

Wind Power Forecasting services for the whole State of Tamil Nadu

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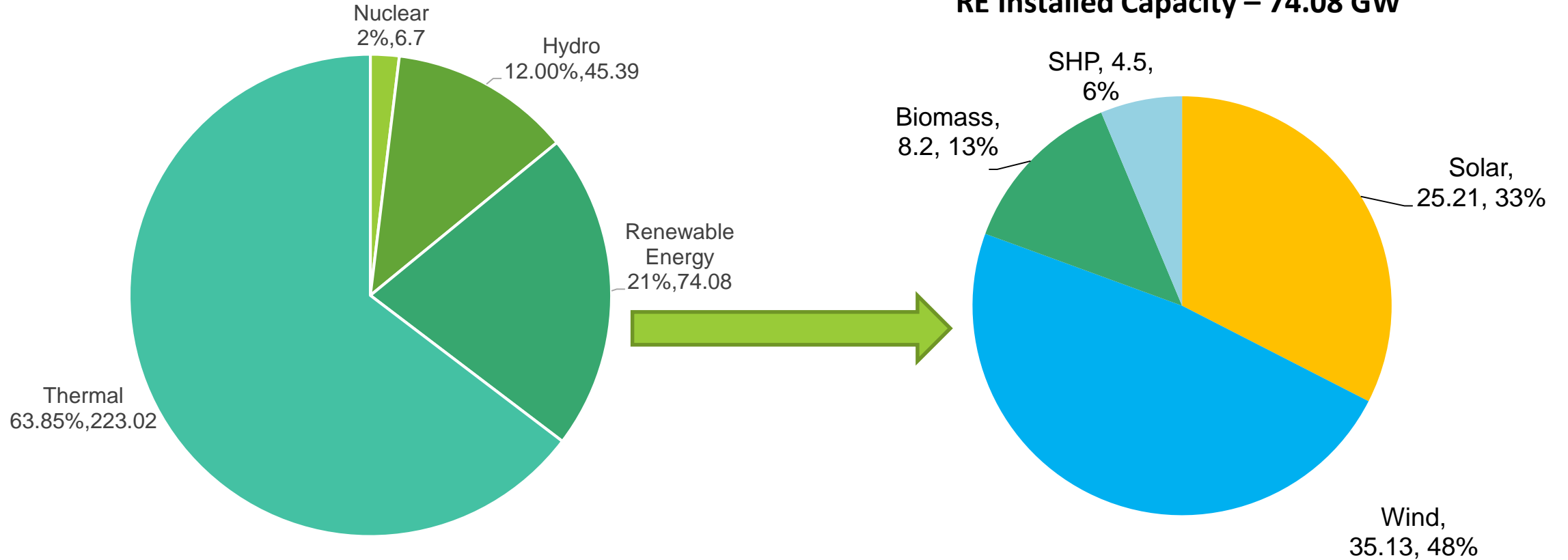
K.BOOPATHI

**Director, Head, R&D and Resource Data Analytics & Forecasting
(R&D and RDAF)**

A.G.RANGARAJ

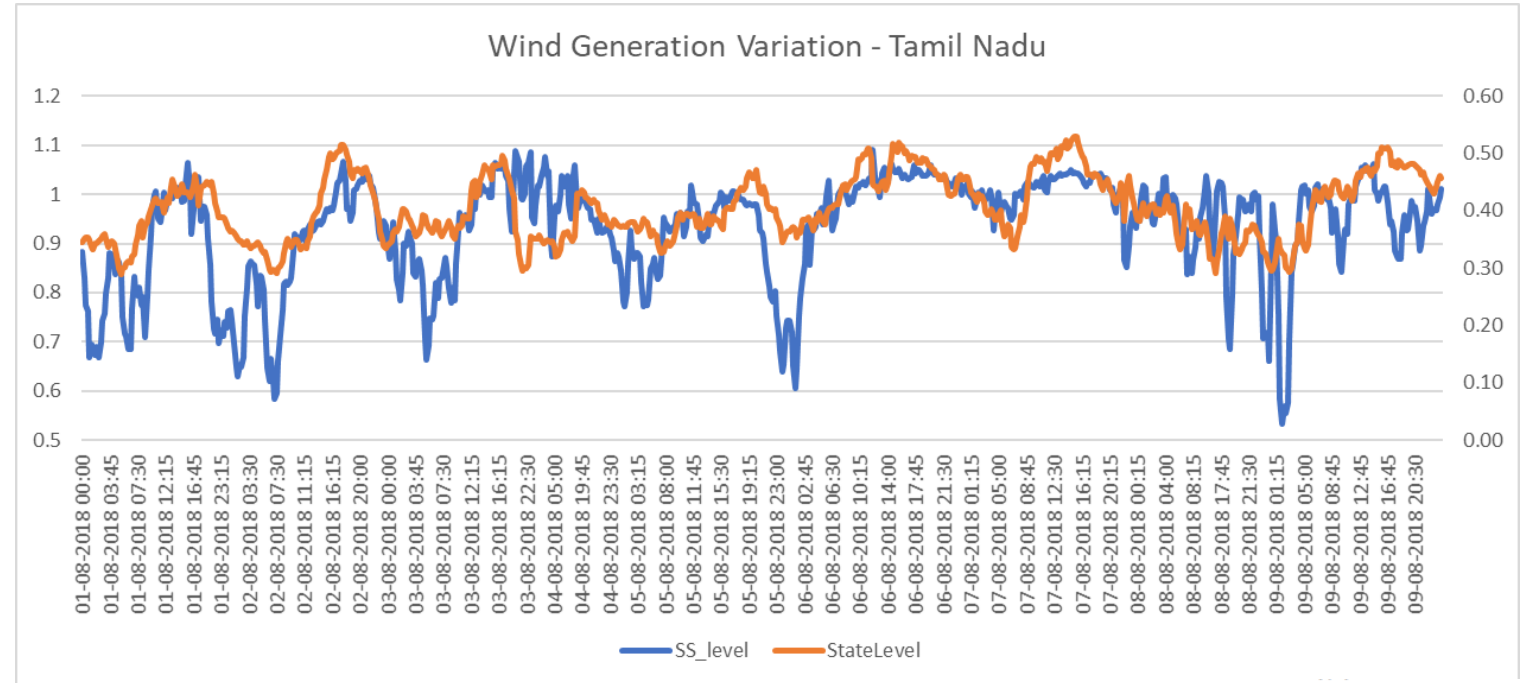
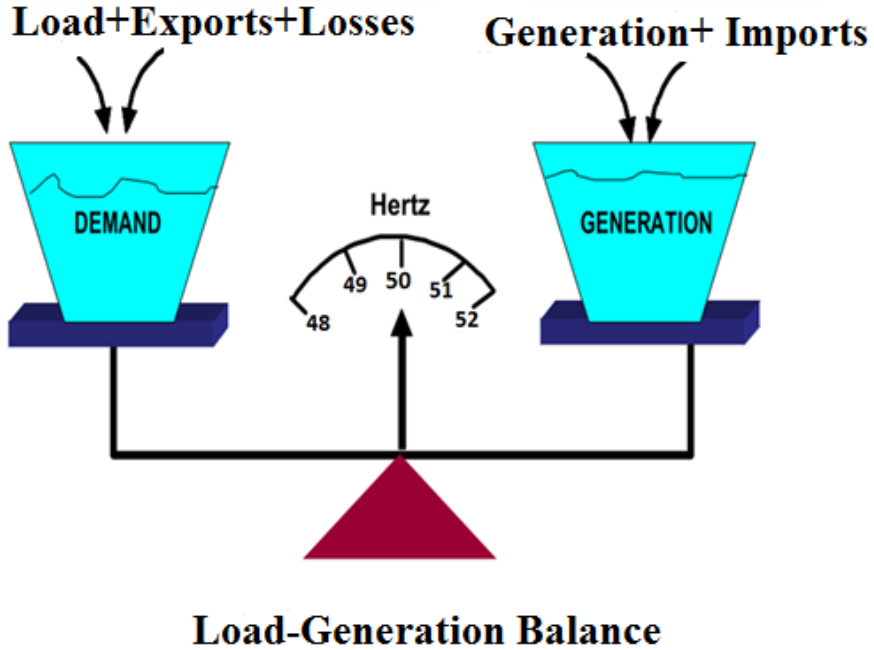
Deputy Director (Technical) R&D and RDAF

