



# Capital Grant Scheme for Offshore Wind Annual Report – January 2005 – December 2005

## EXECUTIVE SUMMARY

The Scroby Sands Wind offshore farm site is situated a little over two nautical miles off the coast of Norfolk. The boundary locations of the project are given in Table 1.

Following an extended planning and consenting process the procurement of plant began in early 2003 with construction beginning in November of the same year. Site commissioning took place in late 2004 with handover to E.ON UK on 31<sup>st</sup> December 2004. The site is now fully operational exporting electricity into the EDF network via a 33KV connection.

The 30 V80 2MW turbines were manufactured and installed by Vestas under a turnkey contract and are maintained by the same company under a Warranty Operations and Maintenance Agreement. Offshore Engineering Design (ode), a company acknowledged as expert in offshore engineering, acted as project supervisors during construction and now act as the clients' representative on all issues related to the wind farm under a site management contract.

The total wind farm capacity of 60MW was constructed at a total cost of £75.543m including a decommissioning provision of £1.617m which equates to a cost £1.259m/MW and £2.518m/turbine. The capital grant of £10m equates to a cost reduction to E.ON UK of £0.167m/MW.

**Table 1 Site Boundaries**

<b>National Grid Reference</b>	
<b>East</b>	<b>North</b>
655.765	310.945
655.917	312.384
655.629	313.600
657.241	313.600
656.806	312.673
657.400	312.200
657.264	310.997
655.765	310.945

## SITE PLAN

The site plan showing turbine position, water depths and cable routes is shown in Figure 1.

