

# **WIND FLOW MODELING IN BUSINESS !!**

**Do more sophisticated models produce more accurate wind resource estimates????**



**Mytrah Energy (India) Limited**

**WindSim User Meeting – June 2014**

# As we go along....



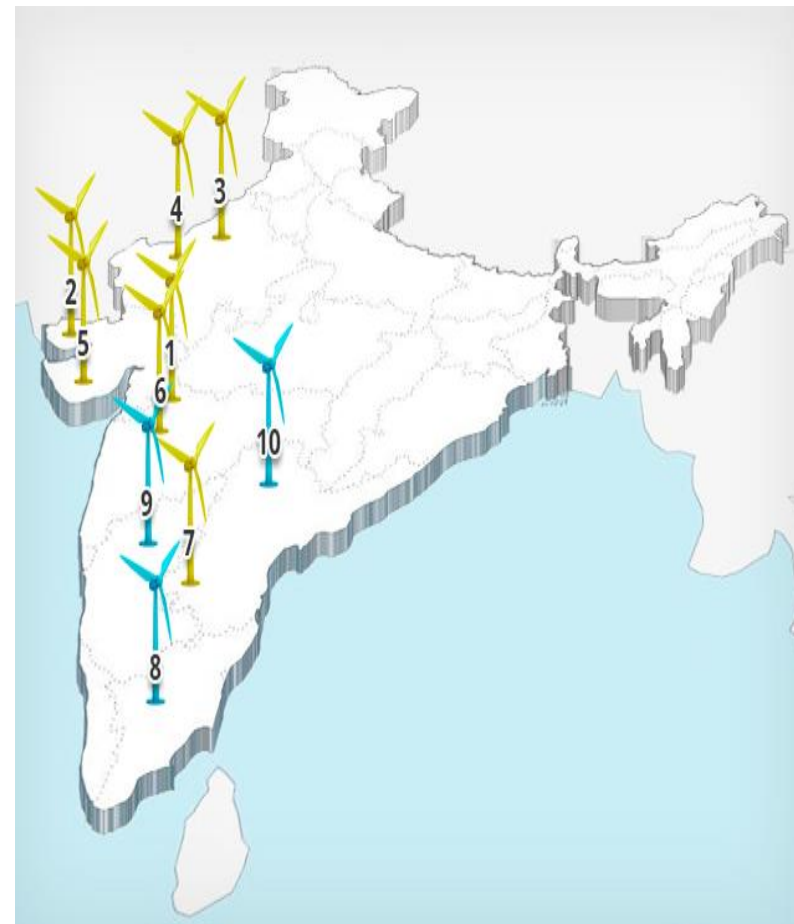
- **MYTRAH : A short profile of the company**
- **Flow of a typical Energy Assessment**
- **Overlook of Uncertainty analysis ; Why it is important ?**
- **Improving the quality of assessment & practices to reduce the uncertainty**
- **Case Study : Assessing the impacts of uncertainty**
- **Summary**



# Mytrah Portfolio and Location



Sl. No	Site (State)	Capacity (MW)	COD
<b>FULLY OPERATIONAL</b>			
1	Chakla (MH)	39	Feb'12
2	Jamanwada (GJ)	52.5	Aug'12
3	Kaladongar (RJ)	75.6	Mar'12
4	Mokal (RJ)	42	Oct'11
5	Mahidad (GJ)	25.2	Oct'11
6	Sinner (MH)	12.6	Sept'12
7	Vajrakarur (AP)	63	Dec'12
	<b>Total</b>	<b>309.9</b>	
<b>New SPVs</b>			
8	Vagarai (TN)	100.5	Partially operational
9	Savalsung (KA)	100.3	Partially operational
10	Burgula (AP)	37.4	Fully Operational



# Wind Resource in MYTRAH



- Wind monitoring, EYA, PMA, TDD, Forecasting etc.,
- More than 150 wind monitoring campaigns are in operation in 7 states
- All the sophisticated software's in the market
- Data base and on-line monitoring
- In house tools and standard procedures
- Real time turbine operational data management and power curve guarantee test
- 200m wind mast installation and LIDAR – a R&D project,



# Wind Flow Modeling



## Linear Models

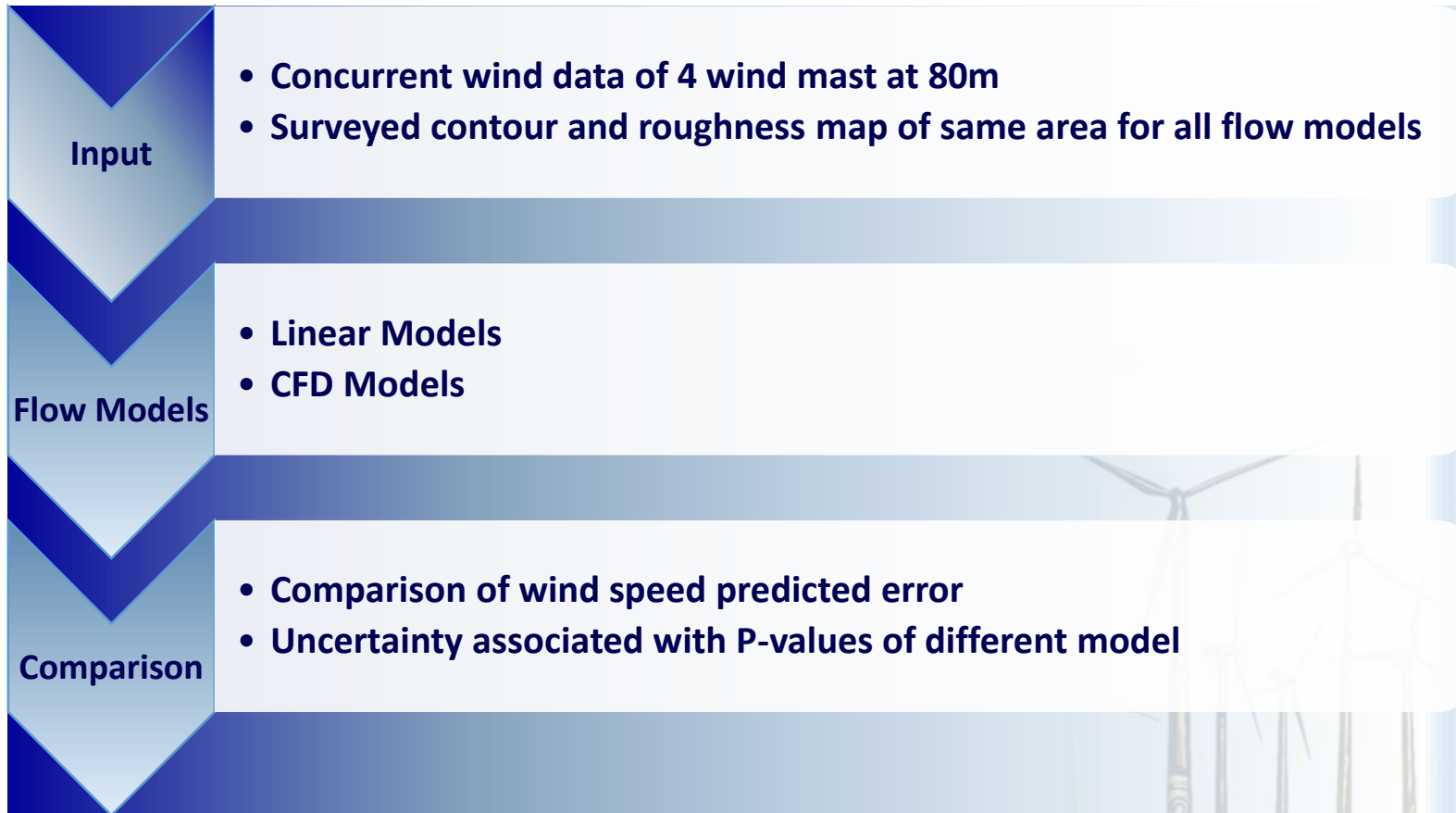
- Suitable for more simple flat terrains
- Moderate flat sites with moderate uncertainty
- Poorly predict flow separation in complex terrain
- Inaccuracy of prediction and uncertainty increases as the terrain complexity increases
- Limitations are more in complex terrain

