Integration of electricity from renewables to the electricity grid and to the electricity market – RES-INTEGRATION

National report: Denmark

Client: DG Energy

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Berlin, 20 December 2011

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Interviewed Experts

We would like to thank all interviewed experts for their very valuable input and their support for this study. We highly appreciate their expert knowledge and their availability in the framework of the RES Integration Project on behalf of the European Commission.

For this country study, the following experts were interviewed:

Bjarne Gellert, Energinet.dk (Danish Transmission Grid Operator)

Anders Højgaard Kristensen, Energistyrelsen (Danish Energy Agency)

Poul Mortensen, Energinet.dk (Danish Transmission Grid Operator)

Sune Strøm, Vindmølleindustrien (Danish Wind Industry Association)

Executive summary

Grid connection	
Effect on integration of RES-E	Positive
Obligation to reinforce if necessary	Yes
Distribution of costs	Shallow
Relevant grid level	Distribution grid (Transmission grid for off-shore wind parks)
Main barriers to integration	No barriers detected

Grid operation	
Effect on Integration of RES-E	Positive
Purchase obligation	No
Occurrence of grid curtailment	Rare
Main barriers to integration	No barriers detected

Grid development	
Effect on Integration of RES-E	Positive
Regulatory instruments	Sufficient
Nationwide grid development studies	Existent
Main barriers to integration	Deadline for obtain permission for grid development not sufficiently specified

Market design	
Functioning markets	All market options available on the common Nord Pool market
Intraday market and gate closure	Intraday available; Gate closure is one hour prior to delivery
Main issue	All market options available

Support scheme	
Support scheme	Feed-in Premium and net-metering
Market integration and/or risk sharing elements	Feed-in Premium, partly sliding, partly no subsidies when market prices become negative
Balancing responsibility for RES producers	Yes, for all RES

Table 1: Overview on grid and market integration Denmark

The overall conditions for the integration of electricity from renewable energy sources in Denmark are considered to be good. No severe barriers have been detected.

There are several levels of electricity grid voltage in Denmark (e.g. 10 kV, 60 kV, 150 kV and 400 kV). Most RES-E generating plants are connected to the distribution grid, except for off-shore wind parks.

The connection process depends on the type of plant and the voltage level of the grid which the plant will be connected to. The connection process is well defined and does not cause any problems. An interesting feature of this process is the lack of clearly defined deadlines for the establishment of a connection. Nevertheless no delays have been reported and the lead time for obtaining connection permission is lowest among the EU countries. As regards grid connection, the only potential barrier is linked to the situation in which a grid with a voltage above 100 kV has to be developed in order to connect a plant.

RES-E enjoys priority in use of the grid. When curtailment is necessary, only off-shore wind parks may be curtailed and only after non-renewable plants have been curtailed first. The operators of the wind parks receive a compensation payment where the output of their parks has to be reduced.

The decision on if, how and to what extent the grid shall be developed belongs to the Danish TSO – Energinet.dk. The decision process depends on the grid's voltage level. In order to develop the distribution grid, the DSO has to consult the transmission grid operator. The process is slightly more complicated on the transmission grid level. If grid voltage exceeds 100 kV, the TSO has to explain the need for the investment to the energy regulator Energitilsynet, and obtain permission from this authority. This part of the process may constitute a barrier.

Denmark is integrated into all markets on the common Nord Pool Spot, where almost 75 % of the total consumption of the Nordic countries was traded in 2010. In the Nord Pool Spot there are two markets for physical trades: Elspot (day-ahead market) and Elbas (intra-day market). All electricity producers have a balancing responsibility; wind onshore generators receive a balancing reimbursement to compensate for their balancing costs.

The general promotion system is a feed-in-premium. Since recently, there are no subsidies for offshore wind farms when the prices become negative. Moreover there is a net-metering scheme for producers of electricity for their own consumption. Eligible parties are exempted from the Public Service Obligation which usually all consumers have to pay depending on their consumption amount.

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Renewable electricity deployment

This chapter at providing a general introduction to the context for the deployment of renewable electricity in Denmark in terms of electricity production, consumption, and grid operation.

Denmark is widely considered as a role model for the deployment of renewable energy. After the oil crisis of 1973, the country set the goal to achieve self-sufficiency and full independence from imports of fossil energy sources. This goal was accomplished in 1997 (Energy Policy Statement 2008) also thanks to the substantial growth in domestic gas production. The energy resources in the North Sea will last until approximately 2015 (Energy Strategy 2005). The new Energy Strategy by the Danish government sets a new ambitious energy target: Denmark is to become independent of fossil fuels until 2050 (Energy Strategy 2011). The country aims at becoming one of the three countries in the world to increase their renewable energy share most until 2020. The share of RES in final energy consumption is planned to reach 30%. The goal set by the Danish government has already had an enormous impact on the development of RES-E in the last 15 years. The share of RES electricity in 1990 was only 2.6% and was raised to 28.7% in 2008 (Eurostat 2011).

Current generation mix and net generating capacity

A graphical overview of Denmark's electricity generation mix in 2010 is shown in Chart 1.

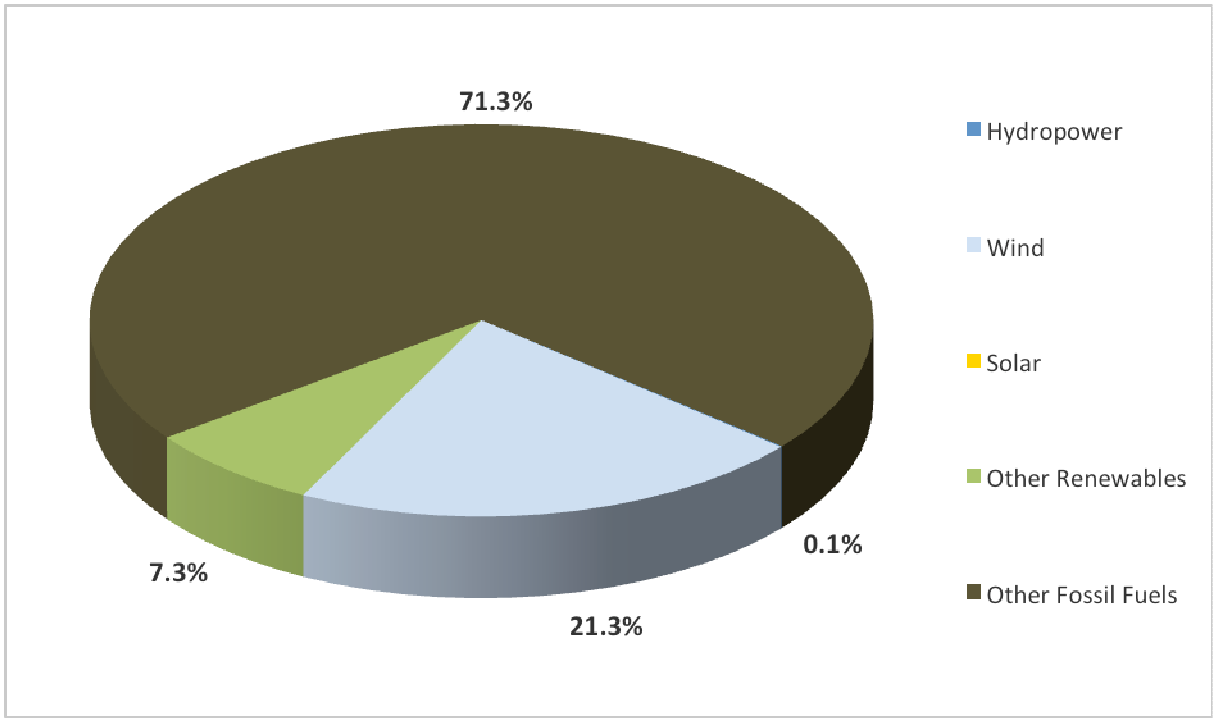

Chart 1: Generation Mix - 2010 (%), Source: own elaboration of Entso-e online database of Detailed Monthly Production. Sources not explicitly mentioned are included either in other renewable or other fossil fuels.

Power generation in Denmark is still dominated by fossil fuels (over 70%).

Another significant energy source is wind power, which accounts for more than 20% of electricity generation. Since Denmark generates hardly any hydro power, one would expect it to face major problems to balance variable renewables. Until now this has not been the case because of strong interconnections and intensive electricity trade with its neighbouring countries Norway and Sweden, which have large hydro capacities.

The net generating capacity is provided in Chart 2.

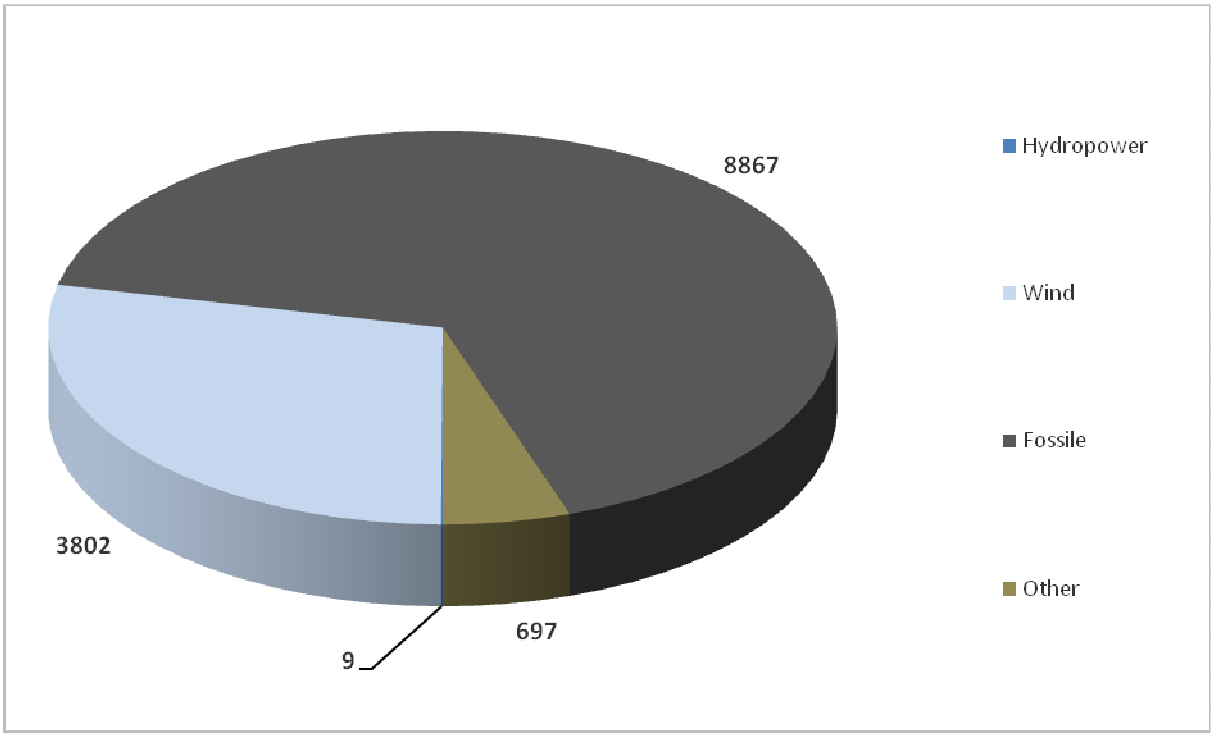

Chart 2: Net generating capacity - 2010 (MW), Source: own elaboration of Entso-e online database of Net Generating Capacity.

