1st Progress Report - May 2016 WindCube LiDAR Validation Phase

MeteoPole

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Installation and configuration of the WindCube

Demonstration and observation of the first results

FOWIND (Facilitating Offshore Wind in India) is a European Union funded project, led by Global Wind Energy Council (GWEC), which **promotes offshore wind power to facilitate India's transition towards a low carbon energy future.**

MeteoPole is a France-based consulting firm – with Indian office in Hyderabad - providing services at each stage of wind farm project development. It focuses on reducing financial risks through a range of advanced technologies : from LiDAR measurements to cloud-based wind simulations (ZephyCloud). **CSTEP** on behalf of FOWIND project consortium, has appointed MeteoPole as the official LiDAR supplier.

The WindCube v2 Offshore : the Best-in-Class Solution for Offshore Wind Resource Assessment.

As part of FOWIND project, a measurement campaign is expected to be performed in Gujarat to assess the offshore potential. The WindCube LiDAR has been chosen as the most suitable solution in terms of device performance and cost-effectiveness. Indeed, being ultra-portable, it enables simple installation on any stable platform and it shows very good accuracy and data availability.

The 5th of May 2016: Demonstration at NIWE Office in Chennai

On the 5th of May 2016, MeteoPole performed a demonstration of the device utilization at the National Institute of Wind Energy (NIWE) office in Chennai. NIWE is FOWIND's Knowledge Partner. It included a presentation of the WindCube working principle, the installation steps and the safety recommendations. The device was also installed and configured to show the first results. The LiDAR has been handed over to NIWE for further FOWIND activities.

WINDCUBE KEY FEATURES

Measurements	Measurement Heights	12 configurable height of measurements from 40m to 200m
	Speed and Direction Accuracy	Speed: ±0.1 m/s. Direction: ±2°
Data	Sampling frequency	1 Hz.
	Output Data	1s/10 min horizontal, vertical wind speed and direction at each height, min & max wind speed, standard deviation, Carrier to Noise Ratio, Data availability, GPS coordinates.
Transportation	Weight and Size	45kg, L-W-H: 543x552x540 mm
Software	Features	Remote or local configuration and control, real-time display, diagnostic

MAIN APPLICATIONS

- ✓ Site prospecting and assessment
- ✓ Optimization of P75 & P90 values (reduce uncertainties – horizontal and vertical uncertainties)
- ✓ Site suitability assessment
- ✓ Power Curve Measurement

1st Progress Report - May 2016 WindCube LiDAR Validation Phase

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NIWE's Kayathar site (WTTS/WTRS)

