



Statistical Downscaling for Seasonal Wind Power Forecasts – A Case Study in India



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enercast power forecast products



enercast standard product

The short- and medium-range wind/solar energy forecasts

enercast seasonal product – Pilot project wind power/ energy generation forecast for the upcoming 6 months



Demand for seasonal energy forecasts

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- Reliable budgeting
- Operational optimization
- Financial risk mitigation
- Statistical analysis based on historical data from the last few years is insufficient for projecting the next year.



Seasonal forecast from climate models

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- Energy Forecasts Unavailable
- Lack of Wind Speed Data at Turbine Hub Height
- Coarse Spatial Resolution
- Systematic Errors Across Timescales



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Converting Wind Speed Forecasts into Site-Specific Power Output

Data level:

- Tried several seasonal forecast resources
- Incorporating wind speed forecasts from surface and pressure Levels
- Utilizing monthly forecast anomalies
- Site data collection and cleansing

Method level:

Various machine learning methods

In addition:

Assessing forecast skill of the indian monsoon*



Data Quality Issues and Data Cleansing



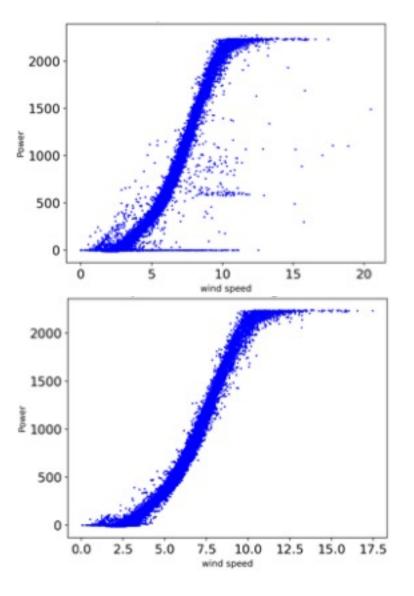


Wind Plant Shutdowns

- Incorrect Data Logging
- Grid Issues and Operational Situations

Data Cleansing Approach:

Enercast's In-House Data Cleansing Automation Individual Handling and Cleansing of +800 Wind Turbines

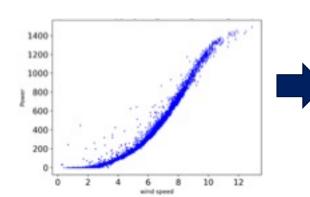


Data Sources and Methodology

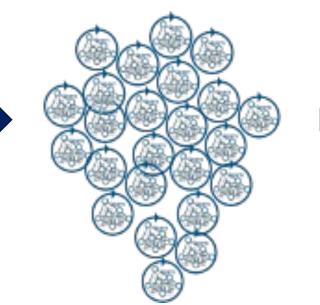




Historical site data



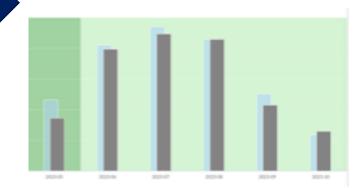
Machine Learning



Site-specific forecast

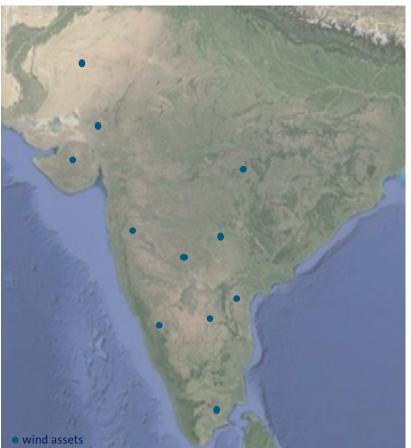
Forecast Delivery Timeline:

- Since April 2022
- Monthly Updates
- Covering the Upcoming 6 Months



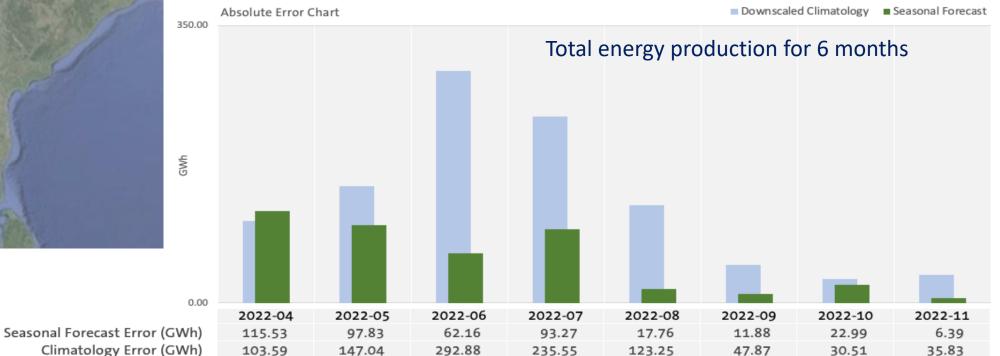
Evaluations-1





- Country-Level Wind Portfolio:
 - Capacity: 1000 MW *
- Evaluation Metrics:
 - Energy Forecast vs. Actuals

