NATIONAL INSTITUTE OF WIND ENERGY (NIWE)

CHENNAI

Under Ministry of New and Renewable Energy (MNRE), Govt. of India

Offshore Wind Energy In India

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Offshore Advantages

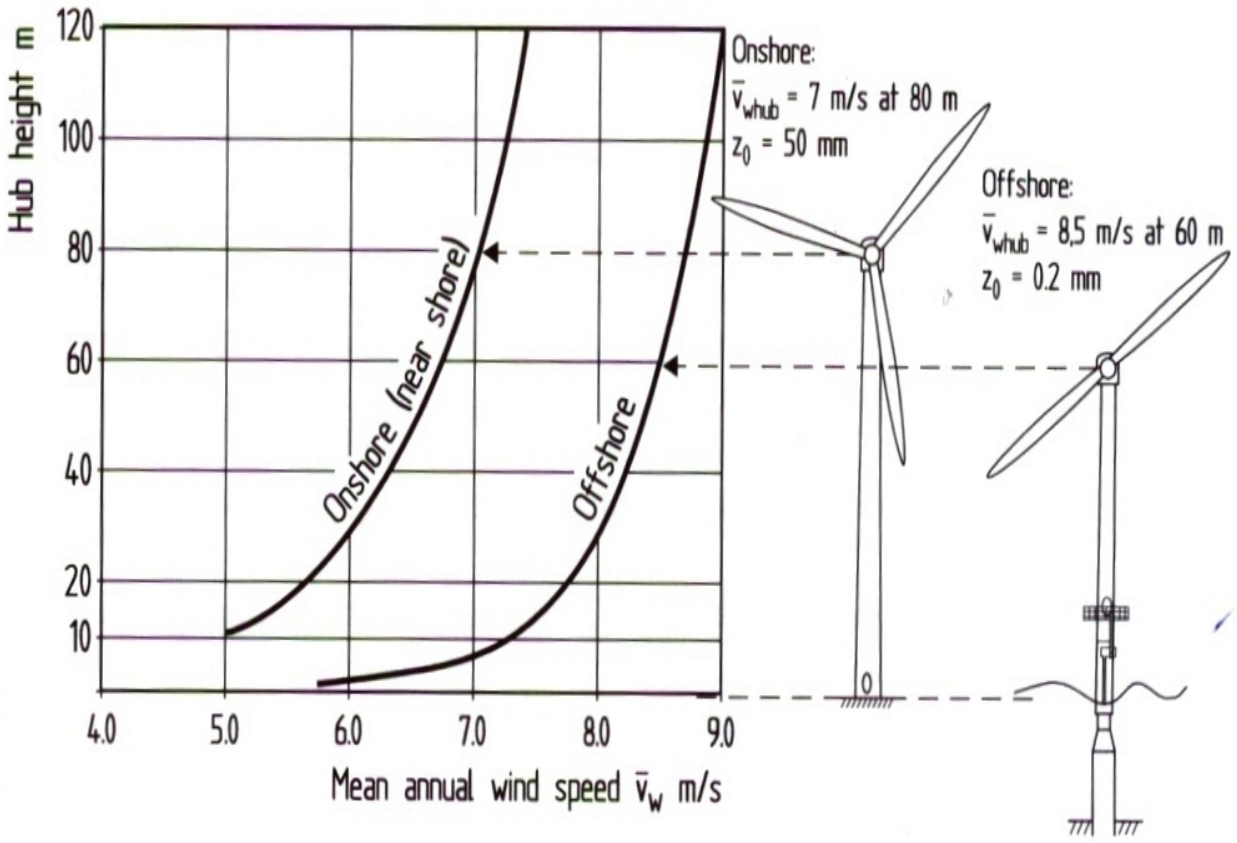
- Higher generation
- Surfaces of seas are generally smooth.
- Low Roughness
- less turbulent and possesses high wind density

High Capacity Utilization Factors (CUF)

Less noise when compared to land based turbines

Offshore Advantages

- Viable and proven technology
- Higher PLF than onshore wind farm – calm, steady and less turbulent wind flow
- Acquisition of Land, Logistic Management, Power Evacuation are challenges for the land based wind farms.



Offshore Wind Speed Meso-Map

- India is blessed with a coastline of 7600km
- Using QuickScat data: First Offshore Indicative wind map prepared at 100m level
- Up to 200 NM(EEZ)
- Data was downloaded at 10m level(0.25 x 0.25 deg Grid)
- Upscaled to 100m by using Power Law Index of 0.11
- Estimated Offshore Potential based on Meso-scale mapping;
  - Gujarat - 36 GW*
  - Tamil Nadu - 31 GW *

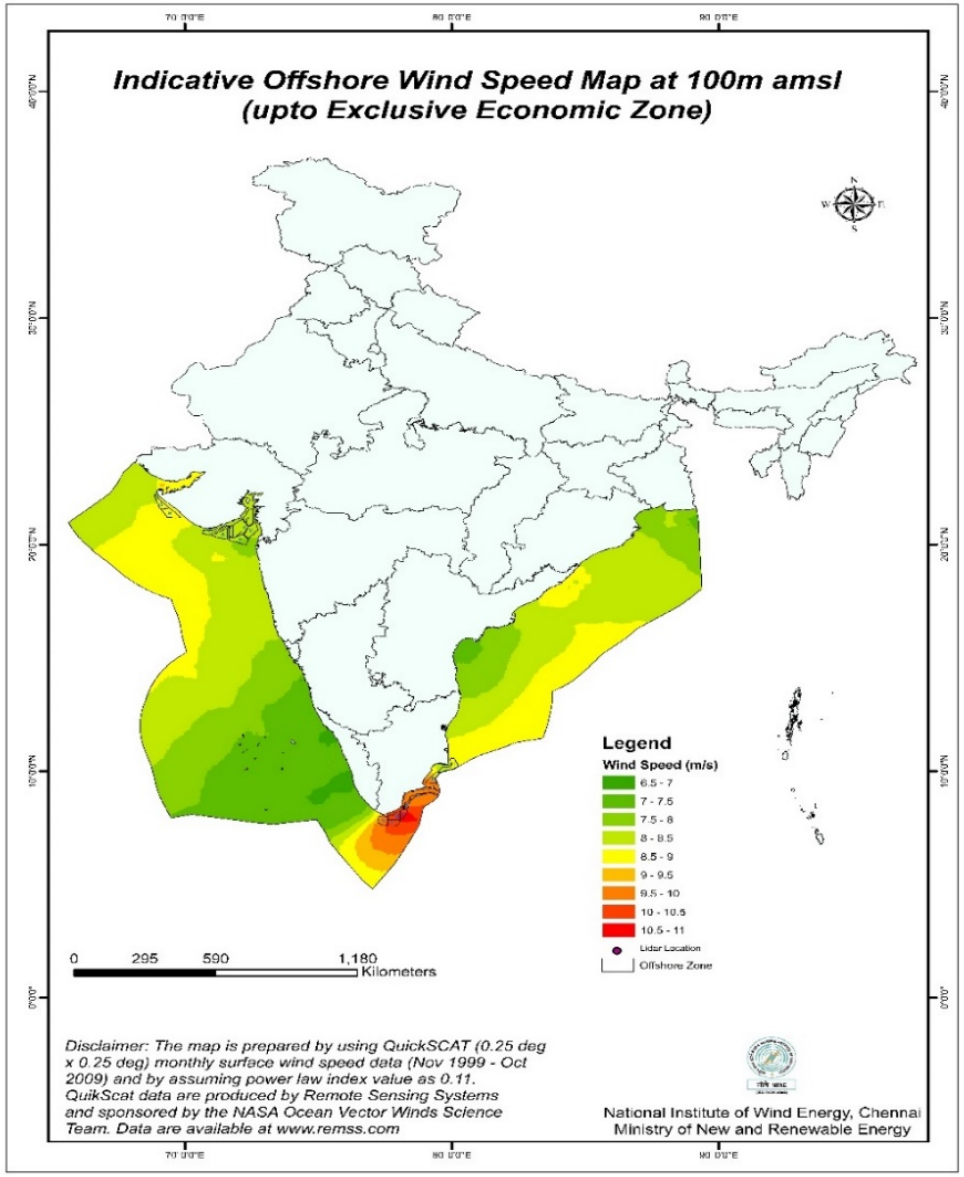
(*Assuming 3MW /Sq. km of seabed area)

