

Storage Options Analysis for Kodiak Electric Association



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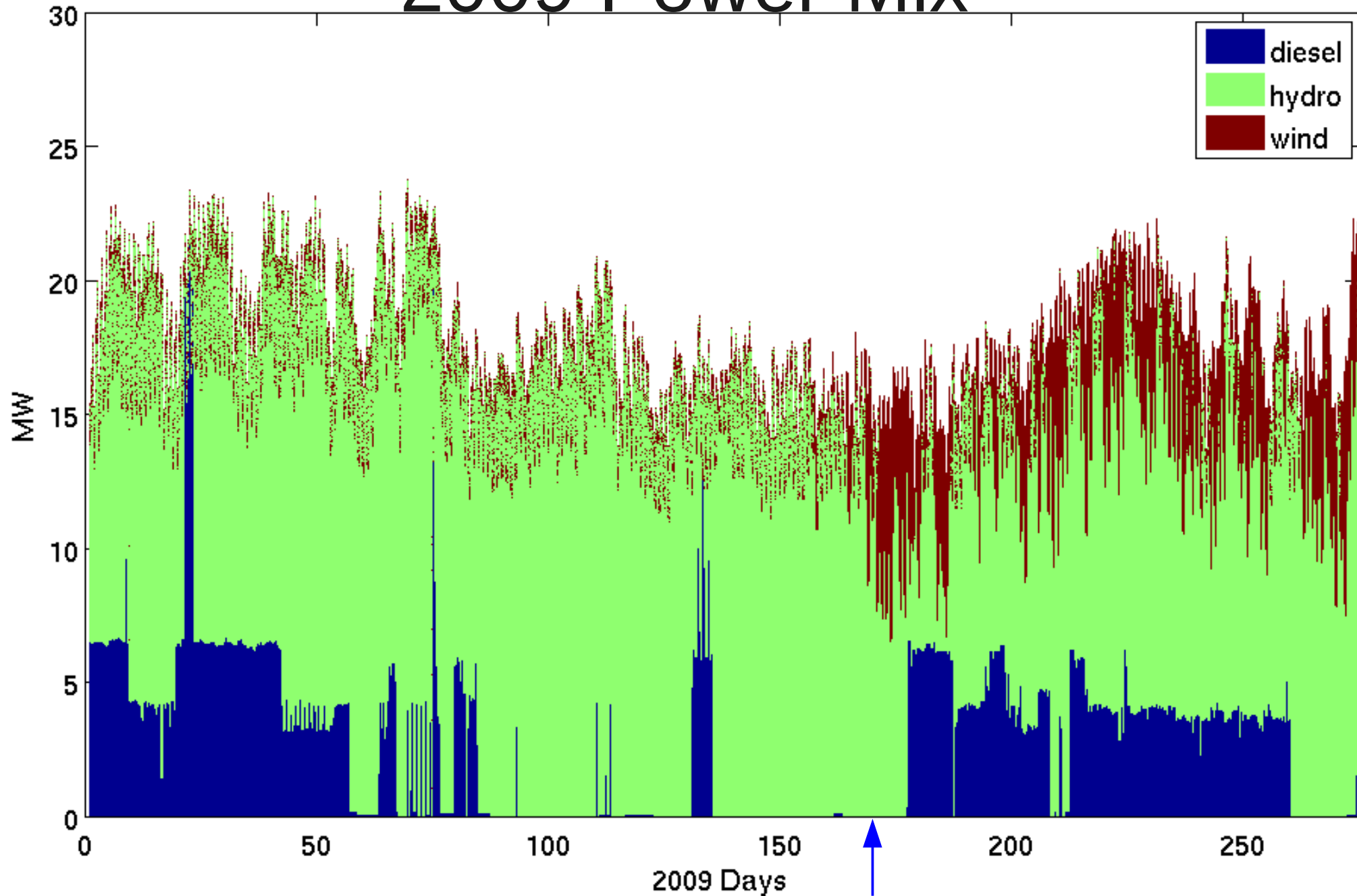
ACEP
Alaska Center for Energy and Power



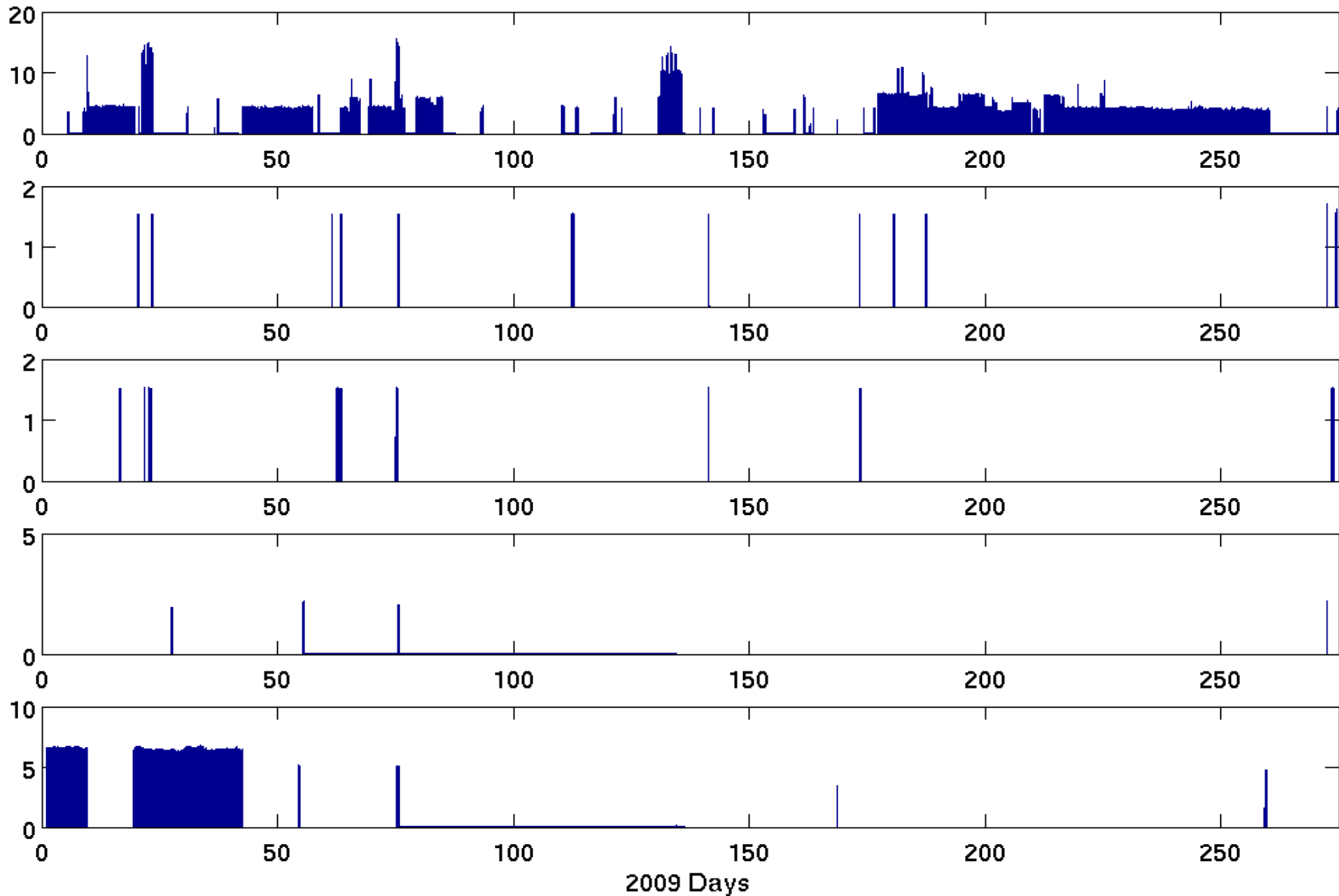
Project Overview

- KEA is an isolated grid (~20 MW)
 - Previously: ~80% hydro, ~20% diesel
- KEA installed 3 1.5-MW GE sle turbines in July 2009
 - Currently: ~80% hydro, ~10% wind ~10% diesel
- Next goal
 - *“Produce 95% of energy sales with cost effective renewable power solutions by the year 2020.”**
- Options
 - Add 3 more 1.5-MW turbines (already surveyed)
 - Add 1 more hydro turbine (2 x 12-MW now)

