

# Environmental Impact Assessment of the wind farm at the Middelgrunden Shoal

Non-technical Summary of the EIA  
1st Revision. January 2001.

**Environmental Impact Assessment of the wind farm at the Middelgrunden Shoal.**

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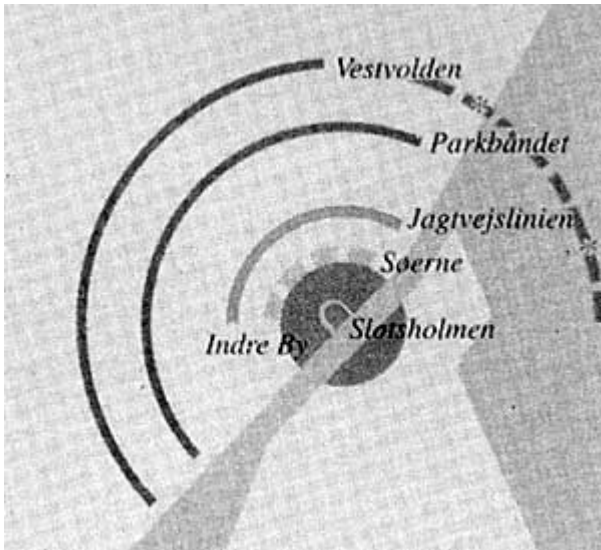
This document is a non-technical summary of the main report "EIA of the windfarm at the Middelgrunden Shoal". The information is up-dated on January 1, 2001, so that data for turbine size etc. matches the actual situation. The leaflet describes the environmental aspects connected to the establishment of 20 wind turbines at the Middelgrunden shoal. In the main report a more detailed description of the environmental impact of the project can be found. In connection to the wind turbine project an environmental impact assessment (EIA) must be made, and the hearing replies will be part of the authorities' environmental approval of the project.

Previous to the Environmental Impact Assessment a public hearing with all relevant authorities was held in 1997 and another at the Copenhagen city hall in august 1998. A number of investigations have been made, which among other things examine relevant environmental and visual aspects of the project. The project obtained planning permission from the Danish Energy Agency in may 1999.

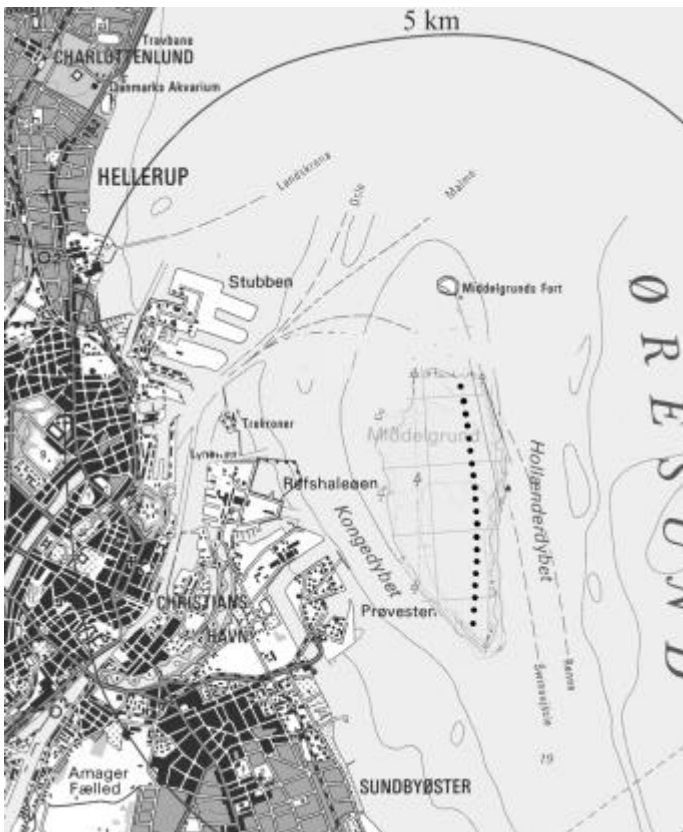
## **Project description**

The builders are the city utility Copenhagen Energy and the Middelgrunden Wind Turbine Co-operative. The wind farm consists of 20 turbines that will be placed in a circular arc with a radius of 12.5 km and with centre at Slotsholmen (The Danish Parliament).

