

# Capital Grant Scheme for Offshore Wind

## Kentish Flats Offshore Wind Farm

### Annual Report January 2006 – December 2006

#### EXECUTIVE SUMMARY

The Kentish Flats Offshore Wind Farm consisting of 30 V90 3MW, Vestas Wind turbines, is located in the Thames Estuary, some 8 to 13km off the North Kent Coast, north of Herne Bay & Whitstable. The main export cables come ashore at Hampton Pier, Herne Bay and run 2.5km inland to an existing substation where connection to the National Grid distribution network is made.

Construction of the Kentish Flats Offshore Wind Farm commenced in August 2004 and was completed at the end of August 2005. The wind farm became operational in September 2005 and the Take Over Certificate (TOC) was signed on 8<sup>th</sup> December 2005.

Environmental monitoring surveys have been carried out in and around the Kentish Flats Offshore Wind Farm site. The survey work covers the pre, during, and post construction phases as required by the licence issued under the Food and Environmental Protection Act (FEPA).

The project was initially developed by Grep Marine UK and was bought from its parent company NEG Micon UK, by the former Danish Power Utility Elsam in 2004. In mid 2006 the Swedish utility company Vattenfall took over the wind farm following a major reorganization of the Danish Power sector.

Main contractors:

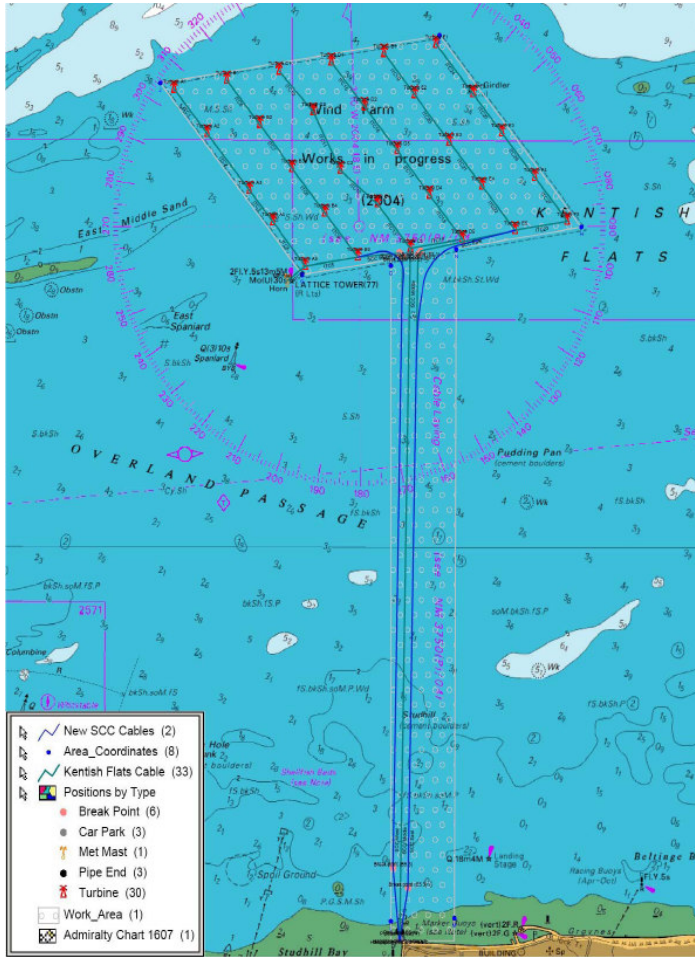
- Grid Connection: EDF Energy, UK
- Wind Farm: Former NEG Micon, UK Now Vestas Offshore

Associated contractors:

- MT Hojgaard, DK (foundations)
- AEI Cables, UK (cables)
- MPI, UK (installation, foundations)
- Global Marine, UK (installation, offshore cables)
- Fitzpatrick, UK (installation, onshore cables)
- A2SEA, DK (installation, turbines)

Overall project cost: £105,000,000 (i.e. £ 3,500,000 per wind turbine)

