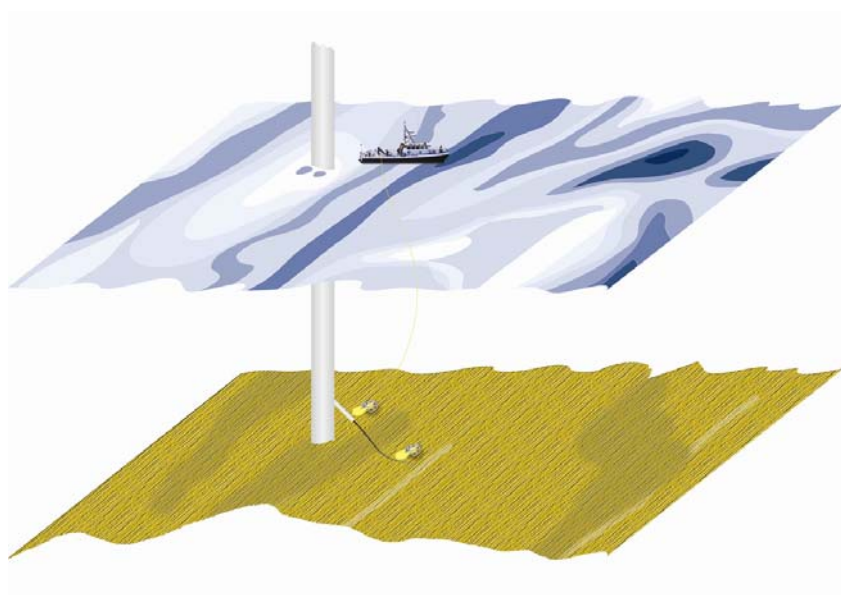


# FINAL REPORT

Post Lay Inspection  
Of  
33 kV HVAC Cable  
At  
KENTISH FLATS WIND FARM

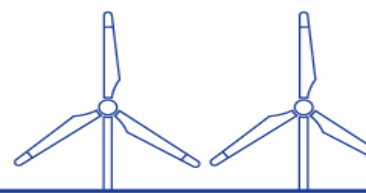
2007



## **SURVEY MAINTENANCE NO. 2**

Sub Sea Power Cable Installation Survey  
SUMMER – 2007

**SURVEY PERIOD**  
**JULY & AUGUST - 2007**



DATE : Report – December 2007

CLIENT : Vattenfall via Dong energy, Erhardt Christensen

PROJECT : SURVEY OF HVAC POWER CABLES KENTISH FLATS OFFSHORE WIND FARM

PRODUCED : CT Offshore by Mr Paw Cortes

TITLE : FINAL AS FOUND POWER CABLE MAINTENANCE SURVEY NO. 01 SPRING 2007

**Introduction**

CT Offshore was awarded the maintenance survey contract requiring Post Installation Maintenance Survey of the 33 kV power cable between the offshore WTG foundations and the land fall cables running ashore.

It was agreed to commence the survey at the identified critical sections – and evaluate along the operation taking the weather and progress in to consideration.

The purpose of the survey was to determine the degree of protection provided to the cables based on the burial depth into the seabed, and the survey data from the survey completed summer 2006.

In other words there are now to independent survey to clarify the seabed cover over the cables along the cable route in all positions along the route where a survey has been completed.

The correlation between the two survey has indicated some cables which remain at risk, and others which has gained burial as and outcome of unexpected sediment movement (sand wave in row A and partly row B)

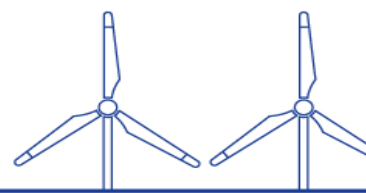
**CT Offshore survey experience**

- NYSTED 80 turbine + main cables Denmark 2003
- HORNS REV 72 turbine + main cables Denmark 2006
- Kentish Flats 30 turbine + main cables UK East Coasts 2006
- Barrow 30 turbines + main cable UK Vest Coast 2006
- Yttrestengrund 5 turbines + main cable Sweden 2004
- DK-National grid 45.000 meters Denmark 2004
- DK-National grid 12 kW Denmark 2007
- Nysted Re-maintenance survey Denmark 2007
- Kentish Flats Re-maintenance survey Denmark 2007
- HORNS REV Re-maintenance survey Denmark 2007
- Lillgrund Post install survey Sweden 2007



ROV (Remote Operated Vehicle) at the deck of the support vessel MV Sander.