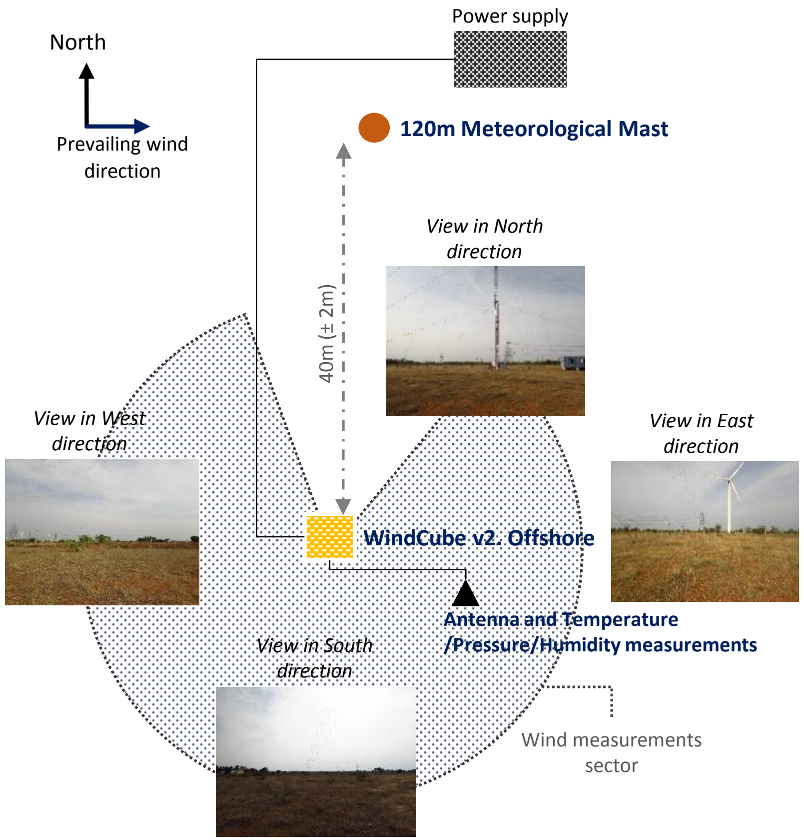
Commissioning of the WindCube

The 18th of May 2016: Validation of the WindCube Performance

Context: As a first step before the offshore deployment, it has been decided that NIWE will lead the validation process to check the WindCube performance and accuracy. This is the first WindCube LiDAR validation conducted in India. This is a key step but also a good opportunity to showcase the LiDAR performance on a well-known site in India.

The Validation Period: The WindCube observed data will be compared to the measurements of a 120-meter met mast located in NIWE's test site at Kayathar in Tuticorin District, Tamil Nadu. On the 18th of May 2016, the WindCube LiDAR commissioning was performed on-site. This validation phase will validate the WindCube accuracy through the comparison of 10-minute average wind speed and direction as well as the performance of the WindCube in terms of data availability. This first campaign also provides the opportunity to try out the WindCube set up (Power supply, remote access and control) before offshore deployment.

INSTALLATION SET UP



VALIDATION KEY FACTS

Terrain Conditions	Flat terrain, low vegetation.
Wind Features	Wind mostly coming from West direction in May-June (no met mast shadow effect).
WindCube Set Up	Measurement height : 40m, 60m, 90m, 100m, 120m, 140m, 160m, 180m, 200m.
Output	10-minute average wind speed and direction, 10-min average temperature, pressure and relative humidity, data availability.
Installation Duration	2-3 hours.
Validation Duration	1 month – 20/05/2016 to 21/06/2016.

VALIDATION PROCESS

Installation: The WindCube was positioned 40m away from the met mast, south of the met mast. The prevailing wind direction on this site is West so the met mast has no influence on wind characteristics measured at LiDAR location.

Data Processing: All wind speeds below 4m/s and above 20m/s are removed from the dataset. The dataset is considered to be complete once 600 data points will be collected, including 200 points for wind speeds between 4 and 8 m/s at 120m, and 200 points for wind speeds between 8 and 20 m/s at 40m. The 10-minute average wind speed and direction of the WindCube and the Met Mast at 60m, 90m and 120m will be compared.

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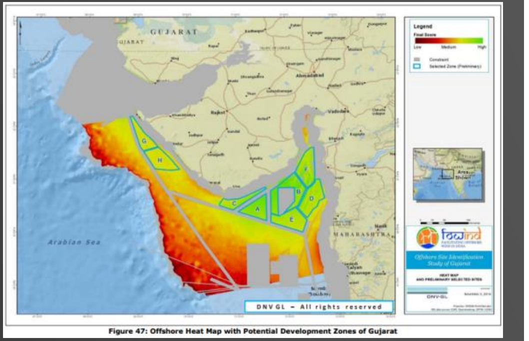

Offshore deployment zone in Gujarat : Source: FOWIND Pre-feasibility Reports

View of the 120m Met Mast

End of June 2016: Expected Results from the Validation Period

Data Analysis: Based on recommendations from DNV GL (FOWIND Technical Lead), the National Institute of Wind Energy and previous studies performed by MeteoPole, the acceptance criteria were chosen as reference to evaluate the WindCube performance and accuracy.
The 10-minute average wind speed and direction will be compared using a linear regression model y=ax+b, y being the WindCube data, x the Met Mast data, a the slope and b the offset. Other key values will be evaluated:

- The *Average Wind Speed Deviation* which is the average difference between the WindCube 10-min wind speeds and the Met Mast wind speeds at each height.
- The *Wind Speed Standard Deviation of Deviation* which quantifies the dispersion of the previous error.
- The *Data Availability* which represents the ratio between the number of measurements done and the maximum number of possible measurements.

