LARGE SCALE OFFSHORE WIND ENERGY IN THE NORTH SEA - A TECHNOLOGY AND POLICY PERSPECTIVE

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Summary

With the ground breaking 160 megawatt wind farm Horns Rev outside the coast of Denmark in the North Sea up and running, the offshore wind energy experts are looking ahead with optimism. With a portfolio for offshore wind farms in north-western Europe that foresees in an accumulated installed power of more than 3 gigawatt by the end of 2006, the future indeed looks bright. But will the expectations for offshore wind energy be met?

Based on experience from technical and market-orientated studies on offshore wind energy (OWE), the Energy research Centre of the Netherlands ECN concludes that the growth of OWE in the next few years will mainly be hampered by insufficient policy support rather than by technical barriers. The realisation of the first two offshore wind farms have been delayed considerably. Only recently it was officially announced that the Dutch policy will shift to a concession system for the issuing of exclusive rights for plots in the North Sea in 2003. For the tendered sites surrounding the UK coast, the margins appear to be relatively tight. Moreover, according to market models, the incentives for offshore wind energy in Germany are insufficient to make it successfully compete with other energy sources in the liberalised European market.

The main technical challenges are the increase of turbine availability by improvement of turbine O&M and a further reduction of wind farm array losses by introducing new ways of turbine operation and farm layout. Focusing on The Netherlands, a significant upgrade of the grid is required to successfully feed in the Dutch goal of 6000 megawatt in 2020.

Keywords: Offshore, North Sea, Costs, Potential, Forecasts, Models, Policy.

Introduction

At the EWEC 2003 in Madrid, the European Wind Energy Association announced that the goal for European offshore wind energy will be 10,000 MW (megawatt) of installed power in 2010 and 70,000 MW in 2020 (conservative approaches to its own belief) [EWEA, ref. 6]. What are the main challenges that the industry will be facing? This paper summarises the conclusions of technology, policy, and market-related ECN studies on offshore wind energy carried out by the departments Policy Studies and Wind Energy. The aim is to provide a more integrated vision regarding the perspectives for wind energy in the Dutch North Sea and in other Western European countries. The paper addresses technical issues (1), market competition for offshore wind energy (2), and policy aspects (3). After a more elaborate description of the market study ADMIRE REBUS (4), conclusions are drawn (5).

This paper does not provide an in-depth analysis of the aspects involved in the design and operation of offshore wind farms. See the list of references for more in-depth studies.

1 Technical Perspective for OWE in the North Sea

Present situation and potential penetration of offshore wind

The total amount of installed offshore wind power in Europe in April 2003 is around 280 MW, of which 164 MW is placed in the North Sea (Beurskens ref. [1]). At this moment this is the first and only large offshore wind farm in the North Sea near Horns Rev with a capacity of 160 MW , commissioned in December 2002 (apart from Blyth). The next major projects that are near completion are the Nysted offshore wind farm in Denmark (around 165 MW), 'North Hoyle' in Wales (60 MW) and a farm outside the coast of Zeebrugge in Belgium (28 MW). The total capacity of planned projects in Europe with an expected commissioning date before 2007 is just over 3000 MW. Approximately 1650 MW of these proposed projects are located in the North Sea. The total capacity of currently proposed offshore projects in Europe adds up to as much as 25 GW [Beurskens, ref. 1]. From these plans it can be concluded that the EWEA targets of 10 GW in 2010 and 70 GW in 2020 [EWEA, ref. 6] will almost certainly be achieved.

The building and commissioning of the first two wind farms in the Netherlands Exclusive Economic Zone (NEEZ) is scheduled for 2005. These are the 60 x 2 MW ’Q7 wind farm’ and the 36 x 2.75 MW ‘near shore wind farm’. Permissions for future offshore wind farms in The Netherlands will be issued on the basis of an exclusive concession system [Ministry of Economic Affairs, ref. 13]. Once granted, competing stakeholders will have to wait pending the approval procedure for the first contender. The maximum size of a concession in the NEEZ will be 100 km^2. This new system will officially take effect in 2004 and replaces the rather restricting so-called preferred areas policy. In any case, according to earlier agreements, future farms must be placed outside the 12 nautical miles (12 nm) border of the Dutch coast. The Near Shore Wind farm is one-time exception to these plans.