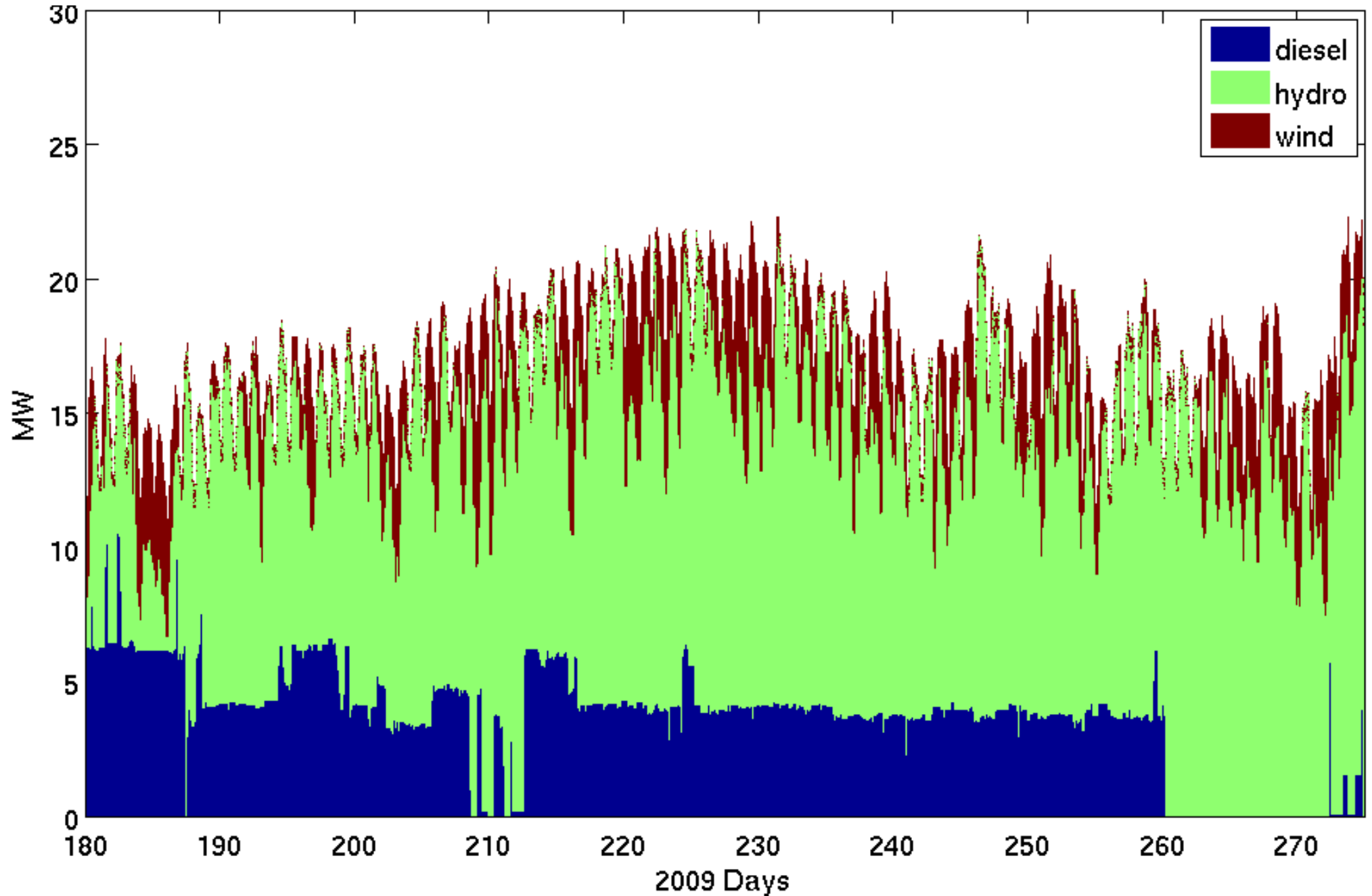
2009 Power Mix



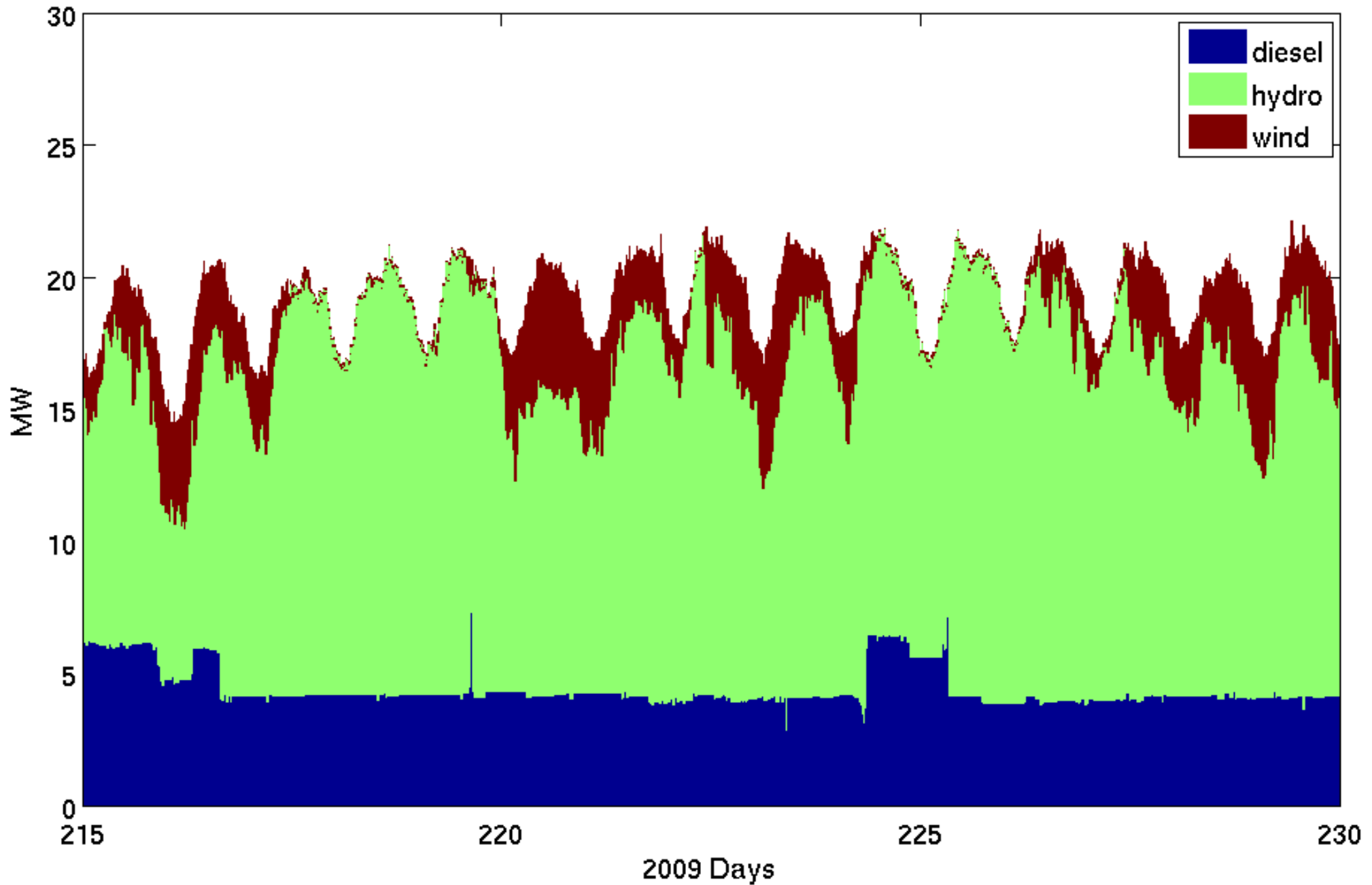
Distributed Diesel Generation



2009 Power Mix (after July 5)

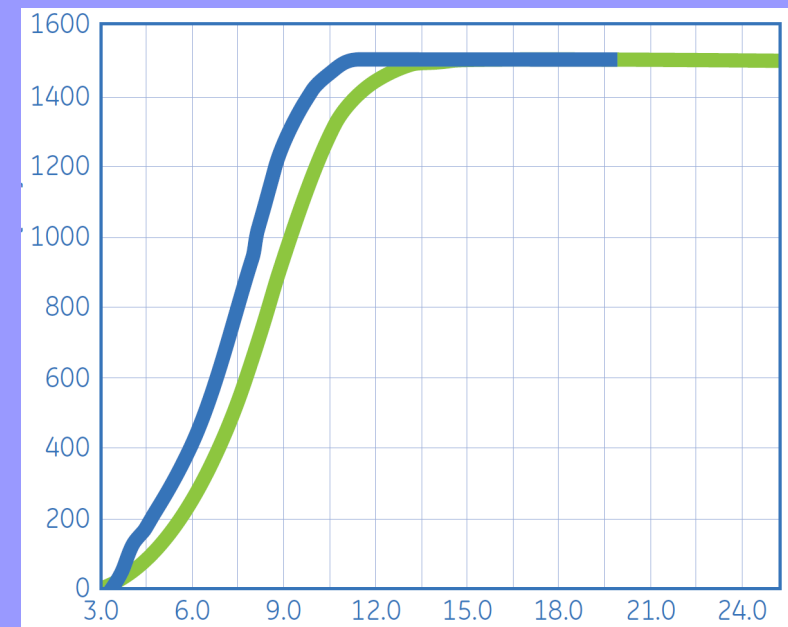


2009 Power Mix (Daily Trends)

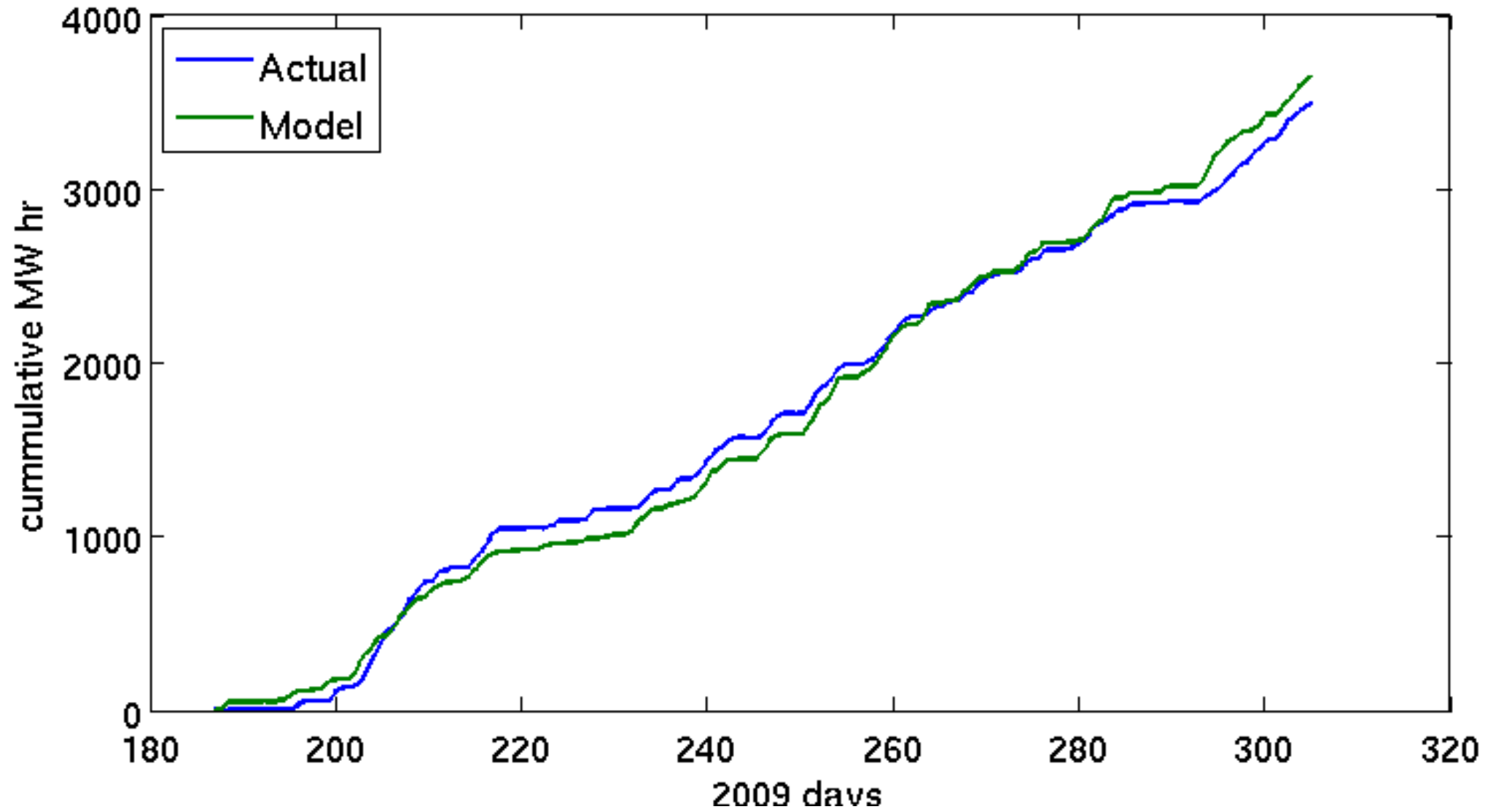


Potential Wind Energy Forecast

