous support schemes over time and wind in particular has been addressed in different ways. As for the present both countries apply tenders for offshore projects and the support levels therefore differs from project to project. Hence, differences in support schemes between Denmark and the Netherlands are not perceived to constitute a barrier.

As Denmark is part of a larger Nordic electricity market and we do not assume that the additional 2 GW offshore wind will replace any of the already installed and planned capacity, the effects on the electricity price with respect to price level will be limited in the shorter run. In the longer run the larger share of wind energy may lead to less volatile electricity prices and affect the profitability of existing base load and intermediate load plants. However, as Denmark already plan a significant increase in the share of wind energy the additional 2 GW from the cooperation will have limited effect relative to the offshore and onshore wind projects Denmark is already planning. The power market effects are therefore not perceived to constitute a barrier for cooperation between Denmark and Netherland.

The network regulations in the two countries are rather similar and only differ in relation to the obligation to reinforce the grid. In the Danish case reinforcements are made when necessary relative to the new plants connected to the grid whereas the system is more rigid in the Netherlands. We assume the Danish network regulation will be followed and the only barrier that may arise is related to the reinforcement and connection to shore costs, which as a point of departure is borne by the electricity consumers, i.e. the Danish consumers. However, we assume that these costs will be handled as a part of the negotiation of the RES transfer price.

The institutional barriers covers the issue of setting up contracts and the cost related to this, the public acceptance and missing penalty for non-compliance and the lack of post 2020 targets in the EU policy. Only the issue of the lack of post 2020 targets is expected to constitute a challenge to cooperation and will be handled in the negotiations of the RES transfer price.

As we assume that Denmark bear the entire risk related to the project development the risk of the projects not being developed as well as the risk that the agreed amount of electricity is not being produced does not constitute a barrier for the Netherlands.

The countries participating in cooperation will have to design a proper compensation scheme taking the costs and benefits into account. The main details to account for are the direct costs and benefits but an assessment of the indirect costs and benefits will inevitable be a part of the negotiation when setting the transfer price.

5 QUANTIFICATION OF EFFECTS/IMPACTS (RESULTS)

The overall prerequisite for cooperation is that both countries benefit from it. The primary benefit from cooperation arises for the user country, the Netherlands, from the lower compliance costs by developing RES in another country. For the host country, Denmark, the cooperation is connected with costs through increased transmission costs. Beside the direct benefits and costs, cooperation is associated with a list of indirect costs and benefits related to employment effects, technological progress and environmental effects. The purpose of this chapter is to quantify the direct and indirect costs and benefits for the two countries to the extent possible and provide estimations of the level of the RES transfer price. The latter involves the investment activity, which takes place in the host country. These effects are therefore most comprehensively covered for the host country.

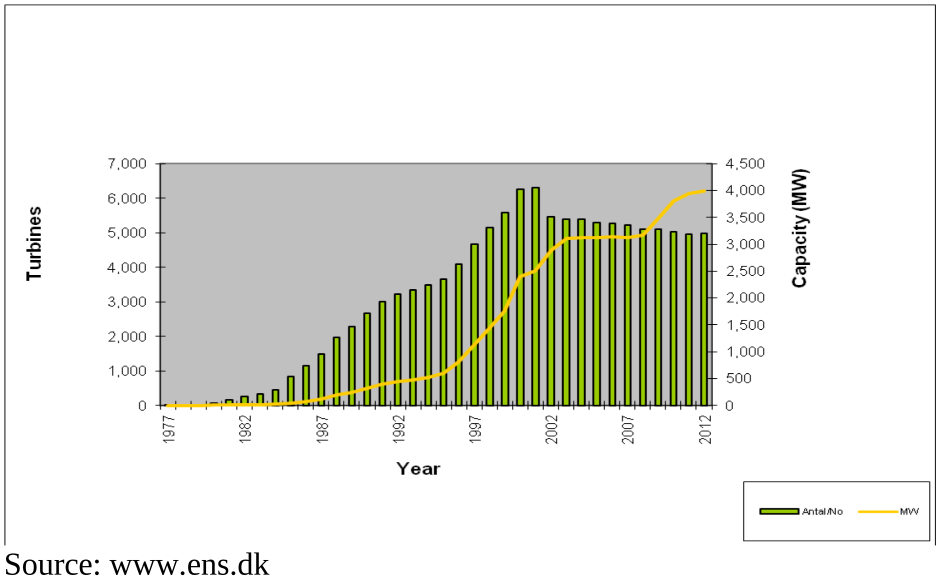
5.1 Host country, Denmark

This chapter includes a description of the Danish power market and an assessment of the effect of installing additionally 2 GW offshore wind capacity. Furthermore, we account for the investment costs associated with a 2 GW offshore wind park. Next we address the issue of how to determine the direct RES transfer price and the necessary support arrangement only taking the investment costs into account. We also cover the situation where we are dealing with a smaller project of only 200 MW offshore wind capacity. Finally, we address the issues of indirect costs and benefits of the host country.

5.1.1 The Danish power market and wind energy

In the following we present the Danish power market with special emphasis on the development of wind energy. Figure 5-1 illustrates the historical development of wind turbine installation in Denmark from 1977 up to present. Up until 2000 the expansion was quite fast but since then the installed number of turbines has declined. Due to repowering and new turbines being much larger than the old ones they replace, the installed capacity has still increased somewhat.

Figure 5-1 Development of total Danish wind installations 1977-2012



Source: www.ens.dk

The increase in capacity in 2009 to 2011 is due to the two offshore parks Horns Rev II and Rødsand (**Table 5-1**). According to the Danish NREAP there is not planned any increase in the total installed wind capacity. This gives an estimate of a total wind capacity of 3960 MW for 2020. In the period between the present and 2020 there will be a slightly higher level of total wind capacity, but decommissioning will reduce the capacity slightly again. With the political energy agreement from Spring 2012,a more realistic target for wind capacity in 2020 will be around 1000 MW higher.

Table 5-1 Danish offshore wind turbine development and project in construction

Location	Size
1. Vindeby (1991)	11 turbines, 5 MW
2. Tunø Knob (1995)	10 turbines, 5 MW
3. Middelgrunden (2000)	20 turbines, 40 MW
4. Horns Rev I (2002)	**80 turbines, 160 MW**
5. Rønland (2003)	8 turbines, 17 MW
6. Nysted (2003)	72 turbines, 165 MW
7. Samsø (2003)	10 turbines, 23 MW
8. Frederikshavn (2003)	3 turbines, 7 MW
9. Horns Rev II (2009)	**91 turbines, 209 MW**
10. Avedøre Holme (2009/10)	3 turbines, 10-13 MW
11. Sprogø (2009)	7 turbines, 21 MW
12. Rødsand II (2010)	90 turbines, 207 MW
13. Anholt (2012/13)	400 MW

Source: www.ens.dk

Comparing the present level of wind capacity to the size of the joint project case study (2000MW) reveals that the joint project is quite large. However, as a 1000MW expansion is already politically agreed on, the project size seems to be within a realistic range. The existing 4000MW capacity at the moment corresponds to more than 20% of Danish electricity generation. It is evident that 2000 additional MW offshore wind will affect the Danish power sector. However, developments in transmission and interconnection capacity will moderate the impact. Furthermore, the Danish market is very well integrated in the Nordic power market of which it constitutes a relatively small part.

Denmark is characterized as the smallest part of the Nordic power market due to its lower level of per capita electricity consumption. This is a result of the absence of energy/electricity intense industries and the very limited amount of electricity based heating. It is also the market with the highest end user prices.

Denmark is positioned in between a hydro dominated Nordic market and a fossil/mixed German/central European market. Today the two markets, Denmark west and Northern Germany, are quite similar with highly correlated prices around 50% of the time due to concentrated wind generation especially in western Denmark and northern Germany. The strengthening of interconnections between Denmark west and east has reduced the amount of time where Denmark west and Denmark east are divided into separate price zones.

In wet years Denmark will be influenced by low Norwegian power prices and be a net importer of electricity with low fossil based generation as a result. Such years, price volatility will be lower and the price impact of additional wind will be very little. In dry years, prices will be higher and more volatile and Denmark will follow German prices to a larger extent. Price volatility will be higher and more wind will have a price reducing effect on average.

Danish dependence on coal based CHP generation has traditionally been very high but is steadily declining. With additional wind the assumption is that fossil capacity remains but the operational time for most fossil based generation is reduced and their share of total generation/consumption likewise.

The effects on the power market of additional 2 GW offshore wind capacity is listed below:

- Generation mix effects: no change on peak production, but intermediate and base load production will increasingly be covered by wind
- Technology composition: only higher wind share
- Effects on the power price level and volatility: small decline in price, no effect on volatility

The expansion with 2 GW wind capacity is a considerable amount in the Danish generation capacity. Based on the existing political agreement of March 2012 (DEA, 2012) (i.e. exclusive the 2 GW from the cooperation project) the total wind capacity will be approximately 5.5 GW in 2020. Out of the 2 GW the 400MW is expected to be covered by the expansion at Horns Rev agreed in March. Since the development of 400 MW is already adopted, this may be an ideal starting point for entering into a cooperation project with the Netherlands. The total case study cooperation project will thus add 1600 MW to Danish wind capacity in 2020. With a wind capacity of totally 7100 MW (Table 5-2) the estimated share of wind energy in the Danish electricity *consumption* will be around 63 %. This covers all generation in Denmark including the part belonging to the cooperation with the Netherlands. In the target compliance for RES in 2020 the generation from these 2000 MW will not count for Denmark. The wind share of total Danish electricity *generation* will be a little lower (60 %) as Denmark will become increasingly a net exporter. With more fluctuating RES generation a larger fraction of Danish generation will be at times with low domestic demand and therefore prices, and will thus to some extent be exported. Without the cooperation project the wind share of generation is projected to be 47 % in 2020. In the NREAP the RES-E share was estimated at 52 % of total electricity generation in 2020 of which wind contribute nearly 30 %.

