Study of Impact of Forecasting Methods on Reliability of RES

Sumbul Hasan

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Outline I

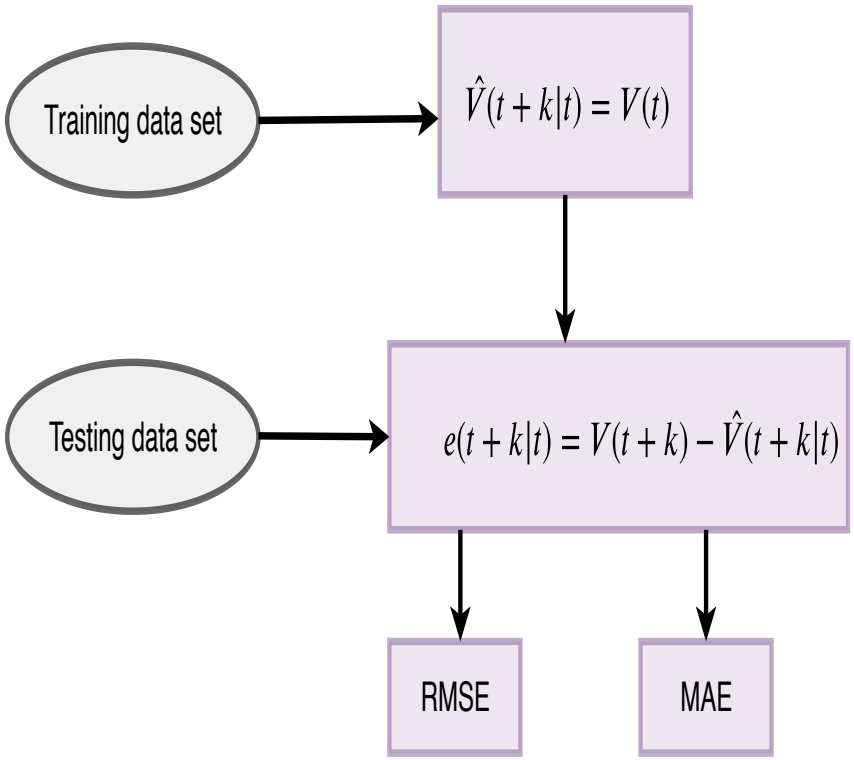
Motivation

- Large scale grid integration of RES has impact on the real time operation of the power system, ancillary service requirement, power quality, upgradation of transmission network and competitive market design.
- BESS is used as energy buffer to mitigate stochastic behaviour of the RES and to make RES dispatchable.
- To make wind power plants dispatchable like traditional power plants, the wind farm operators have to rely on prediction for short term wind power to schedule wind farms.
- The accuracy of the prediction model has economical and technical impact on the operation of grid with high RES penetration.

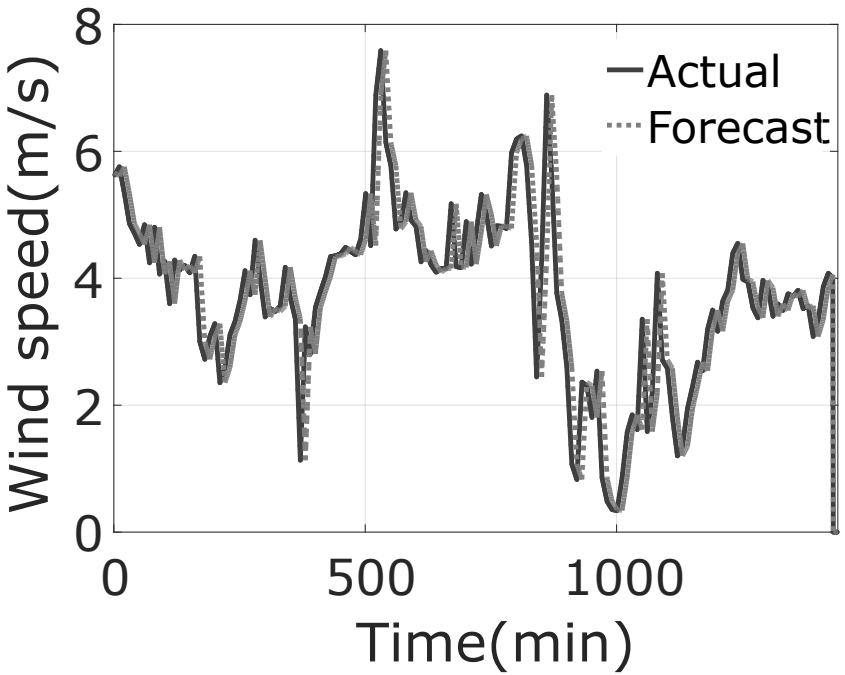
Problem Statemant

- The objective of the paper is to study the impact of different forecast methods on the reliability of the hybrid system(wind farm and BESS) in meeting the schedule dispatches.