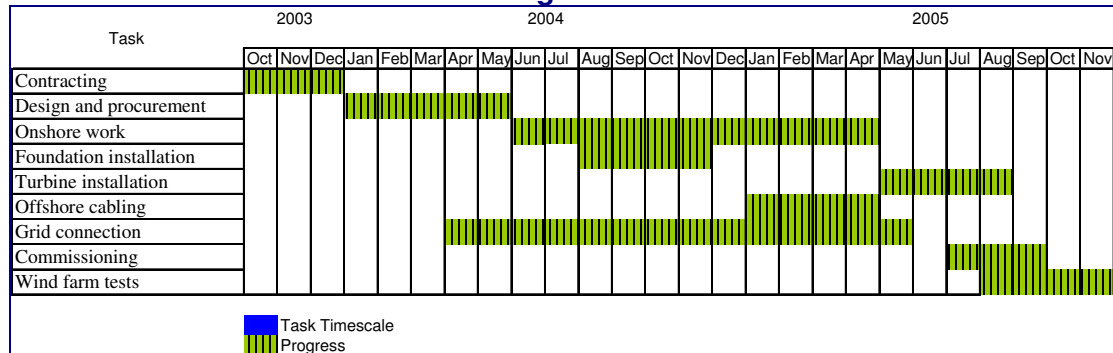
Grant: £ 10,000,000 (i.e. £ 111,111 per MW installed)



Foundation / WTG	No.:	(Alias)	Coordinates UTM Zone 31 - Datum (WGS 84)	
			E	N
KF01	A5		366681,33	5701388,63
KF02	B5		367377,09	5701483,12
KF03	C5		368072,47	5701576,47
KF04	D5		368769,36	5701670,74
KF05	E5		369464,38	5701765,40
KF06	F5		370159,78	5701858,68
KF07	A4		366263,11	5701951,89
KF08	B4		366957,72	5702046,45
KF09	C4		367654,29	5702140,16
KF10	D4		368348,68	5702235,41
KF11	E4		369044,87	5702327,68
KF12	F4		369740,54	5702421,41
KF13	A3		365962,77	5702357,35
KF14	B3		366538,98	5702609,35
KF15	C3		367176,66	5702569,86
KF16	D3		367930,79	5702798,22
KF17	E3		368626,75	5702891,83
KF18	F3		369322,42	5702985,23
KF19	A2		365425,52	5703079,50
KF20	B2		366119,26	5703171,95
KF21	C2		366836,51	5703314,27
KF22	D2		367512,18	5703360,69
KF23	E2		368175,90	5703489,55
KF24	F2		368856,36	5703481,45
KF25	A1		365005,72	5703643,98
KF26	B1		365701,35	5703737,47
KF27	C1		366396,91	5703831,28
KF28	D1		367092,85	5703924,55
KF29	E1		367788,64	5704018,42
KF30	F1		368484,24	5704112,96

## CONSTRUCTION

### An Overview of the Construction Programme



All installation works are completed. Commissioning and testing of the turbines has been completed. A Taking Over Certificate (TOC) was issued by the Employer on 8 December 2005.

## Description of Construction Methods

### Brief description of the project

Kentish Flats Offshore Wind Farm features 30 wind-powered turbines each with a nominal rated capacity of 3 MW.

The offshore wind farm is located on the southern side of the Thames Outer Estuary, approximately 8.5 to 13 km north off Herne Bay on the North coast of Kent. Each wind turbine generator (WTG) has a hub height of 70 m above mean sea level and a rotor diameter of 90 m.

The total weight of the wind farm in terms of consumed steel is approx 15,000 tonnes.

### Foundations

The structure used to support the WTGs is a monopile foundation. This type of foundation was also used for the Horns Rev offshore wind farm in Denmark. A main steel pile is driven into the seabed by means of a hydraulic hammer. Then the transition pieces with a service platform for operation and maintenance and the connecting flange to the wind turbine tower is grouted onto the pile.

In order to connect the WTGs to the grid, the foundation holds internal J-tubes for installation of submarine cables. These interconnect in three groups of ten WTGs, each group having its own export cable to the shore.

### Cabling

The sea cables meet the shore at Hampton Pier and then continue underground for 2.5 km through the town of Herne Bay. The onshore installation route required the cables to cross the railroad and the main road up to EDF Energy's substation in Herne Bay.



Cable installation from barge

The offshore cables were installed on the Flats by means of a special purpose cable installation vessel.

The three main export cables, weighing a total of approx 900 tonnes, were ploughed approx 1.5 metres into the seabed, whereas the cables between the turbines were water jetted into the seabed.

The wind farm is connected to the grid by means of three independent export cables, each exporting the power from 10 turbines. The export cables are operated at 33 kV and terminated in a dedicated switchgear located in EDF Energy's 132/33 kV substation in Herne Bay. The cables themselves do not only hold the three main phases for high-voltage transmission of power from the WTGs, but also vital optical fibre cables for remote communication with the WTGs.