Cost and potential of OWE in the Dutch North Sea: OWECOP project

Under the project acronym OWECOP (Offshore Wind Energy – Cost and Potential) ECN studies the possibilities for offshore wind energy. OWECOP is a tool that combines a Global Information System (GIS) with an integrated cost model. Using the properties of a specific location as they are stored in the GIS database, the cost and scope of offshore wind energy are assessed. So far, the focus has been on the Netherlands Exclusive Economic Zone of the North Sea (NEEZ). The surface of the Dutch North Sea is about 57 thousand square kilometres large. The primary reservations are routes and areas restricted for ships and for military training zones. The potentially available area for offshore wind energy may be analysed using custom defined conditions. For example: summing up the available sea area with a water depths of less than 35 meters that is outside the 12 nautical miles border, yields a technical potential for wind energy in the NEEZ of approximately 27% of the NEEZ, i.e. 15 thousand km^2 (Figure 1). However, much of this area consists of plots that are too small for wind farms. Nevertheless, the 1000 km^2 required to realise the target of 6000 MW appears to be available, although the spread in cost efficiency of the different sites is significant.

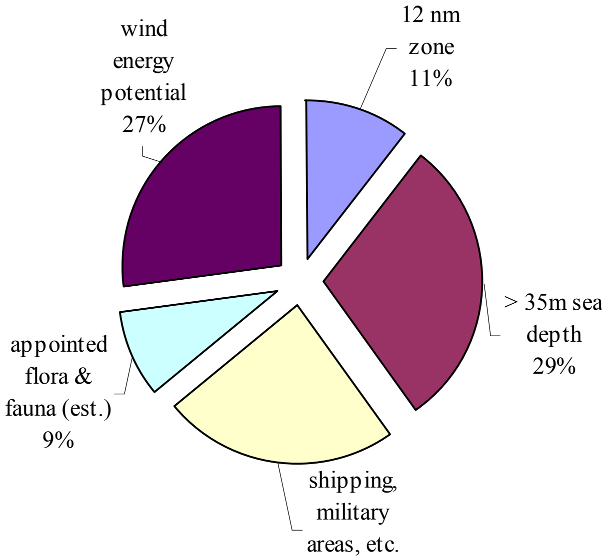

Figure 1: Breakdown of available sea area in the NEEZ.

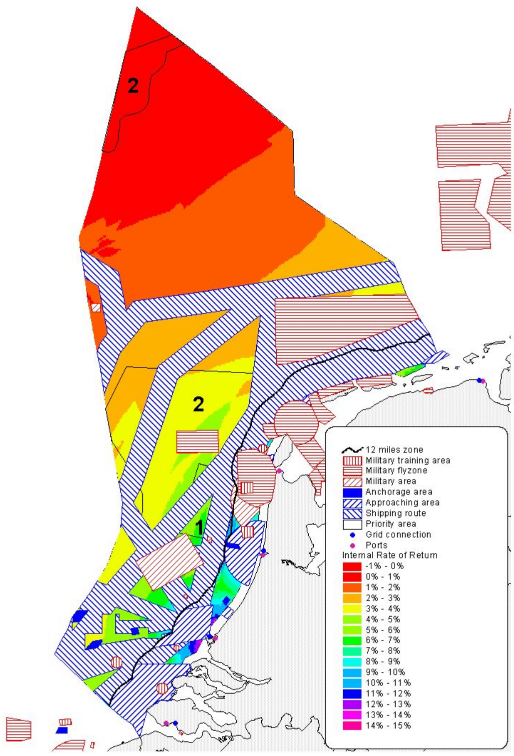

Figure 2: Internal Rate of Return for OWE in the NEEZ (example).

Having established custom-defined wind farm properties and combining these with arbitrary economic properties, the wind energy production costs, or similarly, the internal rates of return are straightforwardly calculated with OWECOP. Figure 2 gives an example. In principal, the procedure can be applied to any sea area other than the NEEZ, provided that the cost models are validated and geographical information is available on wind speed, water depth, etcetera.

Operation and Maintenance

Wind energy at sea calls for maintenance strategies that are quite different from those on shore. The more demanding environment offshore intensifies the wear of components while at the same time accessibility to the turbines is more difficult. Various studies show that averagely 25% to 30% of the energy generation cost goes into O&M. Corrective maintenance, i.e. after a failure is detected, is about two times more expensive than preventive maintenance [Rademakers et al., ref. 16 and 15]. In the case of predicted failures, however, repair costs are significantly less. Moreover, weather windows are more favourable if the work can be scheduled beforehand. The possible revenue losses involved with offshore wind farms is high, particularly because of the large amount of installed power which operates with a relatively high capacity factor. Thus, there are many reasons to keep downtime to a minimum. All actors should therefore seriously consider if they can:

- increase the reliability of the turbines,
- enhance the workability to carry out maintenance. e.g. by developing custom made access systems (Figure 3),
- reduce the maintenance costs, e.g. by developing a system for onsite hoisting,
- develop an optimal preventive maintenance strategy during the design stage through the use of probabilistic calculations on possible failure of the turbine, and
- use condition monitoring once the turbine is operating to monitor wear of components in order to prearrange any necessary action.