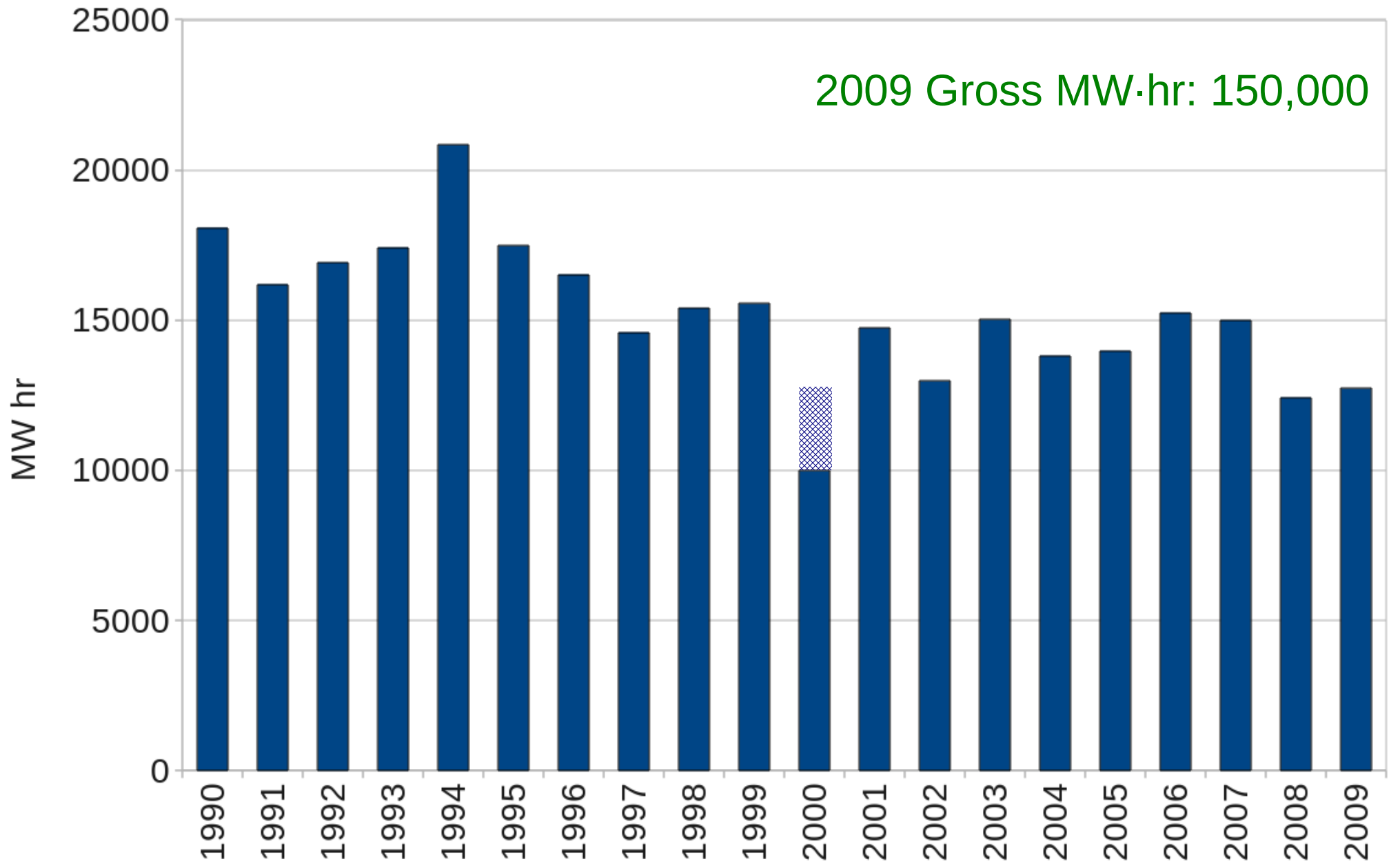
- How would 3 additional turbines affect the mix?
- Use ~hourly wind reported at airport (PADQ)
 - wunderground.com
- Adjust for elevation, hub height, and sub-hourly fluctuations (~70%)
- Use data (July-Nov. 2009) of 15-minute wind power for corroboration.