### **Pre-assembly of wind turbine**

The turbine components were shipped to the port of Felixstowe from Vestas' production units in Denmark and Germany by means of special vessels. A comprehensive logistics puzzle was then completed in Felixstowe harbour, where fitters undertook pre-assembly of the component parts, consisting of tower sections, nacelles, hubs, blades, cables.

Top and bottom tower sections were pre-assembled in vertical position on the quay. Cables, switchgear, ground controller and man-lift installation were completed prior to shipment to the site.

Nacelle and hub were assembled together with two blades, into the so called "bunny ears" configuration.

### **Wind turbine installation**

Batches of two complete WTG subassemblies were transported on a special adapted vessel to the Kentish Flats site. Here, three lifting operations were required for a complete wind turbine erection. The first lift was the complete tower, the second lift was the nacelle with "bunny ears" blade configuration and the third lift was the final blade, which finalised the mechanical installation.

On average, the installation of a complete turbine required about 24 hours, including transport to the Site, positioning and pre-load and three lifts.



A2SEA "SEA ENERGY"

After the above procedure was completed, teams of installation engineers were transported to the turbines by boat in order to perform commissioning, energizing and tests prior to taking over the plant (TOC). The lack of wind in the Autumn 2005 delayed the over speed test on some WTG's, which then delayed the schedule for the individual WTG test, and overall wind farm test.

## Navigational safety measures

The following navigational safety measures are installed at the wind farm:

- Navigation lights (at 8 positions)
- Fog horns (at 4 positions)
- Yellow colour up to 12 meters above sea water level.
- Radar installed at one turbine - integrated into the surveillance system used by Port of London.
- Safety zone (with radius of 50 meter) around each turbine.

## WIND FARM ANNUAL OPERATIONAL INFORMATION

### Availability

**Table 1** Average availability in 2006: **87%**.

Unit	jan	feb	mar	apr	maj	jun	jul	aug	sep	okt	nov	dec	avg
A1	92	89	99	86	92	98	96	77	97	80	96	74	90
A2	99	0	89	97	90	96	100	99	95	100	44	0	76
A3	91	99	100	97	91	97	99	97	90	92	43	77	89
A4	97	98	100	96	88	86	99	99	96	90	93	92	94
A5	92	98	100	96	100	96	100	95	73	97	98	100	95
B1	31	94	82	73	98	98	94	97	89	86	100	98	87
B2	99	100	28	86	98	98	100	99	97	97	18	37	80
B3	100	100	99	96	71	70	100	98	94	100	19	42	82
B4	99	73	97	99	97	84	92	97	89	13	0	0	70
B5	73	77	98	98	97	97	95	98	96	97	39	74	87
C1	100	100	95	100	96	98	95	93	96	75	0	18	81
C2	97	90	96	96	86	99	98	98	98	100	53	50	88
C3	90	93	98	100	95	97	97	99	100	97	99	98	97
C4	99	98	94	100	97	99	95	99	93	96	37	0	84
C5	94	95	92	82	89	78	89	98	93	96	11	0	76
D1	83	99	87	80	97	94	98	100	96	96	99	95	94
D2	90	36	86	56	92	100	94	81	96	87	79	71	80
D3	92	100	98	99	95	95	98	95	97	93	71	88	93
D4	82	33	93	99	93	38	63	99	95	98	100	75	81
D5	97	77	95	96	99	87	99	100	95	100	97	97	95
E1	89	79	68	72	87	73	90	98	97	88	99	99	87
E2	99	99	100	91	100	100	98	98	100	32	99	99	93
E3	100	100	100	98	99	98	98	100	93	53	92	99	94
E4	96	76	98	97	97	100	74	99	68	100	98	97	92
E5	100	97	11	83	75	100	92	95	95	97	62	83	82
F1	88	97	89	100	93	99	96	97	100	100	99	25	90
F2	94	92	80	100	100	99	94	95	100	99	94	74	93
F3	1	69	96	100	98	95	92	94	100	100	99	90	86
F4	99	97	96	100	100	100	94	93	96	97	99	99	97
F5	94	23	72	99	100	100	100	94	97	85	32	5	75
Avg	89	83	88	92	94	92	94	96	94	88	69	65	87
<b>87,0 %</b>													