Once the turbines are in operation, the collecting of failure or near failure data will assist in further optimising maintenance schemes (the more, the better). Condition monitoring of key components is currently gaining interest. Although it does not prevent failures, consequence damage may be prevented. Moreover, maintenance actions can be better planned, design assumptions can be validated (and consequently modified) and condition monitoring may limit costlier regular inspections. Together with turbine owner Siemens, Risø Garrad Hassan, and other partners in a European project called CONMOW [Braam, ref. 2], ECN aims to define the added value of condition monitoring through the interpretation of signals and to demonstrate how to change from corrective maintenance to condition-based maintenance. As yet, no results can be reported .

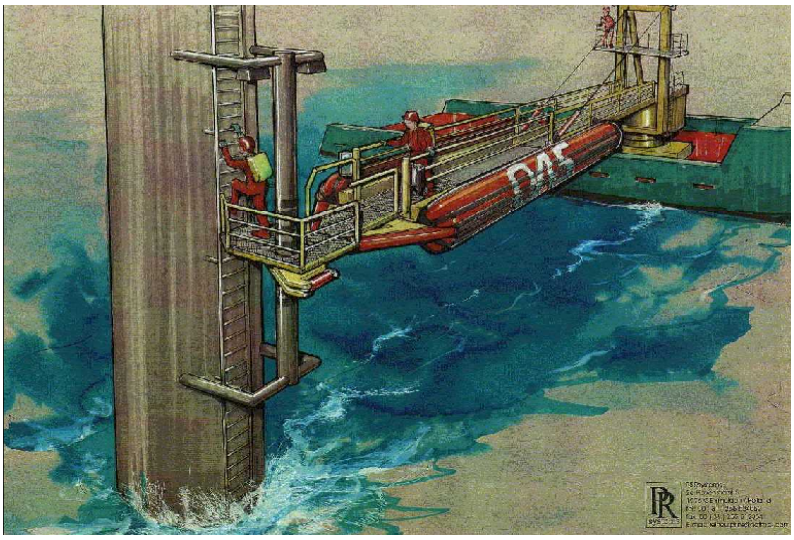

Figure 3: Innovative access system from P&R systems.

Integral design of a large offshore wind farm: DOWEC project

In the DOWEC project (Dutch Offshore Wind Energy Convertor) in which ECN participates together with TUD, Ballast Nedam, LM, NEG-Micon NL and Van Oord ACZ, a 500 MW offshore wind farm was designed and optimised. As a project result, the prototype wind turbine of 2.75 MW was built. This turbine will be used in the 100 MW Near Shore Wind Park project in the Netherlands.

In the DOWEC project, the cost of energy was quantified in terms of the Levelised Production Costs (LPC) [Zaaijer et al., ref. 21]. Therefore, all costs involved from the design of the wind farm to the decommissioning of the wind turbines were considered. The study has shown that the produced electricity at an offshore location in the Dutch North Sea can be competitive in the electricity market, provided that an adequate electric infrastructure, installation procedure and O&M strategy is scheduled [Herman, ref. 9]. Figure 4 shows an example of the DOWEC results when using 6 MW wind turbines for a 500 MW offshore wind farm.

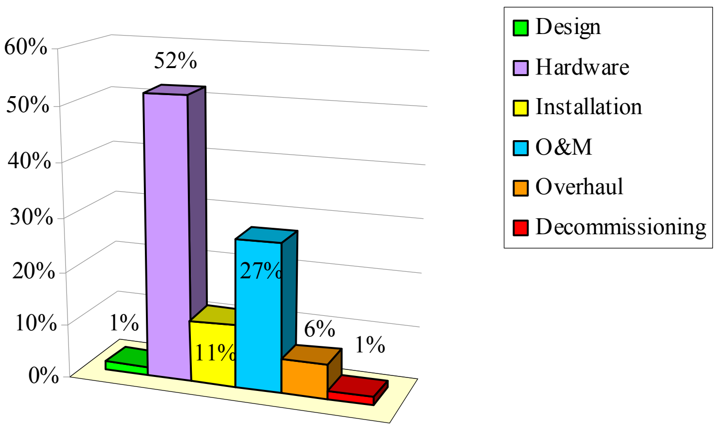

Figure 4: Result from comprehensive DOWEC cost model; contributions to LPC.

Within the DOWEC project, wind turbine control alternatives, different foundation types and the use of scour protection were also evaluated. Moreover, parametric studies were performed to , analyse, among others, the influence of the distance between the wind farm and the grid connection on the LPC for the considered wind farm. An overview can be found in [Herman, ref. 8].

