

Society for Underwater Technology

OFFSHORE SITE INVESTIGATION AND GEOTECHNICS GROUP

Bath Rugby Club

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## **Delivery of an Offshore Wind Farm**

An overview of the expectations and challenges of planning, consenting, installing and operating a large (5>MW Turbines) offshore wind farm.

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# Introduction

- **GEODATA MANAGEMENT FOR OFFSHORE WINDFARMS**
- **MARINE SURVEY – EARLY PLANNING**
  - Planning and Consenting
  - Foundations and Turbines
  - Cables
- **SITE ENGINEERING – ADVANCED PLANNING**
  - Monopile Siting and Jack Up Stability
  - Cable Burial Risk Assessment
- **INSTALLATION – CONSTRUCTION PHASE**
  - Protecting installed Foundations
  - Protecting cables during installation
  - Protecting cables for lifecycle of project

# Planning and Consenting

## **Brief Summary (Example Gwynt Y Mor)**

- 2002-2003 Planning and Tendering of Round 2 Wind Farms
- 2004-2005 Regional survey data acquisition / FEED Study
- November 2005, Developer submits application
- 2006-2008 Stakeholder discussions/negotiations
- Consent granted December 2008 (3 years and 1 week later)

## **Typical Timelines for future projects:**

- Renewable UK - Offshore Wind Project Timelines May 2014
- Multiple year consenting process
- Financial Investment Decision; 1-2 years before construction
- Technology and resources - are the projects possible?

