

# MAHARASHTRA ENERGY DEVELOPMENT AGENCY

MHADA COMMERCIAL COMPLEX, OPP. TRIDAL NAGAR, YERWADA, PUNE 411 006

Ref: IDD/WPP-002/41/2018-19/716

Date: 28/02/2019

The Secretary  
Maharashtra Electricity Regulatory Commission  
13th floor, centre no. 1, World Trade Centre,  
Cuffe Parade, Colaba,  
Mumbai- 400 005

Sub - Petition of Maharashtra State Electricity Distribution Co. Ltd. (MSEDCL) for Review of Order dated 03 April, 2018 in Case No. 41 of 2017 passed by the Commission in the matter of Petition of MSEDCL for revision in Wind Zone classification of Wind Energy Projects with consistently higher generation.

Ref: 1) MERC Order dtd. 9.7.2018 in case no. 152 of 2018.

2) MERC e-mail dtd. 5/2/2019.

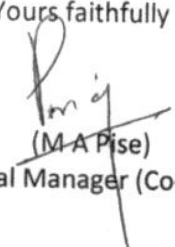
Sir,

MERC vide its order dtd. 9.7.2018 in case No. 152 of 2018 has directed MEDA to review the wind zone classification of the instant 42 wind generators and review the wind zone classification for all the remaining such wind generators at the end of the current financial year based on the actual generation data submitted by MSEDCL / Generators. In this context, MEDA has appointed World Institute of Sustainable Energy (WISE), Pune as a consultant for preparation of report. M/s WISE has submitted report on subject matter.

We are submitting herewith the report on "Study of Wind Power Density Zones of Wind Power Projects Commissioned under MERC Tariff Regulations 2010" We kindly request Hon. Commission for time for presentation of this report.

Thanking you,

Yours faithfully

  
(M. A. Pise)  
General Manager (Co-ordination)

Encl- As above

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# **Study of Wind Power Density Zones of 42 Wind Power Projects Commissioned under MERC RE Tariff Regulations 2010**

DECEMBER, 2018

Submitted to:

**Maharashtra Energy Development Agency**

MHADA Commercial Complex, II floor,

Opp: Tridal Nagar, Yerwada

PUNE - 411 006 (Maharashtra), INDIA

**Prepared by**

**World Institute of Sustainable Energy, Pune**



## Brief Background of the Study

Maharashtra Electricity Regulatory Commission had issued its first Renewable Energy Tariff Regulations 2010 wherein it had specified Wind Power Density (WPD) Zone wise tariff for the projects to be commissioned in Maharashtra over its control period. On completion of its tenure MERC had revised its regulation and new regulation MERC Renewable Energy Tariff Regulations 2015 come into effect after 1<sup>st</sup> April 2015.

Maharashtra Electricity Distribution Co. Ltd, the distribution licensee, had entered in to PPA with wind generators for procurement of power generated from wind power projects commissioned under the control period of the said regulation. MERC had issued annual tariff orders under this regulation for procurement of wind power from the projects commissioned in the respective year.

As per MERC RE tariff Regulations 2010, the wind power procurement tariffs are linked with the wind power density zones defined as follows:

Wind Zone	Wind Power Density at 50 mtr (Watts/Sq mtr.)	CUF (%)
Zone 1	200 to 250	20%
Zone 2	250 to 300	23%
Zone 3	300 to 400	27%
Zone 4	> 400	30%

Maharashtra Electricity Distribution Company Ltd (MSEDCL), the purchaser of electricity generated from the wind power projects observed that most of the wind projects commissioned under this MERC RE Tariff Regulations 2010, were under Zone 1 where the maximum technical CUF of 20% was determined. MSEDCL further observed that 42 wind power projects commissioned under Zone 1 were consistently generating electricity at CUF of more than 20% for consecutive two to three years. Hence, MSEDCL filed a petition before Hon. MERC for

- *“Admit the present Petition as per the provisions of the Regulation 79, 80 & 81 of MERC (RE Tariff) Regulations, 2015.*
- *Revise Wind Zone classification of 42 generators.*
- *Devise a procedure to adopt 80 m. hub height (or more) data for Wind power density measurement, to link up actual generation data with Wind Zone classification.*
- *To issue directives to MEDA to review the Wind Zone classification of 42 Wind generators & revise them as per the actual generation.*
- *To issue direction to MEDA to adopt the methodology suggested by MSEDCL till the procedure to adopt 80 m hub height creation is finalized by MEDA....”*

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On the above prayers under MSEDCL petition, Hon MERC had issued its order on 03 April, 2018 on the Case No. 41 of 2017, In the matter of Petition of Maharashtra State Electricity Distribution Co. Ltd. for revision in Wind Zone classification of Wind Energy Projects with consistently higher generation.

MSEDCL on 18 May 2018 had submitted its review petition on the MERC order dated 3 April 2018 on the case no 41 of 2017. Based on the review petition Hon. MERC has issued its order dated 9 July 2018 on the case 152 of 2018 in the matter of “Petition of Maharashtra State Electricity Distribution Co. Ltd. (MSEDCL) for Review of Order dated 03 April, 2018 in Case No. 41 of 2017 passed by the Commission in the matter of Petition of MSEDCL for revision in Wind Zone classification of Wind Energy Projects with consistently higher generation.”

In the order on case no 152 of 2018, Hon. MERC had issued its directives to Maharashtra Energy Development Agency (MEDA), the state nodal agency to:

*“to review the Wind Zone classification of the instant 42 Wind Generators and review the Wind Zone classification for all the remaining such Wind Generators at the end of the current financial year based on the actual generation data submitted by MSEDCL /Generators”*

Further while undertaking this wind power density review study, Hon. Commission guided that MEDA will consider following points:

- *If the generation is more than the allotted Wind Zones and CUF, then MEDA will make a recommendation about change in wind zone classification after taking into consideration, the wind power density and the technology employed by the generator.*
- *the benefits of technology in terms of injecting more wind power into grid would need to be passed on to the wind generator.*
- *the generator cannot simultaneously take advantage of the higher tariff fixed for low wind zone classification claiming just the technological superiority of the machine*
- *CUF indicated in the respective wind zones is treated as the upper limit for claiming tariff of that wind zone.*
- *Any generation more than the assigned CUF would either change the classification or lapse the additional generation or adjust the additional generation in the subsequent year.*
- *annual verification needs to be carried out for the first three years from the date of commissioning (COD) of such Wind Generators and the correct Wind Zone classification based on average CUF as submitted by MSEDCL/Generators needs to be decided, which will be applicable for the remaining tenure of the EPA, if any, with MSEDCL/Distribution Licensees, so that the benefits of better efficiency can be availed by generators and proportionately shared with consumers of Maharashtra.*

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With the above brief background and directives of Hon. Commission, MEDA entrusted the work to World Institute of Sustainable Energy (WISE) to study, analyse wind power density of 42 wind power projects referred by MSEDCL and prepare report as per Hon. MERC order dated 9<sup>th</sup> July 2018 in case no 152 of 2018 regarding revision of Wind Zone classification of wind power projects.

## MSEDCL's submission/observation on CUF of 42 Wind Power Projects

In the matter of MERC case no.152 of 2018, MSEDCL had shortlisted 42 wind power projects commissioned under Wind Zone 1 and are consistently generating at higher CUF than determined by MERC under its RE Tariff Regulations 2010.

Following 42 wind power projects commissioned in Zone 1 are shortlisted by MSEDCL for revision of its wind zone and related tariff:

Name of Project	District	No of WTG	MW	Year of Commissioning	Zone as per MEDA	Zone proposed by MSEDCL based on actual Generation	Applicable Tariff as per MERC RE Tariff Order	Tariff proposed by MSEDCL for revised Zone
Purushottam Lohia	Satara	1	0.8	2010-11	Zone 1	Zone IV	5.07	3.38
Shraddha Energy & Infraprojects Pvt.Ltd.	Satara	4	6	2010-11	Zone 1	Zone II		4.41
Shraddha Energy & Infraprojects Pvt.Ltd.	Satara	1	1.5	2010-11	Zone 1	Zone III		3.75
Hindustan Zinc Ltd	Nandurbar	2	3	2011-12	Zone 1	Zone II	5.37	4.67
S K Parik	Satara	1	1.25	2011-12	Zone 1	Zone III		3.97
B. C. & Sons.	Satara	1	1.25	2011-12	Zone 1	Zone III		3.97
Shraddha Energy & Infraprojects Pvt.Ltd.	Satara	6	9	2011-12	Zone 1	Zone III		3.97
Pertinent Infra & Energy Ltd.	Satara	1	1.5	2011-12	Zone 1	Zone II		4.67
BMD Pvt. Ltd.	Satara	3	4.5	2011-12	Zone 1	Zone III		3.97
Bhilwara Green Energy Ltd.	Satara	6	9	2011-12	Zone 1	Zone II		4.67
Bhilwara Green Energy Ltd.	Satara	6	9	2011-12	Zone 1	Zone II		4.67
Bhilwara Green Energy Ltd.	Satara	2	3	2011-12	Zone 1	Zone III		3.97
BMD Pvt. Ltd.	Satara	1	1.5	2011-12	Zone 1	Zone III		3.97
Bhilwara Green Energy Ltd.	Satara	1	1.5	2011-12	Zone 1	Zone II		4.67
Green Infra BTV Ltd.	Satara	1	1.5	2011-12	Zone 1	Zone III		3.97
Rajasthan Gum Pvt. Ltd.,	Sangli	1	2.1	2012-13	Zone 1	Zone II	5.67	4.93
Topaz Investments Pvt.Ltd.	Satara	1	1.5	2012-13	Zone 1	Zone III		4.2
BLP Wind Project (Ambheri)Pvt. Ltd.	Satara	2	1.6	2012-13	Zone 1	Zone II		4.93

Bhilwara Green Energy Ltd.	Satara	3	4.5	2012-13	Zone 1	Zone III		4.2
Panama Wind Energy Pvt.Ltd.	Satara	5	8	2012-13	Zone 1	Zone III		4.2
Suyog Development Corporation Ltd.	Satara	2	1.6	2012-13	Zone 1	Zonell		4.93
BLP Wind Project (Ambheri)Pvt. Ltd.	Satara	7	5.6	2012-13	Zone 1	Zone III		4.2
Ratnagiri Wind Power Project Pvt. Ltd.	Satara	9	14.4	2012-13	Zone 1	Zone II		4.93

Bhilwara Energy Limited	<u>Sangli</u>	1	2	2013-14	Zone 1	Zone II	5.81	5.05
Priyadarshini Polysacks Ltd.	Satara	1	1.5	2013-14	Zone 1	Zone II		5.05
Panama Wind Energy Pvt.Ltd.	Satara	1	1.6	2013-14	Zone 1	Zone III		4.31
Bothe Wind Farm Development Pvt.Ltd.	Satara	1	2	2013-14	Zone 1	Zone II		5.05
Ratnagiri Wind Power Project Pvt.Ltd.	Satara	5	8	2013-14	Zone 1	Zonell		5.05
Pristine Industries Ltd.	Satara	1	1.5	2013-14	Zone 1	Zone II		5.05
Bhilwara Green Energy Ltd.	Satara	1	1.5	2013-14	Zone 1	Zone III		4.31
Ratnagiri Wind Power Project Pvt. Ltd.	Satara	4	8	2013-14	Zone 1	Zone II		5.05
Ratnagiri Wind Power Project Pvt. Ltd.	Satara	4	6.4	2013-14	Zone 1	Zone III		4.31
Green Infra Wind Energy Ltd.	Satara	5	7.5	2013-14	Zone 1	Zone III		4.31
Green Infra Wind Energy Ltd.	Satara	1	1.5	2013-14	Zone 1	Zone III		4.31
Green Infra Wind Energy Ltd.	Satara	6	9	2013-14	Zone 1	Zone II		5.05
Ratnagiri Wind Power Project Pvt.Ltd.	Satara	2	3.2	2013-14	Zone 1	Zone III		4.31
Khandke Wind Energy Pvt.Ltd.	Satara	13	10.4	2013-14	Zone 1	Zone III		4.31
Green Infra Wind Energy Ltd.	Satara	9	13.5	2013-14	Zone 1	Zone III		4.31
Green Infra Wind Energy Ltd.	Satara	8	12	2013-14	Zone 1	Zone III		4.31
Green Infra Wind Energy Ltd.	Satara	8	12	2013-14	Zone 1	Zone III		4.31
Green Infra Wind Energy Ltd.	Satara	4	6	2013-14	Zone 1	Zone III		4.31
NSL Wind Power Company(Satara)Pvt.Ltd.	Satara	3	4.5	2013-14	Zone 1	Zone III		4.31

Total		145	205.7					
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MSEDCL had shortlisted a sample of 340 wind power projects which are generating at higher CUF and out of which they further shortlisted 42 wind power projects which are consistently generating at higher CUF than 20% (which is a target for Zone I) for first two/three years. Based on the actual CUF MSEDCL had proposed change in zone of wind power project from Zone I to Zone II or III or IV. MSEDCL has also proposed to change the tariff of these projects as above.

#### **MSEDCL Observations:**

- MSEDCL had analyzed a sample size of 340 wind power projects for its annual CUF during the financial year 2013-14, 2014-15, 2015-16.
- Out of 340 wind projects, wind Zone I has been allotted to 328 projects and wind zone 2 has been allotted to 12 projects by MEDA.
- Out of 328 wind power projects, classified under wind zone 1, 42 wind power projects are getting higher generation with CUF consistently more than 20%.
- Out of the 42 wind projects, 30 projects are getting higher generation with CUF more than 20% for consecutive three years and 12 projects for consecutive two years.
- Higher CUF implies that 19 wind power projects (CUF>20%) should have been classified in to wind zone II, 22 wind power projects (CUF >23%) should have been classified in to wind zone III and 1 wind power project (CUF >27%) should have been classified in to wind zone IV.
- The wind zone classification by MEDA directly determines which tariff is applicable to the wind project and thus huge financial implications on long term basis as long as the projects life span of 25 year.
- Considering the tariff determination of FY 2013-14, the tariff difference between wind zone 1 tariff of Rs 5.81 to tariff of Rs 3.88 p.u. for wind zone 4 is as huge as Rs 1.93 p.u.
- Thus, wind generators are getting unduly benefitted twice; in terms of enhanced generation and in terms of highest tariff at the same time whereas the financial burden is passed on to the common consumers of the state.
- Considering the actual data, the financial implications for 3 years under consideration amounts to Rs. 139Cr.
- In view of above, MSEDCL suggested:
  - Wind zone classification needs to be reviewed at the end of financial year based on the actual generation submitted by the generator.
  - If the generation is more than wind zone 1CUF, the wind zone classification needs to be changed accordingly and the amount should be reconciled.
  - The relevant wind zone tariff needs to be made applicable for the next financial year.
  - If the generation is within the range of classified wind zone, the same wind zone needs to be considered for next financial year.
  - Such type of annual verification needs to be carried out for the first three years from the date of commissioning and correct wind zone classification based on average CUF

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needs to be decided which will be applicable for the remaining tenure of EPA so that benefits of better efficiency can be passed on to the common consumers.

- MSEDCL further clarified that, revision in classification of wind zone will not affect the cost recovery of wind generators at all as they will get the MERC determined tariff in accordance to their CUF, but it will certainly provide relief to common consumers through reduction of power purchase cost.
- MSEDCL suggested that at least for 42 wind generators wind zone classification may be reviewed and revised immediately.

## Analysis:

Based on the suggestions the MERC order 152 of 2018, the analysis of CUF and related issues is being conducted in two parts. In the Part I of the analysis includes only 42 wind power projects under objection. In Part II of the analysis all the projects commissioned under MERC RE Tariff Regulations 2010 are analyzed.

## PART I

### 1.1 Analysis of Data Sample Size selected by MSEDCL

- MSEDCL had shortlisted a sample of 42 wind power projects with total installed capacity of 205.7MW out of the shortlisted 340 wind power projects commissioned under control period of MERC RE Tariff Regulations 2010 and were assigned Zones as per the wind power density at 50 mtr height.
- Further, the shortlisted / analyzed 340 wind power projects were generating at annual CUF of more than 20% (which is the upper limit for Zone 1) for first three years after their commissioning. From the 340 shortlisted projects the 42 projects are consistently generating at higher CUF than that of 20% for the first three years of commissioning.
- The sample of projects studied by MSEDCL is not the complete sample of wind power projects commissioned during the control period of MERC RE Tariff Regulations 2010.

**Table:** Installed Capacity of Wind Power Projects during the control Period of MERC TR Tariff Regulations 2010

Financial Year	Installed capacity wind power projects (in MW) Commissioned under the control period of MERC RE Tariff Regulation 2010
2010-11	239.05
2011-12	407.6
2012-13	288.55
2013-14	1074
2014-15	364.15
Total	2373.35

From above table, it can be analyzed that the sample selected by MSEDCL is not a complete sample and only 8.66% of wind power projects commissioned under MERC RE Tariff Regulations 2010 were analyzed.

## 1.2 Requirement of analysis of CUF and wind power density on wind farm basis

As per wind zoning procedure adopted by MEDA, the wind zones have been defined as per the wind power density of nearest wind mast at 50meter. Further, wind turbines within radial distance of 10 km are allowed to consider the mast data for wind zoning. Hence, the wind turbines close to the wind mast and falling within 10km radial distance will have same wind zone. The sample selected by MSEDCL is based on the higher generation for initial three years of period. The developer/investor may have part of the wind turbines towards prominent wind direction and part of it behind the first / second row of wind turbines which are bound to generate less due to array loss and/or due to positioned at the opposite side of the prominent wind direction. Hence, while analyzing the CUF and wind power density of selected 42 wind turbines the analysis has to be done for every wind mast and all the wind turbines which are referring the same mast needs to be considered while accessing the actual CUF achieved by these projects.

The shortlisted wind power projects and related wind masts, their installation date, ownership etc. related information is tabulated as follows:

Sr. No	Name of the Project	Capacity in MW	Details of Ref Wind Mast	Mast Ownership
<b>Nandurbar District</b>				
1	Hindustan Zinc Ltd	1.5	Mast 1	Suzlon
2	Hindustan Zinc Ltd	1.5	Village Chakla, Dist. Nandurabar 21°16'53.0" 74°18'30.2"	
<b>Kolhapur District</b>				
3	M/s Bhilwara Energy Ltd.	2	Mast 2	NIWE
			Village Katholi, Dist Kolhapur 16°57'54.2" 73°58'28.4"	
<b>Sangli District</b>				
4	GREEN INFRA WIND ENERGY LTD.(BS10 TO 13 SM1,11 T	13.5	Mast 3	ReGen Powertech
5	GREEN INFRA WIND ENERGY LTD. (BS15,4 TO 9 SM 2)	12	Village Bhud, Dist, Sangli 17°21'18.3" 74°41'48.9"	
6	GREEN INFRA WIND ENERGY LTD. (BS16 TO 19,22,24,	12		
7	GREEN INFRA WIND ENERGY LTD. (BS 20,25,27, SM7)	6		
<b>Mast 4</b>				
8	1)SHRADDHA ENERGY & INFRAPROJECTS PVT.LTD. (SH04 T	6	Village - Bhud (Kaledhon), Dist. Satara 17°27'52.8" 74°40'25.0"	ReGen Powertech
9	2)SHRADDHA ENERGY & INFRAPROJECTS PVT.LTD. (SH 09)	1.5		
10	5) PERTINENT INFRA & ENERGY LTD.( RB 08)	1.5		
11	3)SHRADDHA ENERGY & INFRAPROJECTS PVT.LTD. (RB 01	9		
12	6)TOPAZ INVESTMENTS PVT.LTD. (SH08)	1.5		
13	3) NSL WIND POWER COMPANY (SATARA)PVT.LTD. (NSL-03,	4.5		
14	7)PRIYADARSHINI POLYSACKS LTD. (RB 14)	1.5		
15	8)PRISTINE INDUSRIES LTD. (RB 15)	1.5		
16	Green Infra BTV Ltd.	1.50		
<b>Mast 5</b>				
17	Rajasthan Gum Pvt. Ltd.	2.1	Village - Jath II, Dist. Sangli 16°58'48" 75°13'52.3"	Suzlon
<b>Mast 6</b>				
18	3)SUYOG DEVELOPMENT CORPORATION LTD.(F17,18)	1.6	Village Jamb Ambheri, Dist. Satara 17°36'48.9" 74°16'52.5"	Kenersys
19	2)BLP WIND PROJECT (AMBHERI)PVT LTD. ((F1 TO 7))	5.6		
20	3)BLP WIND PROJECT (AMBHERI)PVT LTD. ((F8 TO 9))	1.6		
<b>Mast 7</b>				
21	1) KHANDKE WIND ENERGY PVT.LTD.(KH74,75,77 TO KH 8	10.4	Village - Kaledhon, Dist. Satara 17°26'37.1" 74°40'25.1"	Enercon
<b>Mast 8</b>				
22	17)S K PARIK ( S 021)	1.25	Village - Sadawaghapur, Dist. Satara 17°25'26.7" 73°55'42.2"	Suzlon
23	18)B. C. & SONS. (S 023)	1.25		
<b>Mast 9</b>				

24	3)PURUSHOTTAM LOHIA(CHW03)	1.6	Village - Chavaneshware, Dist. Satara 17°52'48.8" 74°02'32.9"	Suzlon
Mast 10				
25	1) PANAMA WIND ENERGY PVT.LTD.(T8)	8	Village - Palsi, Dist. Satara 17°16'09.8" 73°49'48.4"	NIWE
26	RATNAGIRI WIND POWER PROJECT PVT.LTD. (T27 TO T28)	3.2		
27	1) RATNAGIRI WIND POWER PROJECT PVT. LTD. (T 13, 1	8		
28	2) RATNAGIRI WIND POWER PROJECT PVT.LTD. ( T18,19,	6.4		
Mast 11				
29	1) GREEN INFRA WIND ENERGY LTD. ( GF 07, 08,09,11,	7.5	Village - Humbarne, Dist. Satara 17°16'17.3" 73°48'01.5"	Suzlon
30	2) GREEN INFRA WIND ENERGY LTD. (GF 17)	1.5		
31	3) GREEN INFRA WIND ENERGY LTD. (GF 10,GF12 TO 15	9		
Mast 12				
32	1)BOTHE WIND FARM DEVELOPMENT PVT.LTD. (I-7)	2	Village - Bothe, Dist. Satara 17°47'8.7" 74°22'8.3"	Vestas Wind Technologies
Mast 13				
33	RATNAGIRI WIND POWER PROJECT PVT.LTD. (T 32,34,36,	8	Village - Kalkewadi, Dist. Satara 17°17'54.7" 73°54'08.7"	Green Mint Power Pvt. Ltd
Mast 14				
34	BMD Pvt. Ltd.	4.50	Village - Agaswadi, Dist. Satara 17°33'28.9" 74°37'22.0"	ReGen Powertech
35	Bhilwara Green Energy Ltd.	9.00		
36	Bhilwara Green Energy Ltd.	9.00		
37	Bhilwara Green Energy Ltd.	3.00		
38	Bhilwara Green Energy Ltd.	4.50		
39	BMD Pvt. Ltd.	1.50		
40	Bhilwara Green Energy Ltd.	1.50		
41	Bhilwara Green Energy Ltd.	1.50		
Total		205.7 MW		

