

NLDC Capacity Building Workshop

Solar Power Forecasting

Discussion materials

Athena Renewable Energy India Pvt. Ltd.

22nd May 2024

INDEX

1. Background
2. How is Forecasting done for Solar Projects?
3. How it is governed by the regulators?
4. The Power Forecast : Physical Model & Statistical Model
5. Solar Power Forecasting and Scheduling Structural design
6. Challenges and Way Forward



What is Solar Power Forecasting and Scheduling?

- It is the process of gathering and analyzing data from various sources in order to predict solar power generation on various time horizons and submitting it to the grid operator to facilitate proactive adjustments and maintain grid stability.



Why Forecasting & Scheduling of Generation is necessary?

- With the increasing penetration of renewable energy sources into the grid which comes with the inherent characteristic of variable generation, accurate forecasting of their generation becomes crucial for secure, safe and efficient operation of the grid.



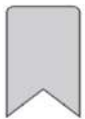
Which regulation governs this process?

- Currently the Central Electricity Regulatory Commission (Deviation Settlement Mechanism and Related Matters) Regulations, 2022 governs this process for CTU connected projects and respective State ERC's similar regulations for STU connected projects.



How this regulation governs this process?

- Any deviation in drawl or injection of electricity from its schedule submitted by the entity shall be managed by the commercial mechanism.

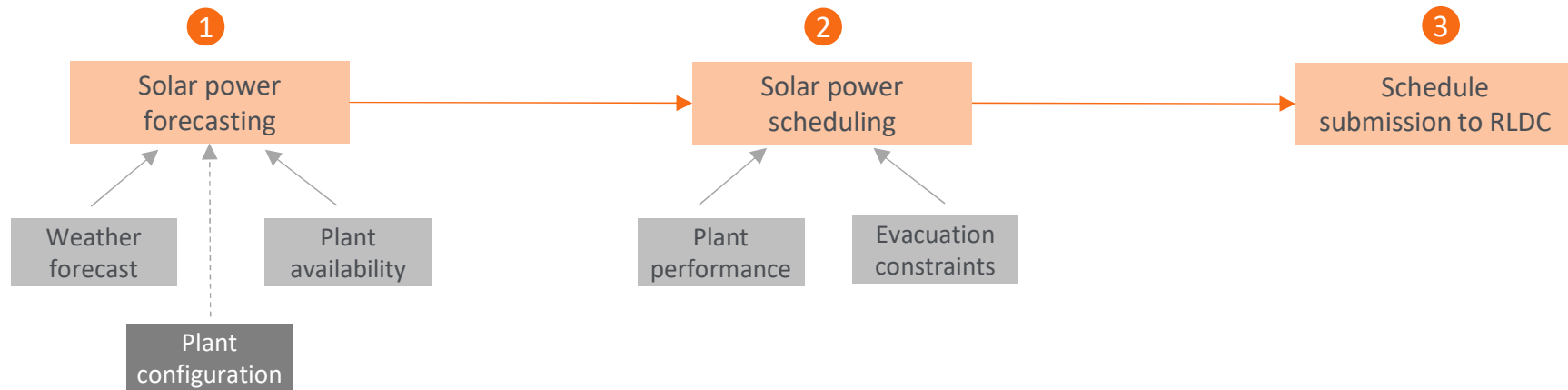


Whom this regulation is applicable?

- CTU connected entity
- other entities engaged in inter-State purchase and sale of electricity.

How is forecasting done for Solar Projects?