Persistense Model



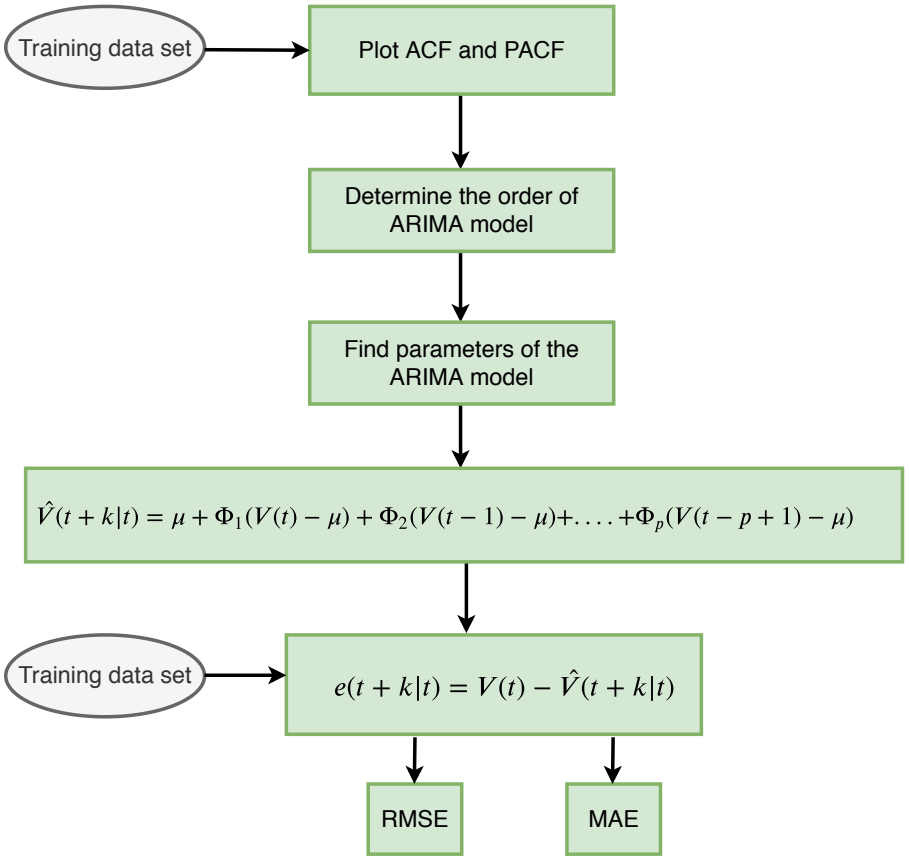
Flow chart of Persistence Model [a]



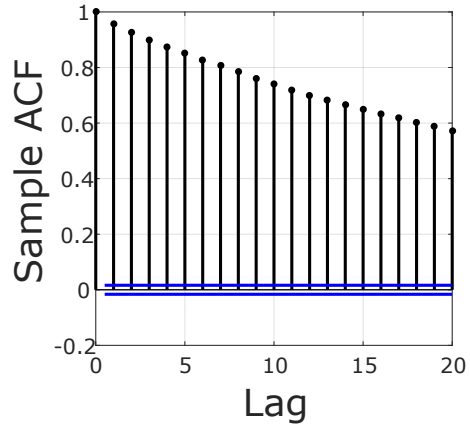
Persistence model

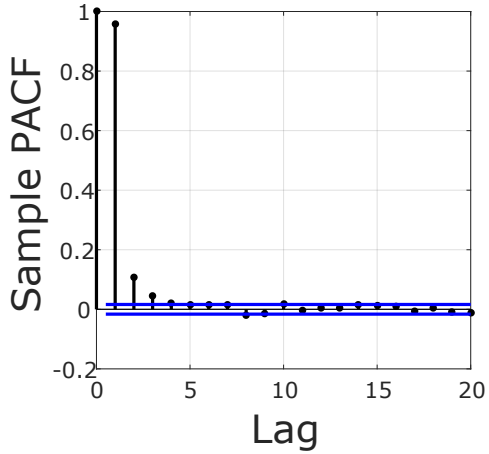
[a] Nielsen, A new reference for wind power forecasting(1998)

ARIMA Model



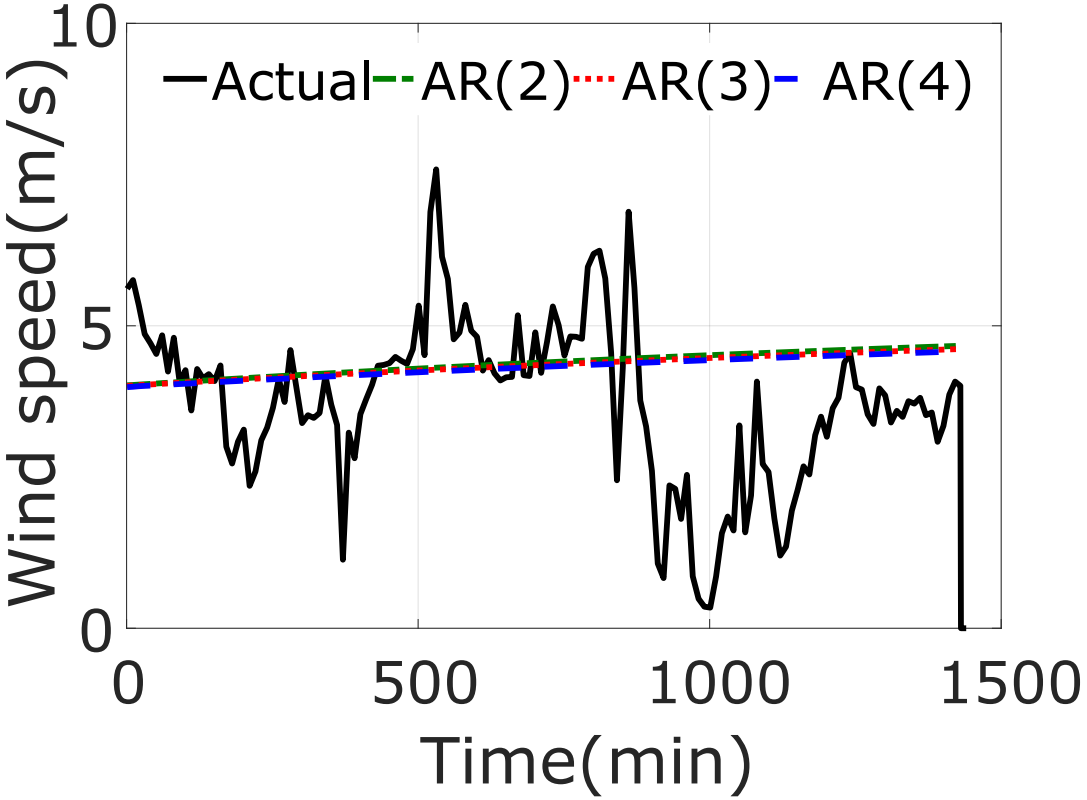
Flow chart of ARIMA Model[a]