Electrical Infrastructure
From specialised studies, e.g. by Garrad Hassan for Ireland [GH&P, ref. 7] and by KEMA and Delft University of Technology for the Dutch North Sea [KEMA, ref. 10], it can be concluded that large offshore wind farms must be treated similar to onshore power plants. Intermittence should be reduced and predictability of power will need to be enhanced. The feed in the Dutch electricity grid of 6000 MW offshore wind power from the Dutch North Sea will impose significant demands on the grid onshore. The two most important issues are the enhancement of transport capacity and also ensuring that sufficient capacity is upheld to regulate voltage levels and reactive power throughout the grid [KEMA, ref. 10]. The study also concludes that at least two major feed-in locations for offshore power are needed to guarantee adequate balancing of power.

For the short-term balancing of electrical power in the Dutch grid (i.e. on a seconds to minutes scale) it is expected that no further adjustments are needed. The long-term balancing of power (time periods of a quarter of an hour to several days) seems more difficult but again adjustments can be avoided, provided that

- the operating method of offshore wind farms shifts more to that of a conventional power plant rather than simply maximising the power output,
- application of power prediction methodologies that are now being developed, e.g. ref. [3], will be widely implemented.

For the long-term balancing of power, adequate distribution of wind power in the Dutch North Sea, i.e. taking advantage of regional variations in wind speed, may be helpful.

KEMA estimates that the cost of necessary adjustments to properly feed in 6000 MW offshore wind power in 2020 lies between 200 and 550 million euros extra when compared to the situation where no offshore wind is applied at all. This corresponds to approximately 2.0% to 5.5% of the total investment costs (around 10 billion euros). The lowest costs apply to the situation where the feed in points are located on the west coast. This is the most densely populated region of the Netherlands, as a result of which transport of power is limited. Different investment sums may be required when using different requirements for stability and transport capacity of the grid. Also important are the properties of offshore wind power itself, e.g. its potential to provide reactive power. Dynamic models are necessary for a more reliable analysis and conclusions regarding modifications of the grid. Such work is carried out in the ERAO II project by ECN, Delft University of Technology and NEG Micon NL, which started in 2002. In the recently completed first part of the ERAO project [Pierik, ref. 14] different options for grid connection have been compared using a quasi-steady state model. It has been concluded that on the basis of minimum cost of energy, an AC grid connection to shore is to be preferred. This is mainly because of the lower investment costs of AC compared to DC. The differences in transport efficiency are generally small, hence having little effect on the outcome.

Turbine Operation and Farm Layout
The average number of wind turbines in a farm has strongly increased over the last years. Now that technology has matured, project developers benefit from economies of scale. Besides this aspect, there is a desire to depreciate project costs that are rather insensitive to the size of the farm over as many turbines in a project as possible. This particularly applies to offshore wind farms where project management, the mobilisation of transport and installation vessels, and grid connection weigh heavily on the total investment. As such, designers have spent much effort on determining the most economic layout of a wind farm and the number of turbines it should comprise.

In addition, researchers at ECN Wind Energy study on the optimal operation of the individual turbines that will yield the maximum farm output. Or rather, they have focused on the advantage to sub-optimise the output of individual turbines in the front rows of a farm. A reduction of the induction factor for these wind turbines by modifying the rotor speed control alleviates the de-acceleration of the wind that is passing through the first rotor disk areas. Consequently, the power of the turbines that are next in line is increased and ultimately the power of the farm as a whole is enhanced. The principle is shortly referred to as 'Heat & Flux' [Corten, ref. 5] and [Schaak and Corten, ref. 4]. During the spring of 2003, wind tunnel experiments were carried out by ECN to validate the above theory. ECN also studies the profit that can be gained from deflecting the wakes, a concept first described by Davide Medici of the KTH Stockholm [ref. 12]. There is also a third way assessed by ECN to improve the array efficiency. This idea is still in a confidential stage.

2 Market perspective for OWE in the North Sea

Whether the level of implementation of the many planned projects is cost-effective remains questionable at the moment as is shown by results from market analysis using dynamic models [ADMIRE REBUS, ref. 20]. In principle, wind energy is an intermittent source of energy; power output relates directly to wind speed. This affects the market potential of wind power, as is elucidated in the text below. However, it is noted that by sub-optimising the power output for example, wind farms can to some extent be operated as fast reacting power plants, i.e. be less intermittent. In any case, the more traditional approach of maximising the power output under all circumstances will not be the way offshore wind farm will be operated.

Electricity Market
The introduction of large-scale offshore wind farms has a significant impact on the dynamics of the liberalised electricity market. The low marginal costs of wind energy, together with the intermittent characteristics of production, affect the price on the wholesale and balancing markets; the latter exponentially increasing with the degree of penetration.