Acceptance Criteria:

Wind Speed – Linear Regression	Slope a	Should be equal to 1 ±0.02
	Offset b	Should be equal to 0 ±0.2 m/s
	R^2	Should be greater than 0.97
Wind direction – Linear Regression	Slope a	Should be equal to 1 ±0.02
	Offset b	Should be equal to 0 ±5°
	R^2	Should be greater than 0.97

Average Wind Speed Standard Deviation	Should not exceed ±0.2m/s
Wind Speed Standard Deviation of Deviation	Should not exceed ±0.15m/s
Data Availability	Should reach 100% during 80% of the validation period.

Next Step: the Offshore Deployment

The WindCube will be transported for final installation at the identified offshore site by FOWIND.
All data generated under this study is the property of the FOWIND Consortium.

CONTACT FOR FURTHER INFORMATION

FOWIND: visit the website www.fowind.in and / or contact Mr. Samrat Sengupta (samrat@fowind.in)
MeteoPole: visit the website www.meteopole.com and/or contact Mr. Emile Dumas (emile.dumas@meteopole.com)

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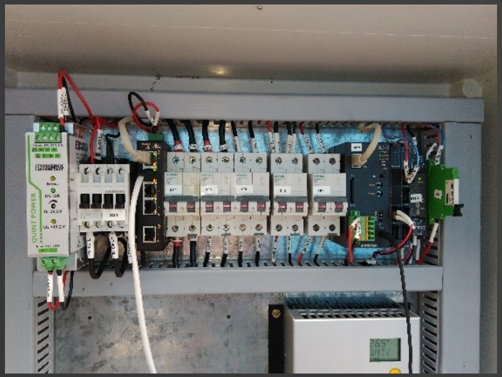
Solar panels : 1000 W

