Empowering the Grid: Unleashing the Potential of Artificial Intelligence in Grid Operation

International seminar on AI applications in Power sector

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By

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Outline:

1.AI Applications in Grid operations

2. Fault Classification using CNN

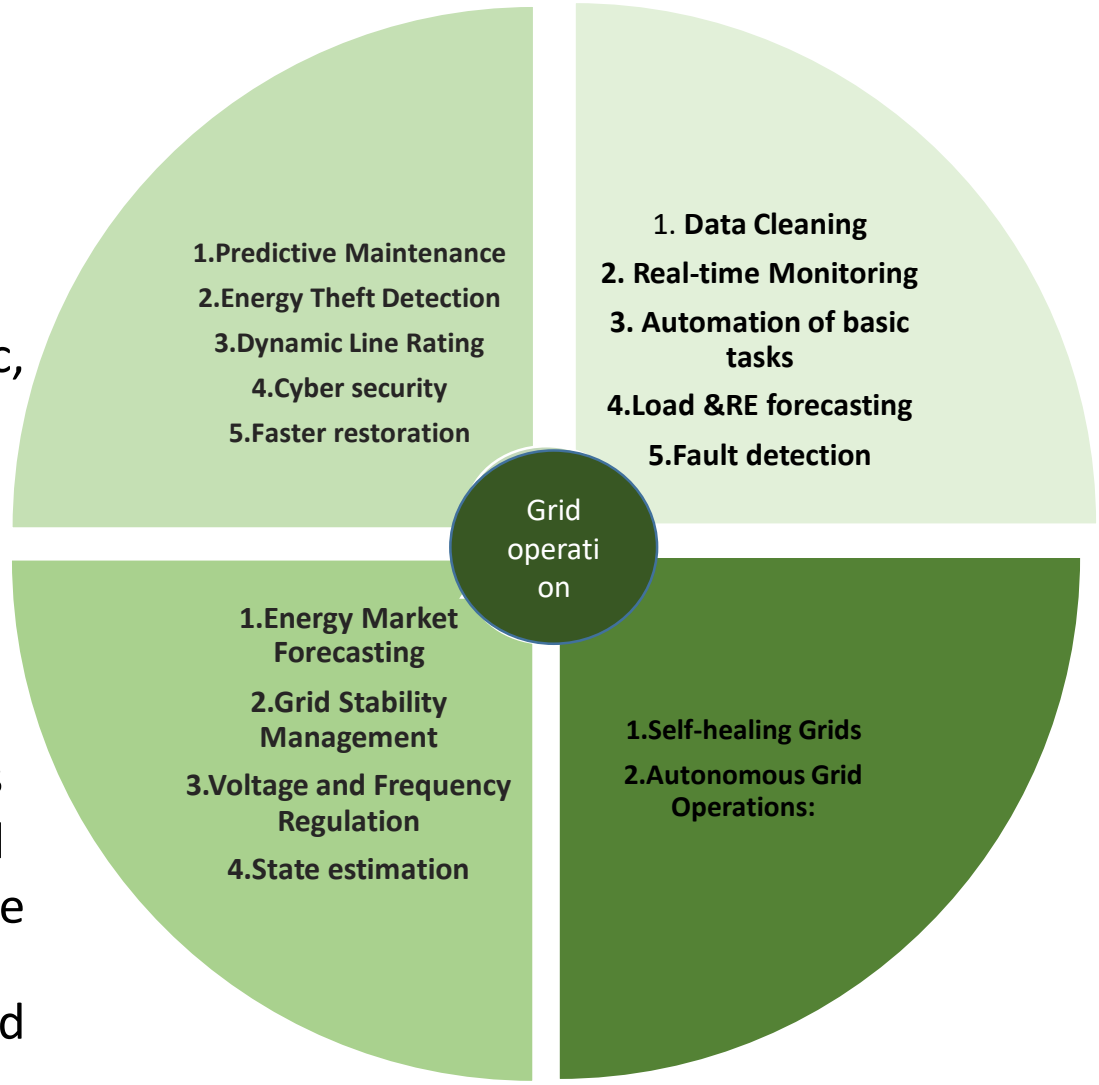
3. Demand forecasting using ANN

4. RE plant Data cleaning using XGBoost

5.Conclusion

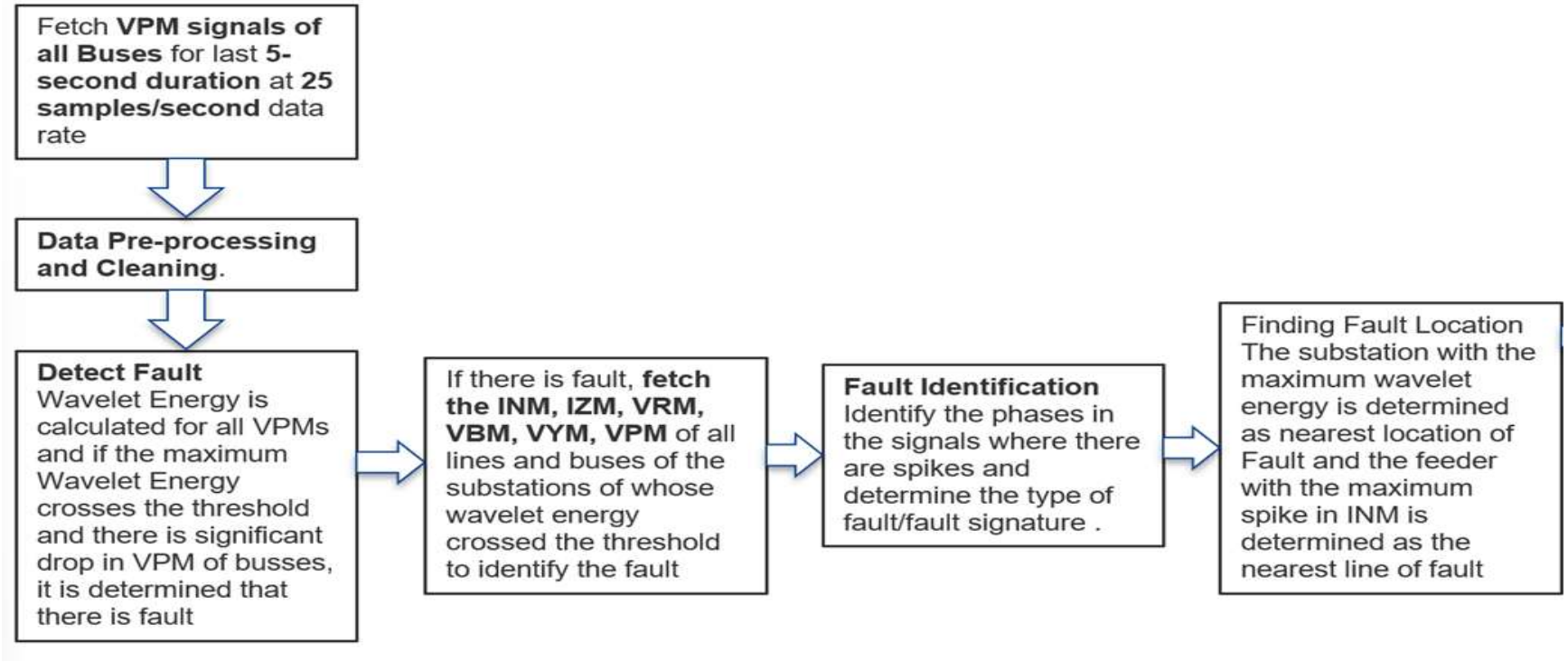
AI In grid operations:

- Increasing complexity of the grid
- Enormous amount of data
  - PMU data at 25 samples/sec