Short-term price effects, system balancing

The key driver for the costs associated with system balancing is the amount of random power fluctuation caused by unpredictable changes in load and generation that need to be accommodated. Electricity sources from wind energy are intermittent sources of production, i.e. having a non-controllable output. As the power sector has to be continuously balanced, otherwise facing the collapse of the system and therefore considerable economic costs, intermittent electricity sources are to a larger or lesser extent a liability to the system. To qualitatively analyse the impact of an increase in offshore wind generation, i.e. an increase in intermittent production in the balancing price, the penetration level of this technology should be considered. It is widely argued that with introduction levels of intermittent energy sources of more than 20%, balancing costs rise considerably. This is because a number of extra measures have to be put into practise (UNIST, 2002).

When penetration levels of intermittent energy sources are lower than the aforementioned level, an increase in price fluctuations would be expected because of the increase in the percentage of fluctuating generation. However, when intermittent generation reaches 20% or 30% of the total demand there will be occasions – low demand and high output of wind generation – that demand is so low that the number of conventional units needed to supply the remaining load will be so few that adequate levels of ancillary services can not be maintained. In this case, extra measure should be put in place, increasing the balancing costs significantly.

Long-term price effect, wholesale market

The introduction of offshore wind also has an impact on the commodity price in general. Due to its low marginal costs it would drive more expensive technologies out of the market. This process is analogous to the effect the increase of imports had on the Dutch electricity market at the beginning of the liberalisation process in 1998. Cheaper imports from neighbouring countries, namely Germany and France, drove more expensive technologies, namely combined heat and power (CHP), out of the market.

In order to quantitatively analyse the effect of introducing offshore wind energy in the Dutch power market, ECN Policy Studies developed a number of scenarios, which included different penetration levels of offshore farms. The scenarios were calculated with ECN's 'Powers model' [Rijkers, et al. 17]. The model simulates a competitive electricity market and strategic behaviour of market parties by simulating the supply sector of the electricity market with a certain electricity demand.

The first issue investigated with Powers was the effect of offshore wind on the commodity price. Maintaining all factors unchanged (ceteris paribus), the penetration level of offshore wind was step-wise increased in order to study its impact on the commodity price. The second issue was the profitability of offshore wind energy penetration under the new market situation. The investment of new capacity was done in an exogenous and iterative way. First the model was run without any new investments. Depending on the resulting future price development, new investments entered the market until the marginal project stopped being profitable. It is of course consistent with this approach that variants with higher prices achieve higher levels of investment in capacity, and conversely variants with lower prices achieve lower levels of investment in new capacity. Furthermore, a number of thermal investments i.e. gas-fired plants, were also introduced in the scenarios, filling up the gap between larger future demand, the decommissioning of old thermal capacities and an increase of offshore wind energy capacity.

Table 1. Offshore implementation path in the Reference Scenario for The Netherlands

Implementation year	Offshore Capacity [MW]
2006	150
2007	300
2008	300
2009	300

The implementation path towards 2010 from the reference scenario of offshore wind farms in The Netherlands is shown in Table 1. The amount of conventional capacity needed to meet increasing demand towards 2010 is around 2200 MW, on top of 1050 MW of offshore capacity in the reference scenario. It must be noted that the profitability analysis is based on the Dutch renewables policy in place until July 2003, i.e. before the introduction of the MEP regulation [Sambeek, ref. 18].

The resulting price development in the electricity market is shown in Figure 5. During the first years, wholesale price is to some extent higher than short-run marginal costs of production. Nonetheless, it can be argued that the pressure of competition and existing overcapacity can even force prices to reach short-term marginal costs of production. As time passes by, with the increase in demand and the closure of a number of plants in the year 2005, overcapacity in the sector decreases, raising prices.