A typical process of Solar Power Forecasting and Scheduling involves following three stages:



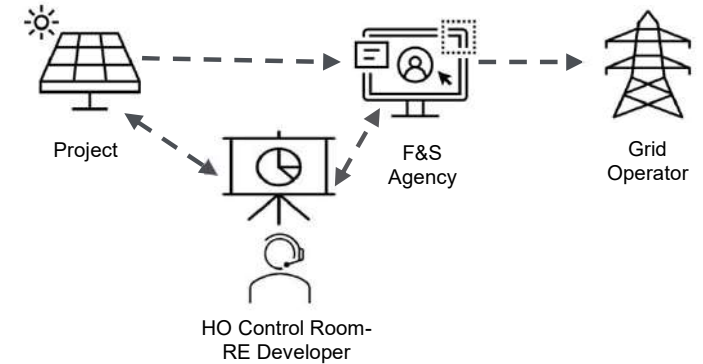
What is the desired outcome of doing this?



Operational process

On-boarding F&S agency		F&S Agency Shortlisting and Onboarding Based on POC and credentials
		Weather and Power Forecast Model Tuning (F&S Agency) Input Project specific configuration
Infra structure for data telemetry		Infrastructure Arrangement for Data Exchange Real Time Plant Data & Site Inputs
		Provide real time data Telemetry of critical parameters Power, GHI, GTI, Temperature, Pressure, Cloud Cover, etc.
		Ensure High Uptime of Real Time Data Telemetry SOP Implementation
F&S operations		Ensure High Uptime of System and Evacuation Availability Efficient O&M
		Qualitative and Timely Inputs from Site On Weather and AvC changes
		Forecasting and Scheduling By expert F&S Agency
		Review and Performance Monitoring of F&A agency For analysis and performance optimization

Layout of Information flow



Role of HO Control Room	
Day-ahead	Validation & submission of next days planned shutdown details to F&S Agency
	Validation of day ahead generation schedule
Intra-day	Monitoring data telemetry
	timely updates from site to F&S agency on changes in AvC and Site Weather
	Ensure implementation of Inputs
	Intermittent monitoring of Scheduled vs Actual generation
	benchmarking weather forecast with other global weather forecasters.

How it is being governed by the regulator?

Any deviation in drawl or injection of electricity from its schedule submitted by the entity shall be managed by the commercial mechanism set out in the governing regulation called the Central Electricity Regulatory Commission (Deviation Settlement Mechanism and Related Matters) Regulations, 2022.

Deviation Calculation Level

- For each 15 min time-block

Deviation Calculation Formula for RE

- $\% \text{ Error} = 100 * (\text{Actual Generation} - \text{Scheduled Generation}) / \text{Available Capacity}$
- Eg: for a 250 MW solar project with scheduled generation 250 MW and actual generation 200 MW and AvC 250 MW, the error % will be: $\text{Error \%} = 100 * (200-250)/250 = - 20\%$

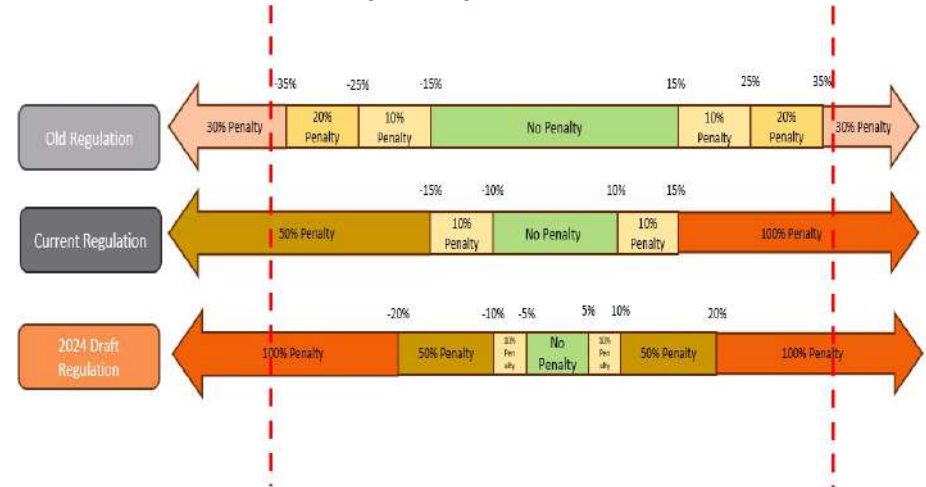
Forecast Revision Frequency

- Every 15 min

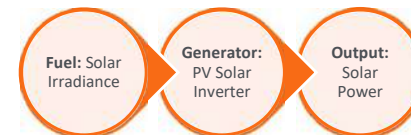
Forecast Revision Implementation Time

- After 7/8 time-blocks (Approx. 2 Hrs.)