System used to perform the survey was the support vessel MV Sander – TSS 440 and the subtrack ROV subfighter 7500 – Data was logged and processed via EIVA survey systems.



## Index

Installation and survey activities until date at Kentish offshore wind farm: .....	3
Mobilised equipment.....	4
Cable detecting equipment TSS 440 .....	4
Vessel.....	4
Survey set-up.....	4
Method statement.....	5
Summary of the survey .....	5
Sections of survey .....	6
Areas of problems .....	5
RAW DATA VIDEO LOGGING.....	7
Validations .....	8
Data and post data processing .....	9
Recommendations with regard to further protection.....	9
Conclusion .....	10
Further content to this final report: .....	11

## Installation and survey activities until date at Kentish offshore wind farm:

The land fall cables were installed by ploughing with a target depth 1.5 meters, and the array cables were installed by post lay jetting and trenching with the “otter” tool.

Installation and burial were undertaken by Vestas who used Global Marine as subcontractor.

Following installation of the cables in year 2005 – the below main activities have been completed and reported.

### **Year 2006 spring / summer - BPI.**

Setech UK develops a burial protection index- which identifies and access the safe burial depth at the site – based on risk and seabed evaluations.

### **Year 2006 summer - SURVEY.**

100% post install survey was completed via TSS 440 mounted at subtracked ROV – the survey found a significant amount of cable below contractual depth. (Whereof approximately 3,700 meters was identified below the BPI recommendations)

### **Year 2007 February - Post burial assessment**

Assessment of required and possible post burial activity which was introduced at site to protect the cables in question (sections of cables identified at risk – meaning less burial than advised by the BPI index approx. 3,700 meters)

### **Year 2007 MAY - Budget assessment of post burial activity**

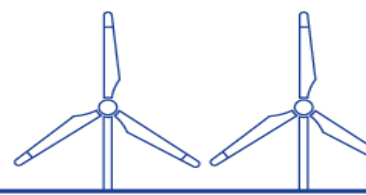
Budget assessment of post lay burial and additional survey recommendation.

### **Year 2007 July August – maintenance survey completed.**

Follow up maintenance survey No. 2 was completed.

Section of reduced burial was re-identified – and existence of a mega ripple in the North west corner was identified.

The survey result from 2006 has been drawn in a map system together with the 2007 results, and it is reasonable to conclude that cables at repeated shallow burial may be categorised as stationary – wherefore additional burial protection over those section may be utilised in near future.



## Mobilised equipment

CT Offshore standard near shore survey vessel MS Sander was mobilised with ROV vehicle – Tss 440 cable and pipeline tracker and Eiva survey logging equipment.

### Cable detecting equipment TSS 440

#### Vessel

Survey vessel MV sander was mobilised for the survey.



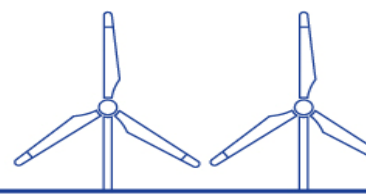
#### Survey set-up.



#### SURVEY system, set-up and software.

The full survey system, consisting of:

- ORE track point 3P
- Tp3p Transceiver \* 2
- Tp3p Hydrophone/transceiver
- Multibeacon transponder/responder 4330B
- Roll/pitch sensor
- Tritech Super Seaking DFP Dual Freq Profiler
- Immaginex Sonar 881A
- NaviPac Integrated Nav software
- Naviscan Multibeam & Sonar data Acquisition  
(Navi edit)
- Full package purchased, installed and tested by EIVA engineers.
- TSS 350 Pipe and Cable tracker
- Mobilised and tested by TSS engineers.
- Furuno GPS Sat compass navigator GP 37 + DGPS
- Installed by Furuno engineers
- HP Tower 3 Ghz P 4Xp Pro system, computer



## Method statement

The offshore activity was carried out in daylight.