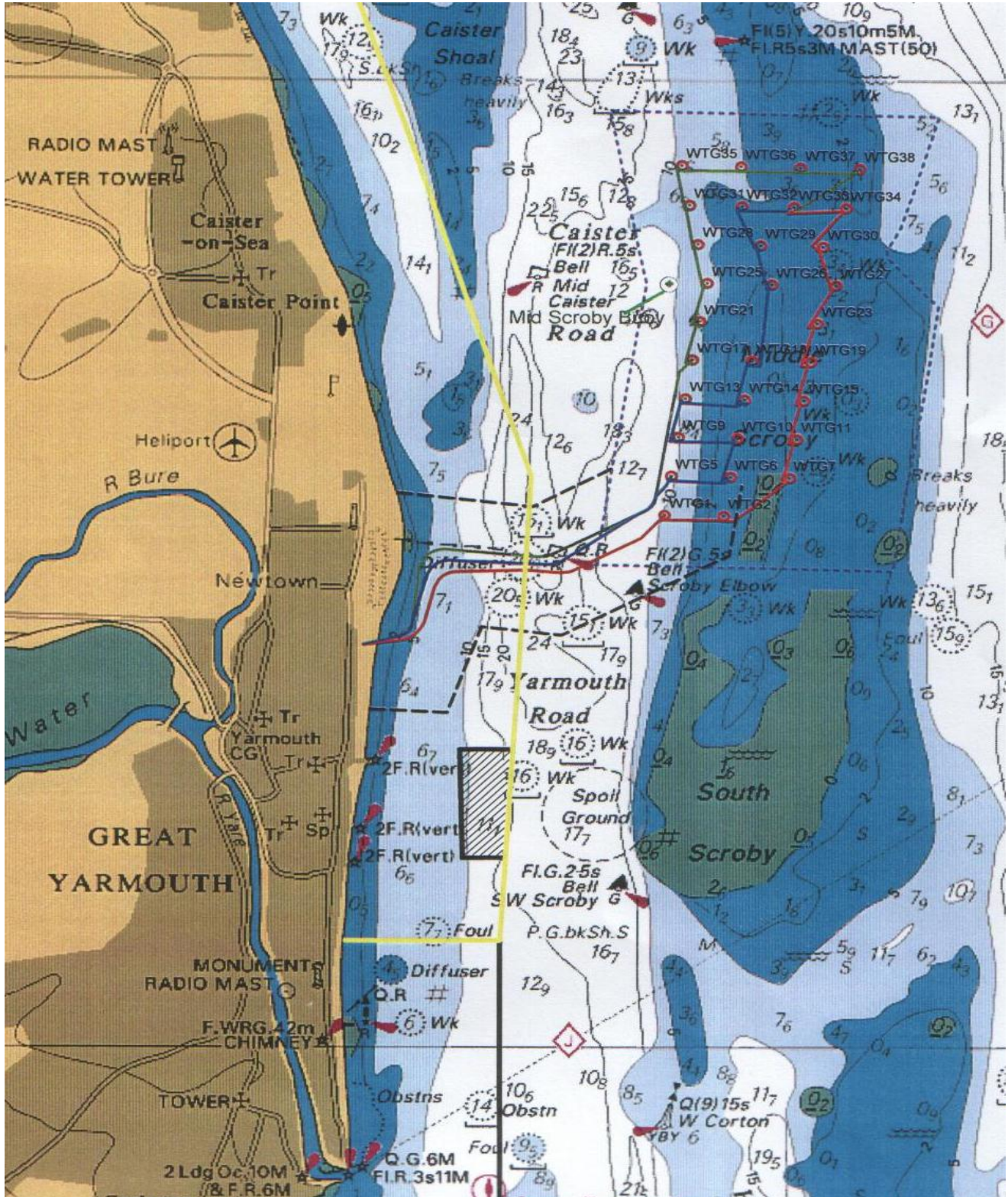


Figure 1. Site Plan

## **SITE CONSTRUCTION**

### **Procurement of plant**

The windfarm was procured in a number of packages. The main package was the provision of the wind turbine generators, foundations and offshore cabling, this was supplied by Vestas Celtic Wind Technology utilising 30 V80 2 MW machines.

The grid connection facility was provided by EDF the local District Network Operator and consisted of a new 33 kV substation to receive power from the windfarm. The substation also houses the windfarm computer control system.

The windfarm was project managed by a combined team of staff from EON UK and ode who brought offshore skills to the team. They also had the advantage of being based in Great Yarmouth.

### **Onshore preparation**

The onshore cabling connecting the windfarm to the substation was supplied in two contracts, one for cable supply from Pirelli cables based in Wrexham and the other for the cable installation by NACAP UK Ltd from Needham, Market. The local council required that the cable was installed during the winter period November to February to minimise the disruption to tourists enjoying the sea front of a large and popular resort.

### **Foundation installation**

Each of the 30 wind turbines at Scroby Sands are supported on a robust foundation known as a monopile (single pile). Each pile is a long cylindrical steel tube measuring 4 metres in diameter and up to 50 m in length, they each weigh around 200 tonnes.

The foundations were provided under a sub-contract to Vestas and were manufactured in Scotland by Cambrian Engineering (on the Isle of Lewis) and by Isleburn Mackay Macleod, at Nigg, and then shipped south. The foundations arrived in Great Yarmouth harbour and were offloaded and stored at the port in preparation for the start of the offshore work.

The piles were installed by Mammoet Van Oord, a Dutch heavy lift and offshore contractor using their specialist installation vessel the “Jumping Jack.” The vessel was loaded with enough material to install piles at five locations. When on location the vessel lowered four extendible legs onto the sea bed and lifted the vessel clear of the water to provide a stable platform for the 300 tonne crane to handle the piles. A hydraulic ram was then used to hammer them into the sea bed to a depth of around 30 metres leaving approximately 8 metres extending out of the sea. During initial hammering of each pile low impact blows were used to warn seals and fish away to protect them from effects of piling noise. The piling operation also took place during the winter months to avoid the breeding season of a nearby protected colony of Little Terns.

Access to the wind turbines is required for maintenance and in case of repairs. To maintain the wind turbines, personnel access them by boat, so each pile is fitted with a “boat landing” comprising of two ladders and boat fenders. Two ladders were installed in order to improve the opportunity for access depending on prevailing wind

and wave direction. The fenders are positioned either side of the ladders and project out from the pile, allowing a small vessel carrying maintenance crew to position itself between them so that personnel can climb onto the ladder. The fenders also double as 'J tubes' which house the power cables which transport the electricity generated to the main land. Fitted around the top of the pile is a platform which will assist maintenance personnel in accessing the wind turbines. The piles and boat landings are painted bright yellow to aid visibility for shipping.

