

Renewables



OPERATIONAL FORECASTING IMPLICATIONS OF INTEGRATED WIND, SOLAR AND ENERGY STORAGE

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AGENDA



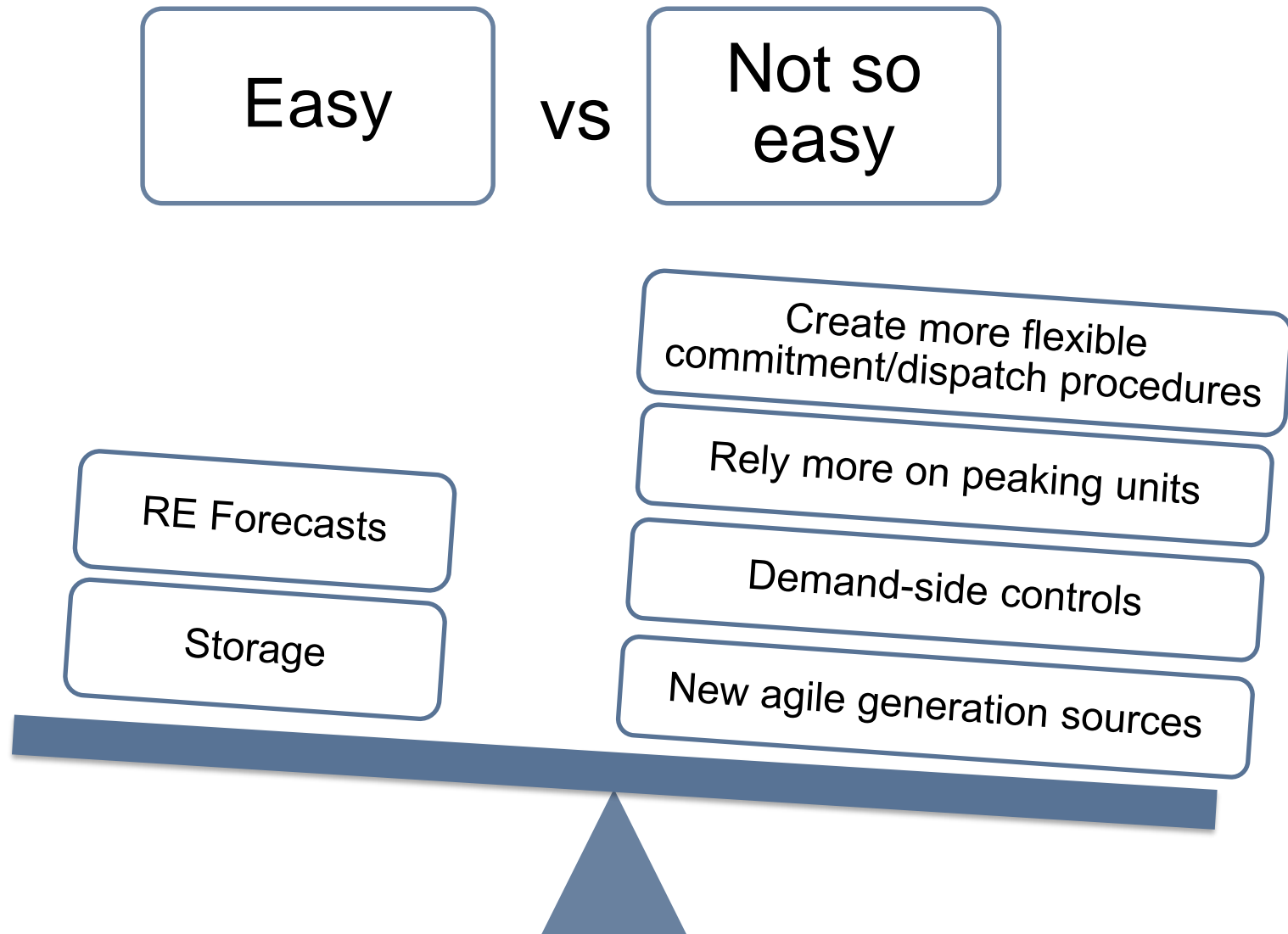
DEFINITION OF THE PROBLEM

Uncertainty associated with wind and solar energy resources can be a costly issue to deal with.

- Reliability concerns on the transmission system due to wind/solar ramp rates, uncertainty with scheduling generation, peak/minimum load issues while meeting base generation operating constraints
- Profit concern for market participant due to non-optimized energy sales or taking penalties from off-taker



SIMPLE SOLUTION: FLEXIBILITY!



OPPORTUNITY

Issued Feb. 15, 2018, [FERC Order 841](#) requires electricity markets to create an energy storage participation model that allows a resource to *“provide all capacity, energy, and ancillary services that the resource is technically capable of providing in the RTO/ISO markets, ...be dispatched and set the wholesale market clearing price as both a wholesale seller and wholesale buyer, ...and account for the physical and operational characteristics through bidding parameters or other means.”*



FORECASTING FOR COMBINED PLANTS

Planning Studies

Much can be done up front to simulate wind and solar generation and forecasts to determine storage capacity sizing, ramping needs, and revenue expectations