TO BE RECHECKED BY FRSH LONG TERM MEASUREMENTS

- National Target

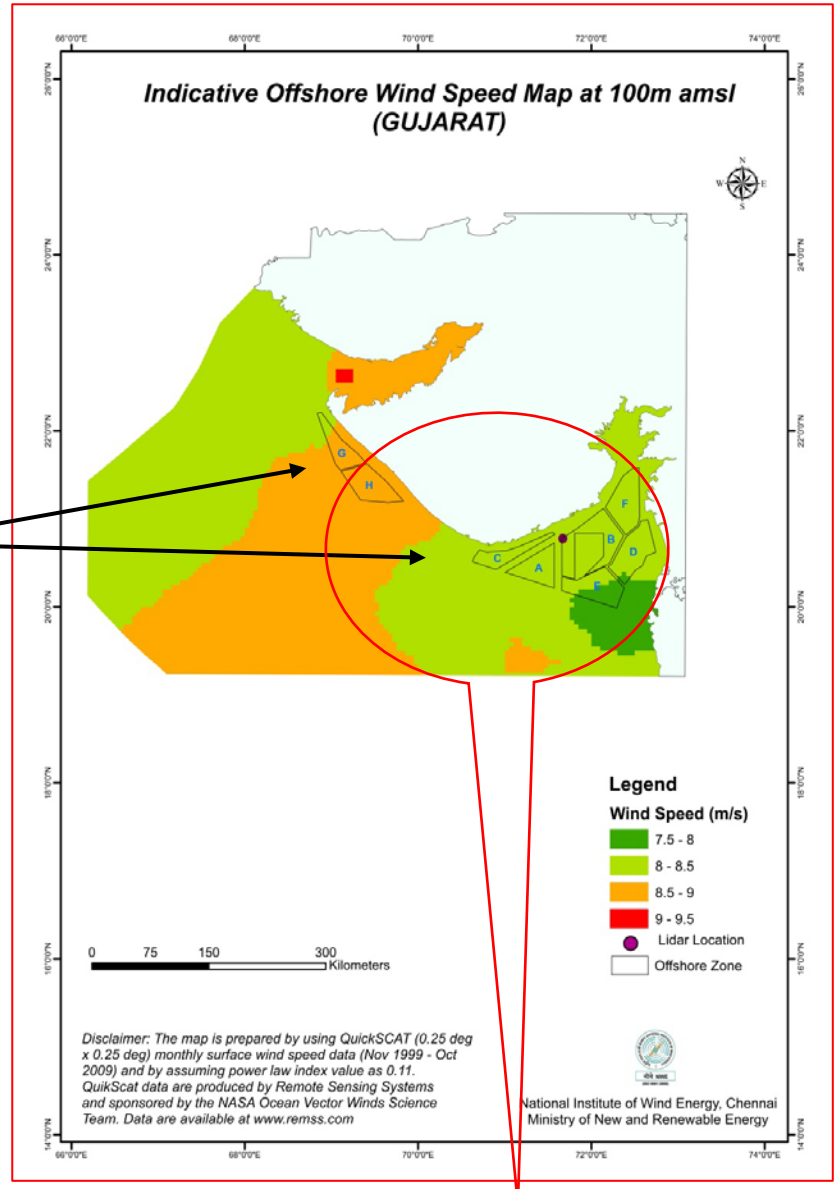
  -5 GW by 2025

  -10 GW by 2030

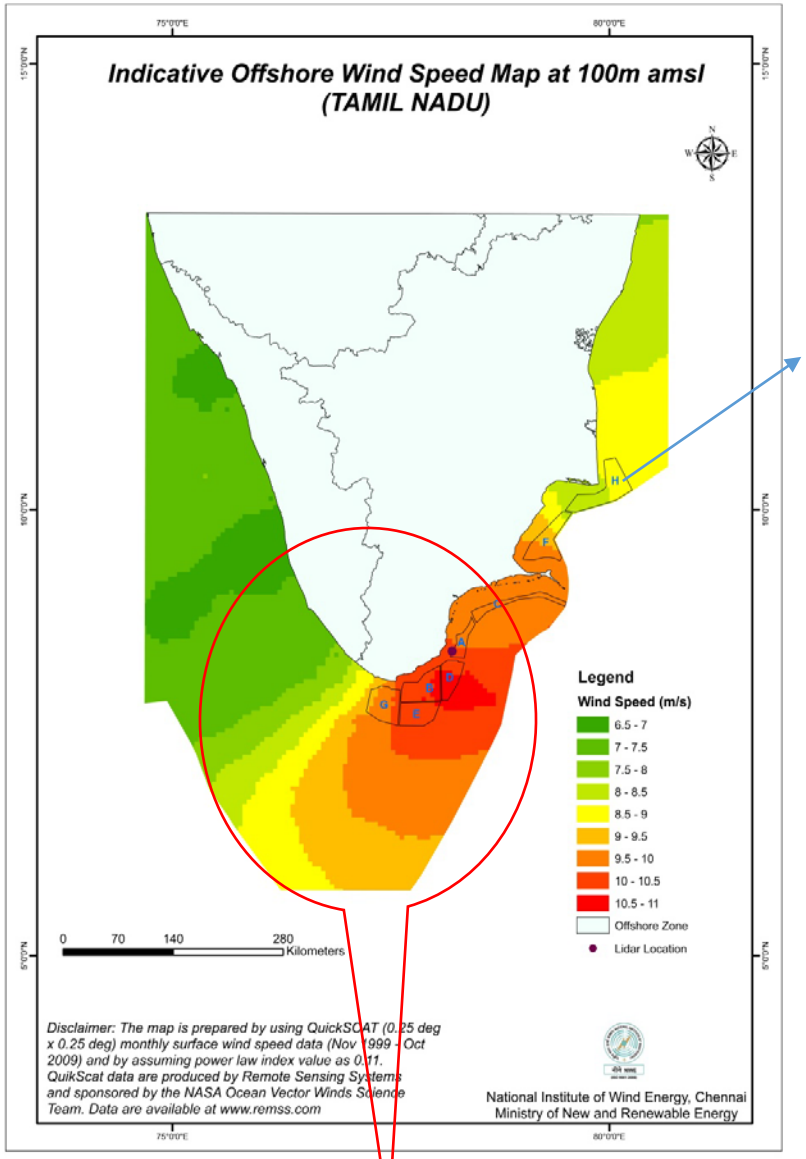


Identified Offshore Potential zones off Gujarat and Tamil Nadu Coast

For C, G and H Zones - clearances are not granted by MoD.



Total area (A,B,D,E &F) = 12414 Sq.km



For H Zone – clearance is not granted by MoD.

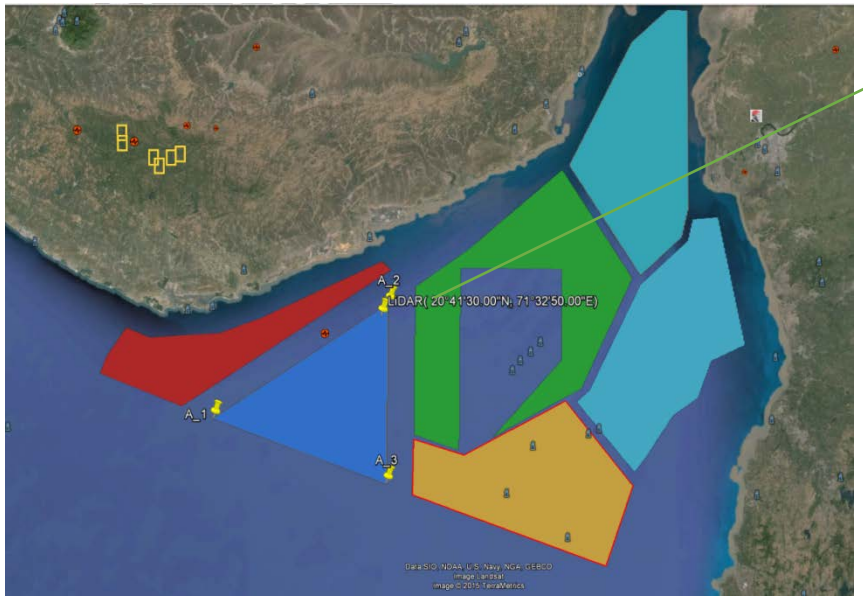
Total area (A to H) = 10558 Sq.km

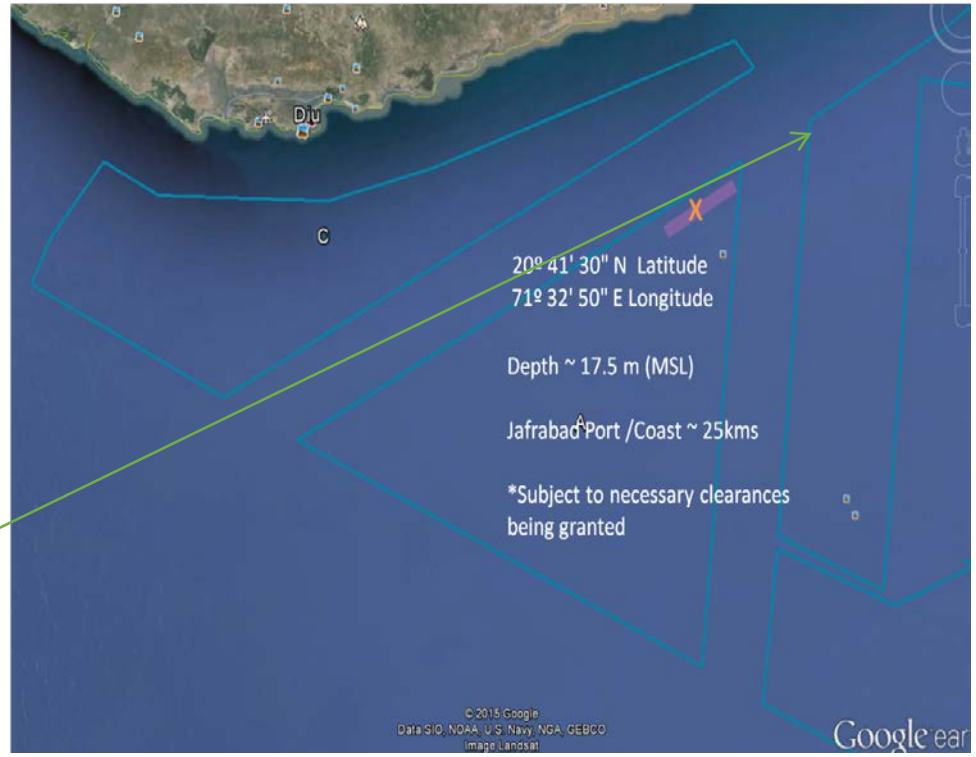
Location of the offshore structure at Gujarat

❖Location: Latitude 20° 46’ 30” N
Longitude: 71° 40’ 50” E
Village: Pipavav, Tehsil: Rajula
District: Amreli

❖Distance from the shore: 23 km

❖CRZ classification of the zone : CRZ- IV as per CRZ notification 2011

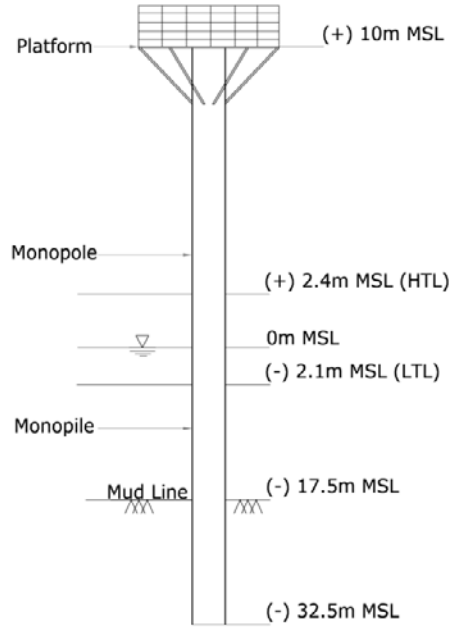




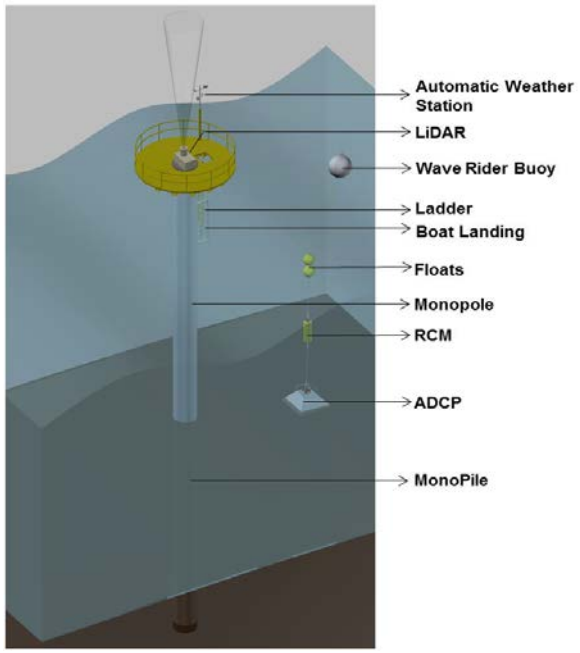
Enlarged view of the proposed location

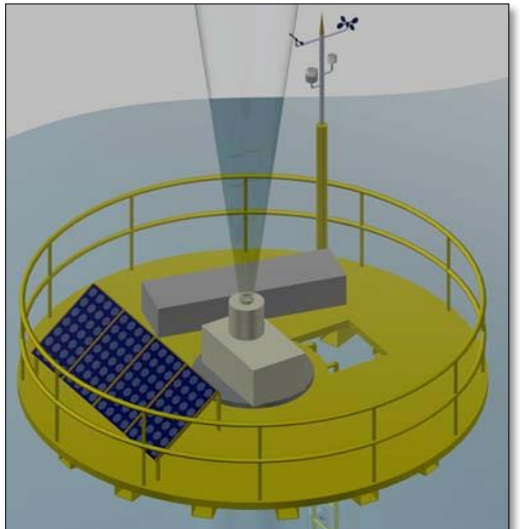
Structure details

- Monopile of 1.2 m diameter – 25 mm thickness
- Total pile length – 47.5 m
- Platform Dia – 5 m