## CFD Models

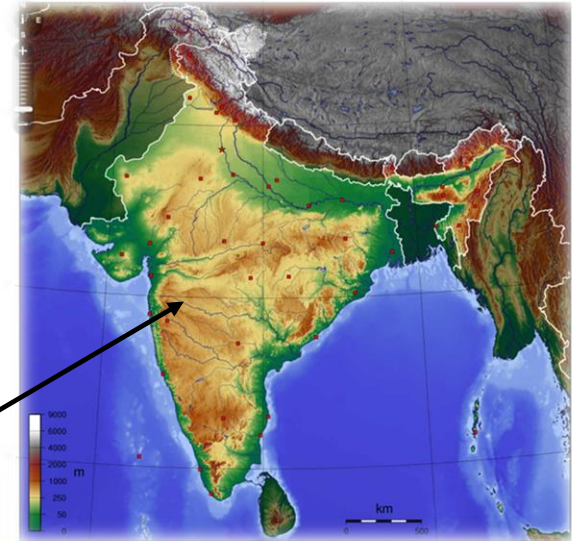
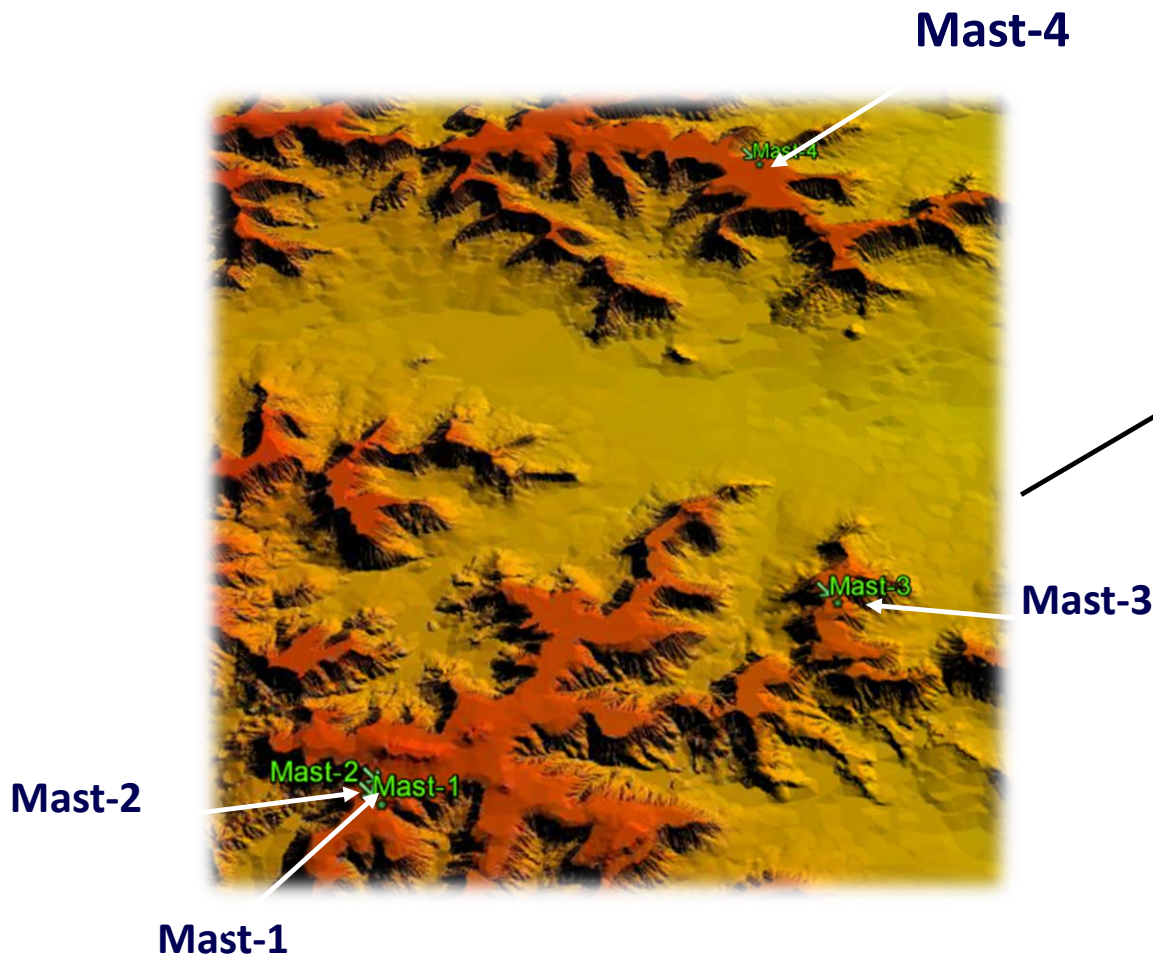
- Navier Stokes solvers are developed in the last decade through CFD codes
- Simulate turbulent atmospheric boundary layer flows over steep complex terrain
- Reduced uncertainty in complex terrain
- Wind variety of turbulence models to calculate local speed ups