The share of wind capacity of total Danish capacity used to be higher than the share of generation, due to the lower annual full load hours for wind compared to conventional capacity. This will be reversed so that the wind share of generation may rise above the wind share of capacity since other generation technologies will experience a considerable reduction of generation time. Wind will thus constitute around 75 % of the RES-E capacity and around 50 % of total Danish generation capacity (Table 5-2).

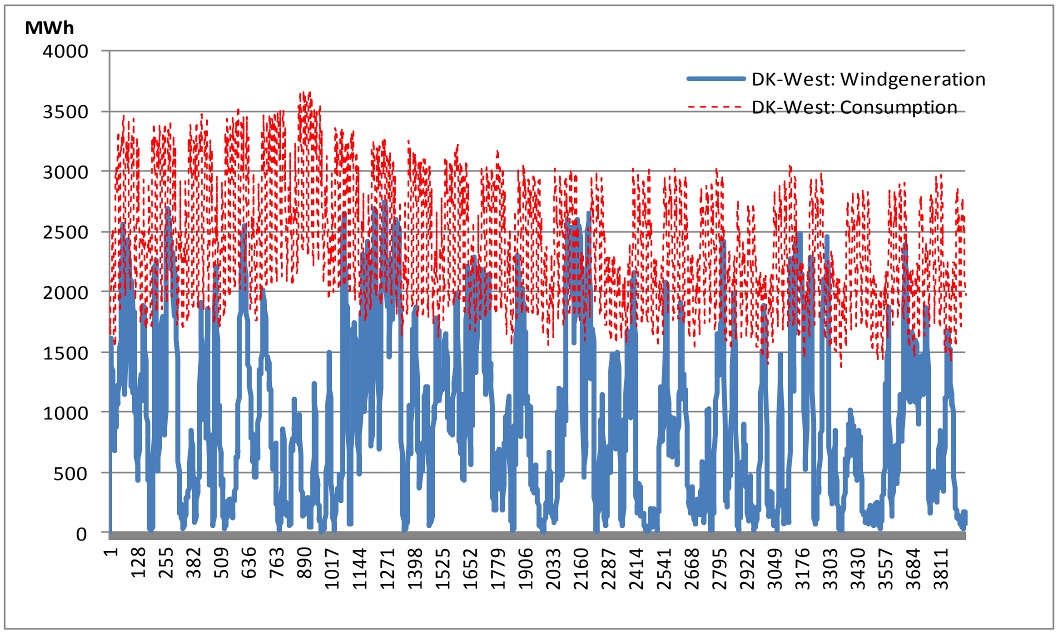
Table 5-2 Composition of Danish generation capacity 2012 and projected to 2020 with the case study cooperation project

Electricity generating capacity	2012		2020	
	Capacity, MW	**Share**	**Capacity, MW**	**Share**
RES	4801	35%	9879	62%
- Wind	3841	28%	7100	44%
- onshore	2985	22%	2900	18%
- offshore	856	6%	4200	26%
- Biomass	947	7%	2779	17%
CHP based	6300	46%	6000	38%
Thermal fossil incl. fossil CHP	8927	65%	6121	38%
Total capacity	13728	100	16000	100

Source: Own calculations based on NREAP (L.W.M. Beurskens et. al., 2011)

The present situation in the Western Denmark power balance is illustrated by Figure 5-2. The western Denmark is linked to Eastern Denmark but with a limit on capacity. As the wind share is already highest in the west and the entire cooperation project will be located here, this is where the most profound effects will be found. There are hours where wind generation exceeds the consumption, but this is for less than 5 % of the time and the large interconnection capacity makes this a less problematic situation as excess generation can easily be exported to the north unless the excess is very large. The problems will be more pronounced if all the neighbouring areas become similar with respect to generation mix with high shares of fluctuating generation (like Northern Germany) and there is nowhere to export the power. In the extreme situation there will be a need to curtail generation for a few hours during a year.

Figure 5-2 Wind generation only exceeded consumption in 178 hours from January to June in 2012 for West Denmark



When there is an excess of wind generation relative to the consumption there is an export from the west region. In reality there are also other types of generation on top of the wind generation for security reasons even at the excess situations, but wind constitutes the major part. The observations in **Figure 5-2** constitute no major problem with regard to excess generation and do not lead to curtailment of generation. The effect in the extreme situation are seen in the power market prices in cases where there is a limit on interconnection capacity and/or the neighbouring power market prices are correlated with the west Danish prices. Low market prices in Denmark are just as much a result of low prices in Germany as a result of high levels of wind generation in western Denmark.

Danish power generation were previously a coal dominated system with a large share of combined heat and power generation with high efficiency. The thermal fossil share has declined already considerably and will decline further up to 2020 both with and without the cooperation project. The technologies replacing the coal based generation were first natural gas and biomass primarily at the small decentralised CHP plants. Furthermore the wind expansion played a major role up to now and with the cooperation project included it continues to play an increasingly larger role. In 2020 the capacity share of wind is projected to have increased up to 44%, where the thermal fossil capacity has declined to only 38 % (Table 5-2). The RES share of capacity is as high as 62 %, where the biomass already in the NREAP is projected to increase considerably around 2014. There is the possibility that this biomass share will be increased somewhat less as the political agreement of the Spring 2012 (DEA, 2012) expanded wind more than originally foreseen in the NREAP plans.

The impact on the power market price from adding zero cost marginal cost generation are expected to be negative (Sensfuß et. al. 2008, Klinge Jacobsen and Zvingilaite 2010) but the extent to which the price will be affected depends crucially on how other categories of capacity are adjusted in the long term. The less other generation is reduced/scrapped the larger the price reducing effect will be. The effect is basically found from shifting the marginal supply curve to the right and thereby the intersection with the demand curve is found for lower levels of marginal generation costs.

This downward price effect will be rather small as Denmark with strong and strengthening interconnections planned is dependent on neighbouring markets and is a part of the Nordic power market. A basic estimate would suggest a ½-1% reduction in prices for the West of Denmark on average, but a more qualified estimation would require a detailed analysis of the entire Nordic power system including details of the interconnection operation and hourly variations in demand and generation conditions.

Based on previous studies (Klinge Jacobsen and Zvingilaite, 2010) the price reducing effect is largest for high price time intervals and less for low price intervals when adding zero marginal cost producers without scrapping other capacity. The newly planned interconnection capacities for Denmark, limits the increase in zero and negative price occurrences, but there is uncertainty about the timing of this capacity increase and the precise net-effect on prices. Already today the zero and negative price occurrences in Demark are to a large extent imported from Germany. That is, when zero price occurrences are seen in western Denmark it is a consequence of no export opportunity to Germany due to a negative or zero price there. When prices in Germany are higher there would not be a large price effect of high wind generation in Denmark.

As the largest impact on prices is for high prices the effect on volatility will be close to neutral. This is based on the assumption that only very little of other generating capacity is scrapped. If a corresponding conventional capacity is scrapped the effect will be a higher volatility, and probably an unchanged price level. The case study assumes that there will be no scrapped capacity due to the additional wind expansion.

As a consequence of the lower prices, other generators in Denmark might have a slight loss due to the cooperation project. This is however small and it is counterbalanced by the benefits of a relatively reduced wholesale prices for the consumers. Consumers will, however, not experience a reduced final price since the support payments are assumed to be financed by the consumers similar to all other RES support payments. These are paid equally by all consumers through a special fee in the TSO transmission tariff per consumed kWh. The credits payments from the Netherlands just reduce the support that Danish consumers will have to finance. Whether this reduction should be passed on to TSO tariff reductions for only 2020 or distributed on a longer time period is open and does not make any difference for the cooperation.

5.1.2 Investment cost details for cooperation project of 2GW size

The total offshore investment costs are presently estimated in the range 2.7-3.3 mill €/MW. With the present downward price pressure on turbines the case study will use the lower end of this interval.

Table 5-3 Composition of offshore investment costs: (Horns Rev)

	Share of costs
Turbine	60%
Foundation	20%
Internal grid etc.	5%
Transformer and connection	10%
Administrative, planning, environment , licences etc.	5%

Turbine costs are the largest component of the investment, and are not dependent on location but mainly the exogenous effects from world market competition in turbine manufacturing, steel prices etc.