[a]Box, George EP and Jenkins,Time series analysis: forecasting and control(2015)

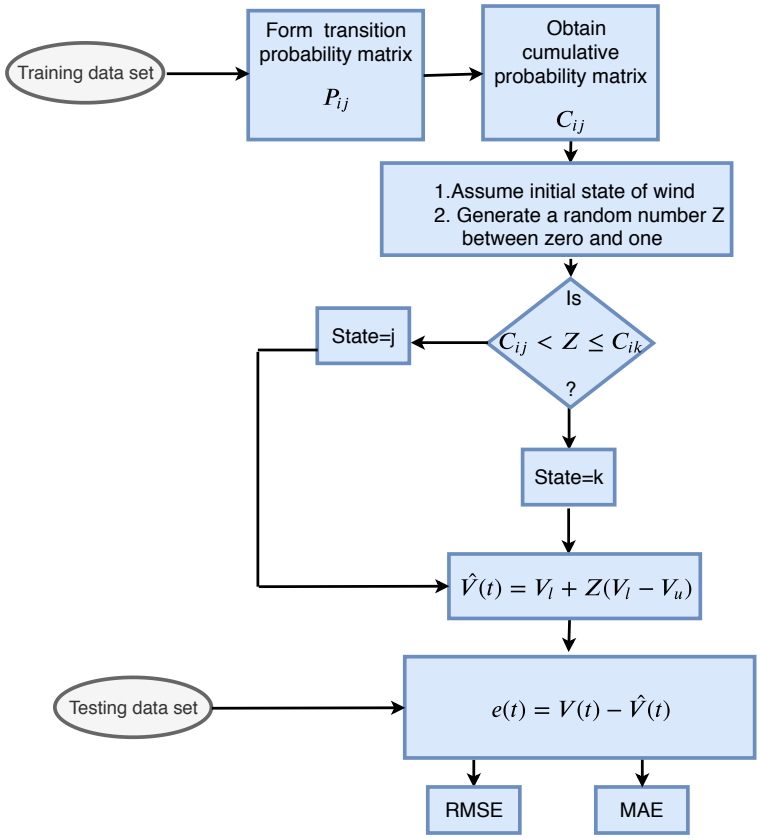
ARIMA Model

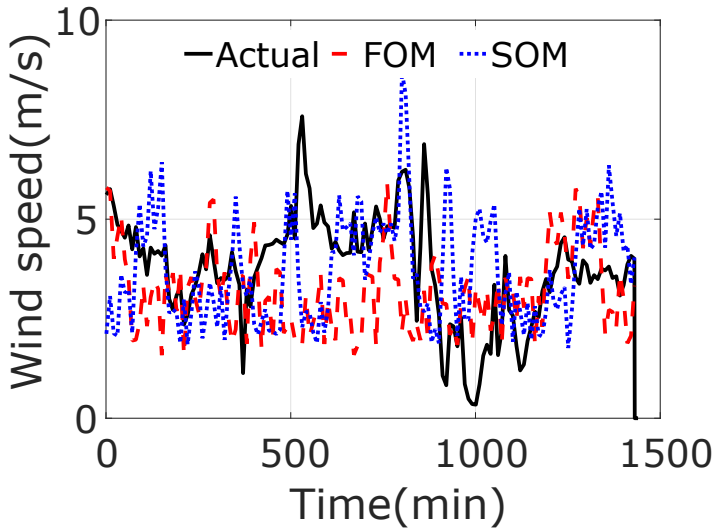


ARIMA Model

- The wind speed obtained for AR(2), AR(3) and AR(4) are usually higher than the actual wind speed.