Indian Power Scenario



Data as on January 2019.
Source: CEA Website

Challenges in System Operations



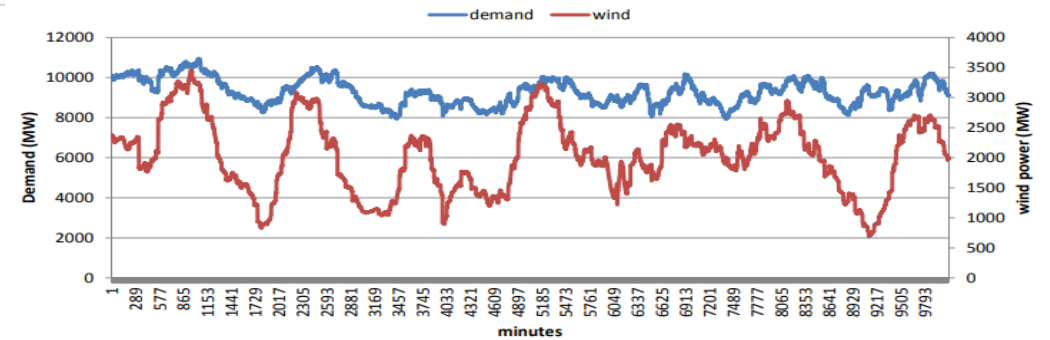
Conventional System

Only Demand is varying -> Demand Forecasting -> Generation follows the load

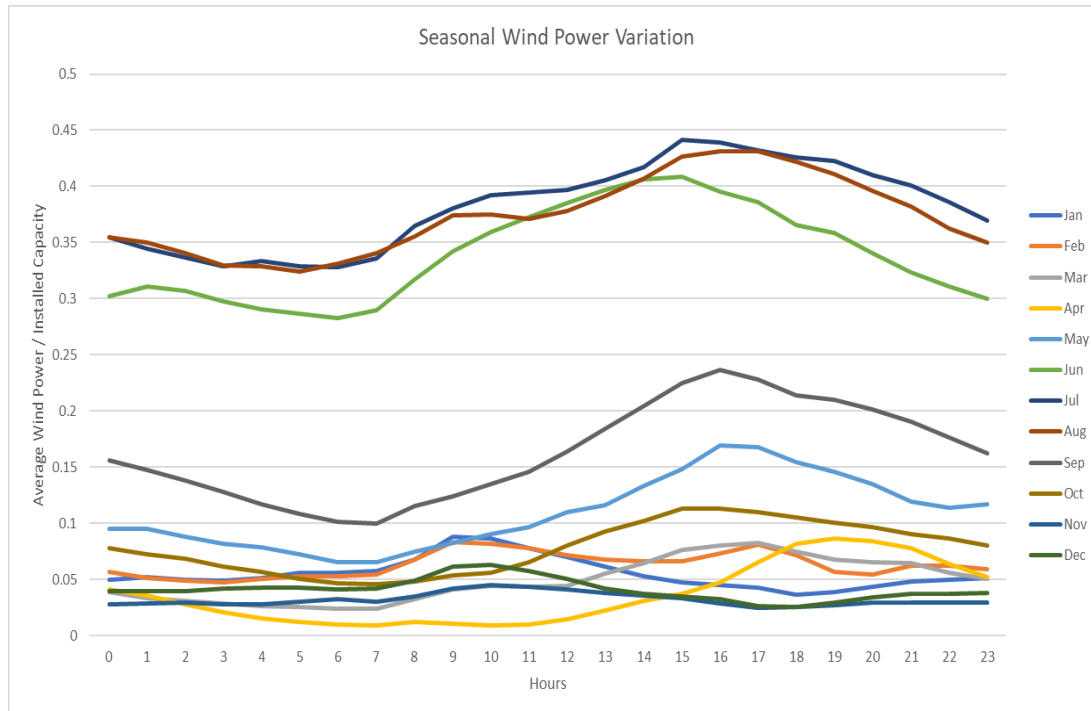
Addition of RE Generation

Both Demand and RE Generation are varying -> Demand + RE Power

Forecasting



Why Wind power Forecasting is Needed



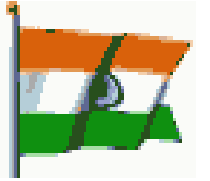
- ✓ Wind Power Forecasting (WPF) provides operational planner to schedule the generation and be able to manage the grid.
- ✓ With out visibility of RE power, ramp up/down of steam based generation would be difficult in short time
 - ✓ Leads to Curtailment of Wind power
 - ✓ Leads to Curtailment of Loads
 - ✓ The letter from IWPA dated 04-05-2015 stated that an annual loss of Rs.1000 crores incurred to wind generators and around 3000 crores for the utility during 2013-2014.

Project Highlights



- NIWE has largest data bank of measured wind and solar resource across the country with **1881** wind monitoring stations and **125** solar monitoring stations
- NIWE has access to **Indian NWP model** data to predict the wind power
- NIWE has developed **In-house Data management system, Indigenous Wind Power Forecasting model, Monitoring System and Forecast simulation tools**
- The NIWE's forecast is **single largest regional forecast** with 17.9 GW (52%) of Wind power across India. NIWE also signed MoU with various SLDCs to provide 13 GW of additional forecasting services in upcoming months this would cover about 90% of entire wind installation in the country.
- **Centre for Excellence in VG forecasting** has been established in NIWE. A dedicated VG (Variable Generation) Forecasting lab has been set up to provide Forecasting service to all wind-rich states of India.
- NIWE already signed MoU with Tamil Nadu, Gujarat, Karnataka, Andhra Pradesh and Rajasthan SLDC to establish operational wind power forecasting system. NIWE proposed to sign MoU with other RE rich states in couple of months.