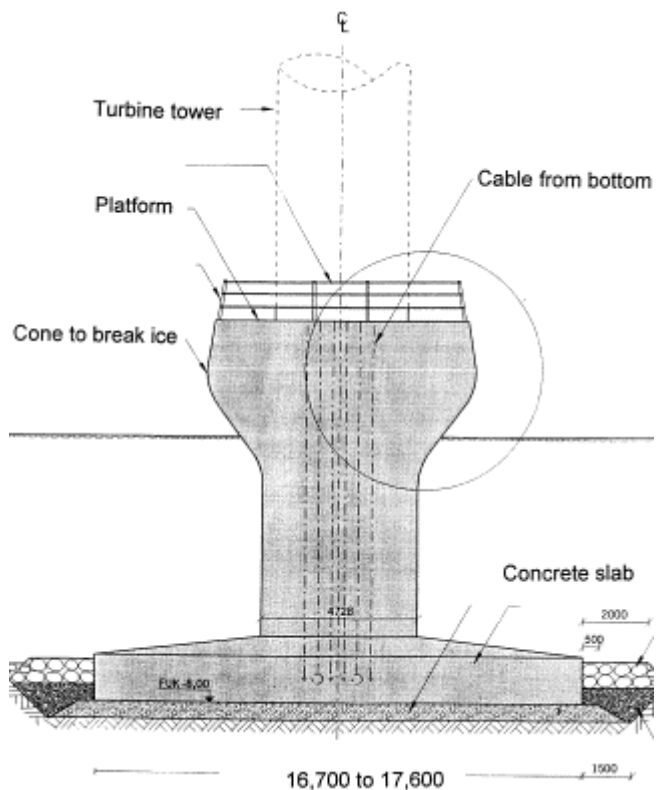
That makes the wind farm part of the arch formed by the historical works of Copenhagen. The distance between the turbines is 183 metres, which gives a total length of approximately 3.4 km. The wind farm takes up an area of about 1 hectare.



The hubs of the turbines are placed at 64 metres measured from the sea level to the centre of the rotor. The rotor has a diameter of about 76 metres, so the height from the sea level to the tip of the blade will be max. 102 metres. Each turbine has a rated power of 2 MW, which gives the wind farm a total power of 40 MW and an annual electricity production of about 89,000 MWh corresponding to 3% of the electricity consumption in Copenhagen municipality. The capital investment is about DKK 352 million (EUR 47 million).



The turbine foundations will be made of concrete or steel and be placed at the seabed like traditional gravity foundations. The two foundation types only have a few differences. The foundations are round with a width of 4.9 metres, and end in a cone-shaped icebreaker at the top above water. Gravity foundations in reinforced concrete are cast and prepared locally in the Copenhagen port at the former Burmeister & Wain dockyard at Refshaleøen. The wind turbines are delivered from the factory to a wharf in the Copenhagen port as modules ready for installation. Later they are shipped and mounted at the foundations.



The area needed for the production of concrete foundations is calculated to 7,500 m<sup>2</sup>. There is a need of about 150 metres wharf with a water depth of four metres so a big floating crane can get access. Construction work starts by removing the top layer of the seabed. The foundations are placed on solid ground, then the towers are mounted at the foundation, and finally the nacelle and the three blades are put up. Cables are flushed down into the seabed in between the wind farm and the Amager Power Plant. Cables between the turbines are dug 0.5 metres into the seabed.

The total installation is expected to take 50 working days under good weather conditions. The sea traffic in and around the Copenhagen Port and the Middelgrunden will not be noticeably disturbed.