Markov Chain Model





Markov Chain Model

Flow chart of Markov chain Model[a]

[a] Carpinone, Markov chain modeling for very-short-term wind power forecasting(2015)

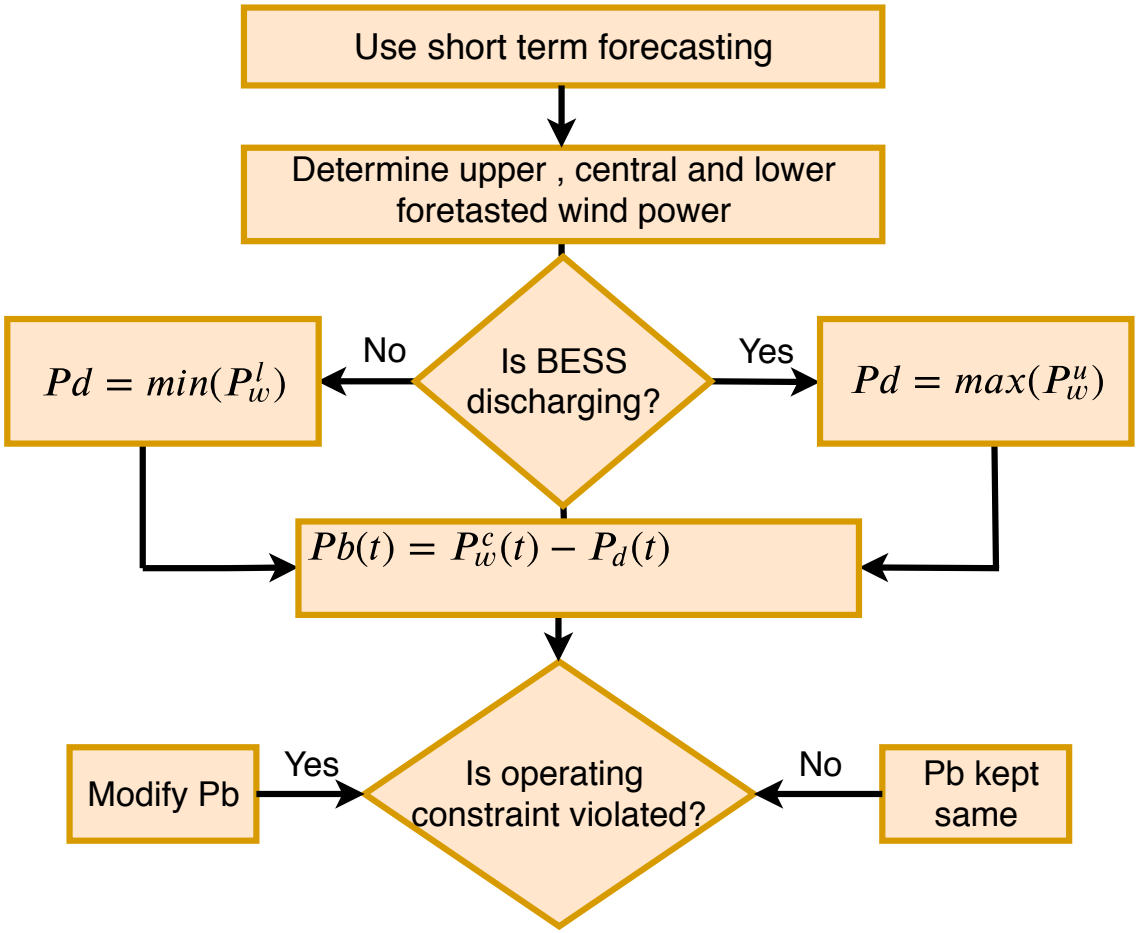
Min-Max Method

To make wind farm dispatchable we have chosen min-max method [1], key features are:

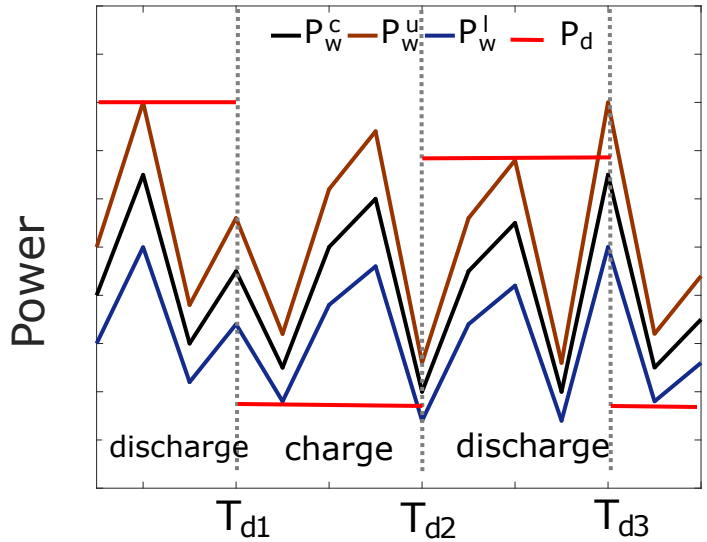
- The wind farm is scheduled based on short term wind forecast.
- The accuracy of wind power forecast is quantified in statistical terms.
- Power dispatches are made with specific confidence level.
- BESS undergoes complete charging and discharging cycles.