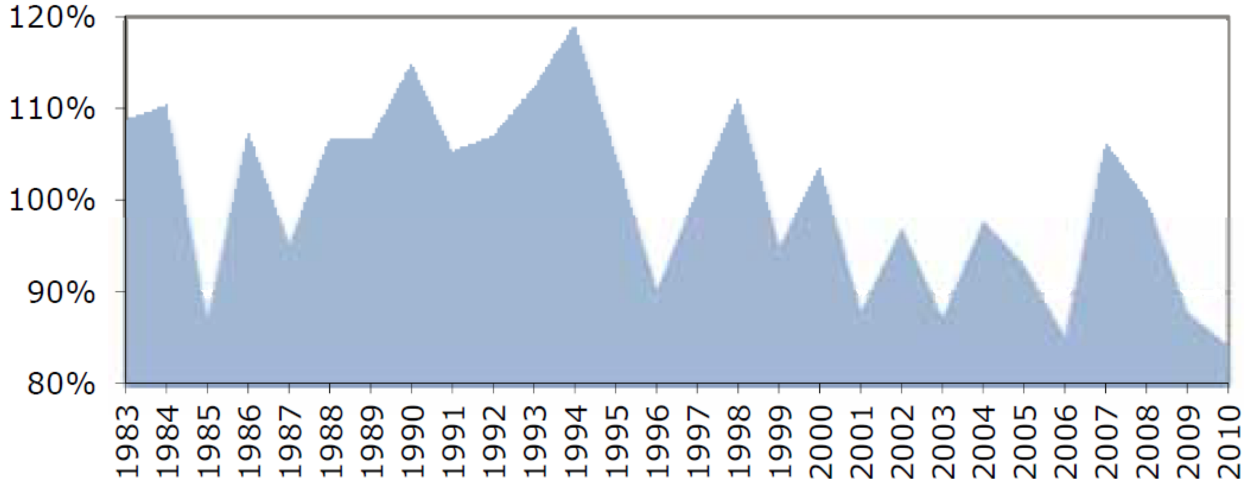
The foundations are the primary components affected by the specific location namely the water depth and the bottom conditions. Danish conditions are generally favourable in cost terms but there might be very local deviations from this.

An alternative is to increase the density of the wind parks with resulting efficiency losses (wake effects). In the Windspeed Roadmap report (Veum et al, 2011) the used distance is approximately 12 km between parks. Reducing this distance when shallower depths are scarce should be considered. The losses would have to be compared to the possible cost consequence of locating further north or at deeper locations.

Wind generation output levels, variation and correlation with market prices

The assumption for the offshore wind farms in the Horns Rev area is that they will generate with an output corresponding to 4100 full load hours annually. As wind is not only fluctuating on an hourly and daily basis but also varies from year to year, there is some uncertainty regarding the generation in a specific year. This is illustrated in **Figure 5-3**, where annual wind in Denmark varies with around +/- 15%. For specific sites the annual variation will be larger. This uncertainty has to be accounted for in the risk allocation agreement and included in the transfer price or other compensation. In the description of the cooperation design all the risk were assigned to Denmark including this generation risk. An alternative solution could be to share this risk equally among the host and the user country.

Figure 5-3 Wind energy content variation and 2020 obligations (100% = normal year)



Source: DEA (www.ens.dk)

The location in the Horns Rev area would suggest 4200 full load hours annually. With the possible denser location of wind parks there might be a reduction to this. These possible wake effects primarily due to reduced distance between wind parks and not within the wind park are included by adjusting downwards the full load hours to 4100 annually.

Experience from the existing Horns Rev parks

Horns Rev I wind farm have been operating for several years, with some initial technical problems. As an estimation of wind generation profile from the Horns Rev area we therefore use a time series that exclude these years, but include normal maintenance operations etc. The generation profile is then matched to the power market variations and an estimate of the average value of the annual wind generation relative to the power market price can be made. Western Denmark data suggest 7-10% lower revenue for wind generators relative to a profile following the demand. This reduction should be considered when calculating the necessary support levels (Table 5-5).

Life time of investments

Previously a lifetime of 15 years was used for the wind turbine investments. This was maybe realistic for onshore wind turbines, when the technical progress (up-scaling) was very fast, but at the present stage of technological development the lifetime must be estimated to be longer. Real experience with single turbines also confirms this. The lifetime has in most cases been extended up to 20 years for calculations and projections. The real lifetime for offshore wind turbines cannot yet be determined as there are not yet real experiences for an offshore wind park's entire life span. The real expected lifetime will probably be around 25 years, which will however require some reinvestment (replacements). The calculations used for Danish tenders of the Anholt offshore parks use a 25 years lifetime.

Summary

The effect on long term costs for electricity generated in Denmark is towards higher costs if the capital costs of the wind farms are included. This is not reflected in the wholesale price projection since the support costs to the renewables are financed outside the wholesale market. The levies financing support will only be seen in the retail price level.

Table 5-4 Total investment costs for 2 GW: (Horns Rev+ area)

	Total costs	Uncertainty
Turbine		Middle
Foundation		Middle
Internal grid etc.		Low
Transformer and connection		low to middle
Administrative, planning, environment , licences etc.		Low
Total	7.5 bill €	Middle

In addition to the investment costs an average maintenance cost of 2 c€/kWh generated is assumed.

5.1.3 Transfer payment – direct costs and benefits

In the following we address the settlement of the necessary transfer payment taking direct costs and benefits into account. We consider the cooperation option II, where the Netherlands only buy the credits for 2020 and Denmark holds the right to the RES for the years after 2020.

Table 5-5 gives an overview of costs for RES technology and how these costs interact with market prices. Table 5-5 thereby forms the inputs for negotiations on the RES credit transfer price between Denmark and the Netherlands for cooperation option II. The primary critical assumption is whether the capacity (i.e. the potential generation for the entire lifetime) or just the credits for 2020 are transferred from Denmark to the Netherlands. Table 5-5 is based on option II with the Netherlands buying only the credits for 2020. For a comparison with the case studies on biomass and on concentrated solar power please consider option I. With regard to physical transfer of generated electricity both situations are included in this illustration for option II. For definition of the two main cooperation options see Chapter 3

Column 2 in Table 5-5 includes the basic levelised cost assumptions in the two countries. Offshore wind cost for the 2000 MW is estimated at around 12 c€/kWh and cost assumptions for the Netherlands are here represented with 15 c€/kWh. This cost is equivalent with offshore wind at deeper locations than the ones possible in Denmark. An alternative, where the upper part of the marginal levelised RES cost curve for the Netherlands is also considered. Column 3 contains the power market price assumptions matching the generation lifetime of the offshore wind in Denmark and the corresponding alternative in the Netherlands. These are the assumed market prices that the generation from offshore wind faces and are somewhat lower than the average market price. The reason is that high wind conditions reduce the market price. Column 4 is the necessary support as the difference between levelised costs and the market price. The entire support to investors will be provided by Denmark and the Netherlands is only providing a contribution to this through the RES credits transfer price. Investors will not be entitled to any support through the Dutch support system. The assumption for lifetime and support period is 15 years for both the Danish offshore wind and the alternative RES investments in the Netherlands. Two possibilities depending on the availability of physical transfer of generation between the two markets are illustrated. If transfer is possible the higher market price in the Netherlands reduce the necessary support costs from 8 c€/kWh to 5.7 c€/kWh. Column 5 calculates the total necessary support payment for 15 years, given that full physical transfer is possible. Column 6 contains the crucial **assumptions** about the value for Denmark of RES credits post 2020. This can be interpreted as the Danish willingness to pay for renewable capacity expansion beyond the 2020 targets or the expected value of credits in a future market. If Denmark assigns no value to post 2020 credits the cooperation corresponds entirely to Option I, where the Netherlands provide the full necessary support to the RES investment.

Represented in column 7 are calculated illustrative examples of the transfer price based on these assumptions. The transfer price will eventually be a result of bilateral negotiations between the host and the user country. The Netherlands have to pay for the difference between the total necessary support and the value that Denmark assigns to post 2020 credits. In the example this is 7 bill € - 5.7 bill €. The share of total support paid by Netherlands is then 1.3 bill € out of 7 bill €, which can be divided on the RES generation credits that the Netherlands receive for 2020 (8200 GWh) corresponding to a transfer price of 15.5 c€/kWh. For sensitivity regarding the physical transfer option for electricity an assumption of no physical transfer is illustrated as well as resulting in a much higher transfer price of 50 c€/kWh due to the drawback of having to sell the power at the low price Nordic market. A much lower credits transfer price would be the result if

Denmark were valuing post 2020 credits at 6 c€/kWh roughly corresponding to support costs for shallow offshore turbines with Danish power market prices. In this case assuming physical transfer to Netherlands would result in an extremely low transfer price of 1.5 c€/kWh for the credits of 2020.

Overview of expected costs and transfer price for project cooperation (main assumptions excluding indirect effects etc.) Option II.

Table 5-5 Overview of expected costs and transfer price ranges depending on various assumptions for project cooperation (main assumptions excluding indirect effects etc) Option II

Country\ Assumptions	**RES Technology costs (offshore wind)**	**Wholesale power price (generation lifetime)**	**Necessary support in DK if power physically transferred to NL or not (italic)**	**Total support costs for 15 years in DK (2000MW, 4100 hours annually)**	**Value to DK of credits post 2020 (14 years)**	**Example transfer price 2020 credits calculated based on necessary support**
Main case						
Denmark	12c€/kWh	*40€/MWh*	*8.0c€/kWh*		**5c€/kWh**	
Netherlands	15c€/kWh	63€/MWh	5.7c€/kWh	**7.0 Bill. €**	**5c€/kWh**	= **15**.5**c€** per *kwh credits in 2020* *Total NL payment = 1.3 Bill. €*
Alternative case with no physical transfer						
Denmark	*12c€/kWh*	*40€/MWh*	*8.0c€/kWh*	***9.8 Bill. €***	***5c€/kWh***	*=* ***50c€*** *per kwh credits in 2020* *Total NL payment =* ***4.1 Bill. €***
Alternative with value of credits post 2020 based on support costs of the cheapest additional Danish RES resources (nearshore offshore wind) and physical transfer						
Denmark	12c€/kWh					
the Netherlands		63€/MWh	5.7c€/kWh	**7.0 Bill. €**	**6c€/kWh**	= **1.5c€** per kwh credits in 2020 Total NL payment = **0.1 Bill. €**

Note: Values marked with red are illustrative assumptions

The levels have been achieved as in the following:

Total support costs for 15 years in DK:
(12c€/kWh-6.3c€/kWh) * 2000MW * 4100h * 15 years = 7.0 bill€.
In this case it is the necessary support costs on top of the wholesale market price in the Netherlands.