Conceptual layout of Sub-structure for mounting LIDAR





Installation of substructure at Gulf of Khambhat, Gujarat

Installation and Commissioning of Offshore Structure – March2017

Automatic Weather Station(AWS) At LiDAR Platform

Date of Commissioning :March 2017

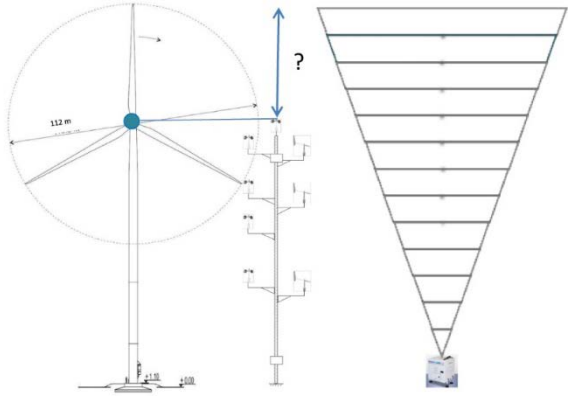
Weather Station at LiDAR Platform (at 20m amsl)

Monthly Wind Data From AWS

Month	Temp (°C)	Pressure (mB)	Air Density (Kg/m^3)	WS (m/s)	WPD (W/m^2)
Apr-17	27.76	1006.68	1.165	6.92	263.75
May-17	28.98	1004.51	1.158	8.06	418.06
Jun-17	29.90	1000.87	1.151	8.30	447.61
Jul-17	28.66	1000.60	1.155	9.58	609.27
Aug-17	20.50	1001.61	1.155	8.34	405.58
Sep-17	28.45	1004.85	1.161	5.45	138.84
Oct-17	29.62	1004.34	1.156	4.67	113.12
Nov-17	21.79	1010.32	1.193	5.16	121.60
Dec-17	22.54	1010.72	1.191	4.62	73.08
Jan-18	23.21	1010.95	1.188	4.39	73.01
Average	26.14	1005.55	1.167	6.55	266.39

LiDAR Installation at Gulf of Khambhat

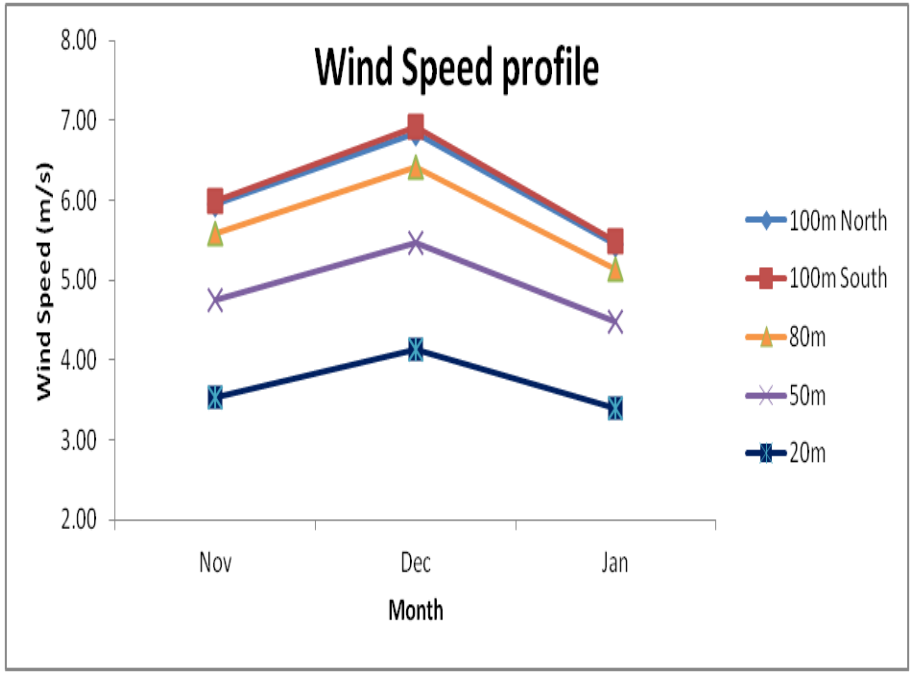
- LiDAR installed and Commissioned on 1st November 2017



Height	Nov-17	Dec-17	Jan-18	Feb-18	Average
40m	5.68	6.10	4.84	5.72	5.54
43m	5.86	6.35	5.02	6.06	5.74
53m	5.96	6.48	5.11	6.18	5.85
63m	6.06	6.60	5.18	6.27	5.94
70m	6.12	6.68	5.22	6.31	6.01
83m	6.23	6.82	5.28	6.36	6.11
90m	6.31	6.91	5.32	6.39	6.18
103m	6.44	7.06	5.39	6.48	6.30
123m	6.62	7.27	5.45	6.51	6.44
143m	6.79	7.46	5.49	6.56	6.58
163m	6.95	7.59	5.51	6.59	6.68
183m	7.07	7.68	5.50	6.57	6.75
No.of data available (10 minutes Interval)	2951 (68.31%)	1652 (37%)	2627 (58.85%)	4032 (100%)	7230 (54.57%)
No.of data Missing (10 minutes Interval)	1369 (31.69%)	2812 (63%)	1837 (41.15%)	0	6018 (45.43%)

Near Shore Mast in Gujarat

- Installed at Bhankodar (Line of Sight With Offshore LiDAR) in November 2017
- Data Measurement under progress



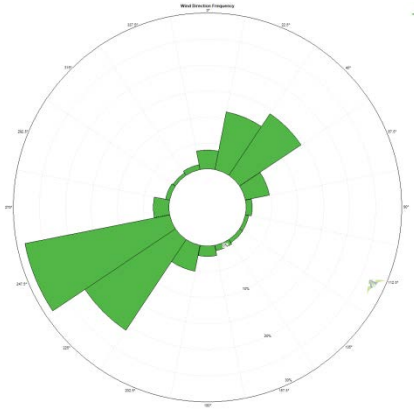
Wind Speeds for Nov 2017 – Jan 2018

Gulf of Khambhat – Jaffrabad mast

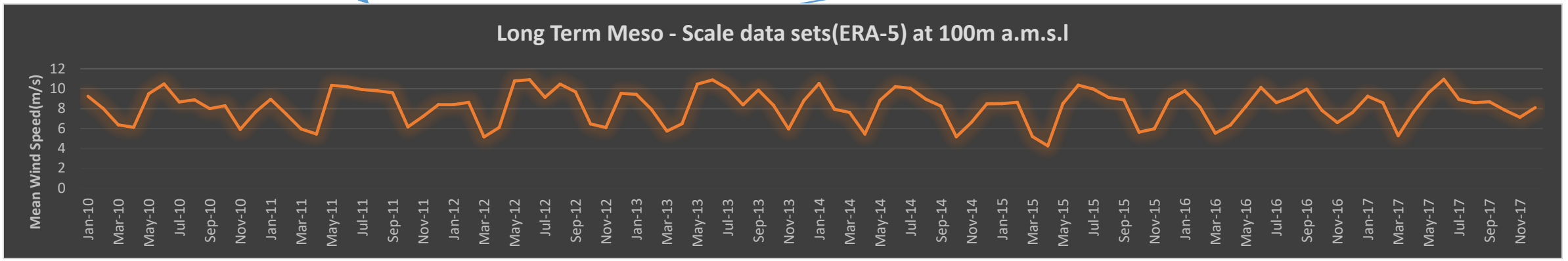
Meso-scale ERA 5 (European Reanalysis Assimilation - 5) at Gujarat

Yearly Average

Year	Wind Speed (m/s) at 100m
2010	8.097
2011	8.29
2012	8.447
2013	8.526
2014	8.182
2015	7.826
2016	8.156
2017	8.375