# Planning and Consenting

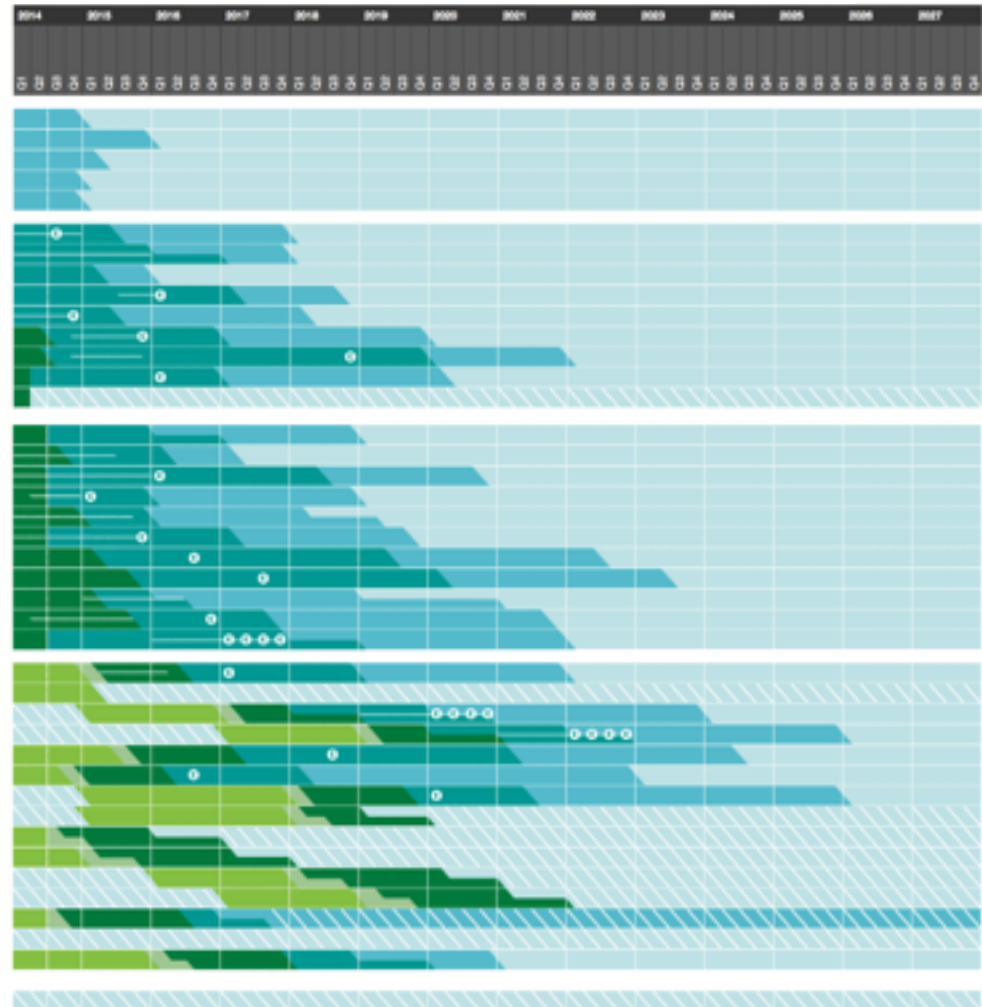
- Source: RenewableUK

Phases of Offshore Wind Farm Development



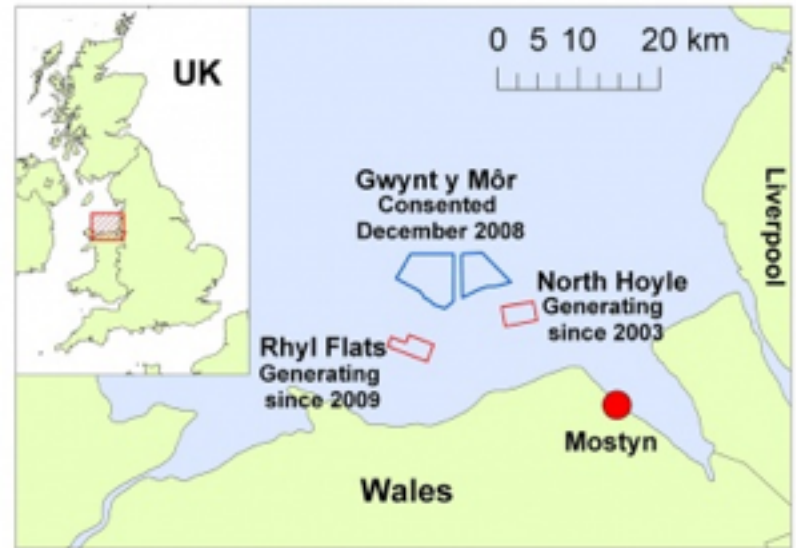
Please note that this data should be considered as indicative and is likely to change over time.

