Power Quality

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Outline

- ✓ Power ramps
- ✓ Reactive power
- ✓ Optimization power quality
- ✓ Conclusion

Power Ramps

- ✓ Variable winds
- ✓ Different horizons wind farm power – time function, e.g.:
  - weeks
  - days
  - hours (of interest at present time)
  - minutes

Definition

- ✓ *PRR* (Power ramp rate): measure of the degree of the power change during a certain time interval

$$PRR = \frac{P(t+T)-P(t)}{T} \quad \text{[kW/min]}$$

$$PRR = \frac{P(t+T)-P(t)}{T \times NPP} \times 100\% \quad \text{[\%/min]}$$

- ✓ t is the current time
- ✓ T is the time interval of the power change
- ✓ NPP (nameplate power) is the power of the wind farm

Data Description

- ✓ 133.5 MW rated power wind farm
- ✓ SCADA collected data is stored at 10-minute intervals (10-minute average data)
- ✓ Model built of 3568 data points
- ✓ Tested on 887 data points

Data Description

Data set	Start Time Stamp	End Time Stamp	Description
1	1/1/06 1:40 AM	1/31/06 11:50 PM	Total data set; 4455 observations
2	1/1/06 1:40 AM	1/25/06 8:00 PM	Training data set; 3568 observations
3	1/25/06 8:10 PM	1/31/06 11:50 PM	Test data set; 887 observations

T + 10 Min Power Prediction (10-min Ahead Predictions)

Metrics Used in PRR Prediction

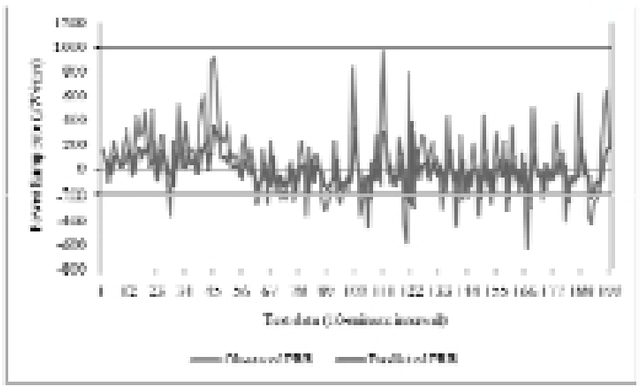
- AE: Absolute error

$$AE = |y - \hat{y}|$$

- y is the observed PRR, $\hat{y}$ is the predicted PRR

Units: kW/min or %/min

T + 10 min PRR Prediction (10-min Ahead Predictions)



The unit of PRR is kW/min (135.5 MW rated power)

Statistics for PRR of Top 15% of Wind Farm Capacity

AE	kW/min	%/min
Mean	191.701	0.1435957
Std	183.894	0.1377486
Max	1091.341	0.8174832
Min	0.016	0

AE = Absolute Error (135.5MW rated power)

Statistics for PRR of Mid-range 20% of Wind Farm Power

AE	kW/min	%/min
Mean	467.627	0.351
Std	481.195	0.361
Max	3556.387	2.664
Min	8.131	0.006

AE = Absolute Error (135.5 MW rated power)

Summary

- ✓The results presented were prepared in a short time for illustrative purposes
- ✓ The results presented can be greatly improved
- ✓ Confidence index is possible to develop