Total Value to DK of credits post 2020:
5c€/kWh*2000MW*4100h*14years = 5.7 bill €.
This assumes that the first operational (support) year is 2020. Netherlands would then have to finance the difference between total support costs and the value that Denmark assigns to post 2020 credits. This amounts to 7 bill – 5.7 bill which equals the 1.3 bill that the Netherlands have to pay for the 2020 credits.

Calculating this per generated kWh in 2020 corresponds to *Example transfer price 2020 credits calculated based on necessary support*, and amounts to
(7.0 bill € - 5.7 bill €)/2000MW*1000*4100h = 15.5c€ per kWh credits in 2020.
This is much less than providing an annual support to RES in the Netherlands for 15 years.

The main message from Table 5-5 is that the range for transfer price depends crucially on the value assigned to post 2020 credits by Denmark and to some extent also whether there are benefits from also physically transferring the electricity. This last part totally ignores the costs associated with providing the necessary additional interconnection capacity. Therefore this has to be seen as an indication on whether the benefits from this match the additional costs of more interconnection capacity. These issues are treated further in Work Package 4, D.4.3 of this project (Heinemann and Bauknecht 2012b). There is considerable uncertainty regarding the average wholesale market prices in each country for the lifetime of the RES technologies. However, it is reasonable to expect that market prices in the Netherlands will continue to be higher than in Denmark. The development of generation capacities implies continued expansion of low marginal costs technologies as wind in Denmark and much less development of such generation in the Netherlands.

Both the option from Table 5-5 and the cooperation Option I with the Netherlands buying all future RES credits from the project are treated in Table 5-10, chapter 5.2. Here the possible cost savings are illustrated based on the transfer price result of the main case in Table 5-5 in comparison with cooperation Option I.

5.1.4 Sensitivity analysis for a 200MW subset of the 2GW possible cooperation project

This subsection provides the results for Option II calculated for a subproject of 200MW out of the total 2GW. This is done to provide illustrative info for a project size that can be seen as a prototype for this specific type of joint project cooperation. No distinction is provided with regard to indirect market effects, but there might be a difference that could influence the wholesale market prices, which is one of the assumptions in both the subproject and the entire joint project case of 2GW.

Table 5-6 Examples of RES credits prices with permanent or single year transfer, 200 MW offshore wind

Assumptions\ Country	RES Technology costs	Wholesale power price (generation lifetime)	Necessary support to investment in country A[a]	Total support cost for 15 years in country A	Value to A of credits post 2020	Support costs covered by country B	Transfer price credits per generated unit in 2020[b]
	c€/kWh	€/MWh	c€/kWh	Mill. €	c€/kWh	Mill. €	c€/kWh
Country A	12	40	*8.0*	*984*	*0*	*984*	*120*
Country B	15	63	5.7	701	0	701	85
Country A	12	40	*8.0*	*984*	*2*	*754*	*92*
Country B	15	63	5.7	701	2	472	58
Country A	12	40	*8.0*	*984*	*4*	*525*	*64*
Country B	15	63	5.7	701	4	242	30
Country A	12	40	*8.0*	*984*	*6*	*295*	*36*
Country B	15	63	5.7	701	6	12	2
Country A	14	40	*10.0*	*1230*	*4*	*771*	*94*
Country B	15	63	7.7	947	4	488	60

[a]: for the entire lifetime of the technology. With and without physical transfer (in italics)
[b]: assuming the support for the entire lifetime of the technology is paid in one single year, 2020

Assumptions underlying the calculations in Table 5-6 are: lifetime of technology 15 years, annual generation 4100 full load hours, no discounting, constant real prices and support levels. The most crucial assumptions are the RES technology costs in columns 2 and the expected value of future credits in column 7. For all levels of expected credit value the calculations are carried out with and without a physical transfer of the generated electricity to the other market. The cost of transfer/interconnection capacity is not included in the calculations.

Again here the calculations of the transfer price for 2020 credits with physical transfer as in row 7 can be exemplified by first calculating the necessary support (column 4):

(Technology cost in A (12c€/kWh) – market price in B (6.3c€/kWh)) * 4100 hour annually * 200MW *1000 * 15 years = 701.1 mill €.
Of this support A will be willing to contribute up to the expected value of 4c€/kWh for the remaining 14 years of generation: 200MW * 1000 * 14 years * 4c€/kWh = 459.2 mill €.

Then B will have to pay 701.1 mill € - 459.2 mill € = 242 mill € for the RES generation credits in 2020. This corresponds to 242 mill €/(200MW * 1000 * 4100h) = 29.5 c€/kWh.

The last column in Table 5-6 is expressing the total lifetime support payments financed by country B per generated unit in one single year, namely 2020. These are in most cases much higher than the necessary support costs per generation unit for the entire lifetime as illustrated in column 4. If the support financed by country B is covering the entire necessary support because country A assign no value to future credits this corresponds to country B buying all the credits at the price of 5.7c€/kWh as in row 3. Such a situation can be expected for many bilateral cooperation possibilities in the EU. For most countries, the value of future RES credits will be rather low, but some countries might expect much higher RES targets for the future or they might have national targets that exceed the 2020 target set by the EU directive. This is for example the case for Denmark that has set higher targets for renewable shares post 2020.

As such the basic cost savings from cooperation is found as the difference between RES generation costs in country A and country B. This is the cost differential in column 2 which is 3c€/kWh except the alternative in the last two rows with only a 1c€/kWh cost difference. Adding the benefits of physical transfer between the two markets is not a result of the cooperation project, but might be achieved with just adding interconnection capacity assuming that the market price differential is not dependent on the RES project. If there is much larger RES expansion than in the present 200MW example, there might be a downward effect on market prices in country A. This would increase the price differential and make the addition of interconnection capacity more economically attractive. However, as adding the interconnection capacity would level out the price differences between the two countries this would also level out the benefits of physical transfer between the two markets.

In reality the transfer price will be a result of a negotiation process and the example of 29.5 c€/kWh is a minimum price as the price have to be higher if country A should have a net benefit from the cooperation.

5.1.5 Indirect benefits and costs

In the following we address the issue of indirect benefits to the host country as a consequence of cooperation. The main indirect benefit as a result of cooperation for Denmark is perceived to be the employment effect. Other important effects are increased security of supply and environmental effects. On the cost side issues such as grid enforcement costs and negative impact on other RES investors are analysed.

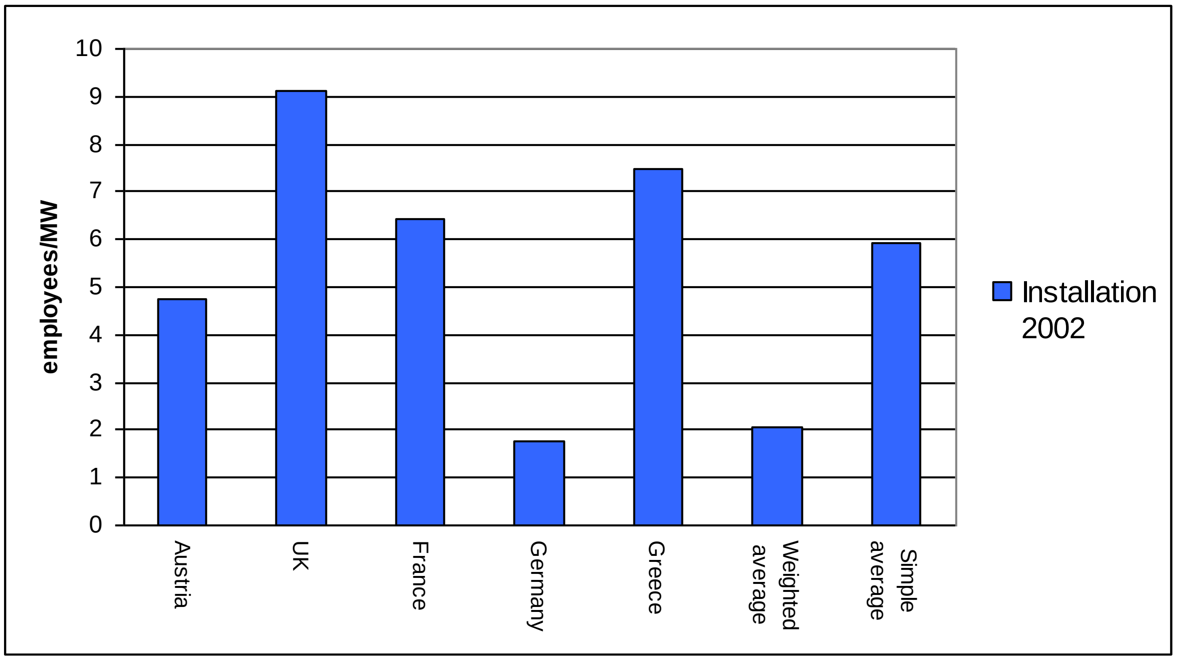
Employment effects

The main indirect benefits for Denmark are seen as the employment effects. These are combined from the building phase and the operation phase. The building phase is the part with the largest employment effect.

For the North Sea Horns Rev area the only reasonable supply port is Esbjerg. That means the construction service and probably the shipment of foundation parts will come from here. As also service industry and facilities for operational services to existing wind parks are located partly in Esbjerg area the additional wind will have an employment effect in Esbjerg/western Denmark.