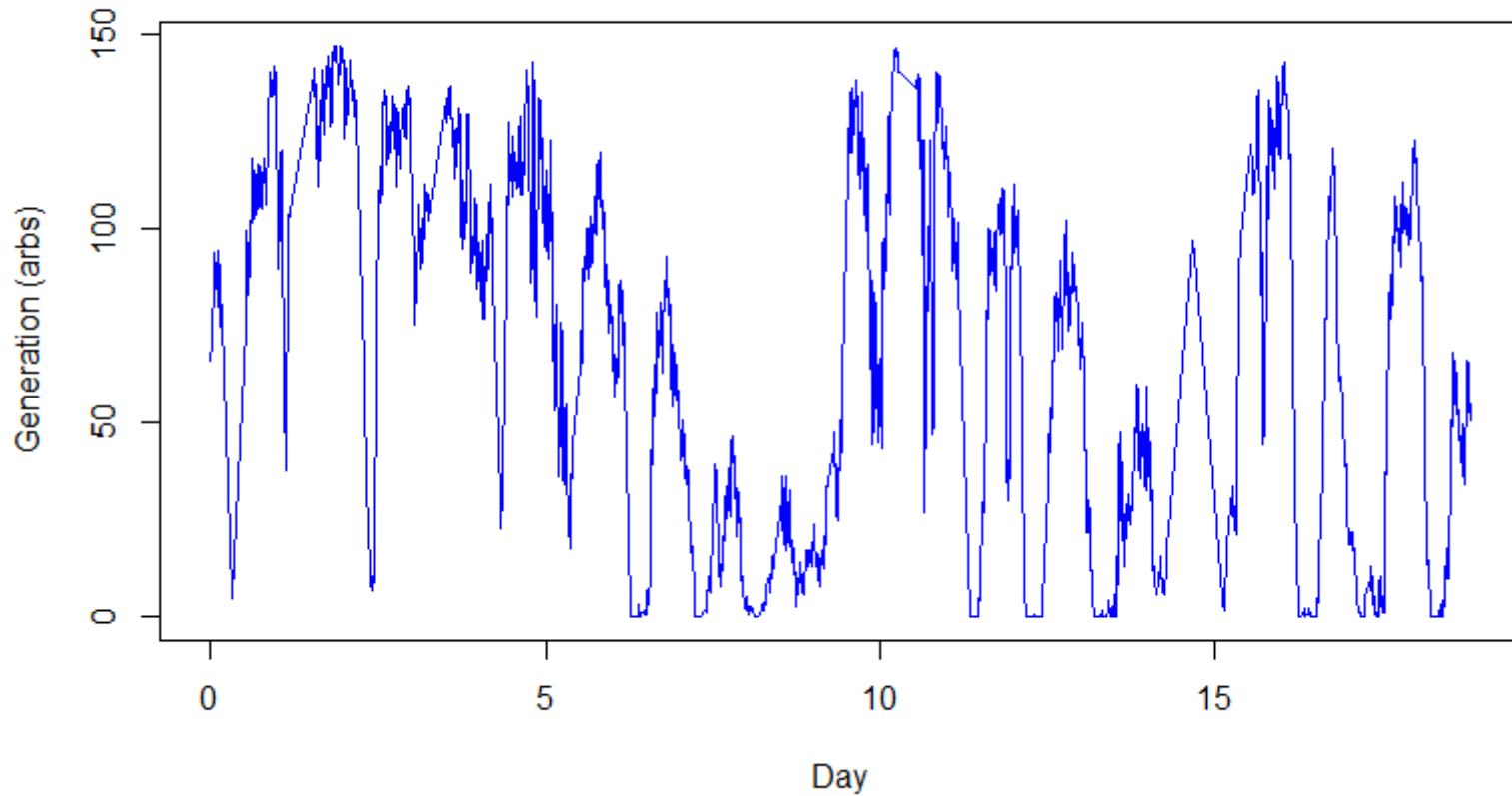
Operational Forecast

Even a simple day-ahead deterministic forecast can help lead to higher revenue from the storage solution