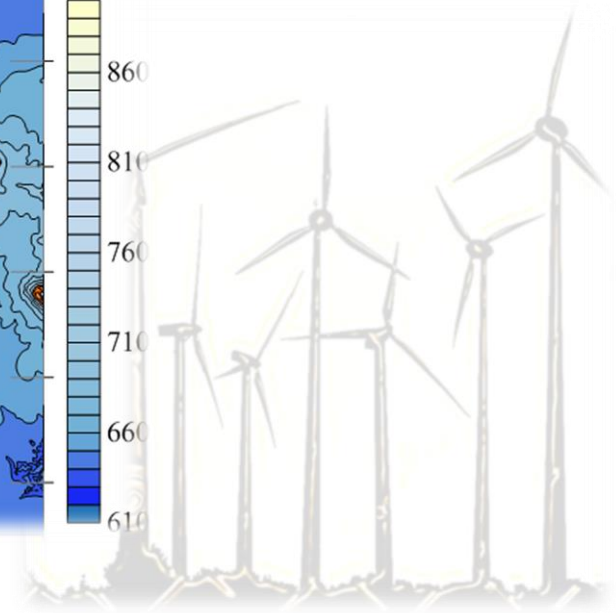
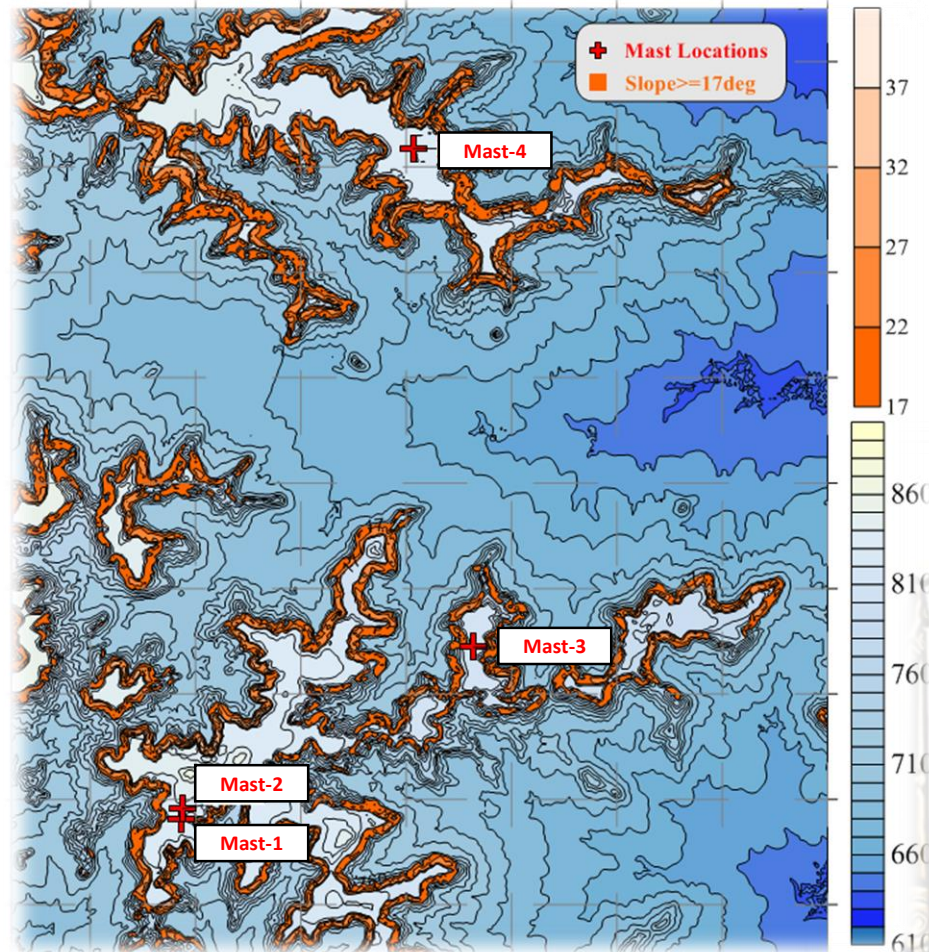
# Approach