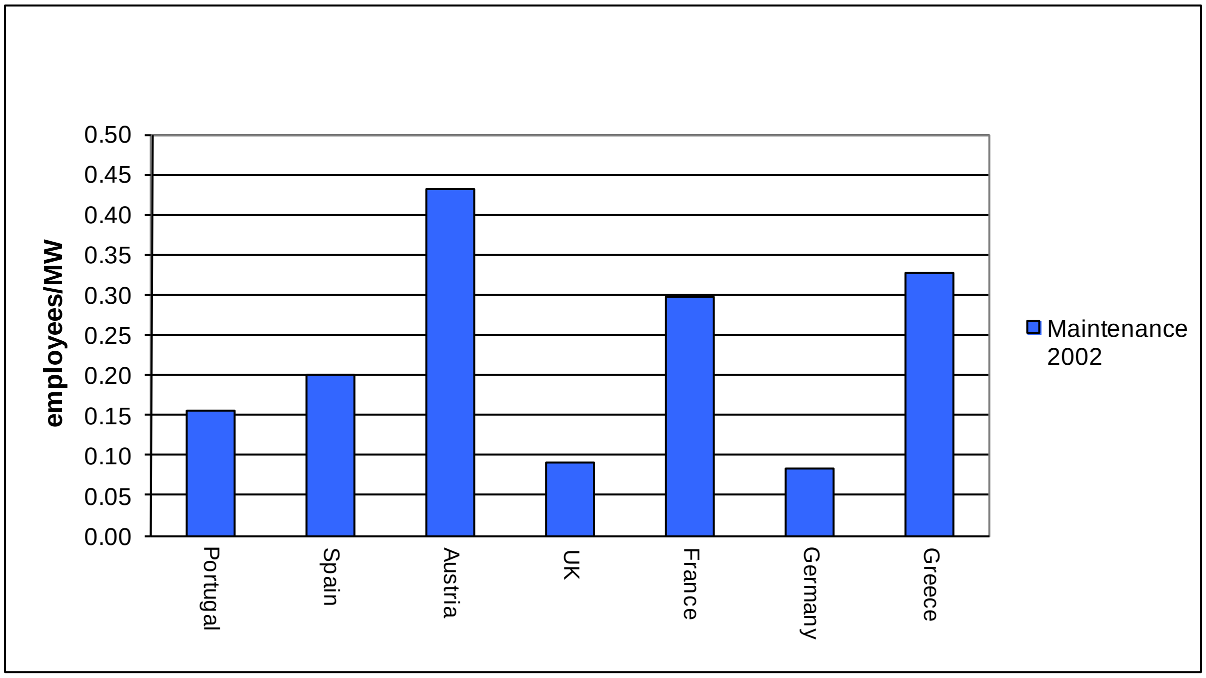
The Danish Energy Authority states that for the employment effect of turbine manufacturing the different offshore projects in Denmark are quite similar. That means the location near Esbjerg does not result in more Danish employment than if the project were at Kriegers Flak in the Baltic Sea. The competition that all Danish projects will be exposed to makes it quite uncertain whether or not the turbines will be manufactured in Denmark. On average it must however be assumed that the average market share that Vestas and to some extent Siemens have in the offshore turbine market is high, even though competition is increasing, and for Danish offshore wind parks these two manufactures will for Danish projects locate the majority of production in Denmark. From this it can with high uncertainty be assumed that around 50% of the turbines will be produced in Denmark. As this is a major contributor to employment effects it also makes the total employment effect quite uncertain. It is not expected that future tendering procedures will include mandatory conditions about localisation of turbine production facilities locally in Denmark as has recently been seen for the French offshore tenders. If this was the case uncertainty on employment effects would be lower

Figure 5-4 Direct employment associated with turbine installation in selected European countries for 2002 (from own calculations to EWEA Wind Energy: The Facts, 2004)



The figures used in the case study are updated versions of the direct employment figures in turbine installations from Figure 5-4 above. The productivity increase from 2002 and onwards will reduce the employee input per MW installed capacity. This is a combination of the general labour productivity increase and the up scaling of wind turbines. The reduction in multiplier is counterbalanced by an increase in employment due to the more complex installation operations for offshore wind relative to the onshore installation examined in Figure 5-4. The higher installation costs for offshore wind compared to onshore is however mostly related to higher capital/equipment costs and not so much manpower. Therefore a moderately higher employment multiplier for offshore is assumed to balance the productivity reduced multiplier from 2002 to 2020. The result is that the weighted average number from Figure 5-4 of 2 employee/ year per MW is used for calculating direct employment effects in 2020 in the Danish North Sea from installation of turbines. The estimation for employment directly in installation is then ***4000 man years*** for the 2GW wind farm project.

Figure 5-5 Employment in maintenance of wind turbines in selected European countries for 2002(from own calculations to EWEA Wind Energy: The Facts, 2004)



As is clear from the above figures from 2002 in Figure 5-5 the employment per MW in maintenance is much smaller than the employment in installation. However, this effect is for the entire lifetime of the wind farm.

We project these employment figures by using a conservative figure of 0.1 employee per MW based on the numbers for UK and Germany in Figure 5-5. This amounts to ***3000 man years*** for the lifetime of the wind farms.

The direct employment from installation and maintenance produce ***7000 man years*** for the entire project lifetime. In addition there is a direct employment in turbine manufacturing in Denmark. This is depending on the turbine supplier chosen and production location of this supplier. With the 50% average Danish expected share of this production a very uncertain figure of ***3000 man years*** in production of turbines can be given. All together directly involved employment associated with the case study project would be ***10000 man years***.

Sometimes an alternative approach using input output figures estimates the employment directly and indirectly associated with the installation, maintenance and production of equipment for the wind farm project. The more uncertain figure is then the indirect employment effects in sectors producing the subcomponents for wind turbines and the other inputs to foundations installations etc. An example of such a calculation is given below.

The indirect employment from installation is assumed to be entirely domestic for Denmark and consists for example of the production of elements for the offshore foundation. This is assumed to be produced in the construction sector that has an employment content per unit of economic output. Constructing foundations is then assumed to have the same employment content as do the average production in the construction sector. Of the total investment costs for the project the 60% is assumed to be the turbines and the remaining 40 % is foundations etc. as shown in Table 5-7. Therefore the share of total investment costs attributed to installation is 3.0 Bill. €. This figure is discounted to 2005 level used for the multiplier on which Table 5-7 is based before multiplying with the multiplier for 2018-2020.

Table 5-7 Calculation of direct and indirect employment for offshore wind *turbine installation* in the Horns Rev area in the period 2018-2020 (employment per mill € investment)

	Share of costs	**Contributing sector**	**Employ-ment multiplier 1995**	**Employment multiplier (projected to 2018-20)**	**Employment 2018-2020**
Foundations	45 %	Construction	18.14	10.76	12000
Infrastructure, platforms etc.	15 %	Construction	18.14	10.76	4000
Electrical installations etc., connections	30 %	Construction /Industrial machinery	15.87	9.50	7000
Grid reinforcement	5 %	Construction	18.14	10.76	1000
Other installation costs	5 %	Other market services	57.61	34.50	4000
Total	**100 %**				28000

The numbers for total direct and indirect employment in installation is ***28000 man years*** but this figure has to be treated carefully as the uncertainty is very high.

The direct and indirect employment from wind turbine manufacturing is even more uncertain as discussed above, due to the international competition in the supply of turbines. With very high uncertainty a 50% Danish share of production of turbines to be installed in Denmark is used here. This means that the investment share and therefore Danish production in current prices will amount to around 2.25 Bill. €.

Table 5-8 provides the projected employment multiplicators based on EWEA (2004). The reduction from 1995 to 2018-2020 is due to productivity increase and specific up scaling of wind turbines (1.5% annually is used). Adding the two elements from Table 5-7 and Table 5-8 we get a direct and indirect employment in Denmark associated with the 2000 MW project in the North Sea of ***44000 man years.*** This number is considerably higher than the estimated direct employment above of around 10000 man years, and must as such be characterised as much more uncertain than the 10000 figure.

Table 5-8 Calculation of direct and indirect employment for offshore wind *turbine production* (employment per mill € investment)

	Input structure	Contributing sector	Employment multiplier 1995	Employment multiplier projected to 2018-20)	Employment 2018-2020
Generator	4%	Electrical goods	14.22	8.5	1000
Gearbox	12%	Industrial machinery	13.6	8.1	2000
Rotor	18%	Rubber and plastic products	14.27	8.5	3000
Tower	18%	Metal products	19.84	11.9	4000
Brakes,	1.5%	Industrial machinery	13.6	8.1	0
Electronic	4%	Office and data processing machines	10.72	6.4	0
Nacelle (remainder)	42.5%	Industrial machinery	13.6	8.1	6000
Total	**100%**				16000

All employment figures have to be interpreted with caution. They do not represent job creation, at least not in the longer run. Also the total figures will be distributed over the lifetime of turbines, with the largest share in the production and installation period 2015-2020.

Security of electricity supply contribution and other indirect effects

The addition of more wind power will only contribute marginally to security of supply within the time horizon up to 2020. The positive impact from more wind generation at low wind conditions is only contributing little and the correlation with other wind generation in Denmark in no generation situations with no wind or storms is quite high. For short term variation (10min-30min) there might be a small benefit from placing the additional wind further west than any other Danish wind generation.

- More efficient generation due to increased interconnection if relevant

This part is only relevant if additional capacity is built as a direct consequence of the cooperation project. This issue directly depends on the establishment of a connection between Denmark and the Netherlands. If such a connection is built as a consequence of the cooperation project it will increase average generation efficiency.