Deviation bands & penalty



- Draft 2024 DSM Regulation: penalty expected to be 8X wrt old regime
- IEGC 2023: Revision implementation time doubled from ~1 Hr to ~2 Hrs.



Key driver of generation forecast accuracy is Weather forecast accuracy

The Power Forecast : Physical Model & Statistical Model

Physical Model Input Variables

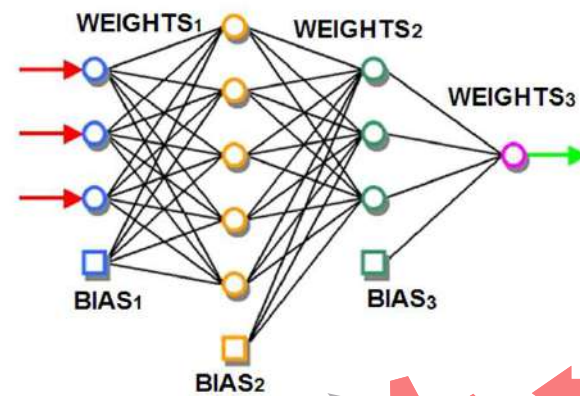
Weather Forecasts Day X

- Day
- Hour
- GHI
- Ambient Temperature
- Pressure
- Wind Speed
- Cloud Cover

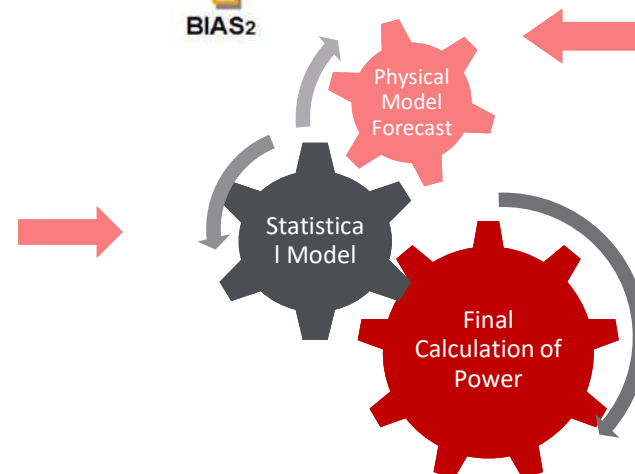
Statistical Models Input variables

- Day of the Year
- Hour of the day
- Trend Analysis
- Real-time power generation
- Historical Actual Generation values