Each piling operation took around 24 hours to complete including positioning of the vessel and making ready for the lifting operation. The piling started towards the end of October 2003 and was completed early in January 2004.

### **Turbine installation**

In February 2004 the components that make up the wind turbines started to arrive at the SLP Engineering's yard, Lowestoft. This facility was chosen because it provided a large quayside area directly adjacent to the vessel births. Each turbine was delivered to Lowestoft in five component parts : two 30 m tower sections, three 40 m blades and a nacelle, housing the a gearbox, generator and power transformer.

The installation was performed under sub-contract to Vestas by two companies A2SEA and Seacore. In March 2004 A2SEA's "Ocean Ady", a transport container ship that has been specially modified into a crane ship, began lifting the turbines onto their foundations. The Ocean Ady is capable of carrying two towers and two complete turbines. In order to manage the heavy lifting work this floating crane ship was lifted slightly out of the water using its 4 submersible support legs to create a stable working platform. Because it was working on soft sand it took four hours to stabilise the vessel and prepare for its principal task – that of lifting the turbine sections onto the foundations. This floating crane ship worked around the clock to carry the various sections and components out to the construction site and install them. The first challenge was to erect the 60m towers. The towers were transported and lifted in two sections. The lower section was lowered directly onto the foundations and the mating flanges then bolted together. The upper tower section was then lifted in place and bolted to the lower section. Two of the blades were pre-fitted onshore to the nacelle hub. Thanks to this concept the cranes only needed to perform four offshore lifts, two for the tower sections, one for the nacelle and one for the third and final blade. The last blade was lifted into place using a purpose-made clamping device developed specially for offshore projects. One of the construction team sat inside the hub and located the 150 bolts on the blade into the 150 holes in the hub.

The whole assembly process took 12 hours and approximately two turbines were assembled every 3 – 4 days. It took around 8 weeks to install the 30 turbines.

To satisfy maritime and aviation safety requirements, selected turbines are fitted with navigation lights, radar reflectors and foghorns for shipping and aircraft warning lights.

### **Offshore cabling**

The offshore power cables consist of three cores for power and a fibre optic cable for controls signal transmission. The whole bundle is wrapped in one or two layers of steel wire armour to avoid damage. The cable is also buried up to 3 m in to the seabed. This task was achieved by utilising a cable plough which is towed by a cable lay

vessel which also carried the marine cable in a large drum. Vestas subcontracted the cable laying activity to CNS Ltd.

The cable lay activity proved to be the most challenging aspect of the construction activity. The rate of cable lay for the cables to shore from the array taking longer than anticipated due to the hard soil conditions found at the edge of the shipping channel between the sand bank and the beach. The other aspect of the cable laying which became time consuming was the use of divers to locate and feed the cable up the J tubes into the turbine towers. Due to the strong tidal currents the divers could only work for short periods of slack water either side of the high and low tides and then only in very benign wave climate.

The depth of burial of a section of the offshore export cable X1 is currently too shallow, being less than the required 3m for a length of around 400m. To remedy the situation it is planned to install concrete mattresses over this section to provide protection to the cable. Vestas were successful in obtaining a separate Food and Environment Protection Act (FEPA) Licence to undertake this work, from of the Department of Environment, Food and Rural Affairs (DEFRA) approval.