### Weather permitting:

- The MV Sander departed in the morning at approx. 0600, arriving at the site approx. at 0630, setting up for ROV launch. Assessing the weather at site before disembarking personal at the tower.
- The ROV was launched, Back Ground Compensation completed and the operation commenced locating the cable, thereafter the survey commenced logging all data as required.
- Survey of the cables was commenced by using the ROV and the cable tracking system TSS 440 with a speed of approx. 300 metres per hour (main cables) and 250 metres per hour (array cables), allowing the equipment to log data and navigate safely along the cable line. To some extent the speed was hampered by strong tidal current.
- When required, verbal communication was recorded along with the cameras and the logged data (pos /bottom profile/depth of burial). This was done in order to identify or clarify any abnormalities observed along the survey.
- One offshore workday was planned to be 11-12 hours, including the transit period between port and work site – 1 hr alongside was further encountered to insure data logging safety back up, and ROV maintenance (total working day 12 hrs). In average the transit period was expected to be ½ hour in each direction with an average transit speed of 20-23 knots (transit time varied along the route). Daily work hrs was nominated to be 12 hrs, including data logging, and data work alongside insuring daily back up, and safety copies of the completed offshore work.
- At arrival alongside, a daily progress report (DPR) was produced and forwarded by e-mail to the client. The activities of the day were logged and backup copies taken and loaded to a DVD media followed by a dive log.

## Summary of the survey

The survey was significantly hampered by poor weather conditions. The survey was planned to take place in July and August – months that are normally known for having workable weather conditions.

Summer 2007 proved to be different and significant WOW was experienced.

Vessel arrived at site 03 July 2007 and departed from Ramsgate the 22<sup>nd</sup> of August 2007.

The ROV suffered from a short circle fault in the main electronics – wherefore equipment was declared offshore for a few days during the survey period.

Full survey was planned for in an order of priority, pending on weather, having completed the critical sections and approx 75% of the cable survey, the remaining survey was cancelled due to the adverse weather conditions experienced at the time.

Below sections of array cables was not surveyed:

- A3 – A4
- E1 – E2
- E3 – E4
- F1 – F2
- D3 – D4

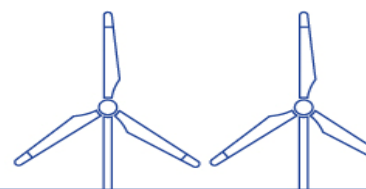
## Areas of problems

Cable sections at reduced burial very near to the tower may be a result of local scour wherefore stabilising precautions may have limited effect, several of the cable sections very near to the tower (within 10-15 meters) were seen at reduced burial. Those near WTG sections may only be protected by rock dump, as the cables are in suspensions or with no slack.

All cable sections “free” from the tower - at burial below 0.6m which is below the risk line, shall be categorised as being in risk, sections of exposed cable and cable at no burial were found at several locations similar to the survey year 2006 e.g.

- E5 – E5
- C4 - C3
- B3 – B4
- B5 – X1

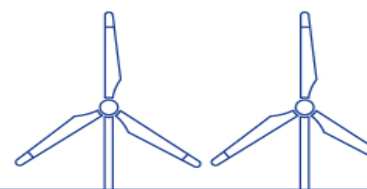
The main cable X1 – the first approx 400 meters away from the tower is logged at reduced burial below 0.5 meter- wherefore it is categorised as being in high risk.



## Sections of survey

**Cooperation sheet listing section of cable in question year 2006 & 2007.**

Year	WT - WT sections	A	B	C	D	E	F	2006 sum
		< SeTech	< SeTech	< SeTech	< SeTech	< SeTech	< SeTech	< SeTech
2007	A1 - A2	Improved sediment cover						0
2006	A1 - A2	70	60	30				160
2007	NO	Improved sediment cover						0
2006	A2 - A3	30						30
2007	A3 - A4	Improved sediment cover						0
2006	A3 - A4	0						0
2007	A4 - A5	Improved sediment cover						0
2006	A4 - A5	30	240					270
2007	B1 - B2	Improved sediment cover						0
2006	B1 - B2	60	110					170
2007	B2 - B3	Improved sediment cover						0
2006	B2 - B3	30						30
2007	B3 - B4	90	20	50	10			170
2006	B3 - B4	90	20	50	30			190
2007	B4 - B5	Improved sediment cover						0
2006	B4 - B5	380						380
2007	C1 - C2		100					100
2006	C1 - C2	30	20	30				80
2007	C2 - C3	Improved sediment cover						0
2006	C2 - C3	20						20
2007	C3 - C4				40	30		70
2006	C3 - C4	20	20	10	30	50	10	140
2007	C4 - C5	80	40					120
2006	C4 - C5	80	210					290
2007	D1 - D2	170						170
2006	D1 - D2	170						170
2007	D2 - D3	30						30
2006	D2 - D3	30						30
2007	No	0						0
2006	D3 - D4	0						0
2007	D4 - D5	40	0					40
2006	D4 - D5	20	20					40
2007	No							0
2006	E1 - E2	0						0
2007	E2 - E3	0						0
2006	E2 - E3	10						10
2007	No							0
2006	E3 - E4	0						0