Trained Neural Network



Forecast Power Generation Day X
15 min Average Predicted Power

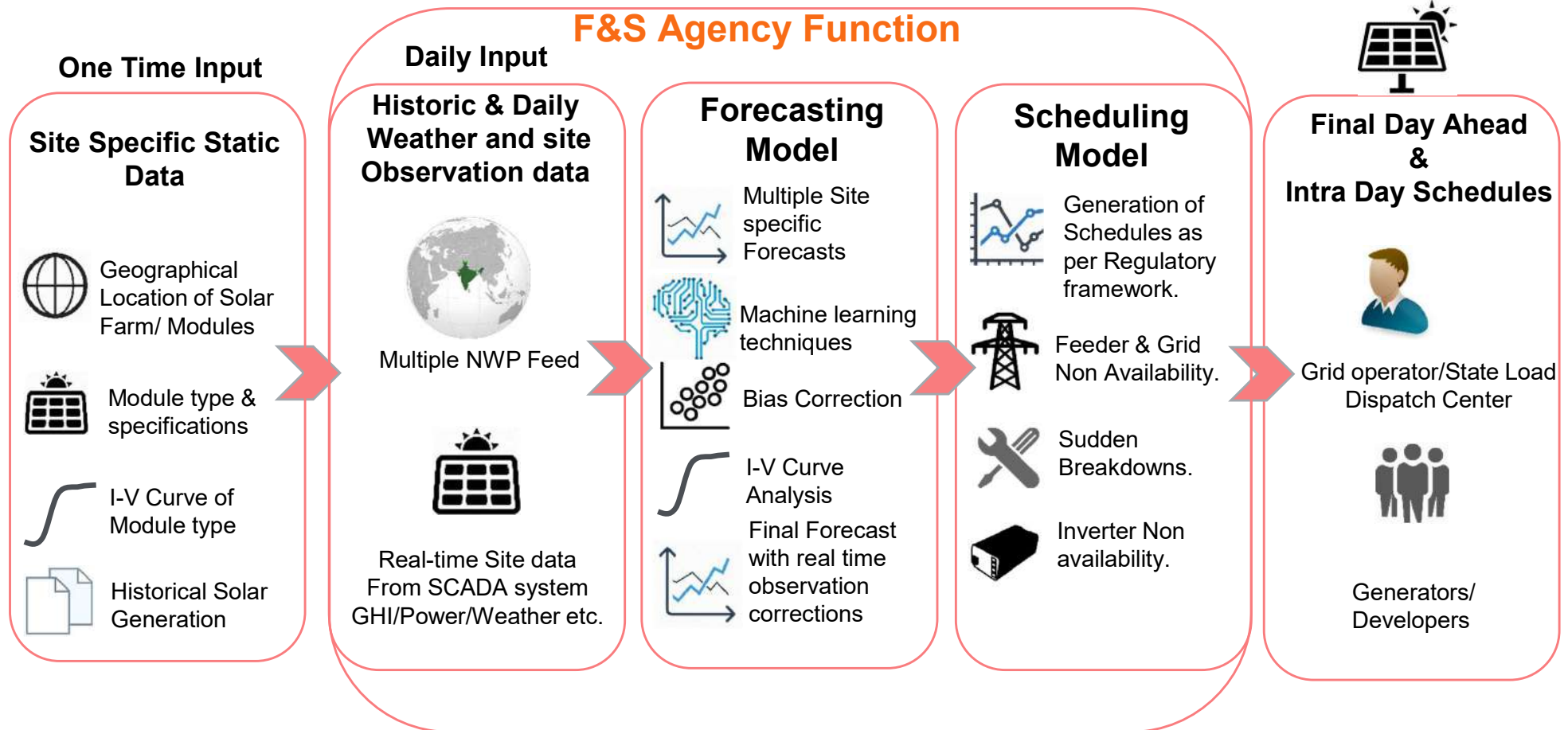


Final Forecast

The statistical architecture uses various inputs which are fed into the In-house machine learning algorithm for determining trend analysis and to incorporate the latest real time power generation. Comparison of both with Actual Power generation, the weights are automatically decided to provide us with final Solar forecast

Solar Power Forecasting and Scheduling Structural design

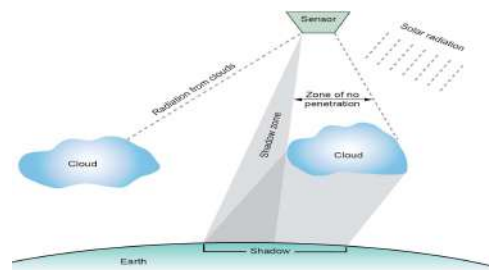
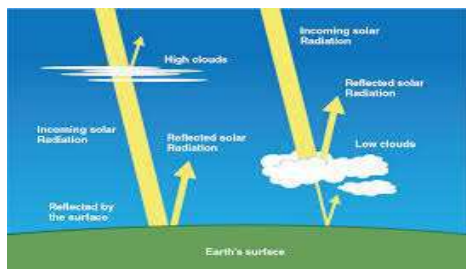
F&S Agency Function