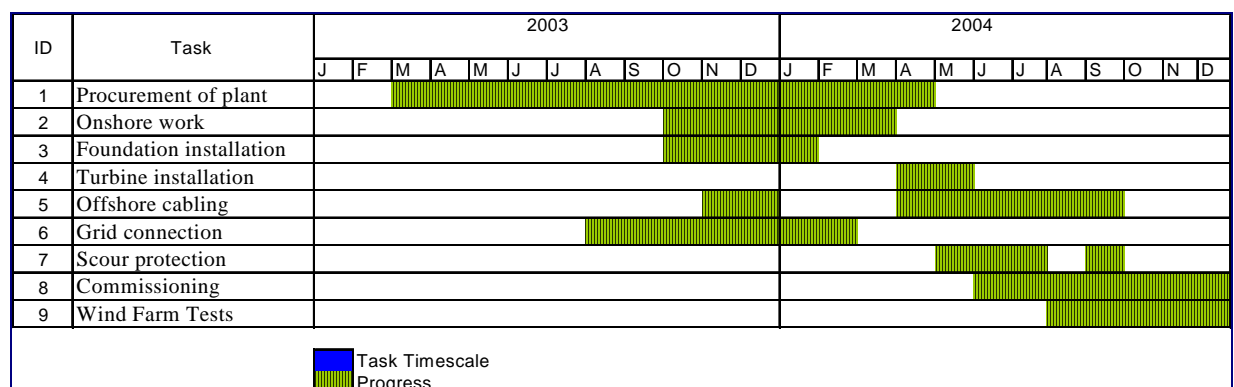
### Grid connection

The grid connection facility was installed on time to meet the requirements of commissioning the wind farm by EDF's own project managers.

### Commissioning

On the 16<sup>th</sup> December 2004 the wind farm generated 60MW for the first time and was taken-over on 31<sup>st</sup> December 2004. There were some minor defects outstanding which are being dealt with under the construction contract. Although the majority of these defects are now cleared, the remainder are being progressed by Vestas and managed by the original project team. Outstanding defects include some non-essential functions on the SCADA system.

### Final Construction Programme



## WIND FARM ANNUAL OPERATIONAL INFORMATION

### PERFORMANCE REPORTING

#### Availability

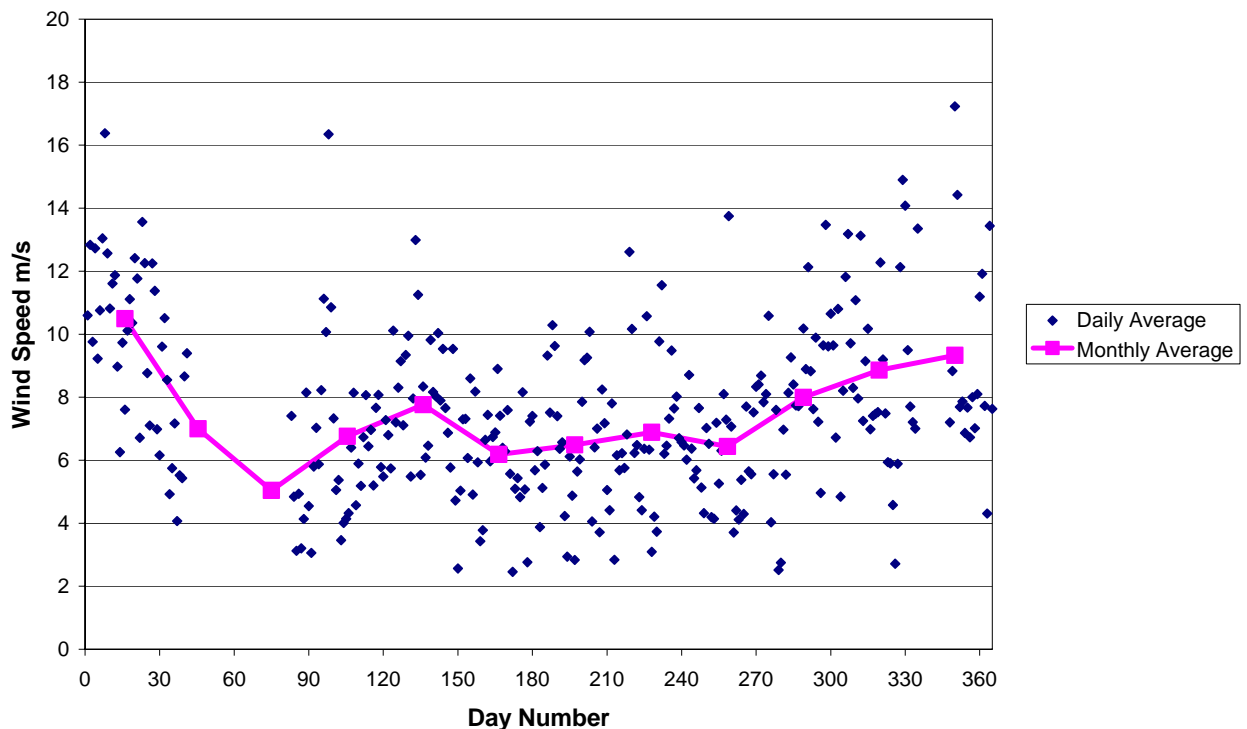
**Table 2** Availability in 2005 against a Planned Availability of 95%