  - SCADA data at each 4-10 secs
  - For all the transmission lines/ICT/BR etc, Hydro/thermal/RE generators
- Real time decision making
  - Historical pattern driven
  - Real time study driven
- Benefits
  - Helps operators to understand current conditions
  - Make better decisions with more analysis in hand
  - Predict potential problems that may occur in the grid.
  - Improves the reliability and efficiency in grid operations



1.Fault classification using Convolutional Neural Networks (CNN):

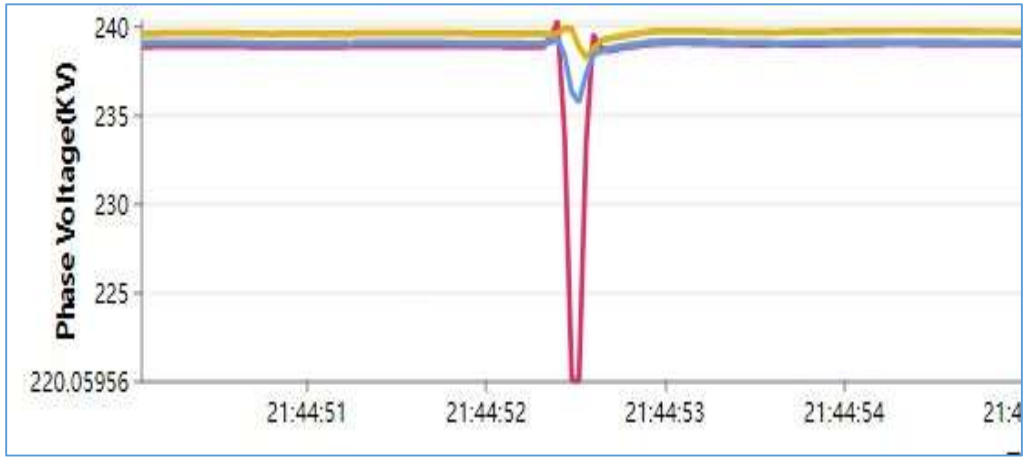
- Traditional Method fault identification and classification:



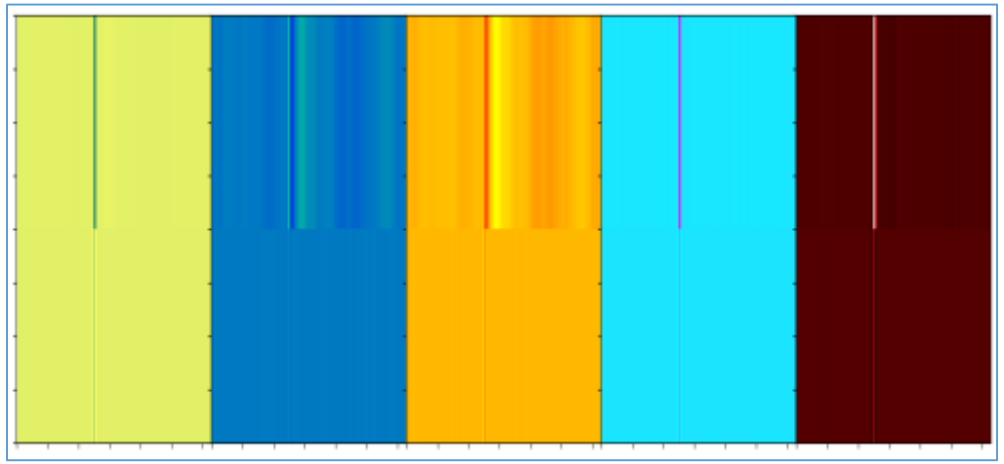
- Challenges:
  - Classification is based on thresholds.
  - Generalizing thresholds for ever changing network is challenging
  - Computational time is high

1.Fault classification using Convolutional Neural Networks (CNN):

- Fault classification using AI
  - Convert wavelet energies into heat map with fault type tag (Around 6000 images used)



Time series fault data

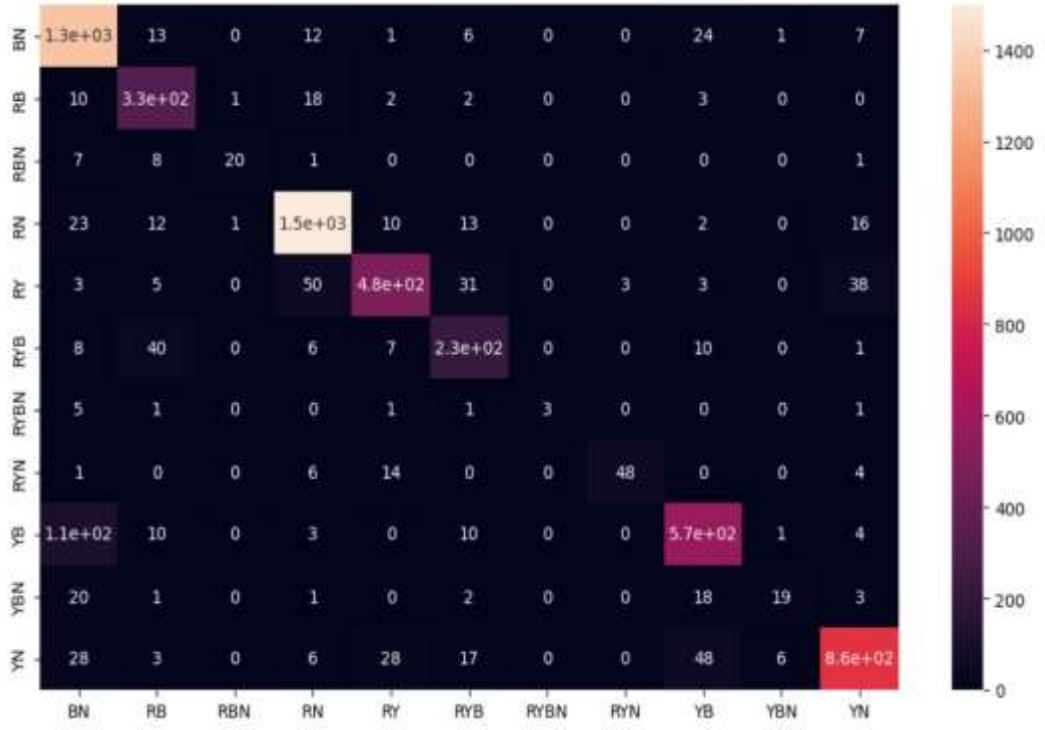


Heat map of Wavelet energy for the same fault

  - CNN Model is trained on these 6000 images.

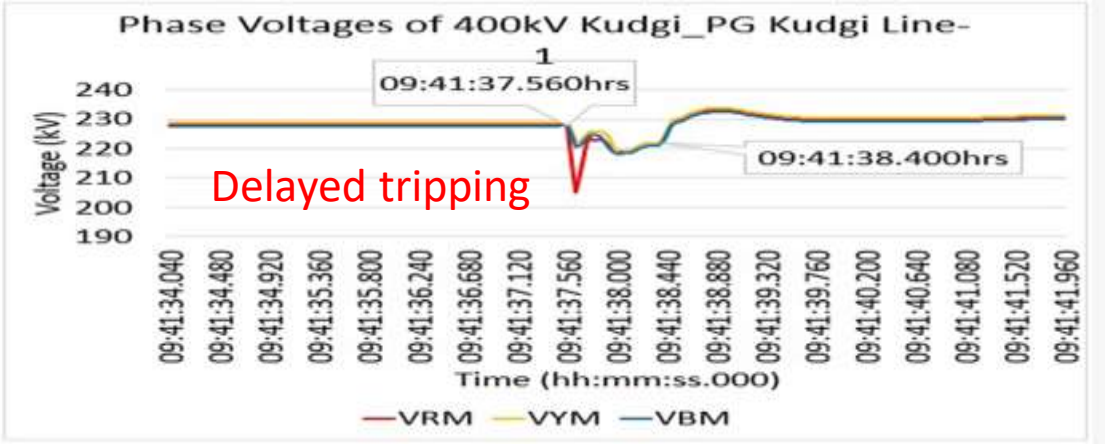
1.Fault classification using Convolutional Neural Networks (CNN):