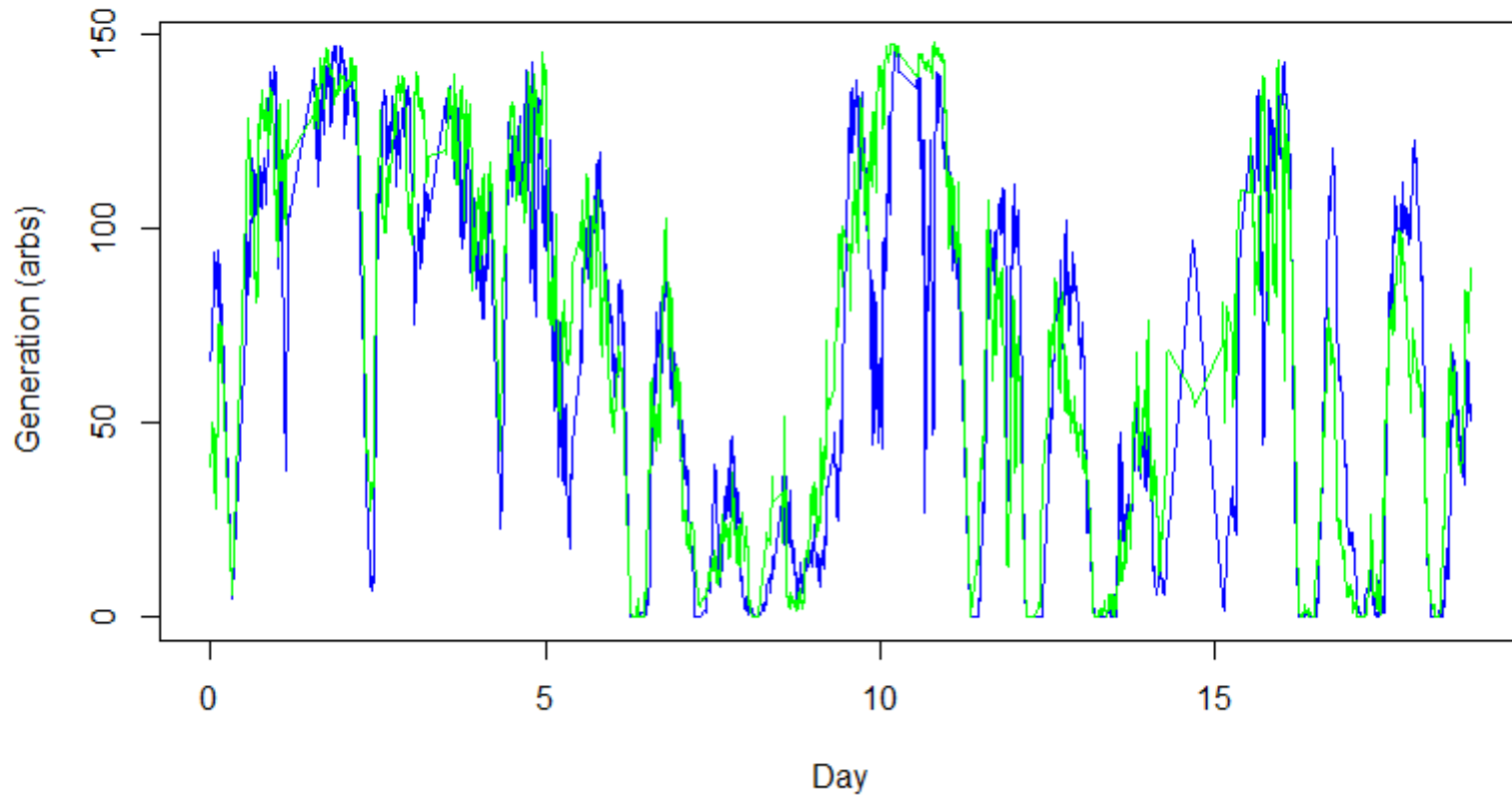
FORECASTING FOR COMBINED PLANTS

Wind Farm 1



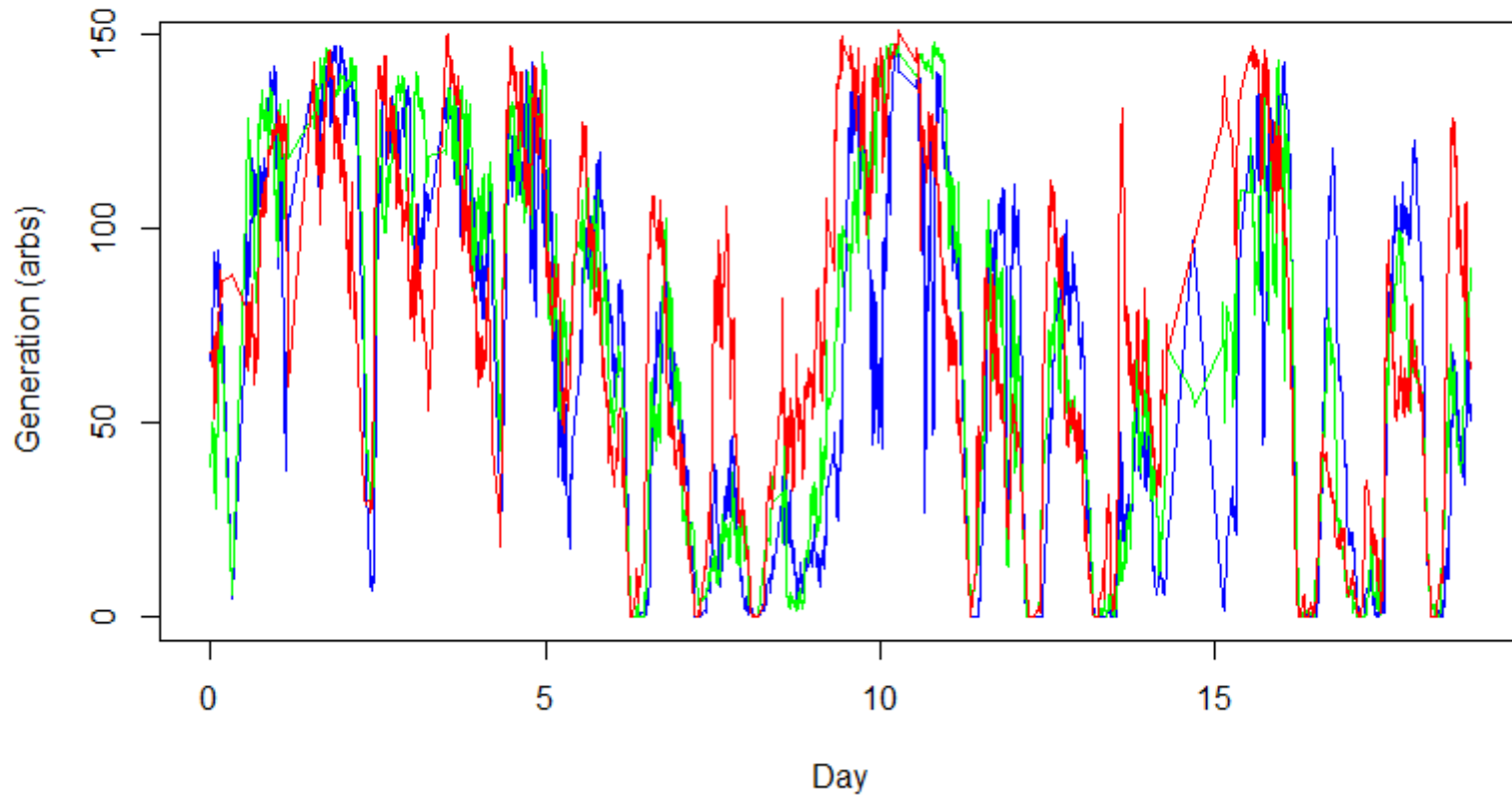
FORECASTING FOR COMBINED PLANTS

Wind Farms 1 and 2



FORECASTING FOR COMBINED PLANTS

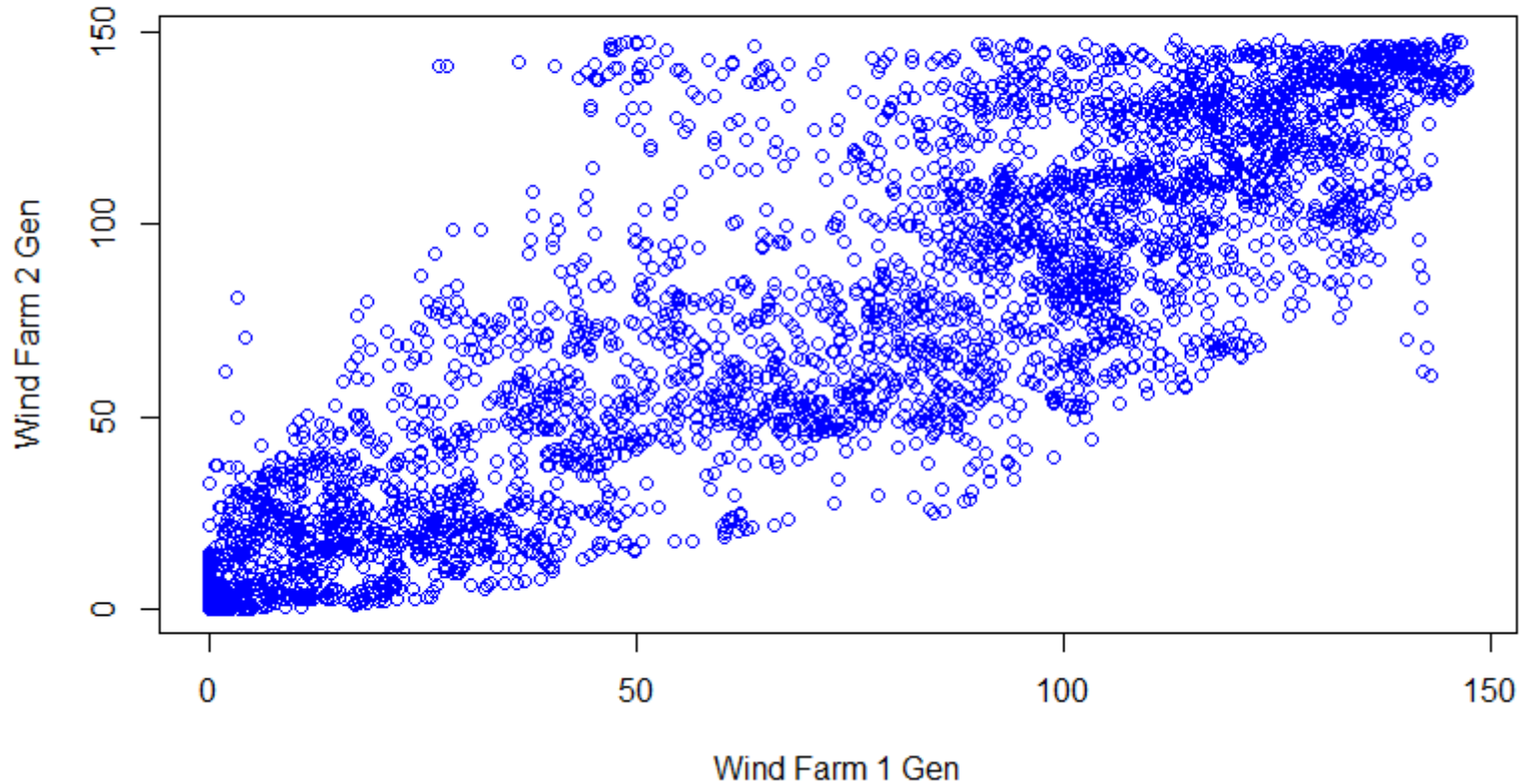