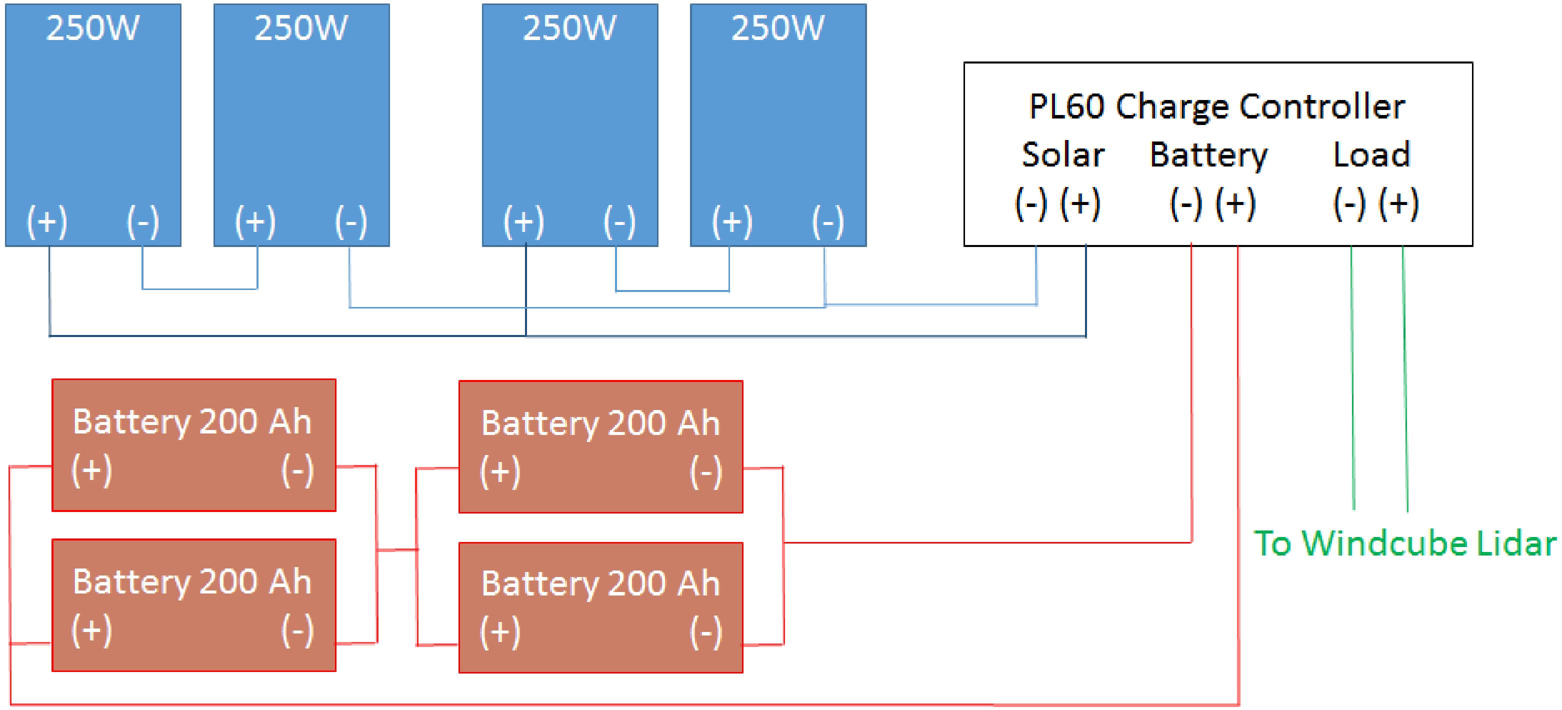


Control panel connected to battery and solar panels

August 2016: Starting of the testing phase of the power system

Configuration : To provide power to the Windcube Lidar offshore, meaning off-grid as well, we need a self power production usable as an UPS (Uninterrupted Power System). The solution has been designed based on solar energy, with batteries to have power all day long. We have 4 solar panels (4 x 250 W = 1000 W) and 4 batteries (4 x 200 Ah = 800 Ah). The batteries and solar panels are connected together through a control panel, managing the charge and discharge of the batteries. The control panel displays, sends and saves the voltage from the batteries. Whenever the batteries voltage is too low, meaning a low charge level of the batteries, an alert is sent by email.

The control panel is connected to internet with a satellite connection, allowing to send alerts but also to interrupt the Windcube Lidar in order to reboot it, in case it is necessary.



CONTACT FOR FURTHER INFORMATION

FOWIND: visit the website www.fowind.in and / or contact Mr. Samrat Sengupta (samrat@fowind.in)

MeteoPole: visit the website www.meteopole.com and/or contact Mr. Bhanu Sunkari (bhanu.sunkari@meteopole.com)

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Cost-effective, dedicated design, made in India:

Solar panel stands: To fix properly and strongly the solar panels to the platform, we designed and made dedicated solar panels stands. They have been made by Spearhead in Chennai. They are made of Stainless Steel 316. Their strong structure is able to withstand high wind. The material used is able to withstand the salty conditions.

Battery box : The batteries need to be protected from outside conditions, including rain, wind and salty conditions. We designed and made a dedicated battery box. It has been made of galvanized aluminum by Spearhead in Chennai. They are hermetic with holes for the battery cables. Water from possible condensation should be avoid with moisture absorber.

Control Panel : To ensure connections between batteries, solar panels and Lidar, we designed a control panel. It has been assembled by ELDAC in Chennai. As explained earlier, the control panel manages the charge and discharge of the batteries with the essential Solar Charge Controller. The control panel includes also circuit breakers, converters and a rooter to connect the LAN cables. It displays, sends and saves the voltage from the batteries. Power is also provided to the satellite antenna.