	(% Availability)												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Mean
Mean	71.96	86.85	87.32	94.52	96.77	94.29	93.06	89.98	88.11	73.23	70.22	63.87	84.18

The values in Table 2 are based on total availability and reflect the time that the turbines are available to operate. Hence, no allowance is made for the effects of grid outages or 'weather days' which could prevent access to turbines for repairs. The planned availability was exceeded for only one month and the availability across the site was below expectation especially during the autumn period. This was due almost entirely to problems with bearings in the gearbox as will be discussed in Operational Issues.

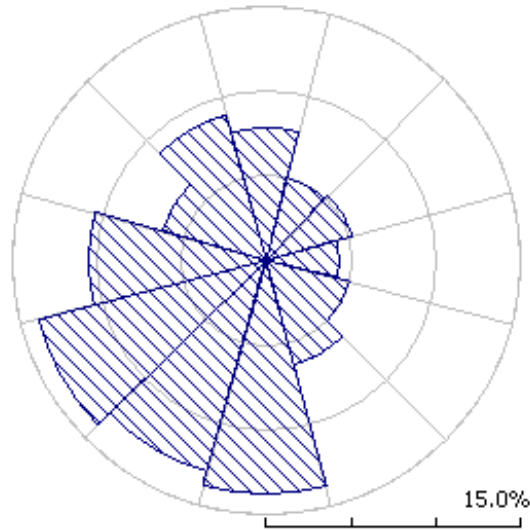
#### Wind Speed

The daily and monthly average wind speeds across the site are shown in Figure 3, and the wind rosette is shown in Figure 4.



**Figure 3** Average Daily and Monthly Wind Speeds Throughout 2005

(Note - Low average wind speed in Feb and March are due to poor data coverage)



**Figure 4** Wind Rosette

## Output and Capacity Factor

The wind farm output on a monthly basis is shown in Table 3 and on a per turbine basis in Table 4.

**Table 3 Monthly Output**

<b>Month</b>	<b>Period Length</b>	<b>Import (MWh)</b>	<b>Theoretical Production at Maximum Rated Output (MWh)</b>	<b>Long Term Monthly Average Budget (MWh)</b>	<b>Gross Power Exported (MWh)</b>	<b>Capacity Factor (%)</b>
<b>January</b>	31	1	44,640	18,279	21,814	48.9
<b>February</b>	28	12	40,320	15,732	15,885	38.0
<b>March</b>	31	31	44,640	16,245	14,316	32.1
<b>April</b>	30	24	43,200	13,680	10,285	23.8
<b>May</b>	31	19	44,640	12,483	16,265	36.4
<b>June</b>	30	36	43,200	11,457	8,625	20.0
<b>July</b>	31	39	44,640	9,918	9,494	21.3
<b>August</b>	31	27	44,640	10,773	10,979	24.6
<b>September</b>	30	29	43,200	12,483	8,915	20.6
<b>October</b>	31	17	44,640	16,074	13,211	29.6
<b>November</b>	30	6	43,200	16,416	12,484	28.9
<b>December</b>	31	10	44,640	17,613	10,301	23.1
<b>Totals</b>		<b>251</b>	<b>525,600</b>	<b>171,153</b>	<b>152,574</b>	<b>28.9</b>