- Less reserve requirements

The effect on the necessary reserves is seen as neutral. Additional interconnection will increase security of supply and thereby decrease reserve requirements, but a larger fraction of fluctuating energy in the system may require more reserves in some instances for example, where wind generation is changing rapidly and not fully predictable.

- Future expansion costs reduced

This effect will be associated to the offshore infrastructure development that may reduce future offshore grid investment costs. It is not expected that this investment in the Horns Rev area will have much effect on the technological development. It is not breaking new ground regarding offshore technology. The project will be quite similar to other offshore wind projects.

- Reduced risk in RES target compliance

The project is not expected to reduce the Danish risk on target compliance. On the other hand it is based on RES resources that are not expected to contribute to the Danish target and therefore do not increase the risk either.

- Possible effect from harmonizing connection, planning, and support administrative procedures (faster implementation of best practices)

There may be a possible positive effect on other Danish offshore projects contributing to the Danish 2020 targets in terms of more harmonised tender conditions and efficient administrative procedures. There is also a positive effect on the marketing part of attracting the attention for Danish offshore wind projects. As a result there may be increased competition in bidding for Danish offshore projects and thereby marginally reduced costs of Danish 2020 RES target compliance.

Environmental and health effects

Among the derived effects from cooperation is the effect on the environment and human health. The effect covers changes in emissions of CO2, NOx, SO2 and particles and occurs as the generation mix may change. Dependent on the assumption regarding physical transfer the effects will differ for the two countries.

Without physical transfer

In the case where there is no physical transfer, i.e. the energy production resulting from the cooperation is being sold at the Nordic electricity market Denmark will experience a decreased energy production from fossil fuels. As we do not assume that the capacity installed as a consequence of cooperation will actually replace other planned capacities, the effect on the capacity is simply increased capacity with an increased share of wind energy. The generation mix is however expected to be affected by the increased share of wind energy. The higher share of wind energy in the capacity is assumed to have two effects: 1. Increased export of electricity, and 2. A higher share of wind energy in the generation mix. Hence, we do not expect the higher share of wind capacity to fully replace generation of other technologies in Denmark. The second effect results in the environmental and health effects listed above.

As a rule of thumb we assume that only 50 % of the additional wind generation will replace electricity produced on other base load technologies, i.e. coal and biomass. With the point of departure in the assumption of the Danish Energy Agency (DEA, 2011) regarding the generation mix of 2020, we assume that the coal consumption will decrease with approximately 2.4 TWh and the consumption of biomass will decrease with approximately 1.7 TWh of which[3] approximately one third is straw and the remainder is wood chips.

[3] For the environmental and health calculations we assume this share. No external effects or emission data are given for biomass waste.

In the estimates of the environmental and health costs we include NOx, particles and SO2. We have not included the effects of CO2 emissions for the following reasons:

- There is no post 2012 agreement regarding specific targets for the CO2 emissions and hence no quota system. Therefore reduced CO2 emissions cannot be related to as a saving with regard to quotas
- Despite estimated costs of reduced CO2 emissions globally the CO2 emission reduction obtained globally as a result of an increased share of wind energy capacity in Denmark is subject to large uncertainty that we choose not to include these effects.

Based on the CASES study (CASES 2008a, CASES 2008b) (Table 5-9) we have estimated the savings related to health effects 0.17c€/kWh on average. Relative to the technology costs (see Section 5.1.2) the health costs are very limited and will only play a minor role in the negotiations regarding the transfer payment.

Table 5-9 External effects and emission data for Danish technologies, 2020

	External effects	Emissions		
		Hard coal CHP	Biomass CHP (straw)	Biomass CHP (woodchips)
	DK, €/ton	kg/kWh	kg/kWh	kg/kWh
NOX	4617	2.66E-04	1.71E-04	1.11E-04
PPMco	583	1.01E-05	1.76E-05	2.62E-06
PPM25	13181	1.14E-05	5.41E-06	8.08E-06
SO2	5017	1.92E-04	3.87E-05	1.38E-05

Source: CASES 2008a and 2008b

With physical transfer

In case of connection of the offshore wind farm to an interconnection between Denmark and the Netherlands we assume here that the entire amount of electricity consumption will be sold at the Dutch electricity market. In this case we assume that there is no effect on the Danish generation mix and hence there is no effect on the emissions of NOx, SO2 and particles in Denmark.

Network reinforcement cost

In the situation where a connection between Denmark and the Netherlands is established there will not be any need for network reinforcement in Denmark and hence no costs related to this. In case such a connection is *not* established there are two effects on the generation of the increased share of wind energy capacity: increased export of electricity and reduced base and intermediate load based on coal and biomass.

The total generation is expected to increase approximately 5 % which call upon minor reinforcement costs as the increased generation is expected to take place primarily within base and intermediate load. The project may contribute to some congestion in northern Germany, but this is not included here.

Negative impact on other supported RES investments

For the host country the lower price level will provide less investment incentives for all types of generators. For fluctuating RES generators the price impact is somewhat larger and hence the negative investment incentive for those based on feed-in premiums is also larger.

5.1.6 Ranking of not quantifiable costs and benefits

Among the difficult costs to quantify are the long term costs of having a less diverse power system with a transmission infrastructure with a very long lifetime that may end up with excess capacity if the cooperation projects are not renewed after the short lifetime RES technologies are decommissioned.

Benefits that are not quantifiable include the part associated with the public domestic opinion about contributing to meeting the aggregate EU target for RES and thereby increasing the probability that future increased targets will be accepted by all member states.

5.2 User country, the Netherlands

In the following we assess the costs and benefits for the Netherlands connected to engaging in cooperation with Denmark regarding 2 GW offshore wind capacity. We consider the effects on the Dutch power market and further assess the direct costs and benefits for the Netherlands to engage in cooperation mainly represented by the technology cost savings. Furthermore, we address the indirect costs and benefits related to cooperation such as the effect on the security of supply, employment effects and finally environmental and health effects.

5.2.1 Power market effects

Earlier (Section 4.2.2) we established that engaging in cooperation with Denmark would decrease the total share of RES of the electricity consumption from 28 % to 23.5 % and that the 2 GW wind energy would constitute a rather modest share of the entire Dutch electricity system. If actual electricity import is expected, cooperation may affect the power market price as well as volatility and thereby the composition of technologies and generation mix in the long run. However, Jansen et al (2011) suggest that even a rather large reliance on any of the cooperation mechanisms only has a mild upward effect on the power price in the Netherlands, compared to the base case (100% inlands RES production to reach the target). The main reason is the strong Dutch transmission network and the efficient interconnections of the transmission network system with neighbouring countries, the UK and Norway.

To conclude, we do not assume cooperation with Denmark regarding 2 GW wind capacity will affect the Dutch power markets significantly.

5.2.2 Direct costs and benefits

Cost savings for the Netherlands are calculated under two alternative assumptions:

a) saved policy costs based on a maximum accepted cost at 15c€/kWh (corresponding a medium to high cost offshore)
b) saved policy costs of 8200 GWh from the top of the levelised cost curve in the Netherlands as found from WP2 RES costs for Netherlands (assuming that cooperation with Denmark is the marginal project results in alternative compliance costs of 23c€/kWh) multiplied by the support period (e.g. 15 years)

The background for choosing these two levels of alternative costs for the Netherlands is a) that this is what developing offshore wind in the Netherlands is projected to cost and this is also what the willingness to accept for RES costs in the Netherlands seems to suggest. Assumption b) is based on the results from WP2 for the average cost of RES expansion that is needed to comply with the last 8200 GWh of the 2020 obligation for the Netherlands.

Calculating the net benefits for the user country, the Netherlands, for Option II is done by using the credit price of the above calculated 15.5 c€ per generated kWh in 2020 with Denmark willing to support post 2020 development with 5c€/kWh. As the alternative cost for the Netherlands, the full project support cost for the alternative development of offshore capacity in the Netherlands is used a) corresponding to 15c€/kWh.

In Option I it is examined the joint project as a transfer of the entire capacity to the Netherlands for the lifetime of 2000MW wind capacity. These two options cannot be compared with regard to the net benefit as there is a fundamental difference with regard to the post 2020 situation and uncertainty with regard to RES targets. With option I, the Netherlands would possess the entire 2000MW capacity to meet future RES targets. Like it was assumed for Denmark this has a value, which is however very uncertain in the present economic situation, where we might even experience difficulties for many countries in reaching the 2020 targets.

The results suggest that the savings for the Netherlands from this cooperation project could be of substantial size. As the main assumption case a) is depending primarily on the cost differential between offshore wind development in Denmark and the Netherlands (3c€/kWh) sensitivity on this assumption is illustrated in the table by using an alternative level of RES costs in the Netherlands b). For Option II the uncertainty regards the value of credits post 2020 for Denmark and a sensitivity illustration for that is shown as well. For all the illustrated cases there is a benefit that amounts to cost savings of 34% up to 98% of the alternative costs in the Netherlands. For the high savings this is not fully comparable with the low number since this option II does not provide Netherlands with RES credits after 2020.