Wind Farms 1, 2 and 3



FORECASTING FOR COMBINED PLANTS

5 Minute Data

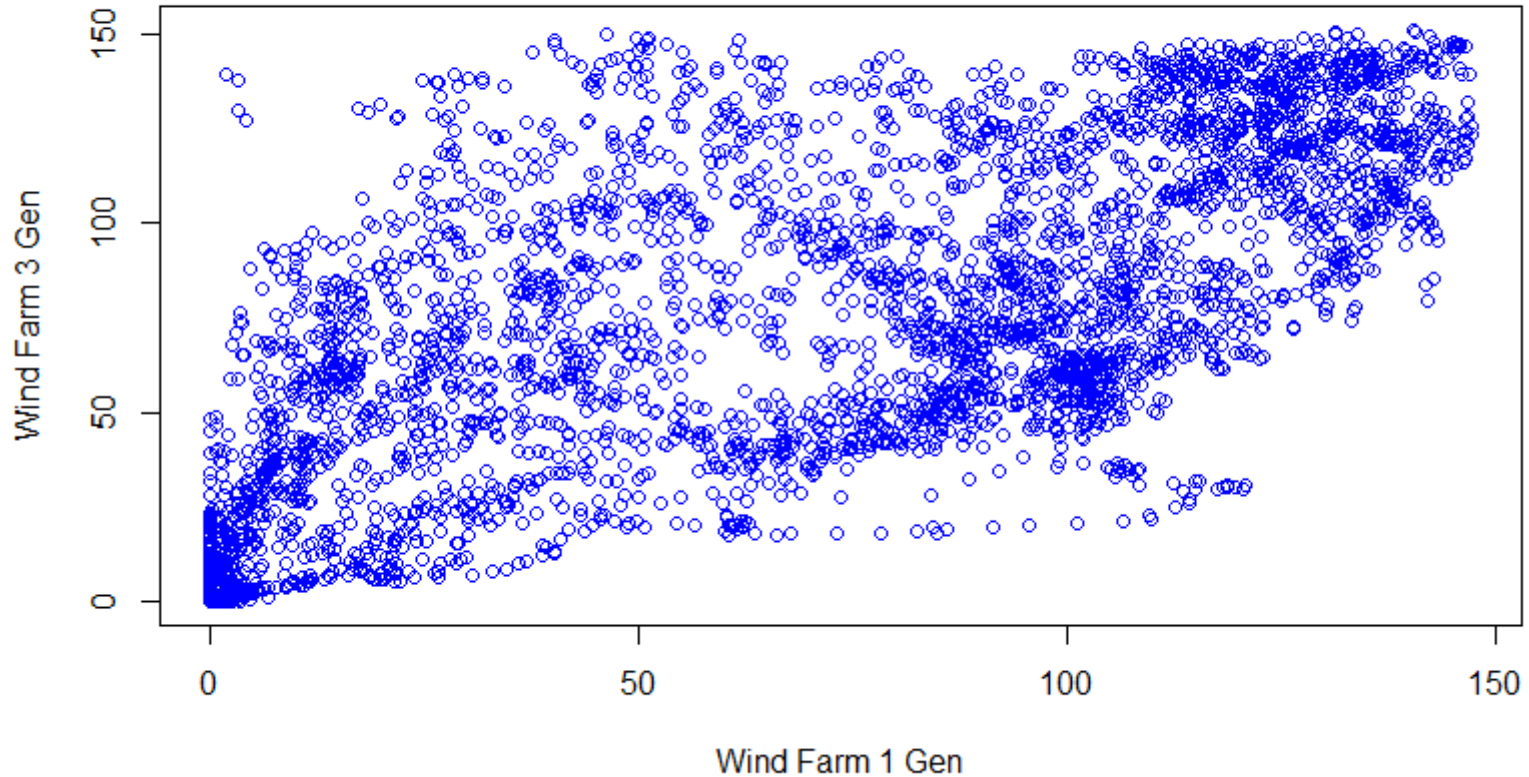
$R = 0.86$



FORECASTING FOR COMBINED PLANTS

5 Minute Data

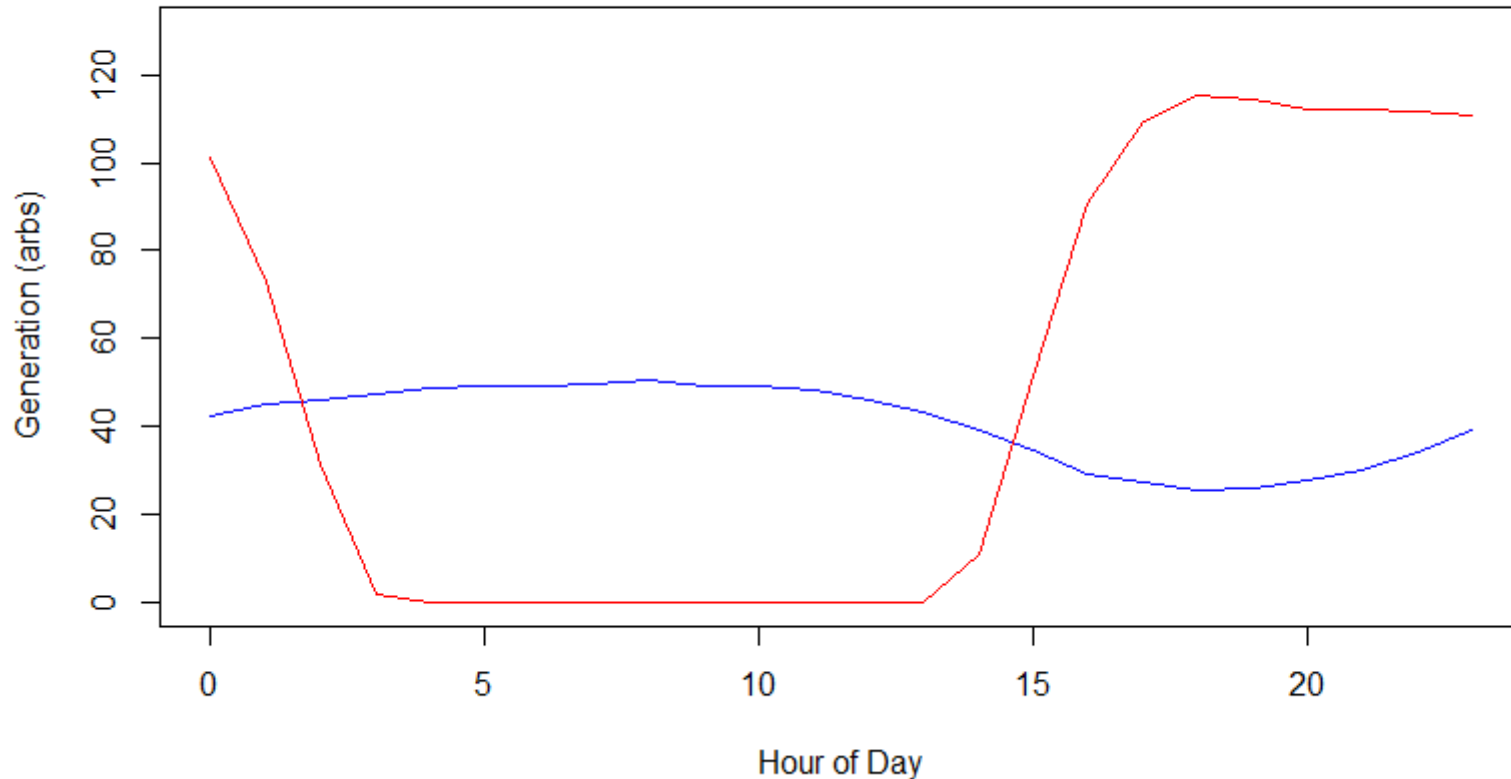
$R = 0.69$