Electricity consumption

In 2010, Denmark consumed 35.640 GWh (ENTSO-E 2011), i.e. approximately 6.4 MWh per inhabitant, which is slightly above the EU average of 6.2 MWh (ENTSO-E 2011, Eurostat 2011). In terms of electricity intensity of the economy, in 2010 Denmark ranked first among the European countries with 157.08 MWh /M€, against an average of 257.7 (ENTSO-E 2011, Eurostat 2011).

Considering the development of electricity consumption over time (EEA 2010), Denmark's average annual percentage change in electricity consumption equals 1.0. This amount is similar in other Central-European countries like Poland, Germany and the Czech Republic, but higher than in other Scandinavian countries (Norway and Sweden).

RES-E share

Chart 3 provides an indication of Denmark's total electricity consumption and RES electricity production up to 2020, according to the submitted action plan (NREAP). In other words, this is not a forecast, but the plan according to the government.

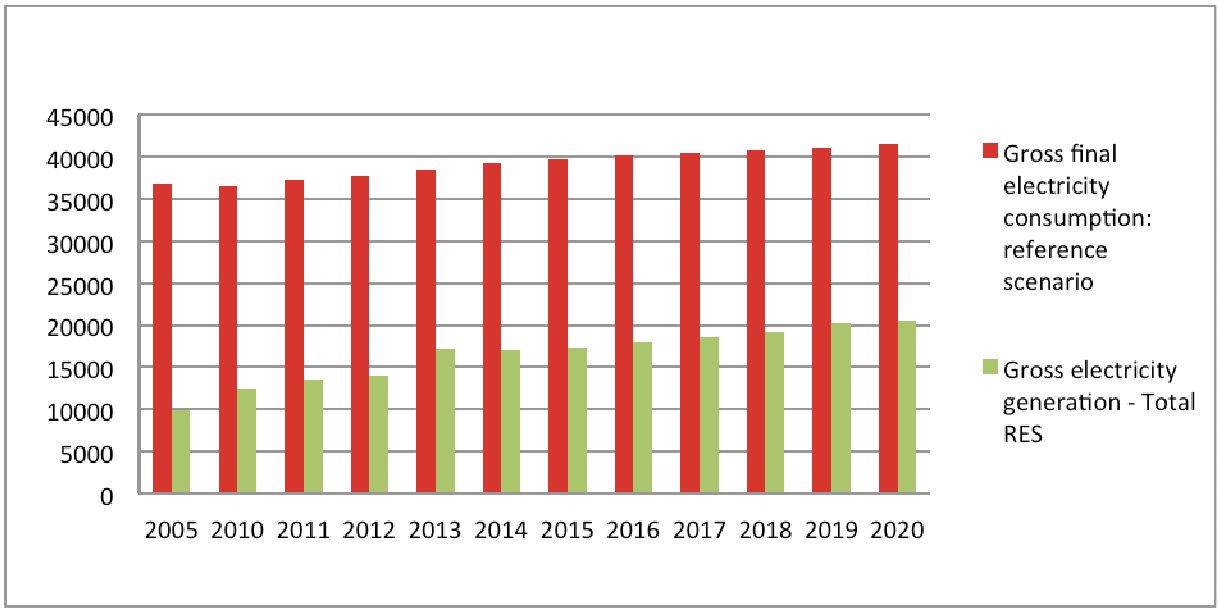

Chart 3: Electricity consumption and RES-E generation (GWh). Source: own elaboration of Denmark's NREAP

According to the Danish NREAP, overall electricity consumption will grow very slightly, despite the efforts to increase energy efficiency. The reason for that is a shift toward the electrification of the society. While the electricity consumption is increasing the entire energy consumption is actually decreasing (Wind Association 2011). The share of RES-E is expected to grow from 33.9% in 2010 to 49.7% in 2020. In absolute terms, this corresponds to a growth of RES-E generation from 12.412 GWh in 2010 to 20.595 GWh in 2020, i.e. a total growth of 65.93% in a period of ten years. This compares with a growth of 24% in the period 2003-2008, and of more than 145% in the period 1998-2008 (Eurostat 2011).

The evolution of renewable electricity generation is illustrated in Chart 4, which outlines the generation shares of wind, solar, hydro-power and other RES-E until 2020. This graph is particularly interesting for the aim of this study, as variable sources (wind and solar) will require a grid infrastructure capable of supporting a high input variability. The higher the share of such sources, the more relevant the issue of grid adaptation will be. Hydropower, on the other hand, is a fairly controllable RES-E, which is well suited to balance the network fluctuations caused by wind and solar energy, thus the larger the share of these sources, the larger the extent to which fluctuations can be mitigated.

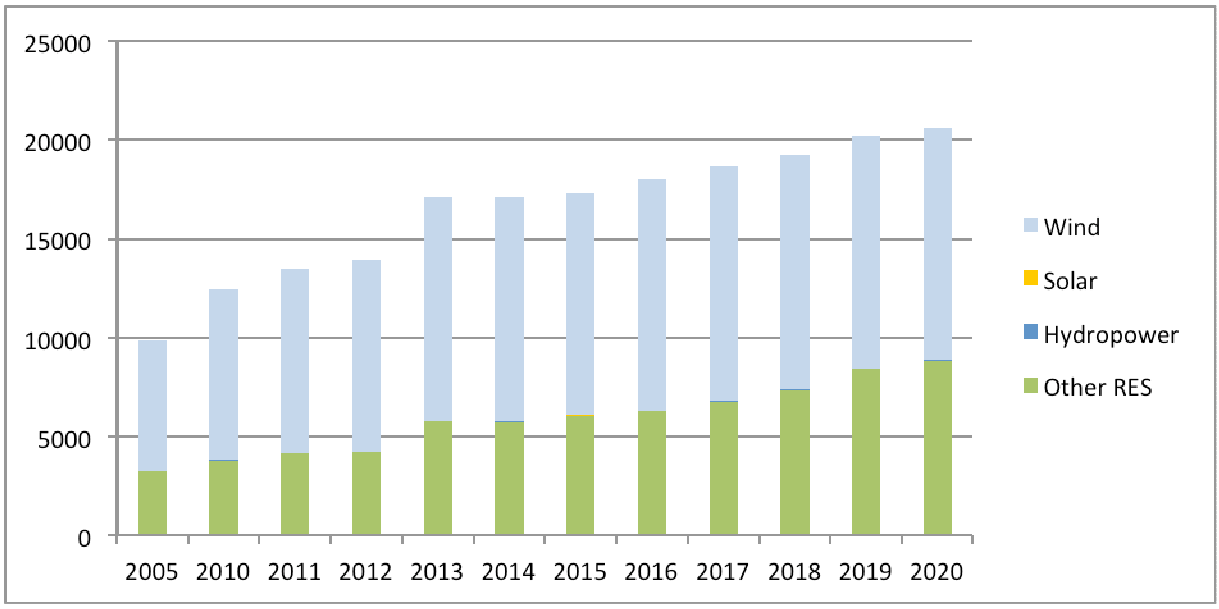

Chart 4: RES-E generation (GWh). Source: own elaboration of Denmark's NREAP

The largest part of planned growth is expected to be due to wind power, which is an variable source. For this reason, growing efforts will be required for the market and grid integration of RES-E, both in terms of grid development and of creating additional storage and balancing power capacities.

Natural resources and geographical structure

Following the context description, this section outlines some elements of the natural renewable resources of the country, and their geographical distribution. This chapter is meant to provide a brief background for the analyses and recommendations in the following chapters rather than an in-depth analysis.

Wind

As shown in Figure 1, Denmark enjoys excellent wind resources in the whole of its area. Conditions are best in the north-western part of the country. Denmark also has outstanding off-shore potential, both in the North and the Baltic Sea.

Solar

The map shown in Figure 2 represents the yearly irradiation in Denmark. Due to low radiation, photovoltaic energy is not expected to contribute to electricity generation. Yet, as mentioned in the Energy Strategy, this may change if PV technology will develop further and become cheaper. CSP is not considered as a relevant technology for Denmark.

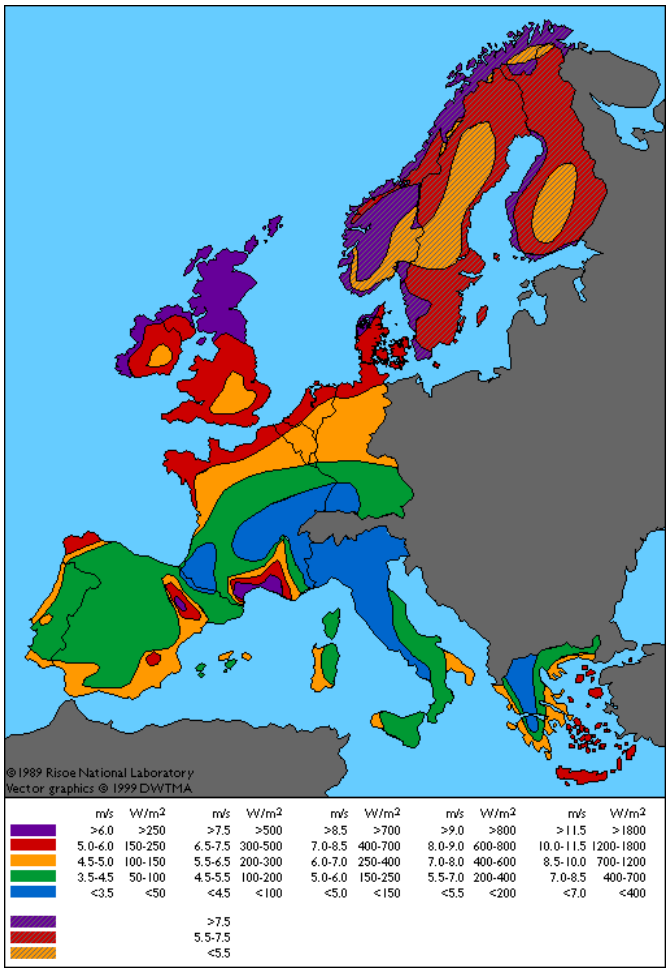

Figure 1: Map of wind resources at 50 meters above ground level for five different topographic conditions: 1) Sheltered terrain, 2) Open plain, 3) Coast, 4) Open sea and 5) Hills and ridges (Source: European Wind Atlas Risø National Laboratory 1989)