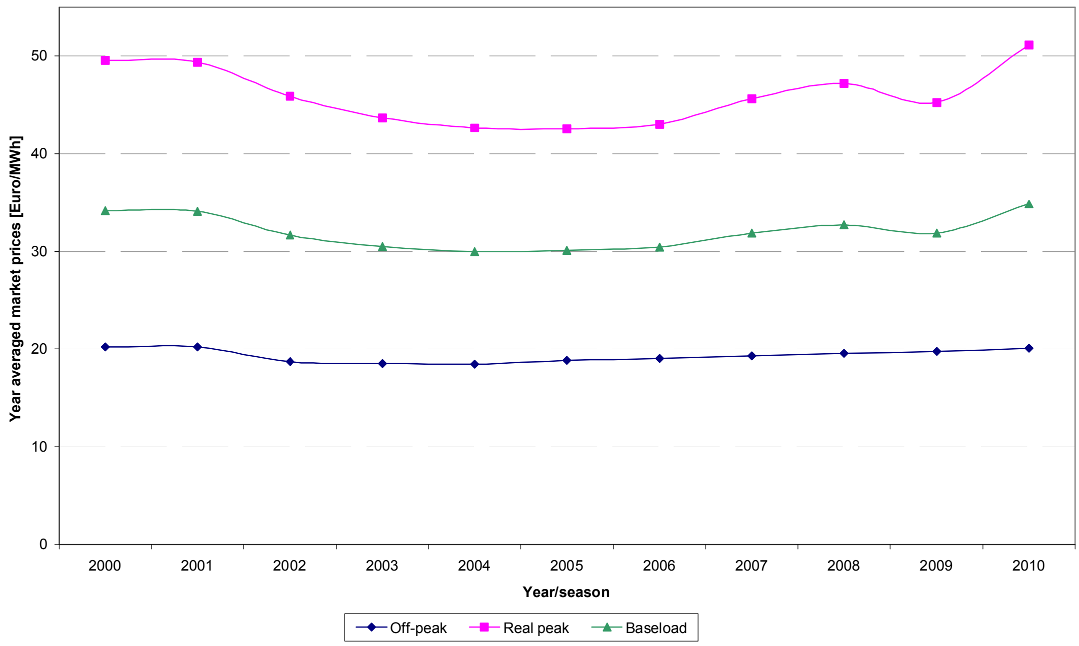

Figure 5: Development of off-peak, real peak and base load prices in the reference variant.

3 Policy in relation to OWE development

Currently the production from renewable sources still partly depends on financial support policies. An offshore wind energy project developer can expect revenues from two markets.

- First, the electricity price paid on the regular electricity market. The price development on the regular electricity market depends on the future development of current means of electricity production, mostly from fossil fuels and nuclear energy. It can be expected that due to the intermittent character of wind energy a penalty can be charged for the dispatching of balancing power.
- Secondly, payment for the greenness of the electricity on the market for electricity from renewable sources. Depending on the type of financial support scheme used, this part of the revenue will be gained on a market or paid directly, for instance as a feed-in tariff.

The market for electricity from renewables has not yet fully developed. The market has a fragmented character, because all EU Member States are using their own national support policies. The differences between the countries are large, both in the level of support granted and in the choice of policy instruments.

Support policies can roughly be divided into two groups. Generic policy instruments treat all renewables in the same way, while technology specific policies, such as feed-in tariffs or most tendering systems are tailored to for example offshore wind. Generic policy is usually shaped as a quota obligation, obliging market actors to have a certain share of renewable electricity in their portfolio. In this case, Tradable Green Certificates (TGCs) provide a cost-effective means of achieving a quota, because trade stimulates deployment of renewable energy based technologies in the most efficient areas and countries. Furthermore, the level of ambition of the target or obligation is reflected in the price of the TGC. In this market-based system, offshore wind energy has to compete with other technologies and the level of the TGC price directly determines its chances on the market.

Currently, specific policies for offshore wind are used in Germany and the Netherlands - feed-in tariffs, and Ireland – i.e. the tendering system AER 6. Tailored policies for offshore wind energy such as in Denmark can lead to good results as has been shown in the past. Examples of countries where offshore wind energy is covered by generic policies (quota obligations) are Belgium and Sweden.

On 27 October 2001, a major milestone in renewable electricity policy in the EU was reached with the adoption of the Directive on the promotion of electricity produced from renewable energy sources in the internal electricity market. The Renewables Directive establishes indicative targets for each Member State for the penetration of renewables. Furthermore, the Directive establishes a kind of minimum framework for renewable energy policy development in the Member States and as such a start for harmonisation of Member State support schemes in the longer run. In 2005, the Commission will present a report on the experience gained with the application and coexistence of different support schemes in the Member States. Based on the findings from the Commission the report may be accompanied by a proposal for a Community framework for RES support schemes. However, the Directive also stipulates that such a proposal for a harmonised support framework should allow a transition period of at least seven years in order to maintain investor confidence.

4 A tool to analyse market interaction with other energy sources: ADMIRE REBUS project

The future market development for offshore wind energy can be analysed using the ADMIRE REBUS model. The ADMIRE REBUS project has been carried out by a consortium led by ECN Policy Studies in the period 2002-2003. The main purpose of the project has been to analyse the market barriers, support policies and potentials for renewable electricity production in Europe. For these analyses a new tool was developed that simulates the development of the European renewable electricity market under different policy scenarios. This tool – the ADMIRE REBUS model – can be used to identify the key market opportunities for investors and traders and to assist policy makers in developing renewable electricity policy strategies.

