Learning from the Experts Webinar Series

Offshore Wind Submarine Cabling

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May 26, 2021

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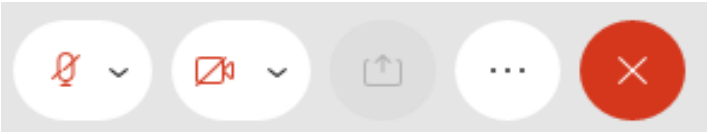

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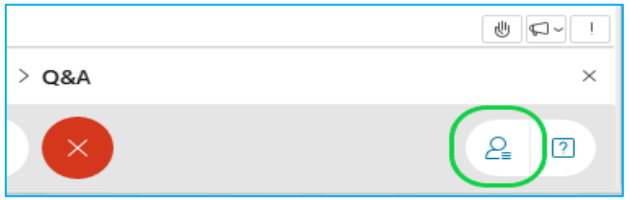

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Learning from the Experts

This webinar series is hosted by NYSERDA's offshore wind team and features experts in offshore wind technologies, development practices, and related research.

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Offshore Wind Submarine Power Cables – An Introduction

Duncan Sokolowski – Sr Project Manager, Submarine Cable Services at Tetra Tech

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Offshore Wind Submarine Cabling

The potential scale of the industry

The American Wind Energy Association estimates that by 2030, the USA will have between 20,000 and 30,000 MW of installed offshore wind power.

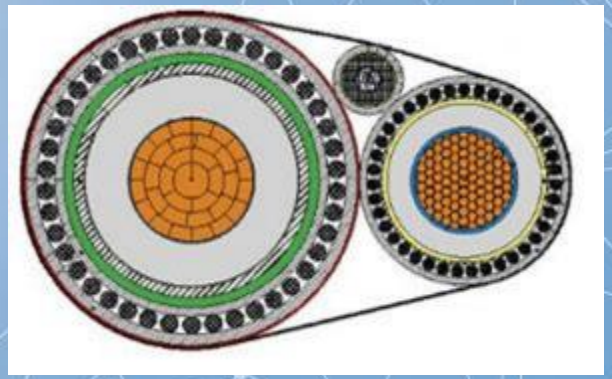
20,000 MW of offshore wind power will require approximately 1,650 turbines (of 12 MW each):-

- Approximately 50 export cables (~3,000 miles)
- 2,000 inter array cables (~2,000 miles).

Offshore Wind Submarine Cabling

An overview of the cabling.

HVAC Cable
Array Cable and Export Cable cross sections



HVDC Cable 'slices'
Neptune project on the left, Basslink (Tasmania) on the right

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Parameter	HVAC Arrays	HVAC Export	HVDC
Outer Diameter Range	4.25 in – 6.3 in (110 mm – 160 mm)	10 in – 13 in (250 mm – 320 mm)	Approx. 6 in (150 mm) NOTE: Return cable is of smaller diameter
Weight in Air	13 lbs/ft – 34 lbs/ft (20 kg/m – 51 kg/m)	Up to approx. 85 lbs/ft (125 kg/m)	Approx. 40 lbs/ft (60 kg/m) for entire bundle
Conductor Cross-Section	3 x 120 mm^2 – 800 mm^2	3 x 800 mm^2 – 1400 mm^2	Up to approx. 1800 mm^2
Voltage Rating (approx.)	< 66 kV	132 – 345 kV	Up to approx. +/- 600 kV
Electrical Losses		Medium (at the longest lengths)	Low
Practical Maximum Length		~60-70miles (100-120km)	Theoretically unlimited, currently the longest submarine HVDC cable is 720 km (450 miles) for North Sea Link
Max power per cable		~400 MW	Currently ~2,200MW for Western Link

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Offshore Wind Submarine Cabling

Impacts/Risks to and from Cabling

Party	Risk/Impact	Consequences
Cable Owner	Cable damage	Loss of revenue Cost of repair operation Increased insurance premiums
Insurer	Insurance claim either to cable owner or commercial/fishing vessel that impacts cable	Insurance payout, future risks on other insured assets
Shipping Industry	Possible legal liability if deemed to be at fault, vessel delays/arrest. Health and Safety	Commercial and legal impacts. Health and Safety
Fishing Industry	Possible legal liability if deemed to be at fault, vessel delays/arrest. Lost fishing gear Health and Safety	Commercial and legal impacts. Health and Safety
Grid Operator	Generating source goes offline	Consequential grid operational implications
Regulatory Authorities	Processes and reputation	Changes to the permitting process Public perception
Environment	Turbidity during installation EMF Heating effects	

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Vineyard Wind Final Environmental Impact Statement – A Summary of Mitigation Measures

Measure Number & name	Description	Expected Effect on Impacts	Authority
11 – Dredging & Cable Installation Methods & Timing	Requires cable installation activities to use the least environmentally harmful method – also defines installation window restrictions	Will reduce the expected minor to moderate temporary impacts on coastal habitats and benthic resources	MassDEP NMFS EFH
12 – Anchoring Plan	Requires an anchoring plan in all areas where anchoring is planned	Reduces the impact on the seafloor etc. Any applicable if anchor barges etc are planned	BOEM
14 – Final cable protection in hard bottom	Natural or engineered stone that mimics the surrounding seafloor, nature inclusive designs	Reduces the expected moderate impacts and improve possible minor benefits	Mass CZM BOEM
15 – Evaluation of benthic habitat prior to cable laying	A minimum of 75 benthic samples & 60 video transects to be taken along the export cable corridor. Information to be used to update habitat maps etc	Wouldn't change the rating but would allow sensitive areas to be avoided	BOEM
18 – Post-installation cable monitoring	Export and IA cable surveys at years 1,2 and every 3 years thereafter, as well as after a 'major storm event'. A DTS system also required.	Wouldn't affect the impacts on benthic resources but could reduce the impacts on commercial fisheries by detecting reduced burial	BOEM
74 – Providing electronic charting information	Make available information on the as-built location of cables	Would allow the fishing industry to make informed decisions re fishing grounds etc	Voluntary by VW
75, 76 & 77 – Compensation funds	Create funds held in ESCROW to compensate the fishing industry for direct impacts	Doesn't change the impact rating	Various
80 – Submarine cable system burial plan	Location and burial depths of the entire cable system to be submitted as a part of final documentation	To be reviewed by USCG & BOEM to aid planning etc	USCG BOEM