2007	E4 - E5	40					40
2006	E4 - E5	30					30
2007	No	0					0
2006	F1 - F2	0					0
2007	F2 - F3	70	10				80
2006	F2 - F3	70	30				100
2007	F3 - F4	20	30				50
2006	F3 - F4	20	30	10			60
2007	F4 - F5	10	5				15
2006	F4 - F5	20	20				40
2007	A5 - B5	450					450
2006	A5 - B5	700					700
2007	C5 - D5	150	30				180
2006	C5 - D5	140					140
2007	E5 - F5	180					180
2006	E5 - F5	180	20				200
2007		400					400
2006	Start X1	400					400
Indicative total length in meters of Array cables below SeTech recommendations year 2006							3680
Indicative total length in meters of Array cables below SeTech recommendations year 2007							<b>2095</b>

*The assessment indicates that approx 2100 meter of cable remain in question, and at risk.*

The assessment is based on two surveys (2006 & 2007) and it is reasonable to conclude that the cable continually being logged at reduced burial may be a more permanent situation wherefore it can be advisable to allow for remedial burial trying improving the safety of the system.

The main cable X1 shall have the highest priority, followed by areas with burial below 0.6 meter at a distance of more than 30 meters away from the foundations, where fishing activity may take place.

## **RAW DATA VIDEO LOGGING**

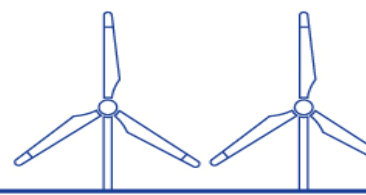
The ROV has a camera, and the camera recording was mixed and recorded together with the raw data presentation which was available to the ROV pilot when operating the vehicle at the seabed over the cable.

Those RAW recordings have been cut in to 10 hot spots which are included on the CD.

**NOTE:**

*Please observe that data seen on the recording is RAW, no post processing or editing has taken place.*