**Time schedule for the installation of the wind turbines.**

Month #	1	2	3	4	5	6	7	8
Foundation								
Casting								
Dredging								
Disembarkation								
Installation of the wind turbines								
Grid connection								
Erosion protection								

**The Middelgrunden shoal today**

The Middelgrunden shoal is placed within territorial waters and therefore the state owns the area. Planning and approval of wind power plants in territorial waters is handled by The Danish Energy Agency. At the map to the right is shown the status for water areas at and around the Middelgrunden shoal. The colours show the objectives for the water quality in the different areas. The Middelgrunden shoal itself is a dumpsite with an eased water-environment objective. The water depth varies between two and five metres within the area where the wind turbines are planned. The sea-lanes Hollænderdybet and Kongedybet are very busy. Sailing at the Middelgrunden shoal is dissuaded because of risk of running aground. Some fishing trade, e.g. eel trap

fishing, takes place at the Middelgrunden shoal. An estimated 28 fishers are involved in this trade. The nearest areas ashore are industries, the port and other technical plants. Recreational areas include the beach Amager Strandpark about 2 km southwest of the wind farm and a number of marinas along the coast. Southeast of the Middelgrunden lies Saltholm surrounded by a shallow area. Saltholm and surroundings is a bird protection area.

For more than a hundred years the Middelgrunden shoal has been utilised as dump site for 1.6 million m<sup>3</sup> of harbour sludge, dredging materials and building waste. The Middelgrunden is therefore officially indicated as "unclean area". The concentration of heavy metals in the sediment generally have the same order of magnitude as the concentrations measured in a number of surface sediments at the seabed between Amager and Saltholm along line of the Øresund connection.

**Average figures for the sediment contamination near the turbine positions at Middelgrunden.**

	mg/kg TS
Lead	4.6
Cadmium	0.19
Chromium	5.8
Copper	8.0
Nickel	5.7
Zinc	21
Mercury	0.05

**Alternatives to the Middelgrunden project**

An alternative to the wind farm could be electricity savings or another form of environment-friendly electricity production corresponding to the production of the turbines. These possibilities are regularly utilized and should more be looked upon as a supplement than a real alternative to the project.

While establishing the project a number of other sites for a wind farm near Copenhagen have been considered. Furthermore the farm's geometrical composition has been profoundly analysed.

Both land and sea based alternatives have been considered, e.g. Nordhavnen (the North Port). But port authorities were not interested in placing wind turbines, just like the Øresund Consortium did not want wind turbines at Peberholmen (an artificial island for the Øresund Bridge).

Two locations north of Saltholm have been closely analysed as an alternative position. The visualisations show that the turbines would be less dominant seen from the Danish shore, while they would be more noticeable from the Swedish shore. Other environmental conditions speak against placing them north of Saltholm. The interests in bird and fish life are bigger here. The risk of ship collision and influence on the water flow through the Øresund sound are also estimated to be higher because of deeper water. Finally the approach for the Copenhagen Airport is over the area.

The economy for a project north of Saltholm would be bad simply because of the need for a 7.5 to 9.6 km long sea cable. Also the foundations would be considerably more expensive as a consequence of the bigger water depth. Because of the different economy it would take 70-180 turbines to achieve the same profitability as for 20 turbines at the Middelgrunden.

Based on the builder's objective to construct a wind farm, there is no technically or economically realistic alternative to the wind turbine project at the Middelgrunden shoal.

During the project a number of different patterns for a wind farm at Middelgrunden have been drafted. The most essential patterns have been visualised in 2 different reports describing the visual impact on the environment from the wind farm. The first report from August 1997 visualised a wind farm consisting of 27 turbines placed in three straight lines. The objections voiced in the hearings of the first proposal led to a reduction and reformulation of the project. A new report describing the reduced project was presented in April 1998. For landscape architectural considerations the authors of the report recommend the chosen pattern with 20 turbines placed in a circular arch.

