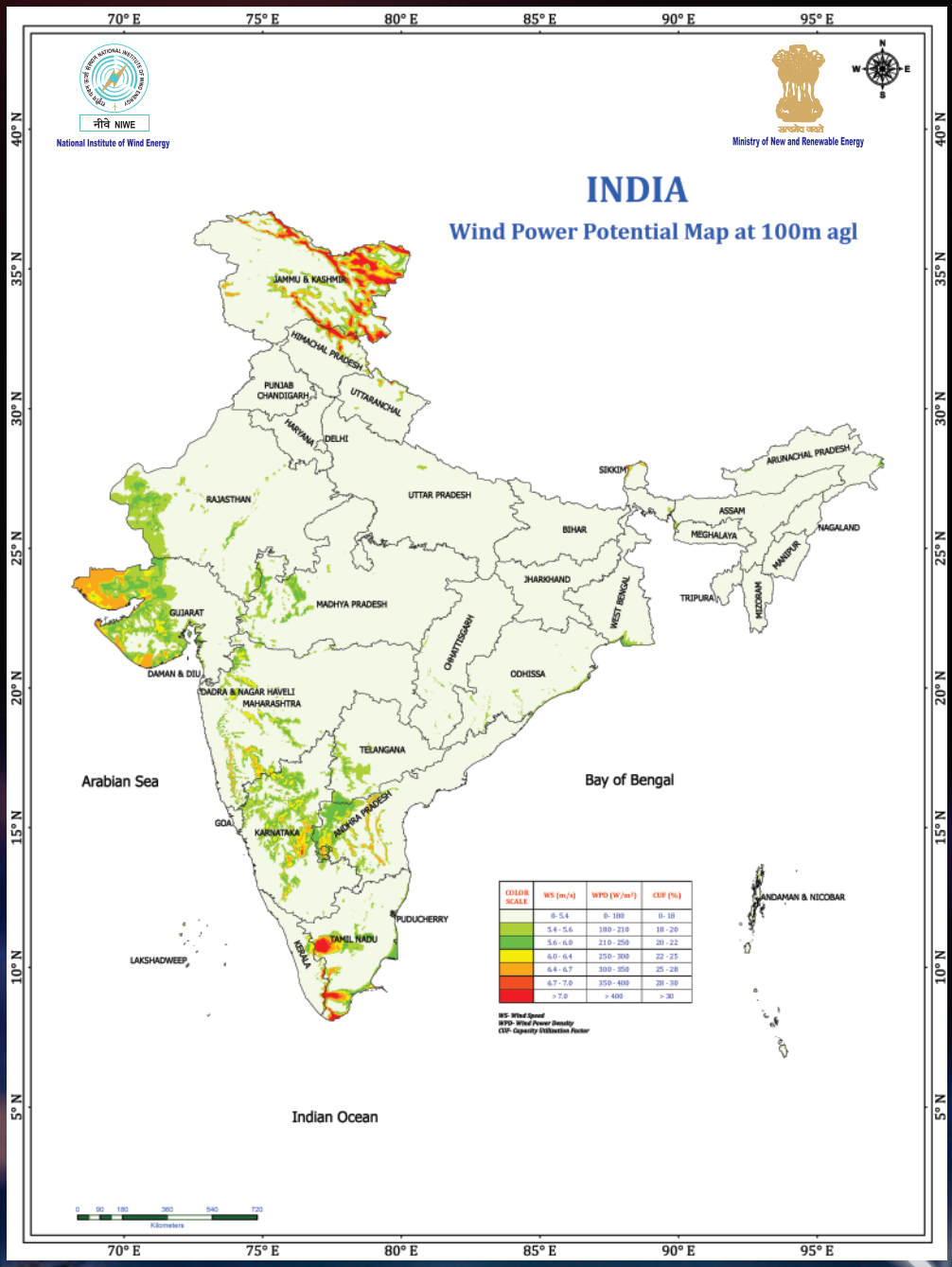
INDIAN WIND ATLAS : ONLINE GIS

WIND ENERGY RESOURCE MAP OF INDIA @ 100m AGL



Background

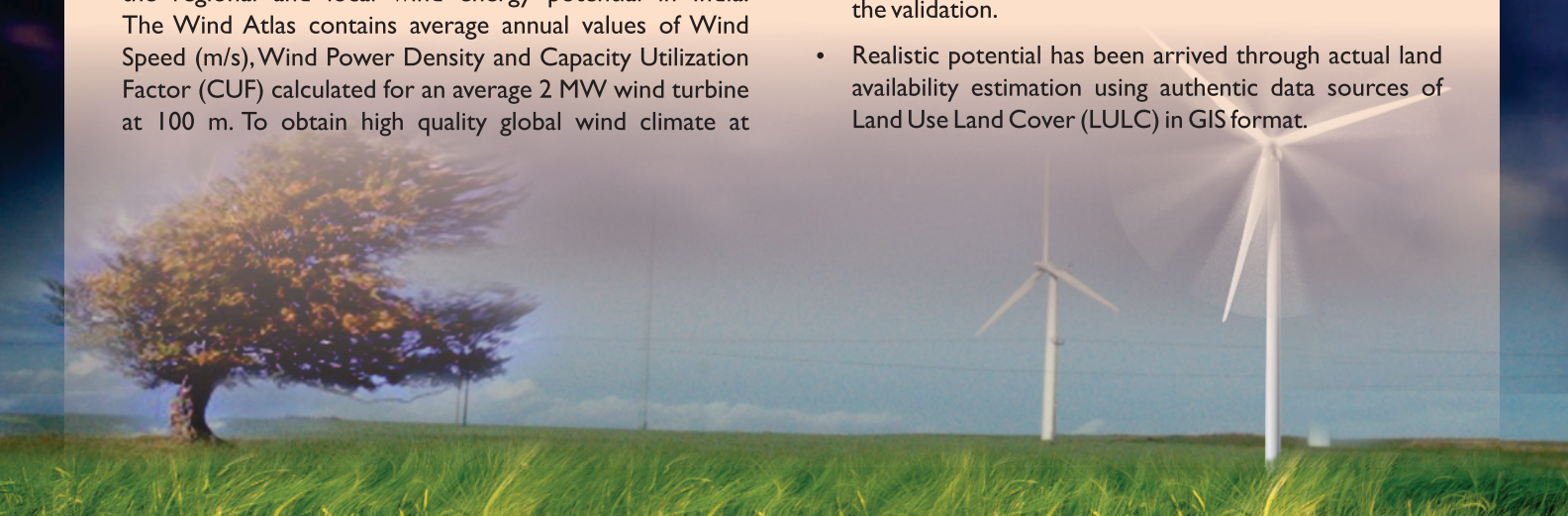
Necessity for energy security and caution on environmental degradation made wind as one of the non-ignorable sources in the Indian energy mix. The government's ambitious goal of 60,000 MW of wind power by 2022 is highlighting the needed focus on the green power's contribution in India's sustainable development. In order to meet these ambitious goals, India is not only committed to refine and strengthen the regulatory framework governing wind power in India, but also to provide the necessary reliable background information on the geographical variation and magnitude of the Indian wind resource and an estimated gross technical potential spread across the entire country at today's wind turbine hub heights. This information is essential for the Policy makers, Private players, Government Agencies and other stakeholders of the industry to move towards achieving the ambitious goal as envisaged by the government. With the above facts into consideration, under the direction of MNRE, NIWE has re-assessed the wind potential within the country at 100m height with scientific rigor and based on authentic latest available data-sets of wind as well as land geologically spread across India. NIWE (formerly C-WET) had already performed the potential estimation study corroborating meso-scale derived wind maps and micro-scale measurements and released Indian Wind Atlas at 50m and indicative values at 80m heights with 5km resolution in April 2010 in collaboration with RISO-DTU, Denmark, which serves as official estimates of 'Indian Wind Potential today. With the technical expertise in the field and prior experience in mapping, NIWE has chosen advanced modeling techniques and revisited this study as per the guidance and directives of MNRE/Govt.of India, with realistic and practical assumptions. The potential assessment presently has been carried out at a very high (10 times finer than 5km) spatial resolution of 500m, using the advanced meso-micro coupled numerical wind flow model and with the corroboration of almost 1300 actual measurements spread all over India, which can be stated as first of its kind.