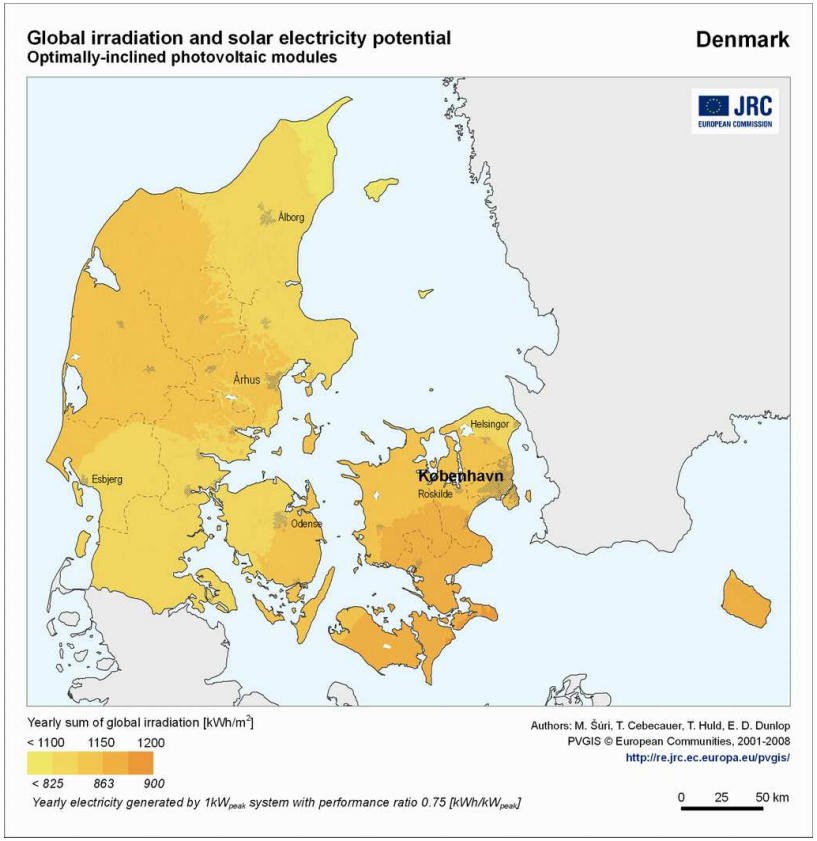

Figure 2: Yearly sum of global irradiation on horizontal and optimally inclined surface, 8-years average of the period 2001-2008 [kWh/m2]. (Source: EC JRC 2007)

Grid operators & dominant generators

Dominant generators

As showed in the table below, power generation in Denmark is still dominated by the central generation plants, which are mostly owned by the energy companies DONG Energy and Vattenfall (Danish Electricity Supply 2008). The rest of the electricity production plants is owned by other energy companies, local authorities and larger industries or co-operatives (owned by local customers). In 2009 around 60% of electricity generation in Denmark was produced by the central generation plants and around 20% by wind turbines (Danish Electricity Supply 2009).

	Capacity MW	Generation GWh
Central power stations	6 419	20 963
Local CHP	1 897	4 616
Wind turbines	3 482	6 721
Hydro power plants	9	19
Industrial autoproducers	587	2 133
Generation total		**34 451**

Table 2: Electricity generation plants (Source: Danish Electricity Supply 2009 – Statistical Survey)

Transmission System Operators

Energinet.dk is the Danish national transmission system operator. It is an independent public enterprise owned by the Danish state and managed by the Ministry of Climate and Energy (Energinet.dk, 2011,II).

Distribution System Operators

In Denmark, there are over 90 DSOs. The seven largest grid companies distribute electricity to more than 100,000 consumers each, which together account for 60% of all consumers in Denmark. The next smaller 50 companies with less than 10,000 consumers each account for fewer than 5% (Danish Electricity Supply 2009).

Interconnections, import/export

Due to numerous and crucial interconnections and a common energy market with the neighbouring Scandinavian countries (Norway, Sweden and Finland), Denmark's overall electricity exchange amounts to a big percentage of its consumption. In the last decade 2001-2010 Denmark in general has been a net exporter of electricity (Wind Association 2011).

DK	DE	NO	SE	Total	% of consumption
Export	2707	4055	4978	11740	32.94%
Import	6471	1458	2656	10585	29.70%
Net	**-3764**	**2597**	**2322**	**1155**	**3.24%**
Total flows	**9178**	**5513**	**7634**	**22325**	**62.64%**

Table 3: Physical exchanges in Danish interconnected operation (Source: ENTSO-E 2011)

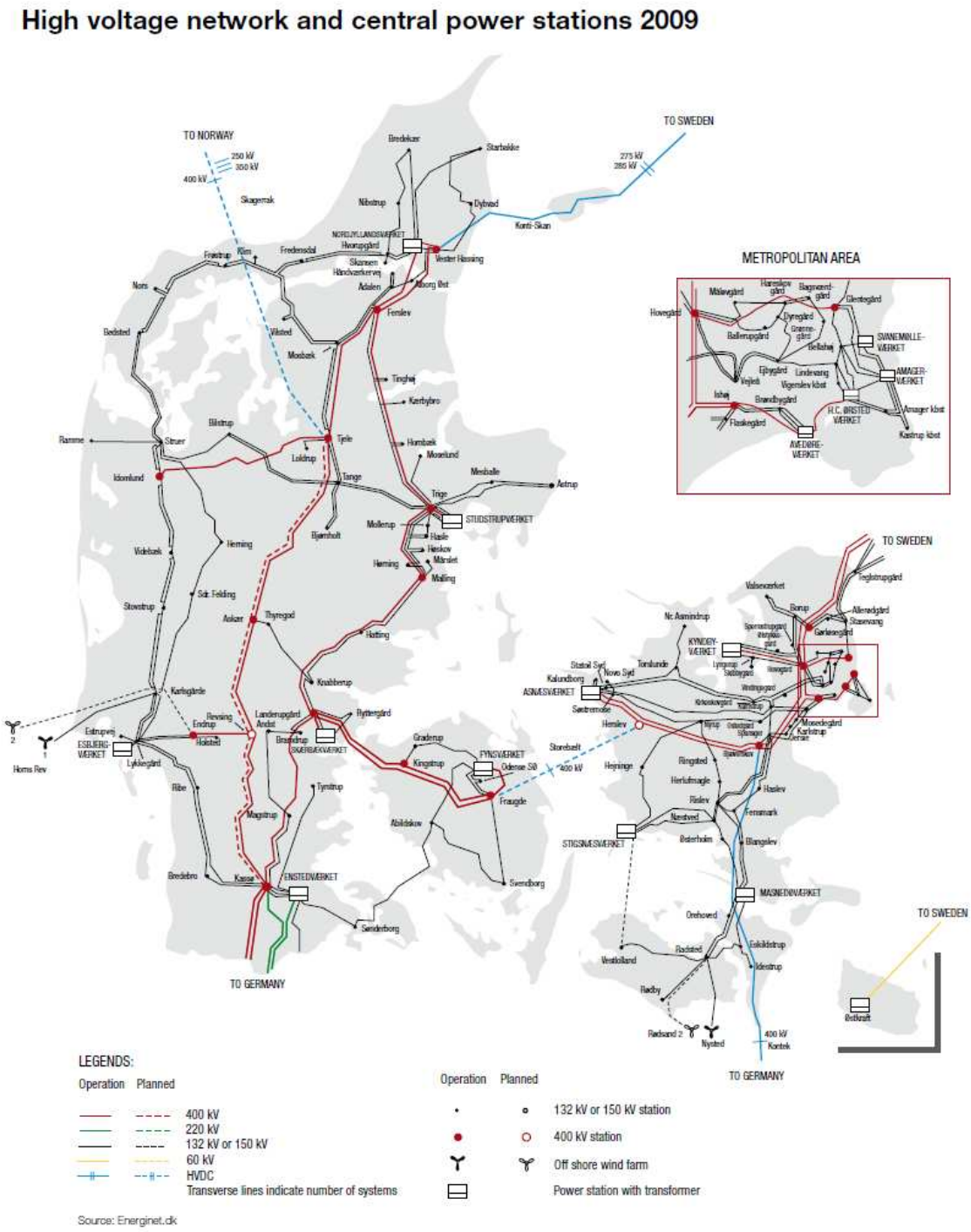

Figure 3: High voltage network and central power stations 2009 (Source: Danish Electricity Supply 2008 – Statistical Survey)

Literature and other sources

Danish Electricity Supply (2008): *Danish Electricity Supply '08. Statistical Survey*. Available at: <http://www.danishenergyassociation.com/~/media/English_site/Statistics/Statistik_08_UK.pdf.ashx> (last accessed on 25 May 2011).

Danish Electricity Supply (2009): *Danish Electricity Supply '09. Statistical Survey*. Available at: <http://www.danishenergyassociation.com/~/media/Energi_i_tal/Statistik_09_UK.ppt.ashx> (last accessed on 19 May 2011).

EEA (SOER 2010): European Environmental Agency, *The European environment – state and outlook 2010*. Available at: <http://www.eea.europa.eu/data-and-maps/indicators/final-electricity-consumption-by-sector/final-electricity-consumption-by-sector-1> (last visit on 10 May 2011).

Energy Policy Statement (2008): *Energy Policy Statement 2008. The report of the minister of climate and energy pursuant to the Danish Act on Energy Policy Measures*. Available at: <http://193.88.185.141/Graphics/Publikationer/Energipolitik_UK/energipolitisk_redegorelse_2008_eng/pdf/energipolitisk_redegorelse_2008_eng.pdf> (last accessed on 19 May 2011).

Energy Strategy (2005): *Energy Strategy 2025. Perspectives to 2025 and Draft action plan for the future electricity infrastructure*. Available at: <http://193.88.185.141/Graphics/Publikationer/Energipolitik_UK/Energy_Strategy_2025/pdf/Energy_strategy_2025.pdf> (last accessed on 19 May 2011).