Solar panel stands : SS316

Battery box : galvanized aluminum

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FOWIND: visit the website www.fowind.in and / or contact Mr. Samrat Sengupta (samrat@fowind.in)
MeteoPole: visit the website www.meteopole.com and/or contact Mr. Mr. Bhanu Sunkari (bhanu.sunkari@meteopole.com)

2nd Progress Report – January 2017 WindCube LiDAR - Power system testing

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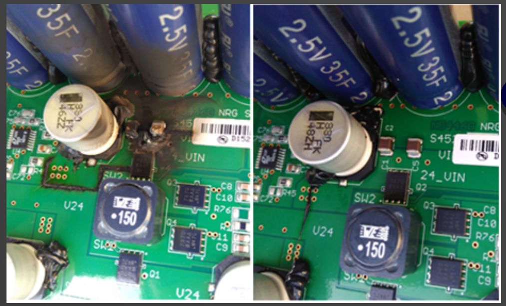

Burnt electronic component

Platform on its fabrication site in Navi Mumbai

End of September 2016: Quick trouble-shooting of a hardware issue

Following of the issue: On week 39, we realized that the Windcube was not started on Tuesday. We quickly understood that the issue was from inside parts of the Lidar and we called Leosphere, the provider of the Windcube, who identified a possible issue to solve this technical problem by phone and did the needful. An electronic component had burnt in the Lidar and they sent a new one. We received it on Friday of the same week and were able to start again the configuration the day after. This major issue has been solved in less than a week thanks to our dedicated team in on the spot.

End of October 2016: Experimental run on batteries only

Context: The batteries are supposed to be able to provide electrical power to the Windcube Lidar during night time as well as during bad weather days and consequently poor solar exposition days. We performed a trial : disconnect the solar panels from the whole system and see how long the system can run with full batteries at the beginning.

Result: Successfully, the batteries were able to provide power to the Lidar for **at least** 2 days and 6 hours (54 hours) before we interrupted the experiment. Consequently, we are insured that in case of bad weather condition and bad charge of the batteries on a couple of days in the row, the measurements won't be interrupted.

End of November: Validation of the power system

The power system has been installed, configured and optimized for the Lidar. This testing phase has been a success and prove that the Lidar and its power system designed by MeteoPole can be installed offshore without connection to the electrical network.

Next Step: the Offshore Deployment

The WindCube will be transported to its final destination at the identified offshore site by FOWIND in Gulf of Khambhat, 25 km from the shore of Gujarat in January. MeteoPole will fix it and its peripheral parts (solar panel and stands, batteries within a battery box, control panel and water tank) to the platform.

All data generated under this study is the property of the FOWIND Consortium.

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FOWIND: visit the website www.fowind.in and / or contact Mr. Samrat Sengupta (samrat@fowind.in)
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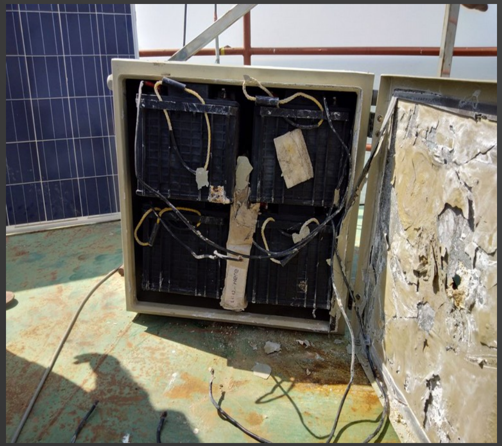
Water Tank



Fallen Batterey Box

30th of October 2017 : Testing of the Windcube - onshore

On the previous report (November 2016), the FOWIND Project finished the installation and the validation of the Power Pack designed by MeteoPole to suit the Windcube requirements. One year after the latest report, it was mandatory to check the Windcube onshore and configure the parts that could be configure onshore. During this testing session, MeteoPole was able to affirm that the Windcube was perfectly working and still calibrated.

31st of Octobe 2017: Installation of the Windcube on offshore platform

Small Issues During Installation

1 – Power Pack Verification

Once on the platform, the FOWIND team noticed that the battery box has fallen on the ground. After further inspection, the four batteries are still working and are well connected to the Windcube. Some small scratches can be seen on the solar panels which do not affect their efficiency. A final verification shows that the output of the power pack fits the requirements of the Windcube.