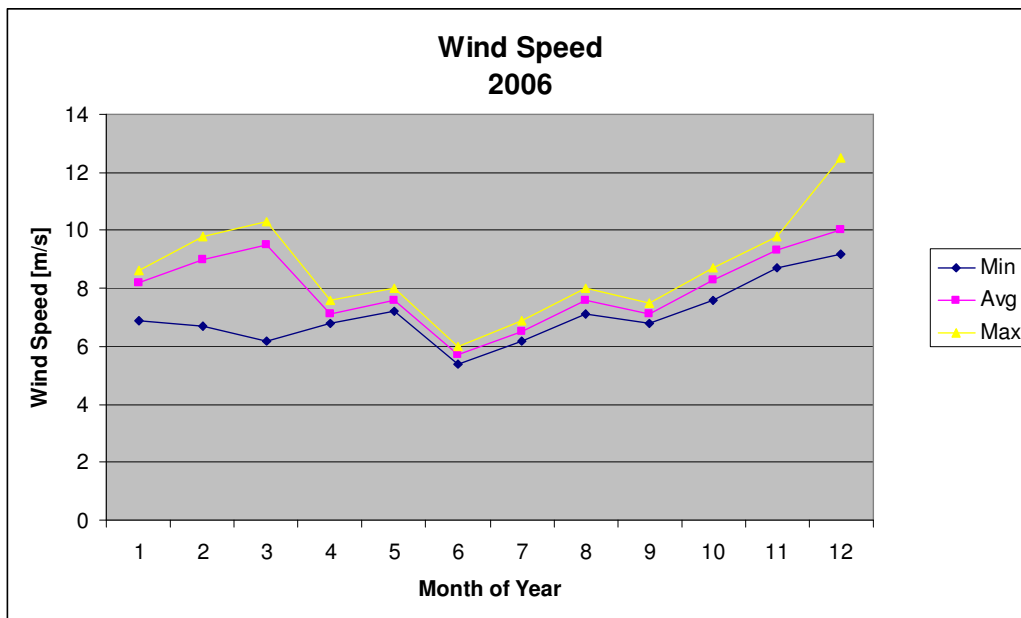
As TOC for Kentish Flats Offshore Windfarm was signed on 8<sup>th</sup> December 2005, the contractual availability had to be calculated in the 12 months period after TOC. The figure achieved was an availability of 88 % i.e. 2 % points lower than expected. Availability for the calendar year 2006 was 87%.

Availability in the first part of the year was relatively low mainly due to faults on generator bearings and rotor cables for the slip ring unit.

During the year as the O&M staff gained experience in solving the faults quicker, the availability increased, perhaps even over expected values in August and September. This was however severely hampered by gearbox failures that started to occur in November, resulting in an extremely low availability in the last two months of the year.

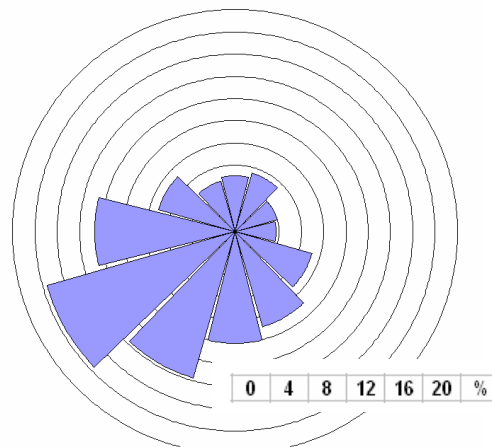
### Wind speed

Monthly average wind speed at hub height.



Yearly average wind speed was calculated at 8.0 m/s compared to the long term wind speed estimate of 8.7 m/s at a height of 70 m in a “normal year”.

### Windrose (Power)



## Power output

**Table 2** Power input- Output and Capacity factor

Month	Period length	Import	Theoretical production at Maximum rated output	Gross Power exported	Capacity factor
	Days	MWh	MWh	MWh	%
January	31	40	66.960	22.196	33,1%
February	28	31	60.480	23.761	39,3%
March	31	23	66.960	30.046	44,9%
April	30	119	64.800	15.899	24,5%
May	31	152	66.960	19.371	28,9%
June	30	179	64.800	8.820	13,6%
July	31	137	66.960	12.159	18,2%
August	31	77	66.960	19.479	29,1%
September	30	79	64.800	14.840	22,9%
October	31	46	66.960	22.360	33,4%
November	30	26	64.800	21.117	32,6%
December	31	62	66.960	17.929	26,8%
Total	365	971	788.400	227.977	28,9%

The annual power production is less than expected.