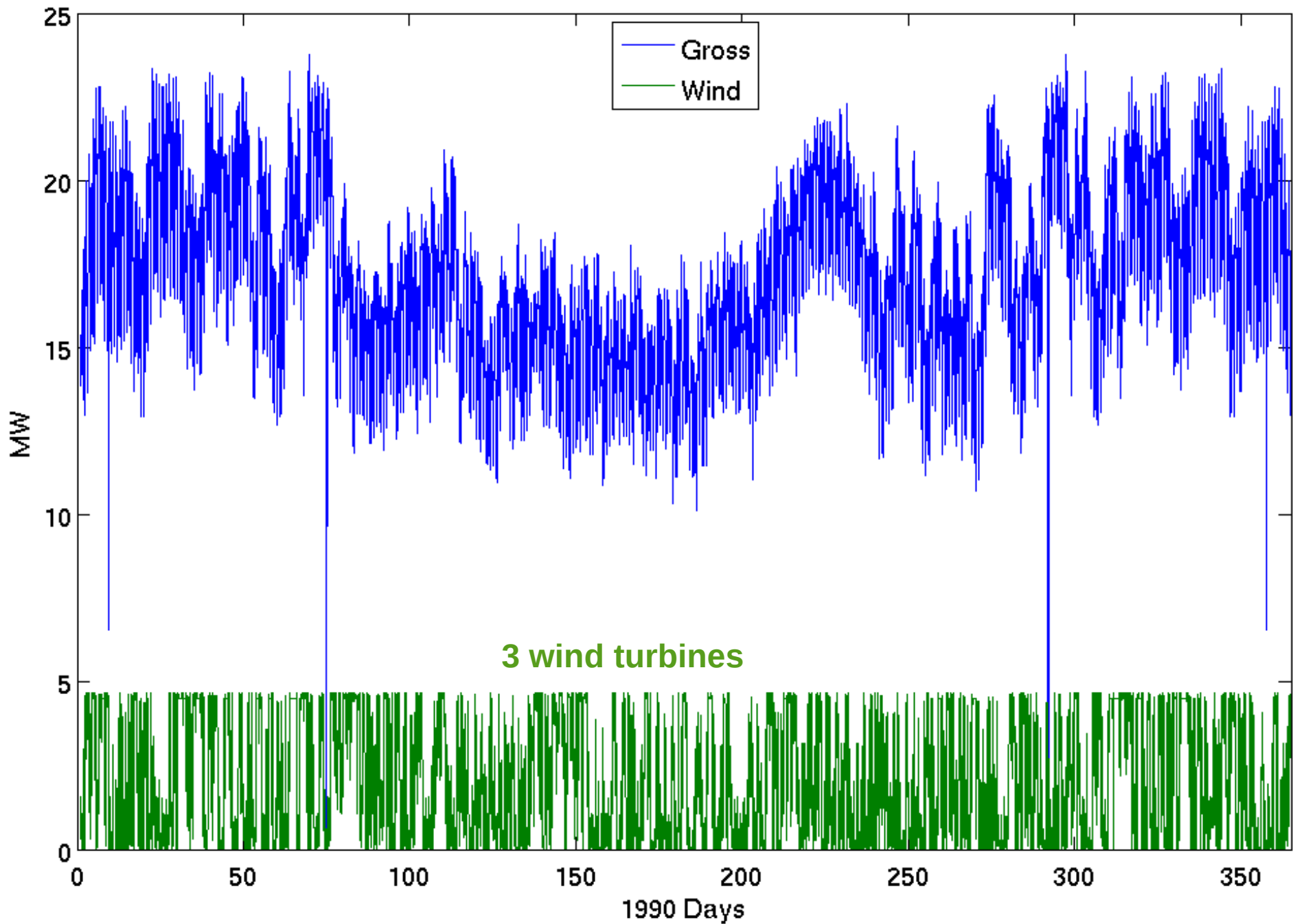
Net Wind Energy 2009



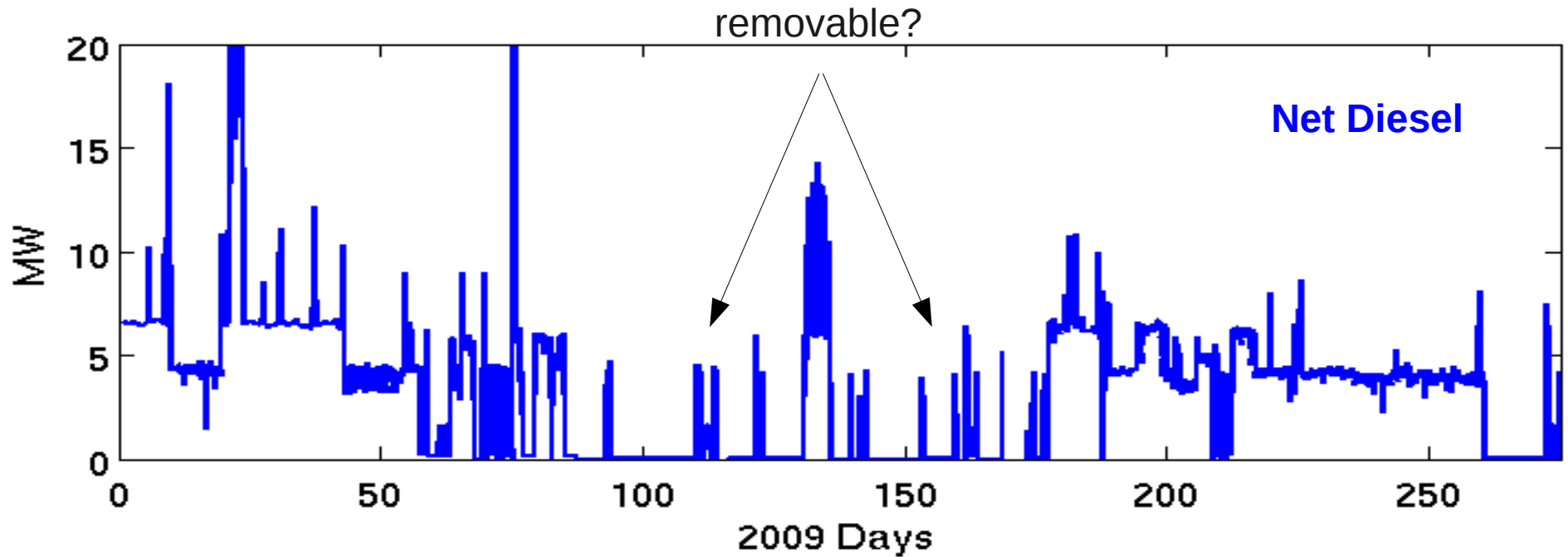
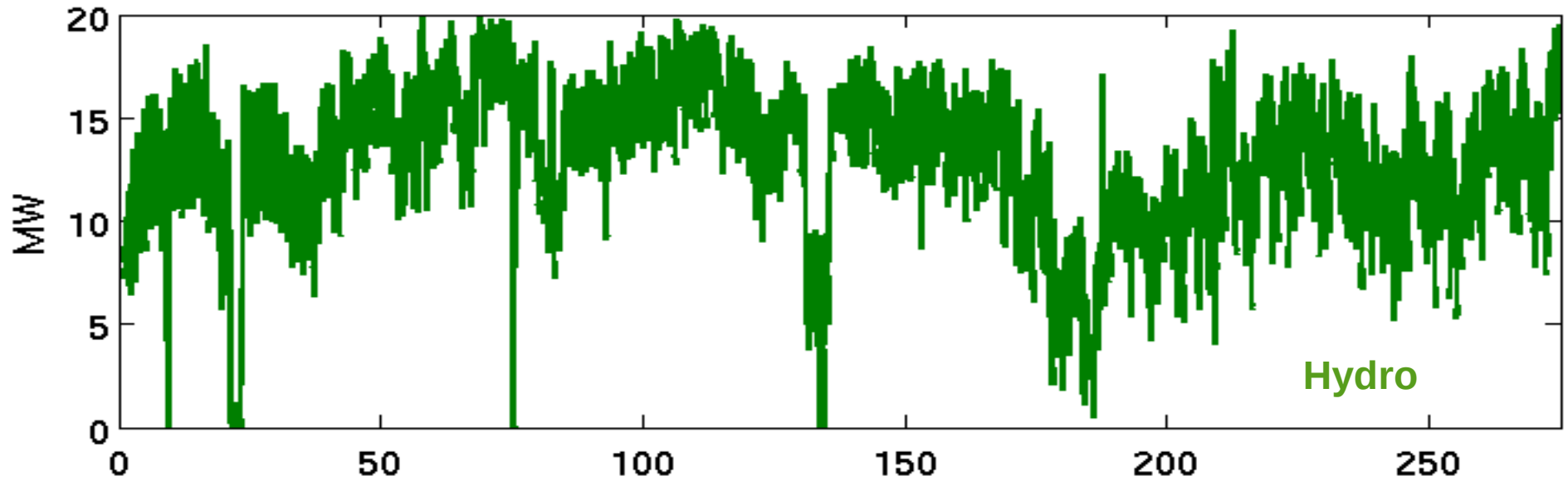
20 Years of Prediction