- From above table it can be seen that the 42 wind power projects shortlisted by MSEDCL are spread across four districts and fourteen wind masts.
- While defining wind zone, data of nearest wind mast was referred. It can be observed that there will be additional wind power projects within the radial distance of 10km of the above 14 wind masts and hence the CUF data of all the projects within the radial distance of 10km needs to be analyzed. Also in some cases there are two wind masts within the radial distance of 10 km and the projects closest to wind mast were allotted wpd zone as per the nearest wind mast.
- Hence, analysis of CUF is done for a) wind farm located around the wind mast and b) for wind projects connected to the nearest substation considering one wind farm is connected to one substation.
- The wind masts associated with the shortlisted 42 wind power projects, their location, ownership details and installation date / data is as follows:

Table: List of Wind Masts Considered for Zoning of 42 wind power projects

Sr. no	District	Wind Farm/Mast details	Date of Commissioning / Period of data considered for zoning	Ownership of Wind Mast
1	Nandurbar	Village - Chakla, Dist. Nandurbar 21°16'53.0" 74°18'30.2"	Aug 2003 to Jul 2004	SUZLON
2	Kolhapur	Kotoli Taluka - Shahuwadi District - Kolhapur ,Latitude- N 16° 57' 54.2" Longitude- E 73° 58' 28.4"	May 1994 to Oct 1997	NIWE
3	Sangli 1	Village - Jath II, Dist. Sangli 16°58'48" 75°13'52.3"	Aug 2008 to Jul 2009	SUZLON

4	Sangli 2	Village - Bhud, Dist. Sangli 17°21'18.3" 74°41'48.9"	Dec 2010 to Nov 2011	ReGen Powertech
5	Sangli 3	Village Bhud Tal-Khatav Dist. Satara Latitude 17° 27' 52.8" N Longitude 74° 40' 25" E	May 2009 to Apr 2010	ReGen Powertech
6	Satara 1	Jamb Ambheri Tal. Khatav Dist. Satara Latitude - 17° 36' 48.9" N, Longitude - 74° 16' 52.5" E & Elevation- 990 m AMSL	Jan 2010 to Dec 2010	Kenersys
7	Satara 2	Khanapur, Tal. Khatav, Dist. Satara ,Latitude- 17° 26' 37.1" N Longitude- 74° 40' 25.1" E	Aug 2009 to July 2010	Enercon
8	Satara 3	Sadawaghapur Tal. Patan Dist. Satara Latitude - 17° 25' 26.7" N, Longitude - 73° 55' 42.2" E	Jul 2008 to Jun 2009	SUZLON
9	Satara 4	Village - Chavaneshware, Dist. Satara 17°52'48.8" 74°02'32.9"	Aug 2009 to July 2010	Enercon
10	Satara 5	Palshi Tal. Patan Dist. Satara Latitude - 17° 16' 09.8" N, Longitude - 73° 49' 34.02" E & Elevation - 1008 m AMSL, having WPD - 203.00 W/m <sup>2</sup> @ 50 m agl	21/10/2000	
11	Satara 6	Village - Humbarne, Dist. Satara 17°16'17.3" 73°48'01.5"	Apr 2010 to Mar 2011	Suzlon
12	Satara 7	Village - Bothe Taluka - Maan District - Satara (Latitude- N 17° 47' 08.7" Longitude- E 74° 22' 08.3"	Jun 2006 to May 2007	Vestas Wind Technologies
13	Satara 9	Natoshi Tal. Patan Dist. Satara Latitude - 17 17' 54.7" N, Longitude - 73° 54' 08.7" E	Dec 2008 to Nov 2009	Green Mint Power Pvt Ltd
14	Satara 10	Village - Agaswadi, Dist. Satara 17°33'28.9" 74°37'22.0"	Dec 2008 to Nov 2009	ReGen Powertech

- From above table it can be analyzed that out of these 14 wind masts one wind mast is owned by NIWE and rest 13 wind masts are owned by private developers. Hence, complete wind data of only one wind masts is available for analysis.
- The masts date of commissioning is not available. However, the period of measurement considered for wpd assessment is available and it is assumed that mast will be commissioned one / two months prior to the period of data collection. Hence, all the wind masts are commissioned prior to the date of publication of MERC RE tariff Regulations 2010 except one located at Budh. The mast owned by ReGen Powertech located at Budh had considered the data from Dec 2010 to Nov 2011 and mast owned by Suzlon located at Humbarne had considered the data from Apr 2010 to Mar 2011.

### 1.3 Analysis of CUF data on wind farm basis

The wind power projects commissioned within the radial distance of 10km or the projects for whom the wind mast data was referred were analyzed together considering to be a part of one wind farm. The detailed list wind power projects around the 42 wind power projects spread across 14 wind masts along with their actual CUF achieved is enclosed as Annexure 1 and its summary is presented as follows:

Sr. no	District	Wind Farm/Mast details	Total Installed Capacity in MW	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	Wind farm Average
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1	Nandurbar	Village - Chakla, Dist. Nandurbar 21°16'53.0" 74°18'30.2"	73.8			25.04	25.23	19.27	22.16	23.46	20.31	22.58
2	Kolhapur	Kotoli Taluka - Shahuwadi District - Kolhapur ,Latitude- N 16° 57' 54.2" Longitude- E 73° 58' 28.4"	42						17.72	19.92	17.04	18.03
3	Sangli 1	Village - Jath II, Dist. Sangli 16°58'48" 75°13'52.3"	14.7				9.05	16.20	17.69	16.94	14.42	14.86
4	Sangli 2	Village - Bhud, Dist. Sangli 17°21'18.3" 74°41'48.9"	105				25.02	20.61	19.27	25.41	21.50	22.05
5	Sangli 3	Village Bhud Tal-Khatav Dist. Satara Latitude 17° 27' 52.8" N Longitude 74° 40' 25" E	97.5				25.30	20.97	22.83	26.18	22.20	23.40
6	Satara 1	Jamb Ambheri Tal. Khatav Dist. Satara Latitude - 17° 36' 48.9" N, Longitude - 74° 16' 52.5" E & Elevation- 990 m AMSL	13.6				20.25		21.16	21.92	18.29	20.41
7	Satara 2	Khanapur, Tal. Khatav, Dist. Satara ,Latitude- 17° 26' 37.1" N Longitude- 74° 40' 25.1" E	31.2					12.40	23.35	25.92	22.17	20.96
8	Satara 3	Sadawaghapur Tal. Patan Dist. Satara Latitude - 17° 25' 26.7" N, Longitude - 73° 55' 42.2" E	29.7	12.47	14.71	20.63	16.40	14.91	17.77	22.92	19.18	18.05
9	Satara 4	Village - Chavaneshware, Dist. Satara 17°52'48.8" 74°02'32.9"	28.8		8.04	18.32	18.75	17.35	16.12	14.20	13.63	15.15
10	Satara 5	Palshi Tal. Patan Dist. Satara Latitude - 17° 16' 09.8" N, Longitude - 73° 49' 34.02" E & Elevation - 1008 m AMSL, having WPD - 203.00 W/m <sup>2</sup> @ 50 m agl	121.6				11.97	16.91	20.12	24.20	21.11	19.59
11	Satara 6	Village - Humbarne, Dist. Satara 17°16'17.3" 73°48'01.5"	20		11.77	10.96	9.83		14.93	22.14	15.76	15.21
12	Satara 7	Village - Bothe Taluka - Maan District - Satara (Latitude- N 17° 47' 08.7" Longitude- E 74° 22' 08.3"	193.4				10.79	19.01	10.87	23.95	23.62	18.05
13	Satara 9	Natoshi Tal. Patan Dist. Satara Latitude - 17 17' 54.7" N, Longitude - 73° 54' 08.7" E	44.8				21.67	15.08	19.76	22.01	19.13	19.65
14	Satara 10	Village - Agaswadi, Dist. Satara 17°33'28.9" 74°37'22.0"	34.50				26.24	22.54	22.82	24.54	20.22	23.09
		<b>Total</b>	<b>850.6</b>							<b>Average CUF</b>		<b>19.36</b>

From above it can be seen that out of 14 wind farms, 6 wind farm's average CUF is above 20%. The reasons for higher generation in the above wind farms may be any of the following:

- Wind farm's zone may be wrongly determined as Zone 1 instead of Zone II/III/IV.
- Higher generation may be due to deployment of high hub height wind turbines than that of 50 mtr

- Wind project / some of the wind turbines got the advantage of best location, elevation, lower array loss etc.
- Improved wind profile/pattern in the year when CUF was assessed as compared to that of the wind profile when wind mast's data was referred for measurement.

#### 1.4 Analysis of technology deployed in the 42 wind power projects

The shortlisted 42 projects under study are evaluated from the point of technology deployment, hub height, rotor diameter, installed capacity and make of wind turbine etc. The details are furnished as follows:

Table: Wind Turbine Technology details of 42 wind power projects

Sr.No	Name of Generator	WTG Capacity in MW	Turbine Make	Hub Height	Rotor Diameter in mtr
1	Rajasthan Gum Pvt. Ltd.,	2.1	Suzlon	80 mts	88
2	Bhilwara Energy Limited	2	Inox	80 mts	93
3	Hindustan Zinc Ltd	1.5	Suzlon	78.5 mts	82
		1.5		78.5 mts	82
4	Purushottam Lohia	0.80	Enercon	57 mts	53
					53
5	S K Parik	1.25	Suzlon	74.50 mts	66
6	B. C. & Sons.	1.25	Suzlon	74.50 mts	66
7	Shraddha Energy & Infra projects Pvt.Ltd.	1.50	Vensys 1.5 MW V77/82	85 mts	77
		1.50			77
		1.50			77
		1.50			77
8	Shraddha Energy & Infraprojects Pvt.Ltd.	1.50			77
9	Shraddha Energy & Infraprojects Pvt.Ltd.	1.50			77
		1.50			77
		1.50			77
		1.50			77
		1.50			77
		1.50			77
10	Priyadarshini Polysacks Ltd.	1.50	Vensys 82	85 mtr	82
11	Pertinent Infra & Energy Ltd.	1.50	Vensys 77	85 mtr	77
12	Topaz Investments Pvt.Ltd.	1.50	Vensys 77	85 mtr	77
13	BLP Wind Project (Ambheri)Pvt Ltd.	0.80	Gamesa Wind Turbine	60.6 mtr	59
		0.80			59
14	BMD Pvt. Ltd.	1.50	Vensys V82	85 mtr	82
		1.50			82
		1.50			82
15	Bhilwara Green Energy Ltd.	1.50	Vensys 77	85 mtr	77



		1.50			77
		1.50			77
		1.50			77
		1.50			77
		1.50			77
16	Bhilwara Green Energy Ltd.	1.50			77
		1.50			77
		1.50			77
		1.50			77
		1.50			77
		1.50			77
17	Bhilwara Green Energy Ltd.	1.50			77
		1.50			77
18	Bhilwara Green Energy Ltd.	1.50			77
		1.50			77
		1.50			77
19	Panama Wind Energy Pvt.Ltd.	1.60	G.E. Energy	80 mtr	82.5
		1.60			82.5
		1.60			82.5
		1.60			82.5
		1.60			82.5
20	Panama Wind Energy Pvt.Ltd.	1.60			82.5
21	Bothe Wind Farm Development Pvt.Ltd.	2.00	Vestas	95 mtr	100
22	Ratnagiri Wind Power Project Pvt.Ltd.	1.60	GE India Industrial Pvt Ltd	80 mtr	82.5
		1.60			82.5
		1.60			82.5
		1.60			82.5
		1.60			82.5
23	Pristine Industries Ltd.	1.50	Vensys 82	83.25 mtr	82
24	Suyog Development Corporation Ltd.	0.80	Gamesa	60.5	59
		0.80	Gamesa	60.5	59
25	BLP Wind Project (Ambheri)Pvt Ltd.	0.80	Gamesa Wind Turbine	60.6 mtr	59
		0.80			59
		0.80			59
		0.80			59
		0.80			59
		0.80			59
		0.80			59
26	BMD Pvt. Ltd.	1.50	Vensys V82	85 mtr	82
27	Bhilwara Green Energy Ltd.	1.50	Vensys 77	85 mtr	77
28	Bhilwara Green Energy Ltd.	1.50	Vensys 77	85 mtr	77
29	Green Infra BTV Ltd.	1.50	Vensys 77	85 mtr	76.84
30	Ratnagiri Wind Power Project Pvt.Ltd. 1 to 5,7 to	1.60	GE india	83 mtr	82.5



38	Green Infra Wind Energy Ltd.	1.50	Vensys 82	85 mtr	82
		1.50			82
		1.50			82
		1.50			82
		1.50			82
		1.50			82
		1.50			82
		1.50			82
		1.50			82
39	Green Infra Wind Energy Ltd.	1.50	Vensys 82	85 mtr	82
		1.50			82
		1.50			82
		1.50			82
		1.50			82
		1.50			82
		1.50			82
		1.50			82
		1.50			82
40	Green Infra Wind Energy Ltd.	1.50	Vensys 82	85 mtr	82
		1.50			82
		1.50			82
		1.50			82
		1.50			82
		1.50			82
		1.50			82
		1.50			82
		1.50			82
41	Green Infra Wind Energy Ltd.	1.50	Vensys 82	85 mtr	82
		1.50			82
		1.50			82
		1.50			82
42	NSL Wind Power Company(Satara)Pvt.Ltd.	1.50	Vensys 87	85 mtr	87
		1.50			87
		1.50			87
Total Installed Capacity		205.70			

From above it can be observed that the developers have installed wind turbines with higher hub heights than that of 50mtr as considered in the MERC RE Tariff Regulations 2010 for wind zone determination. The brief of Hub Height, Rotor diameter and make of wind turbines in the shortlisted 42 wind power projects is as follows:

Table: Brief list of wind turbine technology used in 42 projects

OEM	No of WTG	MW	Total MW	HH	RD
Suzlon	1	2.1	2.1	80	88

Suzlon	2	1.25	2.5	74.5	66
Suzlon	14	1.5	21	78.5	82
Inox	1	2	2	80	93
Vestas	1	2	2	95	100
Enercon	14	0.8	11.2	75	53
GE	31	1.6	49.6	80/83	82.5
ReGen	71	1.5	106.5	85	77/82
Gamesa	11	0.8	8.8	60.6	59
			205.7		

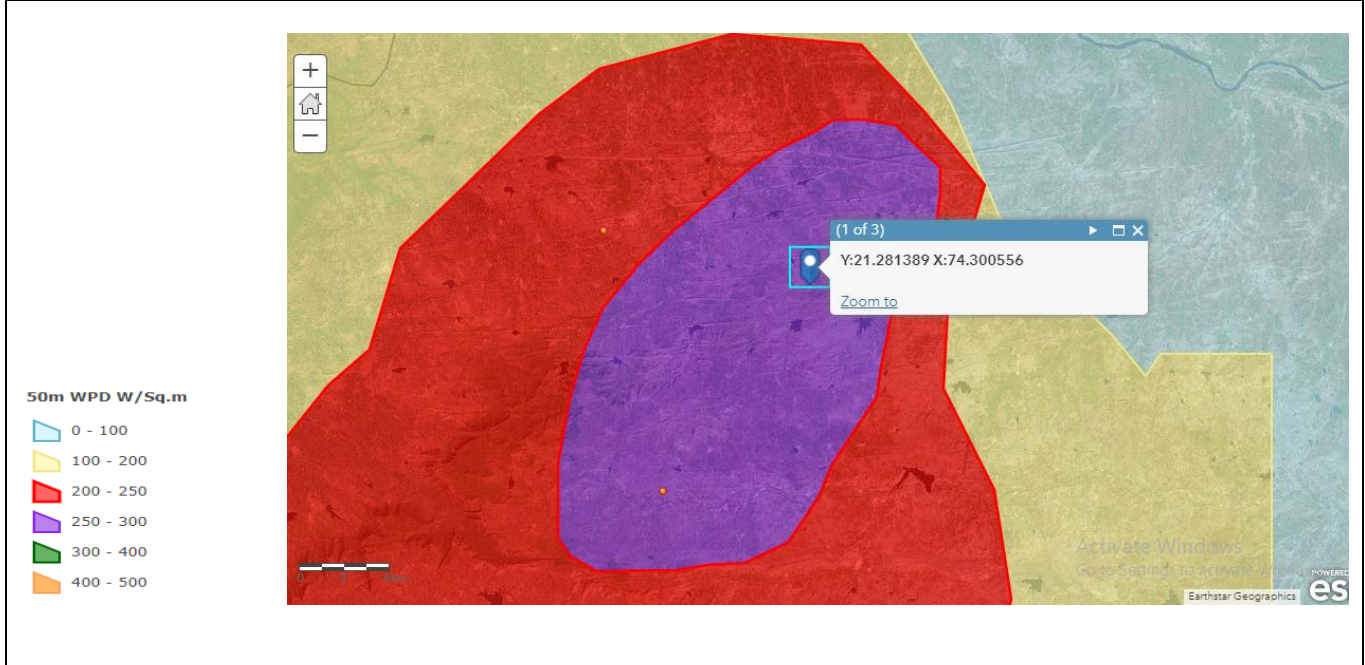
- From above table it can be analyzed that 42 shortlisted wind power projects includes turbines from different OEMs.
- The Hub height of wind turbines deployed is more than 50 mtr and is varying from 60.6 mtr to 95 mtr
- The rotor diameter is varying from 59 mtr to 100 mtr.
- The individual wind turbine capacity is varying from 0.8 MW to 2.1 MW

From above it is clear that all the wind turbines under 42 wind farms have hub height more than 60 meters. Whereas the CUF specified in the regulation is accessed at 50 mtr. Hence, the increased generation may also be due to increased hub height and rotor diameter etc.

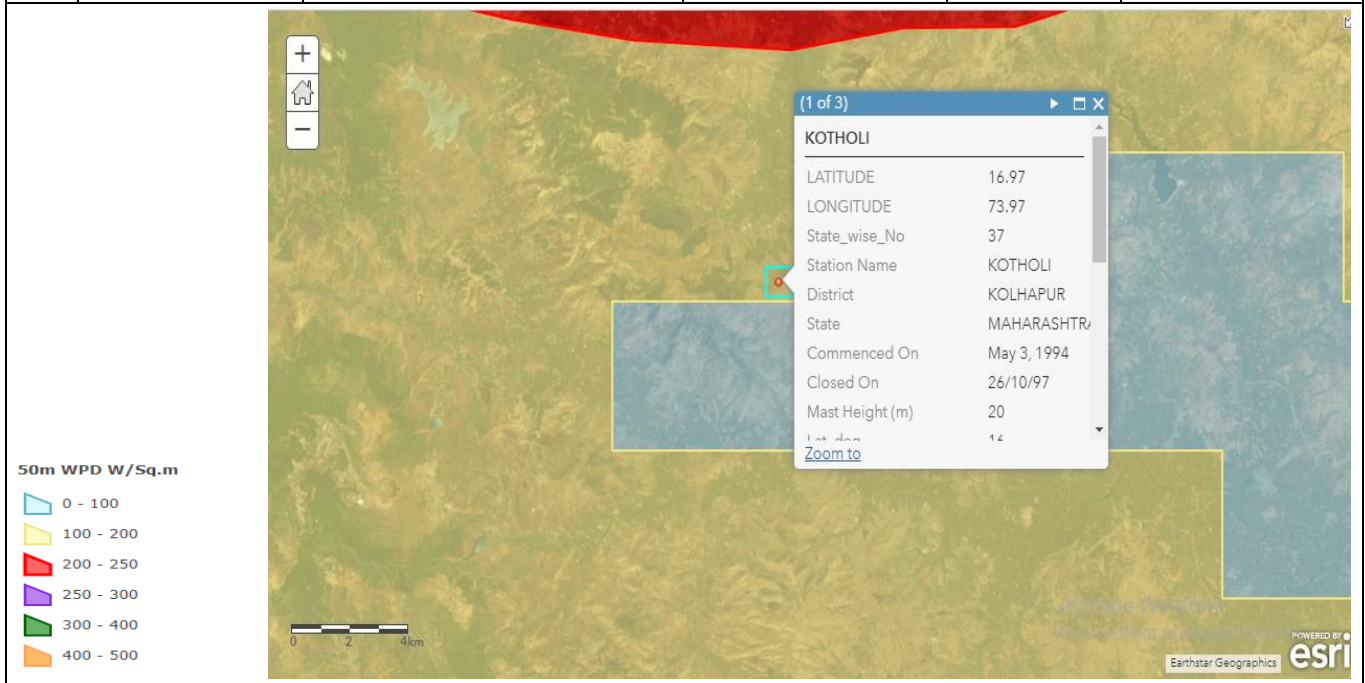
### 1.5 Analysis as per NIWE’s 50mtr WPD map at each wind project location:

NIWE had published 50 mtr WPD map which was used to verify the WPD and wind zone of the 42 wind power projects under study. The wind zoning was done as per the WPD at mast location at 50 mtr and made applicable for projects nearest to the mast and within maximum areal distance of 10 km. The wind masts locations were plotted on the NIWE’s 50 mtr WPD map in GIS arc and results are shown as follows:

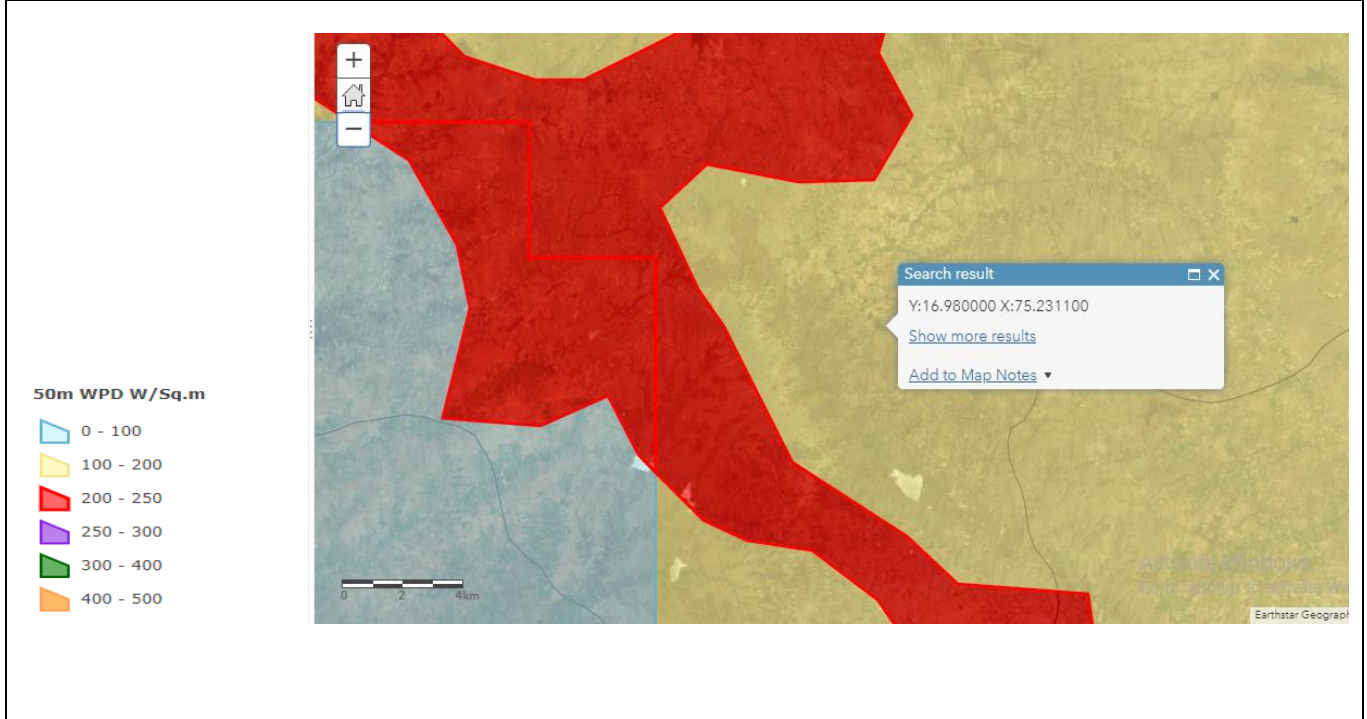
Sr. no	District	Mast details	WPD at 50 mtr as per mast data (Watt/m <sup>2</sup> )	Elevation m amsl	WPD as per NIWE's 50 mtr WPD map (Watt/m <sup>2</sup> )
1	Nandurbar	Village - Chakla, Lat 21°16'53.0" Lon 74°18'30.2"	227.78	353	250-300



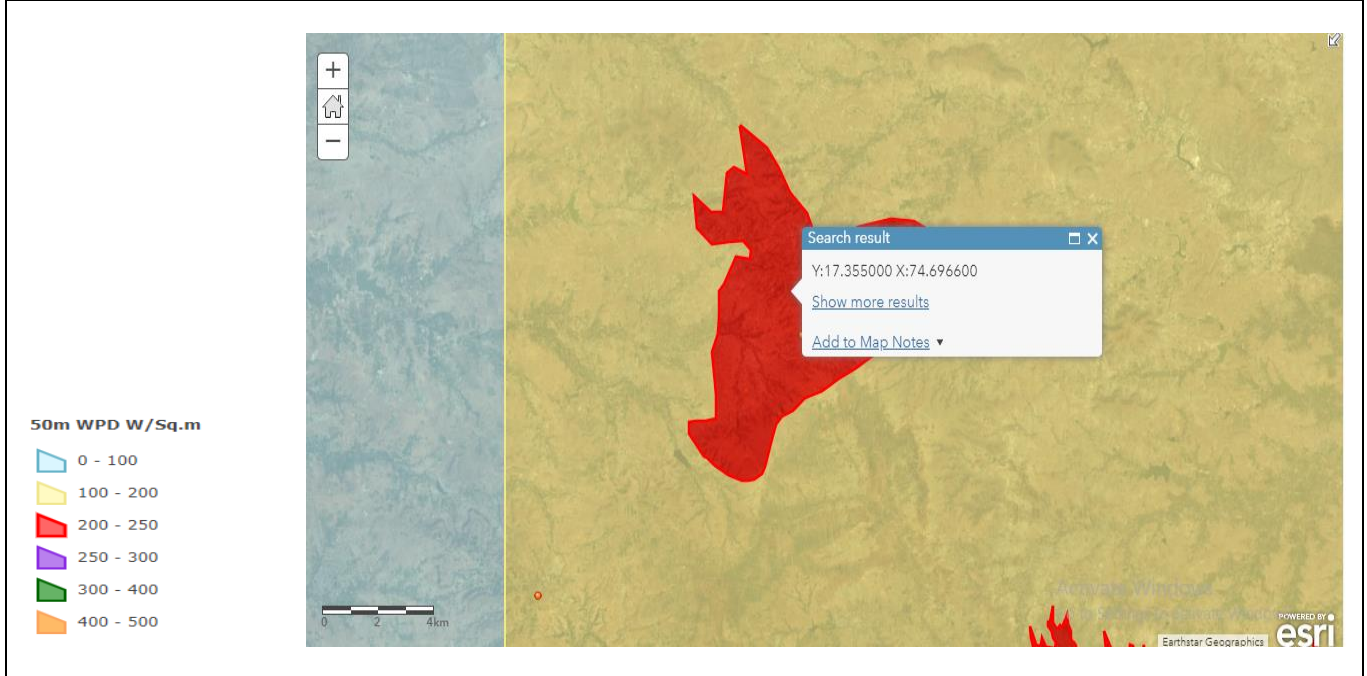
Sr. no	District	Mast details	WPD at 50 mtr as per mast data (Watt/m <sup>2</sup> )	Elevation m amsl	WPD as per NIWE's 50 mtr WPD map (Watt/m <sup>2</sup> )
2	Kolhapur	Kotoli Taluka - Shahuwadi Lat - N 160 57' 54.2" Long E 730 58' 28.4"	180	782	100-200



Sr. no	District	Mast details	WPD at 50 mtr as per mast data (Watt/m <sup>2</sup> )	Elevation m amsl	WPD as per NIWE's 50 mtr WPD map (Watt/m <sup>2</sup> )
3	Sangli 1	Village - Jath II, Dist. Sangli 16°58'48" 75°13'52.3"	210.96	749	100-200

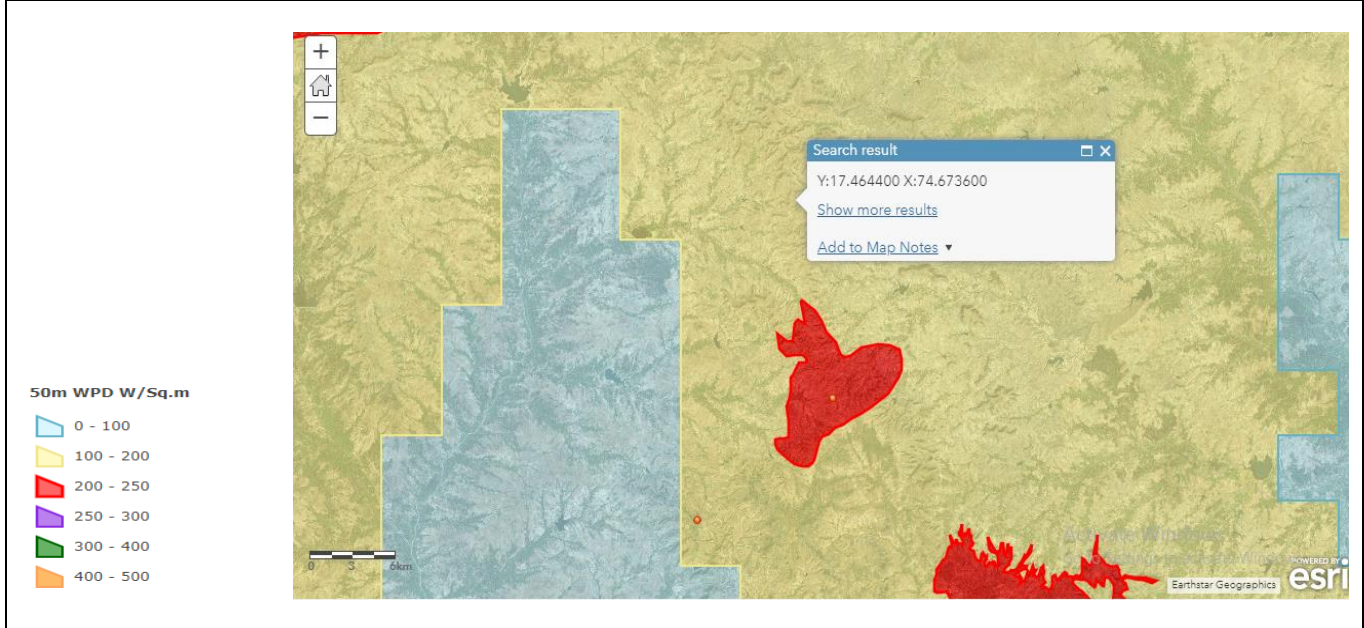


Sr. no	District	Mast details	WPD at 50 mtr as per mast data (Watt/m <sup>2</sup> )	Elevation m amsl	WPD as per NIWE's 50 mtr WPD map (Watt/m <sup>2</sup> )
4	Sangli 2	Village - Bhud, Dist. Sangli 17°21'18.3" 74°41'48.9"	225.99	840	200-250

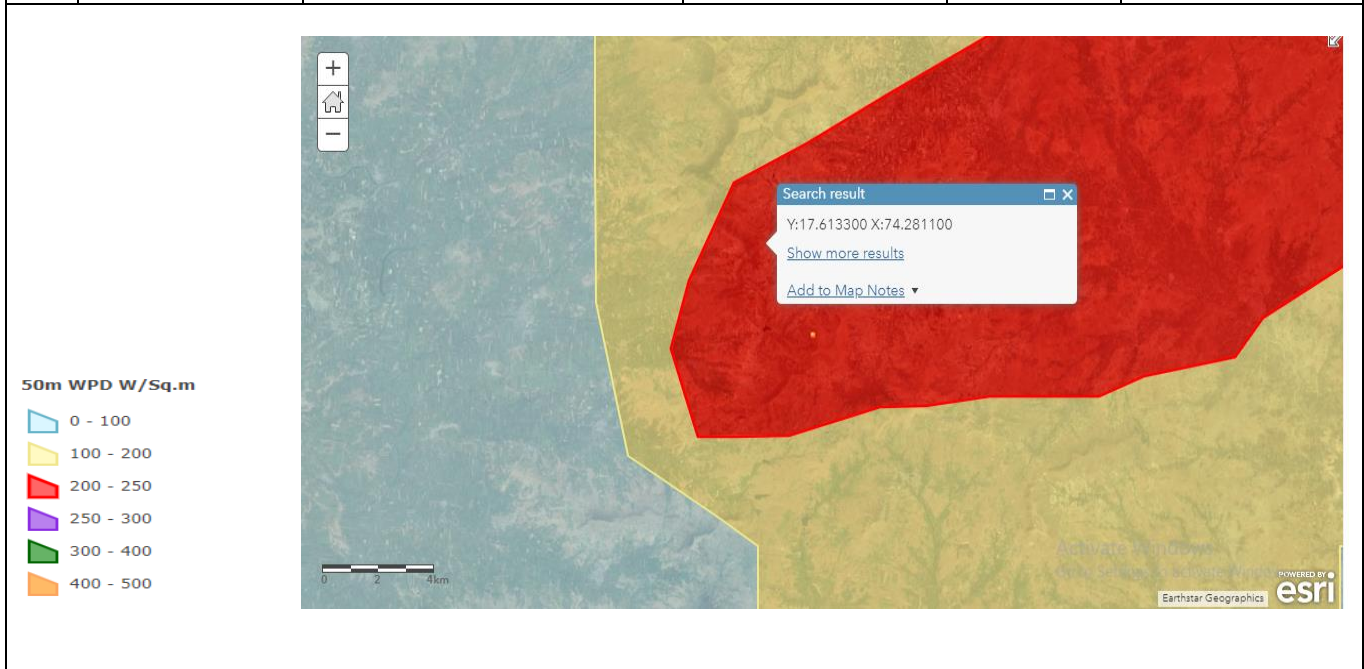




Sr. no	District	Mast details	WPD at 50 mtr as per mast data (Watt/m <sup>2</sup> )	Elevation m amsl	WPD as per NIWE's 50 mtr WPD map (Watt/m <sup>2</sup> )
5	Sangli 3	Village Bhud Lat 170 27' 52.8" N Long 740 40' 25" E	219.34	850	100-200

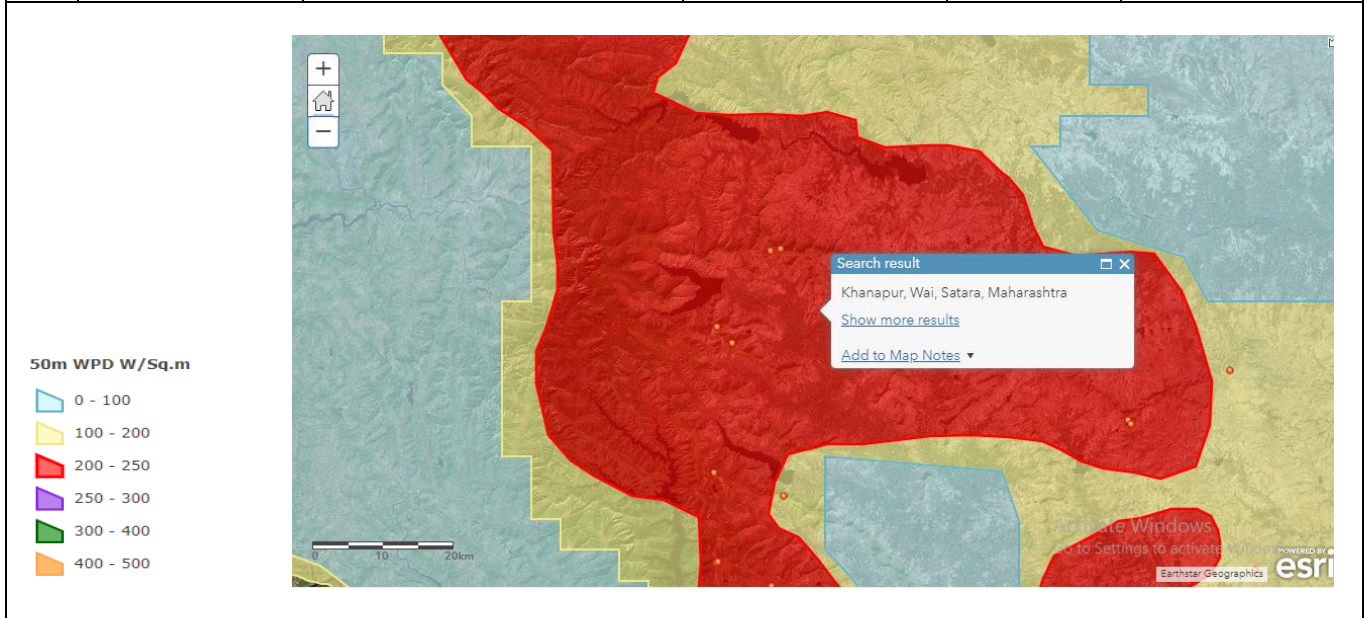


Sr. no	District	Mast details	WPD at 50 mtr as per mast data (Watt/m <sup>2</sup> )	Elevation m amsl	WPD as per NIWE's 50 mtr WPD map (Watt/m <sup>2</sup> )
6	Satara 1	Jamb Ambheri Tal. Khatav Lat- 170 36' 48.9" N, Long 740 16' 52.5" E	203.93	990	200-250

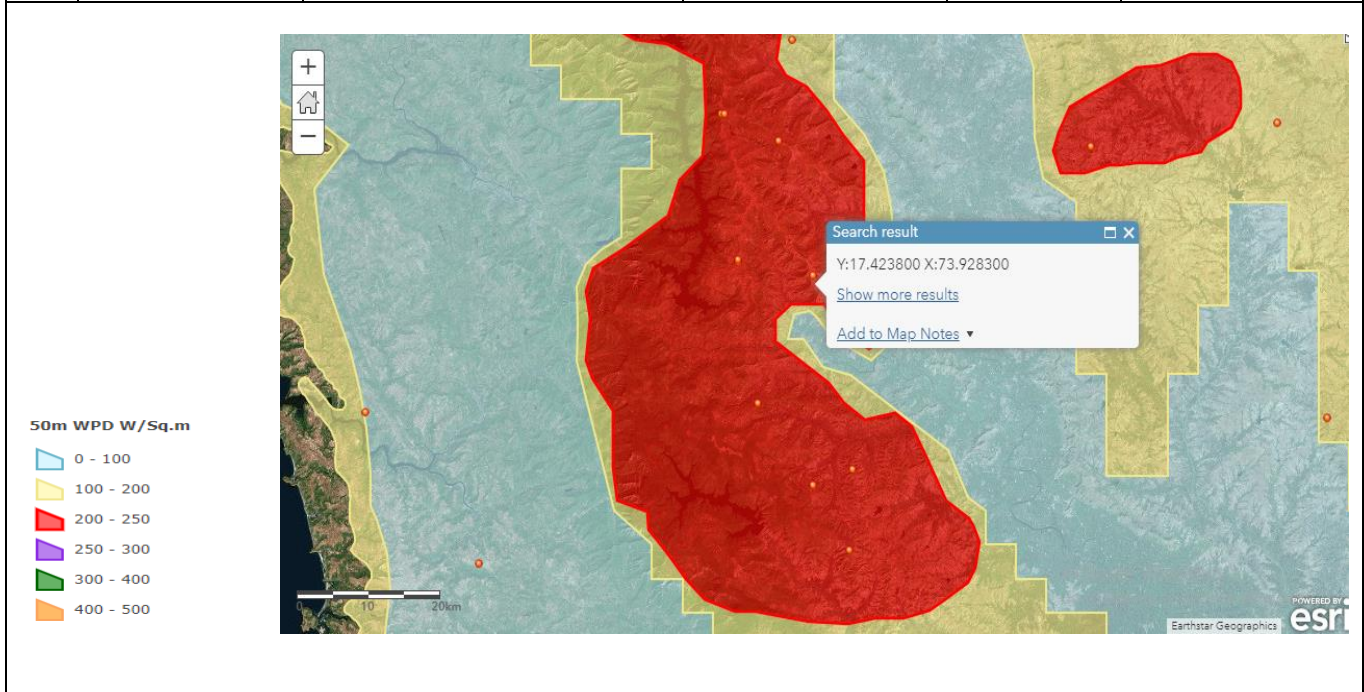


Sr. no	District	Mast details	WPD at 50 mtr as per mast data	Elevation m amsl	WPD as per NIWE's 50 mtr WPD map
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			(Watt/m <sup>2</sup> )		(Watt/m <sup>2</sup> )
7	Satara 2	Khanapur, Tal. Khatav, Lat 170 26' 37.1" N Long 740 40' 25.1" E	211.66	942	200-250



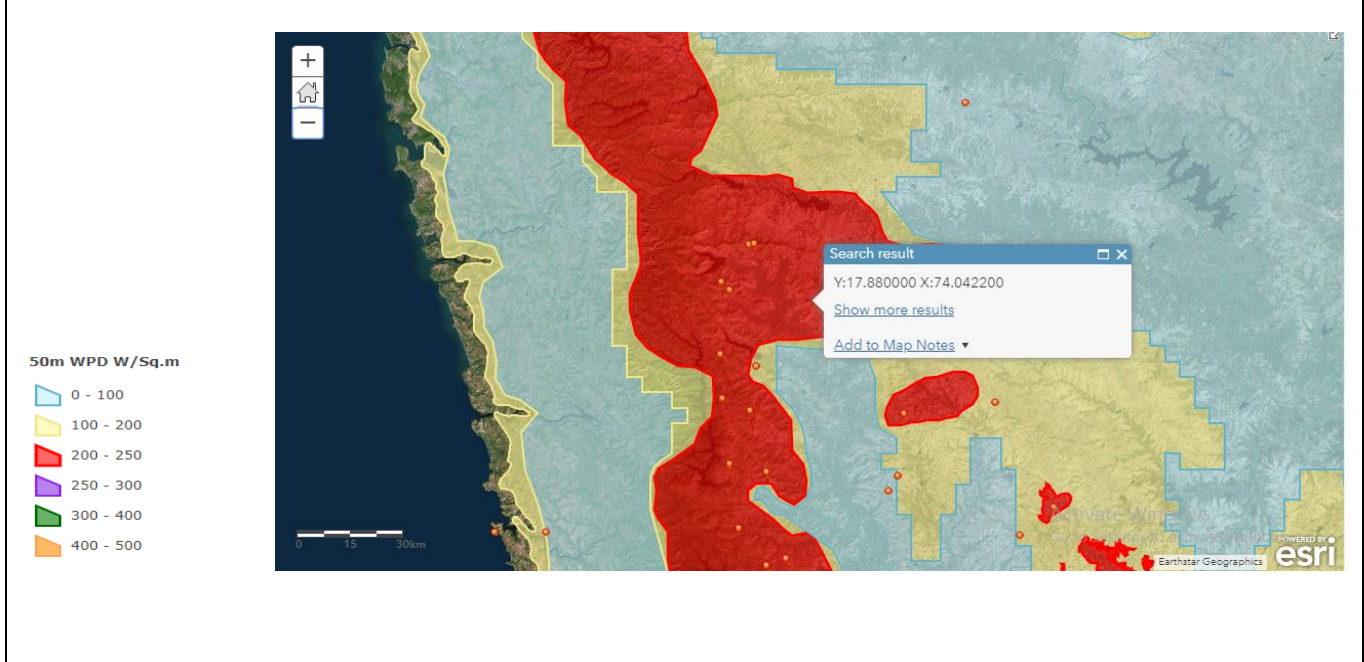
Sr. no	District	Mast details	WPD at 50 mtr as per mast data (Watt/m <sup>2</sup> )	Elevation m amsl	WPD as per NIWE's 50 mtr WPD map (Watt/m <sup>2</sup> )
8	Satara 3	Sadawaghapur Tal. Patan Dist. Satara Lat - 17° 25' 26.7" N, Long - 73° 55' 42.2" E	211.76	1074	200-250