FORECASTING FOR COMBINED PLANTS

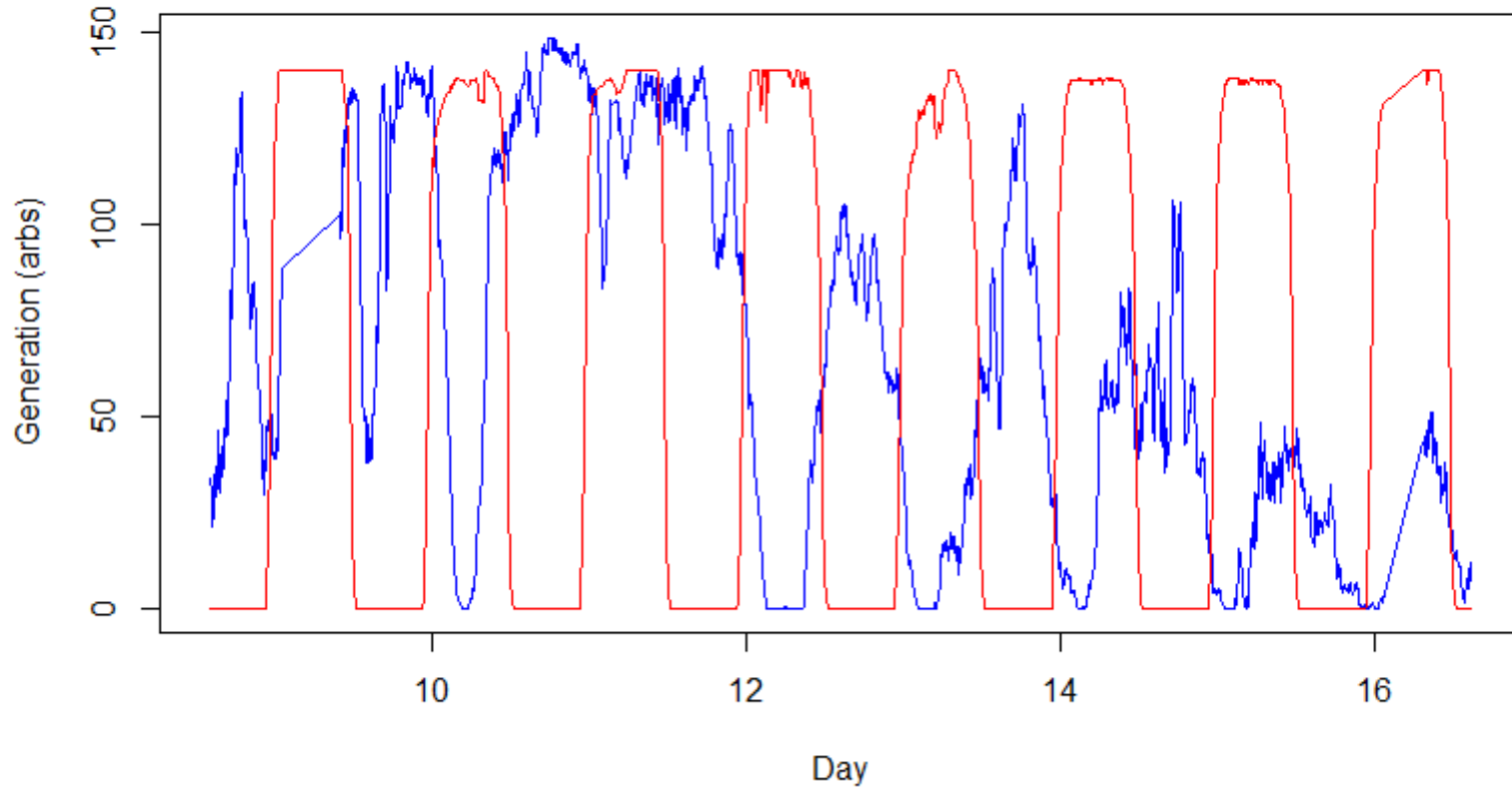
R = -0.86

Diurnal Cycle of Colocated Wind & Solar Generation



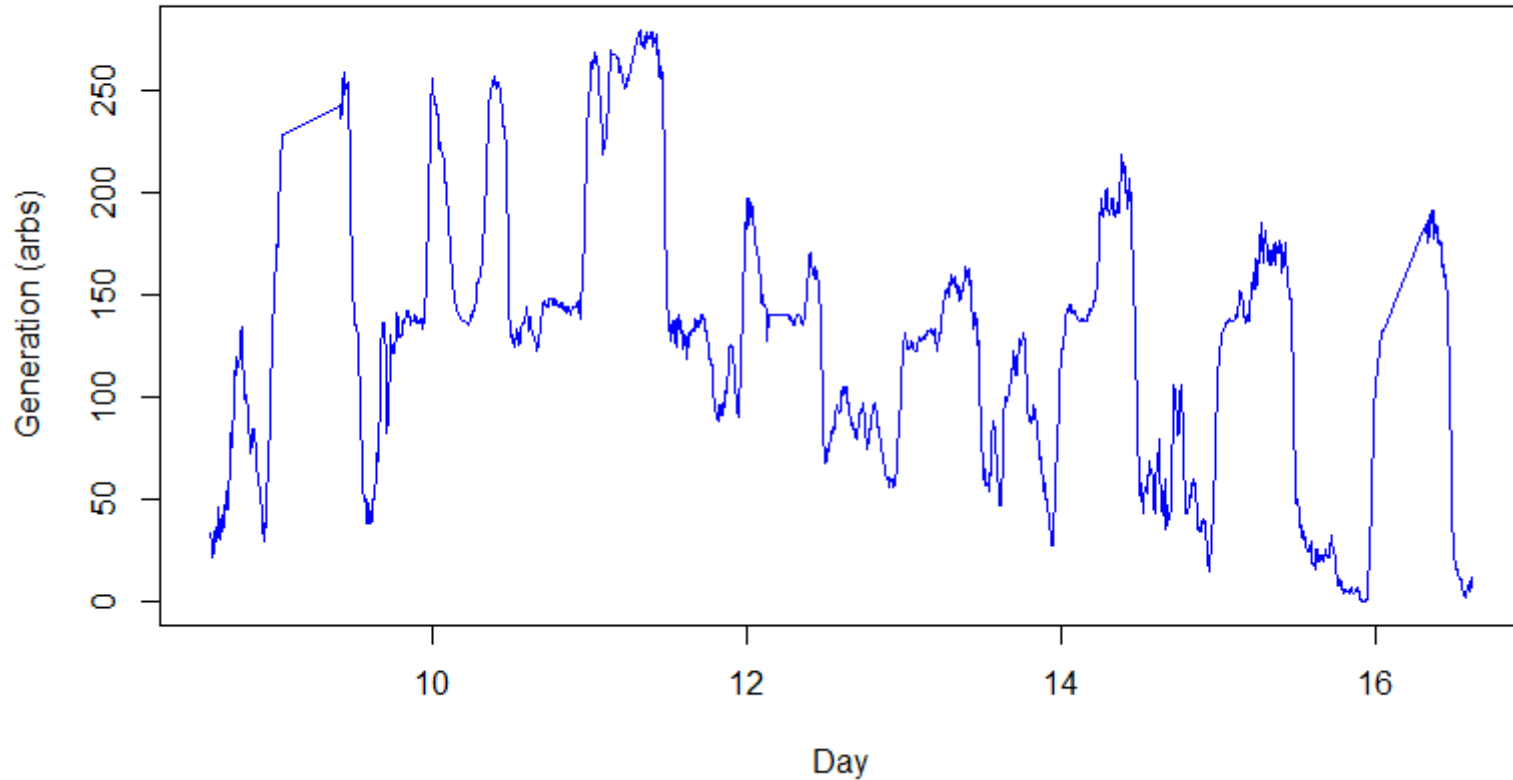
FORECASTING FOR COMBINED PLANTS