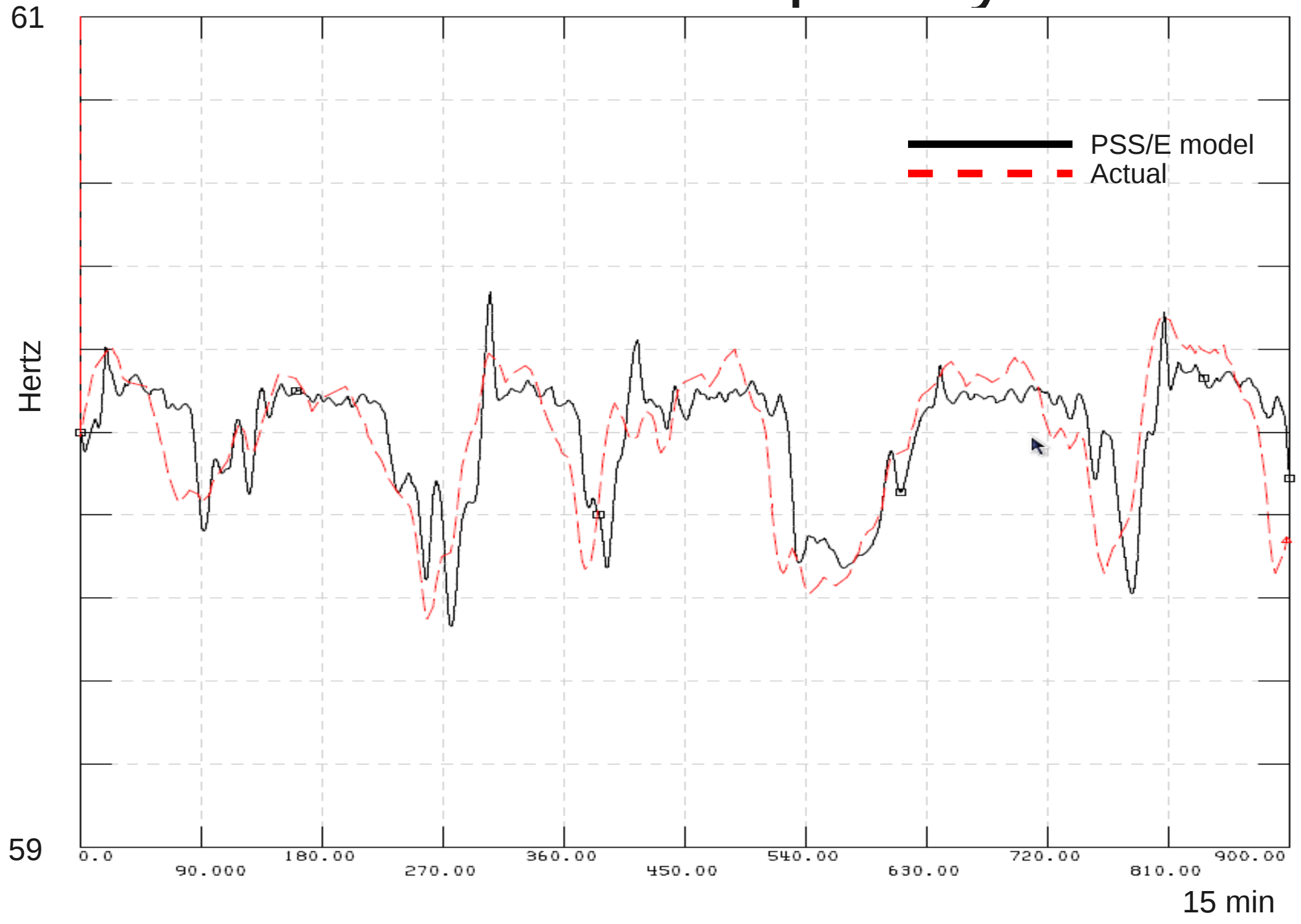
Net Power & Wind Potential



Hydro and Diesel in 2009

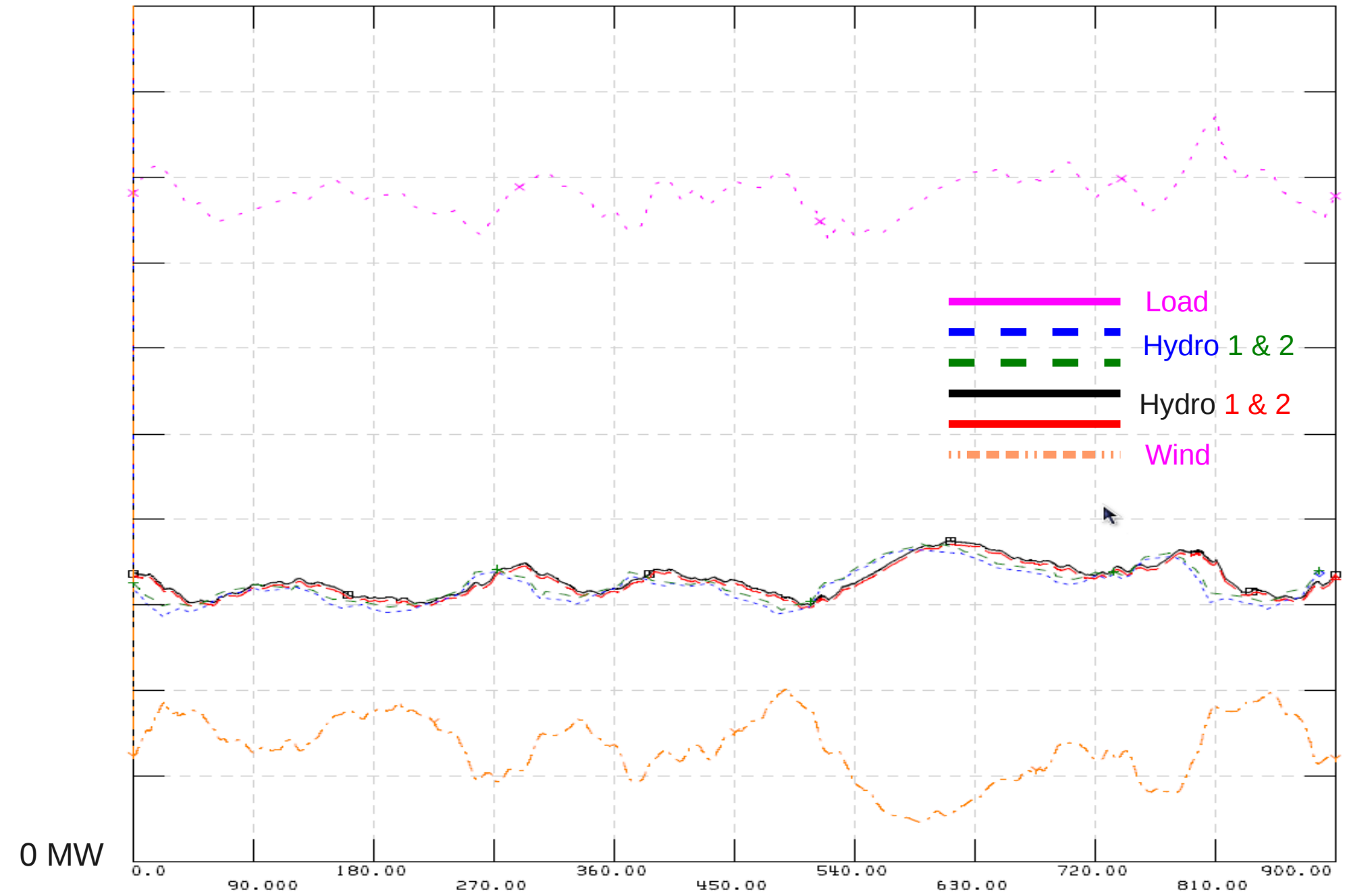


Baseline Frequency

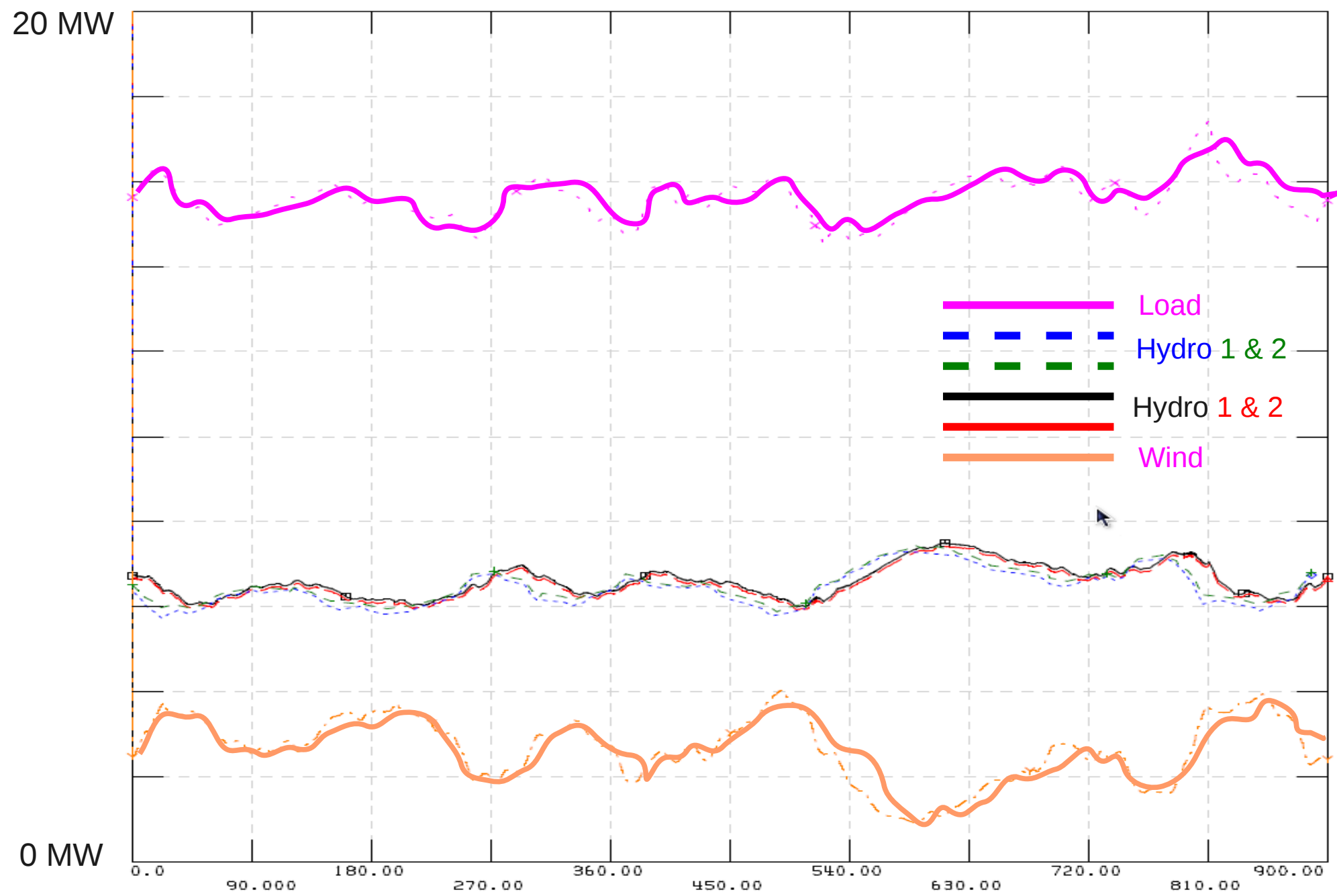


15 min