Wind Rose plot for Direction

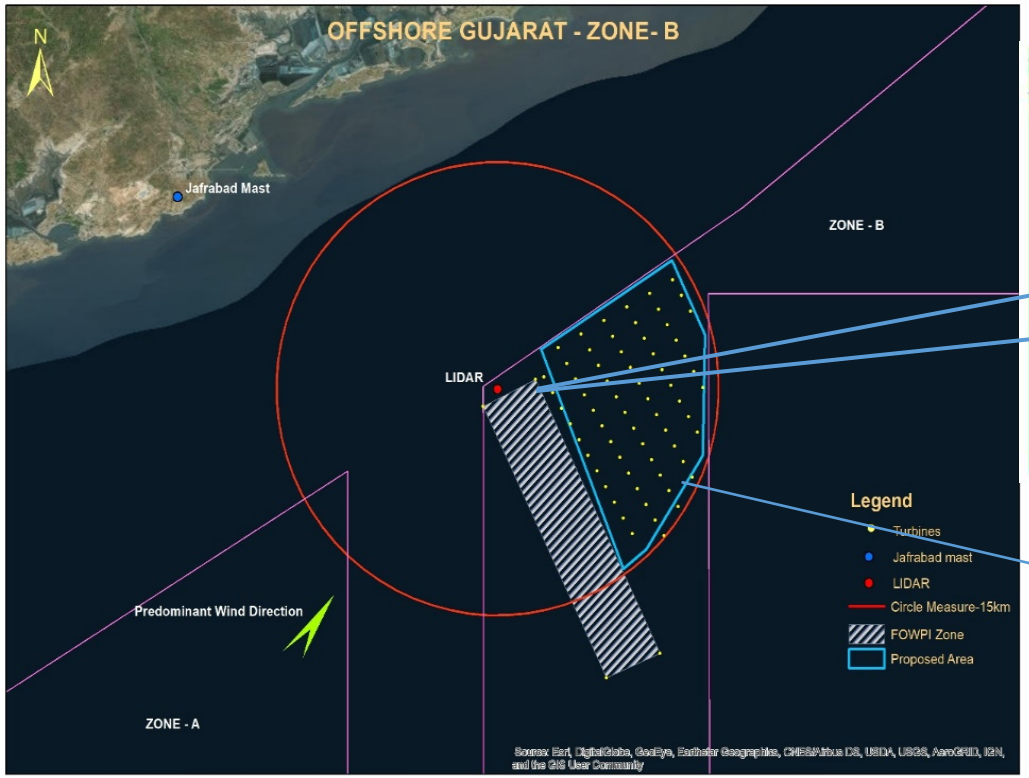


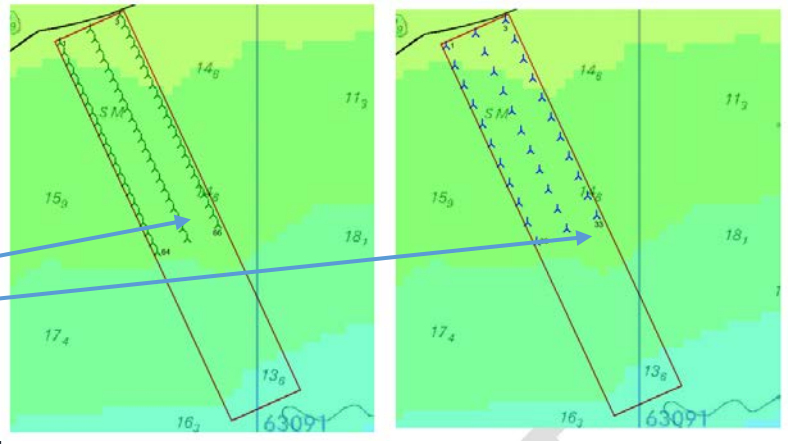
Monthly Average Wind Plot

ERA 5 - Spatial Resolution 31 km

GEOPHYSICAL AND GEOTECHNICAL SURVEY

Geophysical and Geotechnical Survey to be conducted in and around LiDAR location off Gujarat



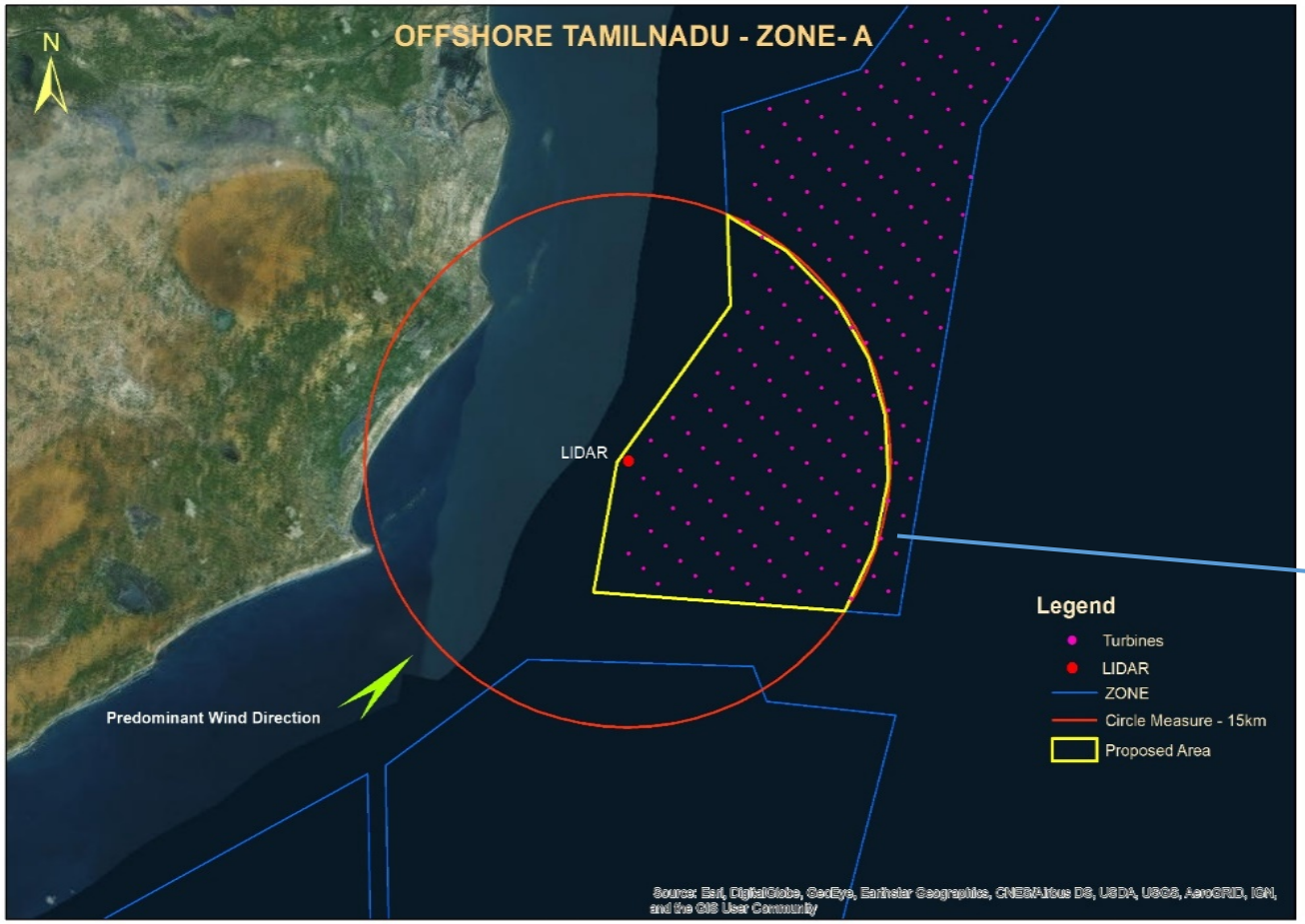


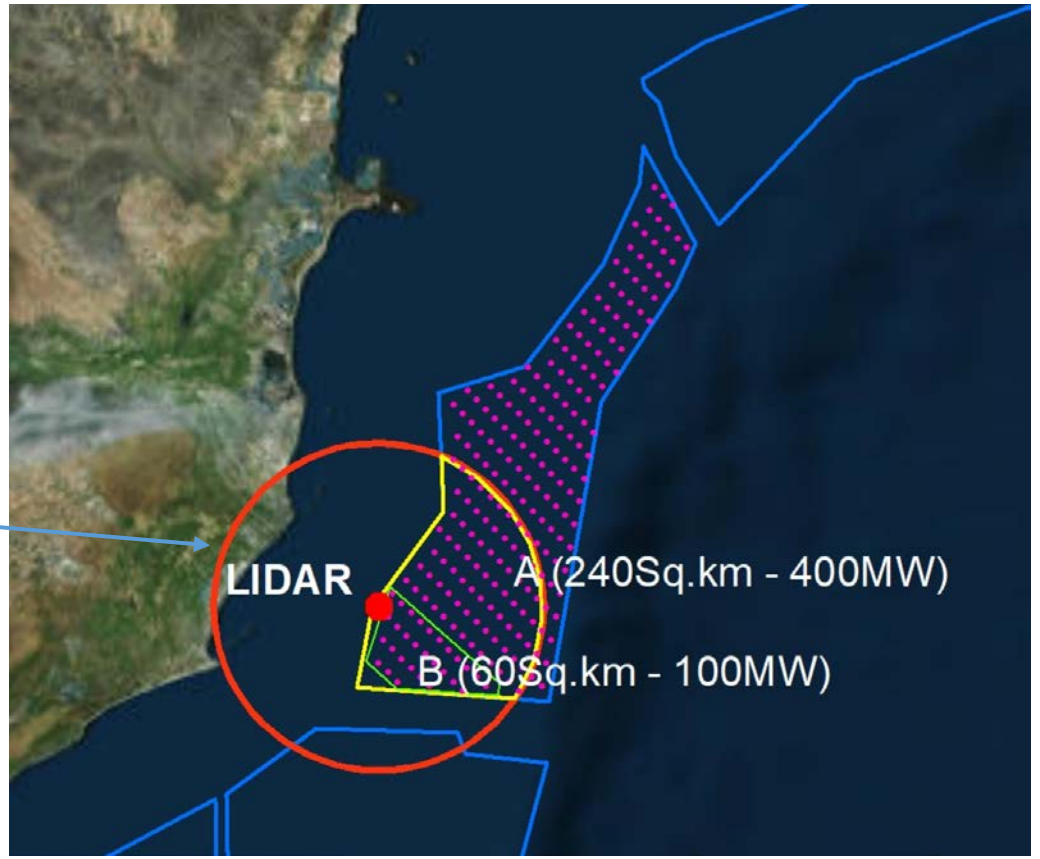
200MW Wind Farm Layout
(by FOWPI)

Indicative 300MW Wind Farm Layout
(by NIWE)

GEOPHYSICAL AND GEOTECHNICAL SURVEY OFF GUJARAT and TAMIL NADU

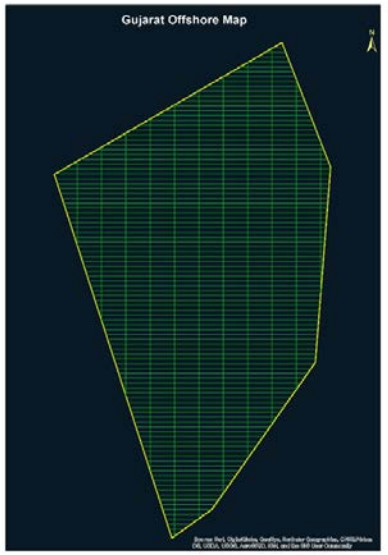
- Geophysical and Geotechnical Survey to be conducted in and around LiDAR location off Gujarat and Tamil Nadu
- Bathymetry/Side Scan sonar/Sub-bottom profile/Magnetometer