Emerging Technology used



NIWE using 27 Emerging Technologies to carry out wind power forecasting services


Module	Purpose
Data Analysis & Modelling	To Monitor, Clean, Analyse, Process and Model the data for generating forecast.
Met. Data Analysis	To analyse the meteorological data and visualize the meteorological parameters for modeling
GIS, Data Management & Reporting	To carry out Spatial analysis and storing / archiving the Generation / Meteorological data
Web based dashboards	To deliver the Forecast results to stakeholders

Data Analysis & Modelling



6 Technologies

Met. Data Analysis



7 Technologies

GIS, Data Management & Reporting



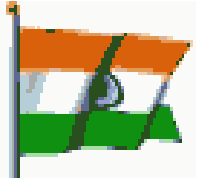
7 Technologies

Web based dashboards

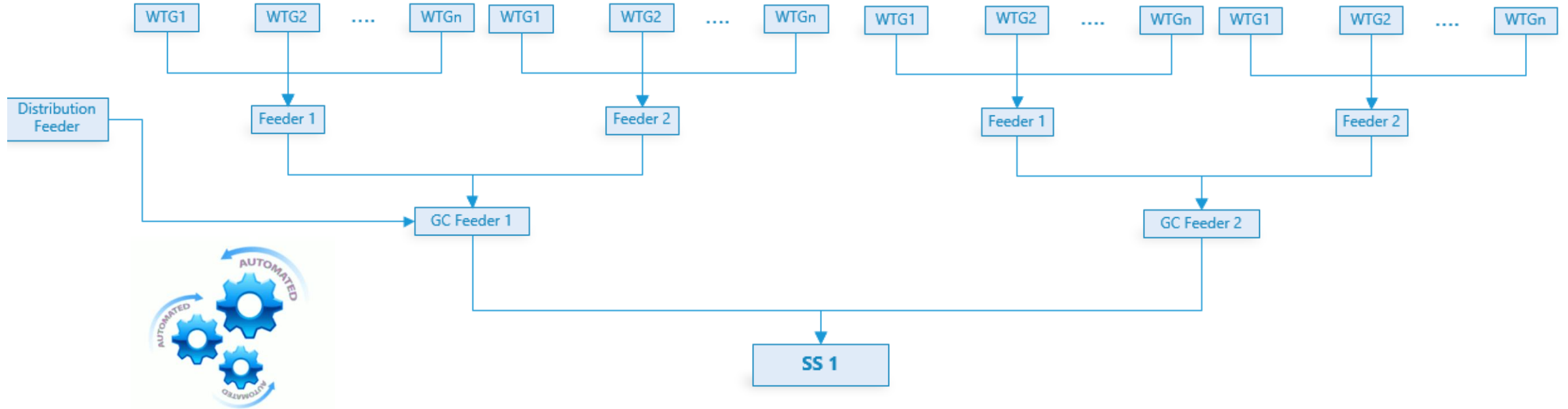


7 Technologies

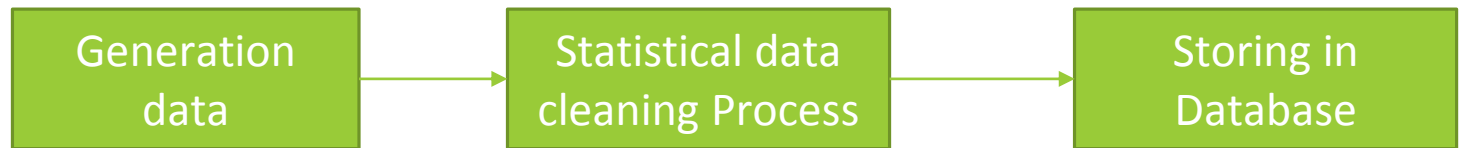
Data Management- Case study TN



Data Receiving from Secured FTP / Web server



Typical Data receiving Structure of one Substation