Baseline Power



Baseline Power

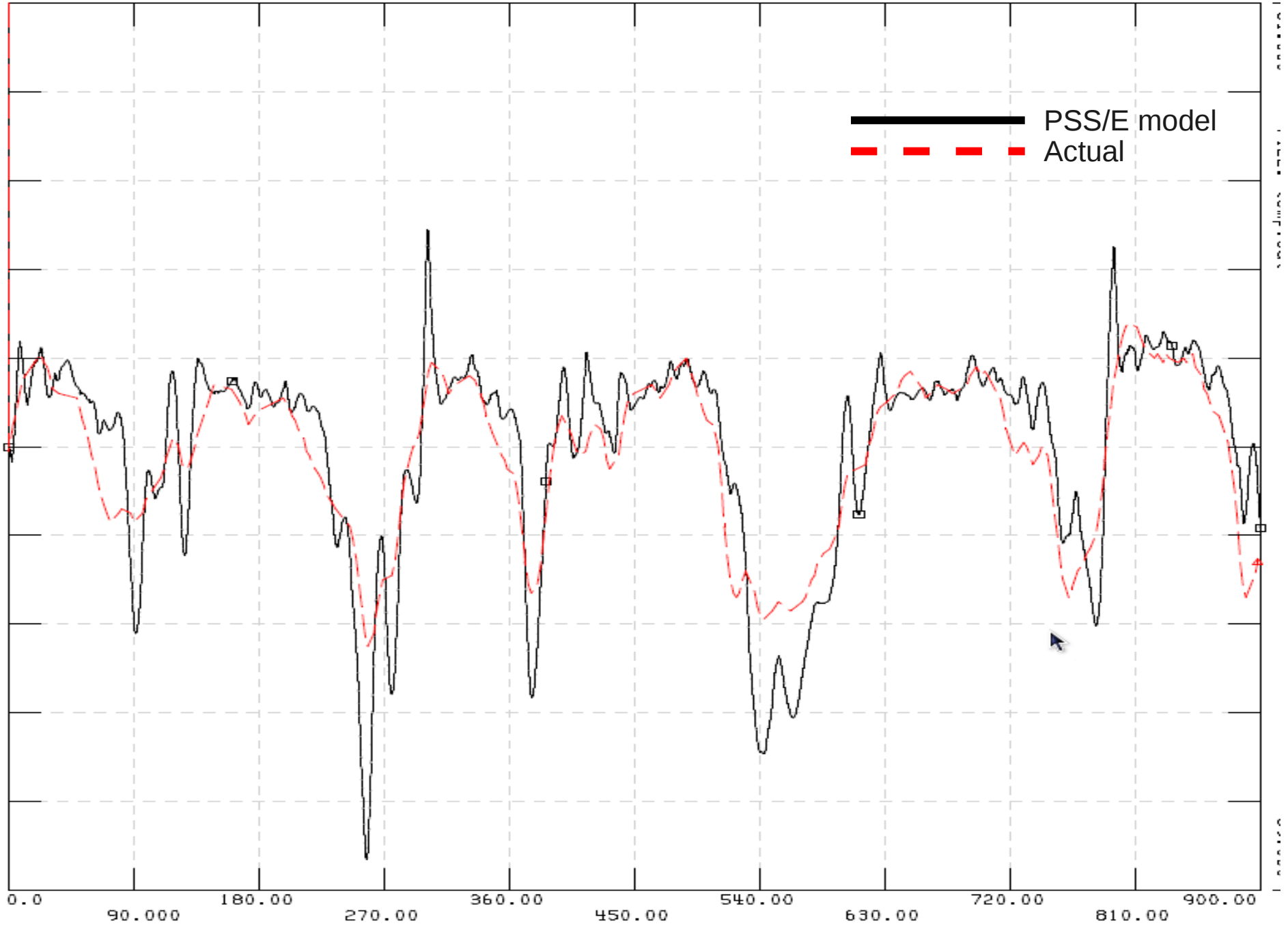


Wind (6) Hydro (3) Frequency

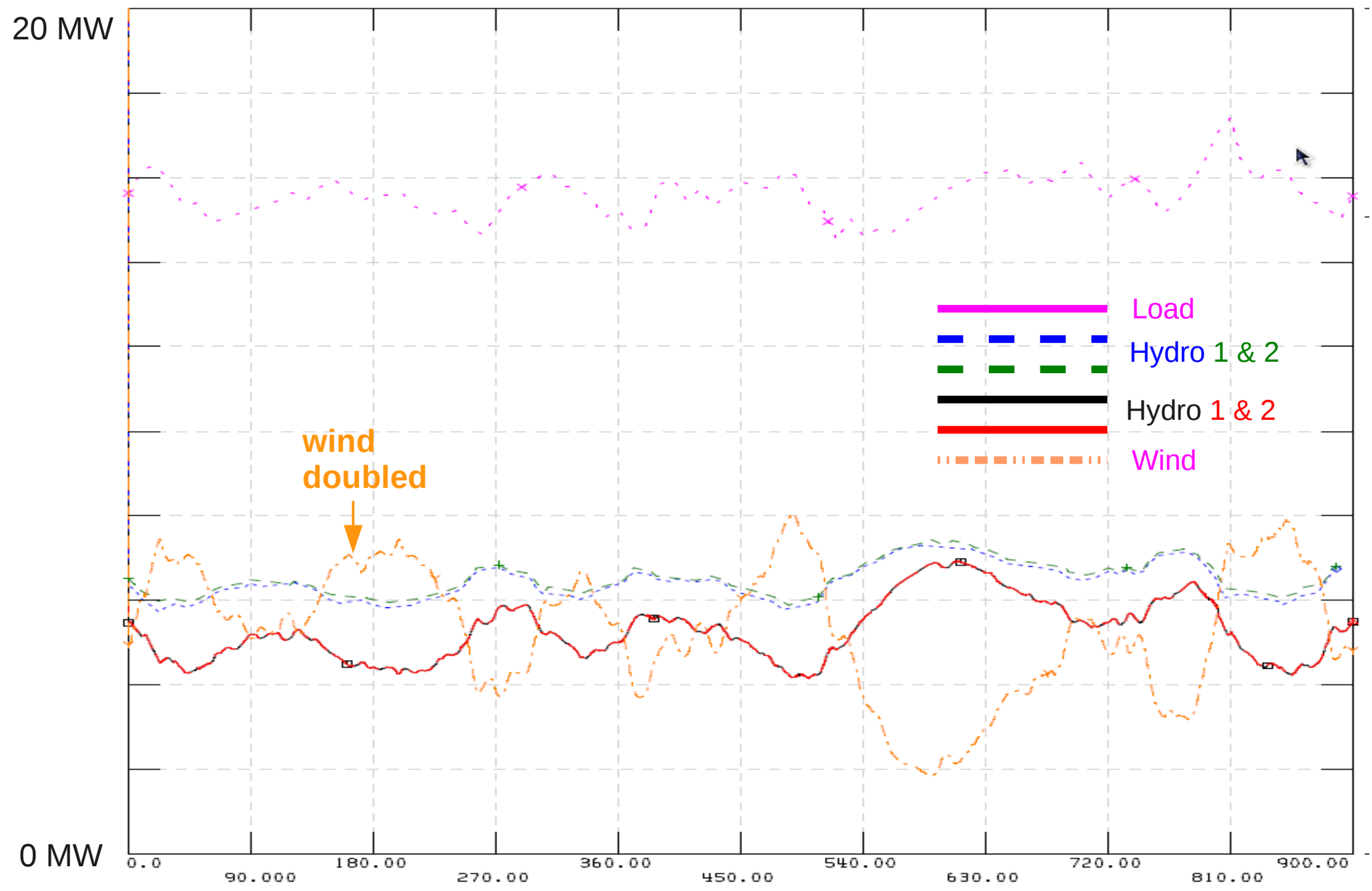
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Hertz