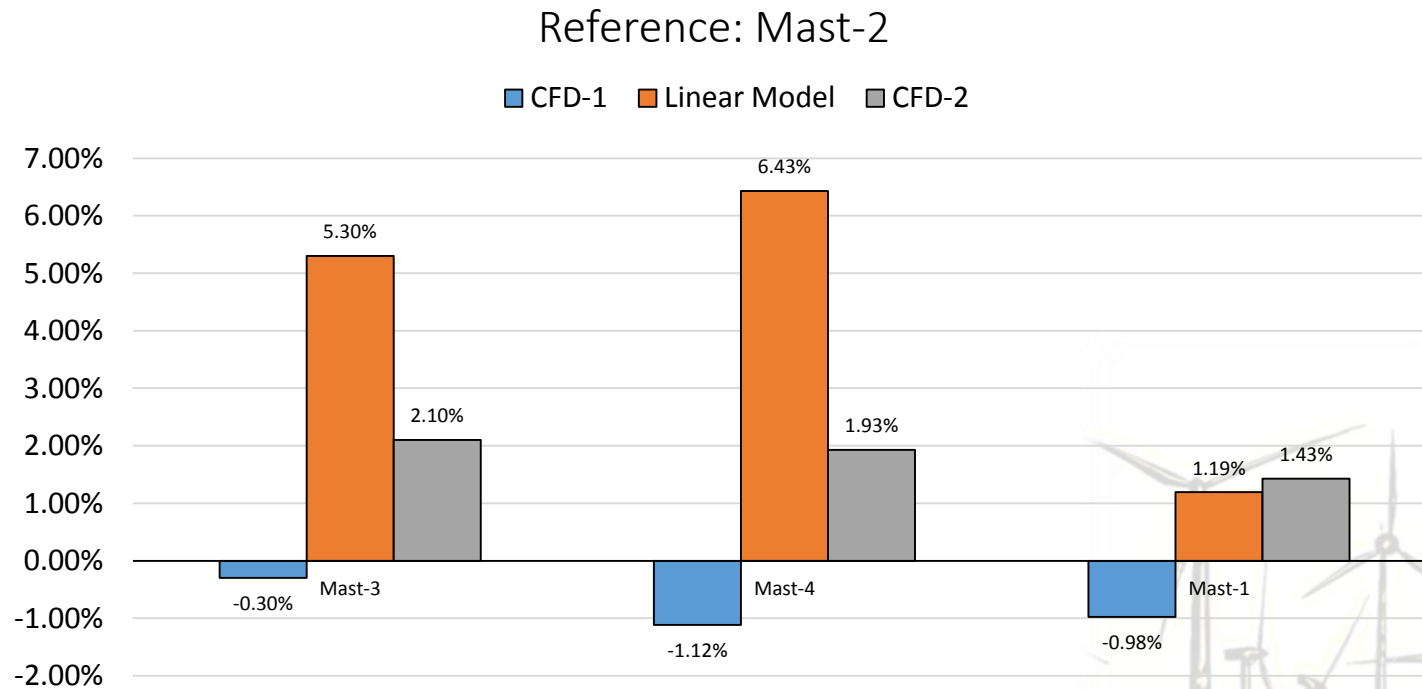
# Test Site



# Mast Location



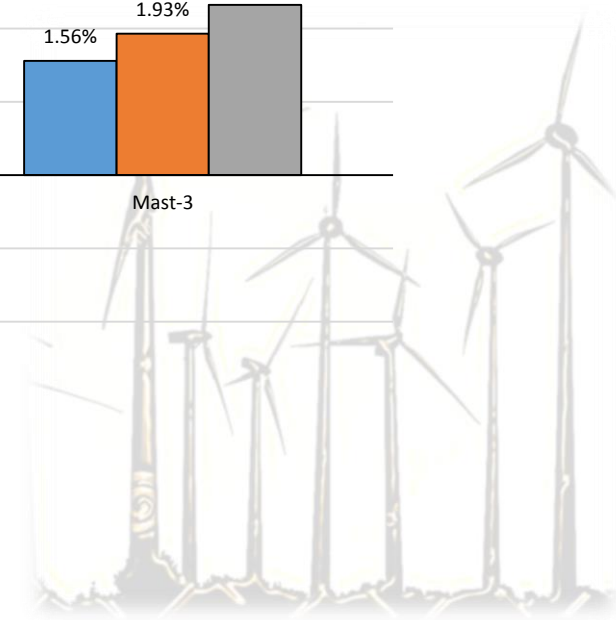
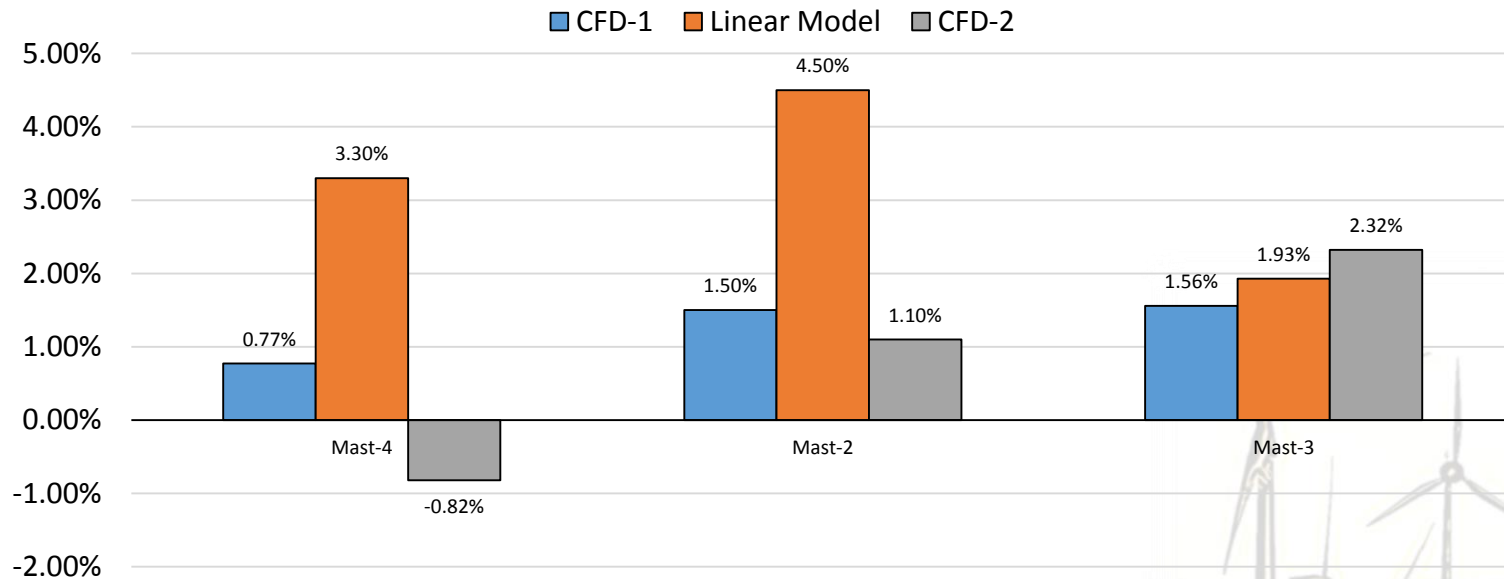
# Wind speed - comparison Results