Challenges in achieving weather forecast accuracy and way forward

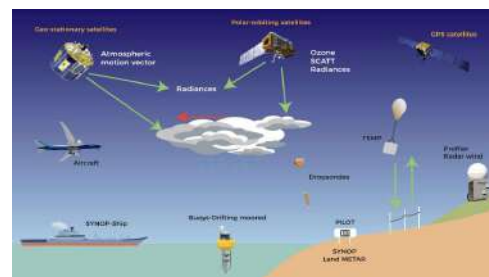
1 Abrupt weather fluctuations- caused by:

- Localized cloud formation and movements
- Momentary/ Fast moving clouds
- Low level and layered clouds



2 Infrastructure Limitations:

- Inadequate numbers of AWS and Radars (to capture micro scale data)
- Locations of AWS and radars not aligned with RE intense zones



3 Existing models need to evolve from meso to micro scale

- NWP model,
- Statistical Methods,
- Synoptical Methods

4 Spatio-Temporal Resolution: The spatial and temporal resolutions used by weather forecast agencies are insufficient to meet the accuracy standards required by regulators for power forecasts from generators, as mandated by DSM commercial regulations.

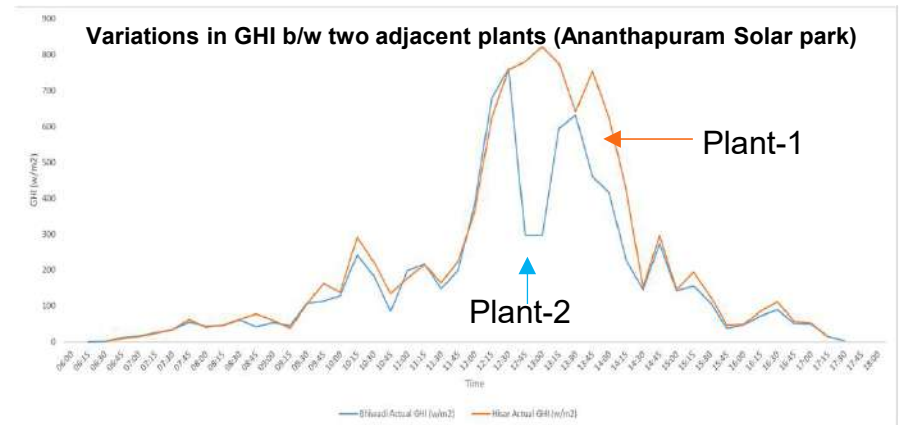
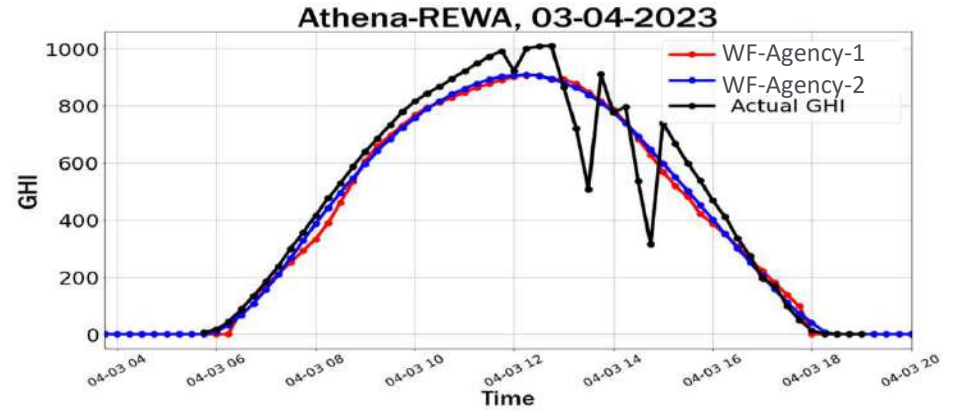
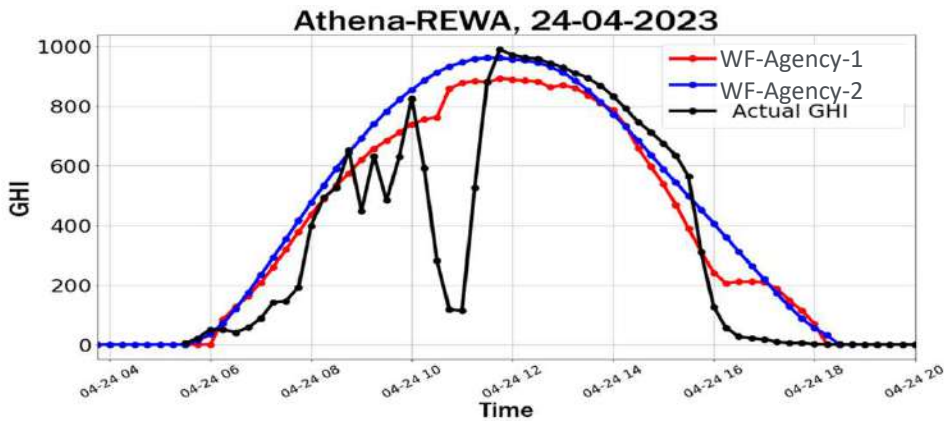
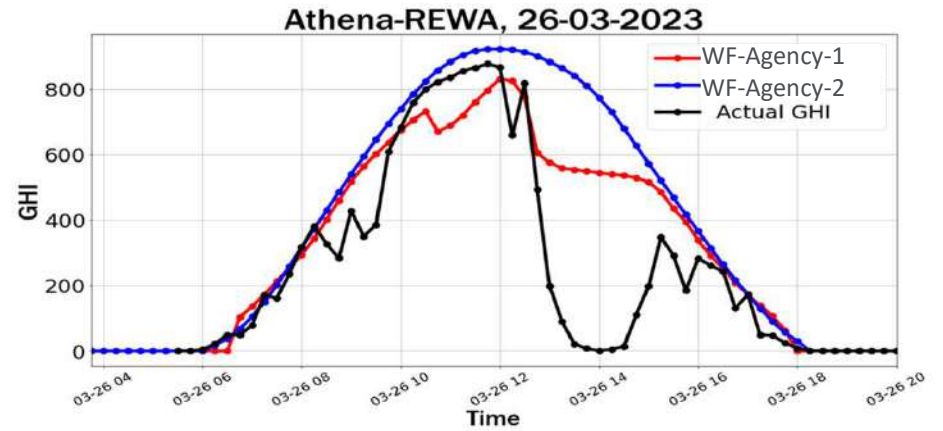
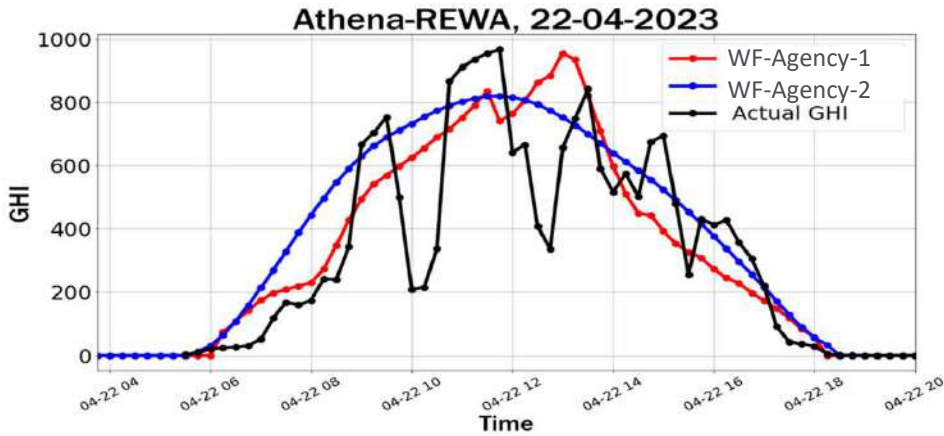