Table 5-10 Benefits for the Netherlands with physical transfer (information on indirect effects not included)

Total credits: **8200 GWh**	**Option I Life time transfer of RES capacity to NL**			**Option II Credit price 15.5 c€ per KWh 2020 generation**		
	Total DK support costs financed by NL 5.7c€/kWh	Cost savings NL development support (8.7 c€) – 15 years	Net benefit 2020 (capacity available for post 2020 targets)	Total costs of credits	Cost savings NL development support (8.7 c€) – 15 years	Net benefit 2020 (excluding post 2020 targets)
Results: Main assumptions a)	7011 mill €	10701 mill €	3690 mill €	1271 mill €	10701 mill €	9430 mill €
Alternative costs of RES in NL (23 c€/kWh) b)	7011 mill €	20541 mill €	13530 mill €	1271 mill €	20541 mill €	19270 mill €
a) +Alternative DK credits price/value (6 c€/kWh)	-	-	-	123 mill €	10701 mill €	10578 mill €

Comparing the joint project approach in option II with total costs of credits 1271 mill € to other cooperation mechanisms is difficult. Some similarity could be seen with the possibility of buying credits via a certificate market scheme, for example the Norwegian/Swedish one. To use this option the Netherlands would have to buy certificates in 2020 where the target obligation for domestic Swedish consumers + the Netherlands should be raised corresponding to agreed transfer volumes of credits. In this way the costs for the Netherlands would also imply buying certificates on the Swedish/Norwegian market for a single year. Hereby the post 2020 risk would be similar to option II in the tables.

There are other uncertainties regarding the use of a foreign country Tradable Green Certificate scheme. It will for example be difficult to reflect the total necessary support cost for building additional RES in Norway/Sweden in the certificate price for a single year. Normally a gradual increase in the obligation over a period of years would produce a more smooth development of certificate prices. There will, if the target is increased for a single year (2020), be a tendency that the certificate prices will reach the level of the penalty and that the necessary RES generation to comply with EU 2020 targets are not realised. If the targets in the Swedish/Norwegian TGC scheme post 2020 are not also increased and the Netherlands take further commitments after 2020, certificate prices will certainly rise above the penalty level in 2020. How the deficit in 2020 is to be divided in 2020 between Sweden and the Netherlands would also pose a large problem with such a type of cooperation. This issue is addressed in more detail in the Deliverable 3.2 of the RES4Less project.

5.2.3 Indirect benefits and costs

In the following we assess the indirect costs and benefits for the Netherlands from engaging in cooperation with Denmark regarding a 2 GW offshore wind project. We consider the effects on the employment, effects such as security of supply, network reinforcement costs and finally environmental and health effects.

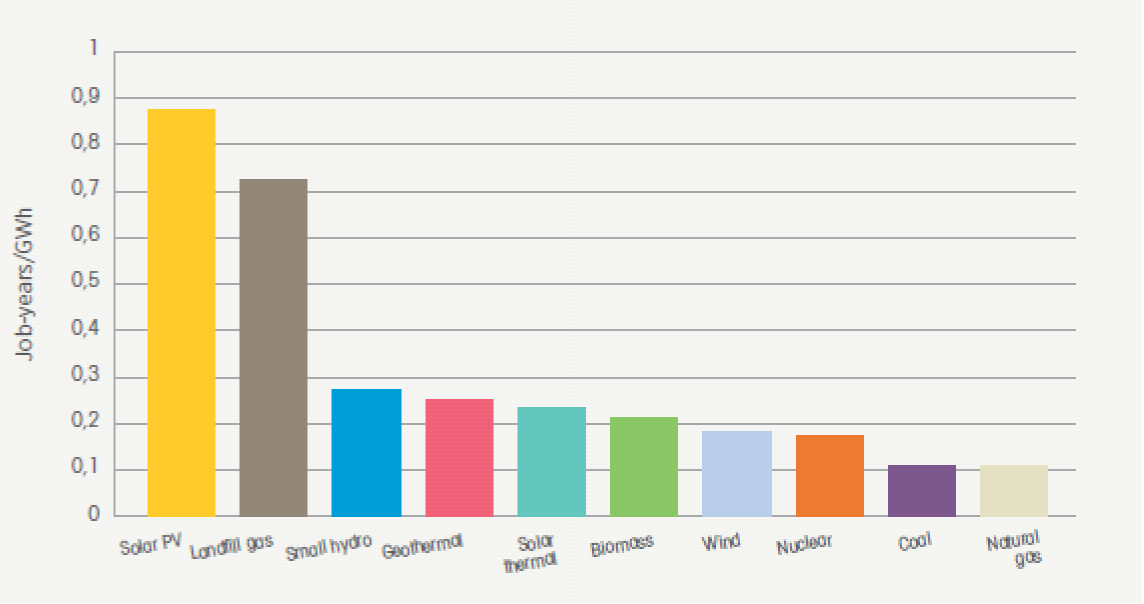
Employment effects

Considering the effects on the employment in the Netherlands as a result of cooperation with Denmark we have to consider the two situations with and without physical transfer. Without physical transfer the Netherlands have to maintain the same capacity as if there were no cooperation and in this situation we assume that the generation is based on natural gas combined cycle. In that situation we therefore compare the employment effects of 2 GW wind with 2 GW natural gas combined cycle.

In the situation with physical transfer the 2 GW wind in Denmark directly replace generation in the Netherlands and the effect is therefore the loss of employment corresponding to establishing 2 GW offshore wind capacity.

EWEA estimate that offshore wind is 2.5 to 3 times as labour intensive as onshore wind (EWEA, 2012). Based on the IRENA study (2011) estimating the employment effect given in job-years/GWh for onshore wind (Figure 5-6) we assume that the employment effect given in job-years/GWh for offshore wind corresponds to 0.17*2.5=0.42. The employment effects natural gas is 0.11 job-years/GWh.

Figure 5-6 Comparison of job-years across technologies (Job-years/GWh)



Source: IRENA (2011)

The net-effect on the employment as a result of cooperation is summarised in Table 5-11 showing that the negative impact on the employment is most noticeable in the case of physical transfer, where we assume that the employment effects will take place in the host country, Denmark, and no additional capacity will be added, hence, no employment will be generated. In this case the net-effect on the employment is -3444 job-years. Without physical transfer the net-effect on the employment is expected to be -2524 job-years.

Table 5-11 Employment effects, with and without physical transfer, job-years

	Offshore wind	Natural gas	Net effect
Without physical transfer	-3444 job-years	902 job-years	-2542 job-years
With physical transfer	-3444 job-years	-	-3444 job-years

Source: IRENA (2011) and own calculations

An employment effect of 2500-3500 job-years is quite modest in relation to the entire labour market of the Netherlands and will only constitute a minor role in the negotiation of the transfer payment.

Security of electricity supply

The impact on security of supply in the Netherlands is mixed: less generating capacity becomes available which would be negative for supply adequacy. Yet the capacity credit of offshore wind is rather low so this negative aspect is quite moderate. On the positive side, integrating offshore wind power injections reduce supply reliability – *ceritus paribus*. Hence if the Netherlands can do with less offshore wind, short-term supply reliability might increase. On balance, the security of supply impact will be limited given the robust Dutch transmission network.

Reduced risk in RES target compliance

Provided a transfer contract of target accounting units has been submitted to Brussels by the investor and the participating countries, the user investor country, the Netherlands, has reduced its risk

Environmental effects

As earlier it is relevant to consider the effects for both the situation with and without physical transfer of electricity. In the situation without physical transfer the Netherlands will have to maintain the same level of generation and the environmental and health effects are given by the additional generation based on natural gas combined cycle.

In the estimates of the environmental and health costs we include NOx, particles and SO2. We have not included the effects of CO2 emissions for the following reasons:

- There is no post 2012 agreement regarding specific targets for the CO2 emissions and hence no quota system. Therefore reduced CO2 emissions cannot be related to a saving with regard to quotas
- Despite estimated costs of reduced CO2 emissions globally the CO2 emission reduction obtained globally as a result of an increased share of wind energy capacity in Denmark is subject to large uncertainty that we choose not to include these effects.

Based on the CASES (2008a and 2008) we estimate the environmental and health effects from the needed additional natural gas combined cycle generation to be 0.7 c€/kWh.

Table 5-12 External effects and emission data for Danish technologies, 2020

	External effects	Emissions
	Natural gas combined cycle	
	DK, €/ton	kg/kWh
NOX	7680	2.54E-04
PPMco	2796	2.84E-06
PPM25	47082	8.68E-08
SO2	11228	6.48E-06

Source: CASES 2008a and 2008b

In the situation with physical transfer there are no environmental and health effects depending on cooperation or not, as the amount of electricity generated in the Netherlands is reduced relatively.

Relative to the total investment savings for the Netherlands the additional costs related to environmental and health effects are relatively modest and will only play a minor role in the negotiation of the RES transfer price.

Network reinforcement cost

In the case without physical transfer, there will be no need of network reinforcement in the Netherlands. In case a connection between Denmark and the Netherlands is established, there will be a need for minor network reinforcement in the Netherlands. However, the 2 GW wind is expected to produce mostly at base and intermediate load and will not give rise to significant need for reinforcement.

Negative impact on other supported RES investment

In the situation with physical transfer of electricity the envisaged project would reduce investment in other technologies the Netherlands.

