



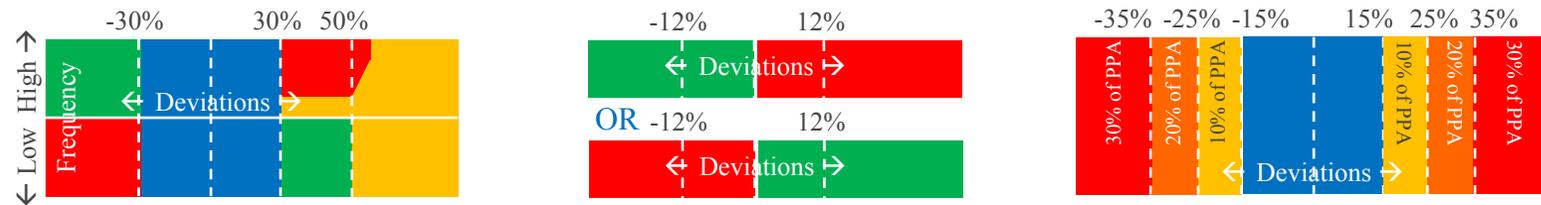
# Wind Forecasting Digital Twin

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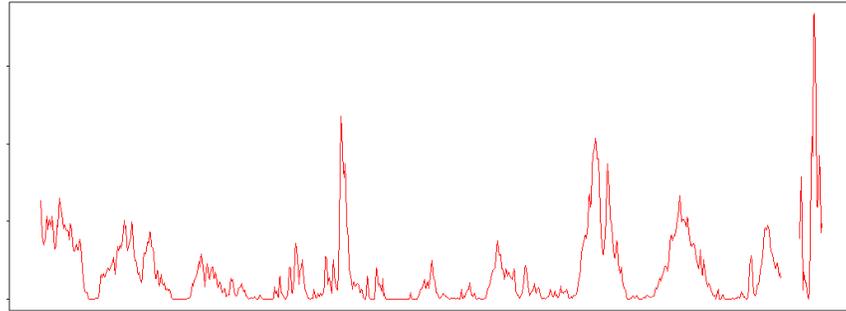
# Evolution of Forecasting Regulation In India

	July 2013	March 2015	August 2015
Applicability	Intra + Inter-State	Inter-State	Inter-State + FORs w/ States
Operating Band	±30%	±12%	±15%
Error Formula	(Actual-Schedule)/Schedule	(Actual-Schedule)/Schedule	(Actual-Schedule)/Available Capacity
# of Updates/Day	8	16	16
Settlement Dependency	Accuracy + Frequency	Accuracy	Accuracy
Settlement Calculation	Frequency Linked	REC Linked	% of PPA

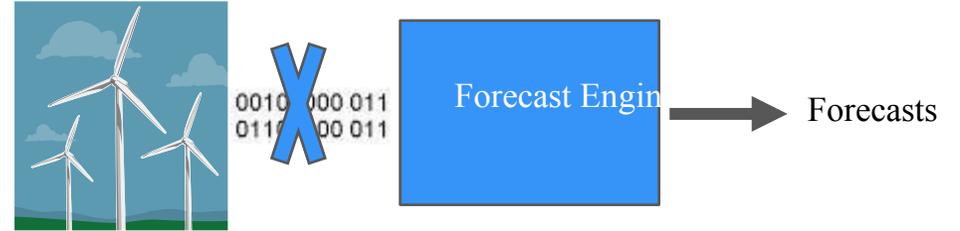
Illustration



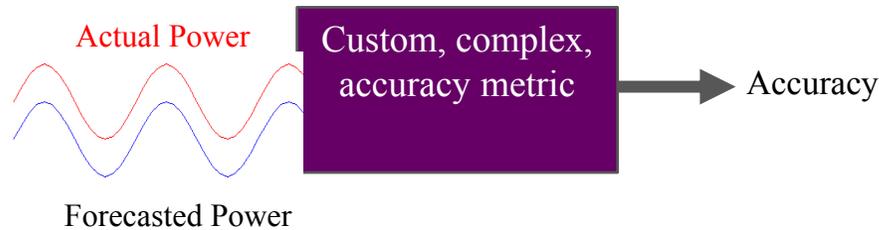
# Technological Challenges



High Variability



Data Availability / Quality



Custom accuracy metrics

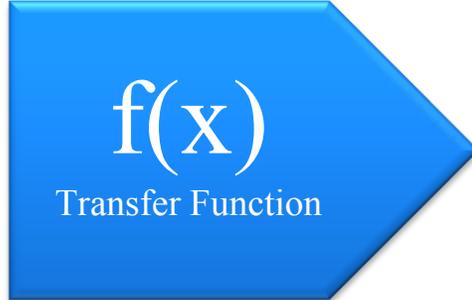
Minutes → Days

Different Forecast Horizons

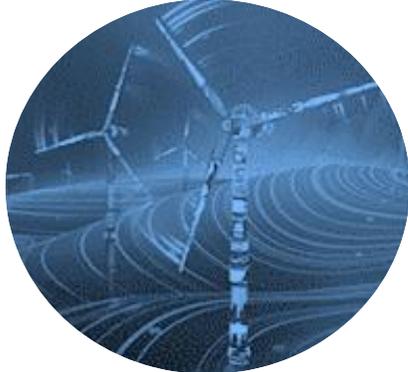


# What is a Digital Twin?

Physical Asset



Digital Twin  
A Learning Digital Model



- 1 Per asset model
- 2 Business outcomes
- 3 Continuously learns
- 4 Adaptable
- 5 Scalable