Total Substations in TN: 120

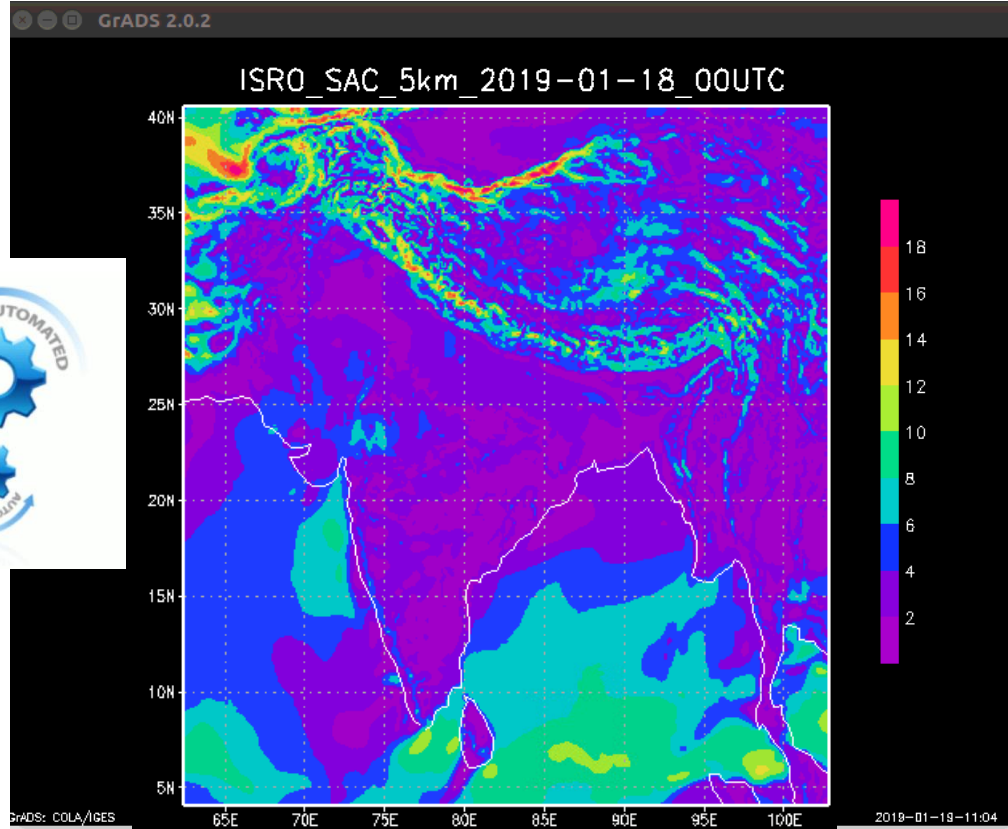
Total wind Feeders : 719

Data receiving frequency : 3 Minutes

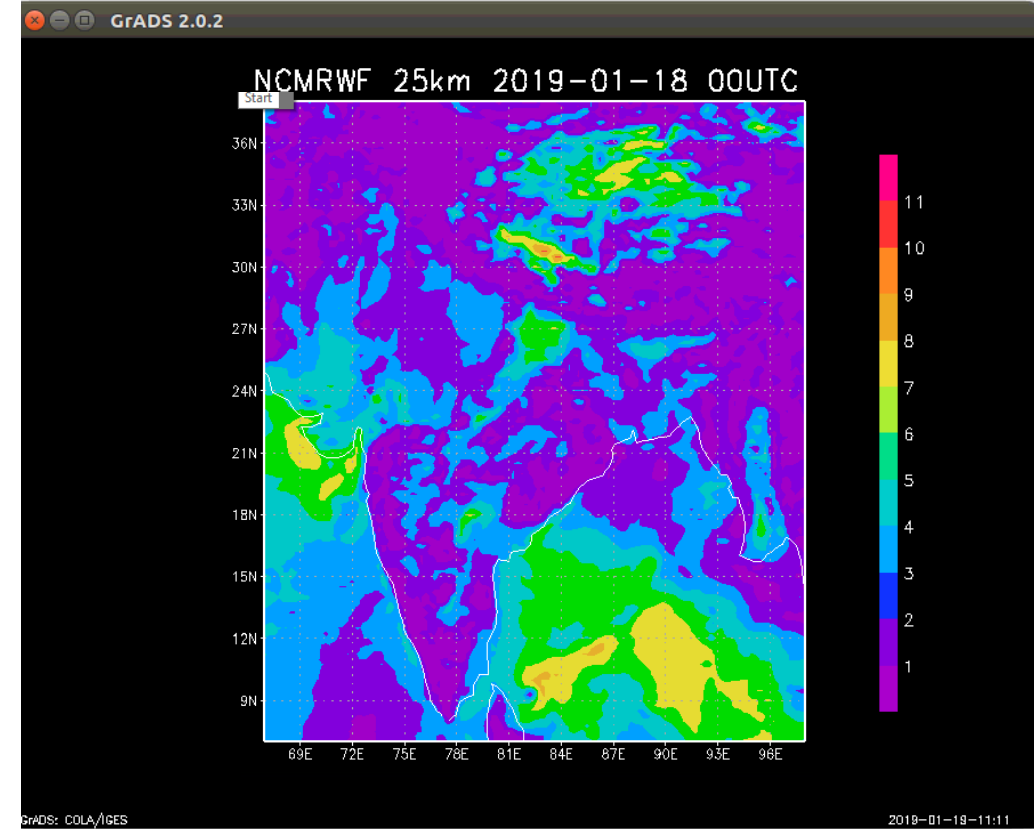
No. of data process cycles in a day: 3,45,120

State of Art Data Management tools is being used to speed up the overall process

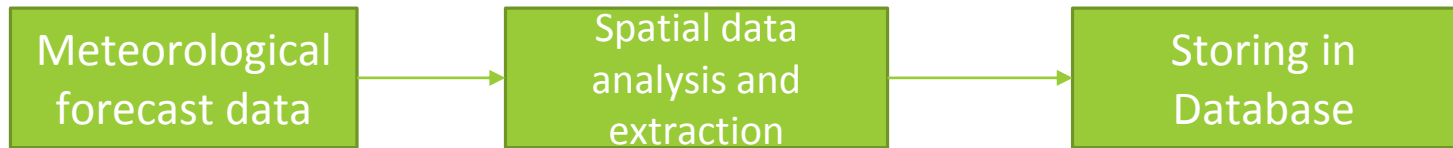
Data Management



Data Receiving from Secured FTP

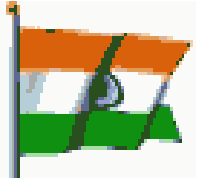


Meteorological forecast received from ISRO_SAC, IITM and NCMRWF
High resolution : 8,10,000 (Grid points)
Global resolution: 15,625 (Grid Points)



In a day Forecast system would process about 2,157 meteorological data stream

Data Monitoring



NATIONAL INSTITUTE OF WIND ENERGY
MINISTRY OF NEW AND RENEWABLE ENERGY
WIND POWER FORECAST MONITORING SYSTEM

नीचे NIWE

Total REFRESH Updated Time : 2019-01-21 10:56:17

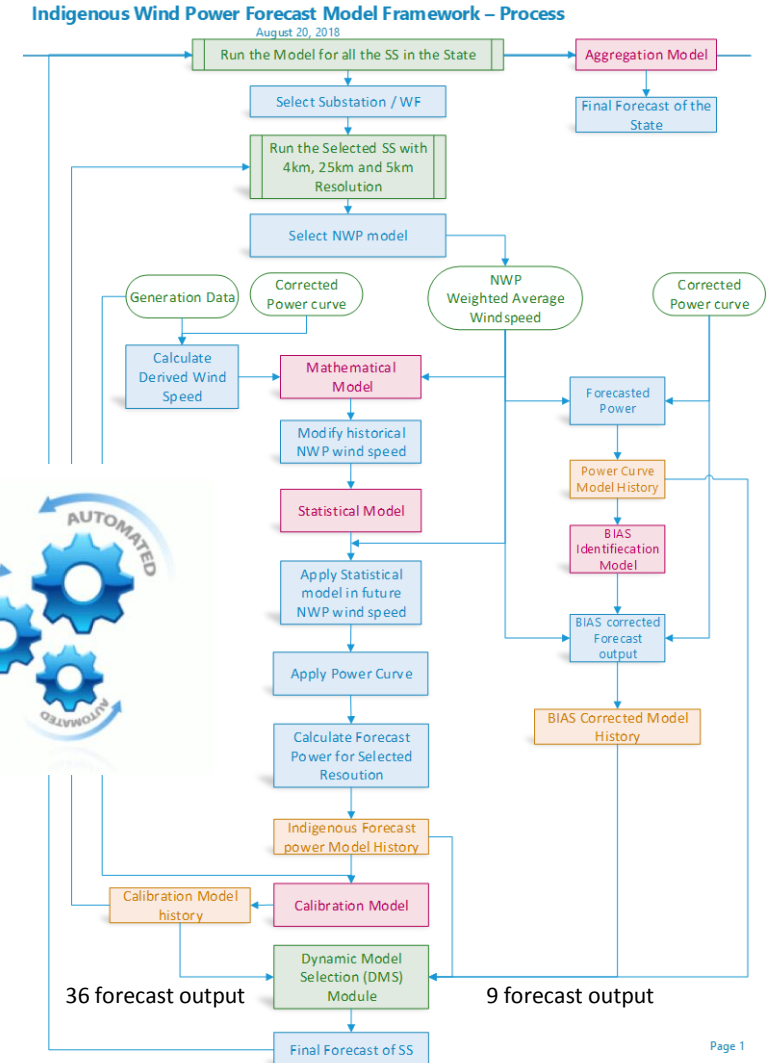
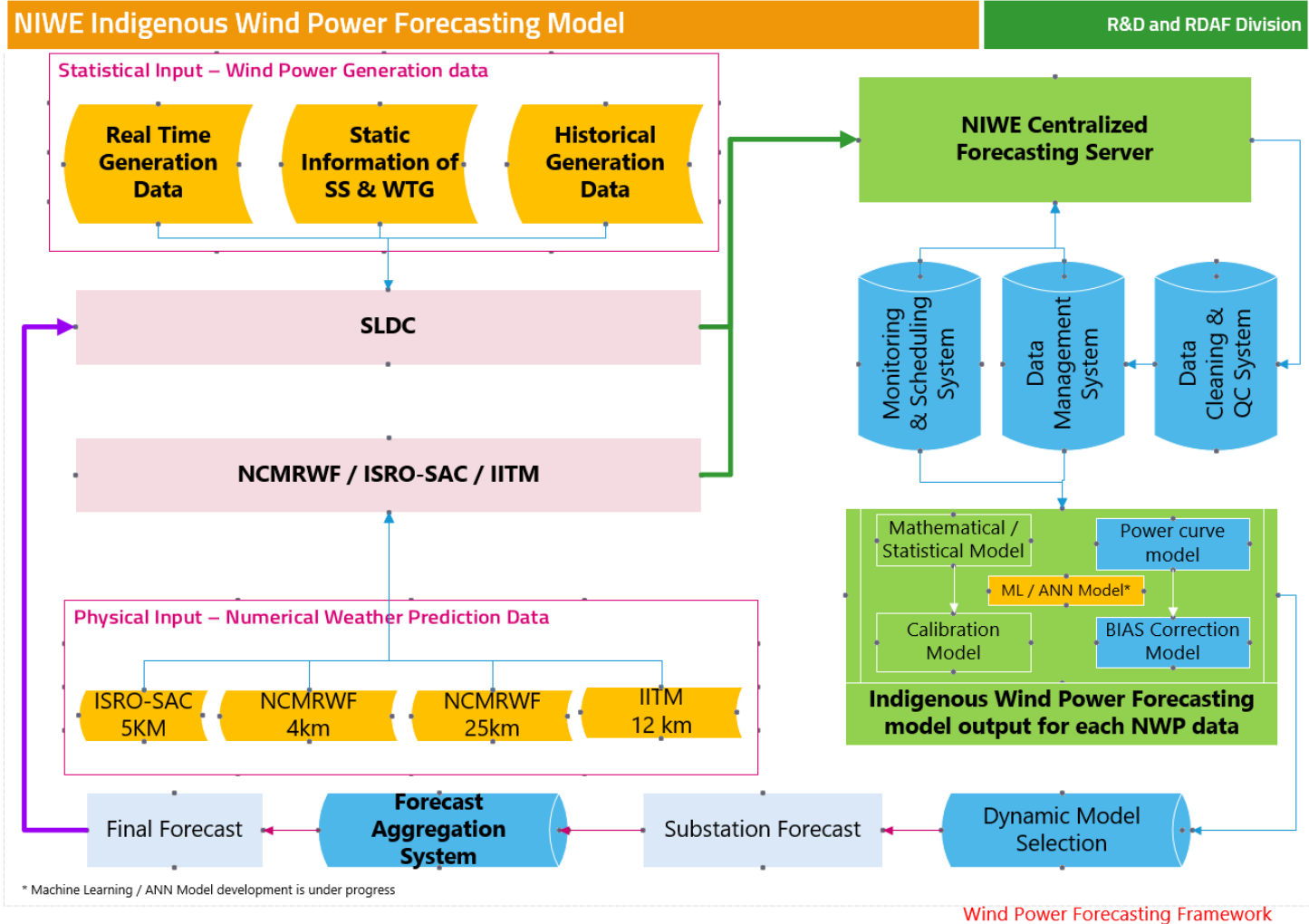
DATA SUMMARY