Baseline: Climatological Energy Production**



*Capacity is slightly scaled down from the original portfolio capacity for the evaluation purpose **Synthetic historical wind speed and power data is generated as a baseline for method evaluation

Absolute Forecast Error (GWh) = |Forecast – Actuals|

Evaluations-2

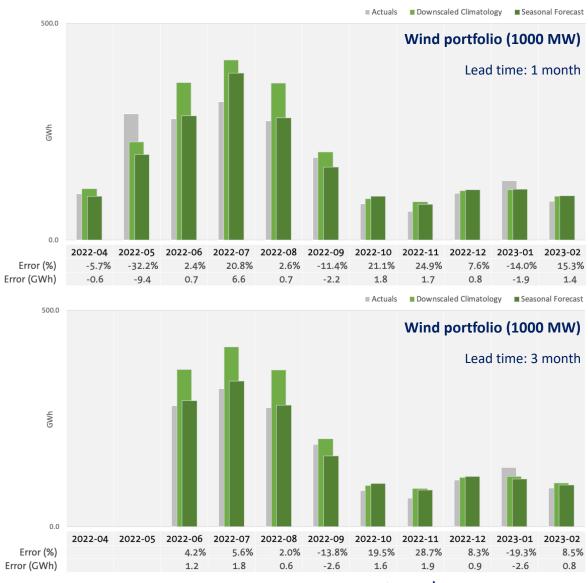


Lead Time: 1 Month

- Seasonal Forecasts captured the trend direction correctly in 7 out of 11 months.
- Seasonal Forecasts outperformed climatology in most months, particularly during the monsoon season.

Lead Time: 3 Months

- Seasonal Forecasts captured the trend direction correctly in 6 out of 9 months.
- Seasonal Forecasts outperformed climatology in most months, especially during the monsoon season.



Error (%) = (Forecast - Meter) / Meter Error (GWh) = (Forecast - Meter)

Summary and Outlook

Seasonal Energy Forecasts Outperform Climatology:

- Lead times ranging from 1 to 6 months
- Excels climatology in most months, particularly during the high-wind season

Seasonal Forecasts significantly enhance 6-month production estimates, which benefits for yearly budgeting and financial planning processes.

Next Steps:

Evaluate Extended Horizons

Pilot Projects in Additional Regions

Providing Uncertainty Range of Forecasts

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onthly View									Meter data i	Current month i	Seasonal Forecast i	Climatology
/pe	2022-11	2022-12	2023-01	2023-02	2023-03	2023-04	2023-05	2023-06	2023-07	2023-08	2023-09	2023-1
藻 PV Plant												
EASONAL FORECAST												
Generation (GWh)	7.360	5.500	6.800	7.300	8.652	7.900	8.873	7.968	8.054	8.030	8.413	7.52
iolar irradiation (kWh/m2)	146.970	151.700	178.960	192.700	213.900	200.400	193.847	216.967	182.334	191.676	206.396	195.23
LIMATOLOGY												
Generation (GWh)	6.384	6.794	7.659	8.099	9.415	8.205	8.857	8.190	8.181	8.121	8.635	7.15
iolar irradiation (kWh/m2)	150.157	156.091	165.791	182.376	218.696	207.726	202.829	229.306	186.340	195.174	213.138	170.0
₩ind Farm												
EASONAL FORECAST												
Generation (GWh)	10.960	20.120	24.170	15.950	24.100	19.530	31.703	91.583	109.605	99.480	45.200	26.48
Vind speed (m/s)	3.390	3.940	5.150	4.050	4.390	4.210	5.198	7.523	8.190	7.741	5.340	4.28
LIMATOLOGY												
Generation (GWh)	19.771	24.253	23.026	21.406	23.031	20.816	49.267	94.636	109.400	99.458	54.434	22.3
Vind speed (m/s)	4.113	4.398	4.346	4.258	4.205	4.124	5.458	7.636	8.157	7.716	5.807	4.10
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