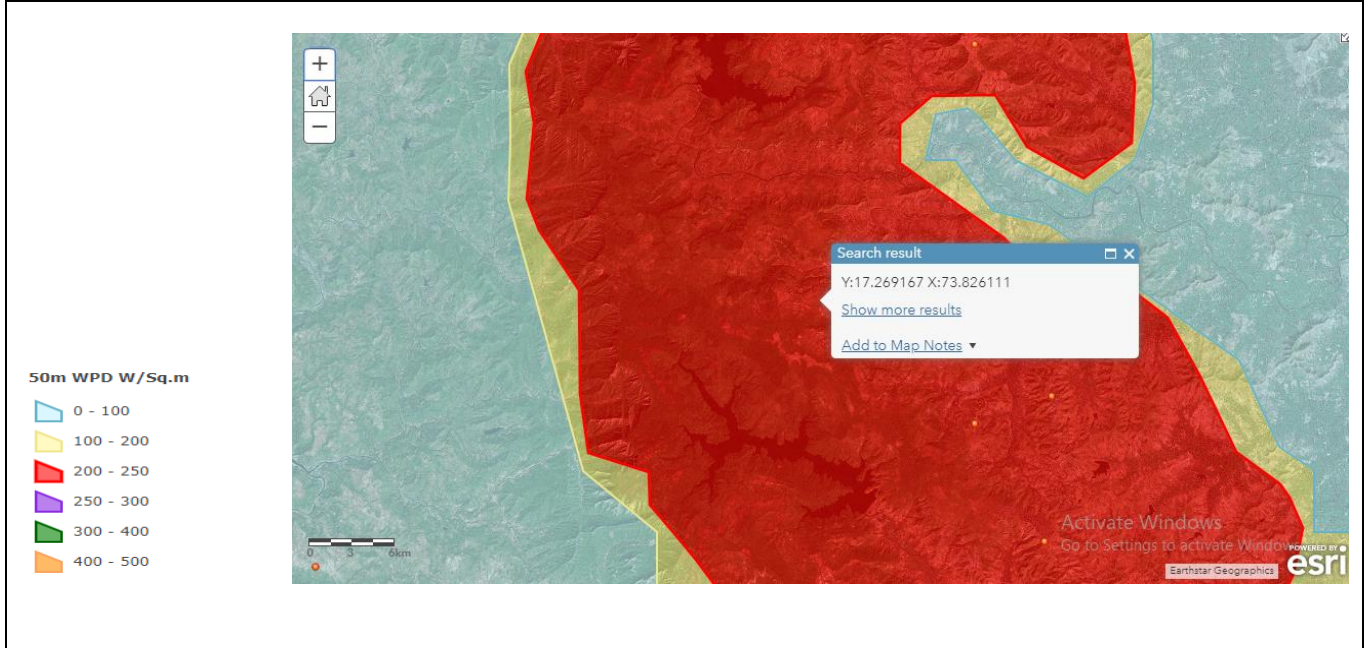
Sr. no	District	Mast details	WPD at 50 mtr as per mast data (Watt/m <sup>2</sup> )	Elevation m amsl	WPD as per NIWE's 50 mtr WPD map (Watt/m <sup>2</sup> )
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9	Satara 4	Village - Chavaneshware, Dist. Satara 17°52'48.8" 74°02'32.9"	234	1185	200-250
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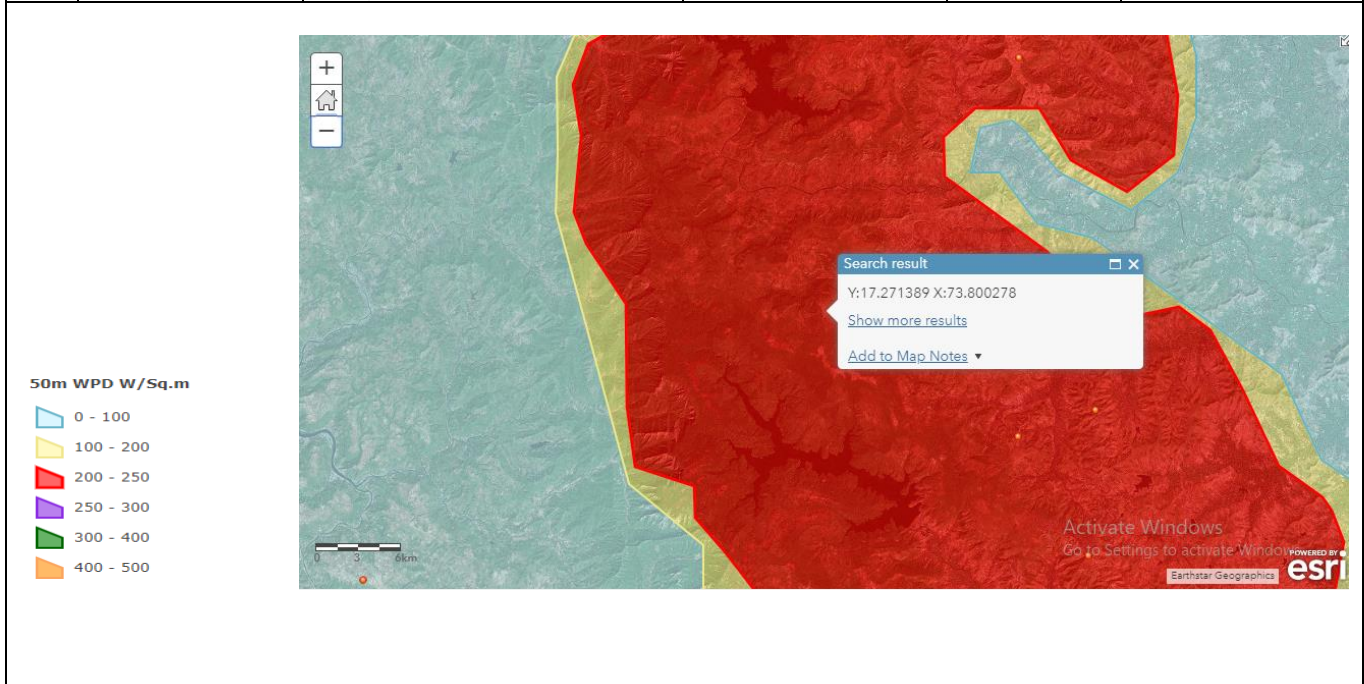


Sr. no	District	Mast details	WPD at 50 mtr as per mast data (Watt/m <sup>2</sup> )	Elevation m amsl	WPD as per NIWE's 50 mtr WPD map (Watt/m <sup>2</sup> )
10	Satara 5	Palshi Tal. Patan Lat 17° 16' 09.8" N, Long 73° 49' 34.02" E	203	1008	200-250

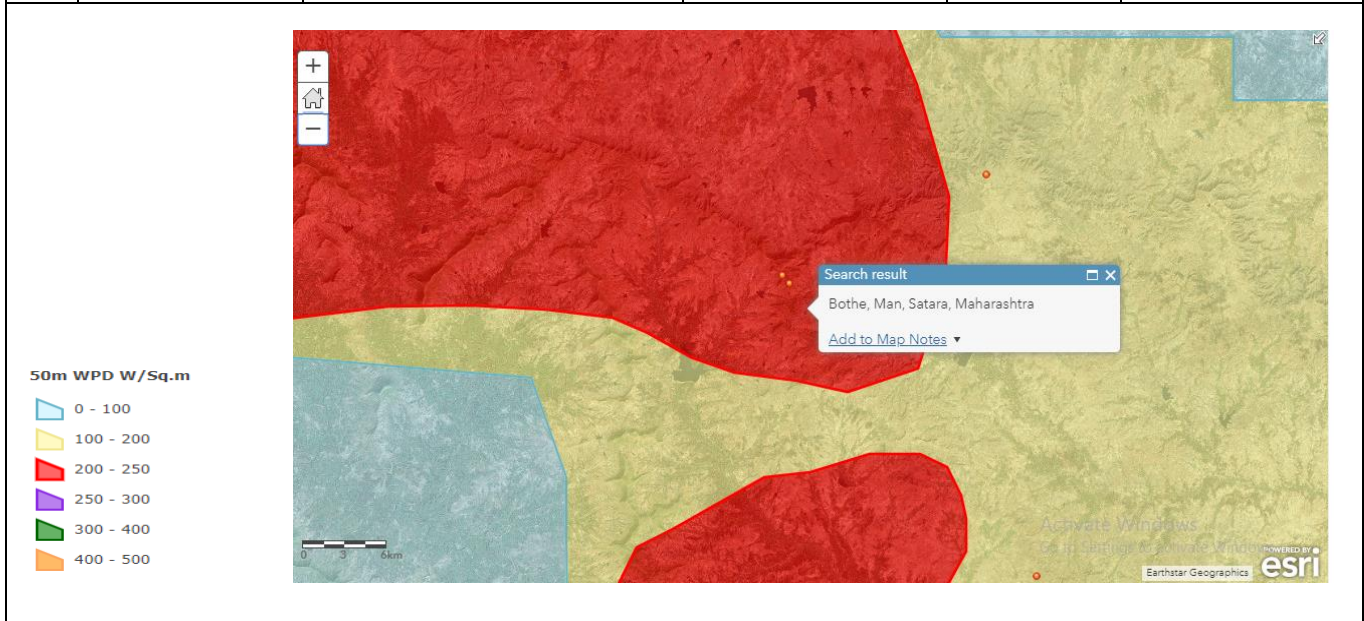


Sr. no	District	Mast details	WPD at 50 mtr as per mast data (Watt/m <sup>2</sup> )	Elevation m amsl	WPD as per NIWE's 50 mtr WPD map (Watt/m <sup>2</sup> )
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11	Satara 6	Village - Humbarne, Lat 17°16'17.3" Long 73°48'01.5"	222.59	1001	200-250
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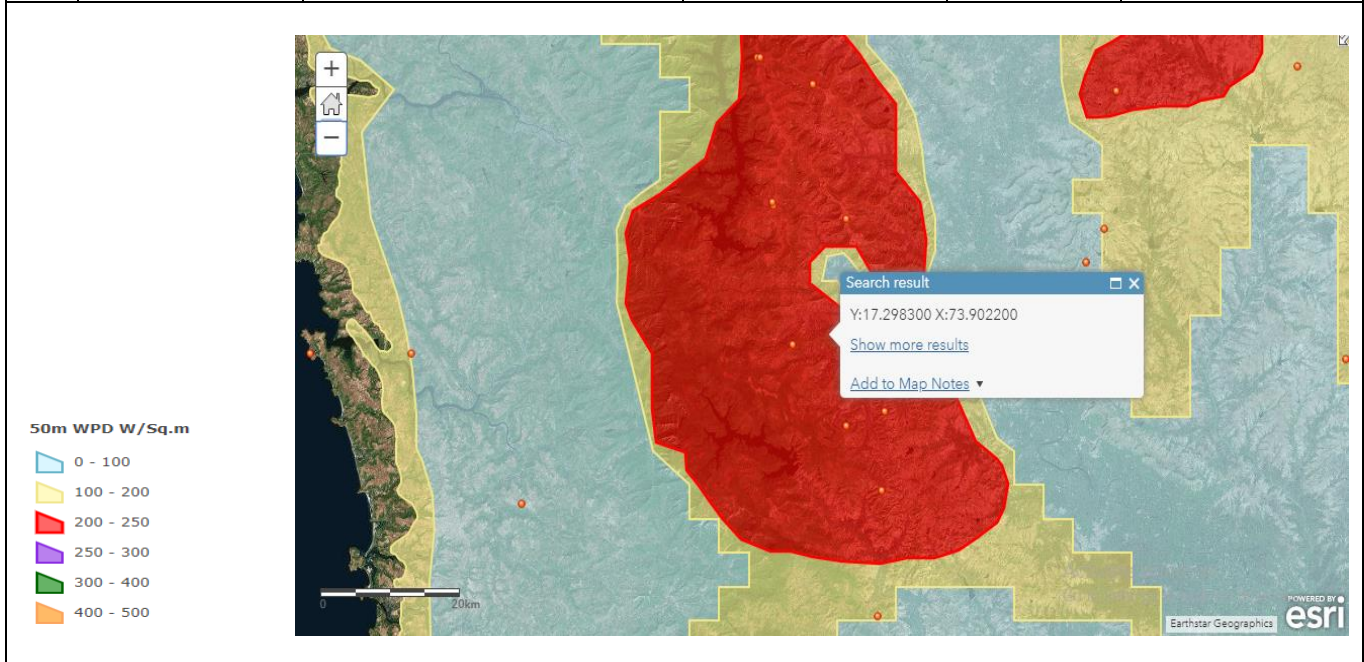
Sr. no	District	Mast details	WPD at 50 mtr as per mast data (Watt/m2)	Elevation m amsl	WPD as per NIWE's 50 mtr WPD map (Watt/m2)
12	Satara 7	Village - Bothe Taluka - Maan Lat N 17° 47' 08.7" Lon E 74° 22' 08.3"	214.2	1040	200-250



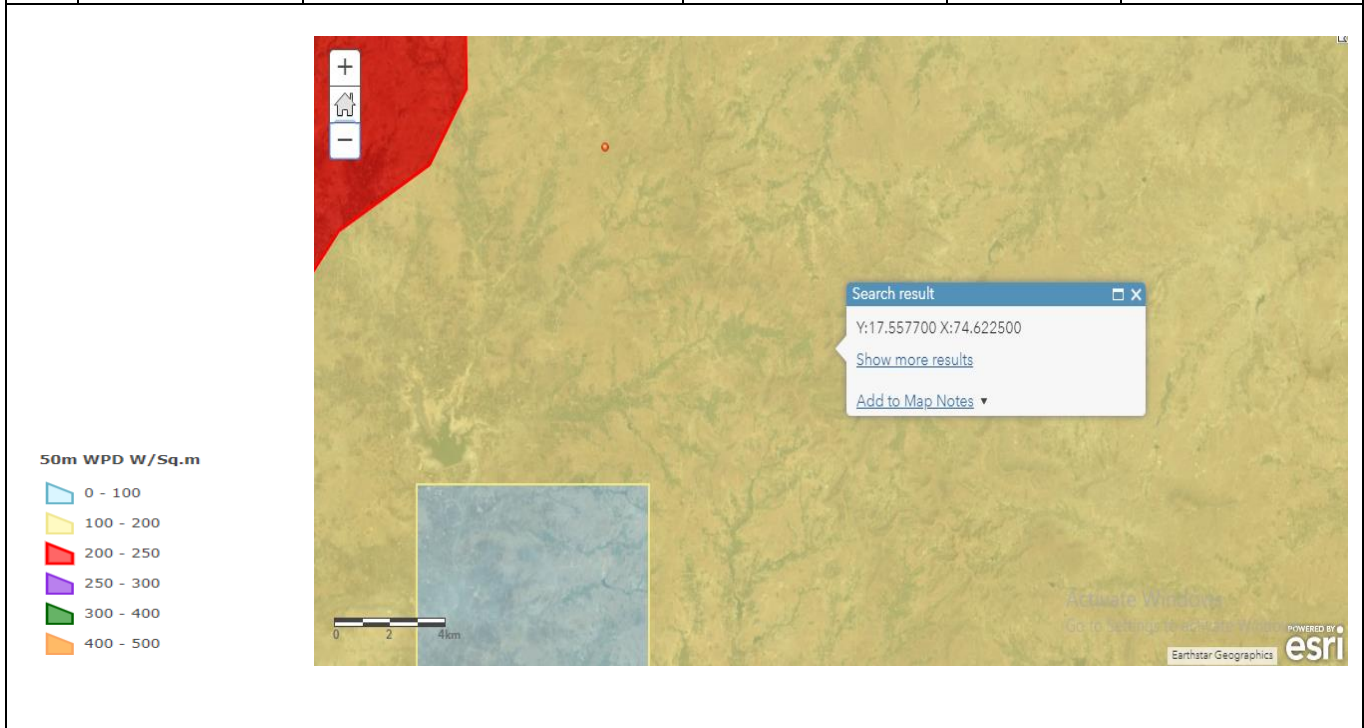
Sr. no	District	Mast details	WPD at 50 mtr as per mast data	Elevation m amsl	WPD as per NIWE's 50 mtr WPD map
--------	----------	--------------	--------------------------------	------------------	----------------------------------



			(Watt/m <sup>2</sup> )		(Watt/m <sup>2</sup> )
13	Satara 9	Natoshi Tal. Patan Lat- 17 17' 54.7" N, Long 730 54' 08.7" E	222.15	979	200-250



Sr. no	District	Mast details	WPD at 50 mtr as per mast data (Watt/m <sup>2</sup> )	Elevation m amsl	WPD as per NIWE's 50 mtr WPD map (Watt/m <sup>2</sup> )
14	Satara 10	Village - Agaswadi, Dist. Satara 17°33'28.9" 74°37'22.0"	200	890	100-200



Observations:

- All the fourteen wind masts under study falls under the WPD up to 250 watts / sq.mtr except the mast located at Chakla in district Nandurbar.
- As per the 50 mtr WPD map of NIWE it is observed that location Chakla falls under the WPD 250 to 300 watts/sq.mtr however, for the same location the extrapolated WPD from NIWE's mast is 323 i.e. within the WPD zone from 300 to 350. So there is in-consistency in NIWE's extrapolated WPD in the list of potential sites and that of GIS arc map.
- Further, all the WTGs located in the Chakla site in Nandurbar are plotted on the GIS arc and all of them except one WTG's falls under WPD zone of 250 to 300 as per the map.
- NIWE had studied the WPD for all the WTG locations in detail and certified the WPD. Based on NIWE's certified WPD for Chakla site the projects were allotted the Zone I WPD.
- The deviations in the extrapolation of WPD as per the NIWE's wind mast may be due to its measurement height at 25 mtr and the measurement was done for the period between April 1999 to June 2000. On the contrary the measurement at Chakla for Suzlon mast was for the period from August 2003 to July 2004 at 50 mtr height and there is no uncertainty with measurement at 50 mtr than that of extrapolated data.

### 1.6 Analysis of extrapolated WPD at Hub Height

It was observed that there is elevation difference at wind mast and WTG location. Further, the WPD was measured at 50 mtr and the same was made applicable for the wind turbines having higher hub heights for wind zone determination. An analysis is being carried out by theoretically extrapolating the wind speed and WPD at hub height. The revised WPD at hub height will be compared with the wind zones specified in the Regulation 2010. The results of said exercise are presented as follows:

Sr. No	Name of Generator	Capacity in MW	Hub Height	Mast height	Mast Elevation	WTG Elevation	WPD at 50 mtr height	WPD at extrapolated height	WPD Zone for extrapolated WPD at Hub Height
1	Rajasthan Gum Pvt. Ltd.,	2.1	80	50.00	749	722	210.96	215.97	Zone I
2	Bhilwara Energy Limited	2	80	50.00	782	798	180	231.78	Zone I
3	Hindustan Zinc Ltd	1.5	78.5	50.00	353	397	227.78	320.69	Zone III
		1.5	78.5	50.00	353	492	227.78	391.81	Zone III
4	Purushottam Lohia	0.80	57	50.00	1185	1019	234		Zone I
			57	50.00	1185	1006	234		Zone I
5	S K Parik	1.25	74.50	50.00	1074	1065	211.76	235.74	Zone I
6	B. C. & Sons.	1.25	74.50	50.00	1074	1067	211.76	238.51	Zone I
7	Shraddha Energy & Infraprojects Pvt.Ltd.	1.50	85	50.00	850	884	219.34	305.59	Zone III
		1.50	85	50.00	850	900	219.34	319.76	Zone III
		1.50	85	50.00	850	900	219.34	319.76	Zone III

		1.50	85	50.00	850	900	219.34	319.76	Zone III
8	Shraddha Energy & Infracorps Pvt.Ltd.	1.50	85	50.00	850	901	219.34	320.60	Zone III
9	Shraddha Energy & Infracorps Pvt.Ltd.	1.50	85	50.00	850	880	219.34	301.82	Zone III
		1.50	85	50.00	850	885	219.34	306.52	Zone III
		1.50	85	50.00	850	884	219.34	305.59	Zone III
		1.50	85	50.00	850	887	219.34	308.35	Zone III
		1.50	85	50.00	850	878	219.34	299.90	Zone II
		1.50	85	50.00	850	886	219.34	307.44	Zone III
10	Priyadarshini Polysacks Ltd.	1.50	85	50.00	850	865	219.34	286.74	Zone II
11	Pertinent Infra & Energy Ltd.	1.50	85	50.00	850	902	219.34	321.44	Zone III
12	Topaz Investments Pvt.Ltd.	1.50	85	50.00	850	900	219.34	319.76	Zone III
13	BLP Wind Project (Ambheri)Pvt Ltd.	0.80	60.6	50.00	990	998	203.93	231.14	Zone I
		0.80	60.6	50.00	990	984	203.93	211.27	Zone I
14	BMD Pvt. Ltd.	1.50	85	50.00	890	883	200	238.16	Zone I
		1.50	85	50.00	890	881	200	235.81	Zone I
		1.50	85	50.00	890	864	200	213.69	Zone I
15	Bhilwara Green Energy Ltd.	1.50	85	50.00	890	918	200	273.46	Zone II
		1.50	85	50.00	890	928	200	281.99	Zone II
		1.50	85	50.00	890	927	200	281.17	Zone II
		1.50	85	50.00	890	922	200	276.94	Zone II
		1.50	85	50.00	890	920	200	275.21	Zone II
		1.50	85	50.00	890	916	200	271.68	Zone II
16	Bhilwara Green Energy Ltd.	1.50	85	50.00	890	913	200	268.97	Zone II
		1.50	85	50.00	890	924	200	278.65	Zone II
		1.50	85	50.00	890	919	200	274.34	Zone II
		1.50	85	50.00	890	938	200	290.02	Zone II
		1.50	85	50.00	890	922	200	276.94	Zone II
		1.50	85	50.00	890	940	200	291.57	Zone II
17	Bhilwara Green Energy Ltd.	1.50	85	50.00	890	921	200	276.08	Zone II
		1.50	85	50.00	890	944	200	294.61	Zone II
18	Bhilwara Green Energy Ltd.	1.50	85	50.00	890	918	200	273.46	Zone II
		1.50	85	50.00	890	924	200	278.65	Zone II
		1.50	85	50.00	890	938	200	290.02	Zone II
19	Panama Wind Energy Pvt.Ltd.	1.60	80	50.00	1008	970	203	189.02	Zone I
		1.60	80	50.00	1008	970	203	189.02	Zone I
		1.60	80	50.00	1008	972	203	192.69	Zone I
		1.60	80	50.00	1008	981	203	207.82	Zone I
		1.60	80	50.00	1008	978	203	203.00	Zone I