If the actual production is adjusted with respect to availability of 95% and expected wind resource, we are convinced that the estimated production would be achieved with good margins.

The exported power 227,977 MWh is 1.4% less than the power produced by the wind turbines 231,144 MWh (table 3). The losses are mainly due to cable and transformer losses and within expected limits.

The yearly import power is quite high compared to other offshore sites. Whether this is due to different wind distribution, inappropriate operation conditions, grid lay-out or difference in measuring principle, will be further examined in the future.

**Table 3** Monthly Power production 2006 for each unit.

Unit	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
A1	797	933	1219	513	695	315	443	554	556	651	1077	699
A2	862	-4	1118	624	651	320	449	728	529	903	399	-1
A3	801	990	1132	616	613	287	418	691	514	752	385	630
A4	838	944	1152	627	574	261	424	699	530	741	1004	947
A5	872	978	1173	620	753	322	441	685	439	861	1084	953
B1	354	964	917	431	739	319	409	704	426	779	1104	949
B2	836	989	179	464	723	308	438	698	533	825	142	448
B3	831	979	1144	578	442	268	428	684	500	861	141	390
B4	834	585	1118	565	724	181	416	641	444	127	-1	0
B5	523	770	1142	589	728	314	435	650	535	858	303	539
C1	867	1018	1120	614	595	304	379	668	508	588	-6	349
C2	833	818	1123	569	488	303	414	691	515	864	539	279
C3	637	881	1114	571	653	295	378	658	497	821	1027	904
C4	840	948	1073	569	709	306	390	652	467	795	275	0
C5	818	940	1110	435	646	309	342	655	498	821	49	0
D1	758	998	976	453	709	297	432	718	501	818	1081	875
D2	717	376	1056	286	630	305	376	533	482	699	889	545
D3	789	964	1115	545	612	292	411	649	497	803	832	719
D4	603	450	1028	554	605	53	253	657	493	820	1044	619
D5	800	670	1136	560	745	285	456	677	546	889	1027	1115
E1	733	644	670	327	571	291	407	696	505	752	1056	946
E2	843	942	1131	502	693	301	403	642	494	277	1003	915
E3	872	959	1150	548	697	295	420	662	448	556	968	921
E4	848	643	1133	546	681	309	326	658	360	828	1016	882
E5	883	955	48	438	392	333	449	592	543	880	733	681
F1	840	973	1092	603	627	331	427	703	519	871	1037	383
F2	833	822	849	570	703	328	411	645	521	826	933	669
F3	-2	780	1115	572	679	313	424	630	525	840	1027	789
F4	877	950	1153	585	725	337	389	595	518	843	1040	926
F5	863	285	991	611	759	357	475	664	567	718	197	72
Total MWh	22779	24145	30477	16086	19560	8839	12261	19777	15008	22665	21405	18141
	<b>231,144 MWh</b>											

## OPERATIONAL REPORTING

### Operational and Maintenance Cost

The Kentish Flats Offshore Windfarm is operated by Vestas Offshore on a 5 year O&M contract and so the Operational and maintenance costs are mainly covered by the O&M contract with Vestas. The amount for this contract is not public, but an approximate breakdown of costs is:

Operating and maintenance costs	1,300,000
Administration	100,000
Import power	120,000
Surveys	130,000
Insurance	450,000
Lease and rent	250,000
	<b>£ 2,350,000</b>

This gives a cost of:

- £ 26,100 per MW installed
- £ 78,300 per windturbine
- £ 10.31 per MWh produced / exported

## **Operational issues**

All work performed can be categorised as either planned or unplanned.

### **Planned work**

The annual planned work included:

- 3 months Turbine servicing - completed April/ May
- Annual Full Turbine Servicing - completed August/September
- Mandatory HV Equipment Inspections
- Safety Inspections of climbing equipment. PPE audit carried out.
- Lift inspections every 6 month. Inspected by a specialist company 'LGH'
- Annual Offshore Safety Rescue exercise "Delta" in cooperation with the Coast Guard
- Annual Inspections of Fire Fighting Equipment
- Environmental Surveys as agreed within the Site Consent

The first 3 month service was longer than expected, mainly due to additional work from completion of outstanding tasks from commissioning. The annual Full Turbine Service also lasted longer than expected, as this was the first full service and in some degree training of the service team too.