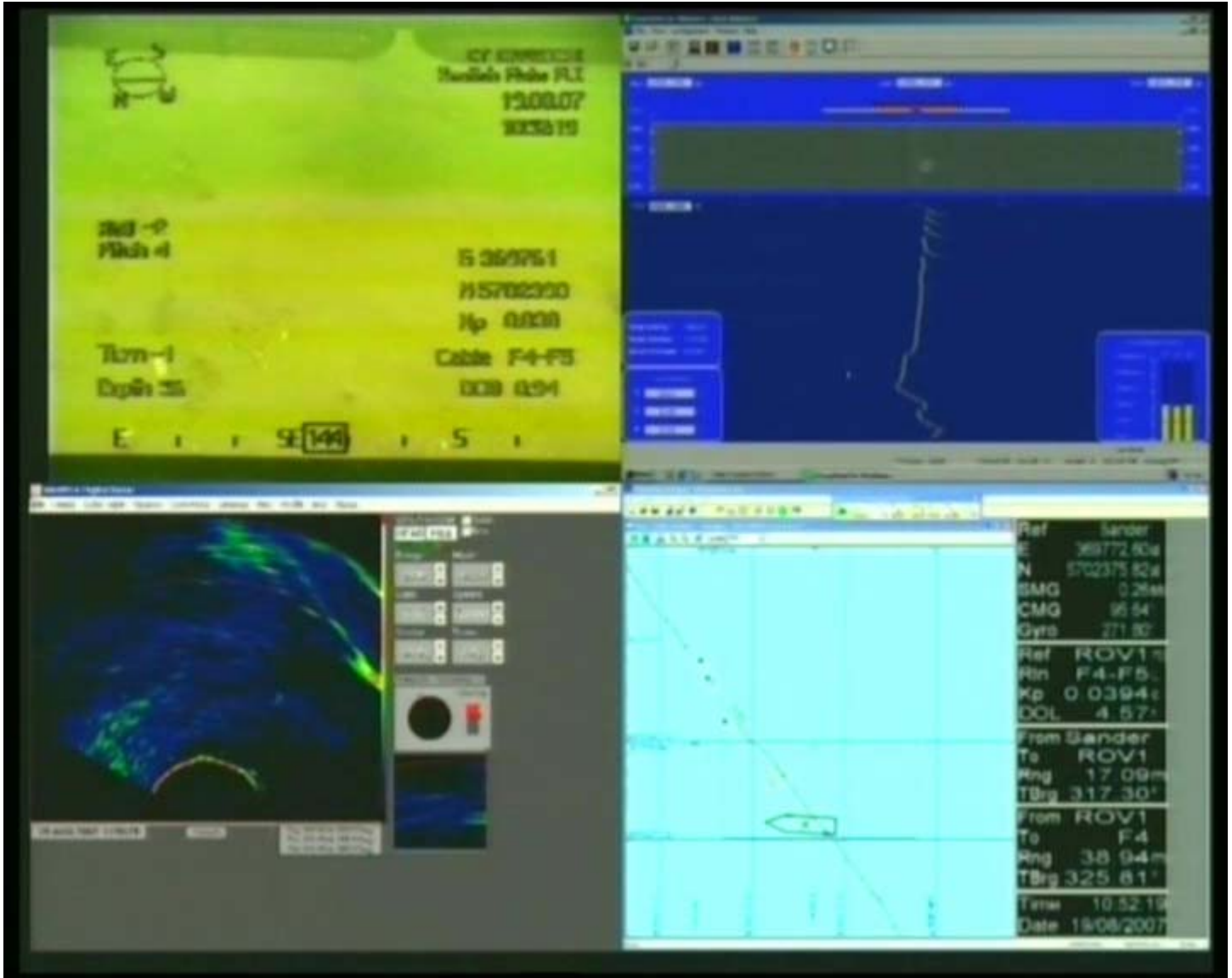
*This raw video may to some extend appears as irregular and defuse tracking or cable, if being analysed by persons with limited experience in the set-up and the survey method.*



Example of Screen dump when ROV is 38 meters from WTG F4 driving towards F5.

1

2



3

4

**Reference number to the screen dump:**

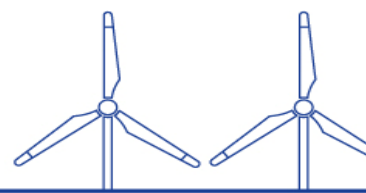
- 1: Front camera of the vehicle – position – KP down the route – time and date – depth and heading
- 2: TSS 440 display burial depth tracing pos of the cable and tracking track of the cable
- 3: SONAR image in front of the vehicle.
- 4: Navman display, position of surface vessel, and sub sea vehicle.

**Validations**

**SURVEY system, set-up and software**

The full survey system, consisting of:

- ORE track point 3P
- Tp3p Transceiver
- Tp3p Hydrophone/transceiver
- Multibeacon transponder/responder 4330B



- Roll/pitch sensor
  - Tritech Super Seaking DFP Dual Freq Profiler
  - Immaginex Sonar 881A
  - NaviPac Integrated Nav software
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  - Navi edit
- *Full package purchased, installed and tested by EIVA engineers.*
- TSS 440 Pipe and Cable tracker
  - Mobilised and tested by TSS engineers.
- Furuno GPS Sat compass navigator GP 37 + DGPS
  - Installed by Furuno engineers
- HP Tower 3 Ghz P 4Xp Pro system, computer
  - Installed and full system test completed after mob of the total set-up completed by Eiva engineers.

## Data and post data processing

The data was logged during the survey by the Eiva software survey system, and relevant information was recorded as text overlay on the ROV camera DVD recording, allowing the client to check and “post” follow the operation and the performance of the ROV by seeing the recordings made while the survey was carried out. (Video copy exists at hard drive)

All logged data was post-processed by using EIVA Navi Edit software, and EIVA survey engineer Walder Degenkamp assisted in the post-processing operation of the data, where spikes were taken out of the data.