Station Description	Reporting Capacity (MW)				Reporting Station(nos)				Reporting Capacity (%)					
	OK	PARTIAL	NOT OK	NO DATA	TOTAL	OK	PARTIAL	NOT OK	NO DATA	TOTAL	OK	PARTIAL	NOT OK	NO DATA
Actual - TN	3898	175	560	179	4812	91	6	15	5	117	77.0% ↑	5.0% ↓	12.0% ↓	4.0% ↓
Actual - GJ	4664	0	139	4	4807	66	0	3	1	70	94.0% ↑	0.0% ↓	4.0% ↓	1.0% ↓
Actual - KA	0	0	4252	21	4274	0	0	83	3	86	0.0% ↑	0.0% ↓	96.0% ↓	3.0% ↓
Actual - SRLDC	250	0	0	0	250	1	0	0	0	1	100.0% ↑	0.0% ↓	0.0% ↓	0.0% ↓
ISRO_SAC - TN	4812	0	0	0	4812	117	0	0	0	117	100.0% ↑	0.0% ↓	0.0% ↓	0.0% ↓
ISRO_SAC - GJ	4807	0	0	0	4807	70	0	0	0	70	100.0% ↑	0.0% ↓	0.0% ↓	0.0% ↓

Actual generation data monitored every 3 minutes :
No. of data process cycles in a day: 3,45,120

Meteorological data monitored every 3 hours
No. of data process cycles in a day: 960

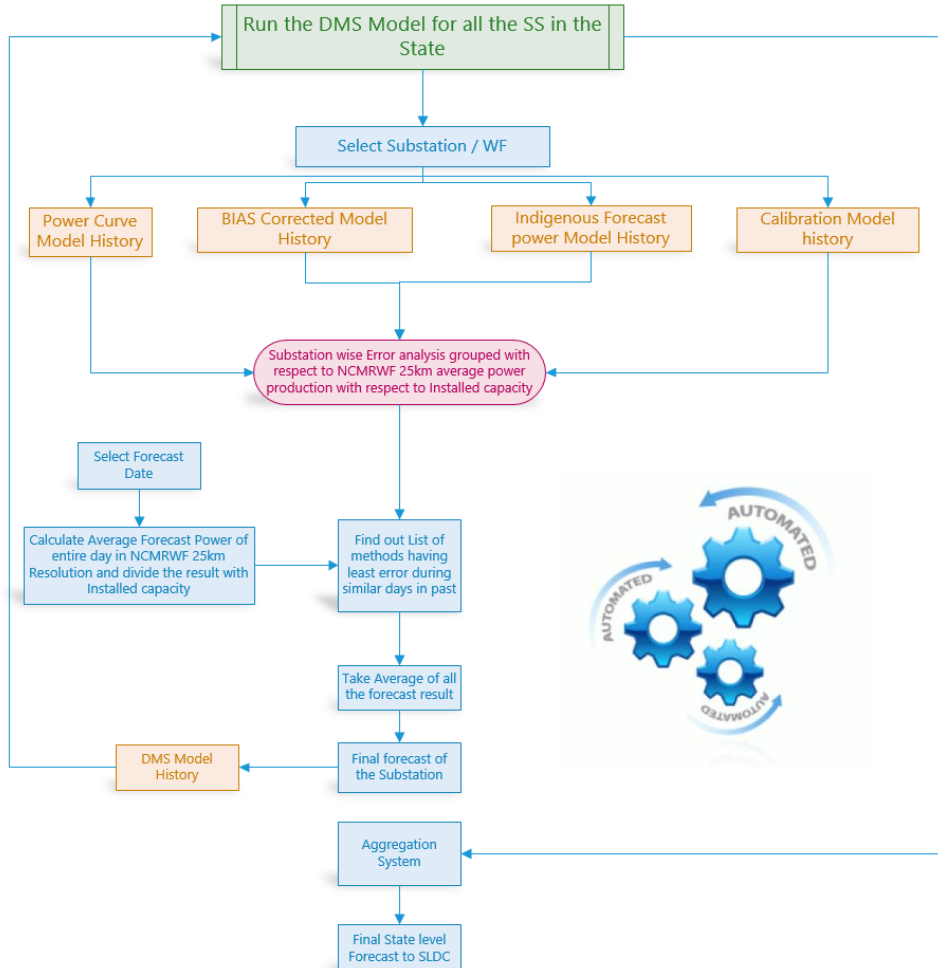
Innovation (Indigenous model)