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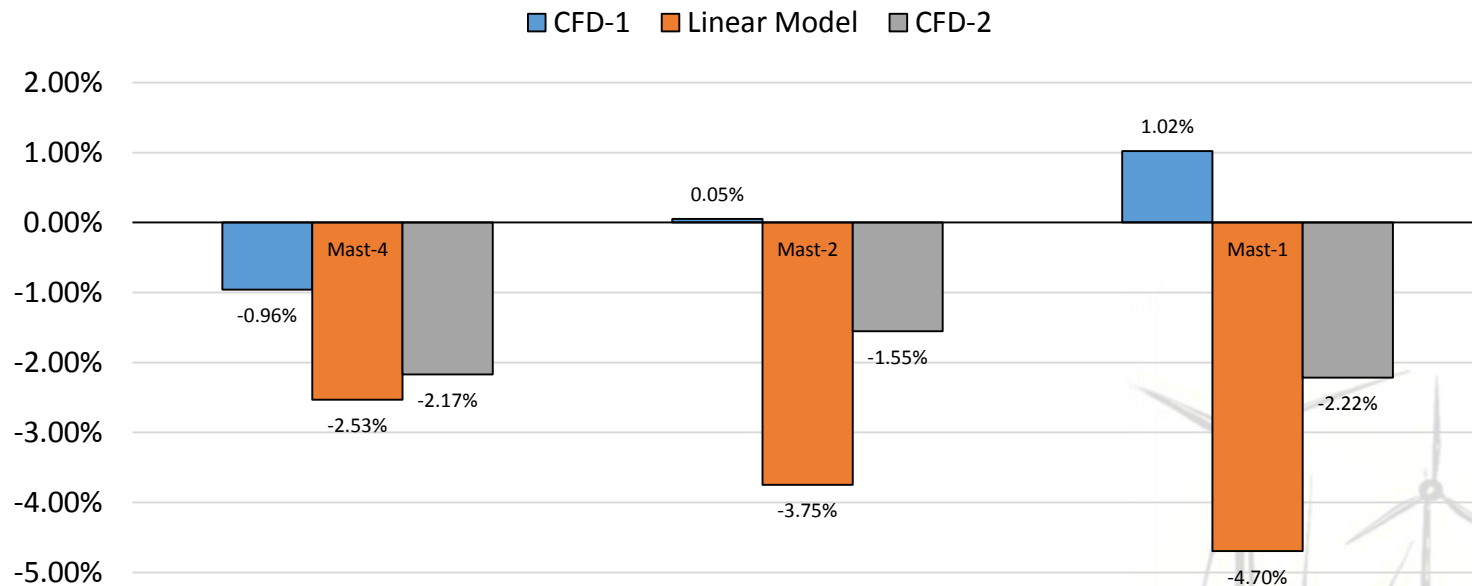
Reference: Mast-1



# Wind speed - comparison Results



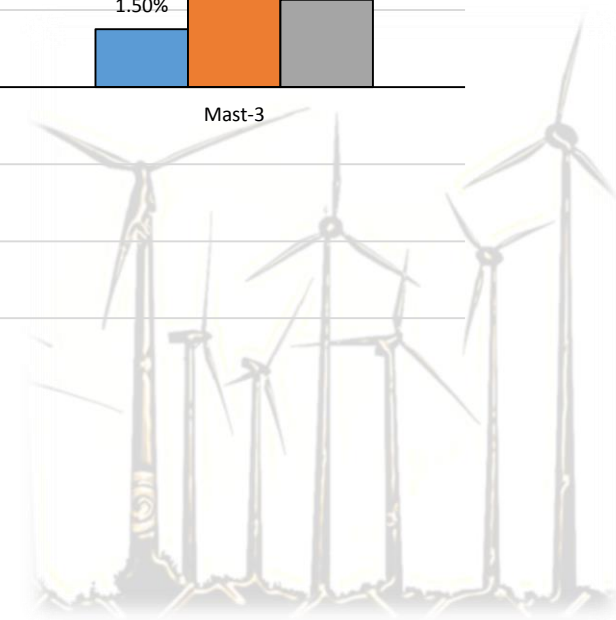
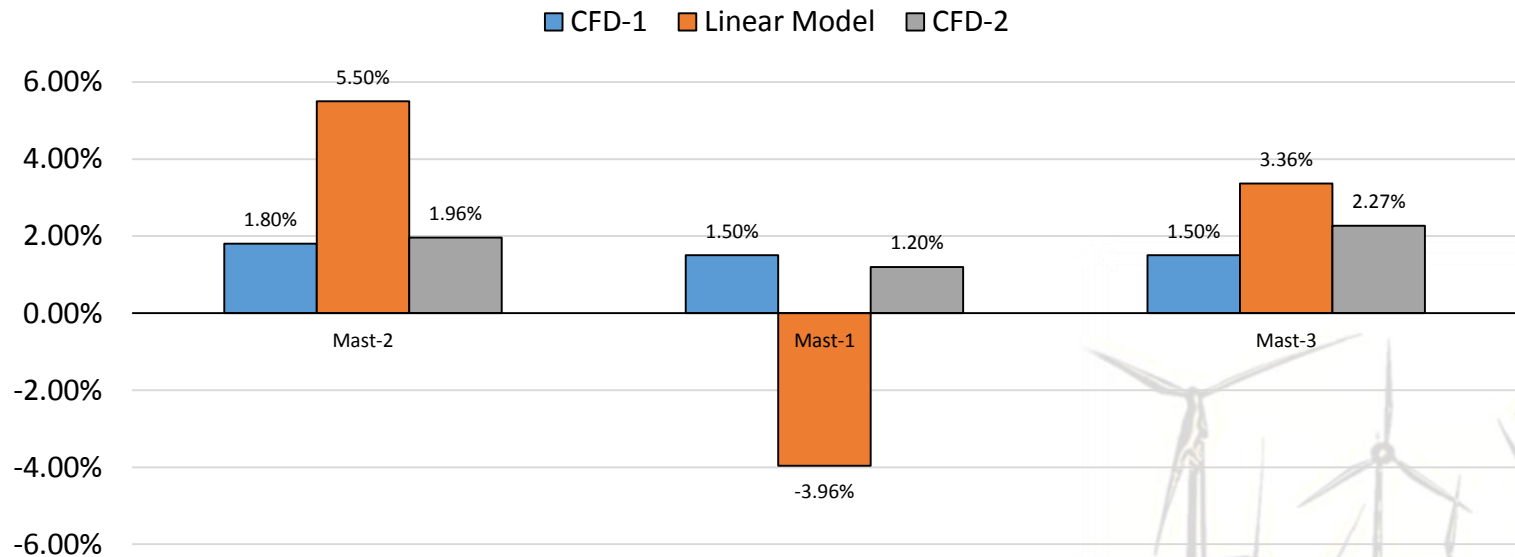
## Reference-Mast-3