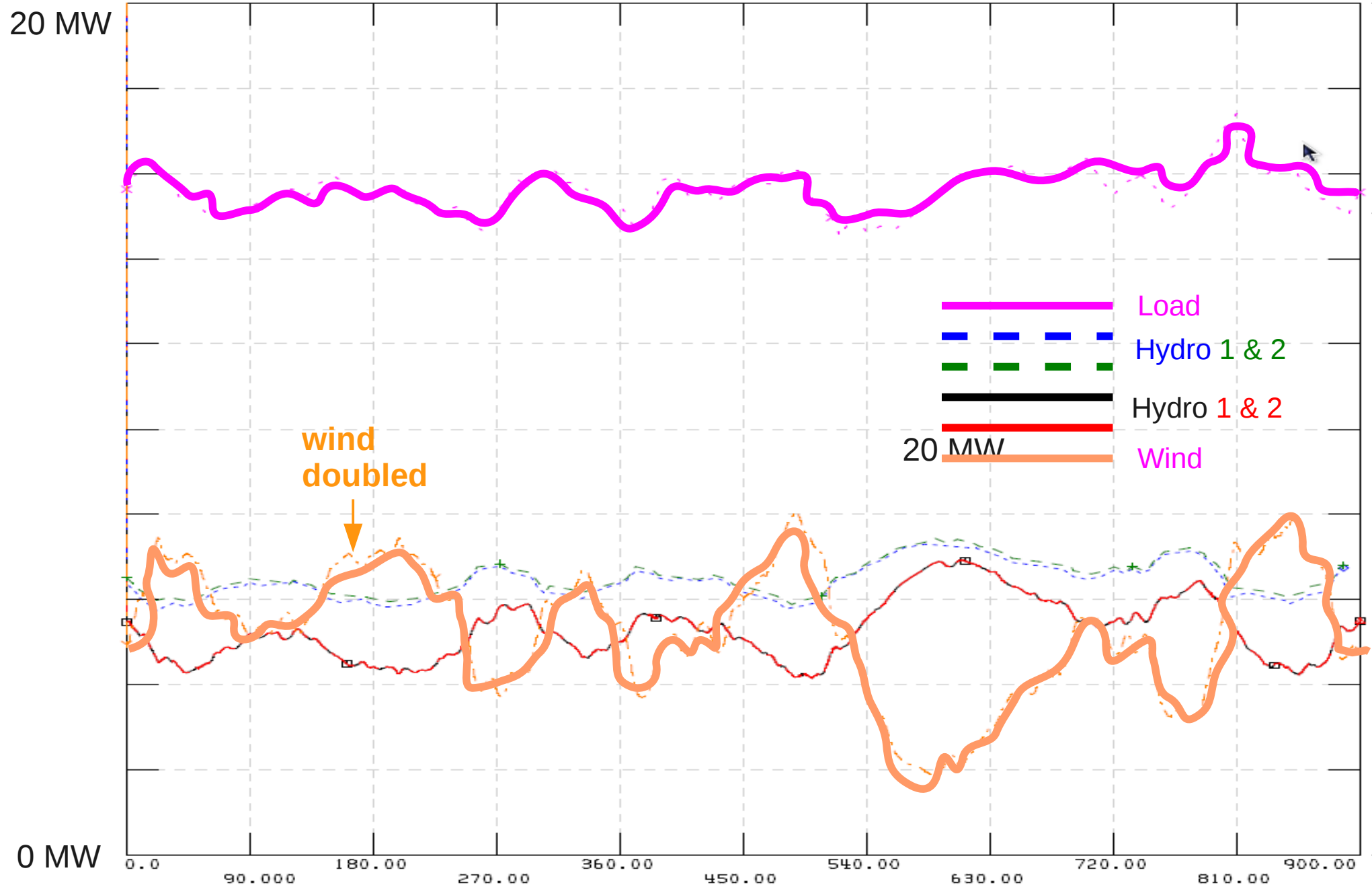
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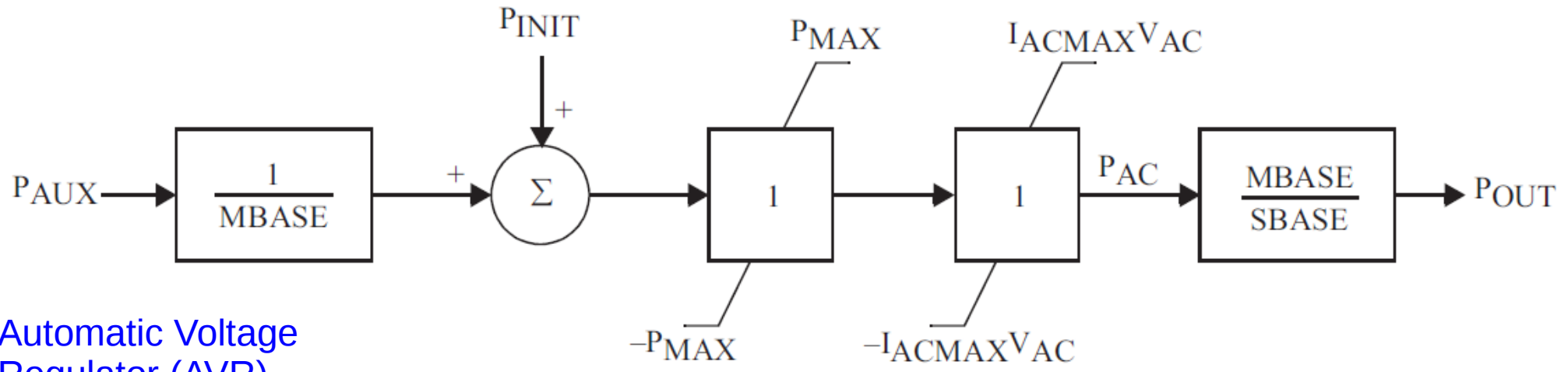
Wind (6) Hydro (3) Power



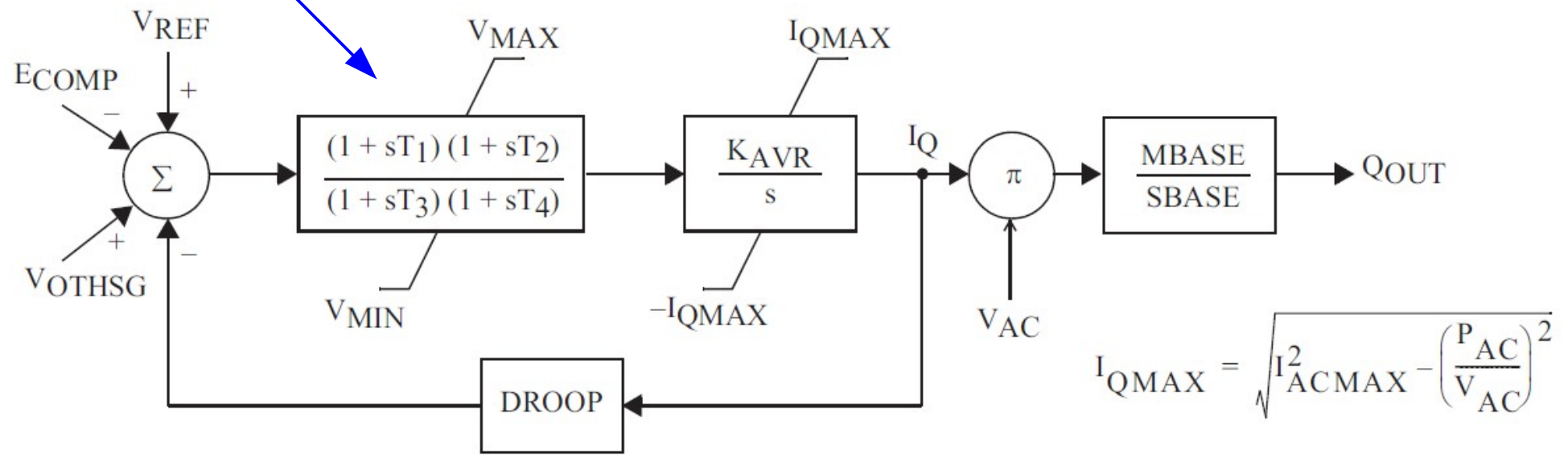
Wind (6) Hydro (3) Power



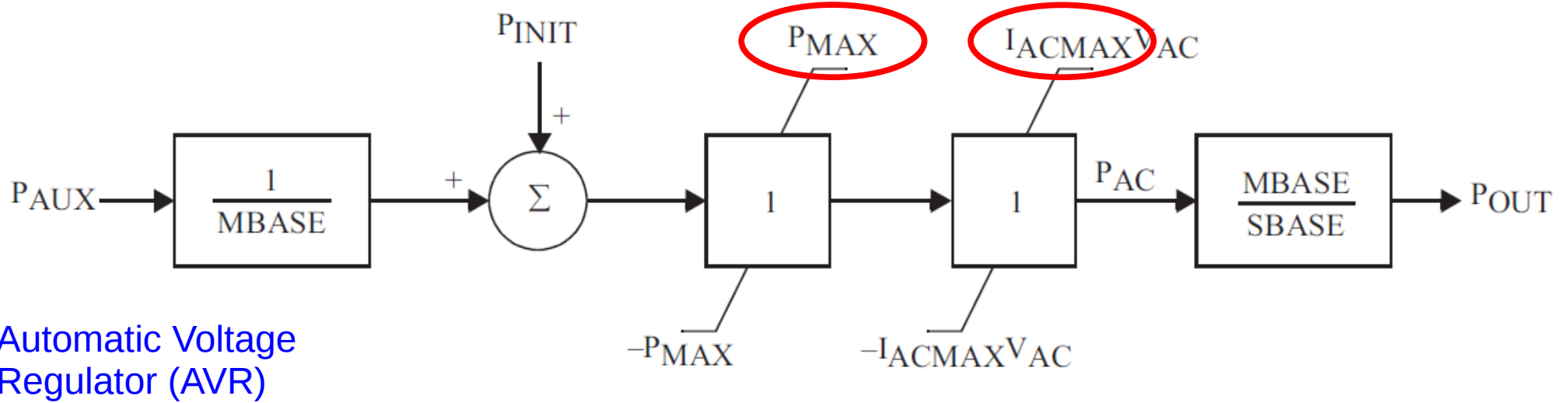
EPRI* Battery Energy Storage (CBEST) Block Diagrams