The Long Term Monthly Average Budgeted production for the site was calculated as follows. Wind data collected from the anemometer mast during the site development phase was compared with simultaneous data from the nearby Met Office station at Hemsby. The resulting correlations were used in combination with long term wind data from Hemsby to provide a view of the Scroby Sands wind resource as though the wind farm had been in existence for the past 20 years. In turn this wind resource, taken with the turbine manufacturer's power curves and our understanding of turbine wake effects and other losses, has been used to predict generation levels averaged over the life of the wind farm. Therefore any variations against this long term budget production can be attributed to availability variations or variations in normal weather patterns (which lead to changes in average wind resource or to the number of bad weather days which prevent access to the turbines).

It can be seen from the table above that the site produced less energy than budget. The main reason for this is the poor availability of the site during the final months of the year (see operational issues).



**Table 4 Output Per turbine**

String	WTG	Production Data	
		MWh	Capacity Factor (%)
1	T01	5484	30.7
1	T02	5738	32.1
1	T07	5702	31.9
1	T11	5045	28.2
1	T15	4967	27.8
1	T19	5970	33.4
1	T23	5536	31.0
1	T27	6161	34.4
1	T30	4100	22.9
1	T34	5960	33.3
2	T05	4336	24.2
2	T06	5497	30.7
2	T10	4527	25.3
2	T09	6155	34.4
2	T13	4643	26.0
2	T14	4404	24.6
2	T18	4602	25.7
2	T22	5093	28.5
2	T29	4284	24.0
2	T32	5852	32.7
3	T17	5766	32.2
3	T21	5114	28.6
3	T25	4845	27.1
3	T28	5193	29.0
3	T31	3611	20.2
3	T35	5256	29.4
3	T36	4677	26.1
3	T37	4038	22.6
3	T38	4430	24.8
3	T33	5589	31.3
<b>TOTAL</b>	<b>Total</b>	<b>152575</b>	
<b>AVERAGE</b>	<b>Average</b>	<b>5086</b>	<b>28.4*</b>

\* slight differences in total production and average capacity factor values in Tables 3 and 4 are due to rounding error.

### Annual Import

The annual and monthly electricity imports are given in Table 3.

## OPERATIONAL REPORTING

### OPERATING AND MAINTENANCE (O&M) COSTS

Table 5 O&M COSTS

Operational Costs	Budget (£)	Actual (£)
Scroby Sands Windfarm	1,714,450	1,484,135

The total annual operating costs in 2005 were substantially below budget primarily due to the absence of the Turbine O&M costs from the normal site operating budgets, this relates to an agreement made during the later stages of the project to compensate E.ON UK for project delays.

The total annual operating cost was budgeted at **£1,714,450**

This relates to a cost of **£28,574/MW** or **£57,148/Turbine** and **£10.02 per MWh** (long term yearly average)

The total actual spend for 2005 (including Turbine O&M costs) was **£1,484,135**

This relates to an actual cost of **£24,736/MW** or **£49,472/Turbine** and **£9.73per MWh**

### OPERATIONAL ISSUES

All work on the wind farm can be categorised as either Planned or Unplanned.

#### Planned work

The annual planned work included:

- Six Monthly Interim Turbine Servicing
- Annual Full Turbine Servicing
- Annual HV Equipment Inspections
- Annual Insurance inspections of climbing systems and lifting equipment
- Annual Inspections of Fire Fighting Equipment
- Environmental Surveys as agreed within Site Consent

The first six monthly service was longer than expected due to operational difficulties which were compounded by the impacts of the unplanned work discussed below.

A 2006 work plan is currently being developed to ensure that all work is completed within the required timescales.

The insurance inspections were completed, although again, this took longer than planned. Improvements for 2006 have been agreed.

The environmental and cable survey work is agreed and managed between E.ON UK and the site manager ode. All work was completed in line with the site consenting requirements. Agreement of the work required for 2006 is currently being finalised.