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So how are submarine cables protected from external aggression, and how are external users protected from cables? How are environmental impacts minimized?

1- Careful route planning, avoid as far as possible areas of high risk and environmental sensitivity. Shipping lanes, anchorages, fishing grounds, steep slopes & hard seabeds, dumping sites & borrow areas, areas of high seabed sediment mobility, other seabed assets (cables, pipelines etc), cultural sites, eel grass and fish-spawning areas (for example) and more

2- Cable Burial. The deeper the cable is buried, the safer it is from external impact and the less impact it will have on other users and the environment (except during installation)

3- Externally applied protection. Used where burial may be difficult or impossible such as areas of bedrock or areas of reduced burial such as at crossings

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Cable Burial is always the primary method of protection for cables.

What drives the specified or recommended cable burial depth?

- Requirements from Federal and state agencies (e.g., USACE in federally maintained shipping channels requires 15’ depth below authorized, maintained channel depth)
- Industry guidance from (for example) standards agency such as DNV GL, experience from organizations such as the North American Submarine Cable owners Association (NASCA) etc.
- Risk appetite of asset owners/insurers/regulatory bodies (

There is a balancing act between too deep (expensive, environmental impacts, ampacity issues) and too shallow (risk both to and from the cable).

So how is a recommended target burial depth derived?

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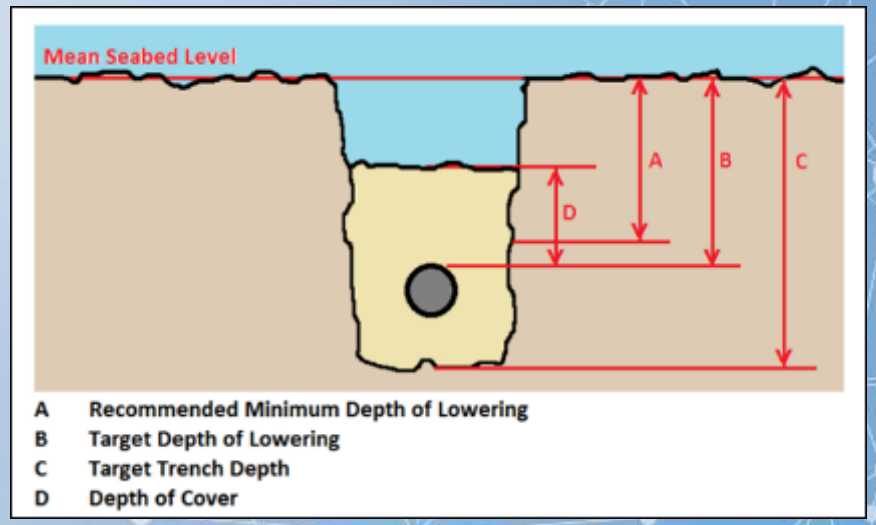
Cable Burial Risk Assessment (CBRA)

A CBRA is a risk-based methodology used to determine the minimum recommended Depth Of Lowering (DOL) for a submarine cable. The CBRA was developed by the U.K's Carbon Trust which commissioned a group of subject matter experts to create a method of determining risk to a submarine cable system and therefore specify a DOL that will reduce risk 'As Low As is Reasonably Practicable' (ALARP).

The CBRA will determine a minimum recommended DOL (A) at each point along the cable route.
To achieve this, the installation contractor will select a burial method to achieve a target DOL (B). This allows for a slight margin of error in case of unexpected hard soils, for example.
A target trench depth (C) will help to ensure that the minimum DOL is attained by accounting for any potential backfill.



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What goes into a CBRA?
Any external factor that can damage the cable, or in turn can be damaged by the cable is taken into consideration, these are a mix of natural and human (anthropogenic) factors.

- Commercial vessel activity
- Commercial (& recreational) fishing activity
- Dumping areas
- Dredging activity
- Obstructions (wrecks etc.)
- Cultural sites
- UXO
- Existing seabed assets
- Steep slopes, shoals, ravines, hard seafloor
- Sediment mobility
- Wind, waves, tides, currents
- Environmentally sensitive areas

Proper route planning will avoid challenging geophysical conditions (steep slopes, hard sediments etc.) as well as areas of human activity where possible. Where this isn't possible, the CBRA will ensure that risk to the cable is reduced as far as is reasonably practicable