20	Panama Wind Energy Pvt.Ltd.	1.60	80	50.00	1008	1008	203	244.08	Zone I
21	Bothe Wind Farm Development Pvt.Ltd.	2.00	95	50.00	1040	1055	214.2	290.01	Zone II
22	Ratnagiri Wind Power Project Pvt.Ltd.	1.60	80	50.00	979	986	222.15	275.72	Zone II
		1.60	80	50.00	979	895	222.15		Zone I
		1.60	80	50.00	979	869	222.15		Zone I
		1.60	80	50.00	979	974	222.15	260.60	Zone II
		1.60	80	50.00	979	851	222.15		Zone I
23	Pristine Industries Ltd.	1.50	83.25	50.00	850	853	219.34	271.34	Zone II
24	Suyog Development Corporation Ltd.	0.80	60.5	50.00	990	986	203.93	214.18	Zone I
		0.80	60.5	50.00	990	985	203.93	212.66	Zone I
25	BLP Wind Project (Ambheri)Pvt Ltd.	0.80	60.6	50.00	990	992	203.93	223.03	Zone I
		0.80	60.6	50.00	990	996	203.93	228.50	Zone I
		0.80	60.6	50.00	990	986	203.93	214.33	Zone I
		0.80	60.6	50.00	990	1004	203.93	238.74	Zone I
		0.80	60.6	50.00	990	1005	203.93	239.96	Zone I
		0.80	60.6	50.00	990	1017	203.93	253.76	Zone II
		0.80	60.6	50.00	990	1014	203.93	250.45	Zone II
26	BMD Pvt. Ltd.	1.50	85	50.00	890	887	200	242.74	Zone I
27	Bhilwara Green Energy Ltd.	1.50	85	50.00	890	885	200	240.47	Zone I
28	Bhilwara Green Energy Ltd.	1.50	85	50.00	890	928	200	281.99	Zone II
29	Green Infra BTV Ltd.	1.50	85	50.00	850	872	219.34	293.98	Zone II
30	<u>Ratnagiri Wind Power Project Pvt.Ltd. 1 to 5,7 to 10</u>	1.60	83	50.00	1008	983	203	215.43	Zone I
		1.60	83	50.00	1008	987	203	221.18	Zone I
		1.60	83	50.00	1008	1001	203	239.35	Zone I
		1.60	83	50.00	1008	993	203	229.30	Zone I
		1.60	83	50.00	1008	993	203	229.30	Zone I
		1.60	83	50.00	1008	987	203	221.18	Zone I
		1.60	83	50.00	1008	988	203	222.57	Zone I
		1.60	83	50.00	1008	985	203	218.34	Zone I
		1.60	83	50.00	1008		203		Zone I
31	<u>Ratnagiri Wind Power Project Pvt. Ltd.</u>	8.00	83	50.00	1008	986	203	219.77	Zone I
			83	50.00	1008	983	203	215.43	Zone I
			83	50.00	1008	962	203	179.27	Zone I
			83	50.00	1008	898	203		Zone I
32	<u>Ratnagiri Wind Power Project Pvt.Ltd.</u>	1.60	83	50.00	1008	904	203		Zone I
		1.60	83	50.00	1008	900	203		Zone I
		1.60	83	50.00	1008	968	203	190.87	Zone I
		1.60	83	50.00	1008	967	203	189.02	Zone I
33	Green Infra Wind	1.50	78.5	50.00	1001	1079	222.59	341.91	Zone III

	Energy Ltd.	1.50	78.5	50.00	1001	1069	222.59	334.05	Zone III
		1.50	78.5	50.00	1001	1068	222.59	333.25	Zone III
		1.50	78.5	50.00	1001	1066	222.59	331.62	Zone III
		1.50	78.5	50.00	1001	1007	222.59	273.24	Zone II
34	Green Infra Wind Energy Ltd.	1.50	78.5	50.00	1001	1022	222.59	290.45	Zone II
35	Green Infra Wind Energy Ltd.	1.50	78.5	50.00	1001	1067	222.59	332.43	Zone III
		1.50	78.5	50.00	1001	1048	222.59	316.13	Zone III
		1.50	78.5	50.00	1001	1032	222.59	300.87	Zone III
		1.50	78.5	50.00	1001	1024	222.59	292.60	Zone II
		1.50	78.5	50.00	1001	1019	222.59	287.18	Zone II
		1.50	78.5	50.00	1001	981	222.59	237.02	Zone I
36	Ratnagiri Wind Power Project Pvt.Ltd.	1.60	83	50.00	1008	988	203		Zone I
		1.60	83	50.00	1008	984	203		Zone I
37	Khandke Wind Energy Pvt.Ltd.	0.80	75	50.00	903	848	211.66	142.52	Zone I
		0.80	75	50.00	903	845	211.66	132.10	Zone I
		0.80	75	50.00	903	866	211.66	189.03	Zone I
		0.80	75	50.00	903	884	211.66	221.51	Zone I
		0.80	75	50.00	903	902	211.66	247.02	Zone I
		0.80	75	50.00	903	886	211.66	224.62	Zone I
		0.80	75	50.00	903	887	211.66	226.15	Zone I
		0.80	75	50.00	903	886	211.66	224.62	Zone I
		0.80	75	50.00	903	908	211.66	254.49	Zone II
		0.80	75	50.00	903	901	211.66	245.73	Zone I
		0.80	75	50.00	903	931	211.66	279.74	Zone II
		0.80	75	50.00	903	904	211.66	249.56	Zone I
		0.80	75	50.00	903	888	211.66	227.65	Zone I
38	Green Infra Wind Energy Ltd.	1.50	85	50.00	840	838	225.99	275.54	Zone II
		1.50	85	50.00	840	849	225.99	288.73	Zone II
		1.50	85	50.00	840	842	225.99	280.48	Zone II
		1.50	85	50.00	840	841	225.99	279.26	Zone II
		1.50	85	50.00	840	828	225.99	262.37	Zone II
		1.50	85	50.00	840	831	225.99	266.46	Zone II
		1.50	85	50.00	840	817	225.99	246.22	Zone I
		1.50	85	50.00	840	814	225.99	241.46	Zone I
		1.50	85	50.00	840	817	225.99	246.22	Zone I
39	Green Infra Wind Energy Ltd.	1.50	85	50.00	840	844	225.99	282.89	Zone II
		1.50	85	50.00	840	844	225.99	282.89	Zone II
		1.50	85	50.00	840	847	225.99	286.42	Zone II
		1.50	85	50.00	840	846	225.99	285.25	Zone II
		1.50	85	50.00	840	851	225.99	291.00	Zone II
		1.50	85	50.00	840	856	225.99	296.53	Zone II

		1.50	85	50.00	840	828	225.99	262.37	Zone II
		1.50	85	50.00	840	809	225.99	233.10	Zone I
40	Green Infra Wind Energy Ltd.	1.50	85	50.00	840	856	225.99	296.53	Zone II
		1.50	85	50.00	840	854	225.99	294.34	Zone II
		1.50	85	50.00	840	856	225.99	296.53	Zone II
		1.50	85	50.00	840	860	225.99	300.80	Zone II
		1.50	85	50.00	840	889	225.99	328.58	Zone III
		1.50	85	50.00	840	890	225.99	329.46	Zone III
		1.50	85	50.00	840	886	225.99	325.94	Zone III
		1.50	85	50.00	840	890	225.99	329.46	Zone III
41	Green Infra Wind Energy Ltd.	1.50	85	50.00	840	846	225.99	285.25	Zone II
		1.50	85	50.00	840	859	225.99	299.74	Zone II
		1.50	85	50.00	840	883	225.99	323.24	Zone III
		1.50	85	50.00	840	894	225.99	332.90	Zone III
42	NSL Wind Power Company(Satara)Pvt. Ltd.	1.50	85	50.00	850	873	219.34	294.98	Zone II
		1.50	85	50.00	850	869	219.34	290.92	Zone II
		1.50	85	50.00	850	863	219.34	284.61	Zone II

205.7

The summary of the 42 wind power projects as per their revised zones if zone wise WPD considered at actual hub height of installed wind turbine.

Summary		
Zones ( as per WPD at Hub Height of Turbine)	No. of WTGs	Capacity(MW)
Zone I	51	71.2
Zone II	55	80.4
Zone III	27	40.5
Zone I	11	13.6

205.7

#### Observations:

- In the case of private wind masts, the measurements were done at 50mtr and hence there should not be error in WPD at 50 mtr. However, in the case of NIWE wind mast at Katoli Dist. Kolhapur, the wind measurement and mast height was at 25 mtr and the same was extrapolated to 50 mtr. Extrapolating the same data further to WTG hub height may be at 80 mtr will further add error in measurements.
- The Wind Zone and related CUF determined in Regulation 2010 was at 50 mtr. If the WPD is measured at hub height and for that WPD zones are determined as per Regulation 2010 then it is observed that out of 205.7 MW commissioned in Zone I about 120.9 MW of installations will fall under Zone II and III.



- Here it needs to be understood that there are about 13.6MW of wind projects whose WTH Hub height is below the mast elevation and are considered in Zone I. In every complex terrain there will be some installations which will get the advantage of high elevation and may yield more generation and some will be at lower elevation and will produce less energy due to elevation.
- Further, some of the WTGs will get the advantage of their location and will generate more than the WTGs which are affect by high array loss within the same wind farm.
- If the CUF has to be accessed for each turbine location then higher generating WTGs will fetch low tariff and low generating WTGs will fetch high tariff. Hence, the issue needs to be analyzed holistically in the generic tariff determination process or project specific tariff for all the turbines will have to be accessed.

### 1.7 Analysis of theoretical CUF of Wind Farm with WAsP

The 42 wind power projects under study are spread across 14 wind masts. Out of these 14 wind masts only one wind mast is owned by NIWE and the rest are all installed by developers. As per the procedure, the wind developers had to get the data certified from NIWE for further development of wind farm. Initially for development of wind farm, the permitted wind power density of wind mast at 50 mtr was minimum 200 watts /sq.mtr and there after this criterion was relaxed. Hence the private developers had to get their wind mast data certified from NIWE. For this privately owned wind mast data, NIWE had NDA with developers, the hence the said wind data is not available in public domain. However, for the wind masts owned by NIWE, an autonomous institution of GoI, the said data is made freely available by NIWE and hence only one wind masts data was available for analysis.

The following mast’s data was owned by NIWE:

Wind Mast at: Kotoli Taluka - Shahuwadi District - Kolhapur,  
Latitude- N 160 57’ 54.2’’ Longitude- E 730 58’ 28.4’’, Elevation 782

With the NIWE’s wind mast data for Kotoli, WAsP analysis was carried out for one turbine from 42 projects list along with neighboring turbines. The WAsP analysis results are as enclosed in Annexure: 3.The summary of analysis is as follows:

Sl. No.	WTG ID	X- location [m]	Y- location [m]	Elevation [m]	Hub Height [m]	Net P50 CUF [%]	Net P75 CUF [%]	Net P90 CUF [%]	WPD @HH	Average CUF as per generation data (%)
1	BHT-01	383907	1878036	748	80	21.8	20.2	19.0	208.6	17.74
2	BHT-02	383694	1877438	732	80	21.7	20.2	19.0	206.7	17.96

3	BHT-04	383566	1876867	704	80	22.6	21.0	19.8	209.4	16.69
4	BHT-05	383671	1877085	711	80	24.2	22.5	21.2	208.0	17.15
5	BHT-11	384929	1876663	751	80	21.3	19.8	18.6	205.0	18.26
6	BHT-13	385383	1877518	805	80	22.2	20.6	19.4	201.0	20.35
7	BHT-14	385599	1878012	807	80	20.9	19.4	18.2	203.0	19.29
8	BHT-15	385517	1877776	800	80	24.7	23.0	21.6	204.1	20.66
9	BHT-03	384138	1875865	716	80	24.5	22.8	21.4	201.8	19.96
10	BHT-07	384278	1875610	727	80	21.7	20.1	19.0	203.0	21.34
11	BHT-08	384032	1876047	723	80	22.1	20.5	19.3	204.7	18.66
12	BHT-10	385131	1876930	796	80	23.2	21.5	20.3	207.0	22.02
13	BHT-17	384703	1876440	741	80	24.2	22.5	21.2	208.0	19.72
14	BHT-18	384282	1876292	721	80	22.1	20.6	19.4	206.3	19.26
15	BHT-19	386384	1876658	798	80	24.7	23.0	21.6	207.0	23.27
16	BHT-23	387106	387106	775	80	22.7	21.1	19.8	200.4	20.35
17	BHT-24	387098	1875772	776	80	22.1	20.6	19.4	207.0	13.68
18	BHT-31	388167	1875533	778	80	21.5	20.0	18.8	201.8	20.69
					Average	22.7	21.1	19.8		19.28

**Observation:**

- From the WASP analysis it is observed that WPD at WTG hub height is close to 200 Watts/sq mtr and it was certified as 180 watts / sq. mtr at 50 mtr height at mast location.
- The WTG no BHT-19 is showing highest generation of 23% at P75 probability and based on the actual generation data it is observed that it is generating at average CUF of 23.27%. Average CUF of the wind farm based on the actual generation was observed at 19.28% as against the WASP estimation of 21.1% at 75% probability.
- Out of the 18 wind turbines about 13 wind turbines location is at elevation lower than that of mast elevation and five turbines location is above the mast elevation of 782mtr. Because of elevation also there is generation gain observed in WASP analysis and also as per actual data.
- Further, from the analysis it was observed that the turbine BHT-19 which is generating consistently at higher annual CUF is due to its location as follows:

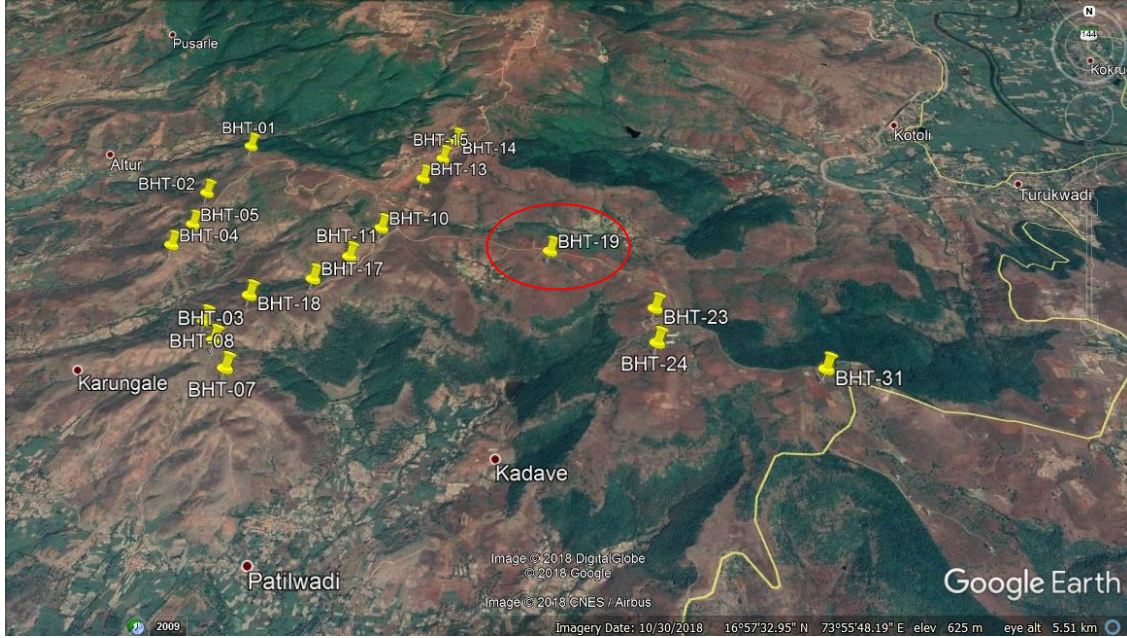


Figure: Location of WTG's in Kotoli wind farm

### 1.8 Review of Sample wind projects data on field

From the wind farms actual generation analysis done as above it was found that six wind farms out of 14 had average CUF more than 20%. The details of the wind farm are as follows:

Sr. no	District	Wind Farm/Mast details	Total Installed Capacity in MW	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	Wind farm Average
1	Nandurbar	Village - Chakla, Dist. Nandurbar 21°16'53.0" 74°18'30.2"	73.8			25.04	25.23	19.27	22.16	23.46	20.31	22.58
2	Sangli 2	Village - Bhud, Dist. Sangli 17°21'18.3" 74°41'48.9"	105				25.02	20.61	19.27	25.41	21.50	22.05
3	Sangli 3	Village Bhud Tal-Khatav Dist. Satara Latitude 17° 27' 52.8" N Longitude 74° 40' 25" E	97.5				25.30	20.97	22.83	26.18	22.20	23.40
4	Satara 1	Jamb Ambheri Tal. Khatav Dist. Satara Latitude - 17° 36' 48.9" N, Longitude - 74° 16' 52.5" E & Elevation- 990 m AMSL	13.6				20.25		21.16	21.92	18.29	20.41
5	Satara 2	Khanapur, Tal. Khatav, Dist. Satara ,Latitude- 17° 26' 37.1" N Longitude- 74° 40' 25.1" E	31.2					12.40	23.35	25.92	22.17	20.96
6	Satara 10	Village - Agaswadi, Dist. Satara 17°33'28.9" 74°37'22.0"	34.50				26.24	22.54	22.82	24.54	20.22	23.09

From above six shortlisted projects which are continuously generating at CUF higher than 20% the following two wind farms are shortlisted for field verification who have highest CUF among the six.:

Sr. no	District	Wind Farm/Mast details	Wind Projects Capacity in MW from 42 project	No of Projects	No of WTGS	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	Wind farm Average
3	Sangli 3	Village Bhud Tal-Khatav Dist. Satara Latitude 17° 27' 52.8" N Longitude 74° 40' 25" E	97.5	8	18 x 1.5MW		25.30	20.97	22.83	26.18	22.20	23.40
6	Satara 10	Village - Agaswadi, Dist. Satara 17°33'28.9" 74°37'22.0"	34.50	8	23 x1.5MW		26.24	22.54	22.82	24.54	20.22	23.09

The above two shortlisted wind farms have 17 projects out of 42 projects under study. Further these 17 wind projects had multiple wind turbines. The wind farm around wind mast located at Budh, Khatav has 18 wind turbines of 1.5MW of Regen Powertech and wind farm around wind mast located at Agaswadi had 23 wind turbines of 1.5 MW of ReGen Powertech. Out of the above shortlisted wind turbines field verification completed for following:

- Verification of location and elevation of wind mast located at Village - Agaswadi, Dist. Satara 17°33'28.9" 74°37'22.0"
- Verification of 24 wind turbine locations (36MW) around wind mast located at Village - Agaswadi completed
- Verification of 14 wind turbine locations (21MW) around wind mast located at Village – Budh, Khatav completed
- Onsite verification of 57 MW of wind projects location out of the 205.7 MW completed. Sample size 27%

#### Observations:

- The latitude and longitude of above all wind turbine locations and that of one wind mast located at Village - Agaswadi, Dist. Satara matched exactly. Minor deviation in last digits observed in some cases. This may be due to the location of measurement around wind turbine and this is accepted.
- There is variation observed in elevation of some of the wind turbines. The variation was close to 1 mtr to 5 mtr. Further, the elevation measurement was found to be different in the three GPS instruments used. This may be due to instrument to instrument error and is accepted.
- Further, it was observed in the field inspection that shortlisted wind turbines had location advantage and hence may have generated at more CUF e.g. valley in front and back of the wind turbine which has least array loss and best wind or the wind turbines located in the first row of wind farm.
- The hub height and rotor diameter could not be measured at site and same were verified with the name plate as available at some locations.

- 
- The areal distance of wind turbine location and mast location was verified in office on google earth and found to be within the permitted limit of 10 km for all the 38 wind turbines.
  - It was also observed that around the Agaswadi wind mast there were some wind turbines owned by Tata power which were not in the list of MSEDCL. Hence, those wind turbines generation couldn't be clubbed together to access the average CUF of wind farm.

## PART II

Part I of the study covers analysis of only 42 wind projects which were shortlisted by MSEDCL based on the consistent higher CUF data. These 42 projects were having total installed capacity of 205.7MW. As per the mandate of the study it is required to analyze the CUF of these 42 wind power projects and to propose revision in WPD and wind zone for these projects based on the actual generation data.

The partially selected wind power projects will not give the clear picture and based on this partial data it will not be prudent to comment on the WPD and revision in wind zone as allotted under MERC RE Tariff Regulations 2010. Hence, analysis of all the the wind power projects commissioned during the control period of MERC RE Tariff Regulations 2010 is required to access the possible revision in WPD zone for to avoid any undue advantage to wind project developers and to protect the interest of consumers of Maharashtra. Holistic review of data of wind projects commissioned during the control period of this regulation is carried out.

### 2.1 Analysis of CUF of wind projects commissioned from 2010-11 to 2014-15 district wise

During the control period of MERC RE Tariff Regulation 2010, i.e. during FY 2010-11 to 2014-15 about 2373.35MW of wind power projects were commissioned in Maharashtra. Of these projects about 1918MW of wind power projects were commissioned for sale to MSEDCL under PPA at MERC determined tariff. Out of 1918MW of wind power projects commissioned for sale to MSEDCL, only 205.7MW of projects were shortlisted by MSEDCL for continuously generating more than 20%. Holistic review of the complete 1918MW of wind power projects is done to access the substation wise and district wise CUF of wind power projects so as to analyze if there is any trend that can be considered for Wind Zone/benchmark CUF revision.