Energy Strategy (2011): *Energy Strategy 2050 – from coal, oil and gas to green energy*. Available at: <http://www.kemin.dk/Documents/Klima%20og%20Energipolitik/Energy%20Strategy%202050%20web.pdf> (last accessed on 18 May 2011).

ENTSO-E (2011): *Online Database*. Available at: <https://www.entsoe.eu/resources/data-portal/> (last accessed on 14 December 2011).

Eurostat (2011): *European Online Database*. Available at: <http://epp.eurostat.ec.europa.eu> (last visit 23 August 2011).

Wind Association (2011): Strøm, Sune, *Vindmølleindustrien* (Danish Wind Industry Association). Interview on 03 May 2011.

Grid Connection

Summary

There are several types of grid voltage in Denmark (e.g. 10 kV, 60 kV, 150 kV and 400 kV). Most RES-E plants, including on-shore wind plants, are connected to the distribution grid. Only the big off-shore plants are connected to the transmission grid (132 or 150 kV) (ENS 2011).

In general, the connection process and the definition of its costs are considered to be well-defined and transparent. No severe barriers have been reported by the stakeholders. The characteristic feature in Denmark is the absence of clear deadlines for the establishment of grid connection. Despite that, the mean time for receiving connection permission is lowest among the countries of the European Union.

The grid operator is obliged by law to connect any electricity generation plant that wishes to be connected. The DSO/TSO also has to reinforce its grid when this is necessary to connect a RES-E plant. In order to receive permission to do so, it has to economically justify the investment to the energy regulator Energitilsynet. The regulator has to approve the planned development, since the electricity consumers will bear the costs of grid development and reinforcement. This process may constitute a barrier, as the deadline for giving permission is not specified. This problem was the main issue in the study conducted last year by the Danish authorities on the possible barriers for the connection of RES-E plants to the grid.

Relevant legal sources

The most relevant legal source defining the rules for grid connection is the Act on Electricity Supply (Bekendtgørelse af lov om elforsyning). In addition, a special rule concerning the cost distribution for the connection of wind power plants is defined in the Law on the Promotion of Renewable Energy (Lov om fremme af vedvarende energi).

Connection procedures, deadlines and information management

The procedure for grid connection is widely considered as simple and transparent, even though the procedural steps are not specified by law (ENS 2011; Energinet.dk 2011). They depend on the capacity of a given plant and on the voltage of the grid this plant will be connected to.

Stand-alone plants ≤ 11 kW connected to grid with a voltage level of up to 100 kV:

APPLICATION	The plant operator applies for connection.
ASSIGNMENT OF GRID CONNECTION POINT	The grid operator assigns a connection point.
CONNECTION OFFER	The grid operator makes a connection offer.
INSTALLATION OF THE PLANT	The developer installs the plant.
CONNECTION AGREEMENT	The grid operator and the RES-E plant operator conclude a connection agreement.
REGISTRATION OF THE PLANT	The TSO registers the plant in its database.
INSTALLATION OF METERS	The plant operator installs the required meters.
SUBMISSION OF DOCUMENTS TO THE GRID OPERATOR	The plant operator must submit general and technical specifications to the grid operator. The grid operator then forwards these documents to Energinet.dk.
PERMISSION TO OPERATE	The grid operator gives the plant operator permission to operate.
CONNECTION	The plant is connected and can start feeding in electricity.

Diagram 1: Connection procedure of plants with a capacity of up to 11 kW connected to low and medium-voltage levels

Wind power plants connected to grids with a voltage < 100 kV:

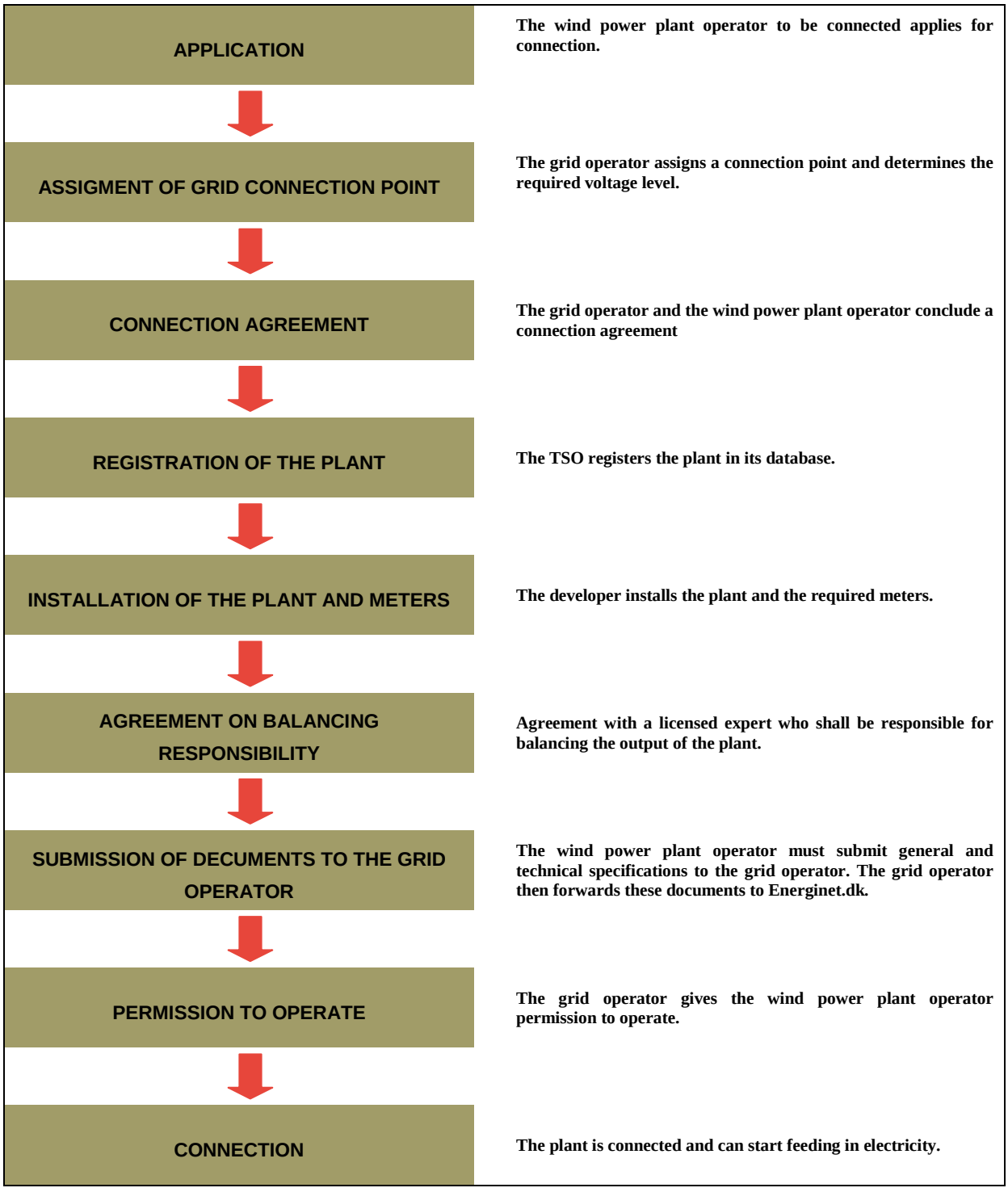

Diagram 2: Connection procedure of wind energy plants to grid systems < 100 kV

Offshore wind parks connected to grid systems > 100 kV:

APPLICATION	A wind park operator shall apply to the transmission grid operator for connection and submit the necessary permits and licences together with the application
CONNECTION AGREEMENT	The grid operator and the wind park operator conclude a connection agreement.
REGISTRATION OF THE WIND PARK	The TSO registers the park in its database.
INSTALLATION OF THE WIND PARK	The developer installs the wind park.
SUBMISSION OF DECUMENTS TO THE GRID OPERATOR	The wind park operator must submit the documents required for a park test to Energinet.dk within 3 months after the wind park is put into operation.
INSTALLATION OF METERS	The plant operator installs the required meters.
AGREEMENT ON BALANCING RESPONSIBILITY	Agreement with a licensed expert who shall be responsible for balancing the output of the plant.
COMMISSION OF THE PARK	Plant commissioning and commissioning report.
TEMPORARY PERMISSION TO OPERATE	The grid operator gives the wind park operator temporary permission to operate and submits the commissioning report and the permission to operate to Energinet.dk.
CONFORMATION OF TEMPORARY PERMISSION TO OPERATE	Energinet.dk confirms the temporary permission to operate and approves the documents.

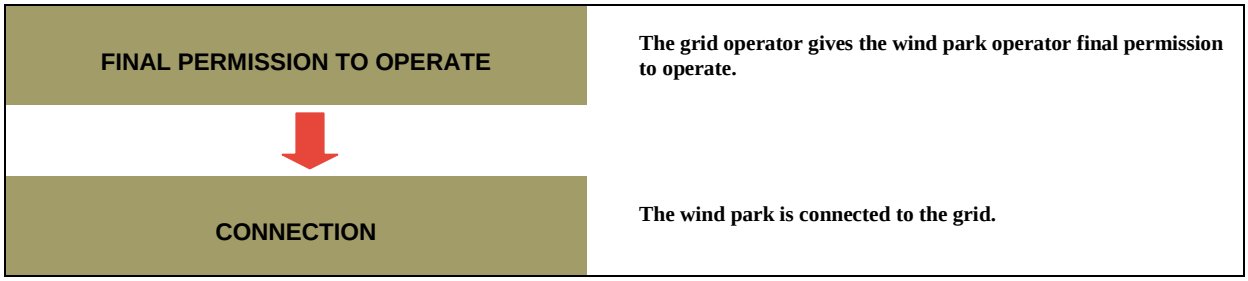

Diagram 3: Connection procedure of offshore wind parks to grid systems> 100 kV

Deadlines

No deadlines are specified for the connection procedure; nevertheless it has to occur within a reasonable amount of time as defined by an EU directive (ENS 2011). According to the Wind Barriers study no delays have been reported in the cooperation between a developer and a grid operator. Moreover the mean time for getting a grid permit is by far the shortest in the EU, with an average of 2.1 months (EU average: 25.8 months) (Wind Barriers 2010)

Information management of TSO/ DSO

The connection requirements for electricity generation installations are publicly available (NREAP 2010).

Obligation, legal responsibilities and enforcement of legal rights

Connection obligation

According to § 26 Act on Electricity Supply, the RES-E operator is entitled to connection to the grid if his plant meets the technical requirements.

According to the Danish Energy Agency, there is no "simple" connection procedure for small RES-E plants. The Danish TSO has different requirements for large and small wind projects and consequently the latter are easier to fulfil.