Wind (blue) and Solar (red) Generation $R = -0.41$



FORECASTING FOR COMBINED PLANTS

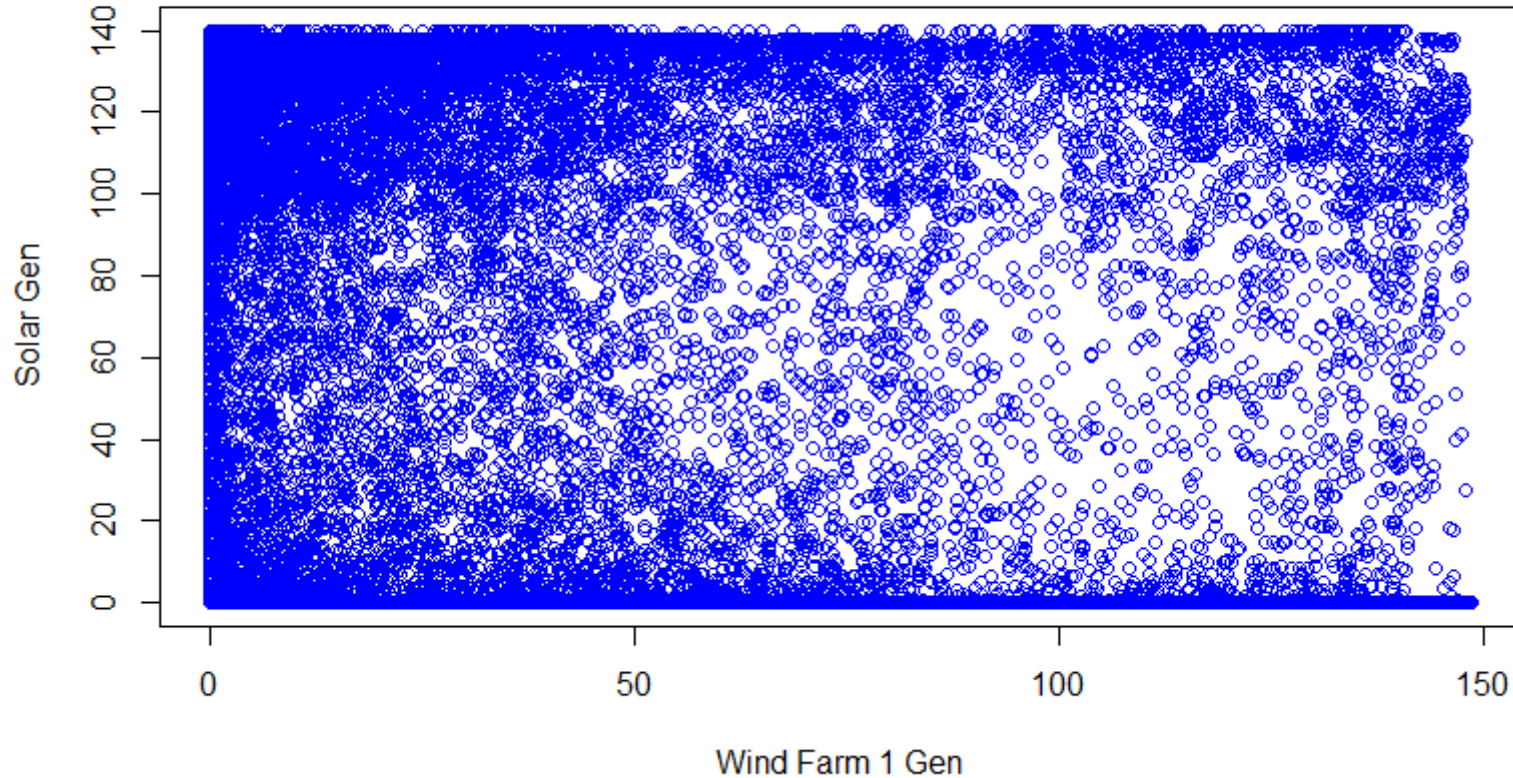
Sum of Wind and Solar Generation



FORECASTING FOR COMBINED PLANTS

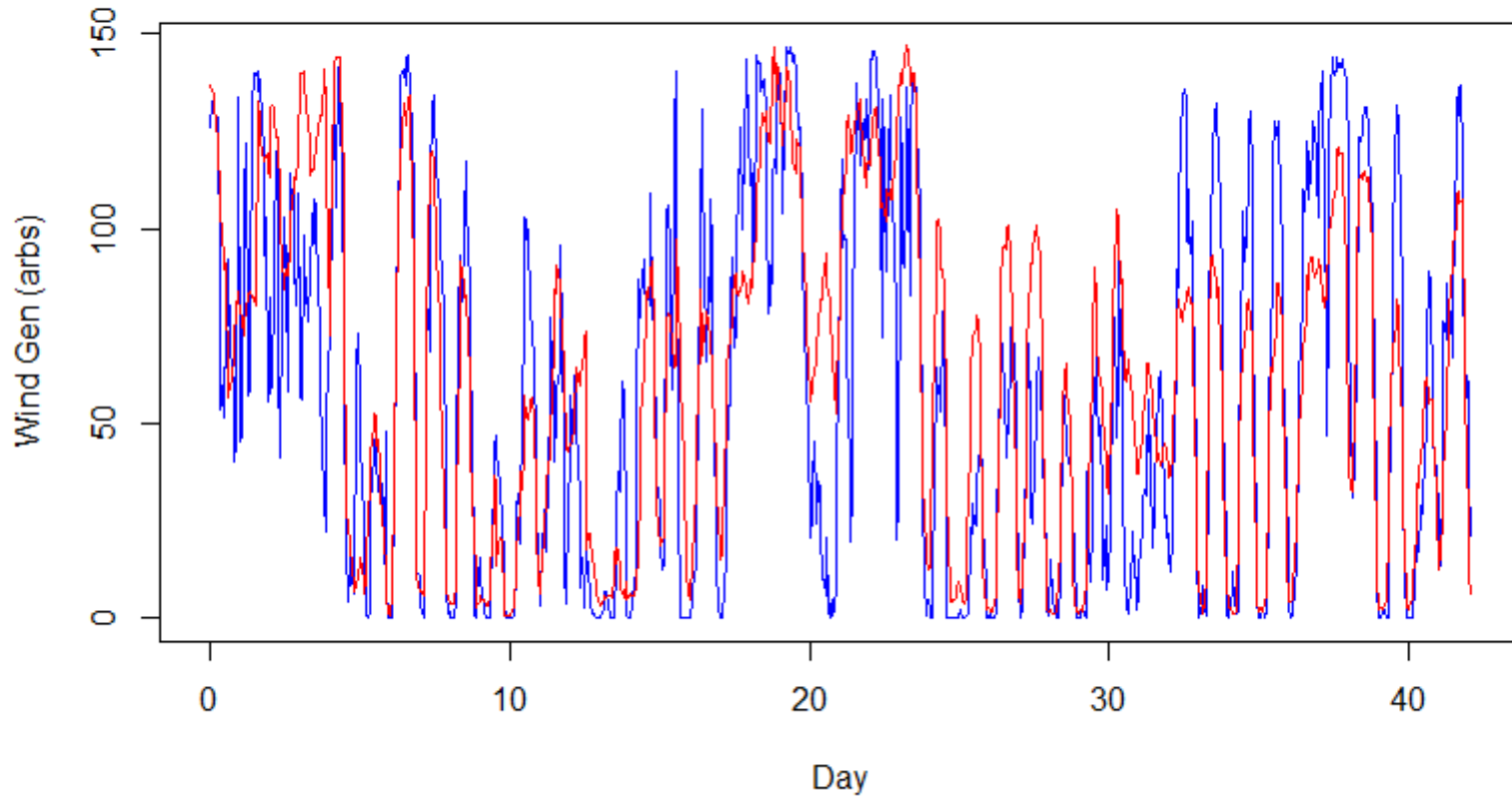
Wind vs Solar Generation