Digital Twin Increases Productivity and Achieves Better Outcomes for Customers



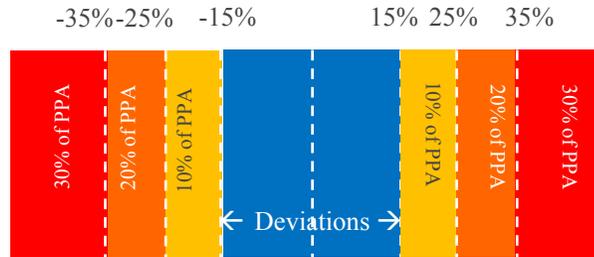
# Wind Forecasting Digital Twin

## 1 Per Asset Model

Approaches	Examples
Stat./ML	Persistence, NN, TS
Numerical (NWP)	GFS, ECMWF, Mesoscale Models (WRF, MM5, etc)
Hybrid Approaches	Ensemble Approaches, NWP+NN, NWP+TS, etc

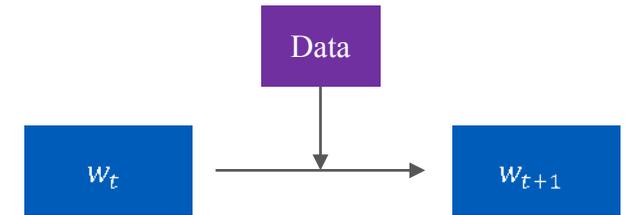
Automatically builds best possible **per farm** model from suite of models

## 2 Business Outcomes



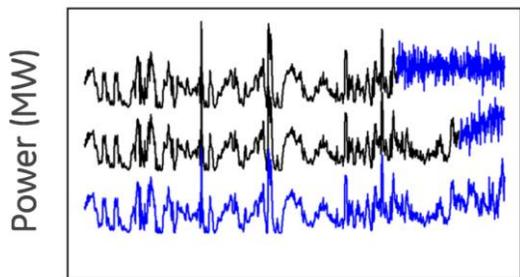
Targets specific regulatory requirements, energy trading needs, dispatch optimization, etc

## 3 Continuously Tuned

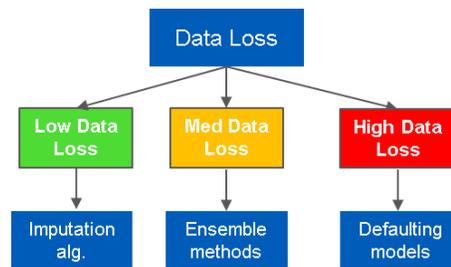


Continually changes weights every time new data is fed to model

## 4 Adaptable



Auto data selection – Selects right data to feed to models dynamically



Automatic data loss adaptation methodology

## 5 Scalable

Algorithms + Platform = Scale  
**PREDIX**

Self-configuring, self-adapting aspects of framework enable custom models to be built at scale



Algorithms to automatically learn and adapt to events such as wind regime shifts, data loss, etc

# Results

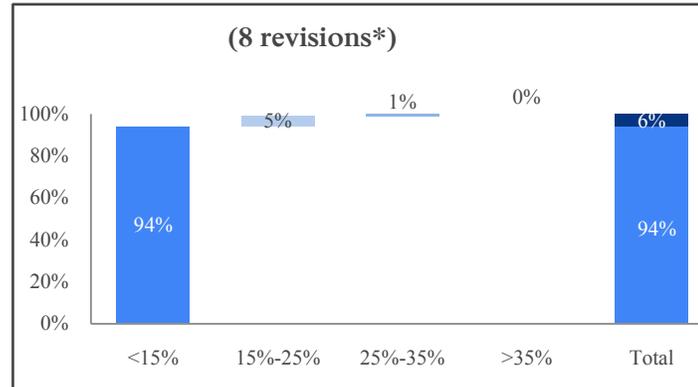
## Pilot

System piloted real-time at 70MW farm  
Performance measured over a one year period  
Achieved > 90% accuracy

## Retrospective analysis at multiple sites

Performance at 5 different sites  
(Different states, Capacities from 15-70 MW)  
Algorithm running in self-learning and self-configuring mode achieved 90%+ in all sites

### Pilot MVP Results



### 5 Farm Trial - Retrospective

Site	Accuracy (Percent energy in 15% band as per CERC )
Site A	97%
Site B	96%
Site C	94%
Site D	95%
Site E	94%





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