For undertaking the analysis of CUF, generation and CUF data shared by MSEDCL was used. As per MSDECL generation data they had shared the data of following 43 substations totaling to 2107.3MW as follows:

Sr.No.	Name of Substation	Installed Capacity of Wind Project As per MSEDCL Data (in MW)	Installed Capacity of Wind Projects after 31 March 2015	Installed Capacity of Wind Projects During FY 2010-11 to 2014-15 (in MW)
1	132/33 KV Kombhalne	47.6		47.6
2	220 KV/33 KV Kaudgaon (Jeur)	20.00		20
3	33/11 KV. PATODA S/S	6.25		6.25
4	132/33 KV Aranvira S/S	73.50		73.50
5	132/33 KV Rajpimpri	80.00		80.00
6	132/33KV BAMBVADE	22.95	0.85	22.10
7	220KV/33KV Gangapur	73.80		73.80

8	132/33KV Khaprle Substation	18.90		18.90
9	100/33 KV ANDRA LAKE	106.40		106.40
10	220/132/22 KV ALEPHATA SUB STN	7.20	7.20	0.00
11	33/11 KV DAFALAPUR S/S	10.00	10.00	0.00
12	33/11 KV Lengare S/S	1.50		1.50
13	110/33/11 KV Jath	33.90	4.00	29.90
14	110/33 KV Valsang S/S	104.00		104.00
15	132/33KV Rile (Shirala) S/s	42.00		42.00
16	132/33KV Vaspeth (Jath) S/s	196.15		196.15
17	220/33 kv Jath s/s MSETCL	19.55		19.55
18	220/33Kv Kadegaon S/s	14.80		14.80
19	220/33 KV Waiphale S/s.	30.00		30.00
20	220/33 KV Shedyal S/s.	201.20	64.65	136.55
21	220/33 KV Mendhegiri S/S	50.40	25.20	25.2
22	220/33 KV Khanapur S/s	66.00	42.00	24
23	33 KV SHEMBALPIMPRI	10.50	10.50	0
24	33 KV MULAWA SUBSTATION	9.00	9.00	0
25	33/11 KV KOREGAON	13.60		13.60
26	33/11 KV MEDHA SUBSTATION	5.70		5.70
27	33/22 KV VIKHALE SUBSTATION	4.50		4.50
28	132/33KV Satara Road S/Stn	12.00		12.00
29	110/33KV MAYANI SUB STATION	24.00		24.00
30	132/33/22 KV DAHIVADI SUBSTATION	20.20	0.00	20.4
31	132/33/22 WAI EHV SUBSTATION	5.10		5.10
32	132/33KV AUNDH SUB-STATION	28.25		28.25
33	132/33 kv AMBHERI	16.00		16.00
34	132/33KV KALEDHON SUBSTATION	31.20		31.20
35	220/33 KV Sadawaghapur S/Stn	29.70		29.70
36	220/33/11KV MALHARPETH SUBSTATION	41.25		41.25
37	220 / 33 KV Vankusawade S/Stn	14.70	6.30	8.4
38	220/33KV Chawaneshwar S/Stn	28.80		28.80
39	220/33KV PANAMA SUB-STATION	70.40		70.40
40	220/33KV RATNAGIRI WIND SUB-STATION	96.00	9.60	86.4
41	220/33KV NIGADE SUB-STATION	45.20		45.20
42	220/33KV HIVARVADI SUB-STATION	181.50		181.50
43	220/33 KV BOTHE SUB-STATION	193.40		193.40
	Total	2107.1	189.3	1918.00

Out of the above 43 substations four substations had the wind projects commissioned in 2017 and hence there were only 39 substations having wind power projects commissioned during the control period of MERC RE Tariff Regulations 2010. Further, these substations had wind projects



commissioned after 31<sup>st</sup> March 2015 and hence the total installed capacity of wind power projects during the control period reduced to 1918MW.

From the analysis it is observed as follows:

Districts with more than 20% Avg. CUF	Pune (21.67%), Nandurbar (22.58%),
Districts with less than 20% Avg. CUF	Ahmednagar (12.19%), Beed (19.83%), Kolhapur (18.18%), Sangli (18.88%), Satara (18.70%)

It can be observed that only two districts are having more than 20% average CUF. Five districts have average CUF of less than 20%. However, there are some of the sites within these districts which are generating at higher CUF and some sites are generating at lower CUF. The substation wise wind power projects generation data is analyzed and is presented as follows:

**District: Ahmednagar**

Sr.No	Name of Substation	Connected Load in MW	CUF in FY 2010-11	CUF in FY 2011-12	CUF in FY 2012-13	CUF in FY 2013-14	CUF in FY 2014-15	CUF in FY 2015-16	CUF in FY 2016-17	CUF in FY 2017-18	Average CUF of Wind Farm Connected to Substation
1	132/33 KV Kombhalne	47.6	0	0	0	0	9.72	11.74	8.14	12.25	10.71
2	220 KV/33 KV Kaudgaon (Jeur)	20	0	0	0	0	0.00	10.08	14.49	16.93	15.71
	Total	67.6	Simple Average								13.21
<b>Waited Avg CUF</b>											<b>12.19</b>

**District: Pune**

Sr.No	Name of Substation	Connected Load in MW	CUF in FY 2010-11	CUF in FY 2011-12	CUF in FY 2012-13	CUF in FY 2013-14	CUF in FY 2014-15	CUF in FY 2015-16	CUF in FY 2016-17	CUF in FY 2017-18	Average CUF of Wind Farm Connected to Substation
1	100/33 KV ANDRA LAKE	106.4	-	4.00	20.94	23.72	22.01	21.42	20.60	21.33	21.67
	Total	106.4	Simple Average								21.67
<b>Waited Avg CUF</b>											<b>21.67</b>

**District: Nandurbar**

Sr.No	Name of Substation	Connected Load in MW	CUF in FY 2010-11	CUF in FY 2011-12	CUF in FY 2012-13	CUF in FY 2013-14	CUF in FY 2014-15	CUF in FY 2015-16	CUF in FY 2016-17	CUF in FY 2017-18	Average CUF of Wind Farm Connected to Substation
1	220KV/33KV Gangapur	73.8		4.79	25.04	25.23	19.27	22.16	23.46	20.31	22.58
	Total	73.8	Simple Average								22.58
<b>Waited Avg CUF</b>											<b>22.58</b>



**District: Beed**

Sr.No	Name of Substation	Connected Load in MW	CUF in FY 2010-11	CUF in FY 2011-12	CUF in FY 2012-13	CUF in FY 2013-14	CUF in FY 2014-15	CUF in FY 2015-16	CUF in FY 2016-17	CUF in FY 2017-18	Average CUF of Wind Farm Connected to Substation
1	33/11 KV. PATODA S/S	6.25		4.79	5.13	9.03	7.99	9.37	4.74	5.05	
2	132/33 KV Aranvira S/S	73.50				3.33	13.48	22.24	18.31	22.09	19.03
3	132/33 KV Rajpimpri	80.00					7.89	21.02	18.38	17.23	18.87
	0	159.75	Simple Average								19.88

**Waited Avg CUF 19.83****District: Kolhapur**

Sr.No	Name of Substation	Connected Load in MW	CUF in FY 2010-11	CUF in FY 2011-12	CUF in FY 2012-13	CUF in FY 2013-14	CUF in FY 2014-15	CUF in FY 2015-16	CUF in FY 2016-17	CUF in FY 2017-18	Average CUF of Wind Farm Connected to Substation
1	132/33KV BAMBVADE	22.1					16.67	17.71	21.12	18.21	18.43
2	132/33KV Rile (Shirala) S/s-411	42.00					0.00	16.88	19.92	17.04	17.94
	Total	64.1	Simple Average								18.18

**Waited Avg CUF 18.11****District: Sangli**

Sr.No	Name of Substation	Connected Load in MW	CUF in FY 2010-11	CUF in FY 2011-12	CUF in FY 2012-13	CUF in FY 2013-14	CUF in FY 2014-15	CUF in FY 2015-16	CUF in FY 2016-17	CUF in FY 2017-18	Average CUF of Wind Farm Connected to Substation
1	132/33KV Khaprale Substation	18.9			13.39	24.92	17.83	22.46	25.61	21.18	22.40
2	33/11 KV Lengare S/S	1.5						19.30	21.20	18.44	19.65
3	110/33/11 KV Jath	29.9			21.42	15.87	16.86	17.43	17.46	15.18	17.37
4	110/33 KV Valsang S/S	104			25.77	12.40	16.68	20.28	20.80	18.37	19.05
5	132/33KV Vaspeth (Jath) S/s	196.15			4.68	11.85	18.68	20.96	21.14	18.85	15.93
6	220/33 kv Jath s/s MSETCL	19.55			9.21	17.11	15.86	16.57	16.86	14.98	16.28
7	220/33Kv Kadegaon S/s	14.8						19.90	21.82	17.40	19.71
8	220/33 KV Waiphale S/s.	30				1.59	25.09	14.13	28.97	26.13	23.58
9	220/33 KV Shedyal S/s.	136.55					0.63	8.56	18.64	20.84	16.01
10	220/33 KV Mendhegiri S/S	25.2				20.20	16.04	15.52	16.16	16.04	16.79
11	220/33 KV Khanapur S/s	24						3.26	22.65	21.77	22.21
12	220/33KV HIVARVADI SUB-STATION	181.5				25.83	20.36	20.16	26.15	21.86	22.87
13	110/33KV MAYANI SUB STATION	24				23.05	22.49	22.03	21.97	20.04	21.91
	Total	806.05	Simple Average								19.52

**Waited Avg CUF 18.88**

**District: Satara**

Sr.No	Name of Substation	Connected Load in MW	CUF in FY 2010-11	CUF in FY 2011-12	CUF in FY 2012-13	CUF in FY 2013-14	CUF in FY 2014-15	CUF in FY 2015-16	CUF in FY 2016-17	CUF in FY 2017-18	Average CUF of Wind Farm Connected to Substation
1	220/33 KV BOTHE SUB-STATION	193.4				10.79	19.01	10.87	23.95	23.62	19.36
2	220/33KV NIGADE SUB-STATION	45.2		11.77	10.85	10.76	16.43	17.19	22.42	17.60	15.87
3	<b>220/33KV RATNAGIRI WIND SUB-STATION</b>	<b>86.4</b>				<b>18.20</b>	<b>18.72</b>	<b>22.23</b>	<b>22.98</b>	<b>20.47</b>	<b>20.52</b>
4	220/33KV PANAMA SUB-STATION	70.4				9.95	15.09	17.79	23.83	20.62	19.33
5	220/33KV Chawaneshwar S/Stn	28.8	2.02	8.04	18.32	18.75	17.35	16.12	14.20	13.63	16.39
6	<b>220 / 33 KV Vankusawade S/Stn</b>	<b>8.4</b>						<b>20.72</b>	<b>28.47</b>	<b>22.51</b>	<b>23.90</b>
7	220/33/11KV MALHARPETH SUBSTATION	41.25				20.91		14.39	16.24	13.35	16.22
8	220/33 KV Sadawaghapur S/Stn	29.7	12.47	14.71	20.63	16.40	14.91	17.77	22.92	19.18	18.07
9	<b>132/33KV KALEDHON SUBSTATION</b>	<b>31.2</b>					<b>12.40</b>	<b>23.35</b>	<b>25.92</b>	<b>22.17</b>	<b>23.81</b>
10	132/33 kv AMBHERI	16					4.29	17.37	17.56	16.28	17.07
11	132/33KV AUNDH SUB-STATION	28.25		7.88	7.05	11.48	20.29	14.59	16.51	13.93	15.36
12	132/33/22 WAI EHV SUBSTATION	5.1		4.68	17.92	15.57	15.39	15.70	19.61	13.62	16.30
13	132/33/22 KV DAHIVADI SUBSTATION	20.4				16.04	14.57	12.67	14.64	13.86	14.35
14	<b>33/11 KV KOREGAON</b>	<b>13.6</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>20.25</b>	<b>0.00</b>	<b>21.16</b>	<b>21.92</b>	<b>18.29</b>	<b>20.41</b>
15	33/11 KV MEDHA SUBSTATION	5.7	0	0	0	18.83	11.91	18.55	33.06	22.11	19.48
16	<b>33/22 KV VIKHALE SUBSTATION</b>	<b>4.5</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0.00</b>	<b>2.69</b>	<b>24.12</b>	<b>27.04</b>	<b>19.02</b>	<b>23.39</b>
17	132/33KV Satara Road S/Stn	12	0	0	0	0.00	0.00	15.93	13.87	14.90	14.90
	Total	640.3	Simple Average								18.52

**Waited Avg CUF**

**18.70**

From above substation level data of wind power projects spread across the districts it can be observed that out of 39 substations, only 12 substations are having wind power projects generating at CUF more than 20% as follows:

Sr.No	Name of Substation	Connected Load (in MW)	CUF in FY 2010-11	CUF in FY 2011-12	CUF in FY 2012-13	CUF in FY 2013-14	CUF in FY 2014-15	CUF in FY 2015-16	CUF in FY 2016-17	CUF in FY 2017-18	Average CUF of Wind Farm Connected to Substation
1	100/33 KV ANDRA LAKE	106.4	-	4.00	20.94	23.72	22.01	21.42	20.60	21.33	21.67
2	220KV/33KV Gangapur	73.8		4.79	25.04	25.23	19.27	22.16	23.46	20.31	22.58
3	132/33KV Khaprle Substation	18.9			13.39	24.92	17.83	22.46	25.61	21.18	22.40
4	220/33 KV Waiphale S/s.	30				1.59	25.09	14.13	28.97	26.13	23.58
5	220/33 KV Khanapur S/s	24						3.26	22.65	21.77	22.21
6	220/33KV HIVARVADI SUB-STATION	181.5				25.83	20.36	20.16	26.15	21.86	22.87
7	110/33KV MAYANI SUB STATION	24				23.05	22.49	22.03	21.97	20.04	21.91

8	220/33KV RATNAGIRI WIND SUB-STATION	86.4				18.20	18.72	22.23	22.98	20.47	20.52
9	220 / 33 KV Vankusawade S/Stn	8.4						20.72	28.47	22.51	23.90
10	132/33KV KALEDHON SUBSTATION	31.2					12.40	23.35	25.92	22.17	23.81
11	33/11 KV KOREGAON	13.6	0	0	0	20.25	0.00	21.16	21.92	18.29	20.41
12	33/22 KV VIKHALE SUBSTATION	4.5	0	0	0	0.00	2.69	24.12	27.04	19.02	23.39
		602.7									

The brief summary of district wise wind power generation projects substations with less than 20% average CUF and above 20% average CUF is as follows:

District	Total installed Capacity (MW)	Capacity of wind power projects with more than 20% Avg CUF	Capacity of wind power projects with less than 20% Avg CUF
Ahmednagar	67.60	0	67.6
Pune	106.40	106.4	0
Nandurbar	73.80	73.8	0
Beed	159.75	0	160
Kolhapur	64.10	0	64.1
Sangli	806.05	278.4	527.65
Satara	640.30	144.1	496.2
Total	1918.00	602.7	1315.3

From above table it can be seen that out of 1918MW of projects only 602.7MW (31%) of projects are generating above benchmark of 20% and rest 1315.3MW (69%) are generating below benchmark of 20% CUF

## 2.2 Frequency and period of Generation data review for redetermination of CUF

The provision to re-determine the tariff as per actual CUF as specified in the regulation is as follows:

### Regulation 28.1

....."Provided that these CUF norms may be revised by the commission through general or specific Order considering data that may become available subsequently"

The regulation intends to review the CUF based on the actual generation data so that no undue benefit is given to the generators at the cost of consumers of Maharashtra. However, the regulation is silent on the period of review.

MSEDCL proposed to revise the CUF of wind power projects commissioned during the control period of MERC RE Tariff Regulations 2010 based on the actual generation/CUF data of first three years. Hence, the substations which have more than 20% average CUF from the date of commissioning to March 2018 are analyzed for average CUF for first three years as follows:

Sr. No	Name of Substation	Connected Load in MW	CUF in FY 2011-12	CUF in FY 2012-13	CUF in FY 2013-14	CUF in FY 2014-15	CUF in FY 2015-16	CUF in FY 2016-17	CUF in FY 2017-18	Average CUF of Wind Farm from COD to FY 2017-18	Average CUF of Wind Farm for first three years
1	100/33 KV ANDRA LAKE	106.4	4	20.94	23.72	22.01	21.42	20.6	21.33	21.67	22.22
2	220KV/33KV Gangapur	73.8	4.79	25.04	25.23	19.27	22.16	23.46	20.31	22.58	23.18
3	132/33KV Khaprale S/s.	18.9		13.39	24.92	17.83	22.46	25.61	21.18	22.4	21.74
4	220/33 KV Waiphale S/s.	30			1.59	25.09	14.13	28.97	26.13	23.58	22.73
5	220/33 KV Khanapur S/s	24					3.26	22.65	21.77	22.21	22.21
6	220/33KV HIVARVADI S/S	181.5			25.83	20.36	20.16	26.15	21.86	22.87	22.12
7	110/33KV MAYANI S/S	24			23.05	22.49	22.03	21.97	20.04	21.91	22.52
8	220/33KV RATNAGIRI WIND SUB-STATION	86.4			18.2	18.72	22.23	22.98	20.47	20.52	21.31
9	220/33kv Vankusawade S/S	8.4					20.72	28.47	22.51	23.9	23.90
10	132/33KV KALEDHON S/S	31.2				12.4	23.35	25.92	22.17	23.81	23.81
11	33/11 KV KOREGAON	13.6	0	0	20.25	0	21.16	21.92	18.29	20.41	20.46
12	33/22 KV VIKHALE S/S	4.5	0	0	0	2.69	24.12	27.04	19.02	23.39	23.39
		602.7									

- The projects are commissioned in different years across the above twelve substations and hence some of the projects have completed more than three years and some have not yet completed three years.
- Five projects average CUF till FY 2017-18 has been reduced than that of the first three years average CUF
- Four projects average CUF till FY 2017-18 has been increased than that of the first three years average CUF
- Four projects average CUF till FY 2017-18 is same as that of first three years average CUF as they have just completed three years or completed less years.
- The average CUF of wind power projects is dependent on the annual wind pattern which is unknown and subject to change year on year. Hence, in some project the annual CUF has been seen to be increased after three years and in some projects it was decreased after three years.
- The wind project is bound to degrade year on year and annual degradation factor was not considered by most of the Commissions. However, due to the effect of changing wind pattern, change in machine availability, change in grid availability it is very difficult to access and comment on the annual degradation factor to be considered based on the actual generation data.

- The tariff is calculated for 13 years of PPA period by considering 20% CUF for Zone I. Even though some of the projects are showing CUF more than 20% during initial few years, it is likely that they may not be able to achieve the similar CUF till the 13<sup>th</sup> year of PPA tenure. Hence, applying the CUF derived from generation data of first three years will not be appropriate.

### 2.3 Analysis of State Average CUF of wind project commissioned under the control period of MERC RE tariff Regulations 2010

The average CUF achieved across all the substations spread in seven districts shows that weighted average CUF of wind projects commissioned in Pune and Nandurbar District are more than 20% and the weighted average CUF of wind projects for rest of the districts is less than 20%. However, if we consider the weighted average CUF of all the projects commissioned under MERC RE tariff Regulation 2010 is 18.86% which is less than that of 20% ceiling for Zone 1.

District	Average CUF (2010-11 to 2017-18)	Weighted Average CUF (2010-11 to 2017-18)	Total installed Capacity (MW)
Ahmednagar	13.21	12.19	67.60
Pune	21.67	21.67	106.40
Nandurbar	22.58	22.58	73.80
Beed	18.95	18.95	159.75
Kolhapur	18.18	18.18	64.10
Sangli	19.52	18.88	806.05
Satara	18.52	18.70	640.30
State Simple Average CUF	18.95		1918.00
State Weighted Average CUF		18.86	

Hence, from the above state level actual wind generation CUF data it is clear that the wind power projects are not generating more than 20% and there is no excess payment to developers for any generation more than 20% if it is seen at macro level. However, the MERC RE tariff Regulations 2010 had specified wind power density zone wise tariff instead of having a common generic state average CUF tariff to the wind power projects commissioned across the state. The Regulation had the provision to re-determine the tariff as per the actual CUF as follows:

#### Regulation 28.1

....."Provided that these CUF norms may be revised by the commission through general or specific Order considering data that may become available subsequently"

Hence, the actual CUF achieved by some of the projects which is more than 20% needs to be accessed along with the project specific techno-commercial parameters considered in the regulation and that with the commissioned projects.