### **Unplanned Work**

There was a substantial amount of unplanned work completed throughout the year, much of which can be attributed to minor technical issues which are to be expected. Such issues were usually corrected either by remote turbine resets, local turbine resets or with minor maintenance work and hence most were resolved within the same day. A smaller number of unplanned works involved larger scale plant problems and as such had more serious implications to resources, costs and downtime.

The primary cause for concern has been the gearbox bearings. To date 27 generator side intermediate speed shaft bearings and 12 high speed shaft bearings have been replaced. Four generators have also been replaced.

The problem generators were replaced with an alternative design. Investigations continue on potential modifications which could prevent future problems in the remaining generators.

The gearbox problems have created a much larger issue and have caused reduced levels of availability in the final three months of the year (see availability profiles). Following extensive investigation and analysis a number of reasons for the bearing damage have been identified, directly related to the design of the bearings. Work is in hand to resolve these issues.

In the first four months of the year the availability was increasing to the planned level and in the absence of the gearbox bearing problems there is little doubt that the availability target would have been exceeded on a month by month basis for the remainder of the year.

### **Access Arrangements**

The turbines are accessed using either a transfer vessel or a rigid inflatable, the safety procedures for which have been agreed. Transfer can take place at wave heights up to approximately 2m. When the wave height is above 2m or adverse weather prevents safe access to the turbines this is agreed as a 'contractual weather day' and recorded in the daily site log. There were a total of 143 weather days (visit to wind farm not possible) during 2005 which are detailed below:

**Table 6 Weather Days**

Month	Number of Weather Days	Monthly Average (%)
January	17	55
February	14	50
March	14	45
April	13	43
May	19	61
June	10	33
July	10	32
August	11	35
September	9	30
October	11	35
November	9	30
December	8	26

These weather days mean that maintaining the availability of the site is more difficult than for an onshore wind farm. In order to compensate for this flexible working methods are adopted to make best use of the days when access is possible. Planned servicing will now be resourced by a larger number of teams in an effort to fully exploit the available weather window for maintenance.

There are also plans in place for 2006 to make better use of weather days for non turbine related work, safety planning and administration.

### **Remote Monitoring**

In order to reduce the number of turbine visits there are two work management systems in place using the Vestas Online SCADA (Supervisory Control and Data Acquisition) system.

The daily monitoring of the SCADA system is carried out by the Vestas O&M team and ode site management team. When a fault, error or alarm occurs on a turbine the teams are able to interrogate the SCADA system in order to understand what the problem might be before sending a team out to correct the defect. In some cases the alarms can be reset remotely removing the need to attend the turbine.

During December 2005 Vestas supplemented the remote monitoring of the site by using the Vestas DK control centre to monitor the site 24hrs a day. When an alarm occurs on the wind farm the Scroby O&M team are contacted to make them aware that a fault has occurred. When such an event occurs outside normal working hours

the control room will reset the fault where possible. This should reduce the time turbines remain out of service for minor errors and defects. In the future the site will also be monitored on a continuous basis at E.ON UK's central control centre.

## Health and Safety

The health and safety standards at Scroby Sands are considered to be good this is reflected by the low incidence of incidents during 2005 and the relatively minor nature of the incidents that occurred. The statistics for the year are:

0 Deaths  
0 Lost Time Injuries  
0 Medical Treatment Injuries (hospital) (visitor)  
2 Minor Injuries (local site first aid only)  
3 Near Hit/Hazard Reports

Minor Injuries:

1. A Technician slipped on the bearing housing in the Nacelle twisting back.
2. A Technician cut a finger whilst carrying out repairs to a turbine bearing.

Near Hits:

There were two Near Hits associated with lifting of oil containers. One of the Near Hits resulted in a small leakage of oil and was reported to the Marine Coastguard Agency (MCA) and Environment Agency (EA) in line with an owner's operator's obligations.

A further Near Hit occurred during the re-energisation of supplies to a turbine without following agreed procedures.