5.3 Overview of results

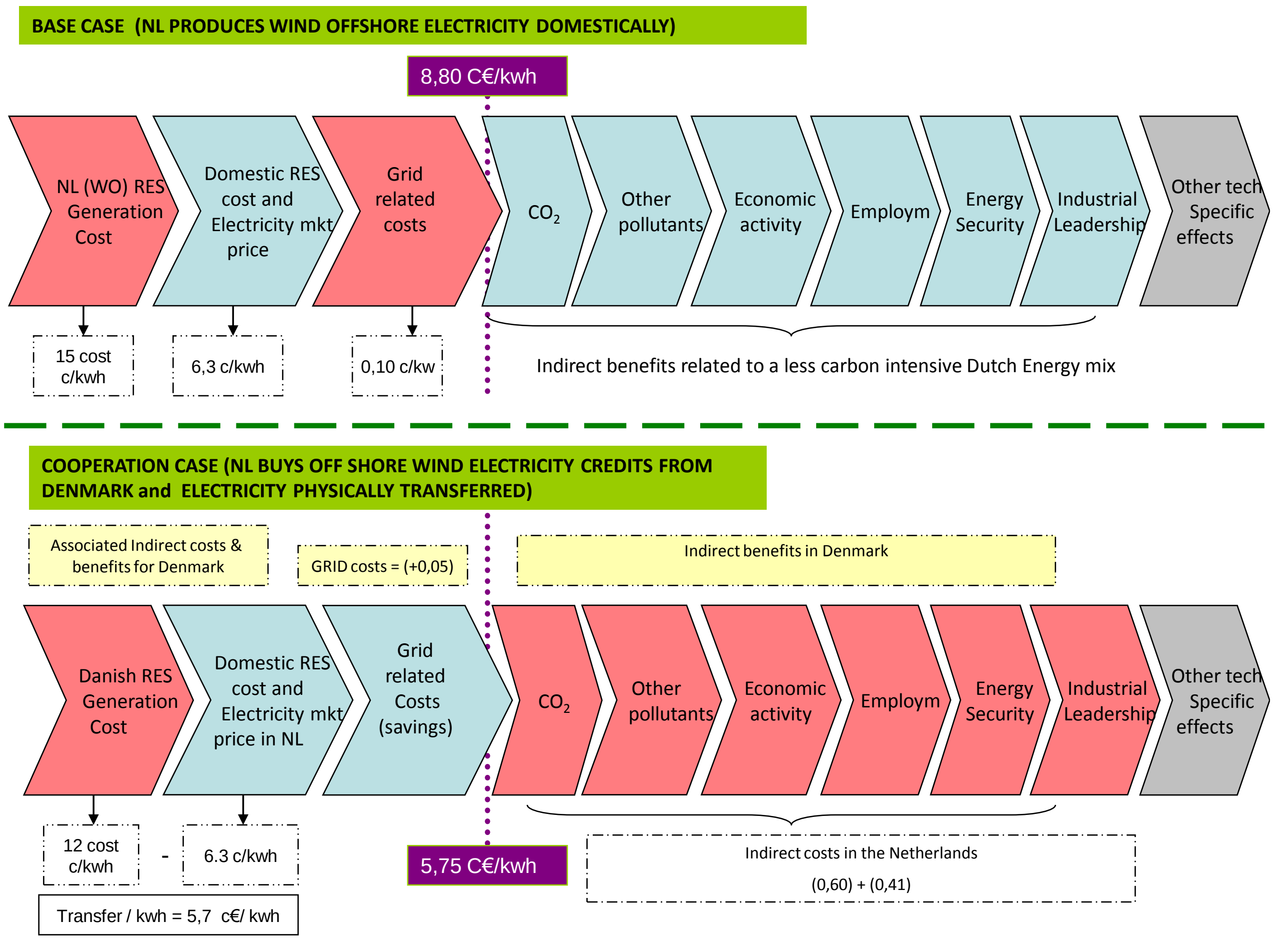
The cooperation project of 2GW of offshore wind capacity is expected to result in credits for 2020 of 8200 GWh that count towards the RES target for the Netherlands. The project risk is in the case assigned entirely to Denmark. Danish authorities will organise the tenders for the offshore wind farms and guarantee to investors that they will receive the promised support. When the tenders are held the Netherlands agree with Denmark to pay a fixed price for the credits in 2020 and receive in 2020 the credits for 8200GWh by a statistical transfer. Denmark can use the transfer amount, in the base case example 1.3 bill€, to finance part of the necessary support of totally 7.0 bill€. Table 5-5 illustrate sensitivity of the results for the Option II type of cooperation which is based on a situation where Denmark assigns a value to future RES credits. This is a cooperation case where the benefits of credits generated from a renewable project are shared among the host and the user country. For the associated risks Denmark has the entire project realisation risk and risk towards the investor. Denmark also carries the risk of the climate related variation in generation from wind that amounts to 10-15% annual variation. The clauses in the Directive about weather/climate related variations will reduce this part of the risk in case it will result in Denmark ending in deficit for 2020 which is most unlikely.

The assessment of the indirect costs and benefits given by employment effects and environmental and health effects revealed that the environmental and health effects from cooperation between Denmark and Netherlands are so limited, that they should only play a minor role in the negotiations of the RES transfer price.

The expected employment effects from establishing additional 2 GW offshore wind in the Danish waters are substantial as the expectation is that a considerable share of the production of the turbines etc. will take place in Denmark. The employment effects in the Netherlands are less distinct. However, the employment effects in the Netherlands will probably play a significant role when deciding whether to engage in cooperation or not.

In Figure 5-7 the option I type of cooperation is illustrated with physical transfer of electricity to the Netherlands. In this option we assume that the Netherlands pays the entire necessary support to the offshore wind farm in Denmark. That means the figures 8.80 c€/kWh and 5.75 c€/kWh are the annual cost for 15 years of meeting the RES target for Netherlands in 2020 by expanding RES in the Netherlands and Denmark respectively. The savings from the cooperation thus amounts to 3.05 c€/kWh for the lifetime generation of the 2GW wind capacity which the case is based on.

Figure 5-7 Overview main effects from option I type of cooperation for Denmark and Netherlands



6 RECOMMENDATIONS AND CONCLUSIONS

6.1 Institutional and legal barriers

Assessing the barriers to cooperation between Denmark and the Netherlands revealed that neither the barriers related to support systems, power market effects or regulatory issues is expected to constitute barriers to cooperation. Only the missing penalty for non-compliance and the lack of post 2020 targets in the EU policy will become a problem and in particular the issue of the lack of post 2020 targets is expected to constitute a challenge to cooperation. This issue will have to be dealt with when agreeing on the future RES transfer price.

6.2 Results

Danish offshore wind development is available for cooperation and joint projects with tendering is relatively simple to establish as it requires no change of support system or legislation. The offshore potential around the Horns Rev area in the North Sea is large and can accommodate up to 2000 MW wind capacity at locations of water depth, wind condition and distance to shore that result in levelised generation costs around 12c€/kWh.

The main conclusion of this case study is that cooperation benefits exists, and that there are two very different options for entering into these types of joint projects. Netherlands could:

I. Acquire the full RES capacity credits necessary for 2020 compliance (no physical transfer of the power generation): Cost example, support cost for 15 years: 80 Euro/MWh annually **corresponding to 1200 Euro/MWh for the 8200 GWh 2020 credits**
Capacity counts towards the Netherlands post 2020 targets (reduced risk)

II. Acquire only the credits necessary for 2020 compliance: Cost example, **350 Euro/MWh in 2020 for the 8200 GWh 2020 credits**
The Netherlands bear the full risk on post 2020 target compliance

Option I is the most expensive and corresponds to Netherlands paying the support (premium over the market price) necessary for Danish investments in these offshore condition given for the Horns Rev area. This option can be compared to the other case studies (D3.4 and D3.5) but then a lifetime cost figure of 8c€/kWh is the comparison criteria without physical transfer and 5.7c€/kWh with physical transfer.

In option II Denmark will have more wind development than needed for 2020 compliance but as a benefit of the cooperation receive a financing contribution to higher domestic targets for RES shares after 2020. As such Denmark will also have additional credits to comply with increased post 2020 EU RES targets.

Benefits in terms of compliance cost savings for the Netherlands can be substantial, i.e. **2.5 bill € - 9.4 bill € depending on design option.** The results for both countries in option II are extremely sensitive to the assumptions regarding the value of post 2020 credits. This has highlighted the important uncertainty that the missing **EU post 2020 targets** is causing and the effect it has on the willingness to engage in cooperation mechanisms.

Indirect effects have been concentrated on the employment effect that is often used as an important objective for domestic RES support policies. The employment in Denmark associated with the project is found in a range between directly 10000 man years and 40000 man years estimated from input output multipliers and including both direct and indirect employment. The last number should be seen as most uncertain and at the high end of realistic figures. No quantification of the employment effect has been made as both the employment effect and the economic benefit from it is uncertain.

The assessment of the indirect costs and benefits given by employment effects, environmental and health effects revealed that the environmental and health effects from cooperation between Denmark and the Netherlands are so limited, that they should only play a minor role in the negotiations of the RES transfer price.

Regarding the employment effects the expected employment effects from establishing additional 2 GW offshore wind capacity in Danish waters are substantial as the expectation is that a considerable share of the production of the turbines etc. will take place in Denmark. The employment effects in the Netherlands are less distinct. However, the employment effects in the Netherlands will probably play a significant role when deciding whether to engage in cooperation or not.

An option of dividing the 2GW in continuous phases of 200MW was also studied and this case specifically illustrated for a variety of sensitivity assumptions regarding cooperation option II and technology costs. The 200MW is basically different from the 2GW in two respects only:

1. A smaller project of 200MW may be located at a lower cost location in the Horns Rev area than the average of 2000MW.

2. The influence on power prices in Denmark will be very marginal and the integration in grid is definitely unproblematic.

6.3 Recommendations

Based on this case study it is recommended that it is clarified by EU authorities if the option II is a suitable and acceptable way of meeting the 2020 targets. This would reduce compliance costs in 2020 for some countries that have a priority for cost minimising solutions for 2020 and do not have ambitions for future higher RES targets. At the same time it could contribute to other host countries with higher RES ambition targets to achieve these at lower cost.

In the longer term this may contribute to setting also higher targets for the entire EU as compliance cost will be lower as some countries have already exceeded the 2020 targets.

Furthermore it is recommended that some clarifications on the future targets of the EU as a whole are announced which also state that each Member State should at least maintain 2020 RES shares in the future.

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