#### 2.4 Analysis of Life time cost of wind power to DISCOM across the states

From the MERC order on case no 152 of 2018 dated 9<sup>th</sup> July 2018, it was observed that MSEDCL had submitted that wind tariffs are highest in Maharashtra than that of the neighboring states for FY 2017-18 as follows:

(in Rs/kWh)

Maharashtra Zone I	Gujarat	TamilNadu	MP	AP	Karnataka
5.40	4.19	4.16	4.78	4.76	4.50

From above, it is observed that the tariff of wind power quoted for procurement by DISCOM is for FY 2017-18 which is out the control period of MERC RE Tariff Regulations, 2010. Hence the comparison has to be done for tariffs during the control period between 2010-11 to 2014-15. Further, it is observed that the wind power is being purchased by DISCOMS for different PPA periods. In Maharashtra the PPA and tariff is for 13 years however in other states the PPA and tariff is for 25 years of project life. Hence, comparison of tariff and cost to Distribution Company for procurement of wind power can be done for first and last year of control period. Here it is assumed that if the wind project is generating at 20% CUF then what could be the net cost to DISCOM over the project life, its NPV at 10% for 25 and 13 years of cashflow as follows:

2010	Maharashtra	Gujarat	TamilNadu	M.P.	A.P	Karnataka
Tariff (1 to 13 Years) without AD (Rs/kWh)	5.07	3.56	3.39	4.35	3.5	3.7
Tariff (14 to 25 Years) without AD (Rs/kWh)	2	3.56	3.39	4.35	3.5	3.7
Capital Cost (Rs. Lakhs)	467.13	462	535	500	470	470
CUF considered in Tariff Order (%)	20	23	27.15	20	24.5	26.5
One year Generation at 20% CUF	17,34,000	17,34,000	17,34,000	17,34,000	17,34,000	17,34,000
Total cost to DISCOM for purchase of wind power over 20 Years (in Rs)	15,59,03,940	15,43,26,000	14,69,56,500	18,85,72,500	15,17,25,000	16,03,95,000
NPV of 25 year Cashflow	6,92,93,039	5,60,32,931	5,33,57,201	6,84,67,205	5,50,88,556	5,82,36,473
NPV of 13 years Cashflow	6,24,48,304	4,38,49,302	4,17,55,375	5,35,79,906	4,31,10,269	4,55,73,713

2015	Maharashtra	Gujarat	TamilNadu	M.P.	A.P	Karnataka
Tariff (1 to 13 Years) without AD (Rs/kWh)	5.7	4.15	3.51	5.92	4.83	4.5
Tariff (14 to 25 Years) without AD (Rs/kWh)	2	4.15	3.51	5.92	4.83	4.5
Capital Cost (Rs. Lakhs)	600.75	568.00	575	596.00	600	600
CUF considered in Tariff Order (%)	20	25	27.15	20	23.5	26.5
One year Generation at 20% CUF	17,34,000	17,34,000	17,34,000	17,34,000	17,34,000	17,34,000
Total cost to DISCOM for purchase of wind power over 20 Years	17,01,05,400	18,01,10,580	15,21,58,500	25,66,32,000	20,93,80,500	19,50,75,000
NPV of 25 year Cashflow	7,70,52,888	6,53,53,511	5,52,45,952	9,31,78,357	7,60,22,207	7,08,28,143
NPV of 13 years Cashflow	7,02,08,152	5,11,16,462	4,32,33,441	7,29,17,940	5,94,92,171	5,54,27,488

#### Observation:

- The capital cost and CUF considered by MERC and other states Commissions are slightly varying for 2010 and 2015 and also the tariff period. In Maharashtra the tariffs are determined for 13 years whereas for other states it is 25 years. As the entire project located in Maharashtra falls under Zone 1 i.e. 20% CUF the tariff is higher than other states where the state average CUF is more than 20%.
- For the sake of comparison of cost to DISCOM on common grounds it is considered that wind project is generating at 20% CUF and then cost to DISCOM for procurement of wind power across the states is compared. It is observed that cost to procure wind power at 20% CUF is higher in Maharashtra than some states and is also lower than some states. Same is the case for NPV of 25 years cashflow discounted at 10%
- However, it is observed that the NPV of first thirteen years of cashflow is highest in Maharashtra than that of other states. This benefits the wind investors in early repayment of debt and also reduces their risk.
- It is also observed that, though the DISCOM of Maharashtra is paying higher tariff for first thirteen years, their tariffs for the period between 14<sup>th</sup> year to 25 year are low as compared to the other states and here they are been benefited with lower costs of procurement of wind power. Hence, the overall cost to DISCOM over the 25 years project life is comparable with other states and is win-win situation in Maharashtra for investors and DISCOM/consumers of Maharashtra.

## 2.5 Generic vs project specific approach for wind project tariff determination

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Wind power project uses multiple wind turbines of capacity more than 225kW, connected to utility grid spread across different locations. While determining tariff for such multiple numbers of small capacity generators generic tariff setting methodology is adopted by the Commissions. However, for single large capacity wind power project or the project with new technology or hybrid projects using wind turbines, the investors can approach the commission for project specific tariffs. In that case Commission reviews operating and financial parameters of specific project and issues project specific tariff.

In generic tariff setting approach SERC usually fixes the benchmark operating and financial parameters for representative project for determination of tariff. Same tariff becomes applicable for all projects commissioned during the control period of the said regulation/order. The benchmark tariff approach could result in unattractiveness for projects that are above the cost benchmark / below the performance benchmark and vice-versa. Also, unrealistic setting of the cost and performance benchmark parameters can burden the developer or the licensee / consumers as the case may be. Under benchmark costs approach the tariff structure and revenue represents underlined cost and performance of the RE power projects.

Hence, under generic tariff approach, the developers are at the liberty to select and deploy technology with lesser cost or with better operational parameters to minimise the risks and maximise the returns.

Similarly in the present case, some of the wind projects will be generating at CUF above benchmark due to better technology/operation and maintenance/resources. If the benchmark parameters are to be revised for selected 42 projects then the demand may come from the projects which are performing below benchmark parameters to reconsider the parameters and increase the tariff. This will lead to unending process and may not promote the best technology or benefit the efforts in optimizing the O&M.

If total capacity of wind power projects selling power to MSEDCL commissioned in the control period of 2010 regulation is accessed it is observed that out of 1918 MW of projects only 602.7MW (31%) of projects are generating above benchmark of 20% and rest 1315.3MW (69%) are generating below benchmark of 20% CUF. Further, it is difficult to apportion the incremental cost of better technology, increased cost of installation and commissioning at best strategic locations or the incremental cost of effective O&M which is yielding more generation. Hence, after analyzing the statistics, at the macro level the overall CUF of wind projects commissioned during the control period is less than 20% and hence it is cannot be the case of undue benefit to developers and investors.



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## Observations and Conclusions:

- Regulation 28.1 of the MERC RE Tariff Regulations 2010 had the provision as: *“Provided that these CUF norms may be revised by the commission through general or specific Order considering data that may become available subsequently”*. And accordingly the review of CUF of wind power projects commissioned under this regulation’s control period was required. However, while undertaking the review, MSEDCL had selected 42 wind power projects comprising only 205MW out of the total installed capacity of 2373.25MW or 1918 MW the capacity of projects selling power to MSEDCL under the said control period.
- Further, the selected sample of 42 projects / 205 MW of commissioned projects were selected for CUF / zone revision based on their two/three years of consistently higher generation (more than 20% determined for Zone I). In every wind farm some of the turbines are bound to generate more than that of other wind turbines of the same farm due to their strategic location within the wind farm which permits the less array loss or faces more wind due to their location facing prominent wind direction. Hence, while undertaking any study for revision of CUF based on the actual generation data, complete wind farm’s sample needs to be accessed.
- While evaluation of these 42 projects, it was observed that their average generation over the period starting from the date of commissioning of these wind turbines till March 2018, had the average CUF more than 20%. These 42 projects were spread across 14 wind masts and hence 14 wind farms were considered for evaluation of CUF. When the neighboring wind turbines were added to these 42 projects so as to have a sample of complete wind farm it was observed that about 869MW of wind turbines were spread across 14 projects. Out of these 14 wind farms only 6 wind farms had average generation more than 20%. Further, it was also observed that zoning was offered based on the nearest wind mast and in some of the cases there were two wind masts on single site. Hence, wind projects connected to one pooling substation are also considered for average CUF calculation.
- Field verification of 57MW of wind turbines out of 205.7MW of shortlisted projects (27% sample) was undertaken to verify the location, elevation and technology deployed. It was observed that these wind projects were falling within the areal distance of 10 km from the wind mast complying with the wind zoning procedure of MEDA. It was observed that 57MW of wind turbines visited had benefits due to their locations and may be due to the turbine hub height, rotor diameter and technology etc.
- All the 42 wind projects / 205MW of turbines were marked on google earth and verified the distances from reference wind mast and its compliance with the MEDA zoning procedure.
- All the fourteen wind masts under study were plotted on 50 mtr WPD map of NIWE in GIS arc and found that all the masts falls under the WPD up to 250 watts / sq.mtr except the mast located at Chakla in district Nandurbar. As per the 50 mtr WPD map of NIWE it is observed that location Chakla falls under the WPD 250 to 300 watts/sq.mtr however, for the same location the extrapolated WPD from NIWE’s mast is 323 i.e. within the WPD zone from 300 to

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350. So there is inconsistency in NIWE's extrapolated WPD in the list of potential sites and that of GIS arc map. The deviations in the extrapolation of WPD as per the NIWE's wind mast may be due to its measurement height at 25 mtr and the measurement was done for the period between April 1999 to June 2000. On the contrary the measurement at Chakla for Suzlon mast was for the period from August 2003 to July 2004 at 50 mtr height and there is no uncertainty as measurements were done at 50 mtr. It was found that NIWE had studied the WPD for all the WTG locations in detail and certified the WPD. Based on NIWE's certified WPD for Chakla site and accordingly the projects were allotted the Zone I WPD. Hence, all the 42 projects are falling under the WPD specified for Zone I at 50mtr height.

- Analysis of estimated wind power generation and WPD at hub height was carried out for only one wind farm located at Kotoli in Dist Kolhapur. From the WAsP analysis it is observed that WPD at WTG hub height is close to 200 Watts/sq mtr and it was certified as 180 watts / sq. mtr at 50 mtr height at mast location. Further, the wind turbine location BHT-19 is showing annual CUF of 23% at P75 probability and 23.27% from the actual generation data. This higher generation was observed to be due to its location within the wind farm. Further, the average CUF of the wind farm was observed at 21.1% at 75% probability in WAsP as against 19.28% from actual generation data. Hence, actual generation is in line with WAsP estimation for the complete wind farm.
- Analysis of WPD at actual WTG Hub Height was done by extrapolating data to Hub Height of 42 wind power projects. And the revised WPD was compared with the zones as per Regulation 2010. From this it was observed that, out of 205.7MW of shortlisted projects 13.6MW of projects / wind turbines hub height elevation was below the mast elevation and was considered in Zone 1 and about 120.9MW of wind projects had higher WPD that of Zone II and III. In every complex terrain there will be some installations which will get the advantage of high elevation and may yield more generation and some will be at lower elevation and will produce less energy due to elevation. Further, some of the WTGs will get the advantage of their location and will generate more than the WTGs which are affect by high array loss within the same wind farm. If the CUF has to be accessed for each turbine location then higher generating WTGs will fetch low tariff and low generating WTGs will fetch high tariff. Hence, the issue needs to be analyzed holistically in the generic tariff determination process or project specific tariff for all the turbines will have to be accessed.
- The 42 projects under study were accessed from the point of technology deployment and it was observed that all these 205.7MW of projects had the wind turbine Hub Height varying from 60.6 to 95mtr and rotor diameter varying from 53 to 100mtr. Hence, all the 42 projects have benefited in generation due to technology and location. The increase in hub height and rotor diameter increases the capital cost and also setting up the project at complex terrain than that of flat terrain increases the cost of logistics and installation and commissioning. Also, the incremental generation may be due to effective O&M. However, it is very difficult to identify these incremental costs and related generation gains.

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- The regulation is silent on the period of review of CUF for revision of CUF norm / zone. MSEDCL proposed to revise the CUF of wind power projects based on the actual generation/CUF data of first three years. The average CUF of wind power projects is dependent on the annual wind pattern which is unknown and subject to change year on year. Further, wind project is bound to degrade year on year and annual degradation factor was not considered by most of the Commissions. However, due to the effect of changing wind pattern, change in machine availability, change in grid availability it is very difficult to access and comment on the annual degradation factor to be considered based on the actual generation data. The tariff is calculated for 13 years of PPA period by considering 20% CUF for Zone I. Even though some of the projects are showing CUF more than 20% during initial few years, it is likely that they may not be able to achieve the similar CUF till the 13<sup>th</sup> year of PPA tenure. Hence, applying the CUF derived from generation data of first three years will not be appropriate.
  - The capital cost and CUF considered by MERC and other states Commissions are varying slightly for 2010 and 2015 and also the tariff period considered in Maharashtra was for 13 years whereas for other states it was 25 years. For the sake of comparison of cost to DISCOM on common ground it is considered that wind project is generating at 20% CUF and then cost to DISCOM for procurement of wind power across the states is compared. It is observed that cost to procure wind power at 20% CUF is higher in Maharashtra than some states and is also lower than some states. Further, it is observed that the NPV of first thirteen years of cashflow is highest in Maharashtra than any other state. This benefits the wind investors in early repayment of debt and also reduces their risk. It is also observed that, though the DISCOM of Maharashtra is paying higher tariff for first thirteen years, their tariffs for the period between 14<sup>th</sup> year to 25<sup>th</sup> year are low as compared to the other states and here they are benefited with lower costs of procurement of wind power. Hence, the overall cost to DISCOM over the 25 years project life is comparable with other states and is win-win situation in Maharashtra for investors and DISCOM/consumers of Maharashtra.
  - Out of 1918MW of projects only 602.7MW (31%) of projects are generating above benchmark of 20% and rest 1315.3MW (69%) are generating below benchmark of 20% CUF. If on the basis of CUF, the tariff / wind zone of 602.7MW (31%) of project is to be reduced, then it will lead to the scope to increase the tariff for 1315.3MW (69%) of projects which are generating at less CUF. Further, it is difficult to apportion the incremental cost of project due to increased hub height, increased rotor diameter, incremental cost in developing project on high elevation and complex terrains, incremental cost of effective O&M by IPPs etc. which is benefiting the wind projects in terms of higher generations.
  - As per the MERC Regulation, the parameters considered for wind zoning are static and fixed and there is hardly any possibility of its deviation while determining the wind zone. The coordinates of wind turbine and mast are fix, their elevation is fix and the same can be verified from Google earth for its permitted areal distance of 10 km. Further, in case of doubts

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in wind zoning, MEDA has referred such cases to NIWE for its WPD certification. Wind zoning was analyzed by the committee constituted by DG MEDA for the purpose and the MERC Regulation specifying WPD measurement at 50mtr was strictly followed. If at all any new methodology is to be adopted for WPD and zone certification the variable parameters like turbine hub height, WTG elevation, turbine technology etc. needs to be correlated to derive an acceptable formula for the new control period.

- The weighted average CUF of all the projects commissioned under the control period of MERC RE tariff Regulation 2010 is 18.86% which is less than that of 20% ceiling for Zone 1. Hence, it is clear that the wind power projects are not generating more than 20% and there is no excess payment to developers for any generation more than 20% if it is seen at macro level. Hence, there seems no requirement for wind zone revision based on actual generation data and change of tariff for part of the projects generating high due to technology and operational parameters.

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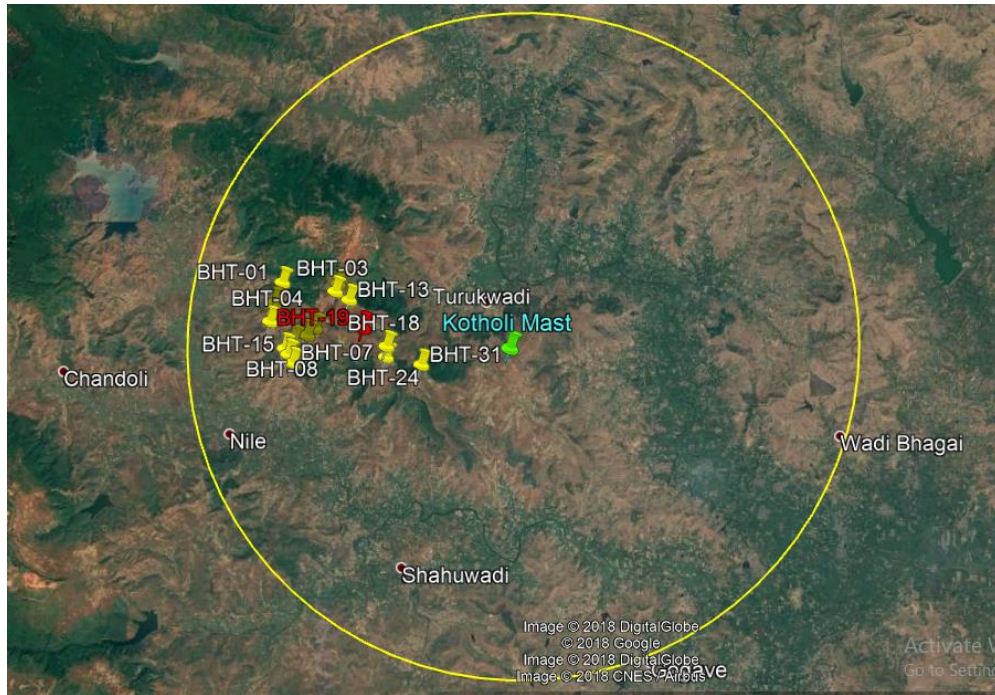
## Annexure

- 1) Mapping of 42 Projects and wind masts on Google earth.
- 2) Mapping of WTG's located in Chakla on NIWE's 50 mtr WPD map and zone classification.
- 3) Estimated Wind Power generation derived WAsP for Kotoli Wind Site in Dist. Kolhapur.
- 4) Copy of excel sheet showing cost to DISCOM for procurement of wind power.

## Annexure I

### Mapping of WTGs under the referred mast

Sr. no	Zones	Mast details	WPD at 50 mtr	Elevation m amsl	Zone WPD (Watt/m <sup>2</sup> )
1	Kolhapur	Kotoli Taluka - Shahuwadi District - Kolhapur ,Latitude- N 16° 57' 54.2'' Longitude- E 73° 58' 28.4''	180	782	100-200

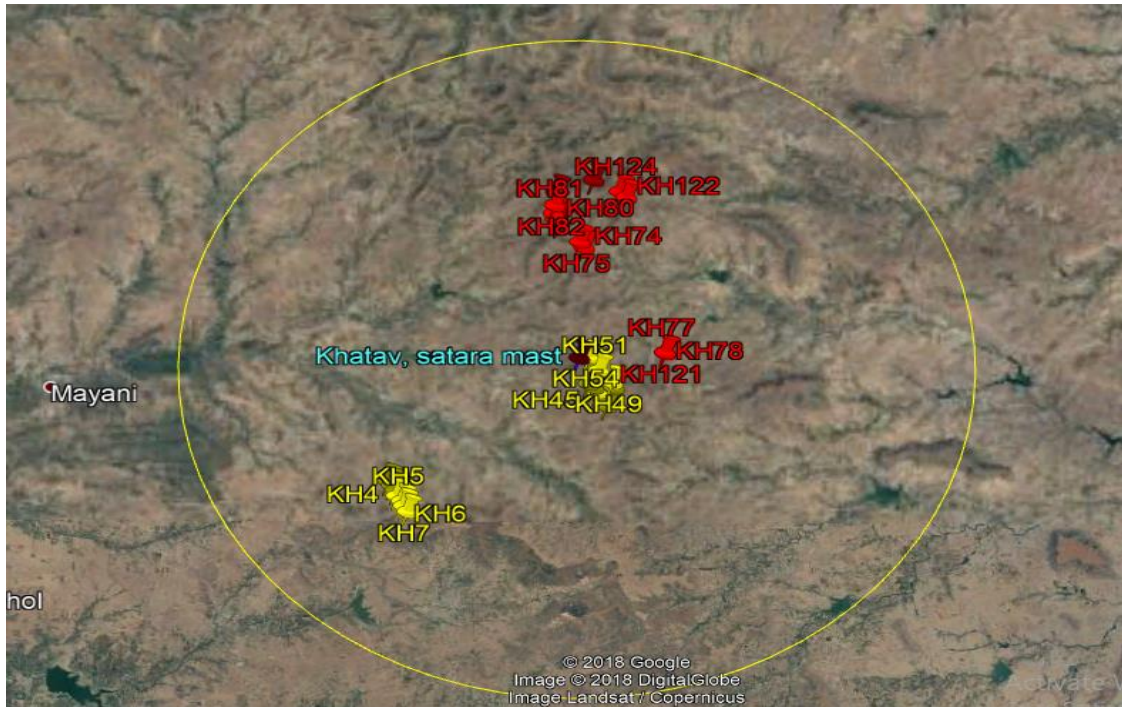


#### Observation:

- All the WTGs under kotholi mast are mapped on google earth. It has been observed that all the WTGs fall under 10 km radius of the mast referred. The WTGs plotted with the red pointer indicates the ones under inspection. The masts are marked in Blue color. The WTGs marked with yellow pointer are the neighboring WTGs under the same mast.



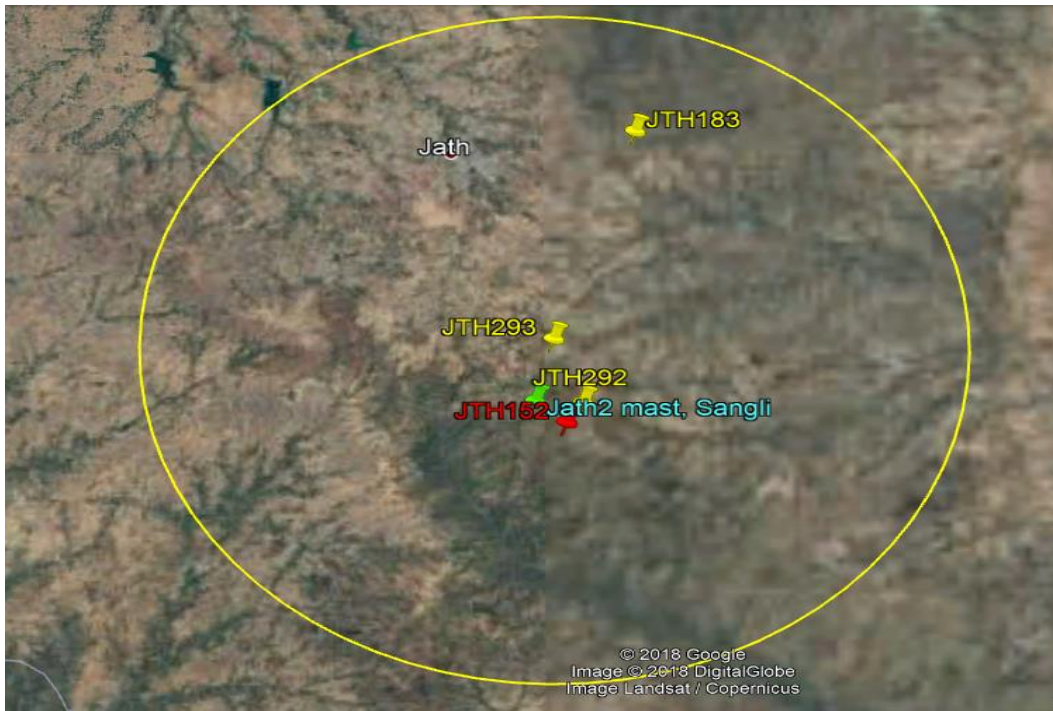
Sr. no	Zones	Mast details	WPD at 50 mtr	Elevation m amsl	Zone WPD (Watt/m <sup>2</sup> )
2	Khanapur	Khanapur, Tal. Khatav, Dist. Satara ,Latitude- 170 26' 37.1" N Longitude- 740 40' 25.1" E	211.66	942	200-250



**Observation:**

- All the WTGs under Khanapur mast are mapped on Google Earth. It has been observed that all the WTGs fall under 10 km radius of the mast referred.