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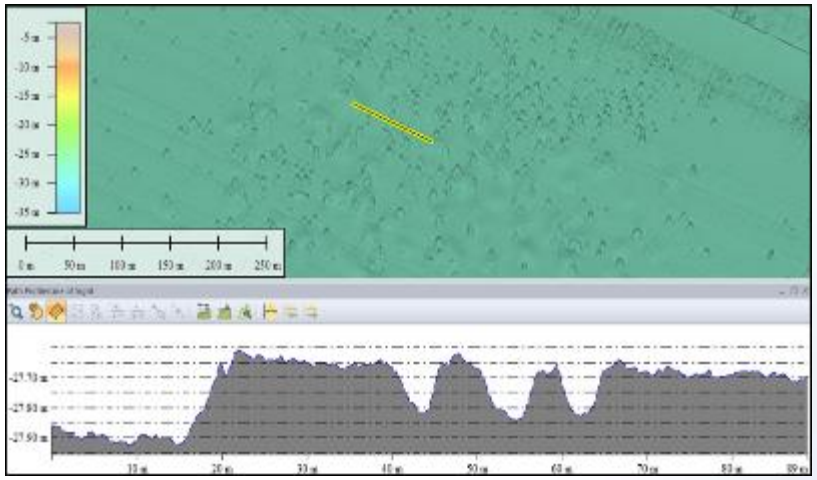
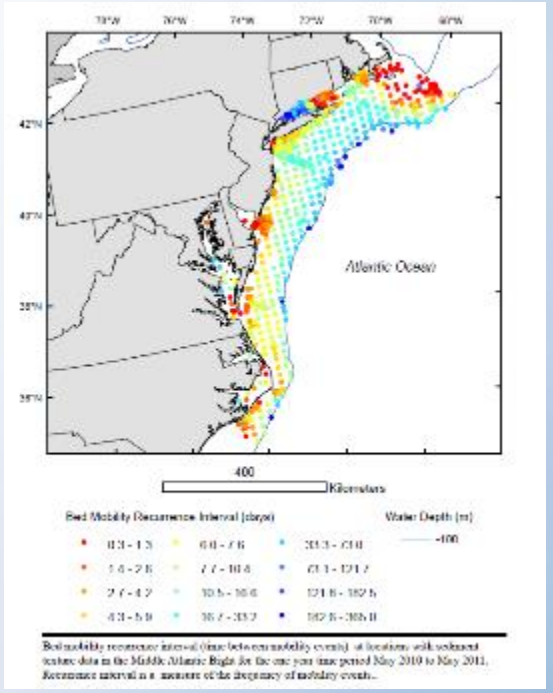
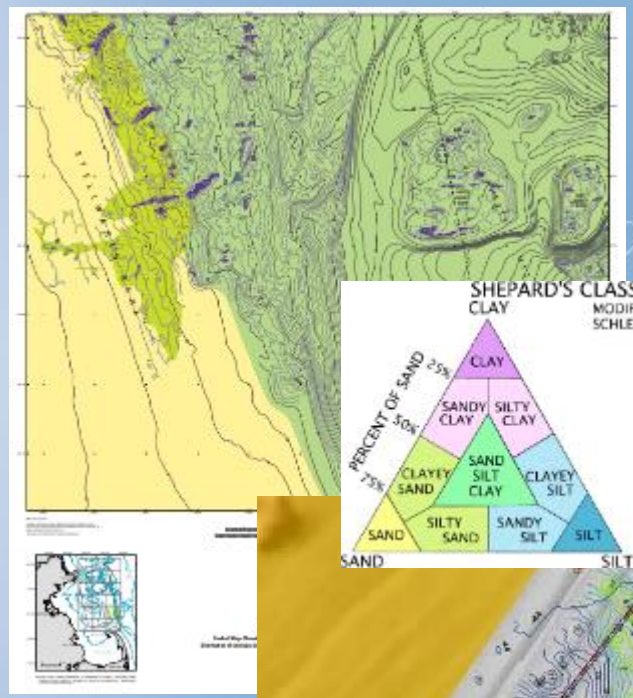
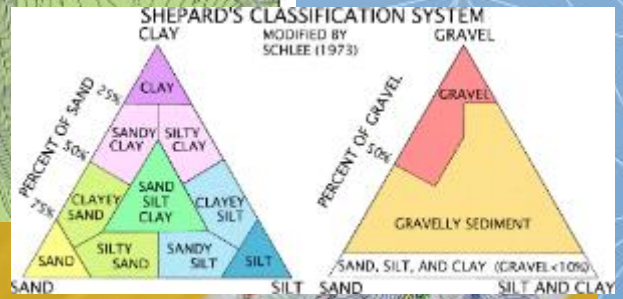
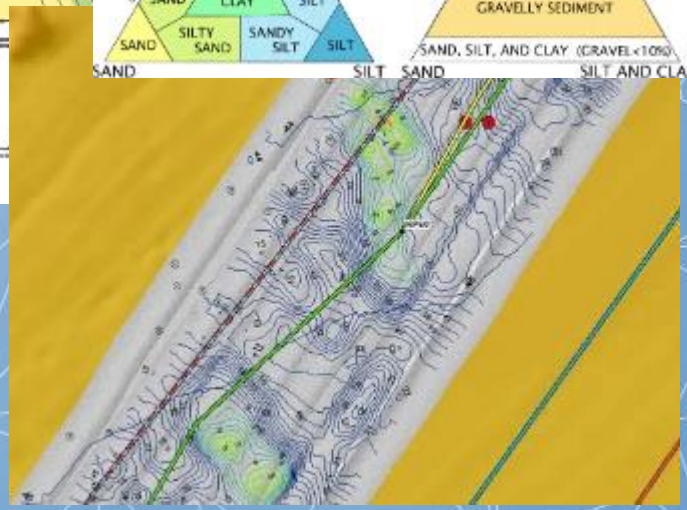
What goes into a CBRA?