Reference	Hub	Project	Current Phase	MW	Number of Turbines	Foundation?	Monopile	Jacket	Gravity	Offtaker	Connection	Avg. Water Depth (m)	Distance to Shore (km)
21	2	Gwynt y Môr	Construction	576	180	-					HVAC	30	16
22	2	Humber Gateway	Construction	218	73	-					HVAC	15	10
23	2	Westermost Rough	Construction	216	36	-					HVAC		8
24	2	Energy Park File	Construction	7	1	-							
25	2	West of Dublin Sands	Construction	269	108	-					HVAC	20	26
26	2	Dulgeen	Consented	402	87	-					HVAC	18-27	26
27	2	Race Bank	Consented	380	91	-					HVAC	4-22	20
28	2	Kanish Flats Extension	Consented	50	15	-					HVAC	4.5	6.5
29	2	Aberdeen Bay (ABWC)	Consented	>100	11	-						20-30	3
30	2	Gallipoli	Consented	340	55-85	-	-	-	-			25-28	27
31	3	Moray Firth - Eastern Dev Area 1	Consented	304	48-62	-	-	-	-		HVAC	42	20
32	3	Moray Firth - Eastern Dev Area 2	Consented	496	48-62	-	-	-	-		HVAC	45	22
33	2/1W	Beaive	Consented	864	80-110	-	-	-	-		HVAC	45	16.4
34	2	Slyth Offshore Demo	Consented	>100	16	-							
35	2/1W	Neart na Sionnle	Planning	450	75	-	-	-	-		HVAC	50	20
36	2	Burbo Bank Extension	Planning	258	32	-	-	-	-		HVAC	9.7	8
37	3	East Anglia Offshore Wind 1	Planning	1200	240	-	-	-	-		HVDC	40	40
38	3	Rampion	Planning	700	130-175	-	-	-	-			30	17
39	2	Walney Extension	Planning	80-90	110-125	-	-	-	-		HVAC	30	56
40	2/1W	Inch Cape	Planning	750	95-110	-	-	-	-			30	22
41	3	Dogger Bank Gryke Bank	Planning	2400	400	-	-	-	-		HVDC	27	140
42	3	Dogger Bank Teesside A&B	Planning	2400	400	-	-	-	-		HVDC	27	190
43	3	Humbly Grove	Planning	1200	130-232	-	-	-	-			30	130
44	3	Navitus Bay	Planning	970	121-194	-	-	-	-		HVAC	27	25
45	3	Firth of Forth Phase 1	Planning	1000	190	-	-	-	-			55	40
46	2	Tilton Knoll	Development	900	100-100	-	-	-	-		HVAC	18	26
47	3	Moray Firth - Western Dev Area	Development										
48	3	Firth of Forth Phase 2	Development	1800								30	50
49	3	Firth of Forth Phase 3	Development	800								55	50
50	3	Dogger Bank Teesside C&D	Development	2400	400	-	-	-	-		HVDC	30	175
51	3	Humbly Grove Wind & Bressay	Development	1800	280	-	-	-	-			26	110
52	3	Humbly (remaining)	Development	2000	400	-	-	-	-			25-28	100-50
53	3	East Anglia Offshore Wind 2	Development	1200									
54	3	East Anglia Offshore Wind 3	Development	1200	130-172	-	-	-	-		HVDC		30
55	3	East Anglia Offshore Wind 4	Development	1200							HVDC		30
56	3	East Anglia Offshore Wind 5	Development	1200									
57	3	East Anglia Offshore Wind 6	Development	1200									
58	3	Celtic Array Rhinoman	Development		147-600							45	28
59	3	Celtic Array North-East	Development	4200									
60	2	First Flight Wind	Development	800	40-120	-	-	-	-		HVAC	27	15
61	2/1W	Islay	On Hold	690								40	16



# Gwynt Y Mor Windfarm

- 4 Export Cables linking 2 offshore substation platforms (OSP)
- 20-22km in length
- 162 Array Cables linking the 2 OSP with 160 monopile turbines
- Typically 1km in length
- Water depths 0m to 30m
- Varied seabed terrain
- Existing infrastructure (pipelines, cables, windfarms)
- Surveys 2002-2013
- Construction 2012-2014



# Marine Survey Data for Offshore Wind Farms

- **What types of Data?**

- **How is it collected?**

- **GEOPHYSICAL**

- Regional/area survey – low to medium resolution – turbine planning
- Cable Survey – medium resolution – export & inter-turbine areas
- UXO Survey – high resolution – export and array cables

- **GEOTECHNICAL**

- Boreholes at foundations, OSP and metmast locations (40m+)
- CPT at turbine foundations 5m+
- CPT for cable routes top 0-3m
- Vibrocores/sampling – for sediment classification (top 0m-3m)