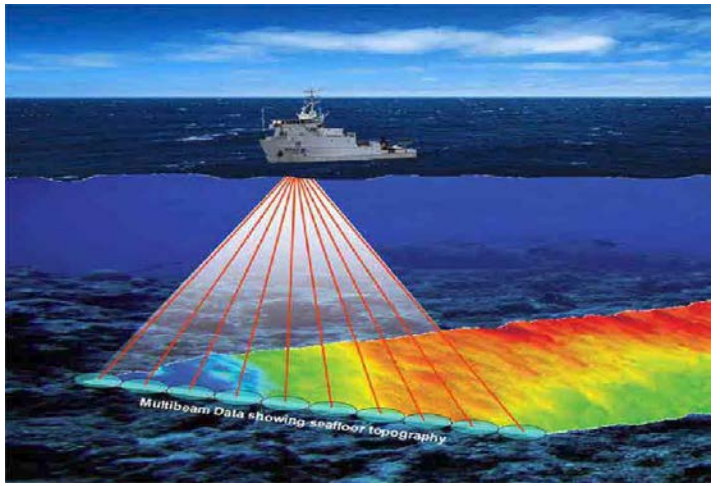


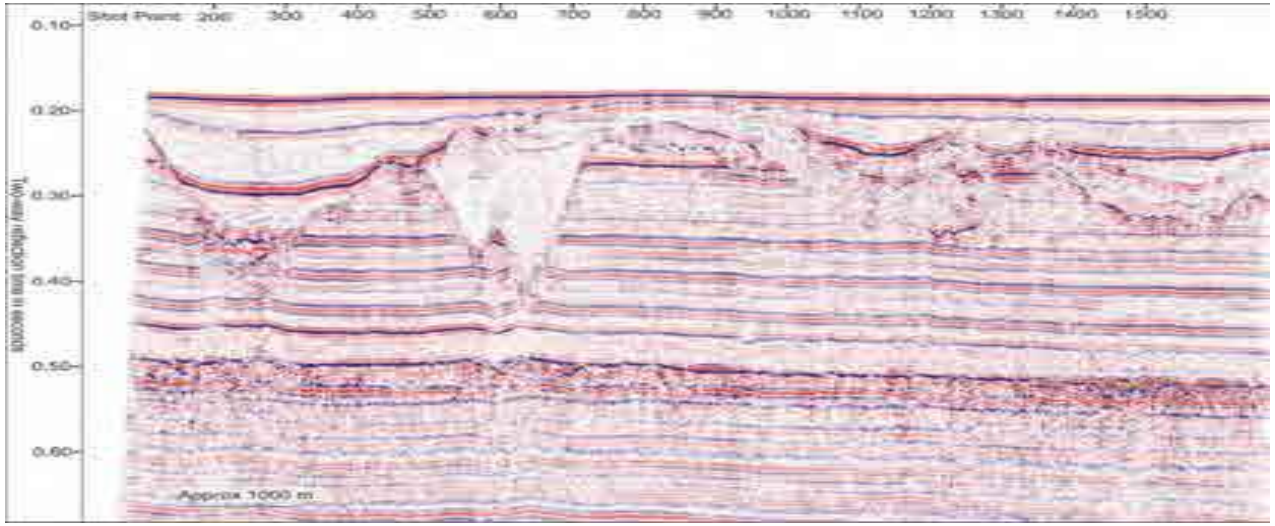


Geophysical Studies

- Work on Geophysical studies outsourced to NIOT (Under MoES)
- Bathymetric Survey: Using Echo Sounder
  - To Ascertain Water depth on Grid lines
  - Both Single Beam and Multi Beam Channels will be used
  - Multi Beam will cover Swathe 3 times the depth of Water
- Sea bed mapping -Side Scan Sonar
  - To better understand Sea bed topography
  - To find features and obstruction on sea bed
  - To find Geo hazards and Hydrodynamic studies
- Magnetic Anamolies - Magneto meter / Gradiometer
  - To find the Ferro metallic objects
  - Ship wrecks, Achohors, UXO's
- Sub Bottom Profiling – Pinger/Boomer/Sparker
  - To understand the Sub bottom profile
  - To understand the different types of soil strata
  - Useful for foundation selection
- The **instruments** are basically of acoustic types which works primarily on acoustic Doppler effect.

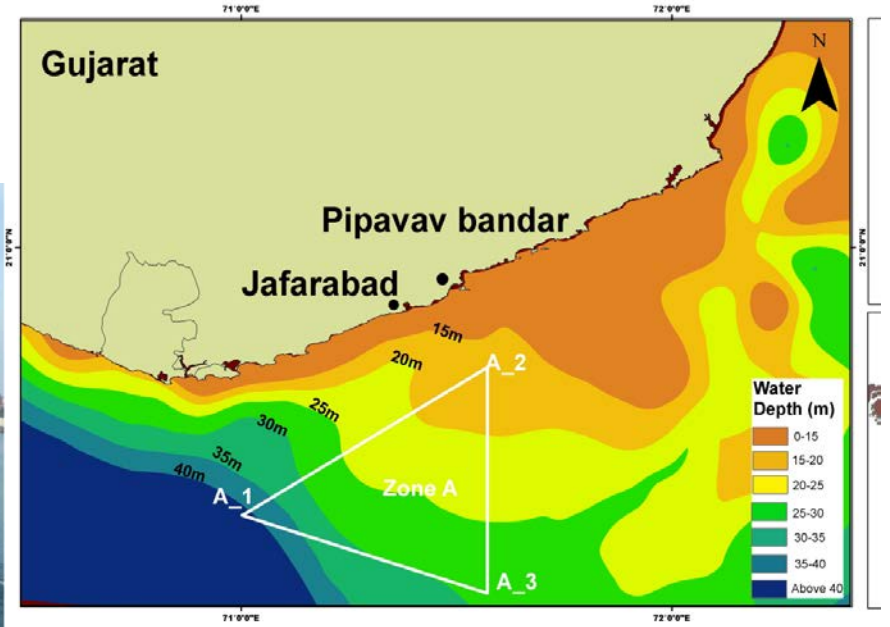


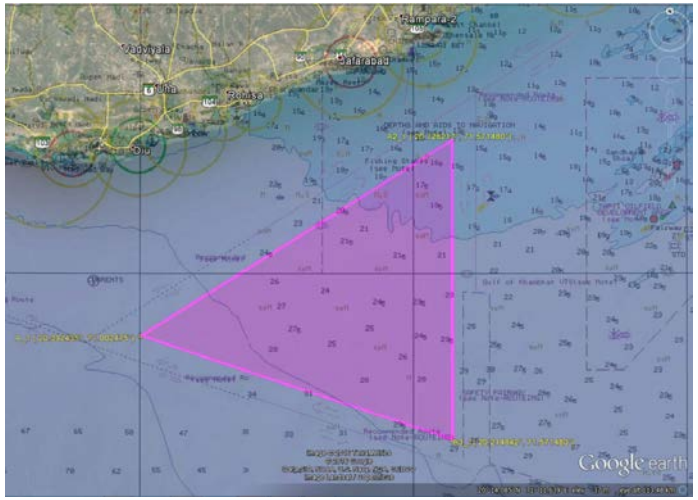


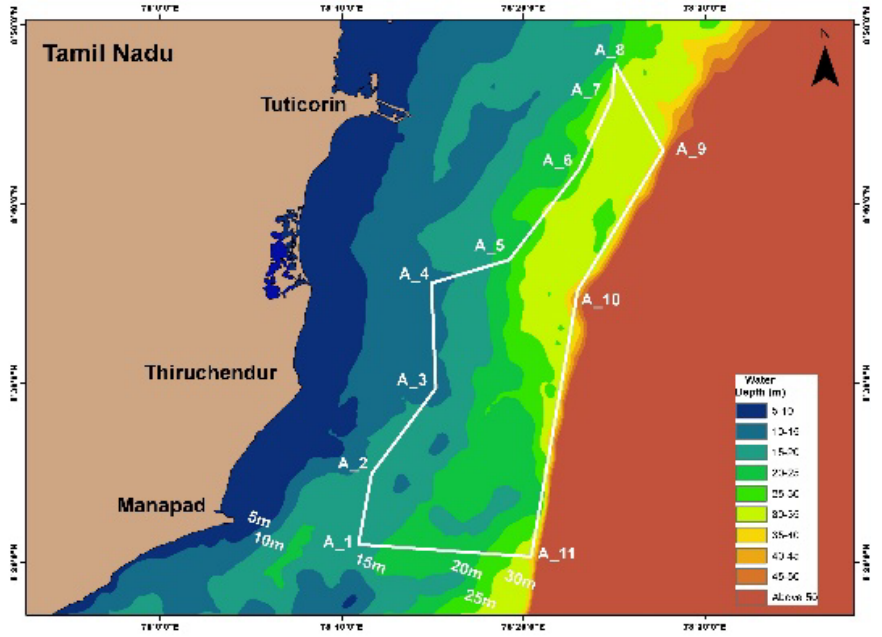


Geotechnical Investigations

- 5-6 boreholes will be carried out for geotechnical investigations based on the inputs from Geo-physical studies
- Continuous Cone Penetration Test to be carried out.
- Friction offered from the sub-surface soil and the tip resistance to be plotted.
- Study will provide useful pointers for designing the offshore wind turbine foundations.