**Saved fuel consumption and pollution**

During an average year the wind farm will produce 89 million kWh electricity corresponding to a good 3% of the

electricity use in Copenhagen municipality. In that way the nature is annually spared the pollution of:

<b>Sulphur dioxide</b>	<b>258 tonnes</b>
Nitrogen oxides	231 tonnes
Carbon dioxide	76.000 tonnes
Dust and clinker	4.900 tonnes

Furthermore the reduction of dust and clinker will supersede quite some transport and need for dumpsites.

### Visual impact

It is primarily from the Langelinie quay, Amager Strandpark and Strandvejen by Hellerup there is a free view to Middelgrunden. Furthermore there is a free view from the passing vessels. The visualisations in this booklet show the view from Middelgrunden Fortress, Langelinie, Amager Strandpark, Charlottenlund Fortress and Flak Fortress. There has been an aim to make the wind farm appear harmonious and simple from all angles, on its own and together with the surroundings. Besides, the geometrical arch has been chosen so it corresponds with the positions of the medieval defences of Copenhagen.

The circular arch will be simple and easily recognisable from all angles. On close hand it will only be perceived as an arch from north or south. Seen from a diagonal angle it will be perceived as an arch at distances greater than 4-5 km. When approaching Copenhagen from air or water the pattern will appear as part of the lines surrounding the centre of Copenhagen. It will appear calm but yet dynamic. The disturbing sight of all turbines behind each other will rarely be seen. From all angles the view to the Middelgrunden fortress will be undisturbed.

The disadvantage of the circular arch is that the wind farm is stretching out far north and south. This means that it takes a big part of the view from the northern part of Amager Strandpark. Seen from the Langelinie quay, turbines will stick up behind the Trekroner fortress.

Each turbine and foundation will be fit into the surroundings with a discreet light-grey colour. And the foundation is designed to be visual only to the extent that is necessary due to the action of ice.

### Dispersal of sediments during construction work

The waste from dredging and handling of the sediment will be maximum 5%. The total need for soil removal is about 25,000 m<sup>3</sup>. The total waste is estimated to a maximum of 1,050 m<sup>3</sup>, which is a little less than one day's waste from dredging at the Øresund Bridge. An amount of 1,050 m<sup>3</sup> will not have any measurable influence on Øresund as a whole, however local environmental effects might occur. If the sediment waste was evenly spread within a radius of 100 meters from the turbines, it would create a layer of 2.7 kg/m<sup>2</sup> or less than 2 mm. The significance of such a deposit is small. The waste from each foundation will last for only a short while, so the shading will have an insignificant influence on the environment. The maximum amount of heavy metals that will be released to the water during the dredging of sediment can be seen in the table.

	<b>Lead</b>	<b>Cadmium</b>	<b>Chromium</b>	<b>Copper</b>	<b>Nickel</b>	<b>Zinc</b>	<b>Mercury</b>
Total waste in kg	0.92	0.02	0.2	15.3	7.14	49	0.6

The assessment is that the relatively small amounts of heavy metals being washed out from the sediment will have no significant environmental impact on the surrounding sea, primarily because the load will appear over a short dredging period of about 40 days. Therefore no measurable effects on flora or fauna will occur in the area. At each and every turbine position heavy metal analyses will be made. The dredged material will be handled following the instructions from the Environmental Protection Agency. Strongly contaminated material will be deposited under control. Possible deposits are Copenhagen Port Environmental Centre and AV-Environment in Hvidovre. Non-polluted sediment will probably be patted at the northern part of the Middelgrunden shoal.

### Animals and plants

Air photographs from 1996 show that a big part of the Middelgrunden shoal is covered by vegetation, primarily eelgrass. Also sea lace and some sweet tangle can be found. It has turned out that eelgrass recovers after a few years at areas being patted. When the eelgrass is back new small plants and common mussels are migrating. Large banks of mussels are covering 10-15% of the Middelgrunden shoal.