Seabed Bathymetry

Sediment Mobility

Seabed Geology

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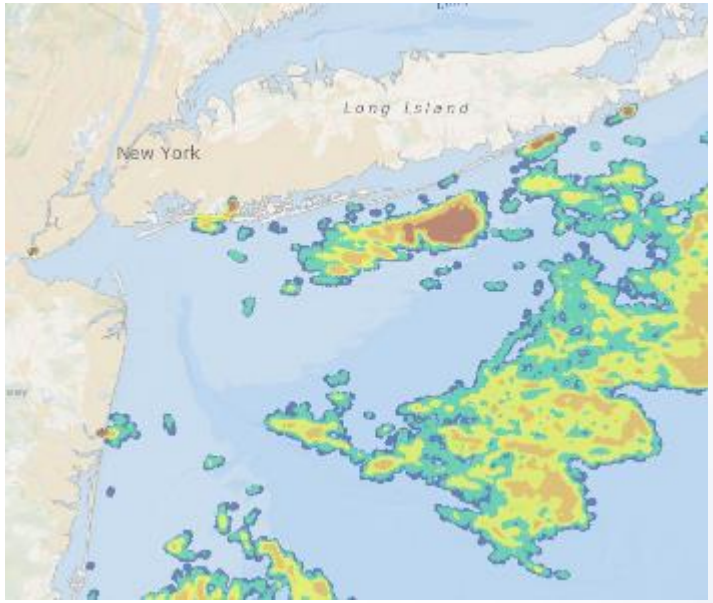
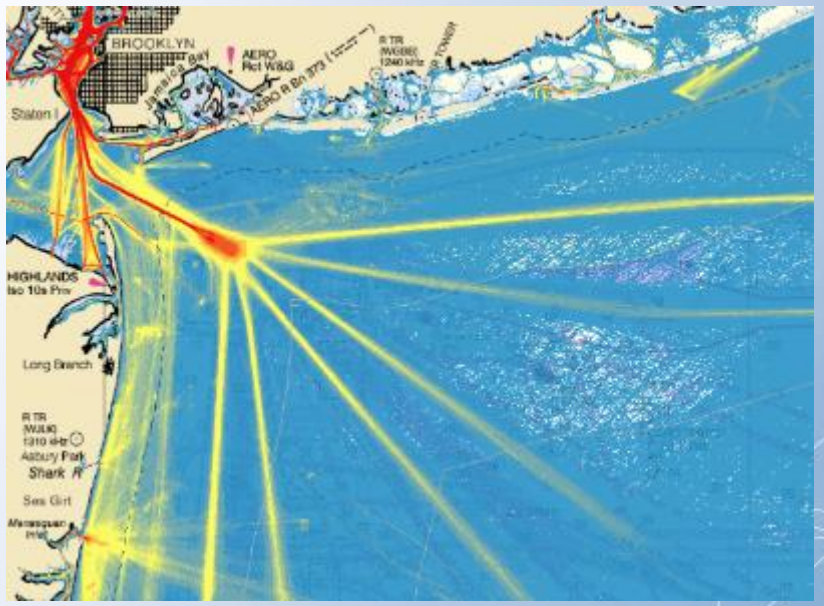
What goes into a CBRA?



Fishing Activity
(Hydraulic surf clam dredging, 2015 & 2016 VMS data)



Shipping Activity
(2019 AIS Data, Mid-Atlantic Ocean Data Portal)