2 – Water Tank Fill in

MeteoPole noticed that the Water Pump is not completely at the bottom of the Water Tank so, this Water Tank should be fill in more often than expected.

CONTACT FOR FURTHER INFORMATION

FOWIND: visit the website www.fowind.in and / or contact Mr. anand Wagh (anand@wisein.org)
MeteoPole: visit the website www.meteopole.com and/or contact Mr. Bhanu Chander Sunkari (bhanu.sunkari@meteopole.com)

FACILITATING OFFSHORE WIND IN INDIA

31st of Octobe 2017: Installation of the Windcube on offshore platform (2)

GSM Network Connectivity Strength

Big Issues regarding the platform

1 – Poor Network Connectivity

One week before the installation, we learned that it was forbidden to use the Satellite Option because the Satellite Antenna was composed of Iridium, a metal component not allowed in Indian seas. Therefore, we configured the GSM option with an Airtel 3G SIM.

The Network Connectivity is quite bad on the platform so, we lose the connection with the Windcube during some parts of the day, especially during working hours.

Still, the Windcube is recording the data the whole time and will upload the data when the connectivity is better (beginning of the day or during night).

This network connectivity issue may be solved by using a High Frequency Transmitter or increasing Airtel connectivity with the help of Airtel. It is not mandatory and this issue will be adressed by NIWE in the next months.

Average time data can be downloaded remotely and we managed to download data from the 1st of November. Everything is working and the Windcube is recording well. Average time is set up on 10 minutes in order to compare with the met mast data.

Real time data can only be downloaded directly through a LAN cable connected to the Windcube.

2 – Moving Platform

The platform is 17 m height so, the Windcube is shaking a bit and it is not perfecly straight. We noticed an average pitch and roll angle of 1°. This is linked to a 3 meters difference between two opposite beams which is still in compliancy with the hypothesis of homogeneous flow.

In case of the pitch or roll angle is higher than 1.5° (i.e. 5 m difference), the data should be discarded.

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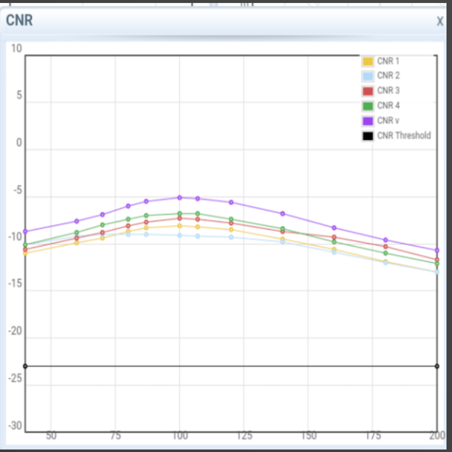


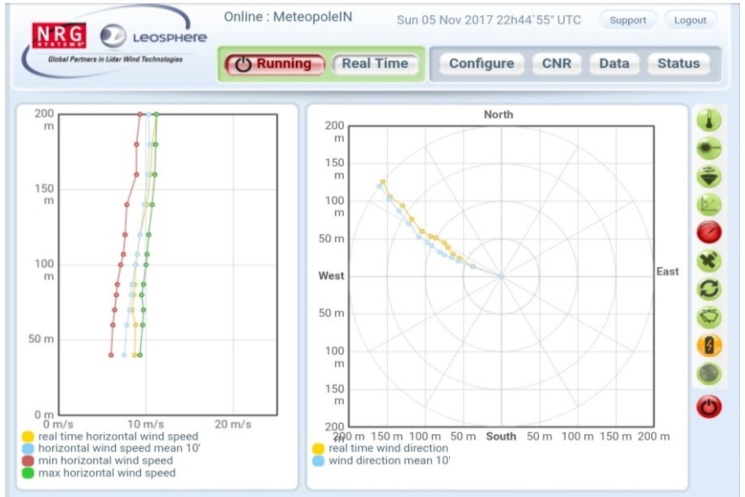
CNR Ratio

Installation of the Windcube by the FOWIND Team

FOWIND Configuration settings

After the successful installation of the LIDAR, we have configured the Windcube on different heights as per the requirement of NIWE : 40, 60, 70, 80, 87, 100, 107, 120, 140, 160, 180, 200.
Due to the structure installed on the platform, it was not possible to turn the Windcube so, an offset of -38° was configured in the Windcube.
All these parameters can still be changed remotely directly by NIWE or MeteoPole.