The ADMIRE REBUS model explores the development of the EU renewable electricity market and provides the investors in renewable capacity with insight in this developing market. The current EU renewable electricity market shows a variety of institutional settings that, when interacting on the emerging international market, may cause trade barriers and distortions. The ADMIRE REBUS model is based on a dynamic market simulation in which national RES-E supply curves are matched with policy-based demand curves. The results are calculated in a way that takes into account the discriminative characteristics of some policies and the ability of producers to choose whether they produce for the domestic market or wish to trade their production.

Although this paper focuses on expected developments for offshore wind, it is useful to describe the two main policy scenarios on which the ADMIRE REBUS analysis is based and which form the background against which offshore wind could develop. It should be noted that these two scenarios represent the extremes, as illustrated in Figure 6.

- 'Fragmented market': continuation of present & planned policies
- 'Targets/Trade and harmonisation': maximum policy effort to achieve targets by means of an EU-wide introduction of quota obligations, based on the targets stated in the Renewables Directive and combined with trade in an open market. In scenarios used for the analysis, trade starts in 2004. Although this is unlikely, it does provide a clear reference point when comparing the two scenarios.

In the next decade, the market will continue to be shaped by policies and the ambition levels of national governments and the EC are major determining factors. In reality, developments are likely to be more moderate. One direction could be clustering: a 'bottom-up process' where groups of countries start trading and harmonising their systems based on similarity of their support schemes.

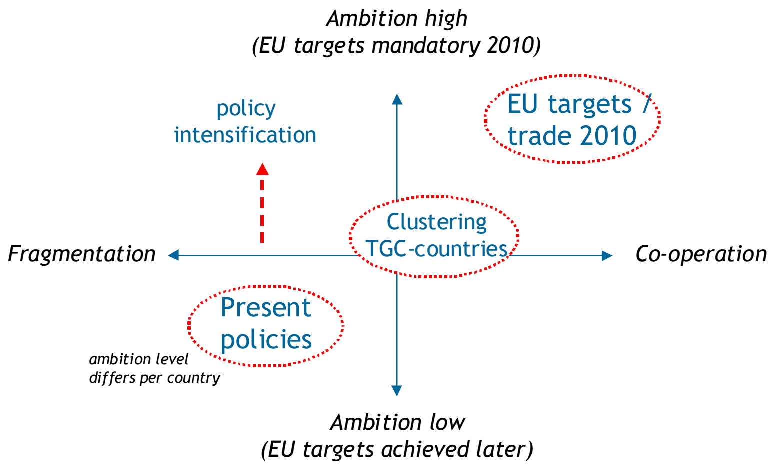

Figure 6: ADMIRE REBUS policy scenario's.

The model results show that in the scenario of continuation of present policies the EU Renewables Directive targets for 2010 will not be met. On an EU level, on average only 82% of the targets will be achieved. Some countries will meet their national target as set in the EU Renewables Directive, but most of them will not. On the other hand, targets will be achieved in the EU Targets/Trade 2010 scenario due to the enhanced possibilities for trade of renewables. However, this achievement results in high TGC prices and thus higher costs for the community compared to the 'present policies scenario'. A selection of the model results for offshore wind energy is shown in Figure 7.

As can be seen from Figure 7 there will be a modest yet declining growth until 2010 with continuation of present policies, but the EWEA target of 10 GW in 2010 will not be met. Development will mainly take place in Denmark, The Netherlands and the United Kingdom. Specific offshore wind policy support levels across the EU are too low compared to the expected future investment costs of offshore wind energy to build profitable projects. If offshore wind can only benefit from generic policy support, competition with other renewable sources reduces its possibilities. Remarkably, with the current German offshore wind support scheme there will be no market opportunities in Germany at all (see also the next section), despite the enormous amount of proposed projects.