Sr. no	Zones	Mast details	WPD at 50 mtr	Elevation m amsl	Zone WPD (Watt/m <sup>2</sup> )
3	Sangli 1	Village - Jath II, Dist. Sangli 16°58'48" 75°13'52.3"	210.96	749	200-250

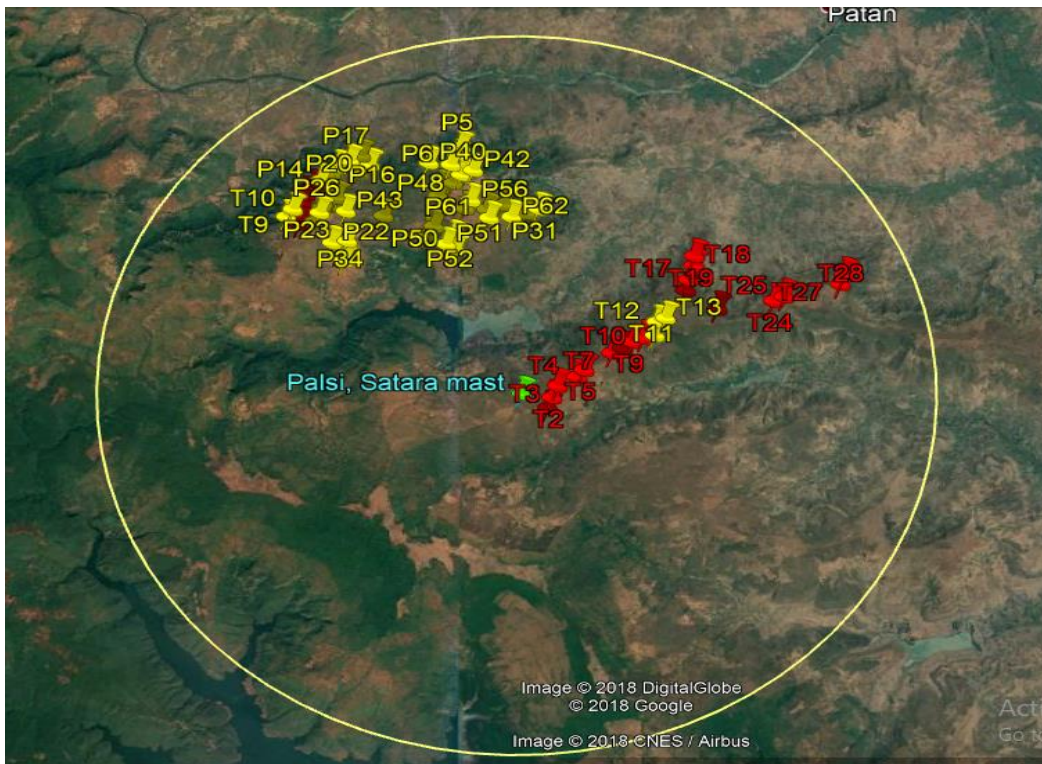


**Observation:**

- All the WTGs under Jath II mast are mapped on google earth. It has been observed that all the WTGs fall under 10 km radius of the mast referred.



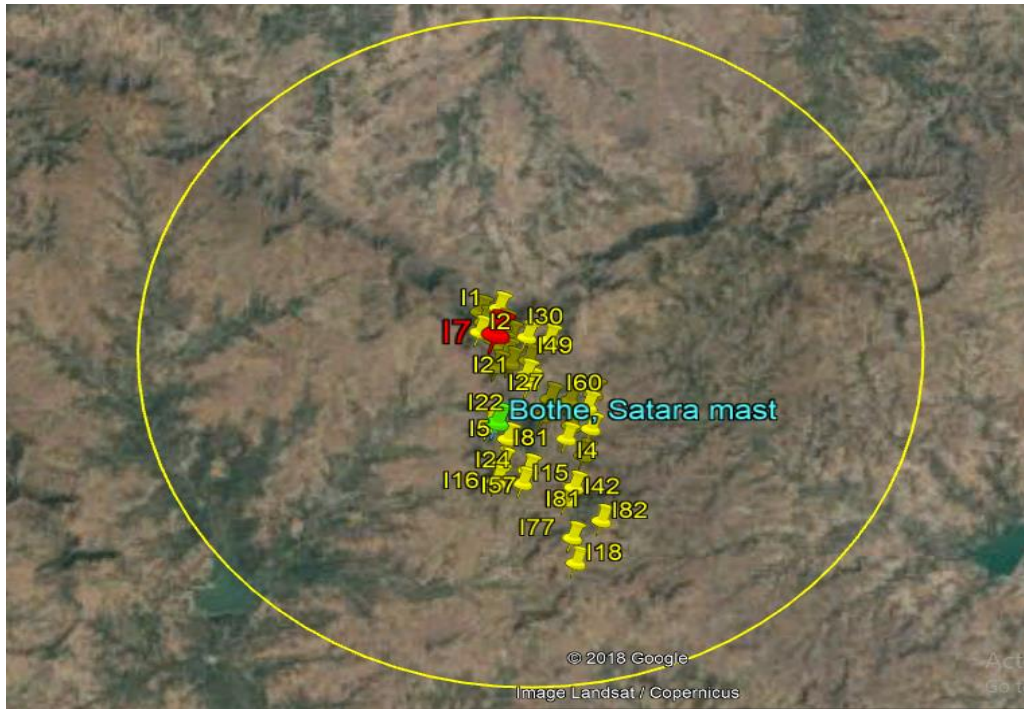
Sr. no	Zones	Mast details	WPD at 50 mtr	Elevation m amsl	Zone WPD (Watt/m <sup>2</sup> )
4	Palshi	Palshi Tal. Patan Dist. Satara Latitude - 17° 16' 09.8" N, Longitude - 73° 49' 34.02" E	203	1008	200-250



**Observation:**

- All the WTGs under Palshi mast are mapped on google earth. It has been observed that all the WTGs fall under 10 km radius of the mast referred.

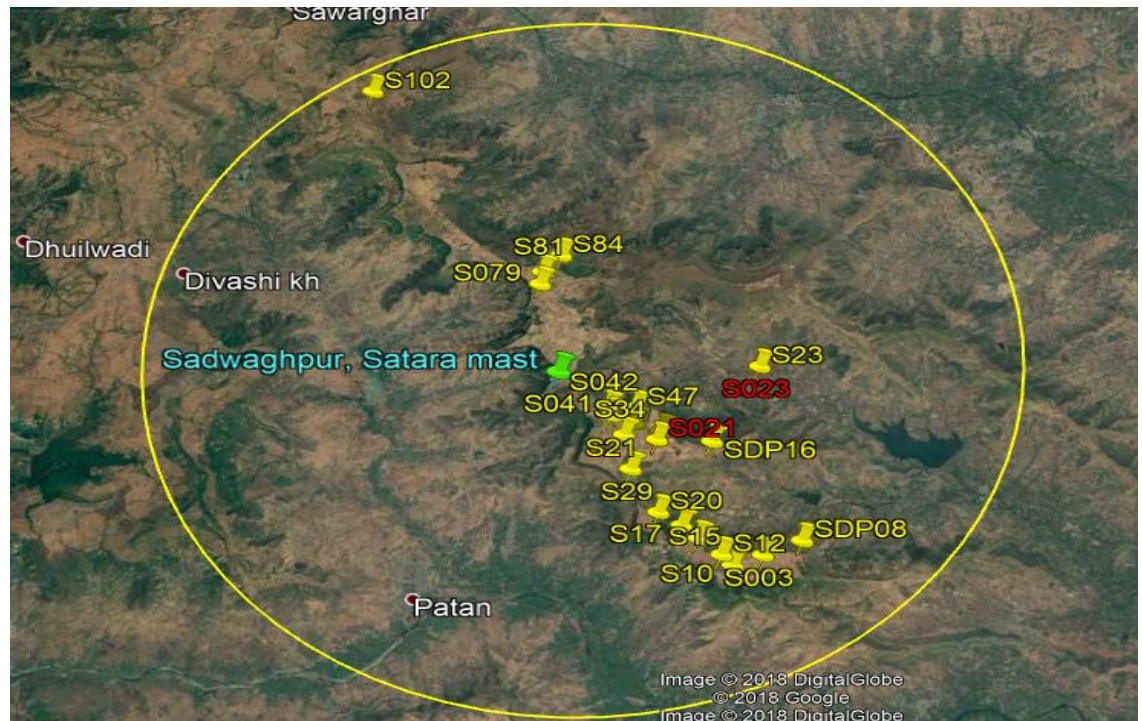
Sr. no	Zones	Mast details	WPD at 50 mtr	Elevation m amsl	Zone WPD (Watt/m <sup>2</sup> )
5	Bothe	Village - Bothe Taluka - Maan District - Satara (Latitude- N 17° 47' 08.7" Longitude- E 74° 22' 08.3")	214.2	1040	200-250



**Observation:**

- All the WTGs under Bothe mast are mapped on google earth. It has been observed that all the WTGs fall under 10 km radius of the mast referred.

Sr. no	Zones	Mast details	WPD at 50 mtr	Elevation m amsl	Zone WPD (Watt/m <sup>2</sup> )
6	Sadawaghapur	Sadawaghapur Tal. Patan Dist. Satara Latitude - 17° 25' 26.7'' N, Longitude - 73° 55' 42.2'' E	211.76	1074	200-250

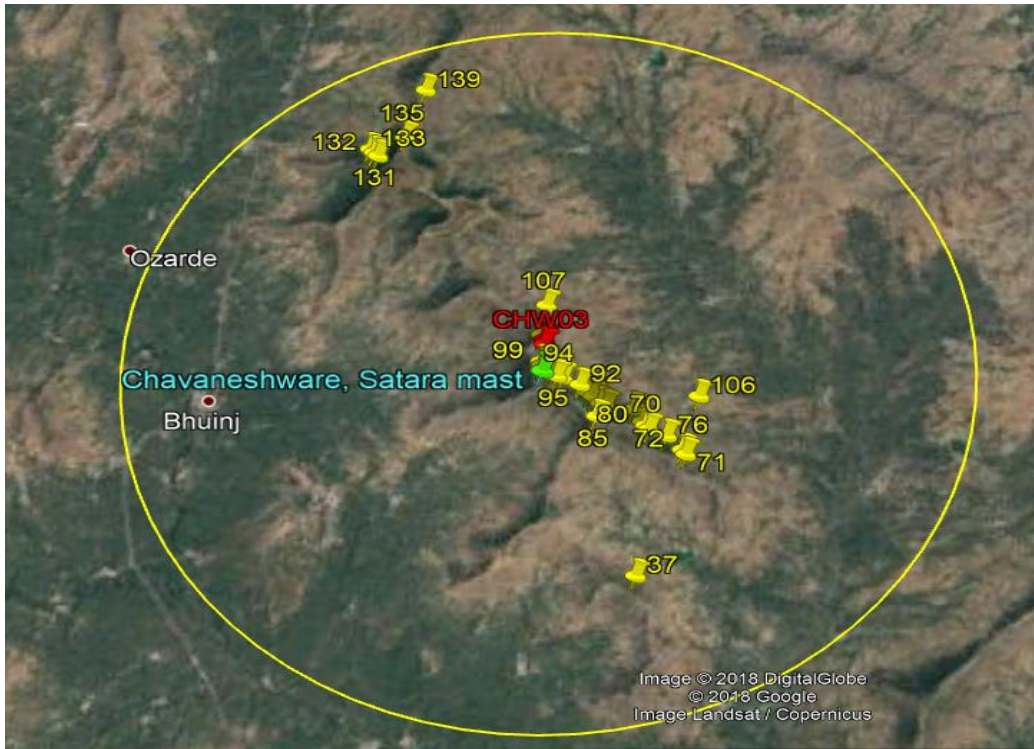


**Observation:**

- All the WTGs under Sadhwaghpur mast are mapped on google earth. It has been observed that all the WTGs fall under 10 km radius of the mast referred.



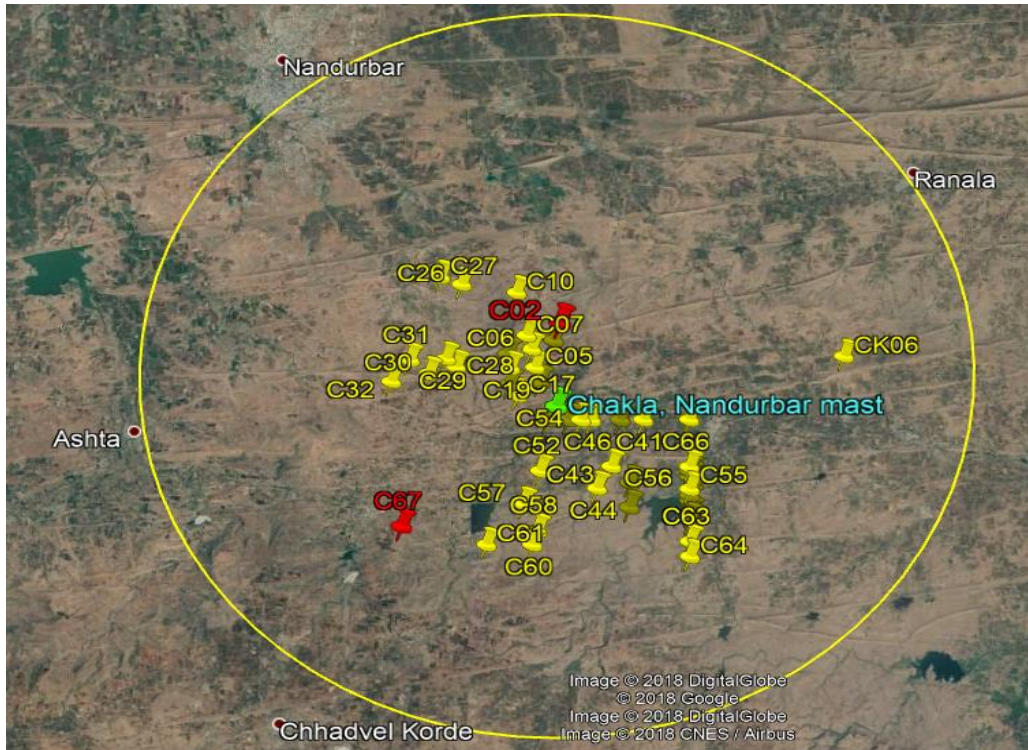
Sr. no	Zones	Mast details	WPD at 50 mtr	Elevation m amsl	Zone WPD (Watt/m <sup>2</sup> )
7	Chavaneshware	Village - Chavaneshware, Dist. Satara 17°52'48.8" 74°02'32.9"	234	1185	200-250



**Observation:**

- All the WTGs under Chavaneshware mast are mapped on google earth. It has been observed that all the WTGs fall under 10 km radius of the mast referred.

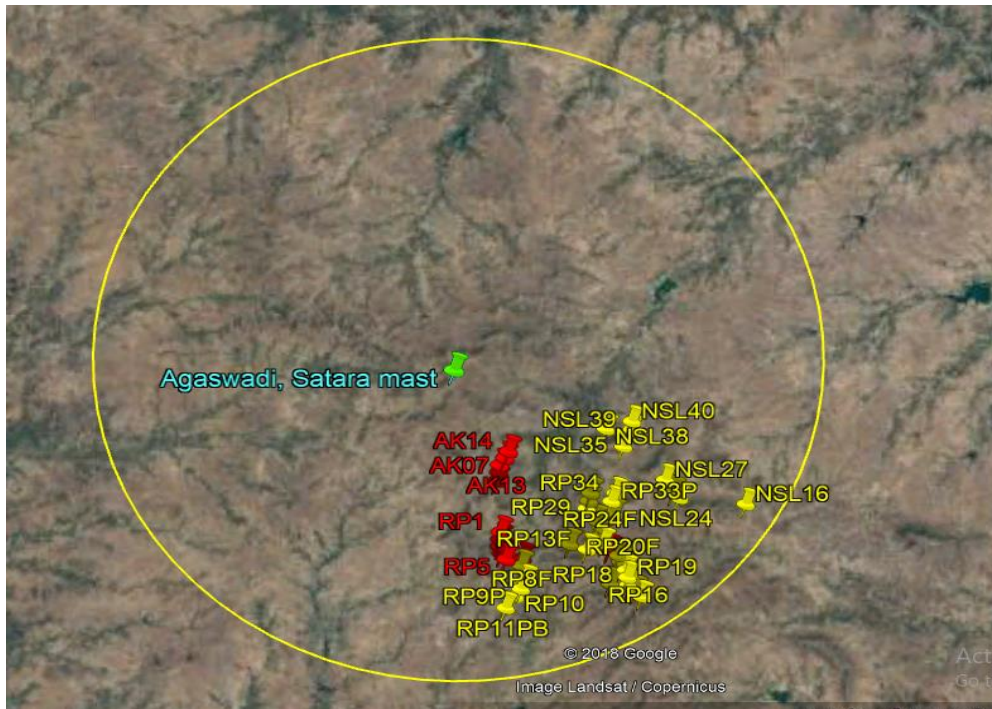
Sr. no	Zones	Mast details	WPD at 50 mtr	Elevation m amsl	Zone WPD (Watt/m <sup>2</sup> )
8	Nandurbar	Village - Chakla, Dist. Nandurbar 21°16'53.0" 74°18'30.2"	227.78	353	250-300



**Observation:**

- All the WTGs under Chakla, Nandurbar mast are mapped on google earth. It has been observed that all the WTGs fall under 10 km radius of the mast referred.

Sr. no	Zones	Mast details	WPD at 50 mtr	Elevation m amsl	Zone WPD(Watt/m <sup>2</sup> )
9	Agaswadi	Village - Agaswadi, Dist. Satara 17°33'28.9" 74°37'22.0"	200	890	100-200



**Observation:**

- All the WTGs under Agaswadi, Satara mast are mapped on google earth. It has been observed that all the WTGs fall under 10 km radius of the mast referred.



## Annexure II

Mapping of WTG's located in Chakla on NIWE's 50 mtr WPD map and zone classification

Sr. no	District	Mast details	WPD at 50 mtr as per mast data (Watt/m <sup>2</sup> )	Elevation m amsl	WPD as per NIWE's 50 mtr WPD map (Watt/m <sup>2</sup> )
1	Nandurbar	Village - Chakla, Lat 21°16'53.0" Lon 74°18'30.2"	227.78	353	250-300



### Observation:

- As per the 50 mtr WPD map of NIWE it is observed that location Chakla falls under the WPD 250 to 300 watts/sq.mtr. Further, all the WTGs located in the Chakla site in Nandurbar are plotted on the GIS arc and all of them except one WTG's falls under WPD zone of 250 to 300 as per the map.

**Annexure III: Estimated Wind Power generation derived WASP for Kotoli Wind Site in  
Dist. Kolhapur**

Inox DF 92_80		
Project Size (MW)		36
<b>Gross Estimated Energy</b>	<b>81.13</b>	<b>GWh</b>
Bhendawade Assessment Results		
<b>Wake Effects</b>	<b>94.8%</b>	
Internal Wake Effects	94.8%	
External Wake Effects	100.0%	
Future Wake Effects	100.0%	
<b>Availability</b>	<b>94.1%</b>	
Turbine Availability	98.0%	
Balance of Plant availability	99.0%	
Grid Availability	97.0%	
<b>Electrical Efficiency</b>	<b>97.0%</b>	
Operational electrical efficiency	97.0%	
Wind Farm consumption	100.0%	
<b>Turbine Performance</b>	<b>98.5%</b>	
Generic Power Curve adjustment	99.5%	
High wind speed hysteresis	100.0%	
Site specific power curve adjustment	99.5%	
Sub-optimal performance	100.0%	
Blade degradation	99.5%	
<b>Environmental</b>	<b>100.0%</b>	
Icing degradation	100.0%	
Icing shutdown	100.0%	
Temperature shutdown	100.0%	
Site access	100.0%	
Tree Growth	100.0%	
<b>Curtailment</b>	<b>100.0%</b>	
Wind Sector Management	100.0%	
Grid Curtailment	100.0%	
Noise, Visual and Environmental Curtailment	100.0%	

Uncertainty Assessment		
Sr. No.	Parameters	Site Uncertainty (%)
1	Annual Wind Variation	4.0
2	Measurement error	2.0
3	Air Density Correction	3.0
4	Power Curve uncertainty	3.0
5	Terrain Description	1.5
6	Long term correlation	4.0
7	Wind Flow Modeling	
	(a) Vertical extrapolation	2.0
	(b) Horizontal extrapolation	4.0
	(c) Wake modeling	3.0
	(d) Accuracy of terrain map	3.0
	(e) Roughness	3.0
8	Mounting error	3.0
<b>RMS Value</b>		<b>10.6</b>

Loss Assumptions:			
Machine Availability :	98.0%		
Grid Availability :	97.0%		
Transmission Efficiency	97.0%		
Turbine Performance	98.5%		
Balance of Plant Availability	99.0%		
Blade Degradation	99.5%		
Specific Power Curve Adjustment	99.5%		
Environmental	99.5%		
External Wake	100.0%		
<b>Overall Uncertainty</b>		<b>10.6%</b>	<b>0.106</b>





2015

Maharashtra																
Tariff	5.7	2														
Generation	1734000															
Revenue																
Year	1	2	3	4	5	11	12	13	14	15	20	21	22	23	24	25
Annual Revenue	9883800	9883800	9883800	9883800	9883800	9883800	9883800	9883800	3468000	3468000	3468000	3468000	3468000	3468000	3468000	3468000
NPV at 10%	77,052,888															
NPV at 10% for 13 Yrs	70,208,152															
Cost to DISCOM in 25 years	170,105,400															

Gujarat																
Tariff	4.16	4.16														
Generation	1734000															
Revenue																
Year	1	2	3	4	5	11	12	13	14	15	20	21	22	23	24	25
Annual Revenue	7213440	7213440	7213440	7213440	7213440	7213440	7213440	7213440	7213440	7213440	7213440	7213440	7213440	7213440	7213440	7213440
NPV at 10%	65,476,684															
NPV at 10% for 13 Yrs	51,239,634															
Cost to DISCOM in 25 years	180,336,000															

TamilNadu			
Tariff	3.51	3.51	
Generation	1734000		
Revenue			