Innovation (Indigenous model)



Dynamic Model Selection Algorithm



- ✓ NIWE Indigenous forecast model uses **Mixed Physical statistical approach**
- ✓ **Day ahead** Model use Meteorological and real time generation data
 - ✓ **45** different statistically analysed **forecast output** would be generated @ every updation of NWP
 - ✓ DMS system would **intelligently** select the **best output**
 - ✓ Day ahead Model will **runs 2 times** in a day
 - ✓ forecast system will carry out statistical analysis of about **10,804 set of calculations**
- ✓ **Intraday Model** uses real time generation data to refine the forecast
 - ✓ Intraday model will runs **16 times** in a day
 - ✓ The forecast system will carry out statistical analysis of about **1,920 set of calculations**
- ✓ State of Art **Statistical analysis tools** / technologies used **to** carry out **calculations in real time**

Data Communication and Security

1	Start	7/udp ALLOW IN 192.168.14.4 (log-all)	SAMBA
2		137/udp ALLOW IN 192.168.14.122 (log-all)	SAMBA
3		138/udp ALLOW IN 192.168.14.4 (log-all)	SAMBA
4		138/udp ALLOW IN 192.168.14.122 (log-all)	
5		139/tcp ALLOW IN 192.168.14.4 (log-all)	
6		139/tcp ALLOW IN 192.168.14.122 (log-all)	
7		445/tcp ALLOW IN 192.168.14.4 (log-all)	
8		445/tcp ALLOW IN 192.168.14.122 (log-all)	
9		29799:29899/tcp ALLOW IN Anywhere	
10		29799:29899/udp ALLOW IN Anywhere	
11		5222 ALLOW IN Anywhere	
12		6000:6007/tcp ALLOW IN Anywhere	
13		6000:6007/udp ALLOW IN Anywhere	
14		5938 ALLOW IN 192.168.14.122 (log-all)	Team Viewer
15		21 ALLOW IN 117.239.142.60 (log-all)	FTP_KA_KPTCL