Analysis of fishing types & commercial vessel types encountered

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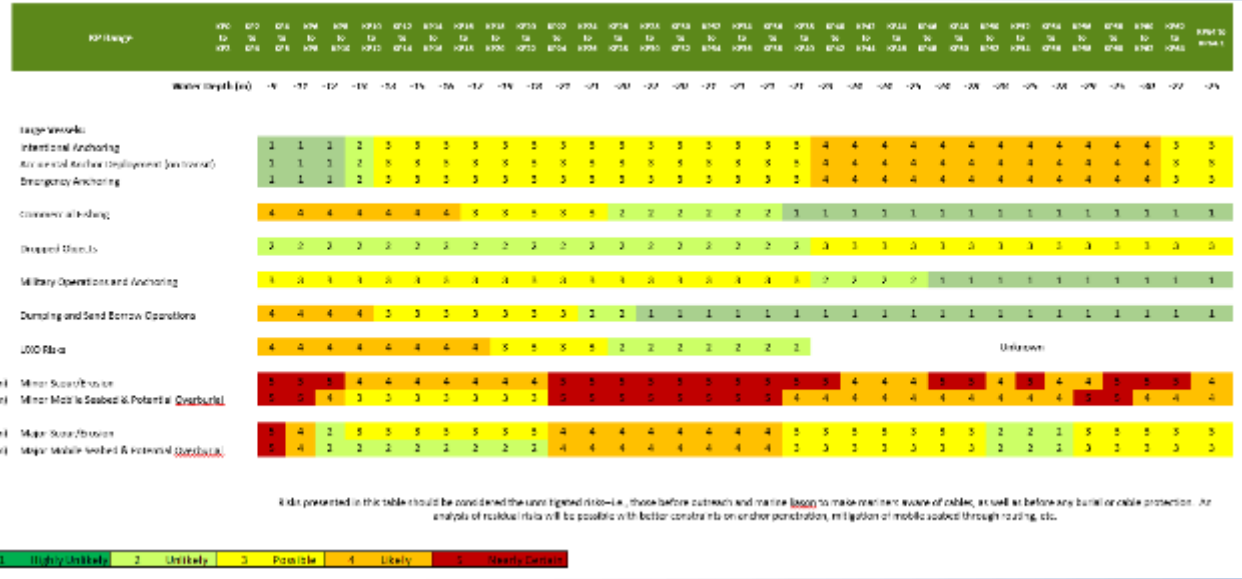
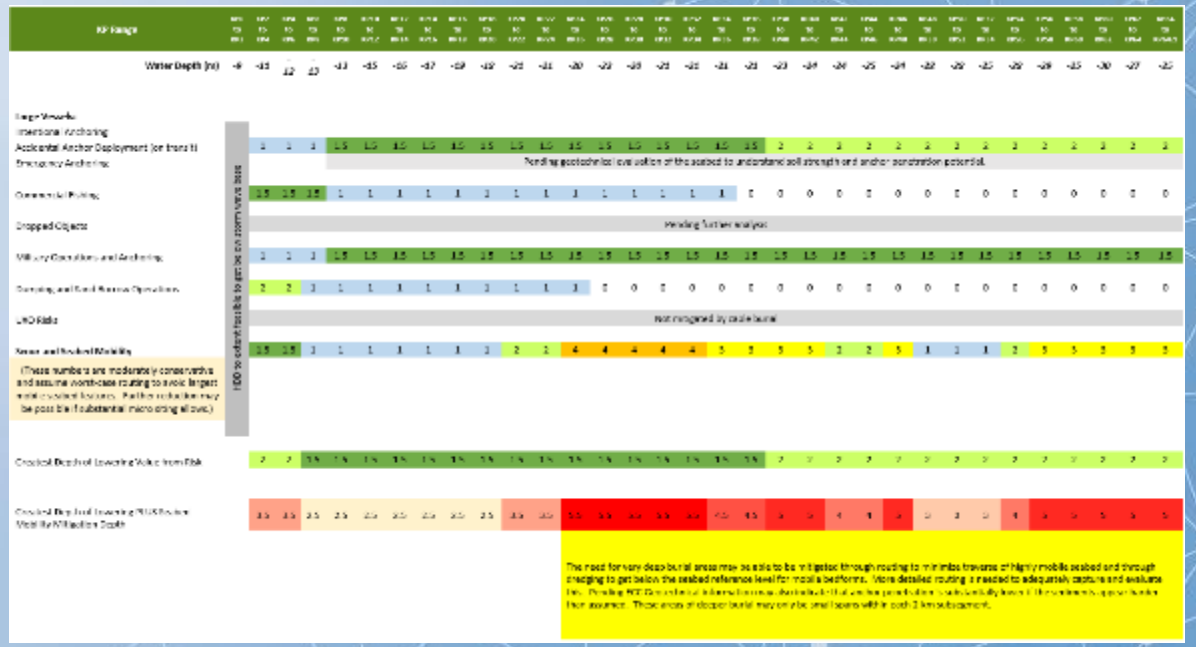
CBRA Output



Risk Assessment

Depth Of Lowering recommendations



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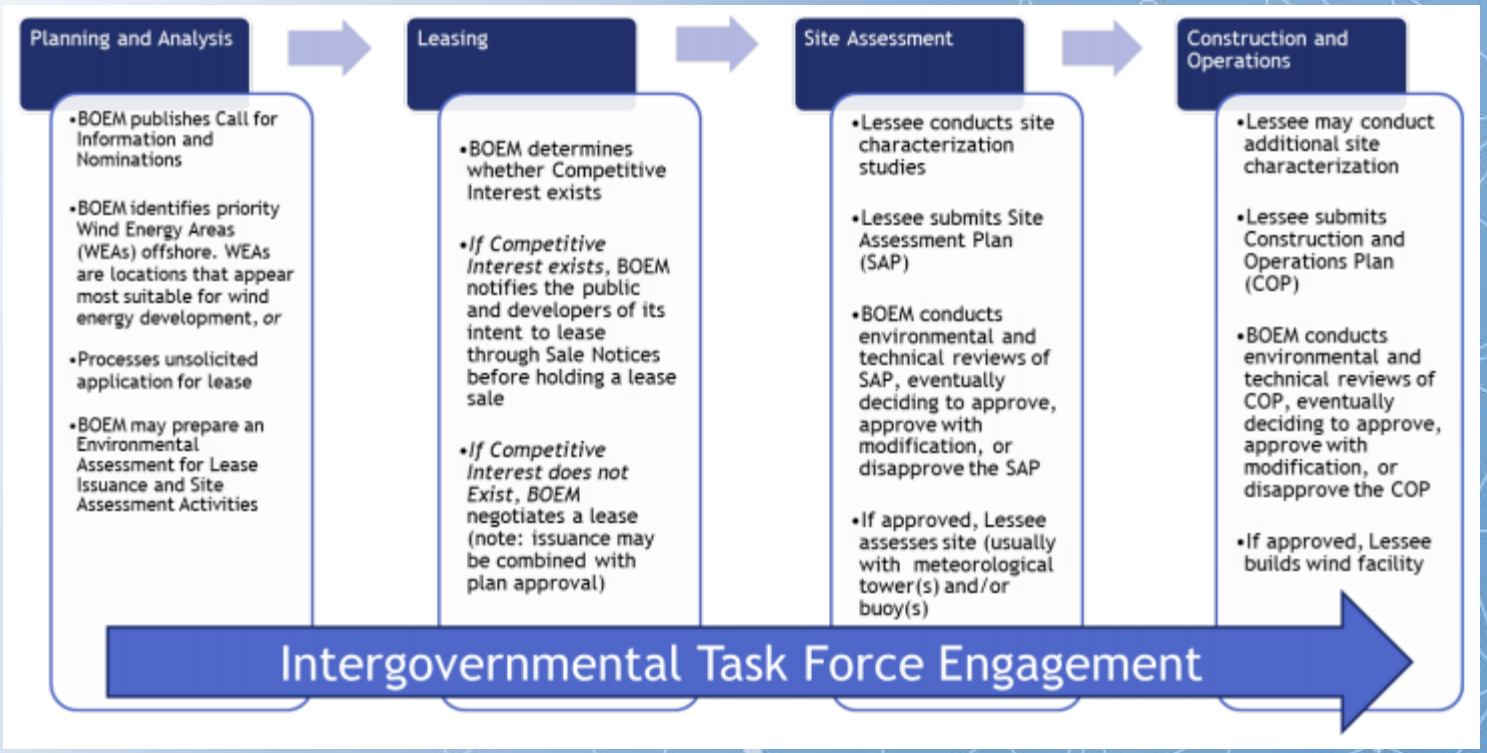
When can cable installation commence?