[1] Li Q, On the determination of battery energy storage capacity and short-term power dispatch of a wind farm(2011)

Min-Max method



Min-max method



Upper, central and lower forcast curve corresponding confidence interval of 99.74 %

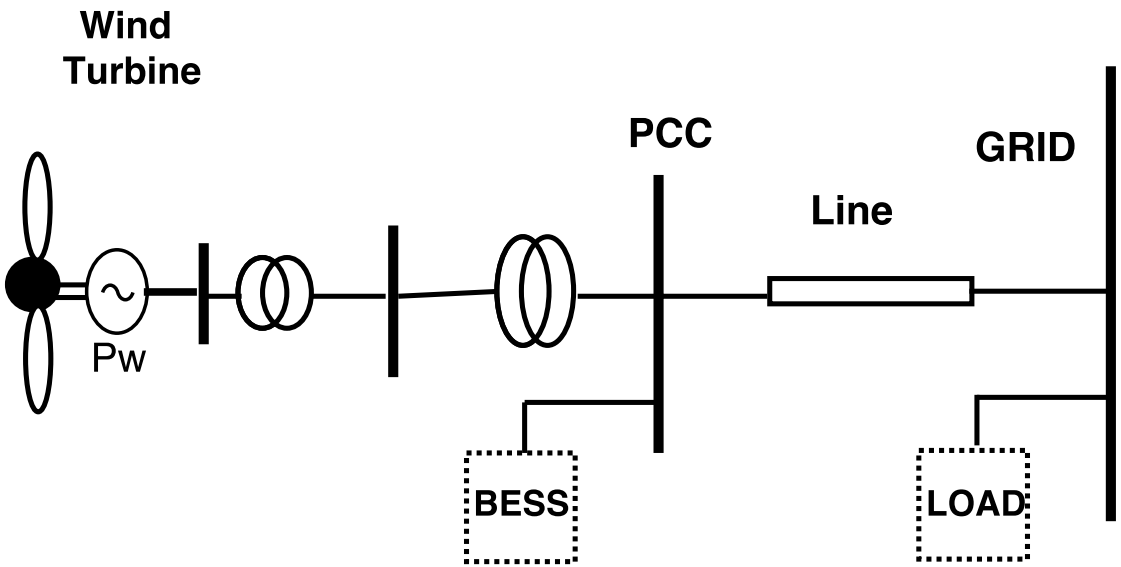
Reliability Indices

$$\mathrm{ES(t)} = \begin{cases} (P_w^c(t) - Pb(t))\Delta t; & \text{Discharging} \\ P_d(t)\Delta t; & \text{Charging} \end{cases}$$

$$\mathrm{ENS(t)} = \begin{cases} P_d(t)\Delta t - \mathrm{ES(t)}; & \text{Discharging} \\ 0; & \text{Charging} \end{cases}$$

$$\mathrm{ENU(t)} = \begin{cases} 0; & \text{Discharging} \\ (P_w^c(t) - P_d(t) - Pb(t)\Delta t; & \text{Charging} \end{cases}$$

System Description



Wind farm model

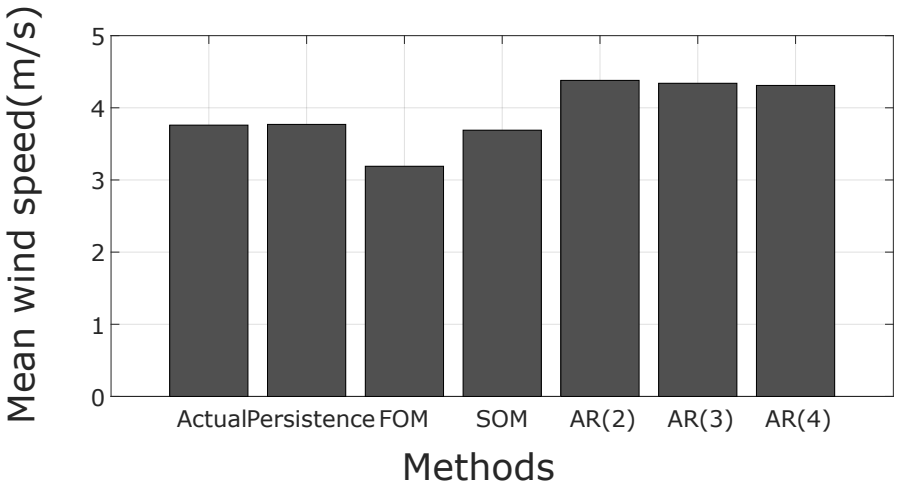
Assumptions made:

- The wind seen by each wind turbine is same.
- The effect of terrain is neglected.
- Self discharging of BESS is ignored.
- BESS rating is given as:

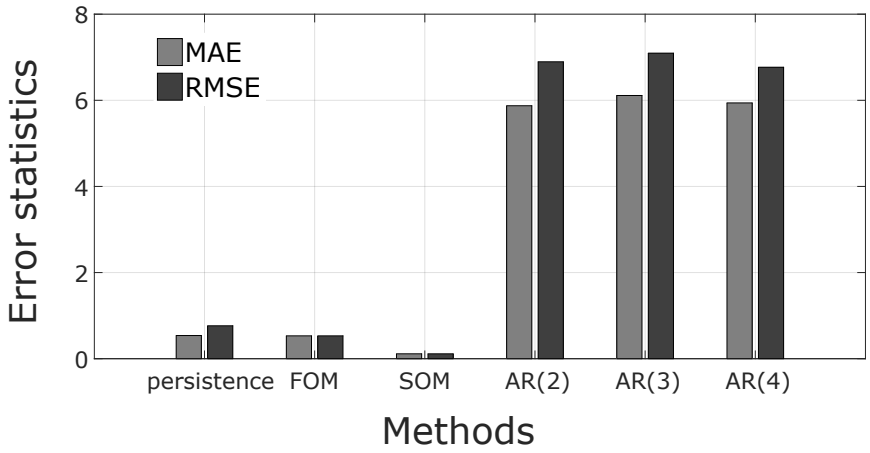
$$P_r = max[|P_{Sch}^{error}|]$$

- Ratio of energy capacity and Power rating of BESS is one.