Spikes are unavoidable, and tolerances were allowed for during the evaluation of the data. The final tolerance is influenced by different factors, but the higher accuracy available, the closer the cable is to the search frame.

Data recorded and logged near the towers, when manoeuvring around in the sediment which had been loosened by the air lifter, may have caused higher inaccuracy than normal, as the vehicle to some extent had sunk in the fluidised sediment, which had disturbed the signals.

## Recommendations with regard to further protection

Mobility of the sediment in the area is evident, as we have logged additional sediment in row A and parts of Row B, sediment in the area is known to move, and it is possible that a mega ripple is under way moving through the park area.

Never the less the sediment movement surveys have repeatedly observed cable at high risk in same sections, some of the sections proved exposed cable in year 2006 & 2007

The comparison sheet made between the reduced burial section from year 2006 and the logged data from 2007 proved that there are sections which would benefit from additional protection if being lowered deeper in to the seabed.

Additional protection shall always “if possible” be obtained by lowering the cables into the existing seabed. The method of lowering the cables may be by jetting or airlifting methods, controlled from surface.

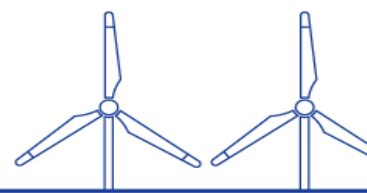
Post lay burial does always have a risk of failing – but the risk normally remains unidentified until onsite attempts have been tested.

*E.g. the cable may not be willing to lower them self if under tension.*

## HOTSPOT Video.

All dives have been recorded in raw video format.

To point out sections of special interest we have produced a hot spot list where short sections of the raw video has been cut out to present the video of the actual survey over those sections.



**INSTRUCTION**

**LOAD THE DVD AND START FILE ---- VTS\_01\_0.IFO**

**Then you shall see the hot spot no:**

DVD NO	Location	KP	Remarks	Visibility	Hotspot NO
1	A5-B5	9	Weak visual identification of j-tube	Bad	1
1	F4-F5	20-41	Closing in on tower F4 – visible cable. Turn the vehicle and commence survey towards F5 Whit sonar picture.	Good	2
1	A2-A3	4-8	Visible j-tube, at A2 Turning around and drive away from tower. Whit sonar picture.	Fair	3
1	B3-B4	394-440	Over cable DOB 0.2-0.0 over this section.	Bad	4
1	A1-A2	6-18	Turning around driving away from tower. J-tube and possible cable.	Fair	5
1	D1-D2	694	At WTG D2. Sonar picture of j-tube.	Bad	6
1	D4-D5	677-690	Driving towards tower D5. DOB going from 0.8 to 0.1 m	Bad	7
1	E5-E4	681-675	Driving on visible cable. Cable rising above the seabed. In suspension.	Fair	8
1	E5-E4	660-632	Driving over cable and cable becomes visible.	Fair	9
1	C4-C3	557-548	Driving over cable, very low DOB 0.2-0.0.	Bad	10
1	B5-X1	9102-9062	Visible j-tube at tower B5. Turning around and driving towards land end. Shallow burial.	Good	11

## Conclusion

The Setech report from year 2006 - concludes that cable shall be below 0.8 and 1 meter of burial depth if they are to be categorised as being safe in the area of which the park is positioned.

Taking out spring in the Setech report and the two surveys – it is evident that approx 2000 meters of cable in the park area requires further protection if the cables are to be categorised as being safe.

Post lay burial of sub sea cable has a risk and it is expensive – but bearing in mind that cable repairs have been priced as high as DKK 30 mio. + production losses – planned upfront precautions may be considered.

Sub sea cable service prices in the market is raising dramatically and availability is getting very limited, wherefore cable damage may become very critical if availability is non existing at the time of the damage.

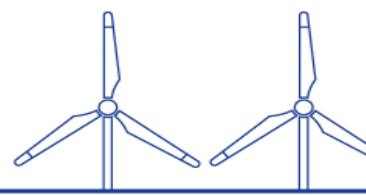
- ***Further protection to insure cable burial below or near to the BPI line shall be considered.***
- ***Sections of exposed and cable at very reduced depth must be categorised as being in HIGH risk.***

The possible burial activity shall be a planned operation including cable identification equipment, to insure that cables are easily identified before lowering the burial equipment over the cables.