# Wind speed - comparison Results



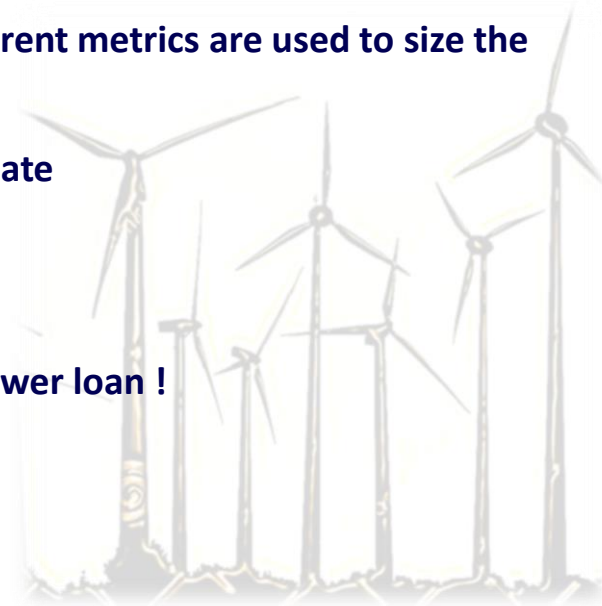
Reference: Mast-4



# Assessment & Uncertainty ; the certain things



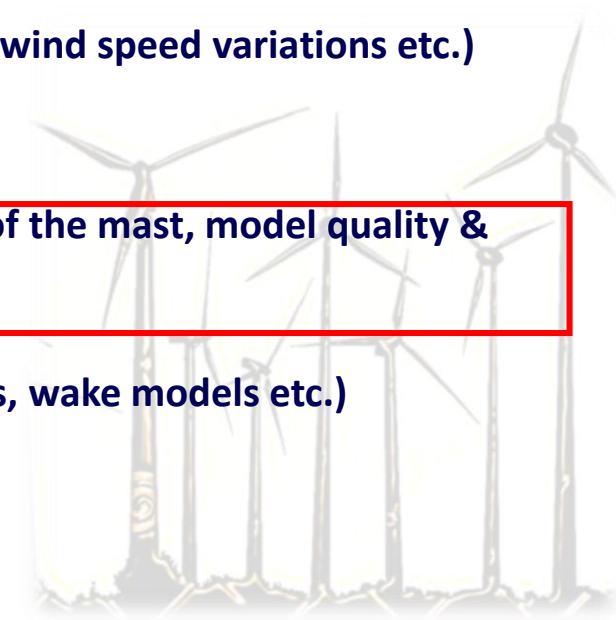
- A number of uncertainties are always inherent in the analysis and effects of these are to be considered on the likelihood of achieving the central estimate energy yield prediction
- Degree of confidence of an energy estimate will fall within a specified range ( essential for a sound financial model)
- Uncertainty assessment is important to minimize the financial risk associated with the project & to quantify the future annual energy production we need a metric.
- Depending upon the lender and the market experience different metrics are used to size the debt.
- P 50 ( Central estimate) - 50% chance of exceeding the estimate
- P 90 - 90% chance of exceeding the estimate
- Lenders are moving from P50 to P99 !!!
- For the same P50 a WRA with higher uncertainty means a lower loan !
- No general rules or global standard values !



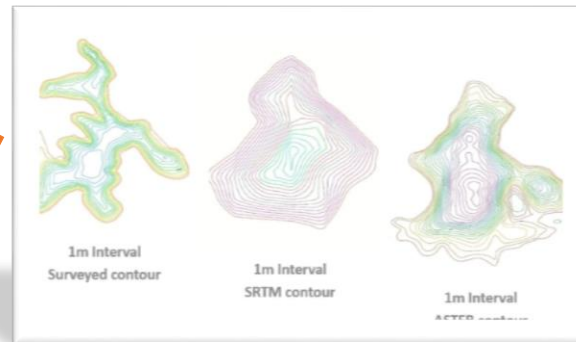
# Uncertainty ; Main categories



- Wind Measurement ( Instrument accuracy, Interference of Mast, Data Quality )
- Long term climate conditions ( Period of measured data, Availability and consistency of long term data, Correlation between met stations etc.)
- Future Wind Variability ( Climatic changes, inter annual wind speed variations etc.)
- Vertical Extrapolation ( Shear !)
- Flow modelling ( Quality of inputs, representativeness of the mast, model quality & error etc.)
- Plant Performance and Losses ( Availability assumptions, wake models etc.)



# Certain uncertainties !



# Case Study



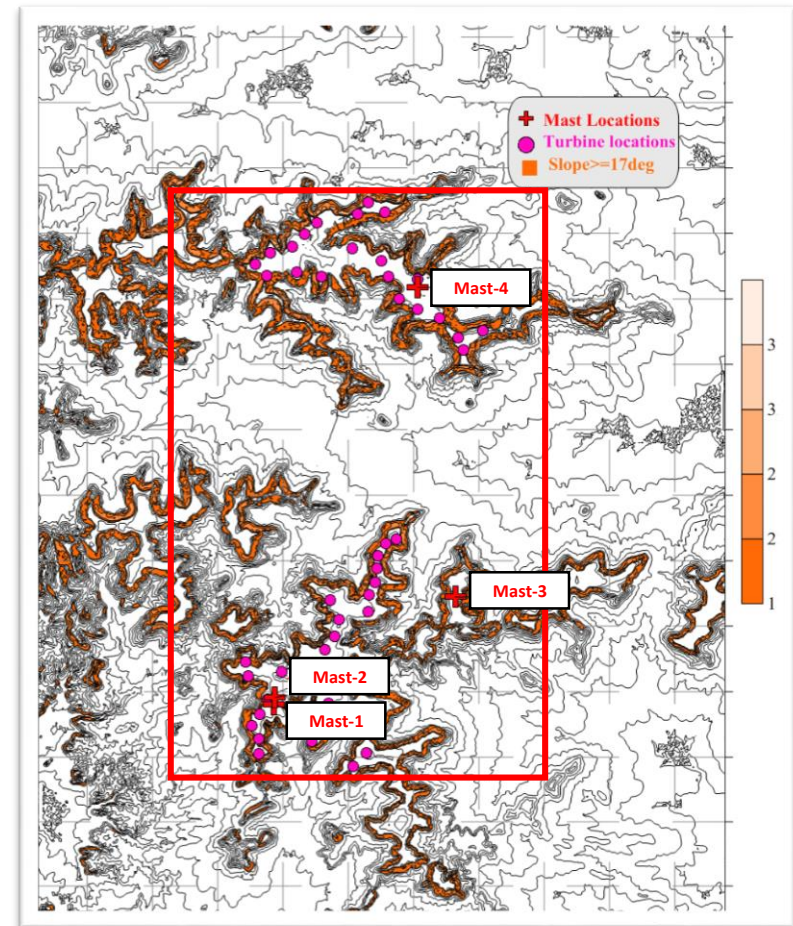
- **Complex site of 100MW capacity**
- **HH mast installed at four locations across the site.**
- **IEC complaint, no data gap ; 1year measurement for all the 4 masts.**
- **Data cleaned for shadow sectors and erroneous values**
- **Advanced flow modelling tools were used along with conventional ones.**