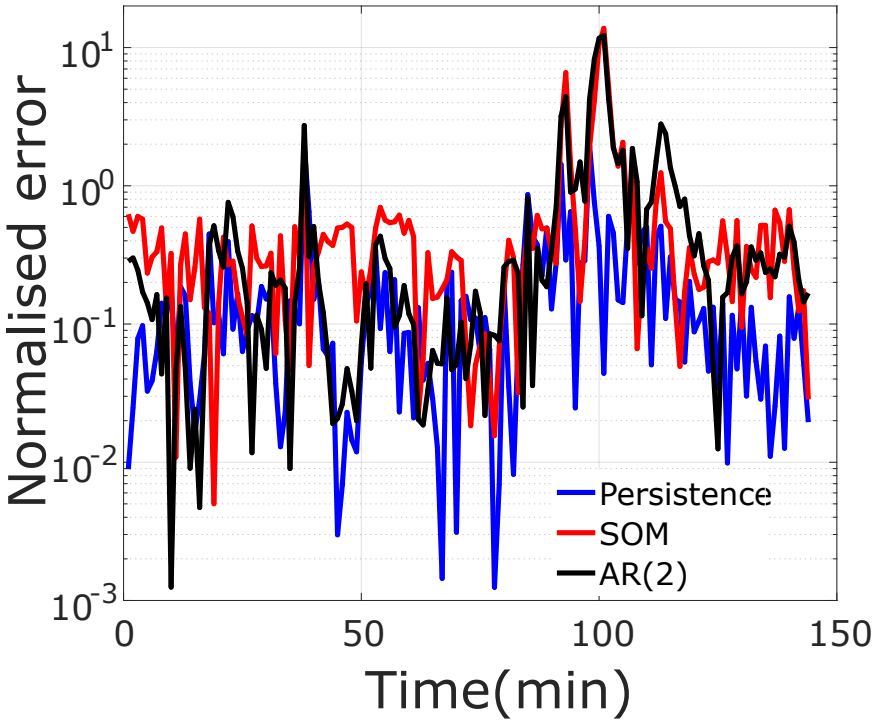
Comparison of Forecasting Model



Mean wind speed

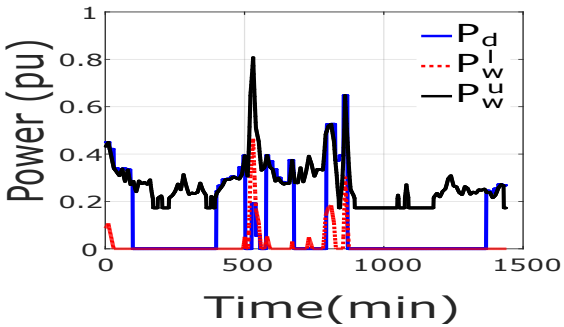


Error statistics

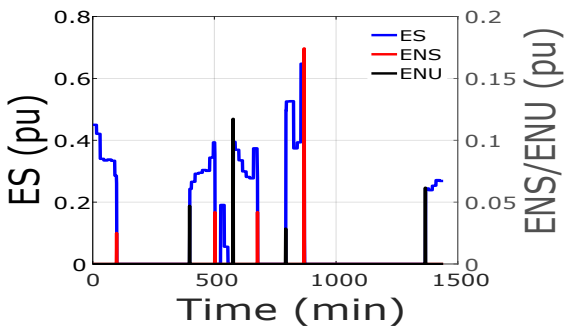


Wind speed error time series

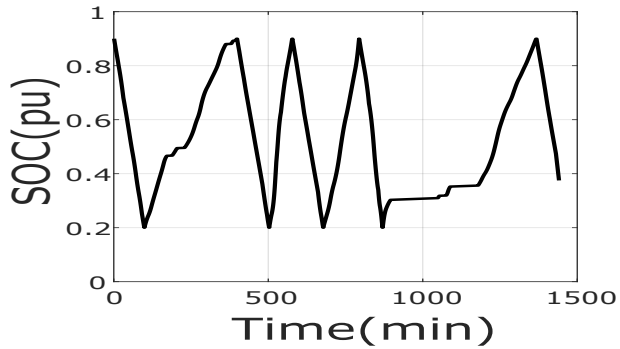
Impact of Different Forecasting Methods on Reliability Indices