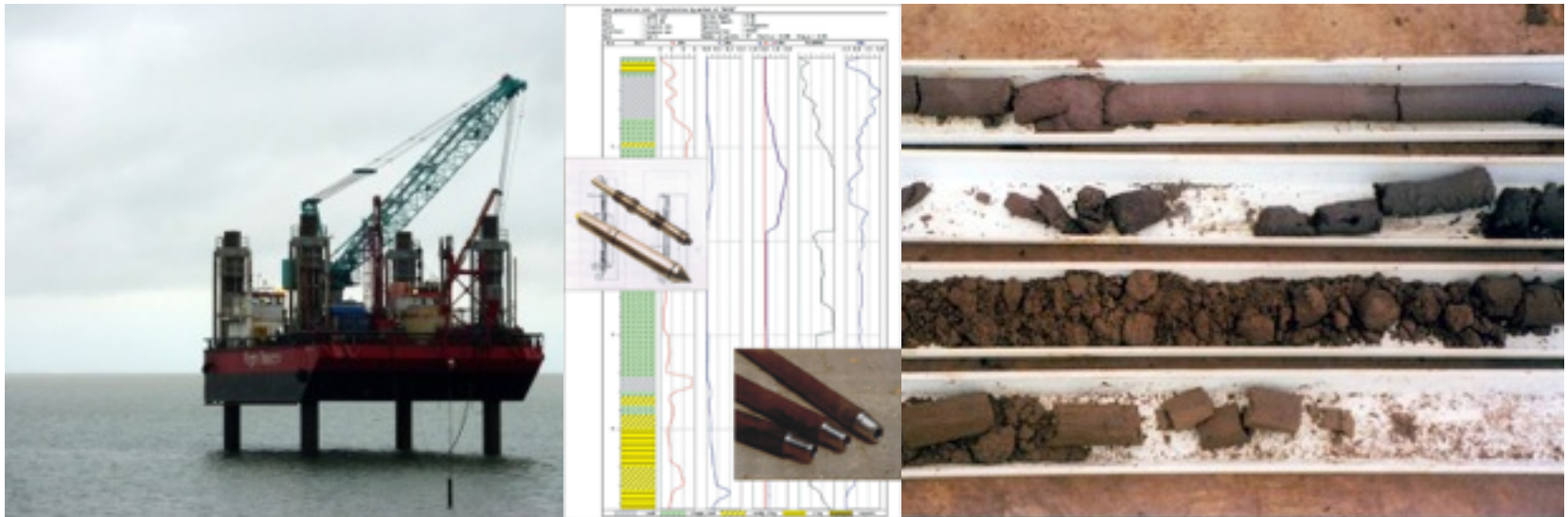
# Survey Data for Offshore Wind Farms

- **GEOPHYSICAL**
- Seabed Conditions – Hazards, sediments, hardness, mobility
- Bathymetry – water depth, slopes, tides, (currents)
- Equipment – survey vessel – sidescan sonar, echo sounder, sub bottom profiler, shallow seismic, magnetometer, sampling



# Survey Data for Offshore Wind Farms

- **GEOTECHNICAL**
- Soil Conditions – composition, hardness/softness, layers
- Equipment – Drill Jack Up/Vessel – Borehole Drilling, Cone Penetrometer Testing, Vibro-coring, drop coring, grab sampling
- Lab Testing – further testing of soil characteristics