# Scenario 1: Single Mast Vs Linear Model Vs 100MW



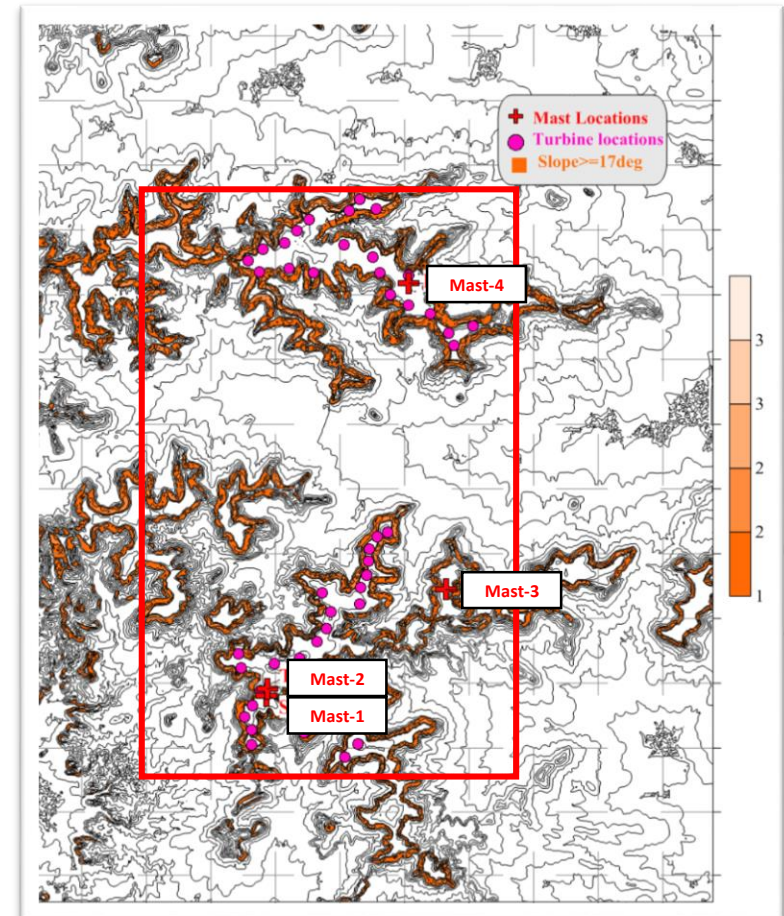
Uncertainties	(%)
Historical wind speed variability	6
Anemometry	2
<b>Topographic model</b>	<b>6</b>
Wake loss model	3
Correlation	0
Power curve	1.5
Vertical extrapolation	0
Map & direction	1
Loss factor assumption	3
P50 / P75 Ratio	0.85254



# Scenario 2: Single Mast Vs CFD model Vs 100MW



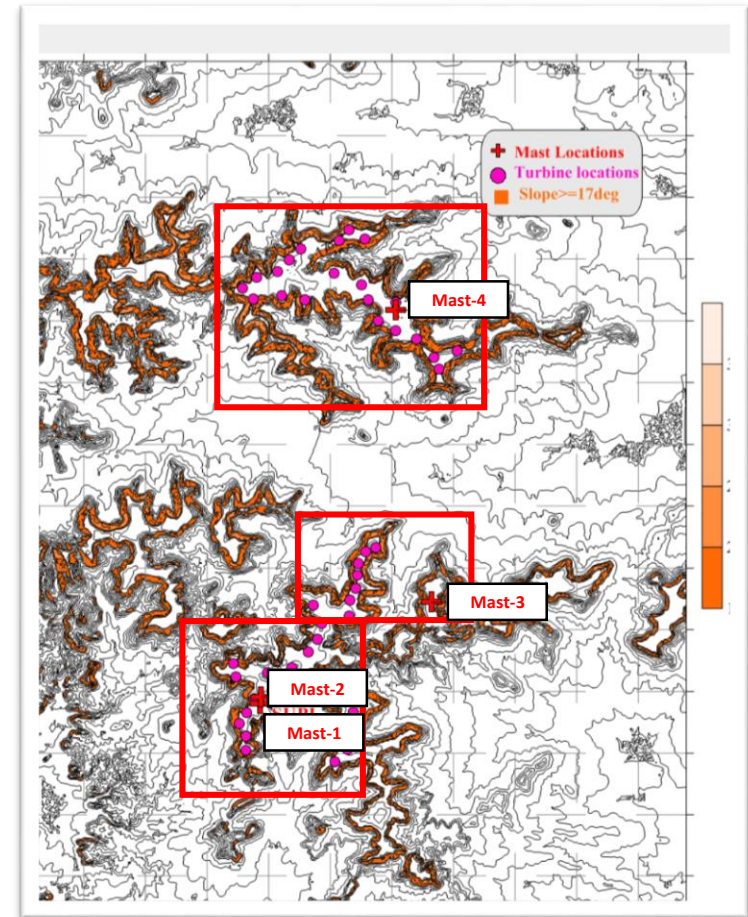
Uncertainties	(%)
Historical wind speed variability	6
Anemometry	2
Topographic model	2.5
Wake loss model	3
Correlation	0
Power curve	1.5
Vertical extrapolation	0
Map & direction	1
Loss factor assumption	3
P50 / P75 Ratio	0.881857