✓ Communication Technology used

- ✓ SLDC is receiving data from Substations using **MODBUS** technology
- ✓ NIWE is receiving data from TANGEDCO through **Secured Webserver**
- ✓ Meteorological data is receiving through **secured FTP connection**
- ✓ NIWE is sharing the forecast result through **Secured FTP**

```

Jan 18 13:13:37 forecast-ubuntu-VH pure-ftpd: [Feb18:21.200.58.55] [NOTICE] /mnt/Storages/ftpusers/TNEB//Schedule/Revisions_Final/2018-02-21/Error_Analysis_2018-02-20.xlsx downloaded (19466 bytes, 947.77 KB/sec)
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✓ Data Security Measures

- ✓ NIWE uses **IP-tables and UFW** tool to secure the server access
- ✓ **White listing** of Public / private IP
- ✓ **RSA 2048 bits encrypted** secure shell connection established
- ✓ **Logging system** created to record complete data usage of the server and stored on a daily basis
- ✓ Regular verification of security arrangements
- ✓ **Back up of data** will be carried out on a daily basis

Operational forecast system



The image displays a complex system interface for an operational forecast system. It consists of a grid of terminal windows, each showing different stages of code execution and system logs. The windows are arranged in a grid, with some windows showing error messages and others showing successful execution. A central window is titled "Terminal".

Annotations on the left side of the image include:

- Test
- Live
- background shell
- sh
- Link to Bulk consolidate
- Link to extract
- freq screen.sh
- Link to Extract

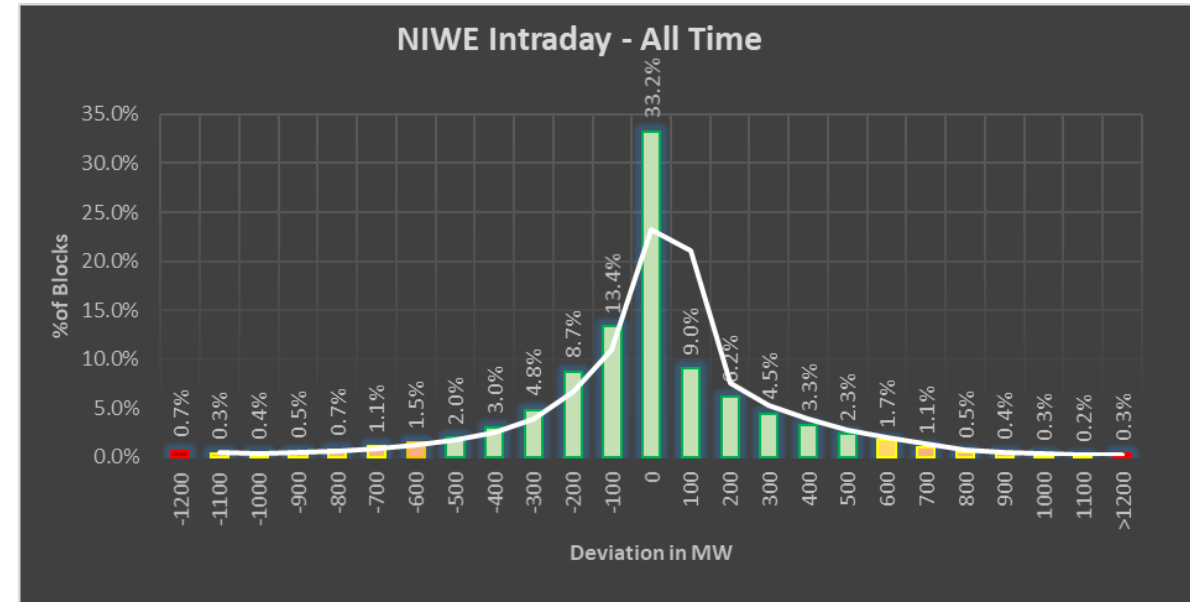
At the bottom left, there is a circular logo with the word "AUTOMATED" repeated around it, and a gear icon.

Error Analysis – Case study TN



Intraday % of blocks within 600 MW		
MONTH	2017	2018
JAN	97%	100%
FEB	98%	98%
MAR	98%	96%
APR	88%	96%
MAY	82%	80%
JUN	82%	78%
JUL	82%	80%
AUG	77%	88%
SEP	87%	88%
OCT	86%	99%
NOV	99%	100%
DEC	95%	100%
Average	89%	92%

Intraday % of blocks within 1200 MW		
Month	2017	2018
JAN	100%	100%
FEB	100%	100%
MAR	100%	100%
APR	100%	100%
MAY	96%	96%
JUN	99%	98%
JUL	98%	97%
AUG	97%	100%
SEP	99%	100%
OCT	99%	100%
NOV	100%	100%
DEC	99%	100%
Average	99%	99%



**Upto 600 MW - 92% of blocks
and
Upto 1200 MW -99% of blocks**

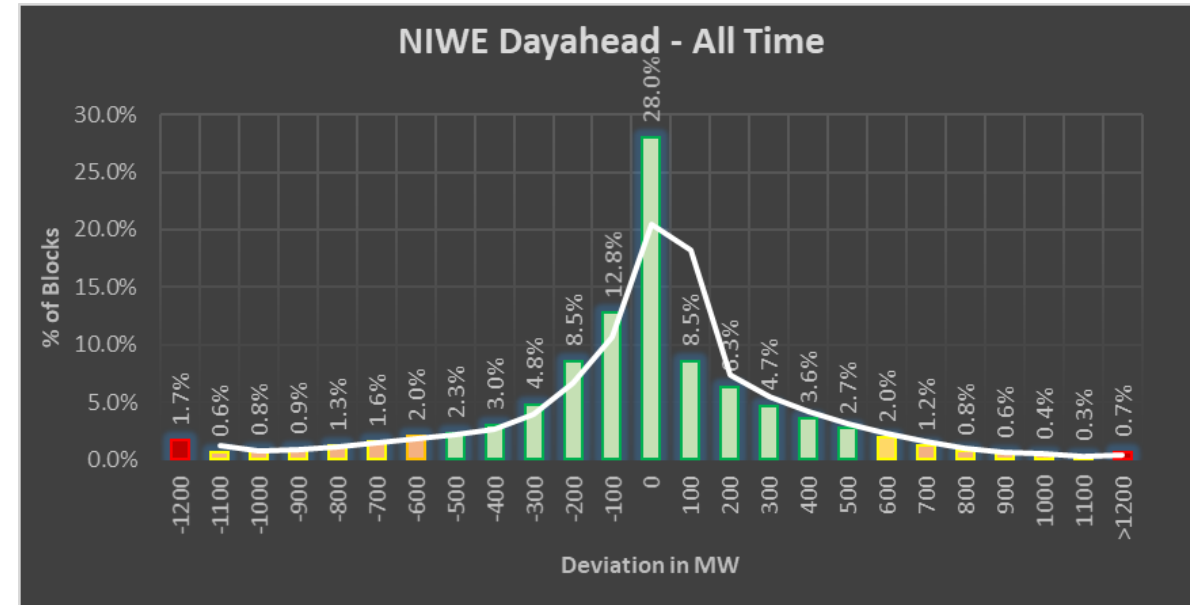
Total Blocks with valid actual generation data: 87,688

Error Analysis – Case study TN



Day ahead % of blocks within 600 MW		
MONTH	2017	2018
JAN	97%	100%
FEB	98%	98%
MAR	99%	96%
APR	85%	96%
MAY	73%	79%
JUN	74%	76%
JUL	75%	77%
AUG	62%	86%
SEP	79%	76%
OCT	75%	99%
NOV	99%	100%
DEC	97%	100%
Average	84%	90%

Day ahead % of blocks within 1200 MW		
Month	2017	2018
JAN	100%	100%
FEB	100%	100%
MAR	100%	100%
APR	100%	100%
MAY	96%	95%
JUN	97%	98%
JUL	97%	96%
AUG	89%	99%
SEP	98%	98%
OCT	95%	100%
NOV	100%	100%
DEC	99%	100%
Average	98%	99%

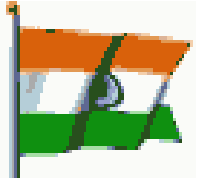


**Upto 600 MW - 90% of blocks
and
Upto 1200 MW -99% of blocks**

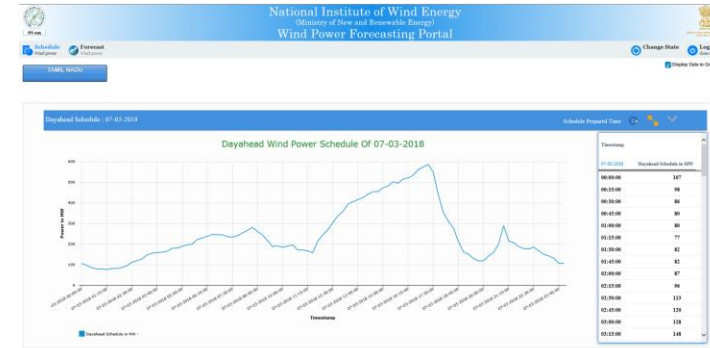
Total Blocks with valid actual generation data: 87,688



Forecasting Portal developed by NIWE



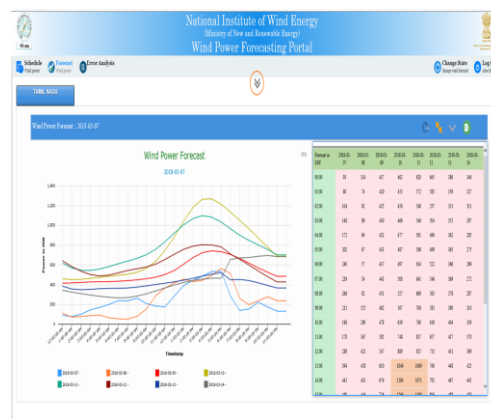
Login Page



Wind Power Forecast portal – Public view

Station Description	OK	PARTIAL	NOT OK	NO DATA	TOTAL	OK	PARTIAL	NOT OK	NO DATA	TOTAL	OK	PARTIAL	NOT OK	NO DATA
Adampal_78	4276	182	108	89	4655	123	3	4	6	136	100.7	100.1	100.1	100.1