ENC for Gujarat and Tamil Nadu

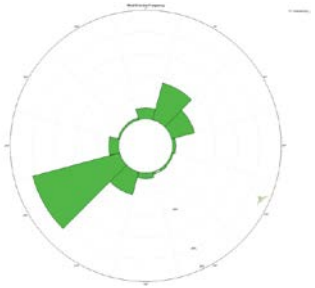
FUTURE PLANS

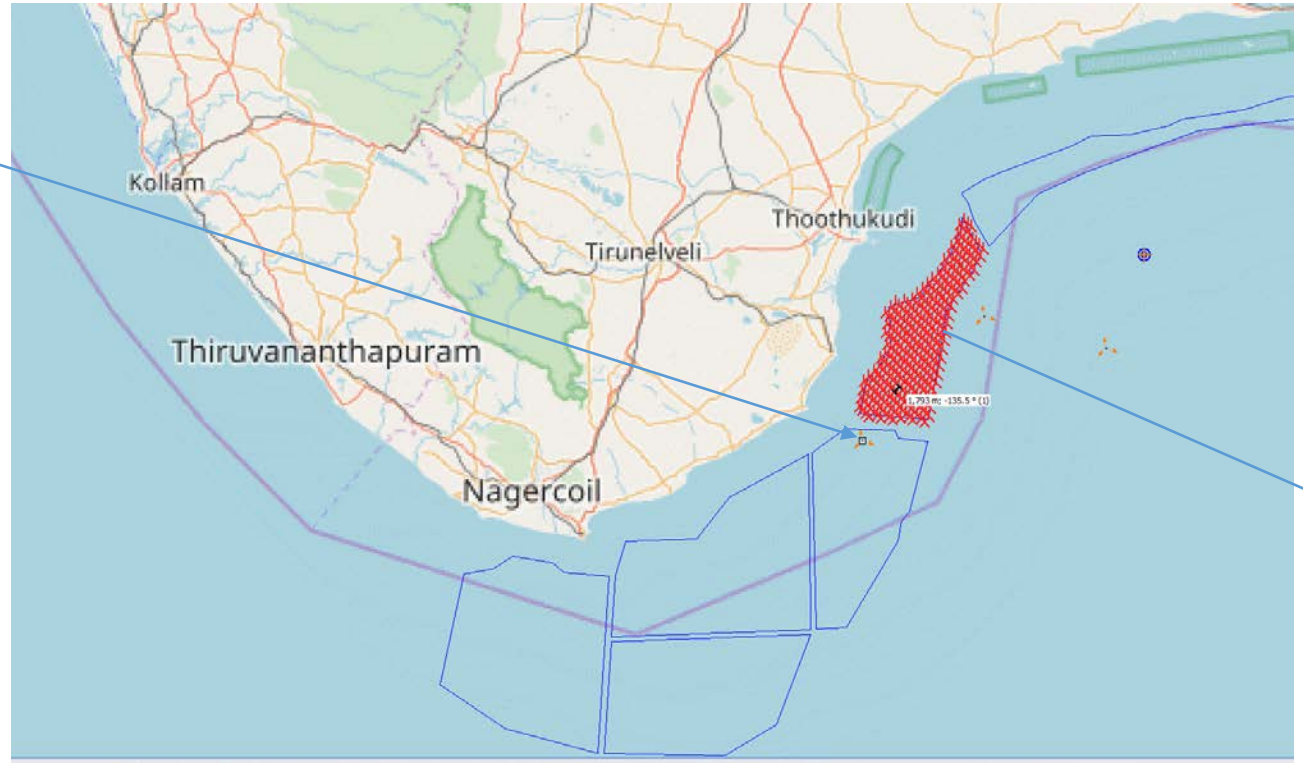
. Installation of LiDAR based offshore wind measurements Gulf of Mannar, Near Tuticorin, Tamil Nadu

- LiDAR procurement underway
- EIA report - Tender floated
- CRZ /HTL/LTL map work awarded to National Centre for Sustainable Coastal Management
- Geotechnical Studies - Work initiated
- Central level clearances obtained – MoD, MEA, MHA and DoS & TMB
- State level clearances underway – TNSCZMA
- Offshore Structure(Monopile & Platform) to be completed by September 2018
- Measurements will be initiated by mid of September 2018

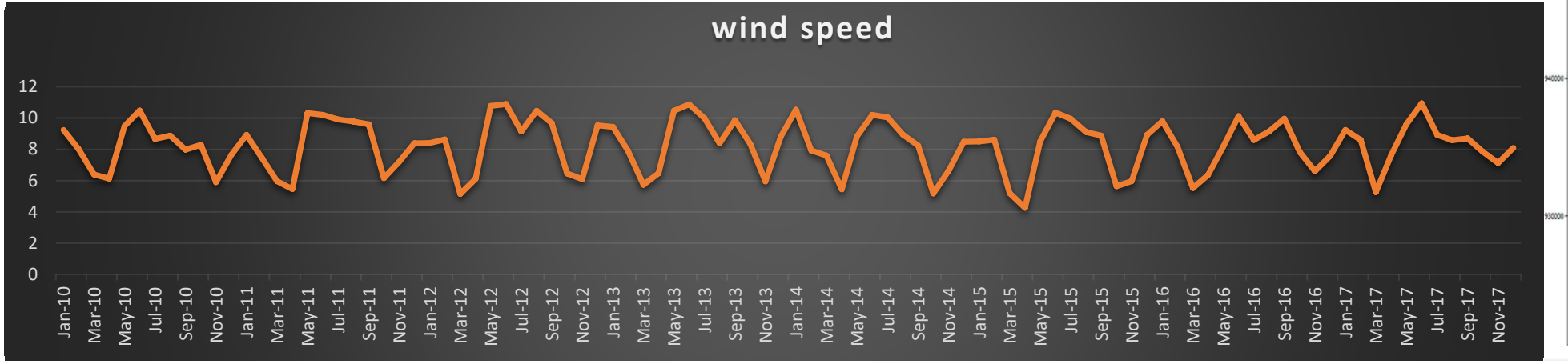
Mesoscale (ERA 5) at Tamil Nadu Zone A

Year	Wind Speed (m/s) at 100m
2010	8.10
2011	8.29
2012	8.45
2013	8.53
2014	8.18
2015	7.83
2016	8.16
2017	8.37



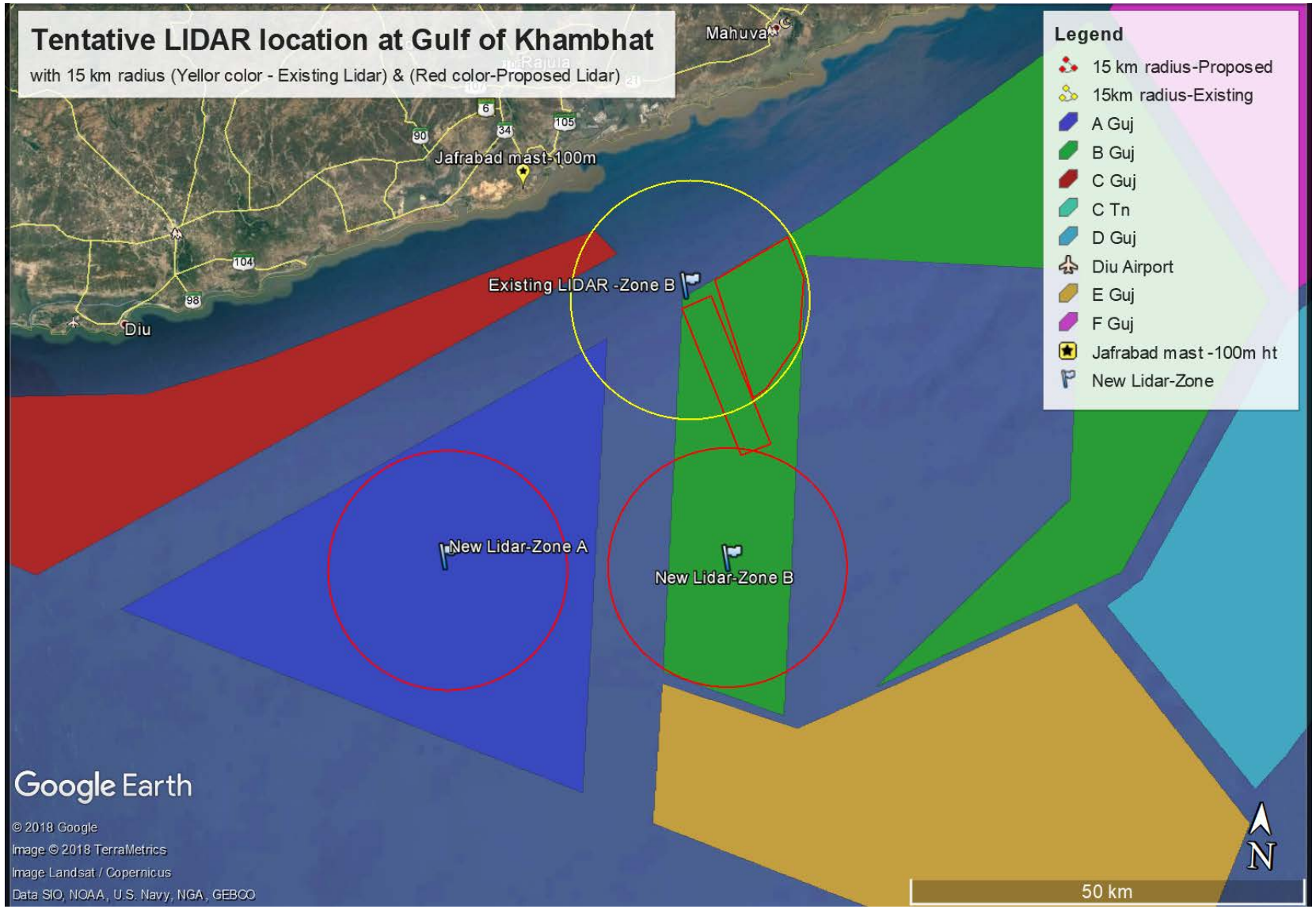


Wind Farm Capacity (MW)	Overall Farm Wake loss %	AEP (FARM) P50 GWH	AEP (WTG) GWH	CUF%
968	6.83	2873.5	11.9	34



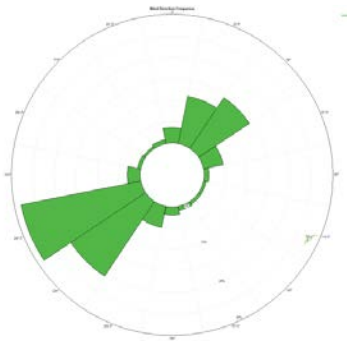
Future Plans

Met-Ocean measurements (Lidar based wind measurement,wave,tide, water current, salinity, temperature etc) at Gulf of Khambhat and Gulf of Mannar for fostering the growth rate of offshore wind in the country



Gulf of Khambhat, Gujarat			
FOWIND Zone	**LIDAR Representation (15km radius)**	**Available area**	**Installable Cap.(MW)***
Zone -B	Existing LIDAR	261 Sq.km	731
	Proposed LIDAR-1	435 Sq.km	1218
Zone-A	Proposed LIDAR -2	705 Sq.km	1974
Total		**1401 Sq.km**	**3923**
Indicative Installable Cap. (GW)			**(~4 GW)**
*Assumption 2.8MW/Sq.km			

Year	Wind Speed (m/s) at 100m
2010	8.097
2011	8.29
2012	8.447
2013	8.526
2014	8.182
2015	7.826
2016	8.156
2017	8.375