The dredging work is expected to have only minor, momentary influence on the fishing. There is no evidence of

possible long-term physical effects on fishing, flora or fauna at or around Middelgrunden during operation. Sailing activities during the construction is not expected to give big inconveniences for the fishing. A security zone, where sailing is prohibited, will be established around foundations where work is going on. After the construction the area can be used like today. Yet fishing cannot take place where the foundations are placed and anchoring will be prohibited as well as ramming down poles around the sea cables. Compensation for lost fishing will be negotiated according to the Salt-water Fishing Act.

There are no breeding-birds in the area. However birds do rest and forage in the area, including mute swan, common eider, shelduck, mallard, pochard, tufted duck, golden-eye, red-breasted merganser, goosander and coot. Morning and evening, quite some sea gulls and ducks are passing over the Middelgrunden area when migrating between Copenhagen and Saltholm. Furthermore some migrating common eider can be found passing through Øresund spring and autumn.

The operation of the turbines will disturb the birds because of noise and changes in the landscape. The disturbance will make resting and foraging birds keep distance to the turbines. On the other hand the turbine's foundations will provide new hiding places, e.g. for mussel-larvae, and 2-5 years after the construction, there will be feeding possibilities e.g. for diving duck.

During dredging for the foundations some sediment will be whirled up and spread out, which makes it difficult for the birds to seek food around the turbines. The assessment is that a minor influence on birds will occur, especially on diving duck, common eider and tufted duck, which are foraging in the area. The influence on bird-life will be limited to the construction period. The assessment is that the birds temporarily will forage outside the construction area, and that no long-term effects will occur because of the spreading of sediments. Naval archaeology will be further documented by inspection at each foundation position.

### **Noise and traffic**

During construction traffic and noise will occur from the shipping area and production plants, at the level of a medium-sized building site. During operation the turbines emit sound, and the sound level at some of the frequented neighbouring areas can be seen at map. Following the Sound Notice noise from the turbines may not exceed 40 dB(A) at recreational sites in domestic areas.

It is established that there are no conflict with prevailing legislation, and it is unlikely that noise from the turbines will be audible or measurable on shore under normal climatic conditions.

### **Water flow**

The foundation's influence on the water flow in Øresund has been analysed. The analysis shows that the water flow will be reduced by maximum 0.005%. Consequently the influence will be quite insignificant for the overall water flow in Øresund. For environmental reasons it is therefore recommended not to compensate the reduced water flow by dredging.

Calculations of the dredging's influence on the relative water flow can be made with an accuracy of +0.2%. The uncertainty of the calculation is therefore about 50 times larger than the influence on the water flow caused by the foundations.

### **Accidents**

The way the wind farm will mark the Middelgrunden shoal means that the ships can avoid running aground, which happens about one time a year at the moment! This means that the risk of running aground and oil pollution from leakages will be reduced compared to the current situation. Though, there is a risk of collision with the turbines and the annual risk during the life span of the project has been estimated to 8%. The risk of a turbine falling down during normal operation is minimal. By total damage oil spill may occur from the gearbox, etc.

### **Decommission**

The wind turbines are deconstructed in opposite direction as they are erected. The foundations can be lifted away in one piece. Cables etc. can be taken away, and none of the above mentioned operations will course any significant disturbance or impact on the environment. The materials in the foundations can be reused by road construction or as addition to concrete, as well as the steel from the turbines can be reused.

### **Surveillance programme**

Before the construction starts a registration of the seabed conditions is made by photo and diving reports. A new registration of seabed conditions etc. will be made two years after the construction. In this way it is possible to monitor re-migration of eelgrass, signs of increased erosion, etc. A few facts will only be clarified during the final design of the project. Seabed samples will only be taken at each turbine position during summer '99, as well as archaeological conditions ill be documented at this point.

### **Hearing**

The main report (in Danish) "Environmental Impact Assessment of the wind farm at the Middelgrunden Shoal" can be ordered from the addresses below. Comments to the EIA can be sent to The Danish Energy Agency, Amaliegade 44, 1256 Copenhagen K, marked: "Environmental hearing conc. a wind farm at the Middelgrunden shoal".