Wind Forecasting Digital Twin

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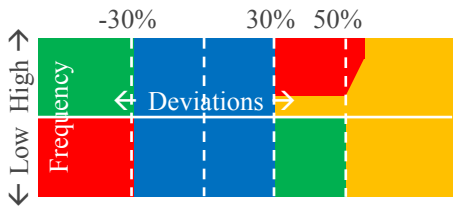
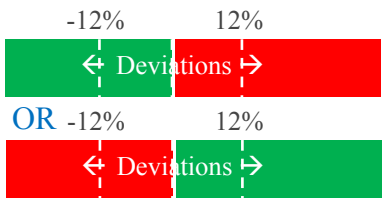
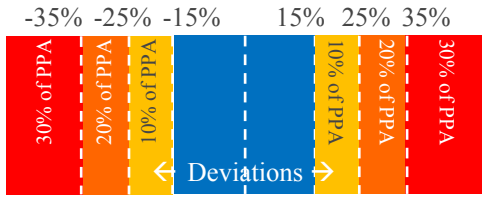
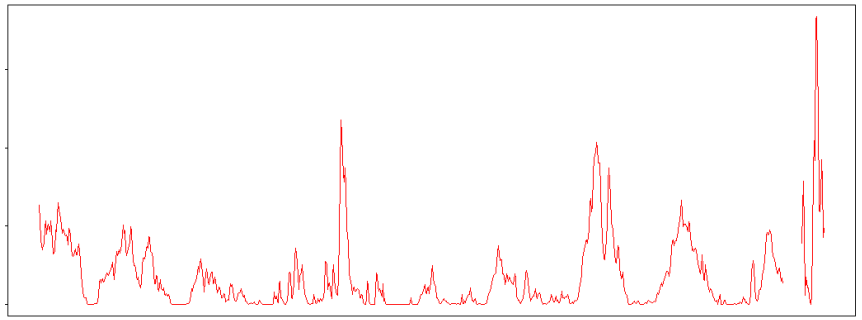
Evolution of Forecasting Regulation In India

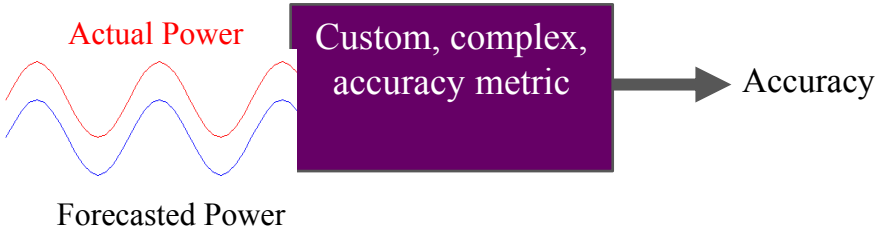
	July 2013	March 2015	August 2015
Applicability	Intra + Inter-State	Inter-State	Inter-State + FORs w/ States
Operating Band	±30%	±12%	±15%
Error Formula	(Actual-Schedule)/Schedule	(Actual-Schedule)/Schedule	(Actual-Schedule)/Available Capacity
# of Updates/Day	8	16	16
Settlement Dependency	Accuracy +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

Technological Challenges



High Variability

Data Availability / Quality



Custom accuracy metrics

Minutes → Days

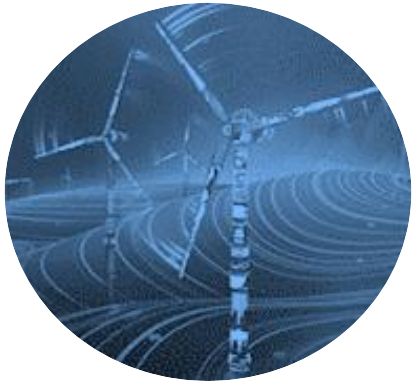
Different Forecast Horizons

What is a Digital Twin?

Physical Asset

f(x)
Transfer Function

Digital Twin
A Learning Digital Model



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

Physics Models + Machine Learning

Digital Twin Increases Productivity and Achieves Better Outcomes for Customers

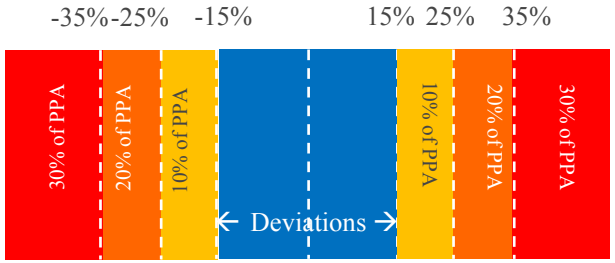
Wind Forecasting Digital Twin

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

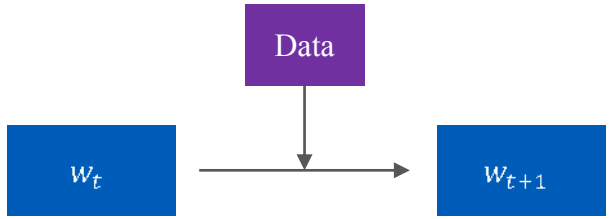
Automatically builds best possible **per farm** model from suite of models

2 Business Outcomes



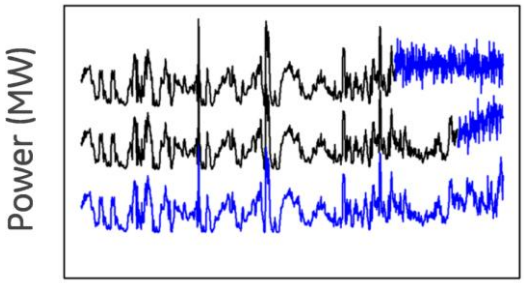
Targets specific regulatory requirements, energy trading needs, dispatch optimization, etc

3 Continuously Tuned

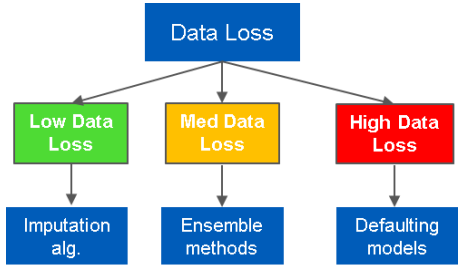


Continually changes weights every time new data is fed to model

4 Adaptable



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



Automatic data loss adaptation methodology

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

5 Scalable

Algorithms + Platform = Scale

PREDIX

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

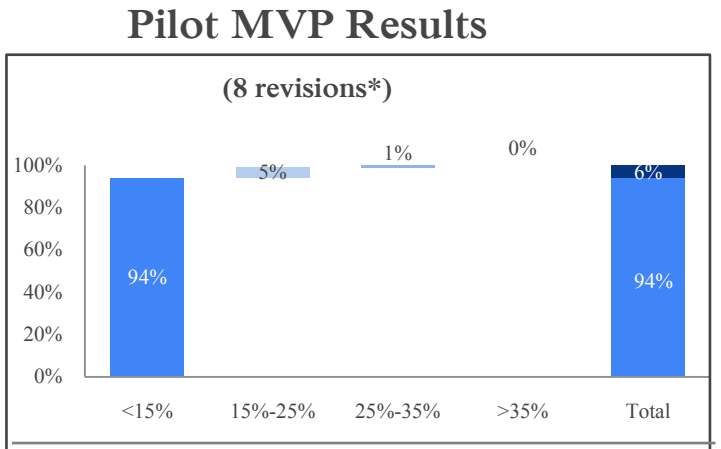
Results

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



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%