# Scenario 3: Multiple Masts Vs Linear Model Vs 100MW



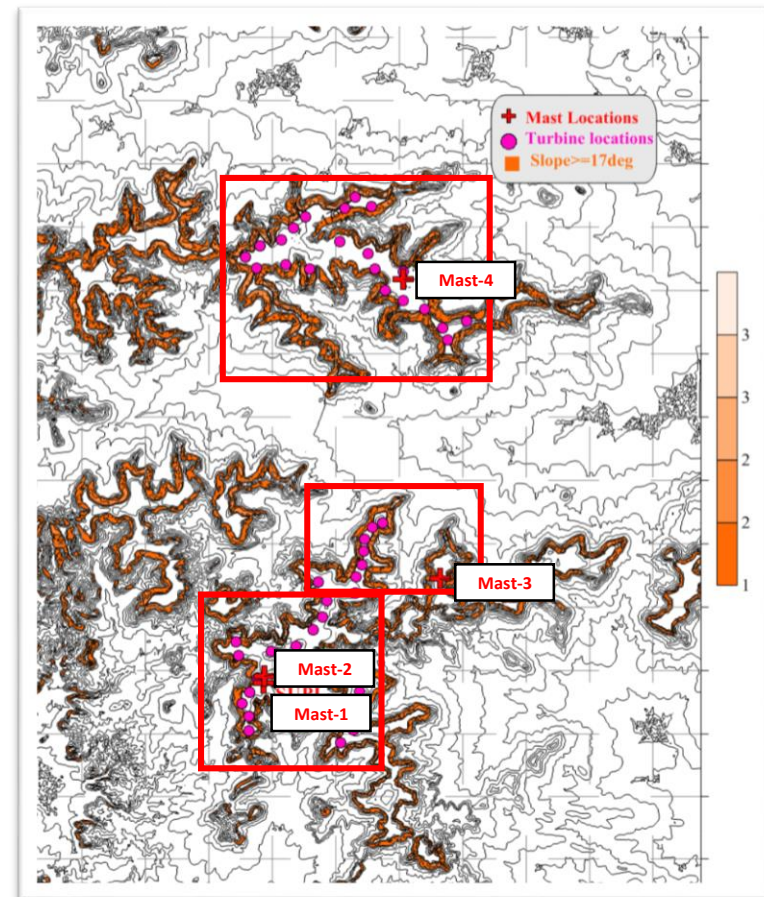
Uncertainties	(%)
Historical wind speed variability	6
Anemometry	2
Topographic model	4.5
Wake loss model	3
Correlation	0
Power curve	1.5
Vertical extrapolation	0
Map & direction	1
Loss factor assumption	3
P50 / P75 Ratio	0.864198



# Scenario 4: Multiple Masts Vs CDF Model Vs 100MW

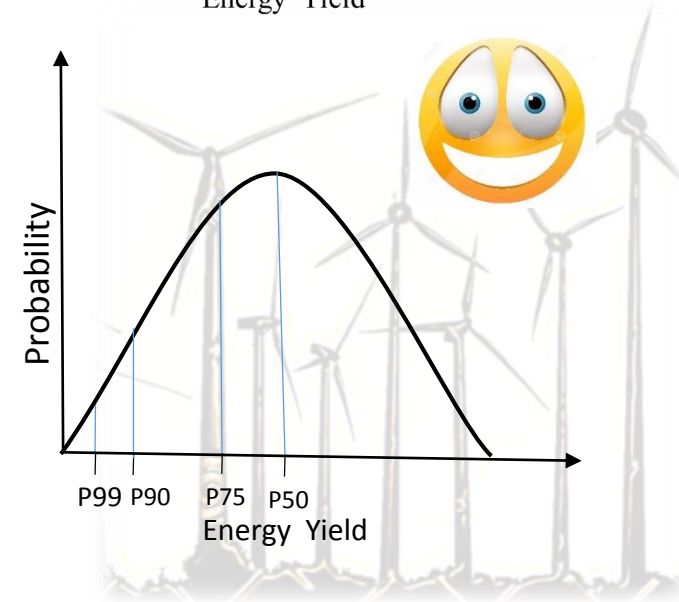
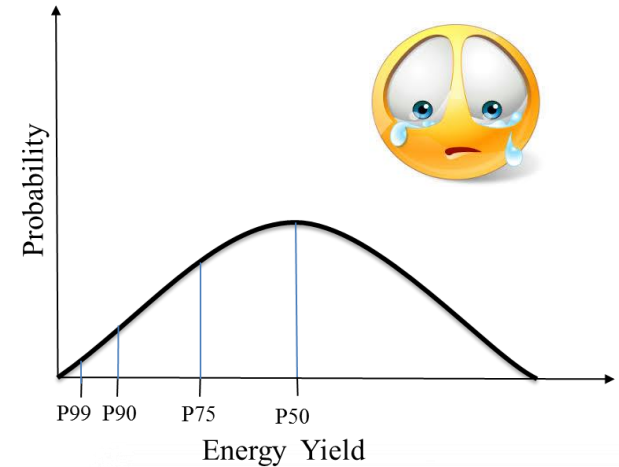


Uncertainties	(%)
Historical wind speed variability	6
Anemometry	2
Topographic model	1.5
Wake loss model	3
Correlation	0
Power curve	1.5
Vertical extrapolation	0
Map & direction	1
Loss factor assumption	3
P50 / P75 Ratio	0.886076



# To conclude....

- A sound resource assessment & Uncertainty analysis is key for a sound financial model.
- CFD models are sophisticated and advanced with a better user interface; user capability matters.
- Time consuming & high computational capability required when compared to classical linear model
- Uncertainty in WRA will have an impact on the project financial model
- Better TI and shear understanding !
- Proper Location (s), mast anatomy, flow models and surveyed map will reduce uncertainty.
- Most of the investment in WRA will pay off later
- The numbers(P75,P90 & P99) really matters.....



# Questions...



# Thank You...

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*Stay Hungry. Stay Foolish.*