Reference is given to earlier reports regarding the requirement and possibility of post lay burial.

Vattenfall shall hereby be advised that risk exists to the sections of cable which are below 0.6 meters of burial – and our general advice is to lower the cable below the BPI recommendations where possible. Sections of much reduced burial must be addressed to insure the safety of the production.

Secondary survey is recommended after 12 to 24 months to confirm the stability of the seabed, and the cable burial, the interval shall be 12 months if no remedial burial is undertaken.



## Further content to this final report:

The final report is followed by additional documentation in line with the listing as seen below:

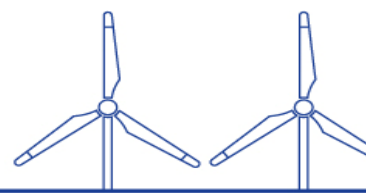
- Survey charts of the cable as found data      forwarded electronically
- GA of support vessel      forwarded electronically
- GA of ROV      forwarded electronically

Yours faithfully

Manager  
Paw Cortes

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*Enclosed: Original acceptance certificate + follow up QA certificate issued by Eiva.*



## **EIVA a/s** MARINE SURVEY SOLUTIONS

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Bankers: Nordea Bank Danmark A/S  
DK-1786 Copenhagen V  
Swift address: NDEADKXX

Our ref.:

31-03-2008

**Subject: Acceptance Test Certificate**

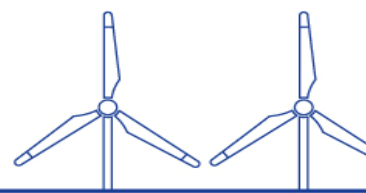
This acceptance test certificate is issued by EIVA to certify that the post-lay ROV survey inspection system comprising:

- ORE TrackPoint 3P underwater acoustic tracking system
- Tritech Super SeaKing DFP Dual Frequency Profiling sonar
- NaviPac Integrated Navigation Software
- NaviScan Multibeam & Sonar Data Acquisition Software
- HP Tower Computer w/ interface card
- Samsung 19" TFT monitors

has been supplied to CT Offshore and installed and thoroughly tested by EIVA and found to fully comply in accordance with applicable specifications.

Yours faithfully  
EIVA a/s

Palle Herskind  
Sales & Marketing Manager



**EIVA a/s** MARINE SURVEY SOLUTIONS

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Bankers: Nordea Bank Danmark A/S  
DK-1786 Copenhagen V  
Swift address: NDEADK33

Our ref.:

15-09-2008

Subject: Acceptance Test Certificate

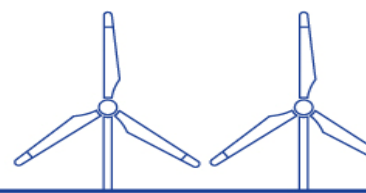
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- HP Tower Computer w/ interface card
- Samsung 19" TFT monitors

has passed a full scale offshore operational test performed by EIVA on August 5<sup>th</sup> through 8<sup>th</sup> 2008 and found to fully comply in accordance with applicable specifications.

Yours faithfully  
EIVA a/s

Palle Herskind  
Sales & Marketing Manager



## EIVA a/s MARINE SURVEY SOLUTIONS

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Swift address: NDEADKKK

Our ref.:

25-04-2007

### Subject: Acceptance Test Certificate

This acceptance test certificate is issued by EIVA to certify that the post-lay ROV survey inspection system comprising:

- ORE TrackPoint 3P underwater acoustic tracking system
- Trittech Super SeaKing DFP Dual Frequency Profiling sonar
- NaviPac Integrated Navigation Software
- NaviScan Multibeam & Sonar Data Acquisition Software
- HP Tower Computer w/ interface card
- Samsung 19" TFT monitors

has passed a full scale offshore operational test performed by EIVA on April 20<sup>th</sup> through 21<sup>st</sup> 2007 and found to fully comply in accordance with applicable specifications.

Yours faithfully  
EIVA a/s

Palle Herskind  
Sales & Marketing Manager