ERA-5 data

Future Plans

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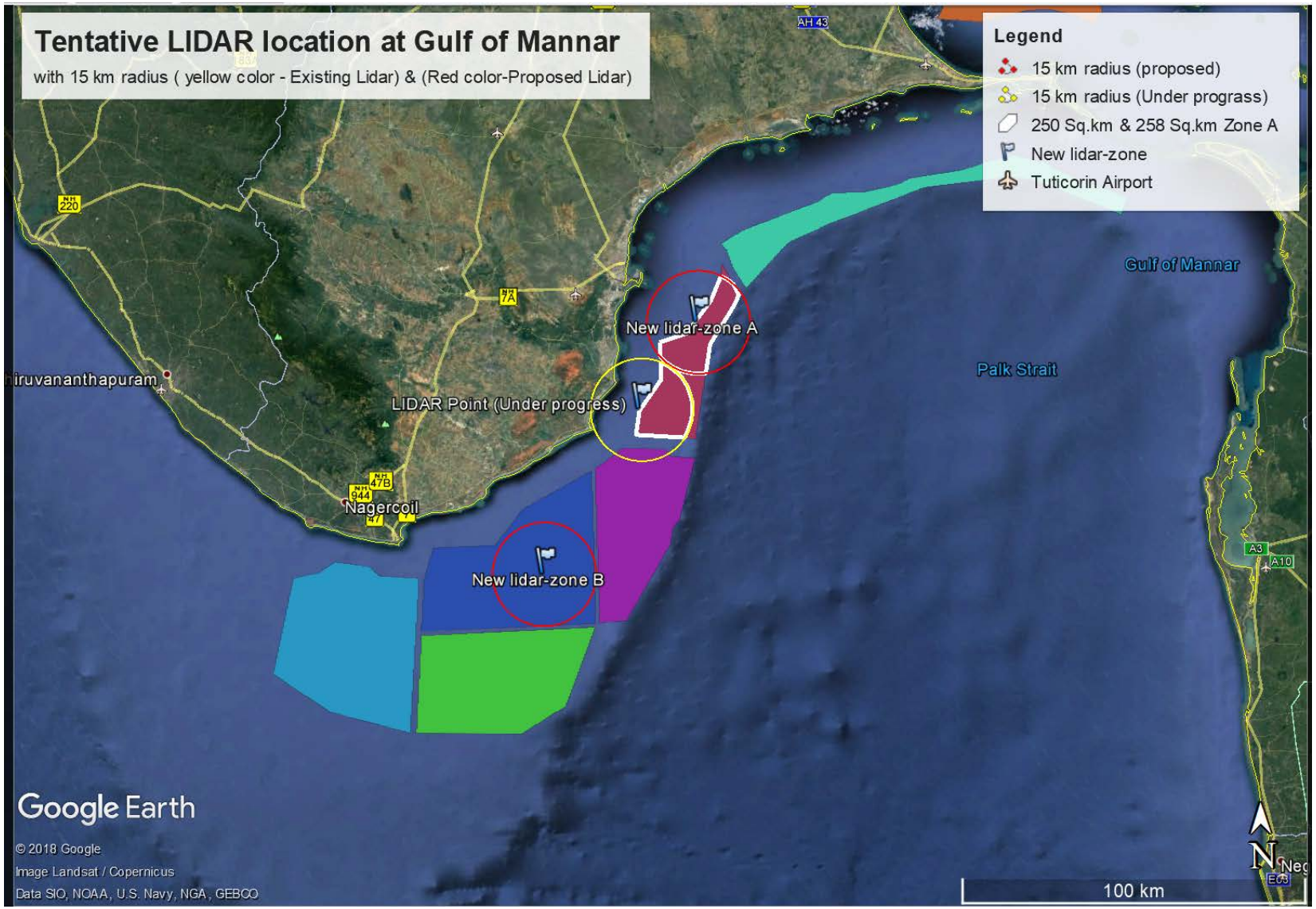
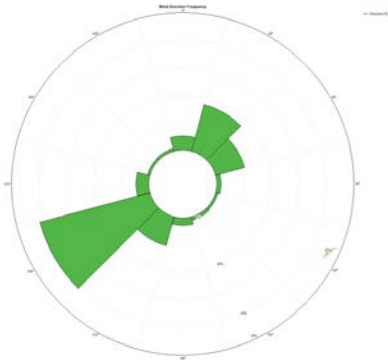


Gulf of Mannar, Tamil Nadu			
FOWIND Zone	**LIDAR Representation (15km radius)**	**Available area**	**Installable Cap.(MW)**
Zone -A	Planning LIDAR	240 Sq.km	672
	Proposed LIDAR-1	261 Sq.km	731
Zone-B	Proposed LIDAR -2	705 Sq.km	1974
Total		1206 Sq.km	3377
Indicative Installable Cap. (GW)			**(~3.4 GW)**
Assumption 2.8MW/Sq.km			

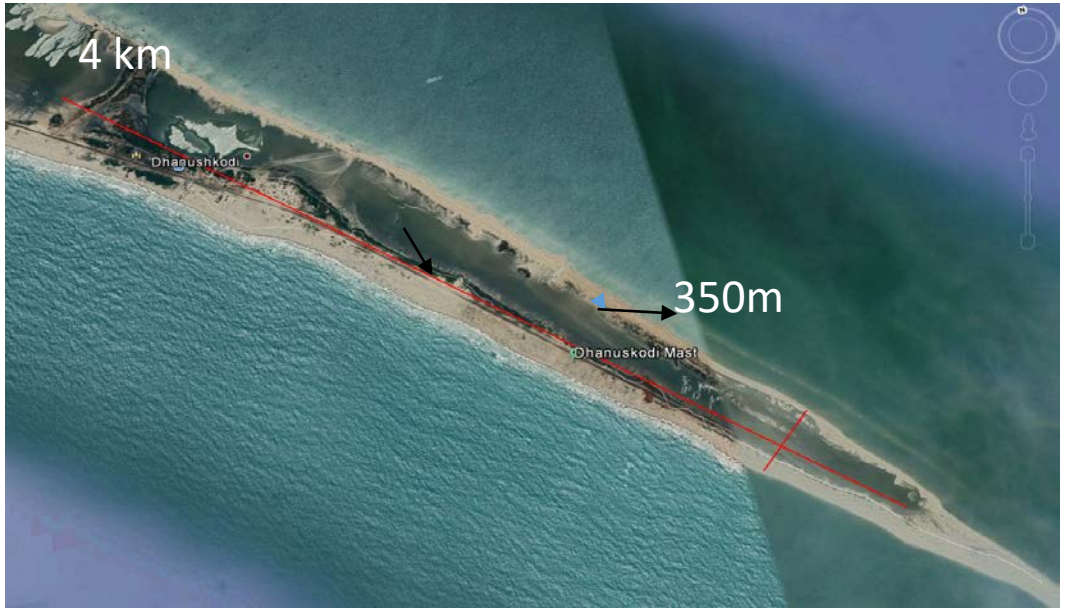
Year	Wind Speed (m/s) at 100m
2010	8.10
2011	8.29
2012	8.45
2013	8.53
2014	8.18
2015	7.83
2016	8.16
2017	8.37



ERA-5 data

PROPOSED NATIONAL RESEARCH AND TEST CENTRE LAYOUT

- Research facility - 8MW plus WTG
- Test beds will be created for testing of offshore wind turbines

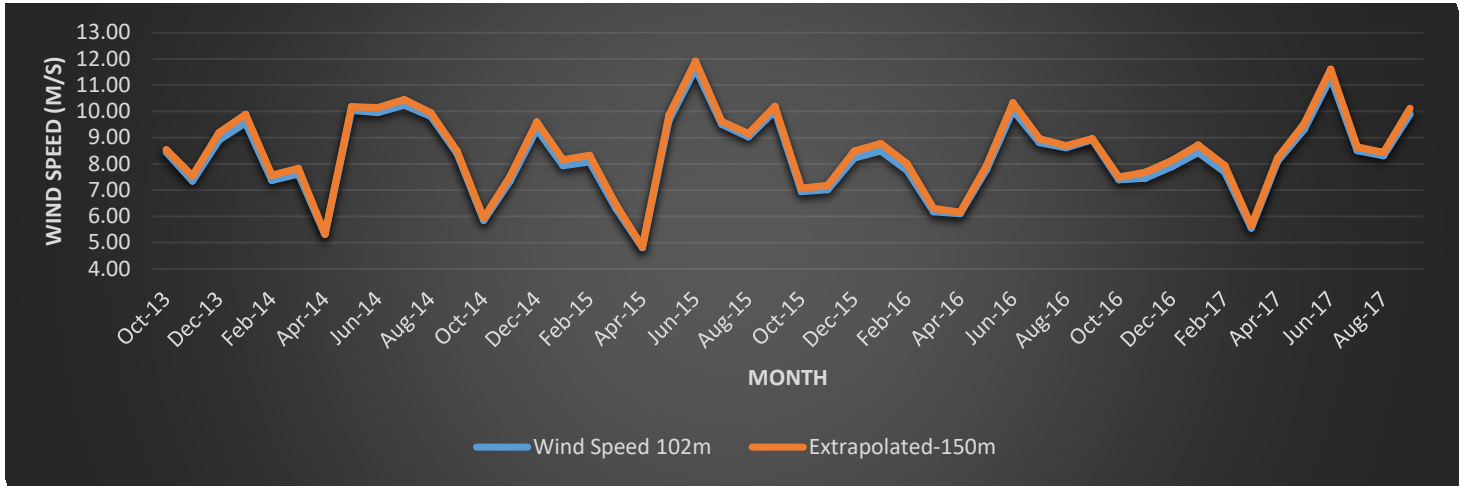


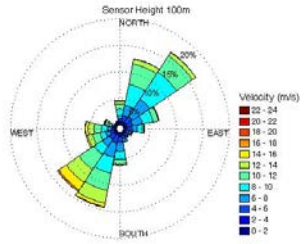
WIND CHARACTERISTICS OF DHANUSHKODI @ 102m (measured) & 150m (Extrapolated)

2013-2014			2014-2015			2015-2016			2016-2017		
Month	Mean wind speed @102m	Extrapolated @ 150m	Month	Mean wind speed @102m	Extrapolated @ 150m	Month	Mean wind speed @102m	Extrapolated @ 150m	Month	Mean wind speed @102m	Extrapolated @ 150m
Oct-13	8.45	8.55	Oct-14	5.85	5.94	Oct-15	6.95	7.08	Oct-16	7.41	7.50
Nov-13	7.35	7.54	Nov-14	7.36	7.54	Nov-15	7.02	7.18	Nov-16	7.46	7.68
Dec-13	8.91	9.19	Dec-14	9.32	9.60	Dec-15	8.23	8.48	Dec-16	7.90	8.13
Jan-14	9.58	9.89	Jan-15	7.93	8.16	Jan-16	8.50	8.78	Jan-17	8.44	8.72
Feb-14	7.37	7.57	Feb-15	8.09	8.33	Feb-16	7.75	8.01	Feb-17	7.69	7.93
Mar-14	7.62	7.83	Mar-15	6.29	6.44	Mar-16	6.18	6.31	Mar-17	5.56	5.65
Apr-14	5.31	5.35	Apr-15	4.81	4.84	Apr-16	6.11	6.16	Apr-17	8.11	8.23
May-14	10.04	10.18	May-15	9.67	9.86	May-16	7.81	7.94	May-17	9.32	9.53
Jun-14	9.96	10.15	Jun-15	11.63	11.92	Jun-16	10.05	10.33	Jun-17	11.30	11.61
Jul-14	10.24	10.45	Jul-15	9.50	9.63	Jul-16	8.81	8.96	Jul-17	8.51	8.65
Aug-14	9.82	9.95	Aug-15	9.04	9.15	Aug-16	8.62	8.69	Aug-17	8.32	8.43
Sep-14	8.39	8.48	Sep-15	10.02	10.19	Sep-16	8.92	8.96	Sep-17	9.90	10.12
Average	**8.59**	**8.76**	**Average**	**8.29**	**8.46**	**Average**	**7.91**	**8.07**	**Average**	**8.33**	**8.51**