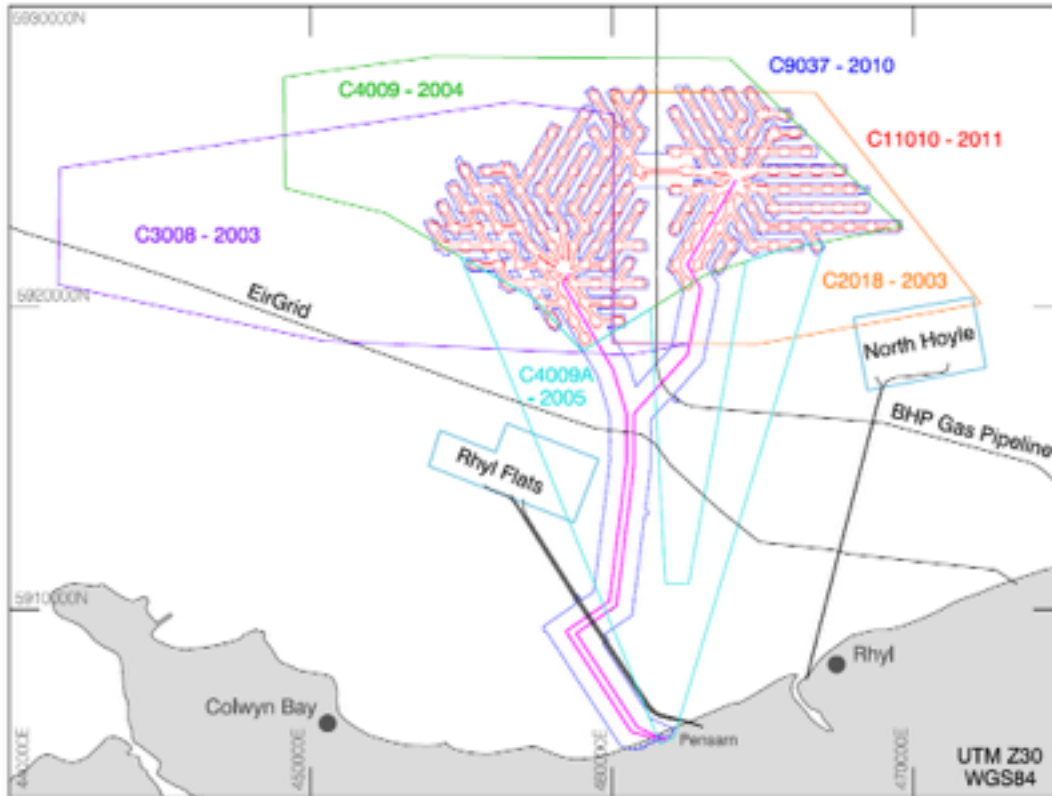


# Survey Data for Offshore Wind Farms

- **OTHER SURVEY DATA SOURCES**
- **HISTORICAL DATA**
- Cable Databases / Oil & Gas Concessions
- UKHO charts
- 3<sup>rd</sup> Party Datasets (academic, government and commercial)
- **DURING CONSTRUCTION**
- Diver Swim Investigations (rock dump and aperture areas)
- Pre Survey ROV survey (cable route and lay down areas)
- Post lay inspection and bathymetry surveys (cables/rock dump)
- Detailed UXO surveys (2014 after 3 x WW2 bombs discovered)

# Survey Data Acquisition on GYM

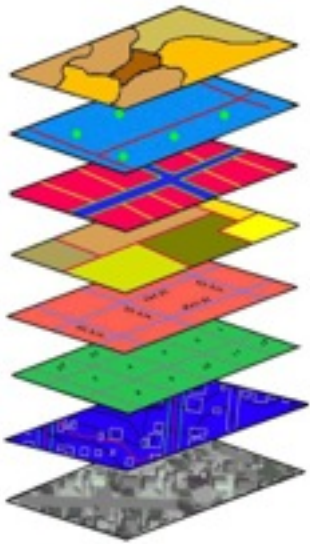
DATA SOURCE DIAGRAM



- » sidescan sonar
- » sub bottom profiler
- » shallow seismic
- » single beam bathymetry
- » multibeam bathymetry
- » coring
- » grab sampling
- » magnetometer
  