(a) Power

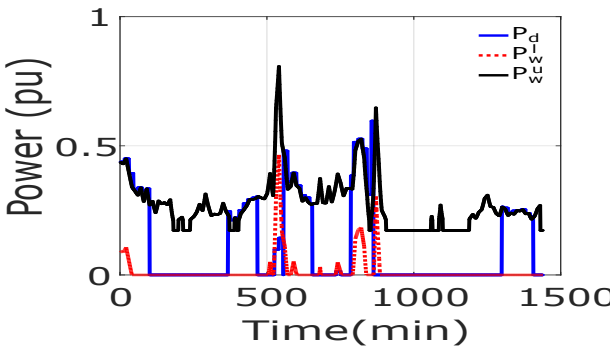


(b) Energy

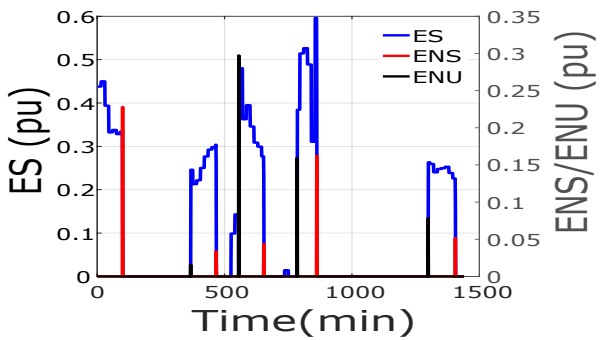


(c) SOC

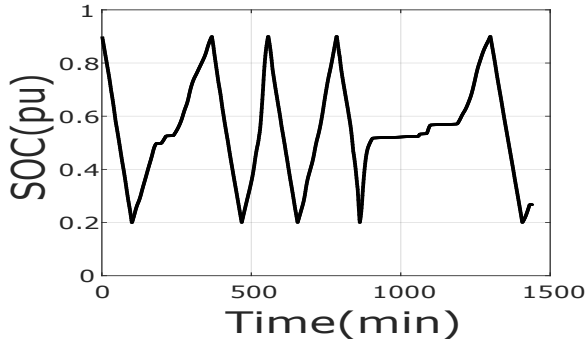
Actual data



(d) Power



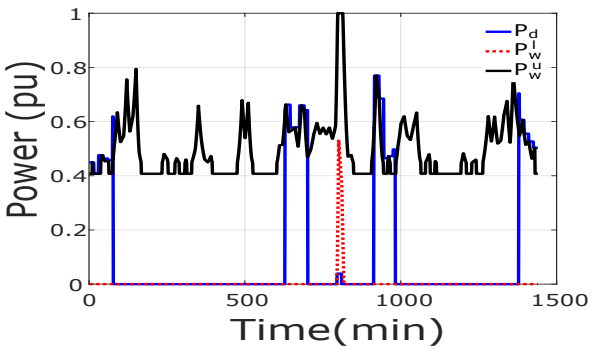
(e) Energy



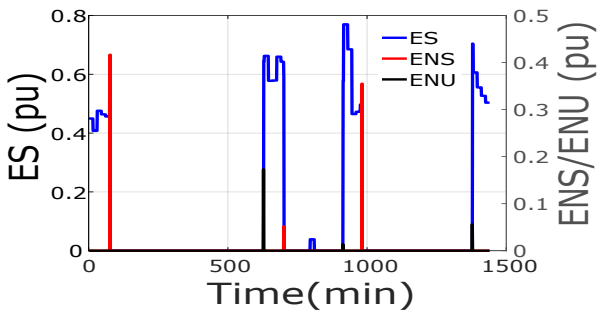
(f) SOC

Persistence Model

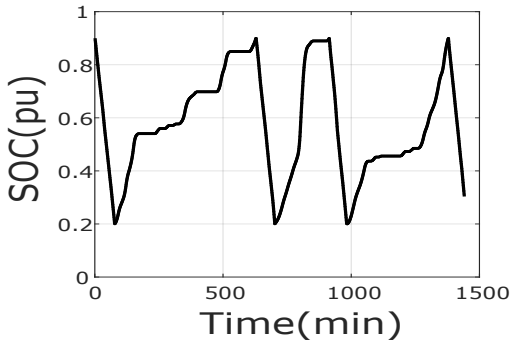
Impact of Different Forecasting Methods on Reliability Indices