Month	P50 (Net) Capacity Factor (%)
Jan	42.99
Feb	34.14
Mar	23.04
Apr	19.18
May	45.12
Jun	57.8
Jul	45.47
Aug	42.5
Sep	45.67
Oct	30.69
Nov	30.13
Dec	43.05
Overall	**38.2%**

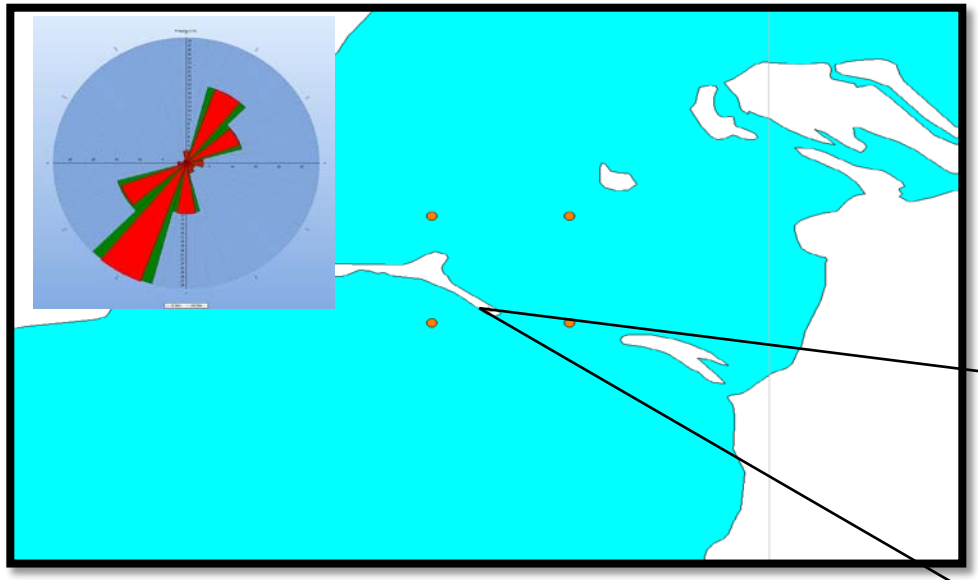
CF based on-8MW WTG

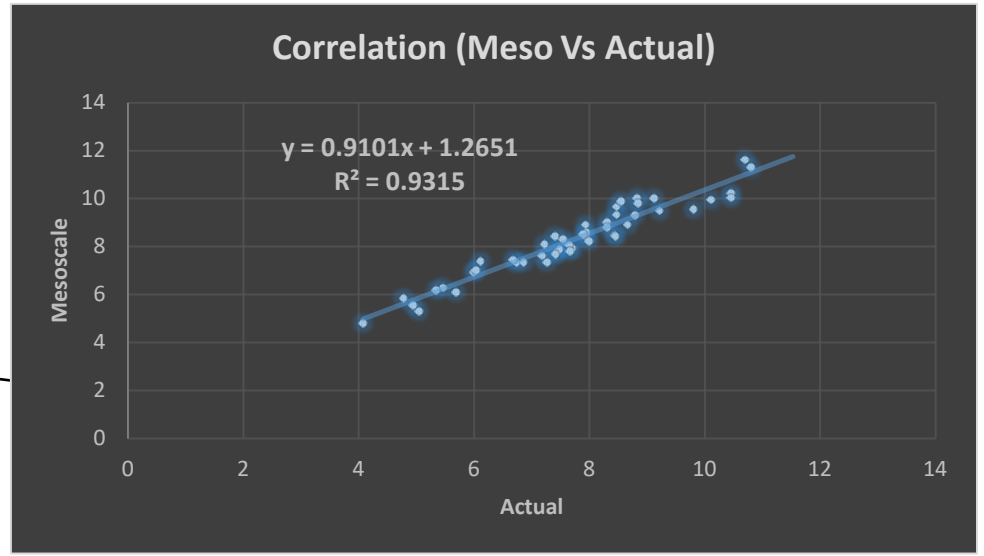


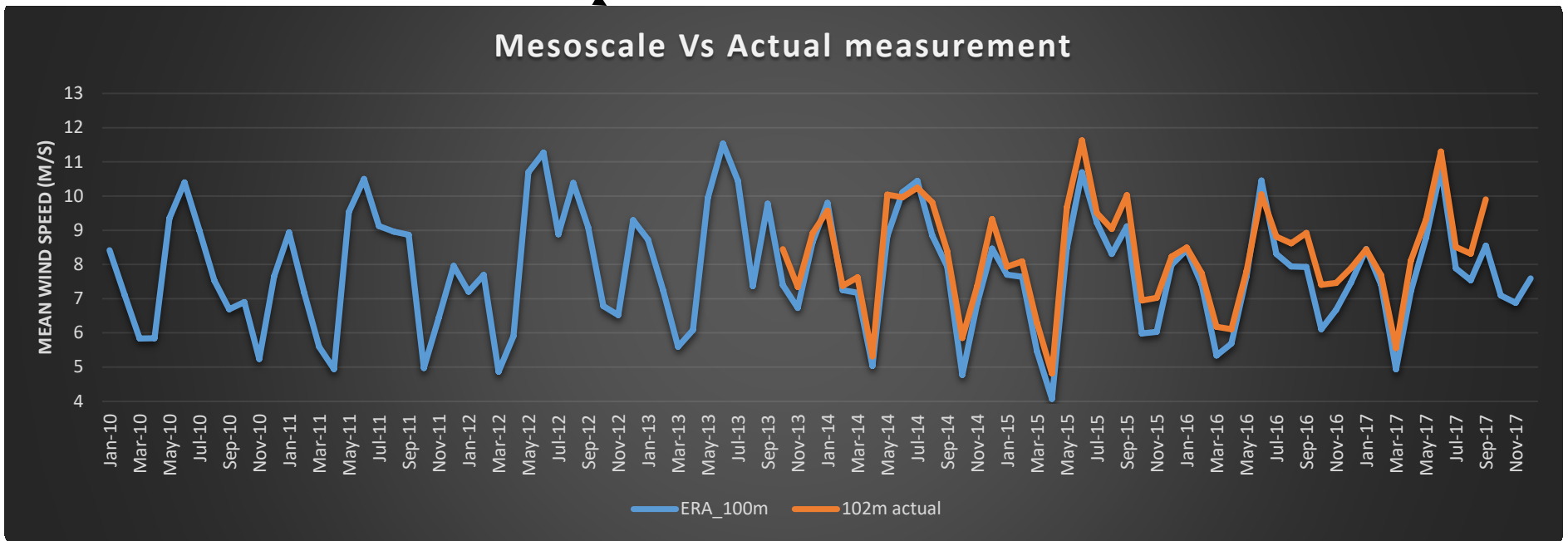


102m Wind Rose

LONG-TERM WIND CHARACTERISTICS OF DHANUSHKODI – Mesoscale Vs 102m (measured)







Future Plans

Proposed -Power Evacuation Facility

International Experience – NTC at Osterild , Denmark

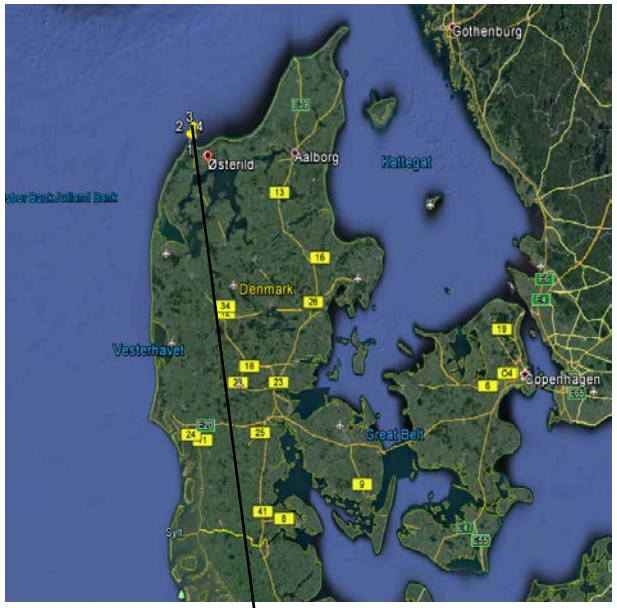
- The terrain and wind conditions at Osterild Test center is unique for the testing of wind turbines.

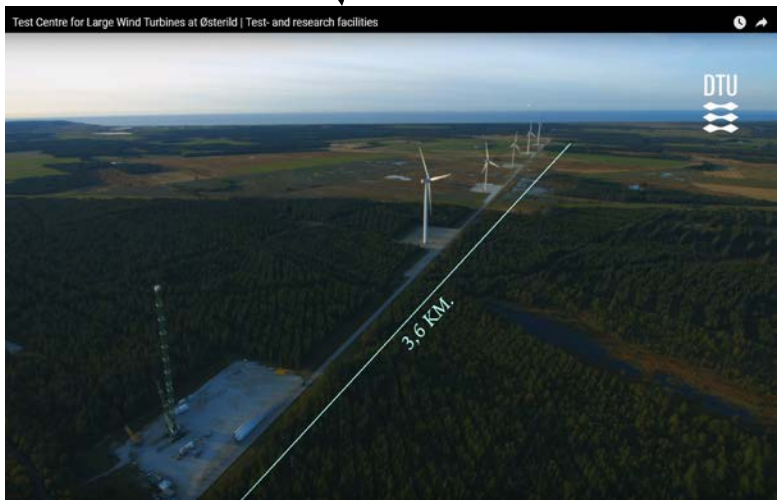
- Manufacturers prefers to test their Offshore wind turbines on land because:

  - ✓ Permanent direct access to the turbines, as technicians often to replace components and perform maintenance and service during the testing.

  - ✓ Access at sea is more complicated and, for long stretches at a time.

  - ✓ Data is much easier to collect on land, where the wind is measured with precision instruments - Very precise data regarding wind measurements is required for data modelling comparisons.





Thank You