The permitting of an offshore wind farm is a process coordinated by BOEM under the National Environmental Policy Act (NEPA) of 1969.

Part of the permit requirements will include installation windows that will limit construction activities to times that won't impact migratory species, fish spawning, etc.



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Cable Installation And Burial – Two common methods

Simultaneous Lay and Burial

The Cable Lay Vessel (CLV) lays and buries the cable in a single operation.

Only one vessel required so saves on vessel day rates, however, the lay operations are a lot slower than if the cable is laid with no burial (surface lay). Therefore, longer weather windows are required.

Post Lay Burial

The CLV lays the cable on the seabed, it is then buried via a separate operation (usually by a different vessel).

Two vessels required but a lot of flexibility with regard to making the full use out of weather windows.

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Simultaneous Lay and Burial

Towed Plow
~3m/10' burial depth
15m long, 6.5m wide
Weighs approx. 50T

Towed jetting sled
~3m/10' burial depth
For shallower water & softer soils

Large Towed jetting sled
~8m/25' burial depth
For shallower water, has optional chain cutter for harder soils

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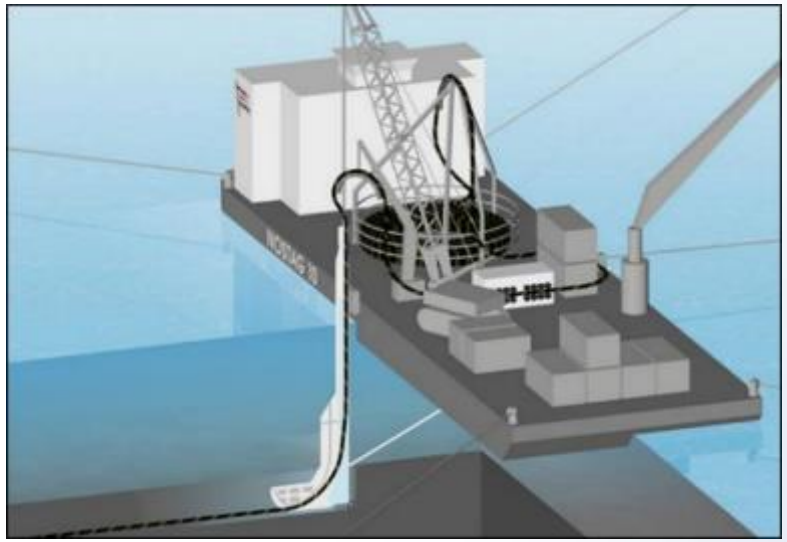
Simultaneous Lay and Burial



Vertical Injector
Up to 10m/33' burial depth
Deployed from a barge
Shallow water, softer soils

Tracked Trencher
Deepoceans T3200
Weighs 170T, jetting and chain cutting up to 3.5m burial depth

Tracked Trencher
Van Oord's 'Deep Dig-It'
Weighs 125T, jetting and chain cutting up to 5.0m burial depth

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Post Lay Burial

ROV
Canyon's T1200
Up to 3m/10' burial depth
Water jetting only

ROV
Enshore's T1000
Up to 3m/10' burial depth
Water jetting only

ROV in 'free-flying' mode
For softer sediments where tracks would sink and cause a loss in maneuverability

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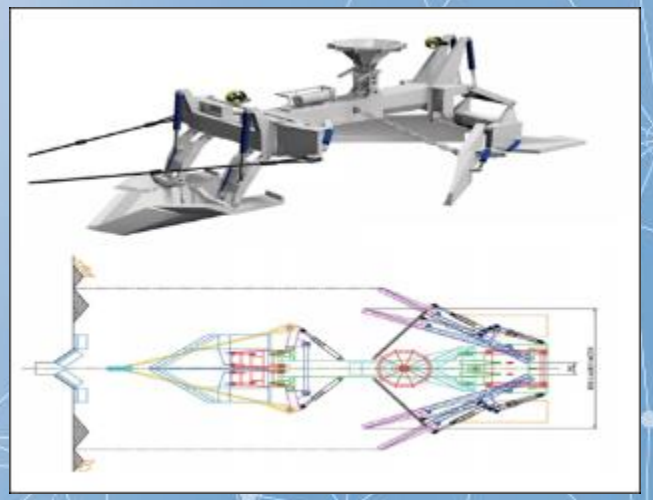
Other burial techniques



Mass Flow Excavator (MFE)

Multimode plow can clear boulders (route clearance mode), cut a trench into which the cable is laid, then can backfill the trench after cable lay. Typically, can cut a 'V' or 'Y' shaped trench between 1.0 and 2.0m in depth, depending upon soil conditions