Measurement Heights



Real Time Data

Next Step

The final steps of the FOWIND Project will be the monitoring of the Windcube data until March 2018 and the comparison between these measurements and the met mast data located 20 km away (onshore).

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22nd of January 2018 : Windcube Maintenance Activity

The Windcube was installed on 31st October 2017. During November 2017, there was a data loss to an extent of 34% and in December it increased up to 63.4%. From our analysis, we believe that this is due to a problem in the power pack and subsequently we have visited the site on 22nd January 2018. We successfully changed the batteries and also carried out some maintenance work. This exercise was also attended by technicians from NIWE, WISE and 2 experts specialised in data boosting.

Corrosion Inside the Connector

Small Scratch on Solar Panel

Observation and tasks during the Maintenance Activity

1 – Solar Panel Inspection

On the platform, we have noticed that the connections of 2 solar panel were not good due to corrosion inside of the connector and were therefore not properly connected to each other. The connectors were fixed with insulation tape in order to avoid the same thing in future.

We also observed some scratches on the back side of a solar panel, but it should not affect its efficiency as it remains superficial.

2 – Control Panel Inspection

During the inspection, we found that the output cable from the control panel was loose and we have fixed the same in proper position.

3 – Other Acivity

After the replacement of the 4 batteries, we have verified their output voltage and connected them to the LiDAR for power supply. Toppling up the distilled water required for LiDAR and other small activities were also performed.

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MeteoPole: visit the website www.meteopole.com and/or contact Mr. Prashant Suthar (prashant.suthar@meteopole.com)

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Download Log Files Of RAW DATA And PL60

LAST 30 Days DATA OF CHARGE CONTROLLER FROM 24December to 22January 2018

DAY	IN	OUT	VMAX	Vmin	FTIM	SOC
1	36	40	25.6Ah	22Ah	0	12
2	38	42	25.6Ah	21.8Ah	0	30
3	40	42	25.6Ah	22Ah	0	14
4	38	41	25.6Ah	21.8Ah	0	15
5	38	41	25.6Ah	22Ah	0	15
6	36	40	25.6Ah	22Ah	0	16
7	32	43	25.6Ah	22Ah	0	17
8	17	2	26.2Ah	23.8Ah	0	20
9	19	44	25.4Ah	21.8Ah	0	16
10	21	5	26.4Ah	24Ah	0	22
11	24	45	25.4Ah	22Ah	0	18
12	28	7	25.6Ah	24Ah	0	24
13	29	36	25.2Ah	22.2Ah	0	18
14	37	41	25.6Ah	22.4Ah	0	20
15	40	42	25.6Ah	22.4Ah	0	21
16	40	42	25.6Ah	22.4Ah	0	22
17	38	27	25.6Ah	22.4Ah	0	22
18	36	67	25.6Ah	22.8Ah	0	19
19	36	8	25.6Ah	24Ah	0	27
20	26	26	25Ah	22.4Ah	0	20
21	21	67	25.4Ah	22.8Ah	0	20
22	35	7	25.6Ah	23.6Ah	0	28
23	35	44	24.8Ah	22.4Ah	0	21
24	26	66	25.4Ah	22.8Ah	0	23
25	38	7	25.6Ah	24Ah	0	30
26	38	30	25Ah	22.4Ah	0	23
27	40	67	25Ah	22.6Ah	0	21
28	42	66	25.6Ah	22.8Ah	0	27
29	38	7	25.6Ah	22.8Ah	0	33
30	28	51	25Ah	22.4Ah	0	26

PL60 Logs Files

1 – LOG Directories of WINDCUBE

We have downloaded the 4 directories of raw data (ALARME, BACKUP, DATA, LEOSPHERE) from WINDCUBE through Local LAN network and sent the same to Leosphere (Manufacturer) to ensure the Windcube system is working well. Leosphere did not observe any issue in the system. The cause of the data missing is that the Windcube was OFF, so no measurement was done. This is consistent with the fact that the data is now available after changing batteries.