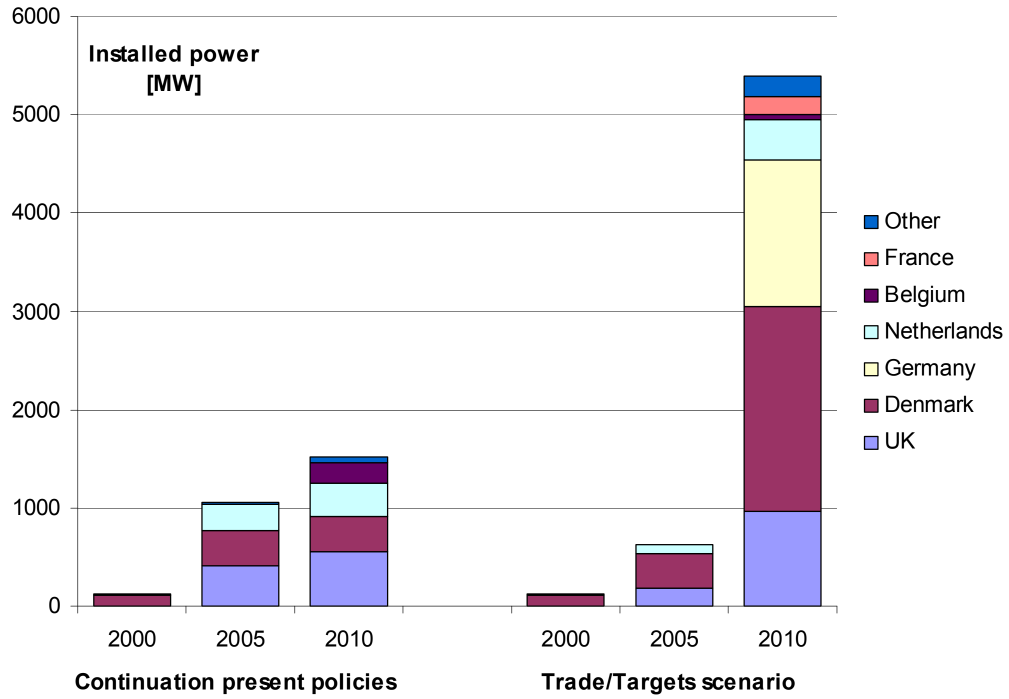

Figure 7: ADMIRE REBUS mode results for offshore wind energy.

However, if the future renewables market is based on international trade in order to achieve the EU renewables target, the future looks bright for offshore wind energy since it will benefit from a higher level of the TGC price. Nevertheless, penetration starts more slowly in 2005 because of competition with other renewables. In this scenario, Germany and Denmark will play an important role. The prediction, using the Trade/Targets scenario for the years after 2010, is that the market opportunities for offshore wind energy improve considerably due to ongoing cost reductions and expected learning effects.

German case
The national targets for offshore wind energy in Germany are 500 MW in 2005 and 2000 to 3000 MW in 2010. Current plans show a large-scale market initiative to construct wind farms offshore: already 15 to 16 GW of projects on different locations are currently under study, of which 1 to 2 GW within the 12 nautical miles zone. However, the analysis based on the ADMIRE REBUS model show that current German offshore wind policy as stated in the German Renewable Energy Act does not match these expectations. This is due to two effects:

1. The German feed in tariff for offshore is on average around 8 €ct/kWh over 20 years. For comparison: the total Dutch support level for offshore wind will be around 9 €ct/kWh. This is the sum of benefits from the new MEP regulation, the ecotax exemption and the regular electricity price [Sambeek, ref. 18]. The ADMIRE REBUS model runs show that with a 20% higher feed in tariff around 1400 MW will be installed in Germany in 2010, equalling the market share in the Targets/Trade scenario.
2. The German potential for favourable sites with a wind regime higher than 9 m/s and closer than 40 km to shore is almost zero compared to for example the Netherlands or the United Kingdom [Matthies, ref. 11]. This implies that German developers have to face higher costs lower returns on their investments compared to countries with more favourable conditions.

5 Conclusions

On the basis of the studies described in this paper some conclusions may be drawn regarding the development of offshore wind energy (OWE) in the North Sea. As for the technical status and future of OWE one may be optimistic. OWE is now a proven technology although further developments are needed. Most important are an increase of turbine availability through improvement of O&M and a drastic reduction of wind farm array losses through introducing novel ways of turbine operation and farm lay out. Significant cost reductions may be expected as developers are gaining experience and learning effects take effect. Specific analysis for The Netherlands has shown that an upgrade of the Dutch electricity grid is needed to feed in the 6000 MW that is aimed for in 2020. Similar challenges may also be expected in countries like Denmark and Germany.

From the ADMIRE REBUS analysis, it can be concluded that the present policies of EU Member States do not match expectations for offshore wind energy towards 2010. In particular the current German level of support is too low. An increase of the feed-in tariff should be considered. This increase should be at least 20% to achieve the German renewable energy target in 2010. Offshore wind energy does have an effect on the long-term price development of the electricity market due to its low marginal costs of generating electricity. In order to avoid long term downwards price effects, Dutch offshore wind in competition with conventional plants can increase to around 1000 MW in 2010. A larger market share can result in a decrease of the long-term electricity price, causing less favourable conditions for offshore wind energy development. This effect will be less when large offshore wind farms can be operated as conventional power plants.

No doubt some dips in the market will be encountered, but with proven technology available and governments in Europe committed, the attainment of the EWEA goal of 70 GW is only a matter of time.

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