Adampal_02	4882	363	0	4	4889	10	0	0	1	11	100.7	100.1	100.1	100.1
Adampal_03	0	0	4382	81	4463	0	0	12	4	16	100.7	100.1	100.1	100.1
CCDC_SAC_76	4882	0	0	0	4882	176	0	0	0	176	100.7	100.1	100.1	100.1
CCDC_SAC_02	4882	0	0	0	4882	70	0	0	0	70	100.7	100.1	100.1	100.1
NEELAMPAL_06_76	4882	0	0	0	4882	176	0	0	0	176	100.7	100.1	100.1	100.1
NEELAMPAL_06_02	4882	0	0	0	4882	70	0	0	0	70	100.7	100.1	100.1	100.1
NEELAMPAL_06_76	4882	0	0	0	4882	176	0	0	0	176	100.7	100.1	100.1	100.1

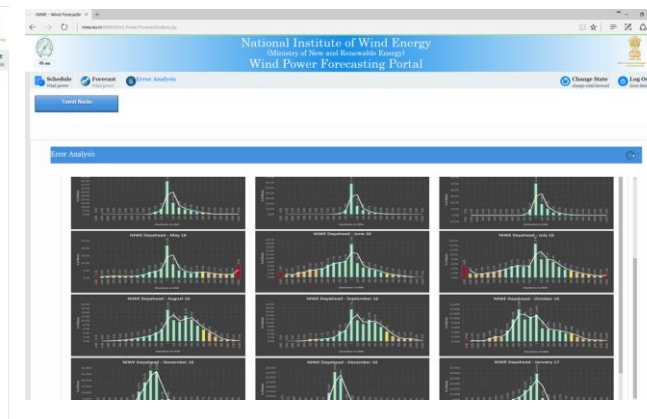
Monitoring Portal



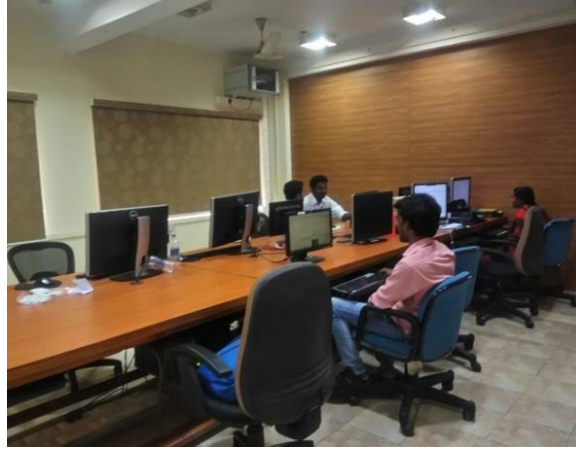
7 days ahead Forecast



Wind Power Forecast portal – SLDC / Client's View



VG Forecasting Laboratory at NIWE



Mission 175 GW of RE by 2022



- ✓ India made a commitment in Paris Climate Agreement
 - ✓ to reduce emission intensity of the economy by one-third and
 - ✓ for having at least 40% electric power installed capacity from clean energy sources by the year 2030
- ✓ Towards this, an ambitious target of 175 GW by 2022 announced in 2015
 - ✓ Solar - 100 GW
 - ✓ Wind - 60 GW
 - ✓ Biomass - 10 GW
 - ✓ Small Hydro - 5 GW
- ✓ Forecasting of RE is critical for seamless integration of Renewables in the Grid

Societal Impact

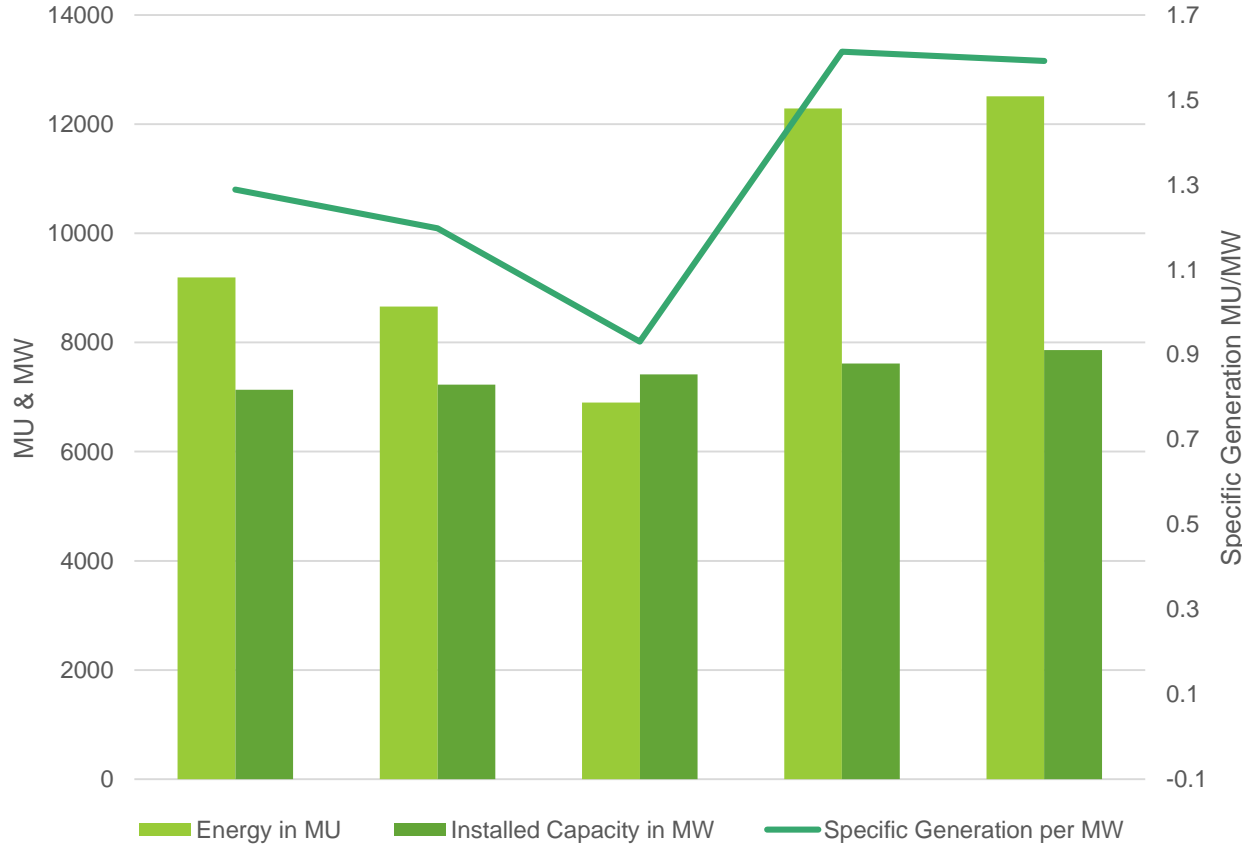


- ✓ **Greening the Grid** there by adhering to climate change commitment by the country
- ✓ India's Ambitious target is by 2022 – 60 GW of Wind Installation
 - ✓ Centre For Excellence (CFE) in VG Forecasting project, NIWE focuses to expand the forecasting services to all RE Rich states.
 - ✓ This project is acting like a catalyst to **facilitate the industry** to achieve the India's Ambitious target
 - ✓ The energy cost of wind and solar reached Grid parity and effective integration through forecasting would reduce overall cost of energy
- ✓ NIWE forecasting services is one of the **successful** industry relevant ongoing projects
- ✓ NIWE's forecast helping substantial **improvement in wind power evacuation** and **lesser back down** of Wind generators in the State.
- ✓ This project facilitate to **evacuate more Green power** which means **reduction of carbon emission**
- ✓ It helps to provide available sufficient electricity for the people, which has **tangible effects on improving the productivity of the citizens.**

Year wise MU generated – TN



Wind Generation Evacuation



TN Wind Generation Days (MU)									
MU	2018	2017	2016	2015	2014	2013	2012	2011	2010
>100	10	2	0	0	0	0	0	0	0
75-100	55	62	46	6	20	3	40	0	5
50-75	26	43	63	43	52	66	98	45	23
40-50	21	16	9	24	30	27	11	44	51
30-40	19	23	9	32	16	30	12	46	43
20-30	16	28	12	32	19	17	19	45	43
10-20	70	62	52	32	59	50	44	56	53
<10	148	129	175	196	169	172	142	129	147

Source: Consolidation of SLDC daily generation data

Generation evacuation improved by more than 70%

Way Forward



- ✓ NIWE is actively working on to **predict the Medium and long term** forecasting.
- ✓ Ministry of New and Renewable is in process on signing a MoU with Ministry of Earth Science **to collaborate on the indigenous weather prediction model.**
- ✓ NIWE focuses on improving the existing operational forecasting model of wind and solar generation to include the **Machine learning and Artificial Intelligence.**
- ✓ NIWE is in process on **creating an Resource data analytics portal Indigenously.**



Thank you