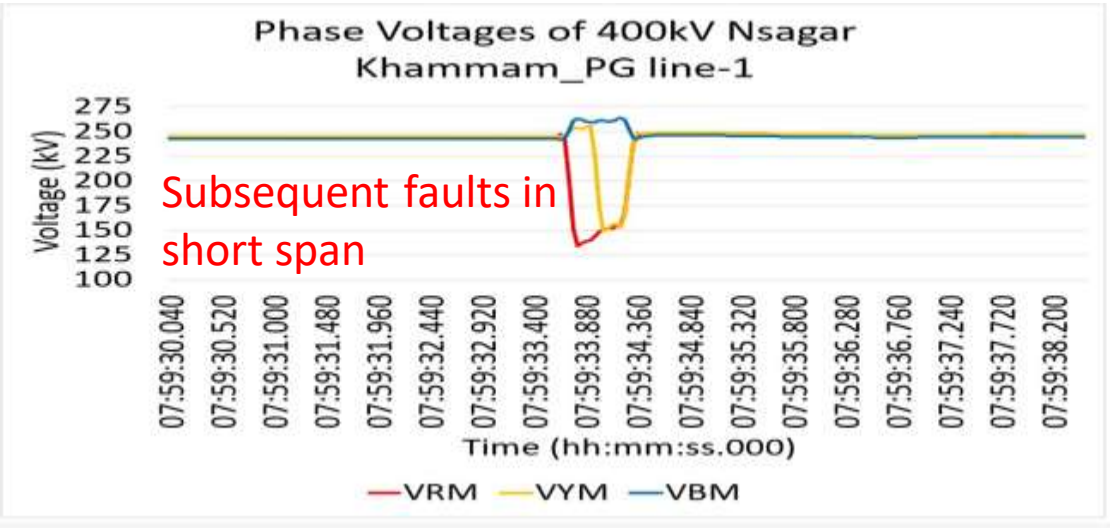
- Results & Future work:



Confusion matrix for Fault classification

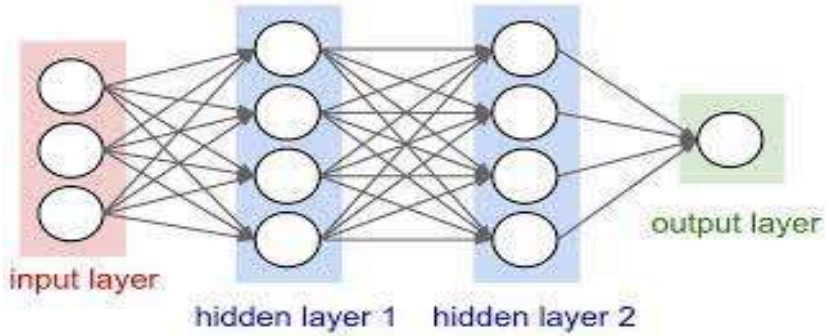
- Accuracy of around 90% is achieved.
- Identifying other special signatures





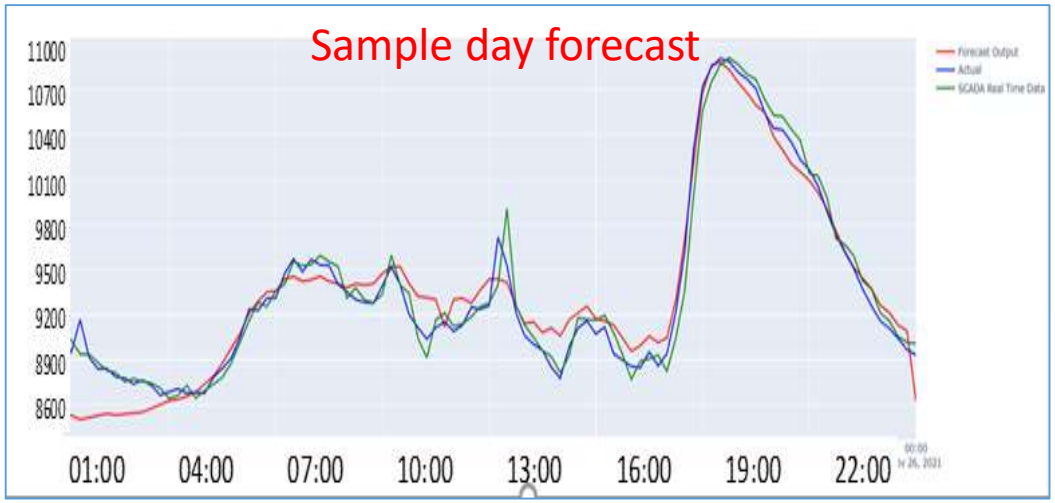
2.AI Based Day ahead electricity Demand Forecasting:

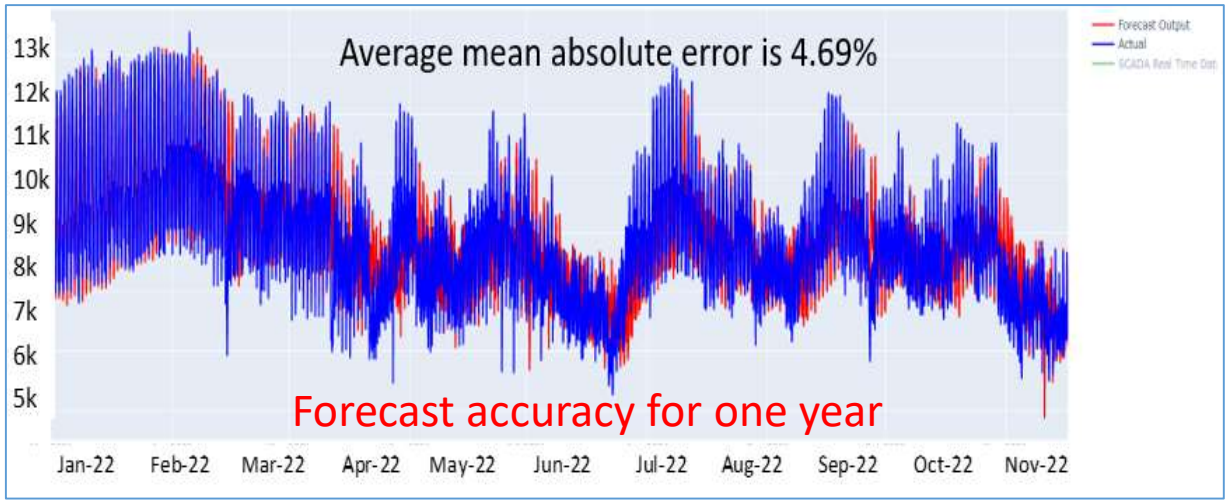
- Day ahead Operation planning starts with demand and RE forecasting.
- Method - Feed Forward Neural Network (based on Artificial Neural Network)
- Total 46 parameters as explained below are considered as input parameters:
  - History Demand Data (D-2, D-3, D-4, D-7) : 4 input (SCADA)
  - Weather Data (Temperature ,Humidity , Rainfall): no of location (13)*3
  - Day of the week (Monday to Sunday(1to 7)): 1
  - Block of the day (1 to 96 blocks): 1
  - Event Value (1/0 for holiday/normal day): 1



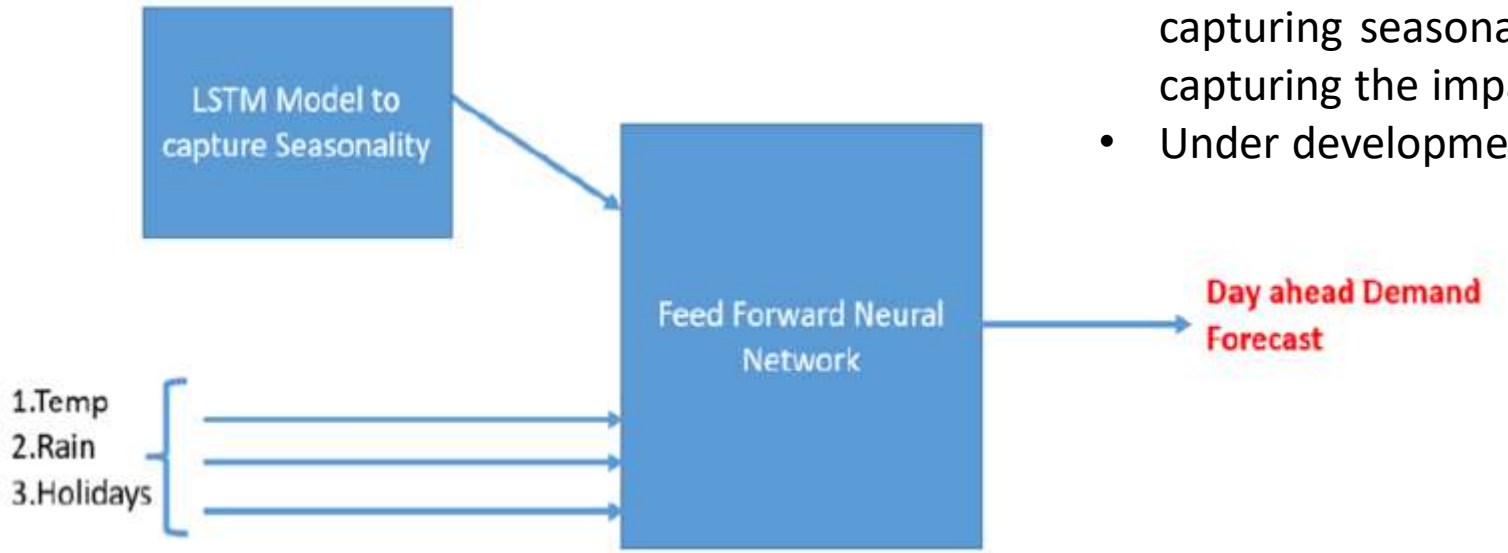
- Output : **Day Ahead Forecast(15 Min Block)**
- model=DemandModel (input_size=46, hidden_size1=29, hidden_size2=15, out_size=1)
- Activation function is RELU(Rectified Linear Unit), Optimizer= ADAM