$R=-0.14$



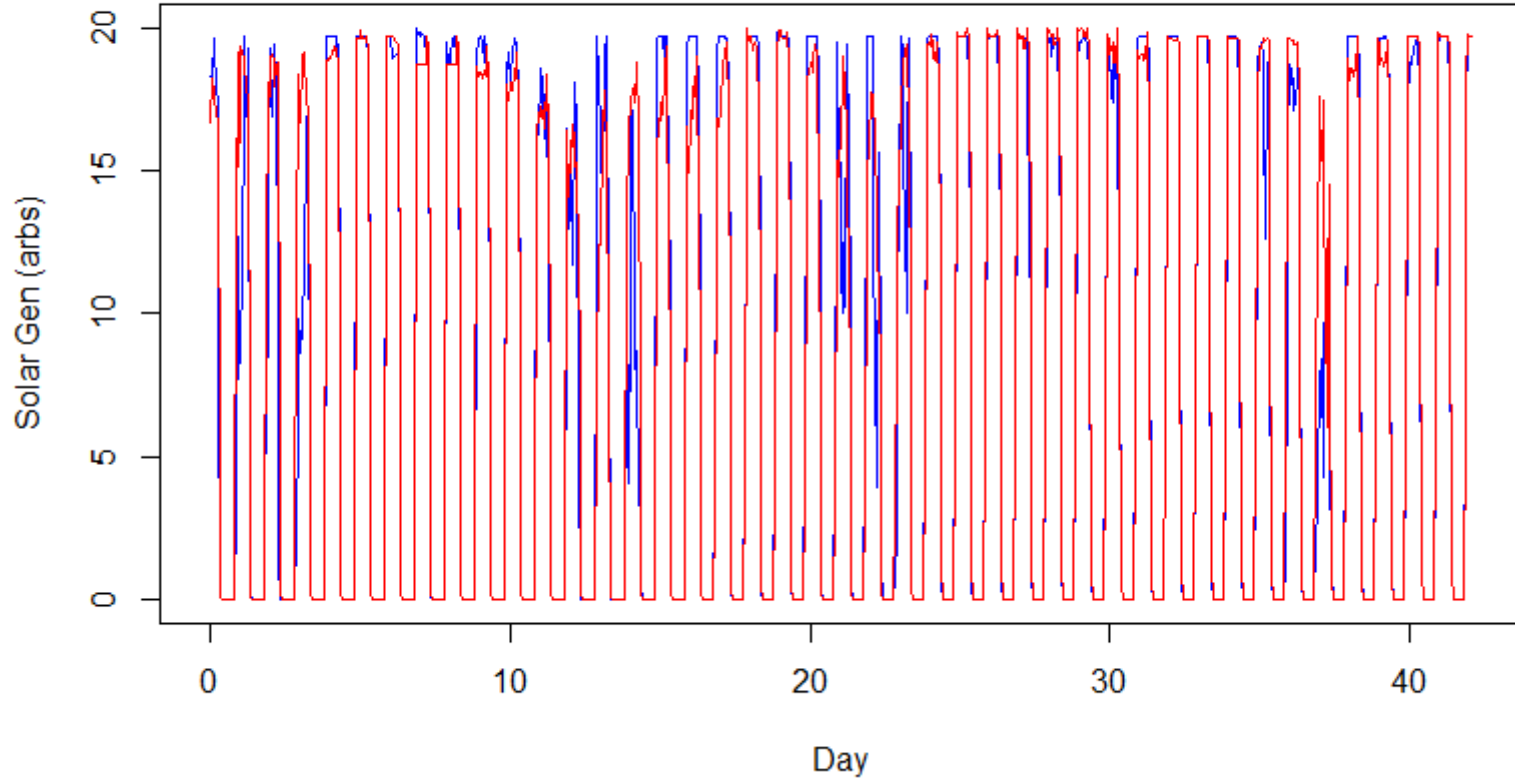
FORECASTING FOR COMBINED PLANTS

Wind Fcst Vs Truth



FORECASTING FOR COMBINED PLANTS

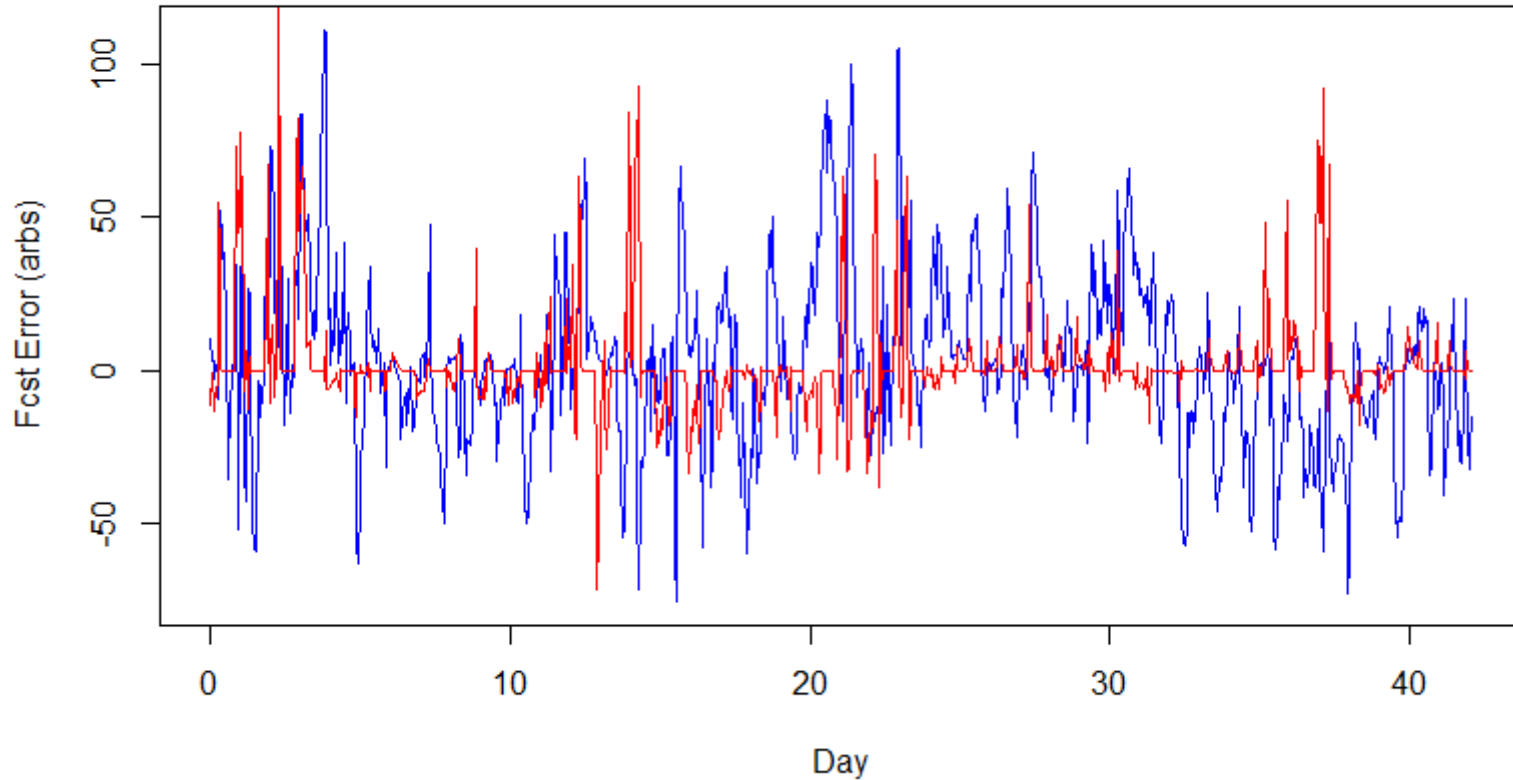
Solar Fcst Vs Truth



FORECASTING FOR COMBINED PLANTS