2 –PL60 LOGS FILES of Solar Panel

We have Downloaded the last 30Days DATA of charge controller from 24 December to 22 January 2018 in that we can see following below:-

IN-The amount of energy collected in Amp hours.
OUT-The amount of energy used in Amp hours.
VMAX-Maximum battery voltage since midnight.
VMIN- Minimum battery voltage since midnight.
FTIM-Time of the day the regulator entered the Float state.
SOC- Percentage estimate of the state of the battery based on the Amp hours. A very rough 'fuel gauge'.

From Logs File of PL60, we have seen that the batteries were not get fully charged from the solar panel. This is probably due to the low acid level inside of the batteries (as mentioned in previous report batteries were found on laying down on the platform during the visit of October 31st 2017), that lead to a lower capacity and efficiency of the batteries).

CONTACT FOR FURTHER INFORMATION

FOWIND:visit the website www.fowind.in and / or contact Mr. Anand Wagh (anand@wisein.org)
MeteoPole: visit the website www.meteopole.com and/or contact Mr. Prashant Suthar (prashant.suthar@meteopole.com)

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Additional Installation

1 – Installation of Aviation Lamp -
WISE has Installed an aviation lamp with separate solar based power supply and battery.

2 – Installation of Data Booster -
Data booster team did not manage to get continue network connectivity on the platform, so they were not able to boost signal continuously. Therefore decision was taken not to install the data booster as it would not be able to work properly.

3 – Anemometer & wind vane -
NIWE team has Installed one Anemometer and one wind vane on the platform. They also fixed alert lamps (red) on platform stairs. NIWE team was interested in fixing a camera on the platform, but as the data booster was not successfully installed they could not fix the camera.

Aviation lamp

Anemometer & Wind vane

Next Step

The final steps of the FOWIND Project will be the monitoring of the Windcube data until March 2018 and the comparison between these measurements and the met mast data located 20 km away (onshore).
As of now, the monitoring of the Windcube did not report any missing data, which allow us to reasonably think that the issue on the powerpack was properly solved by replacing the batteries.

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12th of September 2018 : Windcube Maintenance Activity

On a 22nd January 2018, we had maintenance activity of the Windcube and changed the batteries. We are able to access the Windcube and get 100% data till 13th of July. After that, we are not able to access the Windcube and we did not receive any data so we decide to visit on-site. We have visited the site on 12th September 2018. We successfully managed to turn on Lidar with two battery and carried out some maintenance activity. This exercise was also attended by two technicians from NIWE.

The reamaining battery inside the battery box

Output voltage of the 2 batteries Power pack

Observation and tasks during the Maintenance Activity

1 – Power pack verification.

Once we reached on the platform we noticed that out the 4 batteries we found 2 batteries were on the floor, one in a battery box and one battery on the edge of falling into the sea because of the platform continuous movements. From the 3 available batteries, one is completely damaged and we can not use it any more, we managed to turn on the Windcube with 2 batteries. Fortunately, the output voltage were still matching the LiDAR requirements (25V). Finally, we fixed the battery box properly and tied it with copper cable so in the future we can cope with this problem.

2 – Control Panel Inspection

After the battery box we did the inspection of the control panel, we checked the input and output connection of the control panel, everything was clear and we also checked that the PL60 and other components were working well.

3 – Other Acivity

After solving the battery problem and having finished the inspection of the control panel , we have verified their output voltage and connected them to the LiDAR for power supply. The water tank was damaged so we replaced it, we toppled it up with distilled water required for LiDAR and cleaned the air filter & solar panel and other small cleaning activities were also performed.

One battery on the edge of falling into the sea

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