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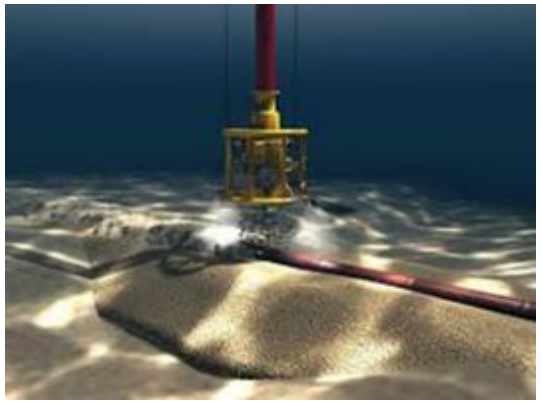
Other Cable Protection



Rock Dumping

Grout/Rock Bags

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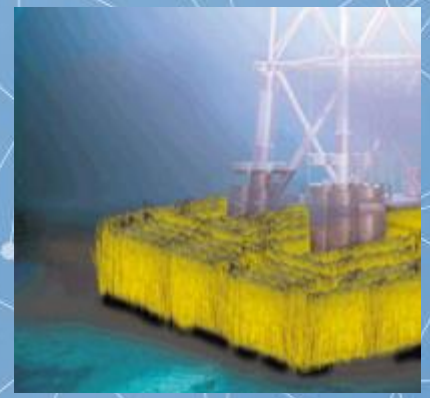
Concrete Mattresses

Other Cable Protection



Frond Matts/Nature Inclusive Designs

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Other Cable Protection

- Articulated Split Pipe
- Uraduct
- Cable Protection Systems

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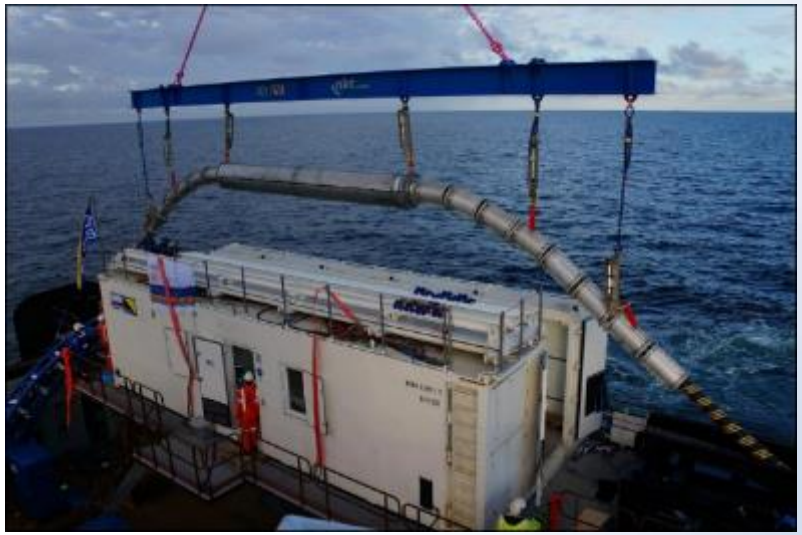
Cable Repairs



Cable joint being lifted out of jointing container

Cable joint being deployed from vessel

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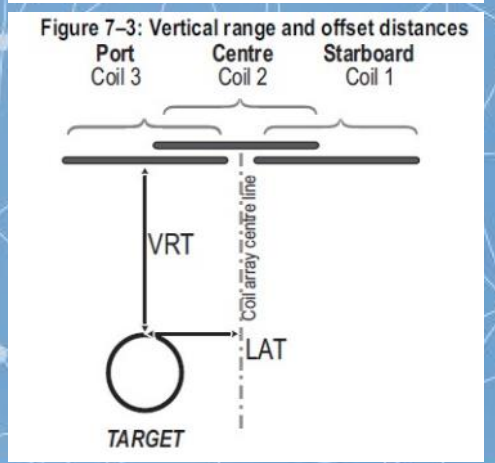
Cable Surveys

Cables are surveyed to ensure that the target depth of lowering has been achieved (after burial) and at periodic intervals to ensure that the cable isn't becoming too shallow or conversely, that the cable isn't becoming too deeply buried.

Cables that get shallower (mobile sediments move away for example) are at risk of damage.
Cables that get deeper reduce the current carrying capability due to the reduction in thermal conductivity.

How often?

It depends on site-specific conditions (e.g., how mobile the seabed is) as well as regulatory permitting requirements. It may be that initially, surveys are carried out every 1 to 2 years to establish baseline data, then the frequency can be reduced once the cable burial depth trend is more understood.