Wind Error (blue) Vs Solar Error (red)

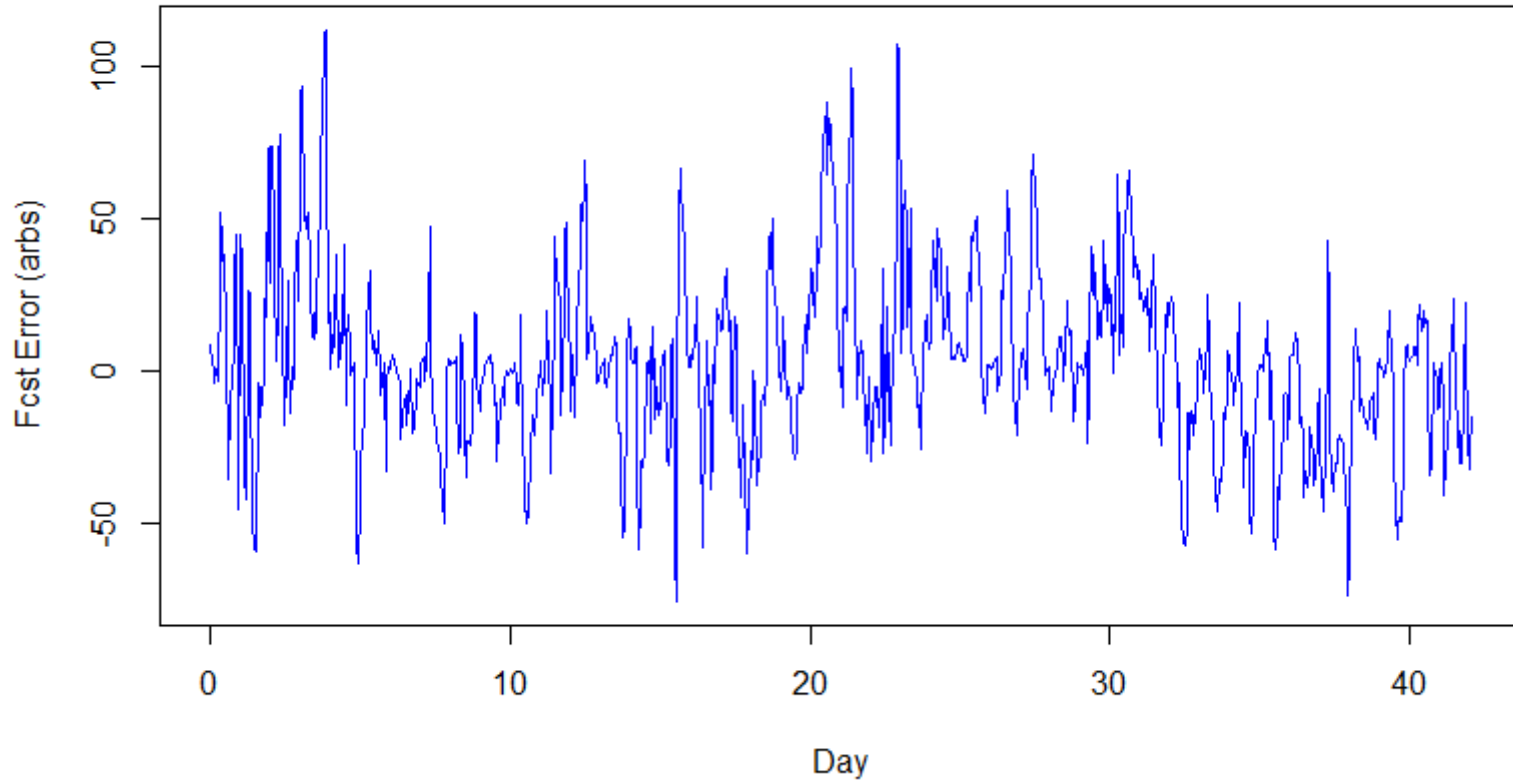
$R = 0.03$



FORECASTING FOR COMBINED PLANTS

Wind + Solar Error

MAE of Sum= 22;
Sum of MAE's = 24



Questions?



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