### **Unplanned work**

During the first year a substantial amount of unplanned work has been performed, some of this due to minor technical issues which are to be expected. Most of these issues have been corrected either by remote resets or local turbine resets or minor repairs.

Another category of unplanned works involved larger scale plant problems and as such imposing more serious implications to O&M resources, costs and downtime.

- Main Gearbox
- Generator bearings
- Generator rotor cable connections from slipping unit
- Pitch system

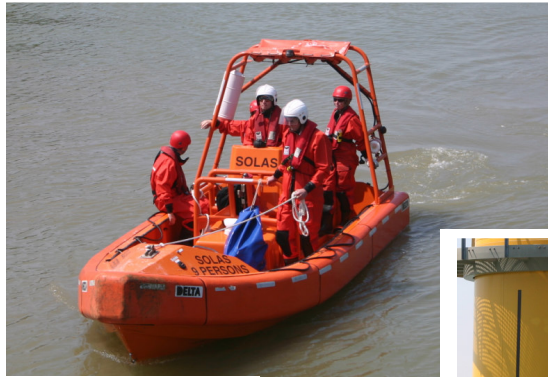
At the beginning of the period the problems causing the primary concern were generator bearings and rotor cables, with long periods of downtime, due to the fact that the generator sub supplier had to do the repairs not to jeopardize the warranty. After some time, members of the local service team were authorized to do the job, and the waiting time was reduced to normal. The root cause identification is pending, and a final solution to the Generator problems has yet to be determined.

In late October the first main gearbox damage was detected. By the end of 2006 an intensive endoscope campaign, carried out by the contractor in cooperation with the gearbox manufacturer, revealed that about 12 gearboxes needed to be replaced. Twelve gearboxes out of 30 exhibited this problem and so this was considered as a serial defect. Gearbox damage is a serious concern, which might turn out to be a problem for all gearboxes in the wind farm. The matter has received the highest priority, and the contractor is required to determine a root cause and secure a durable solution for the future. The gearbox problems has resulted in only 2/3 of the turbines

available i.e. around 65% availability for the last two months of 2006, and this is expected to continue in the first quarter of 2007.

### Access arrangements

The wind turbines are accessed using either a transfer vessel or a rigid inflatable boat. Transfer can take place at wave heights up to about 1.5 m. When wave heights are above the safety limits or adverse weather prevents safe access to the turbines the day is registered as a ‘weather day’.



Rigid Inflatable Boat



The "CELTIC STORM"

Weather days influence the availability, but do not jeopardize the contractual availability, as this is included in the contract on the contractors account. As Kentish Flats is situated in sheltered waters weather days are limited and for 2006 counted for 31 days.

Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1	7	3	0	3	0	1	3	2	1	5	5
3%	23%	10%	0%	10%	0%	3%	10%	6%	3%	16%	16%
Total of 31 weather days in 2006											

### Remote monitoring

The daily monitoring of the SCADA system is carried out in daytime by the operator’s local O&M team situated in the service centre at Whitstable harbour. During night-time and at week-ends the operator’s 24h surveillance centre in Denmark takes over and handles what can be done remotely.

In parallel a 2 Mbit ADSL connection to Vattenfall central O&M surveillance centre in Esbjerg, Denmark, gives the owner access to the SCADA system.

## **Health and Safety**

The health and safety standards at Kentish Flats are considered to be good which is reflected in low occurrence of incidents during 2006.

The statistics for the year are:

- 0 Deaths
- 1 Medical Treatment Injuries (casualty department / hospital)
- 3 Minor Injuries (local site first aid only)
- 2 Near Hit / Hazard Reports

### **Medical Treatment Injuries:**

A large wave caused a boat skipper to bang his head on wiper motor. A gash to top of his head was treated at local Accident and Emergency department by cleaning the wound but no stitches or further treatment was necessary.

### **Minor Injuries**

- 1) When putting a box down a worker accidentally caught a finger underneath. Outcome: Cut and bruised.
- 2) Whilst handling an accumulator cylinder in turbine hub, (2 persons) the cylinder bag caught on a bolt and upon freeing the bag it moved and hit one person in his left eye. Outcome: Swollen blackened eyelid.
- 3) While taking a slip ring unit apart, carbon dust from the brushes entered a workers left eye. Outcome: Initial stinging in left eye followed by an ache after further washing.