Reinforcement obligation

The grid operator is obliged to reinforce the grid if this is necessary to connect a new plant or to feed its electricity into its grid (ENS 2011; Energinet.dk 2011; Wind Association 2011).

Another barrier may appear where the grid has to be developed or reinforced. In order to receive permission for grid development, a grid operator has to economically justify such an investment to the energy regulator – the Energitilsynet. The regulator has to approve the investment, since the costs of grid development are covered by the electricity consumers. This justification process is not clearly defined and may constitute a barrier for RES. Although in general the DSO is co-operative, it may happen that the grid reinforcement takes a long time, if there is no interest on the side of DSO. This

may constitute a problem since the deadlines for grid reinforcement are not defined (Wind Association 2011).

If the problem will come up more often, the DSO should become more involved in the decision process of justifying the costs for reinforcement. Another possible solution could be to introduce legally defined deadlines until when the grid reinforcement process is ready. However, experiences from other Member States have shown that this solution should be treated with great caution. Quite often, deadlines are too long, not legally binding or cannot be enforced because of loopholes such as useless actions that extend the deadlines. For this reason, it would be wise to combine the defined deadlines with qualitative criteria such as that the reinforcement shall take place "without delay" or "promptly".

Costs of grid connection

The connection costs are well defined by law. They are so-called shallow costs, i.e. the developer only has to pay for the part of the connection up to the closest connection point. If such a development of the grid is necessary for the connection, the additional costs of a reinforcement of the grid are borne by the Danish TSO Energinet.dk. In the end, such investments are paid by every electricity user through the PSO-tariff (Public Service Obligation Tariff) (Energinet.dk 2011; Wind Association 2011; ENS 2011).

Since all the consumers bear the costs of grid reinforcement, there is no need for rules for distributing them among previous and future producers of electricity (NREAP 2010).

According to § 67 Act on Electricity Supply, the costs a RES-E plant operator has to bear for grid connection shall not exceed the costs that would incur if his system was connected to the 10-20 kV grid. This is also the case even if the grid operator chooses to connect the plant to a different voltage level.

There is a special rule regarding the distribution of the costs for the connection of a wind power plant. According to § 30 Law on the Promotion of Renewable Energy (Lov om fremme af vedvarende energi), these cost are divided between the plant owner and the transmission grid operator.

For offshore wind farms established under the public tendering system it should be noted that it is the Danish TSO that is obliged to establish and finance the substation and cable to shore (E.on 2011). As estimated in the Wind Barriers study, the average connection costs in Denmark are by far the lowest in the European Union. They constitute only 1.14% of the total project costs compared to the EU average of 5.1%.

Other

Last year the Danish authorities conducted a survey on possible barriers for the connection of RES-E plants. They focused especially on the challenge of timing.

The grid operator has to take two interests into account. On the one hand, the consumers are interested in a low electricity price. On the other hand, the developers are interested in the construction of new plants and expect the grid to be reinforced if necessary. The grid operator has to do the planning for the possible future connections, but he will not make the actual investment until he is sure that the wind plant is going to be constructed. The lead time for the reinforcement of a transmission grid is around 2-3 years and thus longer than the construction of a wind plant (ENS 2011)

Barriers identified			Solution proposed	Detailed description (Page)
Stand Alone	Cause	Consequence		
Deadlines for grid reinforcement not defined			It may be reasonable to introduce a definition of deadlines.	21-22
Investment for grid reinforcement must be justified by grid operator to the regulator, possible barrier if there is a disinterest of the DSO			DSO may be more involved in the process of justification of the costs for grid reinforcement.	21-22

Table 4: Connection: Summary of identified barriers and proposed solutions to overcome barriers

Literature and other sources

Energinet (2011): Gellert, Bjarne, *Energinet.dk* (Danish Transmission Grid Operator). Interview on 13 April 2011.

ENS (2011): Højgaard Kristensen, Anders, *Energistyrelsen* (Danish Energy Agency). Interview on 05 April 2011.

NREAP (2010): *National Renewable Energy Action Plan* (Denmark). Available at: <http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm> (last accessed on 17 Mai 2011).

RES LEGAL (2011): Website on Legal Sources on Renewable Energy. Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Available at: <www.res-legal.eu> (last accessed on 15 April 2011).

Wind Association (2011): Strøm, Sune, *Vindmølleindustrien* (Danish Wind Industry Association). Interview on 03 May 2011.

Wind Barriers (2010): *Wind Barriers – Administrative and grid access barriers to wind power*. European wind energy association, Available at: <http://www.windbarriers.eu/fileadmin/WB_docs/documents/WindBarriers_report.pdf> (last accessed on 19 Mai 2011).

Grid Operation

Summary

Renewable energy sources enjoy guaranteed access to and a priority in the use of the grid. There is no purchase guarantee for electricity from RES.

The process of curtailment is clearly defined. The RES-E can be curtailed only after the reduction of energy production from the non-renewable sources. Furthermore, only the producers of off-shore wind power parks are entitled to receive a compensation payment.

Relevant legal sources

The legal source specifying the rules for the operation and use of the grid is the Act on Electricity Supply (Bekendtgørelse af lov om elforsyning).

Obligations, legal responsibilities and enforcement of legal rights

RES-E producers are not entitled to a purchase guarantee. There is no regime that obliges any party to purchase electricity produced from renewable energy.

According to § 27c par. 5 Act on Electricity Supply, renewable energy shall be given priority use of the grid.

The RES-E producers are obliged to operate in line with network requirements specified in grid codes (Wind Association 2011). There is no specific legal obligation for wind plants to provide ancillary services, but new wind power plants are already designed to provide them (Energinet.dk 2011).

Grid curtailment

Curtailment is legally regulated, but has been necessary only two or three times so far. RES plants are prioritised in the curtailment process, i.e. in case the security of a grid is at risk, the grid operator has to curtail fossil electricity production plants before reducing the output of RES plants (ENS 2011).

Curtailment in cases when grid security is endangered is allowed for both on-shore and off-shore wind farms (ENS 2011; Energinet.dk 2011). Compensation payment for the curtailment only applies to two existing offshore wind farms (Horns Rev 2 and Rødsand 2). Also the offshore wind farm Anholt, which is under construction, will be entitled to the compensation in case of curtailment (Wind Association 2011; ENS 2011).

According to § 27c par. 5 Act on Electricity Supply, the principle of priority may only be violated for reasons of network security.

Barriers identified			Solution proposed	Detailed description (Page)
Stand Alone	Cause	Consequence		
No barriers detected				

Table 5: Operation: Summary of identified barriers and proposed solutions to overcome barriers

Literature and sources

Energinet.dk (2011): Gellert, Bjarne, *Energinet.dk* (Danish Transmission Grid Operator). Interview on 13 April 2011.

ENS (2011): Højgaard Kristensen, Anders, *Energistyrelsen* (Danish Energy Agency). Interview on 05 April 2011.

Wind Association (2011): Strøm, Sune, *Vindmølleindustrien* (Danish Wind Industry Association). Interview on 03 May 2011.

Grid development

Summary

The legal framework obliges the grid operators to develop and expand their grids to the extent necessary. This also means that they have to reinforce their grid if this is necessary to connect a plant or to feed its electricity into its grid.

The Danish TSO – Energinet.dk – decides on the general development of energy infrastructure and on how and to what extend grids have to be developed. In this decision process, renewable energy sources are given special attention. Energinet.dk shall provide grid development studies and grid development plans on an annual basis.

The decision process on the development of a grid depends on the grid's voltage level. If a distribution grid is to be extended, the DSO has to consult the transmission grid operator Energinet.dk. If the voltage of the grid in question exceeds 100 kV, permission from the energy regulator Energitilsynet is needed. Since this process is not sufficiently defined, the development of the high-voltage grid may constitute a barrier.

The reason for the obligation to receive permission is the high costs of such an investment that have to be covered by the electricity consumers through the so-called Public Service Obligation.

Relevant legal sources

The relevant legal source obliging the grid operators to develop their grids is the Act on Electricity Supply (Bekendtgørelse af lov om elforsyning).

Regulatory framework for grid development

§ 20 Act on Electricity Supply obliges the grid operators to develop and expand their grids to the extent necessary. If a particular grid operator fails to fulfil this obligation, the Ministry for Climate and Energy delegates responsibility for the expansion of the grid to the Danish TSO Energinet.dk.

The development of a grid has to be initiated by a grid company. It has to contact Energinet.dk. For the development of a grid whose voltage exceeds 100 kV, the grid company also has to obtain approval from the Danish energy regulator Energitilsynet (ENS 2011).

The TSO is responsible for the development of energy infrastructure in general (Energinet.dk 2011,II). Energinet.dk is also responsible for decisions on how and to what extend grids have to be developed (Energinet.dk 2011).

Obligations, legal responsibilities of the grid operator in relation to the RES-E producer

§ 20 Act on Electricity Supply obliges grid operators to both expand the grid to the extent necessary and to connect electricity suppliers to their grids. As a consequence, they shall reinforce their grid if this is needed to connect a plant or to feed its electricity into its grid (ENS 2011; Energinet.dk 2011; Wind Association 2011).

If the grid that has to be developed exceeds the voltage of 100 kV, the grid operator has to obtain permission from the energy regulator. To receive this permission, the grid operator has to justify the necessity of this investment. The process of obtaining permission is not sufficiently defined. Apart from that, there are no deadlines for grid reinforcement (Wind Association 2011).

A possible solution to this problem would be to define the process and deadlines. That could however lead to the less flexible handling of the particular issues. Therefore the effects of this solution should be first considered by the government.

Regulatory instruments to encourage grid development

According to § 21 Act on Electricity Supply, the inclusion of renewable energy sources is given special attention in the process of grid development. Renewable energy sources are also named as a main goal in grid development studies (Energinet.dk 2011).

Grid development studies and planned improvements

The Danish TSO Energinet.dk is in charge of conducting grid development studies and planning of the development of the grid. The related long and short-term studies are published every year (Energinet.dk 2011; ENS 2011).

In February 2011, the Danish government published the new *Energy Strategy 2050 – from coal, oil and gas to green energy*. This strategy sets the goal for Danish energy policy to make the country independent of fossil fuels by 2050. The strategy names the following key elements for the achievement of this goal:

- efficient energy consumption,
- electrification of heating, industry and transport,
- more electricity from wind power,
- use of biomass and biogas,
- PV and wave power as possible supplements for wind power in electricity production, and

- intelligent energy system.

The scope of the last element – the intelligent energy system – includes means like the expansion of transmission capacity and interconnections, intelligent networks with smart meters, and the development of storage facilities.