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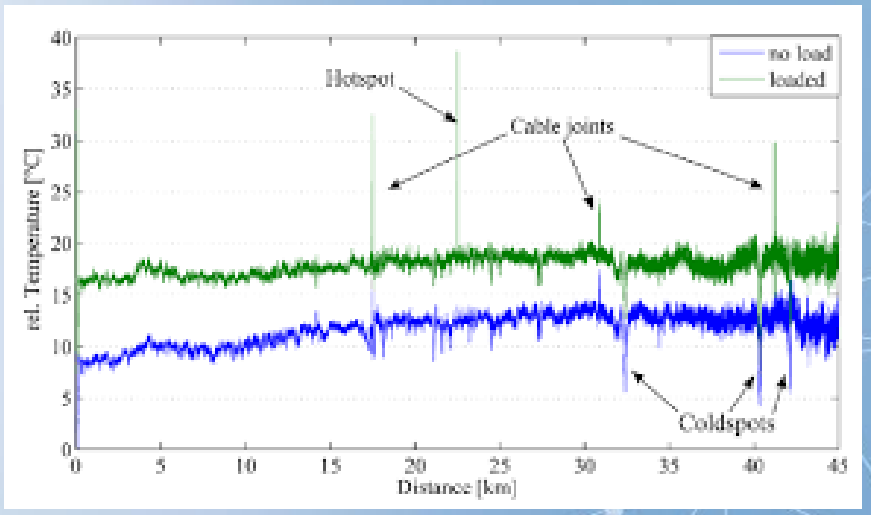
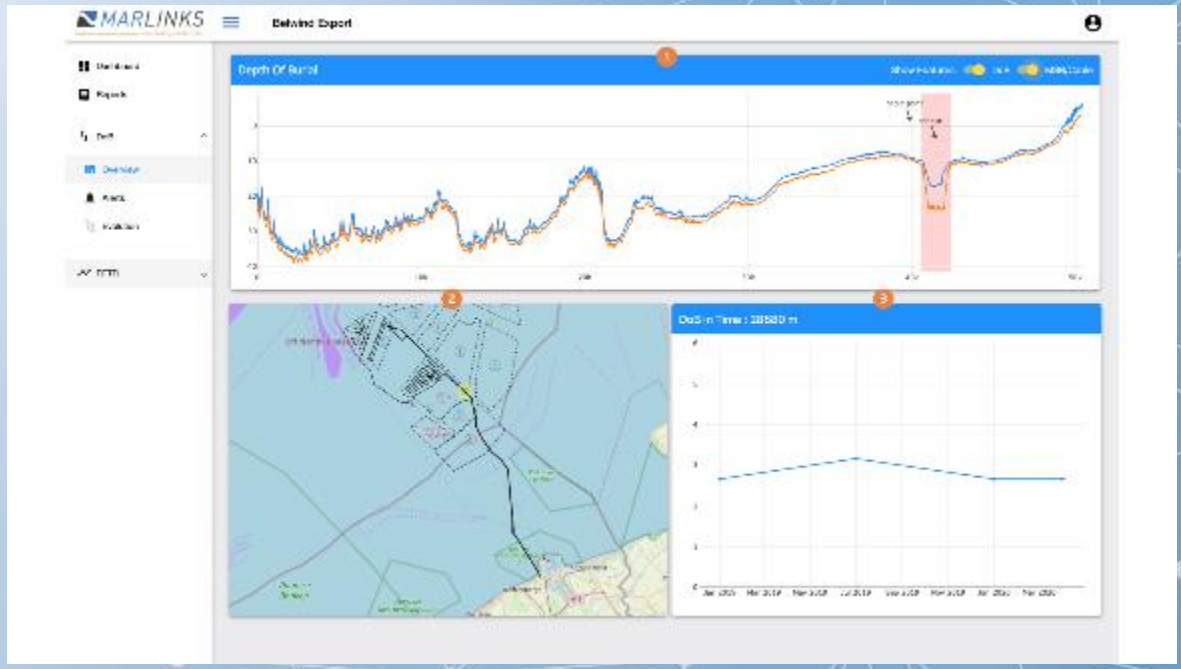


Cable Sensing

Distributed Temperature Sensing

- Equipment located in the control room & offshore substation
- Utilizes one of the optical fibers
- Monitors the temperature at approximately 1 to 5m intervals along the cable
- Benefits?
  - Cable can be operated closer to 90°C (dynamic rating)
  - Temperature trends monitored, data analyzed to monitor depth of burial
  - Strain sensing also possible



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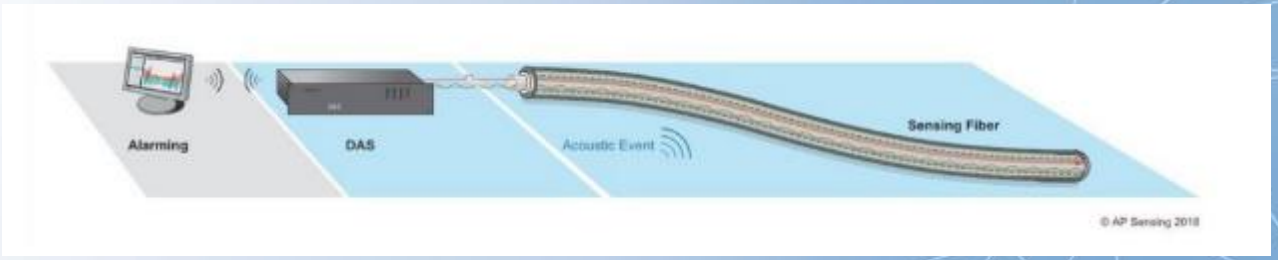
Cable Sensing



Distributed Vibration Sensing

- Equipment located in the control room & offshore substation
- Utilizes one of the optical fibers
- Monitors the acoustics at 1m intervals along the cable
- Benefits?
  - Increased noise implies reduced burial
  - Advance warning of anchoring, fishing etc
  - Certain types of fault can be located

Offshore Wind Submarine Cabling

Thank you, Any Questions?

Duncan Sokolowski

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Coming Next:

June 9, 1:00 p.m. ET

Digital Aerial Surveys to Inform Offshore Wind Development

Julia Robinson Willmott, Normandeau Associates

June 23, 1:00 p.m. ET

The Science of Visibility

Gordon Perkins & Kiva VanDerGeest, Environmental Design & Research

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