- **Forecast results:-**

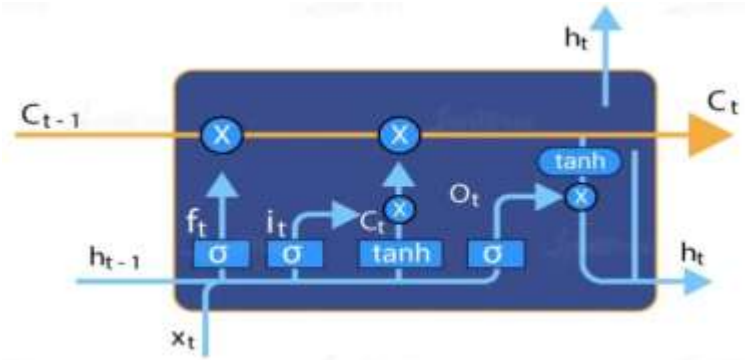




- **Proposed model – Under development**

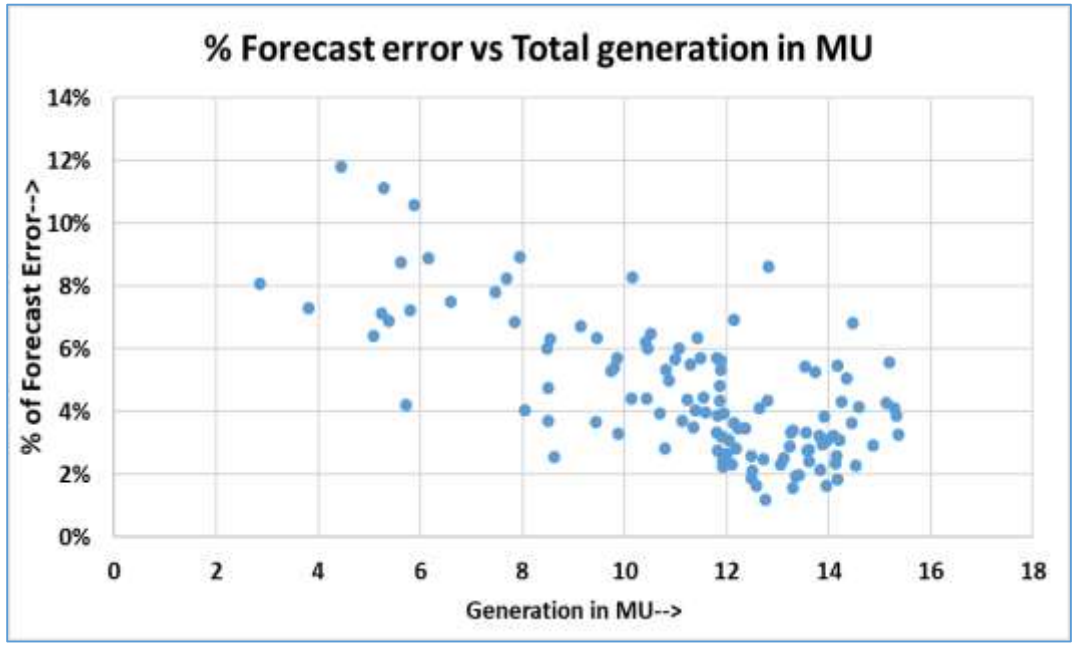


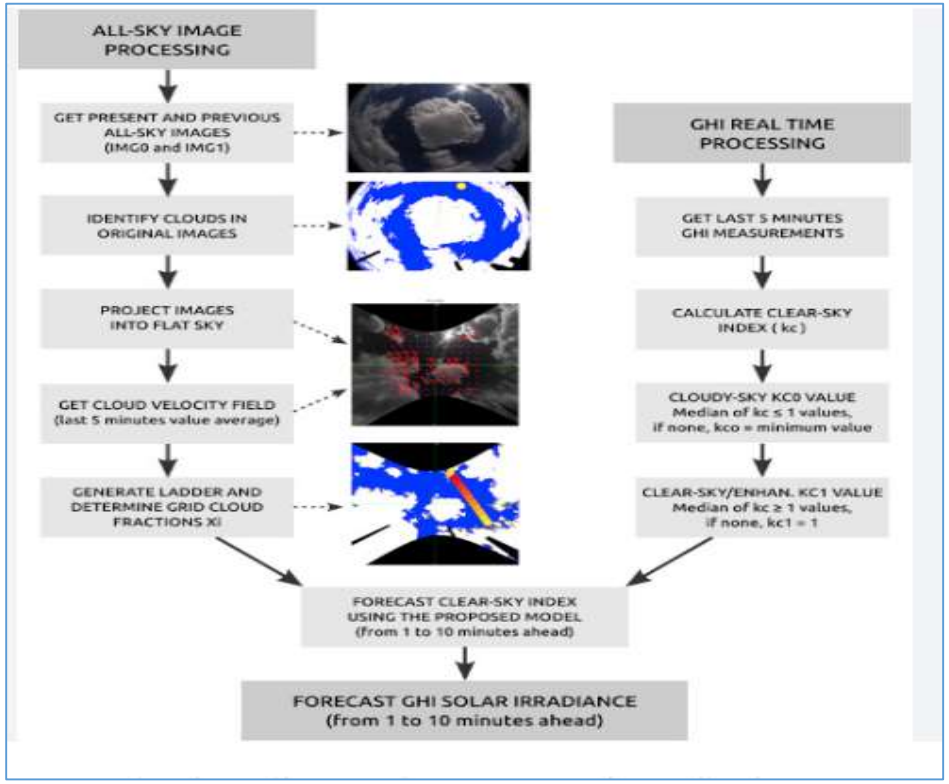
- Hybrid model using Long Short Term Memory (LSTM) for capturing seasonality and feedforward neural network for capturing the impact of weather and Festivals.
- Under development



Required applications in forecasting:

- Cloud image processing for short term solar generation forecasting
  - Cloud detection and velocity field calculations are performed using image processing techniques used on sequential images.
  - Solar Generation variations could not be forecasted during cloudy days.