Interconnections

Grid connections with the neighbouring countries play a very important role in Denmark's energy supply and trade. The country is well interconnected with the other Scandinavian countries (Sweden and Norway) and Germany. Those interconnections play a crucial role in the further expansion of renewable energy sources, since the hydro-power available especially in Norway can serve as a storage for excess electricity and, more generally, help to balance the electricity in the grids (Energy Strategy 2011).

The further development of interconnections, especially towards the south, (towards Germany and the Netherlands) is planned (NREAP 2010).

Intelligent network

The use of smart meters and the gradual adjustment of energy demand to electricity supply are mentioned in the Energy Strategy as one of the key means to achieve full independence of fossil fuels. Especially installations like heat pumps or electric cars should "consume" electricity when supply is high and other demand is low (Energy Strategy 2011).

The National Renewable Energy Action Plan of Denmark also declares the development and introduction of the intelligent network to be very important issue. According to the Plan, it is expected that 50% of consumers will use intelligent meters in the next few years.

Storage facilities

The most important storage facilities are the hydro-power facilities in Sweden and Norway. The strong interconnections and constant cross-border trade of electricity between the countries make it possible to adjust the power flows in the Scandinavian region (Energy Strategy 2011).

The Energy Strategy also mentions other options. It does not specify the particular technologies that will satisfy this demand.

The National Renewable Energy Action Plan states that the introduction of electric vehicles as flexible storage facilities is expected to be a central element in the future development of renewable energy. However, this objective is not mentioned in the Energy Strategy, which mentions electric cars only as a measure to eliminate the use of fossil fuels in the transport sector.

Costs

According to § 67 Act on Electricity Supply, the costs of grid development are first borne by the grid operator. § 8 par. 7 Act on Electricity Supply entitles the operators to pass on these costs to the electricity consumers.

These network fees are a part of the so-called Public Service Obligation (PSO). The amount of the obligation depends on the level of electricity consumption of particular consumer.

There are some small grid usage fees that have to be paid by the production site, but the RES plants are except from this fee (ENS 2011).

Barriers identified			Solution proposed	Detailed description (Page)
Stand Alone	Cause	Consequence		
Deadlines for grid reinforcement not defined			It may be reasonable to introduce a definition of deadlines.	21-22
Investment for grid reinforcement must be justified by grid operator to the regulator, possible barrier if there is a disinterest of the DSO			DSO may be more involved in the process of justification of the costs for grid reinforcement.	21-22
Grid operator must justify reinforcement/expansion investment to regulator, process for obtaining permission not transparent			It may be reasonable to define the process, yet it hast to remain flexible.	32

Table 6: Development: Summary of identified barriers and proposed solutions to overcome barriers

Literature and sources

Energinet.dk (2011): Gellert, Bjarne, *Energinet* (Danish Transmission Grid Operator). Interview on 13 April 2011.

Energinet.dk (2011,II): *Energinet.dk's Website*. Available at: <http://www.energinet.dk> (last accessed on 18 May 2011).

Energy Strategy (2011): *Energy Strategy 2050 – from coal, oil and gas to green energy*. Available at: <http://www.kemin.dk/Documents/Klima%20og%20Energipolitik/Energy%20Strategy%202050%20web.pdf> (last accessed on 18 May 2011).

ENS (2011): Højgaard Kristensen, Anders, *Energistyrelsen* (Danish Energy Agency). Interview on 05 April 2011.

NREAP (2010): *National Renewable Energy Action Plan* (Denmark). Available at: <http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm> (last accessed on 17 Mai 2011).

Market integration

Summary

Denmark is integrated into all markets on the common Nord Pool Spot, where almost 75 % of the total consumption of the Nordic countries was traded in 2010. In the Nord Pool Spot there are two markets for physical trades: Elspot (day-ahead market) and Elbas (intra-day market). All electricity producers have a balancing responsibility; wind onshore generators receive a balancing reimbursement to compensate for their balancing costs.

The general promotion system is a feed-in-premium. Since recently, there are no subsidies for new offshore wind farms when the prices become negative. Moreover there is a net-metering scheme for producers of electricity for their own consumption. Eligible parties are exempted from the Public Service Obligation which usually all consumers have to pay depending on their consumption amount.

Relevant Legal Sources

The Danish electricity market is regulated by the "Act on Electricity Supply" (Bekendtgørelse af lov om elforsyning), which was implemented on 21 November 2006.[1]

As from 1 September 2009, the law on the "Promotion of Renewable Energy Act" (Lov om fremme af vedvarende energi) came into force; the last amendment was made 16 June 2010. Its general purpose is the promotion of electricity from renewable energy sources.[2]

With the BEK 804/2010 the Regulation on Net-metering for RES-E was introduced. Since 1 July 2010 the law authorises the exemption of some producers from the surcharge on electricity.[3]

Market Design

Denmark's electricity market consists of an Eastern and a Western market and is integrated into the Nord Pool market. West Denmark joined the Nord Pool in 1999 and East Denmark joined in 2000. There is a HVDC connection between the two areas, however electricity trading happens separately in the two areas via the common Nordic power exchange (Nord Pool Spot AS, owned by the TSOs of the participating countries: Norway, Sweden, Finland and Denmark).

Market liberalisation began in 1998 and was fully achieved in legal terms in 2003. The Danish Energy Regulatory Authority (DERA) is the regulator for the Danish markets of electricity, natural gas and district heating. DERA regulates prices for those companies with a supply obligation but also for the

[1] Act on Electricity Supply : http://www.ens.dk/da-DK/Info/Lovstof/Hoeringer/2009/Documents/Lovbekg_286.pdf
[2] Promotion of Renewable Energy Act: http://www.ens.dk/en-US/Info/Legislation/Energy_Supply/Documents/Promotion%20of%20Renewable%20Energy%20Act%20-%20extract.pdf
[3] https://www.retsinformation.dk/Forms/R0710.aspx?id=132740

distribution operators and Energinet.dk, the Danish TSO. The regulation is based on a non-profit regulation, i.e. there is a cap on their profits and thus on their tariffs (DERA 2010).

General availability of markets

In Denmark nearly all electricity is traded on the Nord Pool Spot AS (MASSIG 2008). Almost 340 companies from 18 countries trade their electricity on this spot market. Traded electricity was 307 TWh in 2010, which equals almost 74 % of the total consumption in the Nordic countries. There are two markets for physical trades: Elspot (day-ahead market) and Elbas (intra-day market). Eltermin is the market for financial trade.

Since 31 November 2009 there are negative prices in the spot market (with a price floor of DKK 1.7 KWh), which allow the participants to take the price as an adequate market signal to adjust their production if there is an excess supply in the grid.

Day-ahead market, Intra-day market and Gate closure

The day-ahead market Elspot is based on an implicit capacity auction. There are three different bidding types: hourly bids block bids and flexible bids. All Elspot participants must have a balancing agreement with a TSO or with another third party.

After Elspot has closed, market participants can trade on Elbas, the continuous cross border intra-day market. Trading only happens between the supplier and the Nord Pool spot, which is the central counter party in this market. The trading period is always between two hours after the closure of the day-ahead market and one hour prior to actual delivery. The minimum contract size is 1 MWh (Nordpoolspot Webpage). All trading has to be reported to the respective TSO. Besides trading on Elbas, the market player can also trade bilaterally up to one hour before delivery. However, bilateral trades can only be made within each bidding area. Whereas, until November 2011 Sweden constitute one area, Norway is divided into five bidding areas and Denmark is divided into two bidding areas (Energinet.dk webpage).

	Nordic power exchange - Nord Pool			energinet.dk
Product	***Futures***	***Elspot***	***Elbas***	***Regulating Power Market***
Operational specifications				
Type of auction	Uniform price auction	Uniform price auction	Discriminatory auction	Uniform price auction
Gate closure	15:30 two days before	12 a.m., day ahead	1 hour before delivery	30' before delivery
Trading period	day, month, year	one session per day, daily trade	continuous	continuous
Technical specifications				
Minimum bid size [MWh]	1 MW	0,1 MWh	1 MWh	1 MWh
Minimum bid duration [h]	12 hours	1 hour	1 hour	1 hour
Available products	Peak/Base	Hourly, block bid (defined period and volume and price - reflects start-up cost), flexible hourly bid (defined price and volume, hour flexible - demand response)	hourly	1 hour

Table 7: Specification of power markets (Source: MASSIG 2008)

The Nordic Balance Settlement market

Like in all Nordic countries there is no national market for all ancillary services in Denmark. Balancing is maintained within the joint Nordic regulating power market, established on 1 September 2002, and in cooperation with the other national TSOs (RESPOND 2009). The Nordic regulation market (or regulation list) is not an organised common market place. It is a compilation of bids from the different TSOs (NordREG 2007). Accepted balancing suppliers can offer bids to the TSO, which than forwards them to the Nordic Operation Information System (NOIS). NOIS is a common compilation list, which includes all bids from Danish, Swedish, Norwegian and Finnish balancing suppliers. If necessary, the best price offer is selected. Thus, the market guarantees maximum economic efficiency and flexibility. No matter in which country the balancing needs to be accomplished, Energinet.dk is always responsible for the Danish regulating bids as for the regulation of the power stability (Energinet.dk Webpage).

The supplier of ancillary services has to meet slightly different requirements depending on whether it offers its services in the Eastern part of Denmark or in the Western part of the Great Belt (Energinet 2011d). In both areas, primary and secondary reserve minimum bid size must be 1 MW, tertiary bids size must be 10 MW. Producers can balance their electricity portfolio on their own or they assign a special Balance Responsible Party (BRP). BRPs have to sign an "Agreement on balancing responsibility" with Energinet.dk. There are more providers for primary reserves, but only two providers for Secondary reserves, DONG Energy and Vattenfall. Thus, the TSO need to enter into contract with one of them. As local CHP-plants offer tertiary reserve competition is bigger in this market (MASSIG 2008).

Support Scheme Design

General support scheme design

The long-lasting prevailing promotion mechanism for RES-E, the classical feed-in-tariff has been replaced for most technologies by a price premium on top of the market price. Support measures were defined in the Electricity Supply Act (Elforsyningsloven, 1999). Since December 2008 the "Promotion of Renewable Energy Act" has been in force, which includes an increase of the level of the feed-in premiums (Klinge Jacobsen, Zvingilaite 2010).

There are two types of price supplements: the `maximum bonus´ and the `guaranteed bonus´. The maximum bonus varies according to the market price so that a certain maximum price (the sum of the market price and the bonus) is not exceeded. The guaranteed bonus grants a fixed amount, which is independent from the market price (§§ 36-48 VE-Lov 2010). The distinction depends on whether a wind generation plant has been erected by a private investor or by a power company. The latter always receives the maximum bonus and in addition it gets a guaranteed bonus of DKK 0.10/kWh (approx. 1.34€ cent) for an unlimited amount of time. Private investors receive the guaranteed bonus for onshore wind plants and the maximum bonus for offshore wind plants.