Introduction

The new Indian Wind Atlas is an important online GIS (Geographic Information System) tool for identification of the regional and local wind energy potential in India. The Wind Atlas contains average annual values of Wind Speed (m/s), Wind Power Density and Capacity Utilization Factor (CUF) calculated for an average 2 MW wind turbine at 100 m. To obtain high quality global wind climate at different resolution a High-resolution numerical modeling has been used. This is designed to downscale climate wind conditions up to 100m horizontal with levels in the first 150m. Downscaling is made in a nesting down procedure where atmospheric flows are refined with enhanced physics options adequate to each scale; Macroscale meteorological inputs obtained from the newest NCEP version of reanalysis: Climate Forecast System Reanalysis (CFSR) that was completed over the 31-year period of 1979 to 2009 in January 2010. The CFSR was designed and executed as a global, high resolution, coupled atmosphere-ocean-land surface-sea ice system to provide the best estimate of the state of these coupled domains over this period. The CFSR global atmosphere resolution is ~55 km (T382) with 64 levels extending from the surface to 0.26hPa. The global ocean is 0.25° at the equator, extending to a global 0.5° beyond the tropics. The core of the technical modeling approach for this digital atlas is the atmospheric model Weather Research and Forecasting System (WRF) employed operationally by Vortex, Spain. The model assessment has been carried out in two stages: (1) Preliminary modeling runs with a maximal resolution of 500m has been employed as a baseline for model performance quality assessment and (2) Final modeling runs with a maximal horizontal resolution up to 500m covering the whole of India and representing a 20-year time span.

Features of Indian Wind Atlas 2015 : Online GIS

- The resultant layers are at the very high resolution of 500m.
- Joint frequency tables have also been derived for the entire country at 500m resolution.
- High resolution Re-analysis data set has been used for the study – NCEP/CFSR (0.5^0lat x 0.5^0long resolution), which enhanced the accuracy of the mapping.
- Uses dynamic meso-micro coupled WRF modelling technique.
- Around 1300 met mast results have been utilized for bias correction and validation.
- Actual site's generation details have also been utilized for the validation.
- Realistic potential has been arrived through actual land availability estimation using authentic data sources of Land Use Land Cover (LULC) in GIS format.



Data Sources

S. No	Data Set	Source
1	Wind Parameters Map	Meso-microscale map 500m resolution - WRF
2	Land Use Land Cover Data Set	NRSC / ISRO, Hyderabad- 56m resolution (AWiFS)
3	Road, Railway lines, Administration Boundary, Reservoir, River details	NNRMS (National Natural Resource Management System)
4	Elevation & Slope information	SRTM (Shuttle Radar Topography Mission) 1 arc (30m resolution)
5	Airports	Google Earth / Online Sources
6	Protected Areas	WDPA (World Database on Protected Areas)

Improvements in Indian Wind Atlas 2015: Online GIS over April 2010

Parameter	Indian Wind Atlas 2010	Present 100m Potential Map (2015)
Flow Model	KAMM - WAsP	WRF
Model Resolution	5Km	500m
Final Outcome	Wind Power Density (WPD) map	Capacity Utilization Factor (CUF) map

Height	50m, 80m	100m
Land Availability Estimation	Assumption of 2% for Windy states and 0.5% for poor windy states	Actual Land availability estimation using NRSC Land Use Land Cover (LULC) Data – AwiFS 1:250K
Validation	Up to 50 m	Up to 100m
GIS layers	Static, digital	Dynamic, Online

Methodology

Deriving Basic Wind Parameters

- Generation of Basic Wind Parameter Layers for the entire country at 500m resolution using dynamic meso - micro coupled multiscale WRF modeling.
- 20 years of NCEP/CFSR (0.5 deg x 0.5 deg resolution) Re-analysis data set is used for initiation of the model.
- Wind Speed, WPD, Weibull A & k, Air Density, Temperature, Joint frequency distribution have been derived.
- Uncertainty estimation.