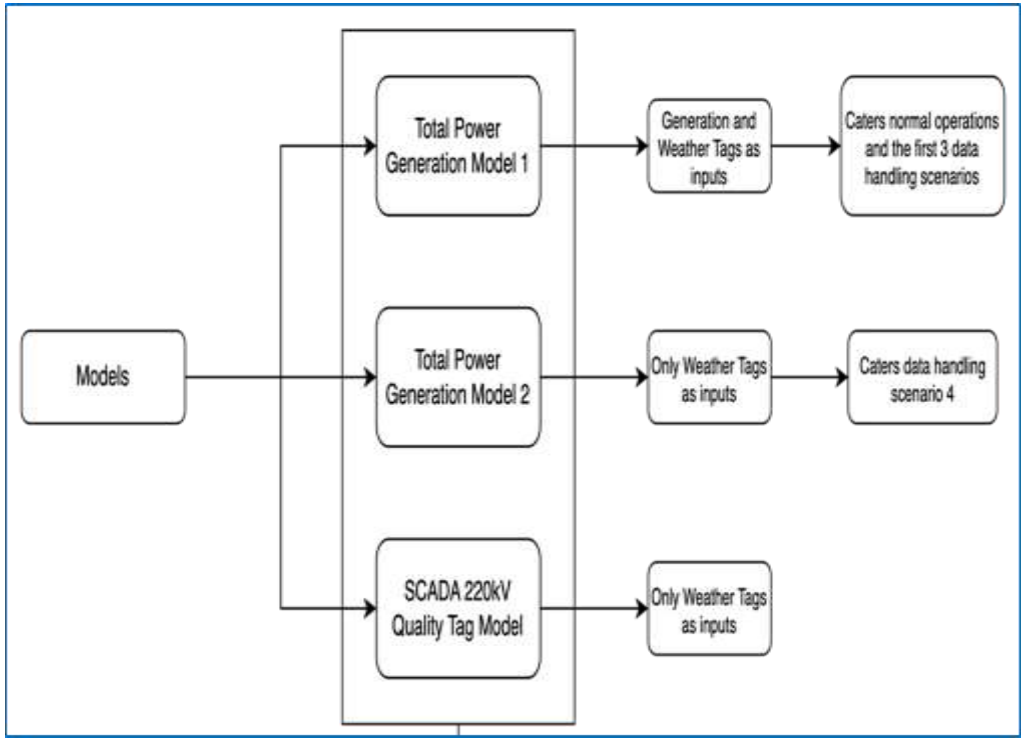


Source: https://doi.org/10.1016/j.renene.2019.05.069

- Wind patterns recognition for improving the wind power forecasting.

3.AI based Renewable Energy (RE) Data Cleaning:

- In collaboration with IIT Kanpur
- Developing engine to clean real time RE data using AI/ML model.
- Feature engineering on minute wise RE generation and weather parameters.
- Total three model used for this pilot project
- Data used for Modeling (Total 200 no features)
  - Direct point values
  - Previous point values (Feature Engineering)
  - Mean values (Feature Engineering)
- Model can handle following scenarios
  - Data of many inverters in a block is not updating
  - Data of few inverters in few blocks not updating
  - Weather data not updating
  - Entire station data not updating in real time



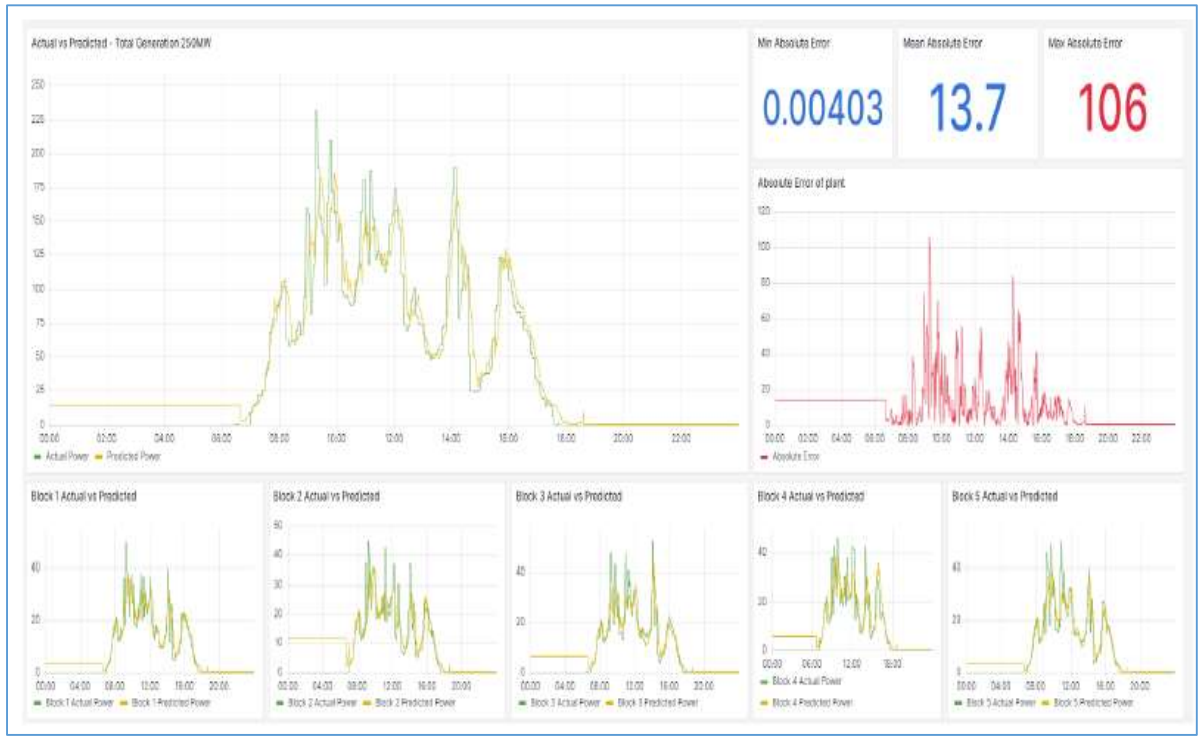
AI based Renewable Energy (RE) Data Cleaning:

- Nine versions of model based on different architectures like XGB Regressor(3 Versions), LGBM Regressor, CatBoost Regressor, LSTM, CNN, ANN.
- Initially model developed based on entire data.
- **Data balancing:** All data points where difference between SCADA and SEM power more than 50 MW are dropped.

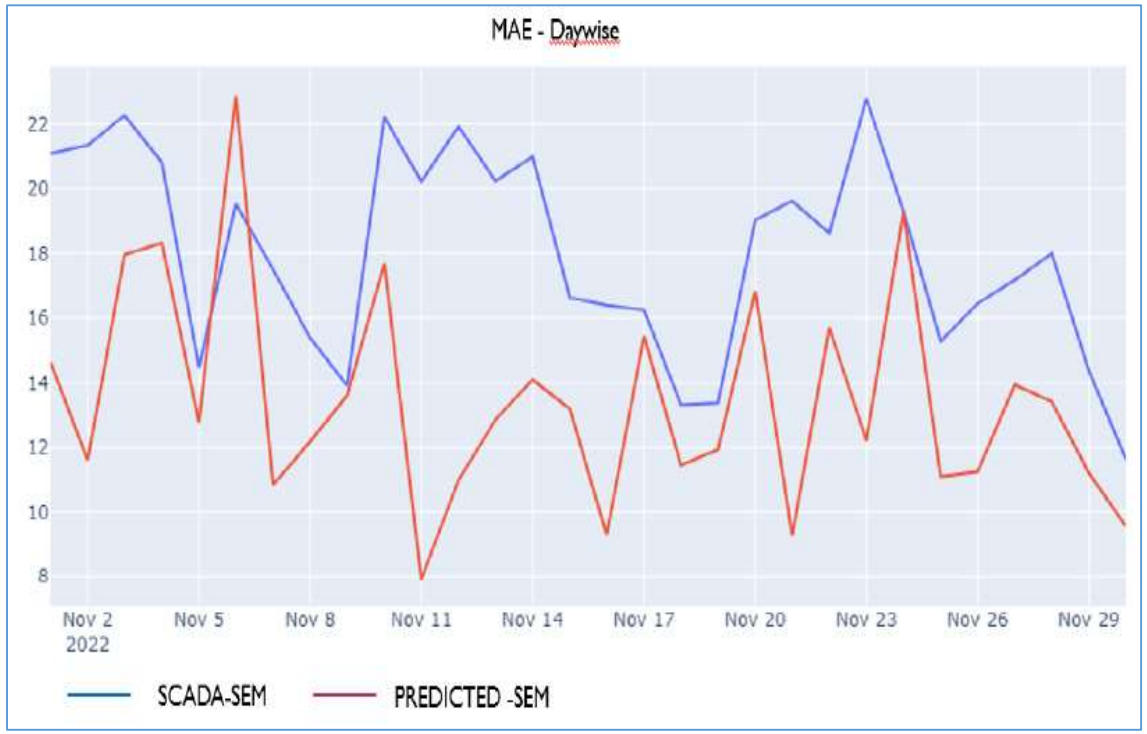
Model	Mean Absolute Error (MAE)	Mean Squared Error (MSE)	Root Mean Squared Error (RMSE)
XGB ensemble ML model	5.47	85.23	9.23
CNN	5.44	118.58	10.88
ANN	5.90	127.79	11.30

- Out of all nine versions of different model comparison, it was concluded that the XGBoost (Extreme Gradient Boosting) Regressor is performing better for real time data cleaning.

AI based Renewable Energy (RE) Data Cleaning:



Dashboard



Results

Conclusions:

- **In grid operations usage of AI is at the initial stages, in the coming days it is expected to take off at faster pace.**
- **AI may not completely automate the entire grid operations (based on present understanding), but definitely ease the system operators job and improve the reliability and economy in the system operations.**

Thank you