Since 1 January 2009, Energinet.dk provides guaranteed loans (§ 21 VE-Lov) for the investigation of further wind plant projects, e.g. for the investigations of the area, noise pollution etc. (Danish Energy Agency webpage).

Support mechanisms for onshore wind plants

Feed-in-premium

The support measures for onshore wind plants made a step-wise transition process from a fixed feed-in-tariff to a premium on top of the market price. For wind plants connected to the grid before 2000 there was only a FiT remuneration for 10 years. Differentiation was made by system size so that small and less efficient turbines received a higher subsidy. Plants connected between 2000 and 2002 obtain a FiT for a production limit of 22.000 full-load hours; afterwards a premium (including a balancing reimbursement) is paid until the generation plant reaches 20 years. System size was only relevant to turbines established before 2000. Since 2003, wind generators receive a premium on top of the market price. There was a cap of approx 4.8€ cent/kWh for the premium plus the market price which was removed in January 2005 (Munksgaard, Morthorst 2008).

The "Promotion of Renewable Energy Act" (1 September 2009) brought an increase of the premium so that plants which were connected after 21 February 2008, receive DKK 0.25/kWh (approx. 3.35€ cent) for 22.000 full-load hours. Additionally, they get a balancing reimbursement of DKK 0.023/kWh (approx. 0.31€ cent) for their balancing settlement. This balancing reimbursement is granted for the whole lifetime of the plant (IMPROGRES 2010 a, Klein et al 2010).

Scrapping scheme or re-powering

From 2001 until the end of 2003 the first re-powering scheme was implemented. It enabled smaller wind producer to decommission their wind turbines (up to a capacity of 150 kW). If a plant operator replaced an old wind turbine with a new one it was qualified for a scrapping certificate which guaranteed it a price supplement for a specific load hour. This scheme made it possible to install much bigger turbines. In this time 80 % of wind farms, of the capacity range between 55-95 kW, have been decommissioned (Munksgaard, Morthorst 2008).

A second re-powering scheme was introduced for the period 2005-2009, this time for much bigger wind-mills (up to a capacity of 450 kW). However, this re-powering scheme did not have the same effects as the first one. According to Munksgaard, Morthorst (2008) it has been challenging to find sites where to built new wind plants with such a capacity especially since existing ones are not approved for replacement because of stronger restrictions to current legislation. Moreover, there is a maximum limit for the total remuneration (including the spot price, environmental premium and the re-powering certificate). Thus, the re-powering certificate value will be reduced if the total remuneration is bigger than the maximum limit.

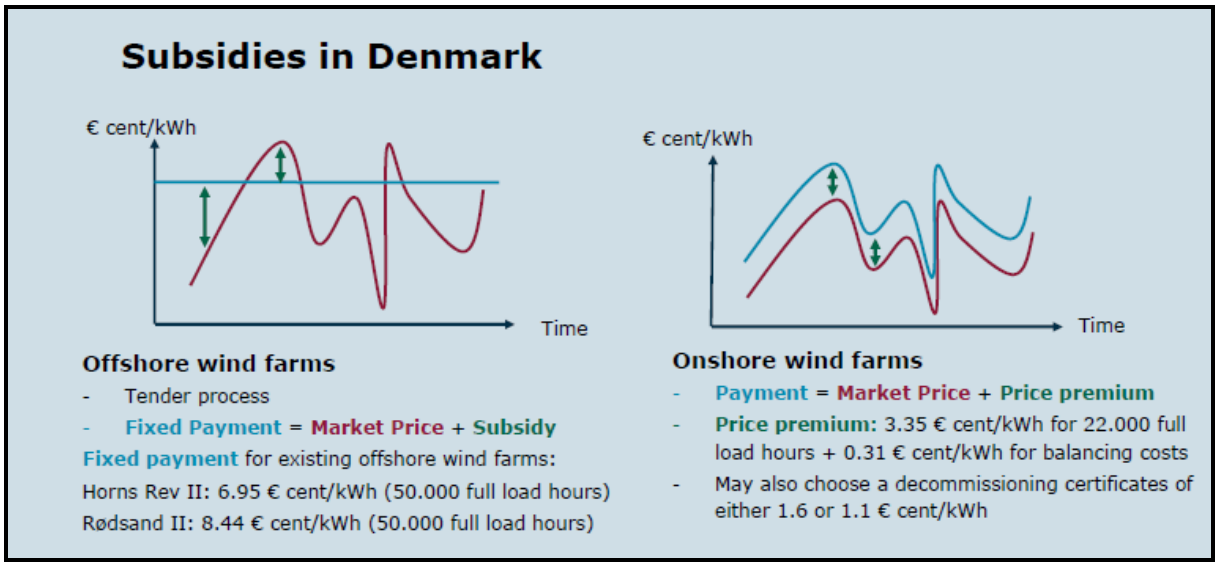

Figure 4: Subsidies in Denmark (Source: Energinet 2011c)

Support mechanisms for offshore wind plants

For offshore wind plants producers need an approval from the Minister for Climate and Energy to exploit energy from wind in Danish territories. The approval is passed by a special tendering procedure or by an application of a wind producer (§§ 22-23 VE-Lov 2010). In the tendering procedure, the Danish Energy Agency announces a specific size and area for the plant. Interested parties can submit their offers for which they are willing to produce. If they succeed, the premium plus the market price adds up to the announced bidding price (Klein 2010). Thus in principle the support mechanism is more market oriented, as the most cost efficient producer will be eligible for the premium for a pre-specified amount of full-load hours. However, experience showed that there was no strong competition for this tendering procedure. Rather, "tendering was a game including well-known actors from the Danish power industry" (Munksgaard, Morthorst 2008).

Denmark is the country with the longest experience with offshore wind generation – the first offshore wind park was established already in 1991. First offshore plant support measures started with a FiT for a specific full-load hour (Horns Reef I & II, Nysted I & Nysted Rodsand II) or a time limit (Middelsgrunden & Samso) for private investors and where than replaced by a premium on top of the market price. After the generation plant reaches a production time of 20 years only the market price will be paid (see Table 5).

Since 21 February 2008 a sliding premium or 'maximum bonus' is paid up until 10 TWh but only until a maximum of 20 years. Under this scheme the overall payment depends on the result of the tendering procedure. As mentioned above, systems financed by utility companies receive in addition to the premium a guaranteed bonus of DKK 0.10/kWh (approx. 1.34€ cent) for an unlimited amount of time.

Wind farm location	Stage 1		Stage 2		Stage 3
	Feed-in tariff c€/kWh	Limit	Market price c€/kWh	Limit years	
Horns Reef I/Nysted I	6.1	42,000 flhs	Market price+1.6	20	Market price
Middelgrunden and Samsø	6.1	10 years	Market price+1.6	20	Market price
Horns Reef II	7.0	50,000 flhs	Market price+0.3	20	Market price
Nysted-Rødsand II	6.7	50,000 flhs	Market price+0.3	20	Market price

Table 8: Tariff structure for Danish offshore wind farms (Source: Munksgaard, Morthorst 2008)

A new market element will be introduced starting with the `Anholt´ offshore wind park (planned connection time 2012-2013). This is based on a sliding premium that depends on the market prices (see figure below). The additional restriction that there are no supplementary payments if the market price becomes negative encourages the producer to provide the necessary system services i.e to supply less energy if there is already congestion in the grid.

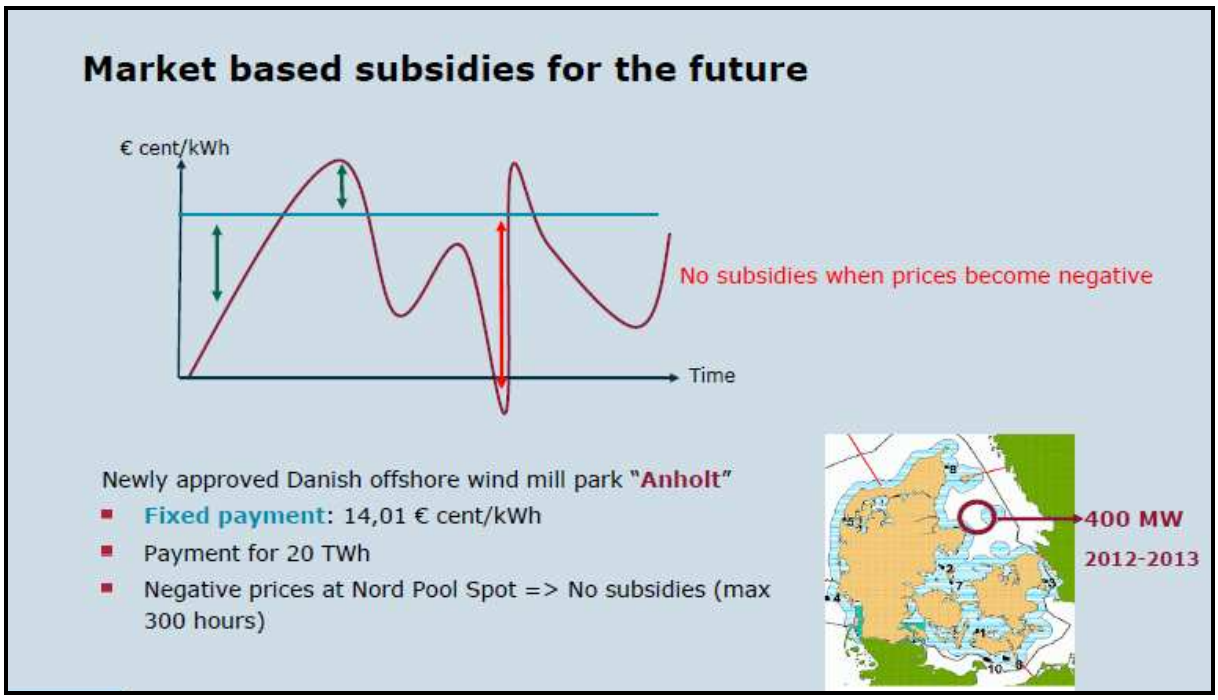

Figure 5: Market based subsidies for the future (Source: Energinet.dk 2011c)

Other RES producers are also entitled for a price supplement (guaranteed or maximum bonus, or fixed and sliding premium) by statutory law. The bonus applied to a specific project depends on a number of criteria (e.g. for systems deemed to be of strategic importance by the government) (RESLEGAL 2011). Operators are entitled to receive the premium for a specific full load hour differentiated by RES sources. Photovoltaic plants need to have a higher capacity load than 6 kW, hydro-electric power plants a higher capacity than 10 MW to get supported by this premium (RESLEGAL 2011, IMPROGRES 2010a).