### **Near Hit / Hazard Reports**

2 episodes with items being lifted falling down into the sea or onto boat deck.

### **Proactive Safety Initiatives:**

In order to support a continuous 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 Operators HSE system in copy to the owner Vattenfall.
- Incidents are reviewed at the regularly O&M meetings
- Compulsory use of Method Statements / Risk Assessments
- Initiative to get near hits reported by focusing on legitimacy on reporting
- Monthly Site Safety audit

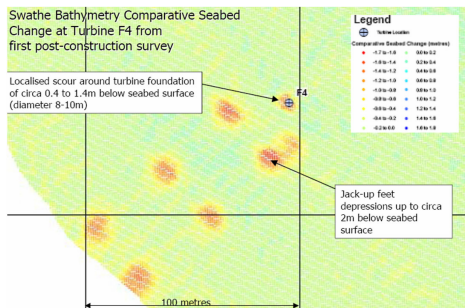
## **Environmental**

### **Seabed Monitoring**

Surveys to measure and evaluate the effects of scour around the base of a representative number of the turbine foundations and interconnecting cable routes,

continued throughout 2006 at six monthly intervals, as required under the FEPA licence issued by Defra.

The third post-construction scour survey was completed in early April 2006. Seabed level around the four turbine foundations surveyed showed that scour was generally stable with only small increases and decreases recorded when compared to the previous surveys. The seabed depressions created by the jack-up vessels used for installation continue to backfill naturally. Cable routes showed no change when compared to previous surveys.



The fourth post construction scour survey was completed during October 2006. The results recorded were similar in nature to those described above with only very slight variations in the depth of scour, indicating that scour around the turbine bases has stabilised. This survey also reported the continued natural backfilling of the jack up depressions.

### Monitoring the Benthic Ecology

Samples collected from the seabed in and around the Kentish Flats site during June 2005 have been analysed and were reported in June 2006 as part of the annual benthic monitoring program required under the FEPA licence issued by Defra. Comparison of the 2005 data to the pre-construction monitoring data indicates that there have been no significant changes to the benthic fauna across the wind farm area.

Further benthic samples were collected from the site during June 2006 and will be reported shortly as part of the ongoing monitoring program.

### Fish Monitoring

The program of seasonal fish monitoring at Kentish Flats was completed in June 2006, as required under the FEPA licence issued, and all of the data sets collected during the 7 separate surveys have been analysed and reported in November 2006. The surveys show a natural variation in fish populations across the survey area and throughout the period considered. The report has concluded that the survey data collected shows no evidence of any deleterious effects on fish populations within this area.

### Bird Monitoring

Boat based and aerial bird survey data were collected in and around the Kentish Flats area during 2005 (covering the turbine erection and initial operational phases). Data has been analysed and reported during 2006, in relation to the key ornithological monitoring objectives set out under the FEPA licence issued by Defra. Patterns of distribution and use of a variety of bird species continue to show natural changes but the report concludes that in most cases these can not be attributed to the wind farm construction, although some localised temporary disturbance to some seabirds was noted during the construction period.

The boat based and aerial survey effort for birds has continued throughout 2006, as agreed with Defra and Natural England, and will be reported shortly.

## Public Relations

The Kentish Flats Offshore Windfarm was taken over by Vattenfall on December 8<sup>th</sup> 2005. No official opening has taken place, but awaits completion of the local O&M facilities in Whitstable Harbour.



O&M facilities at Whitstable Harbour

Kentish Flats has been very popular with the local population as well as tourists admiring the Windfarm from the coastline at Tankerton Beach. The local tourist office reports big interest for the Windfarm. A local company has even gained success offering trips by rigid inflatable boats to the Windfarm.

As part of the lease agreement with Canterbury City Council a grant of £ 200,000 was dedicated to establishing a local Sustainable Energy Centre, but local disputes about the goal and placement, has delayed establishment of the centre.



PM Tony Blair  
visiting Kentish Flats

In July 2006 Prime Minister Tony Blair visited Kentish Flats, presenting the Governments new Energy Plan with more focus on renewable Energy. A statement from the PM: “If we are going to protect our environment and our energy supply in years to come, then there is no question that we need to bring on projects like Kentish Flats much faster”.

**This report was prepared by Vattenfall Danmark A/S.**

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**For further information on the Capital Grant Scheme contact Mr. Adam Terry at [adam.terry@aeat.co.uk](mailto:adam.terry@aeat.co.uk) or on Tel 0870 190 6158**