Proactive Safety Initiatives:

In order to support a continual improvement of safety standards at the site a number of initiatives have been put in place:

- All Safety and Environmental Incidents are reported through the E.ON Renewables Control Centre
- Monthly site based safety meetings
- Frequent tool box talks at site
- Production of a site safety plan
- Action plan for introduction of E.ON HV and BWEA Wind Turbine Safety Rules
- Introduction of E.ON's work planning processes and 'approved work procedures'.

## Environmental

### Coastal and Sea Bed Monitoring

Monitoring of sedimentary, benthic and hydrological processes by CEFAS was carried out through out 2005, in line with the consent requirements, to enable the effects of the wind farm on coastal processes and sea bed to be assessed through the early part of its operational life. Thus far all surveys have not identified any areas for concern. Following the bathymetric surveys some scour pits have been identified with a depth of 5m and diameter of 60m around each turbine, which were predicted by the original EIA. We now have an improved understanding of the extent of this scour and importantly the scour tails local to each turbine and in each area of the wind farm. This information will be useful in determination of the necessity for scour protection in future years. In addition an area of low water depth around the south of the wind farm has now appeared due to variations of the Scroby bank over the past year.

CEFAS conclude that the surveys provided an extensive learning opportunity and have significantly increased the understanding of how monopiles affect coastal processes. Further bathymetric surveys are planned for 2006 starting in the spring.

Six month beach surveys are completed by the EA (with funding from E.ON UK) along the entire coast. In addition interim topographical surveys were completed at three month periods giving detail of the beach and elevation, these studies were completed by EDI. These will continue during 2006.

Benthic sea bed surveys using grab samples are now complete and the final report is awaited

### **Seal Monitoring**

Fifteen aerial surveys were completed during 2005 which showed there were no significant changes during 2002-2005 of common seal populations and grey seals were found to be increasing in numbers (following a UK trend). The seal monitoring surveys have now concluded inline with the agreed consenting process, although consideration is being given to supporting a further years study.

### **Little Tern Monitoring**

The 2004 construction study identified some disturbance to the colony and a short term impact. The 2005 post construction study recently concluded that there were no direct impacts caused by the operation of the wind farm, however it was unable to determine if the wind farm had any indirect effects related to feeding stocks of herring. The little tern studies will continue in 2006.

### **Cable Depth Surveys**

E.ON UK is also required to monitor the depth of sub-sea cables in the early years of operation to ensure they remain buried. Surveys completed during 2005 have concluded that all cables remain buried, although the depth of burial has changed across the cables routes. In some cases this suggests a depth now greater than the original 3m and in other areas burial now less than the original 3m installed depth. Further surveys are planned using either remote observation equipment or divers to understand the long term risks for the cables and to supplement the Vestas X1 cable defect resolution.

## Public Relations

In 2005 E.ON UK officially opened its Scroby Sands offshore wind farm. This was marked with a high profile event in March attended by E.ON UK Chief Executive Paul Golby and double Olympic sailing gold medallist Shirley Robertson who helped with the opening ceremony. The event included a donation of £10,000 to the local Caister Lifeboat Appeal and a free firework display. The opening of Scroby Sands resulted in media coverage in the regions newspapers (Eastern Daily Press, East Anglian Daily Times and Norwich Evening News), radio (BBC radio Norfolk) and TV (ITV East Anglia and BBC east). The event was also covered in the trade press.

The success of the opening ceremony and the offshore wind farm in general is evident from the 35,000 visitors who annually pass through the doors of the visitors information centre. In August of 2005 the visitor centre took part in the British Wind Energy Foundations 'Windy Weekend' and opened it's doors to the public so they could learn more about renewable energy. Scroby Sands has also proved popular with the national media as a broadcast location, with BBC Breakfast, BBC News 24 and BBC 4 radio all carrying out interviews at site.

**This report was prepared by E.ON UK.**

**For further information on the Scroby Sands Wind Farm contact E.ON UK Renewables either by telephone on 02476 424000 or via email address [renewables@eon-uk.com](mailto:renewables@eon-uk.com).**

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