Net metering and support for CHP plants

In general, all technologies (except geothermal energy) depending on the system size are eligible for net-metering. Producers who use their own electricity do not need to pay the Public Service Obligation

surcharge (PSO). Usually the subsidies for RES-E are passed on to the consumer through the PSO tariff[4], which depends on the consumption level of each consumer. The PSO also covers some expenses for research and innovations projects (IMPROGRESS 2010a).

A special system for CHP plants was introduced in 2007. Thermal generators with a capacity of less than 5 MW can choose between a fixed lump sum payment and a triple feed-in-tariff in a dispatching priority regime. The latter incentivises the generator to account for the actual demand in its electricity production (IMPOGRESS 2010a). The triple FiT is differentiated in two different ways, as shown by the following table: first by season (summer and winter) and second by load periods during the day (peak, high and low loads). Plants with a capacity above 5 MW participate in the spot and the balancing market (MASSIG 2008).

Working days	Low load	High load	Peak load
Winter (October - March)	21:00– 06:00	06:00 – 08:00 12:00 – 17:00 19:00 – 21:00	08:00 – 12:00 17:00 – 19:00
Summer (April - September)	21:00– 06:00	06:00 – 08:00 12:00 – 21:00	08:00 – 12:00

Table 9: Seasonally defined time periods for the Triple Tariff (Source: MASSIG 2008)

Balancing for RES-E

As mentioned above, all RES generators are responsible for balancing their production schedule. They can either announce a Balancing Responsible Party or they take balancing responsibility on their own (Energinet.dk 2007, MASSIG 2010). As mentioned above, onshore wind plants receive a special balancing reimbursement for an unlimited time.

[4] To limit the burden on electricity-intensive industries, the PSO is reduced for customers with a consumption of more than 100 GWh per year.

Literature and sources

Danish Energy Agency (2011): http://www.ens.dk/en-US/Sider/forside.aspx.

DERA (2010): Danish Regulatory Authority, *Results and Challenges 2010*. Available at: <http://energitilsynet.dk/> (last visit on 18 Mai 2011).

Energinet.dk (2011c): Egebert-Gjelstrup, Lene, *Renewable energy policy in Denmark*. Available at: <http://www.energy-regulators.eu/portal/page/portal/FSR_HOME/ENERGY/Policy_Events/Executive_Seminars/Edition1/2011.04.07-LENE.pdf> (last visit 8 June 2011).

Energinet.dk (2011d): *Ancillary services to be delivered in Denmark*, Tender conditions Valid from 1 January 2011, Doc. 8871/11 v1, Case 10/2932. Available at:<http://www.energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/El/8871-11%20v1%20Ancillary%20services%20-%20Tender%20conditions.%20Valid%20from%201%20January%202011.pdf> (last visit 19 Mai 2011).

Energinet.dk (2007): *Regulation A: Principles for the electricity market* December 2007. Available at: <http://www.energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/El/Regulation%20A%20Principles%20for%20the%20electricity%20market.pdf> (last visit on 17 Mai 2011).

Energinet.dk (2008): *Regulation C2: The balancing market and balance settlement* December 2008 Available at: <http://www.energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/El/Regulation%20C2%20The%20balancing%20market%20and%20balance%20settlement.pdf> (last visit on 17 Mai 2011).

Energinet.dk (2011a): *Regulation C1 – Terms of balance responsibility* January 2011. Available at: <http://www.energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/El/Regulation%20C1%20-%20Terms%20of%20balance%20responsibility.pdf> (last visit on 17 Mai 2011).

Energinet.dk (2011b): Mortensen, Poul, *Energinet.dk*, Interview on 28 April 2011.

IMPROGRES (2010a): Nieuwenhout, Frans; Jansen, Jaap; van der Welle, Adriaan; Olmos, Luis; Cossent, Rafael; Gómez, Tomás; Poot, Jos; Bongaerts, Martijn; Trebolle, David; Doersam, Barbara; Bofinger, Stefan; Lichtner, Patrick; Gerhardt, Norman; Jacobsen, Henrik; Ropenus, Stephanie; Schröder, Sascha; Auer, Hans; Weissensteiner, Lukas; Prüggler, Wolfgang; Obersteiner, Carlo; Zach, Karl: *Regulatory strategies for selected Member States (Denmark, Germany, Netherlands, Spain, the UK*. Available at: < http://www.improgres.org/fileadmin/improgres/user/docs/D8_Final.pdf> (last visit 19 Mai 2011).

IMPROGRES (2010b): Nieuwenhout, Frans; Jansen, Jaap; van der Welle, Adriaan; Olmos, Luis; Cossent, Rafael; Gómez, Tomás; Poot, Jos; Bongaerts, Martijn; Trebolle, David; Doersam, Barbara; Bofinger, Stefan; Gerhardt, Norman; Jacobsen, Henrik; Ropenus, Stephanie; Schröder, Sascha; Auer,

Hans; Weissensteiner, Lukas; Prüggler, Wolfgang; Obersteiner, Carlo; Zach, Karl: *Market and regulatory incentives for cost efficient integration of DG in the electricity system*, Final Report.

Klein et al. (2010): Klein, Arne; Merkel, Erik; Pfluger, Benjamin; Held, Anne; Ragwitz, Mario; Resch, Gustav; Busch, Sebastian; *Evaluation of different feed-in tariff design options –Best practice paper for the International Feed-In Cooperation*. A research project funded by the Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

Klinge Jacobsen, Zvingilaite (2010): Klinge Jacobsen, Henrik; Zvingilaite, Erika; *Reducing the market impact of large shares of Intermittent energy in Denmark*, Energy Policy 38 (2010) pp. 3403–3413.

MASSIG (2008): Obersteiner, Carlo; Weißensteiner, Lukas; Haas, Reinhard; Erge, Thomas; Sauer, Christian; Sothmann, Dominik; Siewierski, Tomasz; Szypowski, Michal; Wedzik, Andrzej; Watts, Melanie; Ekanayake, Janaka; Andersen, Anders N.; Maeng, Henning; Tambjerg, Leif; *Market potentials, trends and marketing options for Distributed Generation in Europe.* Available at <http://www.iee-massig.eu/papers_public/MASSIG_Deliverable2.1_Market_Potentials_and_Trends.pdf> (last visit on 19 Mai 2011).

Munksgaard, Morthorst (2008): Jesper Munksgaard, Poul Erik Morthorst, *Wind power in the Danish liberalised power market—Policy measures,price impact and investor incentives*, Energy Policy 36, pp. 3940–3947.

NordREG (2007): Nordic Energy Regulators, *Monitoring of the Nordic Regulation Power Market.* Report 6/2007. Available at: <https://www.nordicenergyregulators.org/upload/Reports/monitoring%202007.pdf> (last visit 7 June 2011).

Ragwitz et al. (2010): Ragwitz, Mario; Held, Anne; Stricker, Eva; Krechting, Anja; Resch, Gustav; Panze, Christian; *Recent experiences with feed-in tariff systems in the EU – A research paper for the International Feed-In Cooperation*. A report commissioned by the Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

RES LEGAL (2011): Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (Federal Ministry of the Environment, Nature Conversation and Nuclear Saftey), *Website on Legal Sources on Renewable Energy*. Available at: <www.res-legal.eu> (last visit on 15 March 2011).

RESPOND (2009): Renewable Electricity Supply interactions with conventional Power generation, Networks and Demand Research, Lobato, Enrique; Olmos, Luis; Gómez, Tomás; Andersen, Frits M.; Grohnheit, Poul Erik; Mancarella, Pierluigi; Pudjianto, Danny; *Regulatory and other Barriers in the implementation of Response Options to reduce impacts from variable RES sources*, Project supported by the European Commission, Directorate-General for Energy and Transport, under the Energy Intelligent Europe (EIE) Programme.

RETD (2008) Renewable Energy Technology Deployment, *Final Report - Innovative Electricity Markets to Incorporate Variable Production to IEA – Renewable Energy Technology Deployment*.

VE-Lov (2010): *Law on the Promotion of Renewable Energy*. Last amended on16.06.2010. Available at: <http://www.ens.dk/en-US/Info/Legislation/Energy_Supply/Documents/Promotion%20of%20Renewable%20Energy%20Act%20-%20extract.pdf> (last visit 7 June 2011).

NREAP Analysis

The table below presents an overview on the identified national barriers of the RES Integration study as well as on the respective NREAP content. Throughout the study, the consortium carefully analysed, if the identified barriers of this study are addressed in the national energy action plan and whether or not the NREAP does foresee a solution approach:

- The column “Barrier identified in RES Integration Study” lists the various barriers, which the present study identified and addressed. The list contains barriers from the section connection, operation as well as development.
- The column “Is the barrier Contested?” would indicate, whether stakeholders in the country under concern would oppose to the identified barrier, namely if they do not see the listed issue as a barrier to the system.
- The column “Section in NREAP” identifies, if and where the respective NREAP is addressing the barrier under concern. The column would list the specific section of the national action plan.
- The column “Summary of foreseen Measure” would contain a short description of the foreseen measure of the NREAP, to overcome the addressed barrier. The column would be empty, if the respective NREAP does not identify the barrier, respectively if the NREAP does not propose a solution to the issue.
- The column “Comments & Evaluation” would contain a short analysis of the proposed NREAP solution and would evaluate, whether the solution is an appropriate and credible option to overcome the existing issue. If the NREAP does not identify the barrier, this section may also contain a short summary of the identified issue.

For a detailed description of the identified barriers in the framework of the RES Integration study, we kindly refer to the sections above, regarding connection, operation, development and market integration of RES-E installations.

Barrier identified in RES Integration Study	Is the barrier contested?	Measures foreseen in NREAP		
		Section in NREAP	Summary of foreseen Measure	Comments & Evaluation
Deadlines for grid reinforcement not defined		**4.2.6 h)**	It has been acknowledged that the process of grid development needs to be amended in the future.	Problem acknowledged but no solution proposed
Investment for grid reinforcement must be justified by grid operator to the regulator, possible barrier if there is a disinterest of the DSO		**4.2.6 h)**	It has been acknowledged that the process of grid development needs to be amended in the future.	Problem acknowledged but no solution proposed
Grid operator must justify reinforcement/expansion investment to regulator, process for obtaining permission not transparent		**4.2.6 e)**	It is foreseen to optimise the administrative process of the grid development-	Problem acknowledged but no solution proposed

Table 10: Summary of identified barriers and treatment of barriers in NREAP