Processing of Data sets

- Processing model output - wind parameter layers.
- Processing of NRSC Land Use Land Cover (LULC) layers.
- NNRMS administration Layers.
- SRTM (1 arc resoln.) DEM is also processed for elevation and slope details.

Capacity Utilization Factor (%CUF) Map Preparation

- Preparing frequency distribution for each 500m grid point using Weibull A & k parameters.
- 2 MW Normalized power curve derivation.
- Preparing Capacity Utilization Factor grid layer for the country at 500m resolution using frequency distribution & normalized power curve (air density corrected at each grid point).
- Arriving P90 %CUF value with standard corrections & uncertainty assumptions.
- Validation of the resultant GIS layer using available actual measurements.

Area Exclusion

- Land features which are not suitable for wind farming has been excluded from the potential map with appropriate buffer/set-off.
- In addition, other developments such as Roads, Railways, Protected Areas, Airports, etc., have been excluded.
- Land area with elevation more than 1500m and slope more than 20 degree have also been excluded.
- All the information have been converted into vector layers and clipped off from the potential map.

Estimation of Installable Wind Potential

- Zones with CUF of 20% and above (Capacity utilization factor-CUF) are considered for wind potential estimation. 18-20% CUF range is shown in the map as an indication, which may be possible to be exploited with future technology development into consideration.
- Installable wind power capacity is estimated by considering 6 MW per sq.km in each %CUF range with assumption of 5D x 7D micro-siting configuration.

Installable Wind Power Potential

INSTALLABLE WIND POTENTIAL @ 100m (MW)				
State	Rank I*	Rank II*	Rank III*	Total
Andaman & Nicobar	4	3	1	8
Andhra Pradesh	22525	20538	1165	44229
Chhattisgarh	3	57	16	77
Goa	0	0	1	1
Gujarat	52288	32038	106	84431
Karnataka	15202	39803	852	55857
Kerala	333	1103	264	1700
Lakshadweep	3	3	1	8
Madhya Pradesh	2216	8259	9	10484
Maharashtra	31155	13747	492	45394
Odisha	1666	1267	160	3093
Puducherry	69	79	4	153
Rajasthan	15415	3343	13	18770
Tamil Nadu	11251	22153	395	33800
Telangana	887	3348	9	4244
West Bengal	0.034	2.042	0	2
Total in MW	**153020**	**145743**	**3489**	**302251**
Total in GW	**153**	**146**	**3**	**302**

* Rank I - NRSC Level-II Classification Values : 12, 13, 15, 19
Rank II - NRSC Level-II Classification Values : 2, 3, 4, 5, 6, 10, 18
Rank III - NRSC Level-II Classification Values : 7, 8, 9

Validation

The mean wind speed and mean wind power density values from 1300 actual met mast measurements obtained from various sources have been utilized in this study for bias correction and validation purpose. In order to validate the Capacity Utilization Factor (%CUF), generation information obtained from 50 nos. of sites (which also includes operational wind farms) have been utilized.

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Disclaimer : Even though authentic data sources have been used in the re-assessment of wind potential to arrive at a total potential for the entire country at 100m, a micro scale evaluation of wind potential in every state of India will be pursued further by NIWE taking due consideration of state specific policies, priorities, status of current RE (Wind and Solar) projects, fuzzy land owner/revenue land usage-pattern, allocation of systems, evacuation and logistical infrastructure development plans and so on. There is a probability of marginal changes (upward/downward) in the estimated potential in individual states while applying state specific variations from the present national level uniform criteria and assumptions adopted to get at the national gross wind energy potential.