Illustration of GHI fluctuations & prediction vs actual



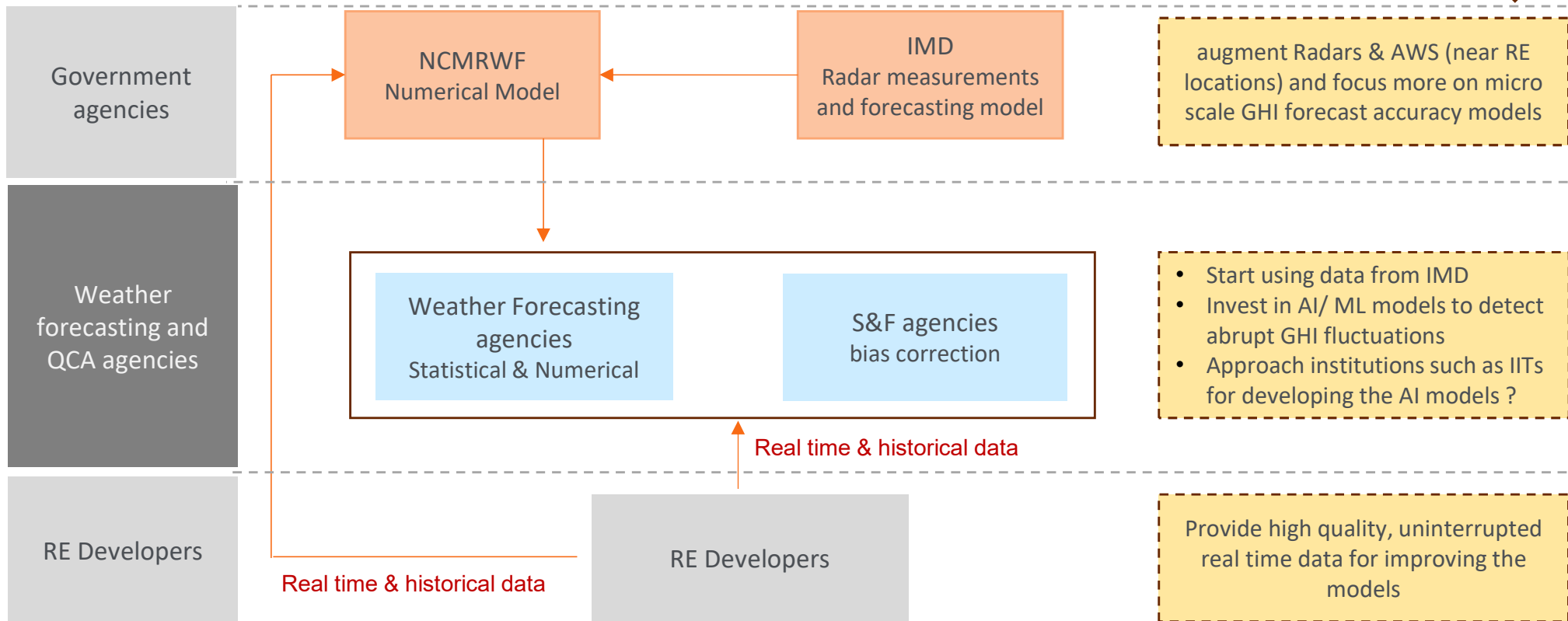
Last 14 months data: 90% of the penalty was incurred in 10% of time blocks; need of the hour is to address these micro scale fluctuations

Way forward: increase the momentum of the ecosystem



All the stake holders need to collaborate and work synergistically to improve the weather forecasting accuracy, the main driver for Generation accuracy; government agencies to continue to lead the way

Way forward ↓



Thank You!