- » towed gradiometer
- » ROV gradiometer
- » AUV hi res sidescan

# Survey Data Management

- **DATA HANDLING** - creating a unified mapping database



**Seabed bathymetry**

**Sediments**

**Seabed Hazards (boulders, wrecks, UXO)**

**Infrastructure (pipelines, cables, buoyage)**

**Boundaries (permits, shipping zones etc)**

**Planned construction (foundations/cables)**

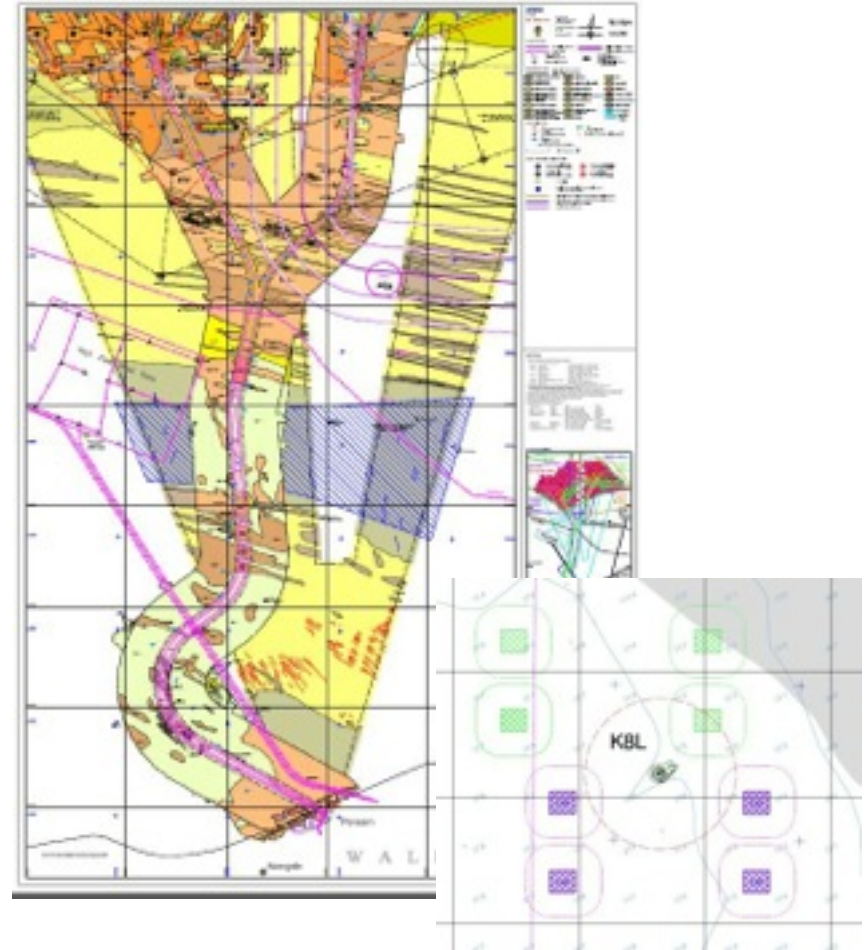
**Temporary infrastructure (jack-ups etc)**

**As built construction (foundation, topsides, cables)**

- **CAD and GIS DATABASES**
- **Evolving as works continue**

# Cable Burial Assessment: Data Usage

- **CHART SERIES**
- 1:15000 OVERVIEWS
- 1:3000 ANCHOR PLANNING
- 1:500 TURBINE FOOTPRINTS
- **DATA FORMATS:**
- CAD
- GIS (SHAPE DATA)
- PDF (CAN BE VIEWED BY ALL)
- DIGITAL BUT CAN BE PLOTTED



# Lessons Learned: Survey

- Good survey data is required to select appropriate cable burial methodology and equipment
- Early planning of cable routes, orientation of turbine connections
- Consideration of data coverage to accommodate anchor patterns
- Educating the end user on data suitability, resolution and data deficiencies/shortcomings
- Ensuring project flexibility to collect additional survey data when needed
- Standardise mapping and vertical reference datums

# Lessons Learned: Installation

- **Good quality survey data** is vital for safe installation
- Engage with construction contractors early in project lifecycle
- Design cable routes with flexibility for different burial tools
- Carefully consider the threat level vs difficulty of installation
- Ensure lessons learned are passed on to other projects
- **We are still installing, there will likely be more lessons!**

# Conclusions:

- GYM generated first power in September 2013
- Construction to be completed 2014 (turbines), early 2015 (cables)
- Remedial works will be required on array cables
- High scour area - seabed monitoring will be required across site
- **Expect the unexpected.** We discovered 3 WW2 bombs on site

**THANK YOU, ANY QUESTIONS ?**