(g) Power

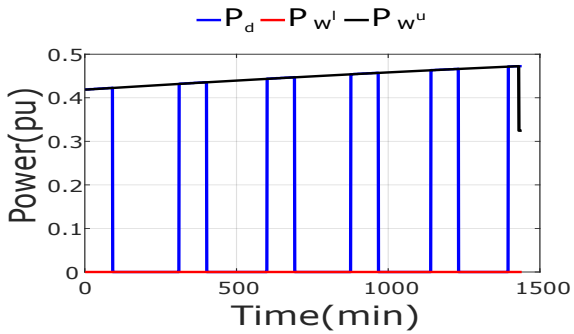


(h) Energy

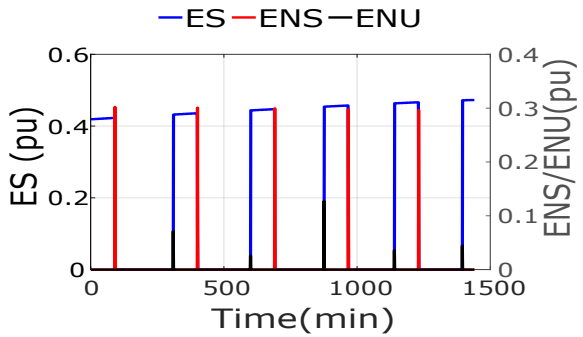


(i) SOC

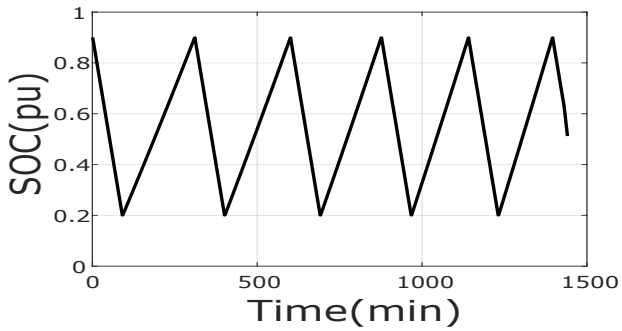
SOM model



(j) Power



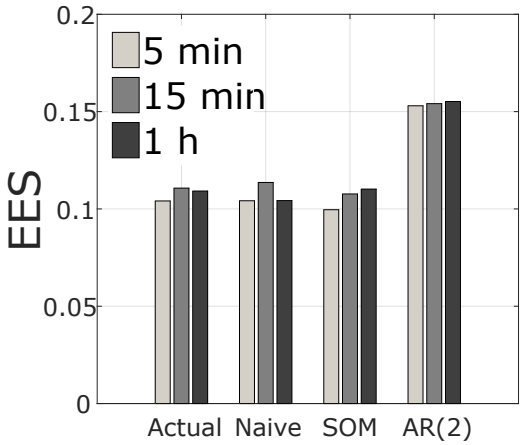
(k) Energy



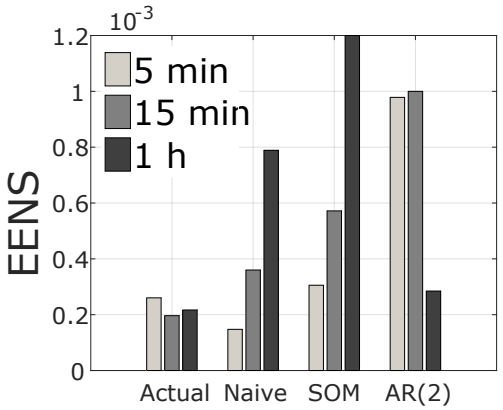
(l) SOC

AR(2) Model

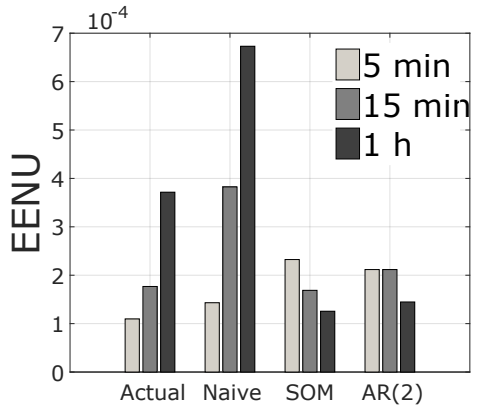
Impact of Different Dispatch Intervals on Reliability Indices



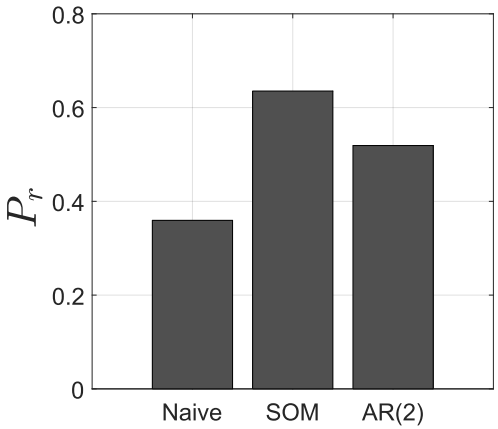
EES



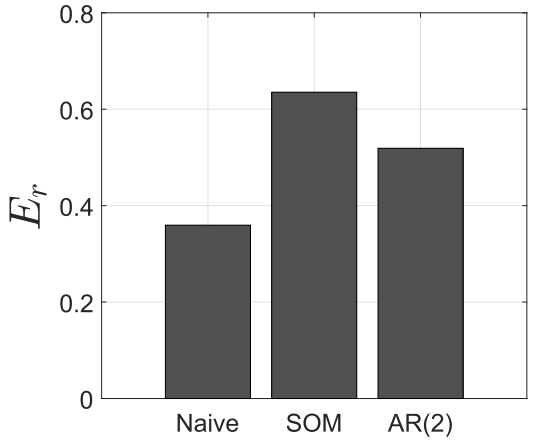
EENS



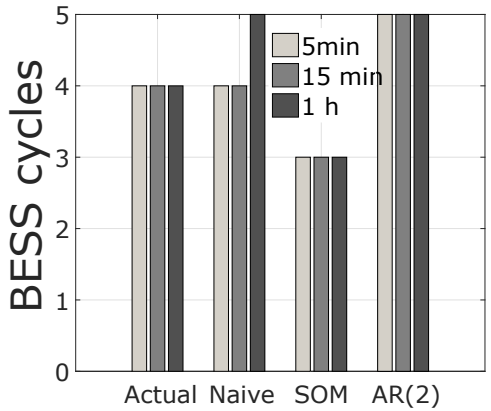
EENU



Power rating



Energy capacity



Number of BESS cycles

Conclusion

- The impact of the forecasting methods on the operation of the WPP with the BESS is evaluated by calculating EES, EENS and EENU.
- SOM model gave better statistic than persistence and AR(2).
- EES is more when AR(2) forecasting model is used.
- BESS energy and power rating is highest for SOM and least for persistence model.
- BESS undergoes least number of cycles for SOM model and highest for AR(2) model.

Thank You !