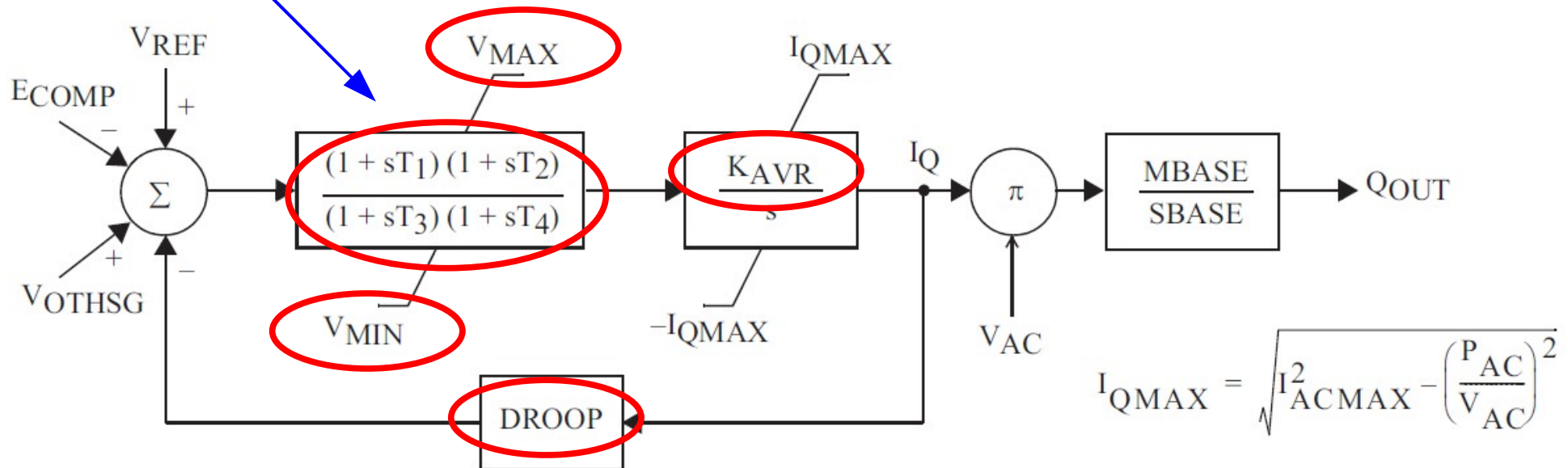
Automatic Voltage Regulator (AVR)



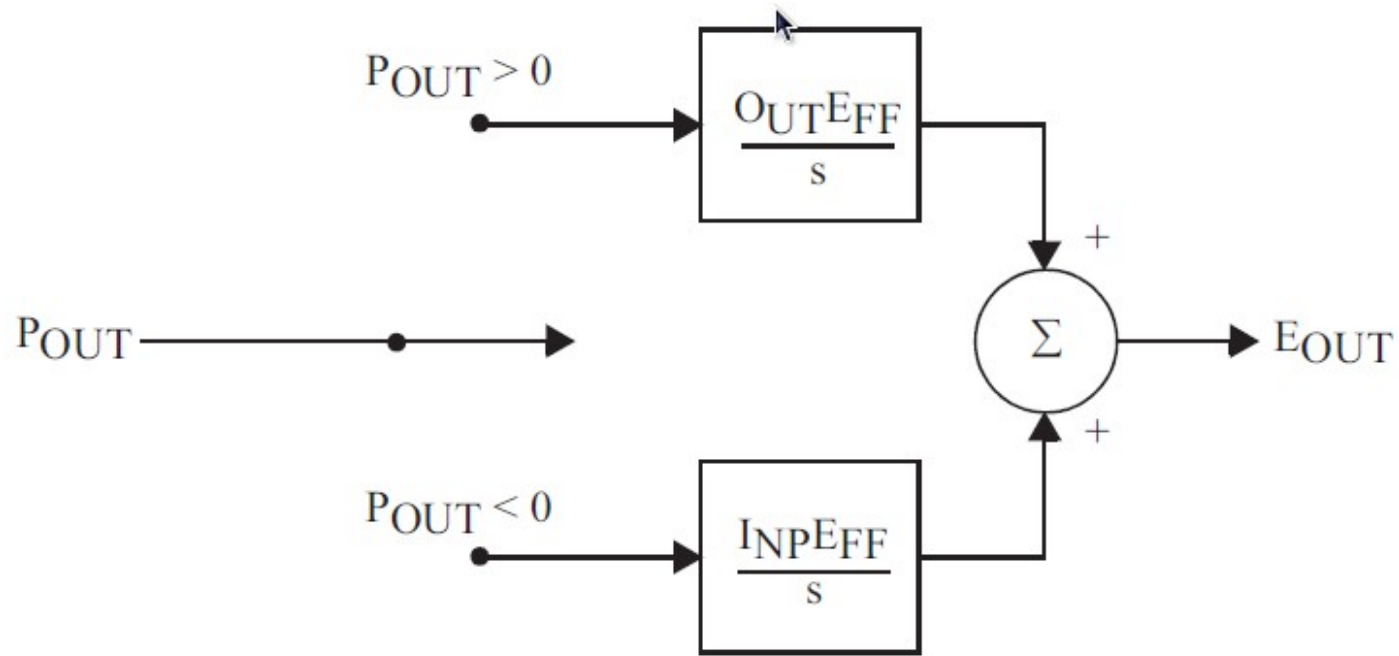
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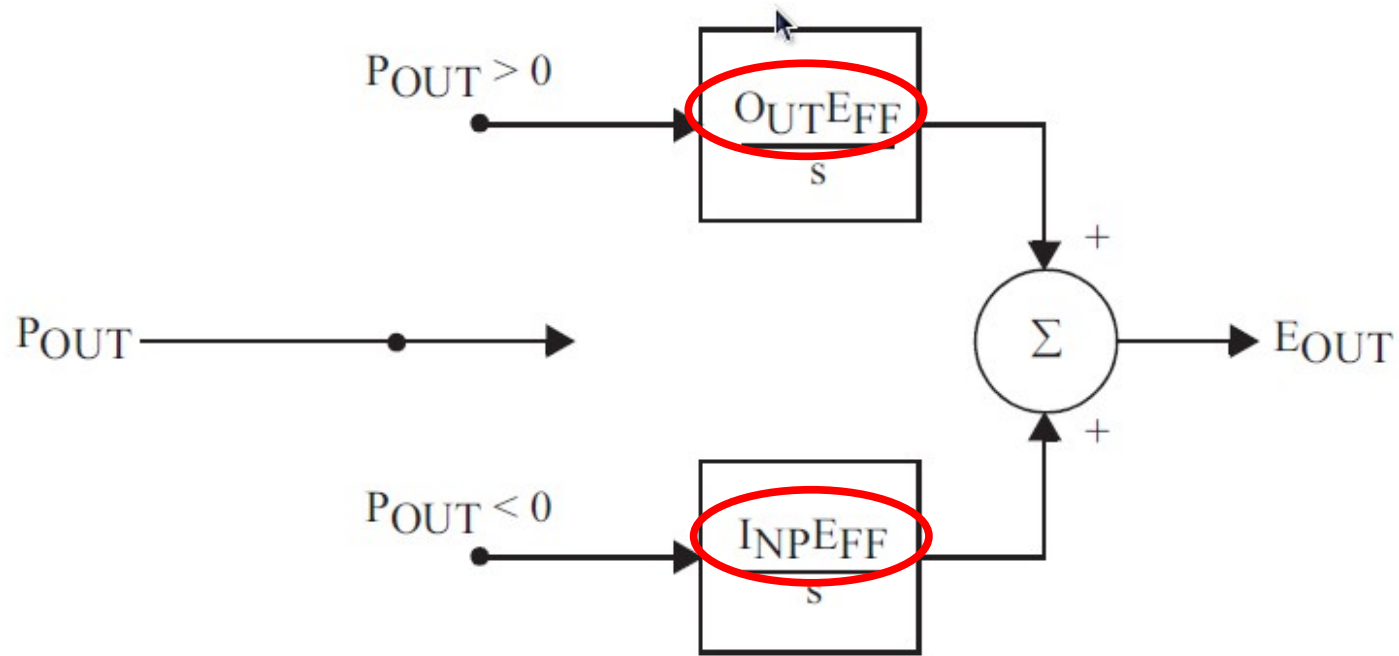
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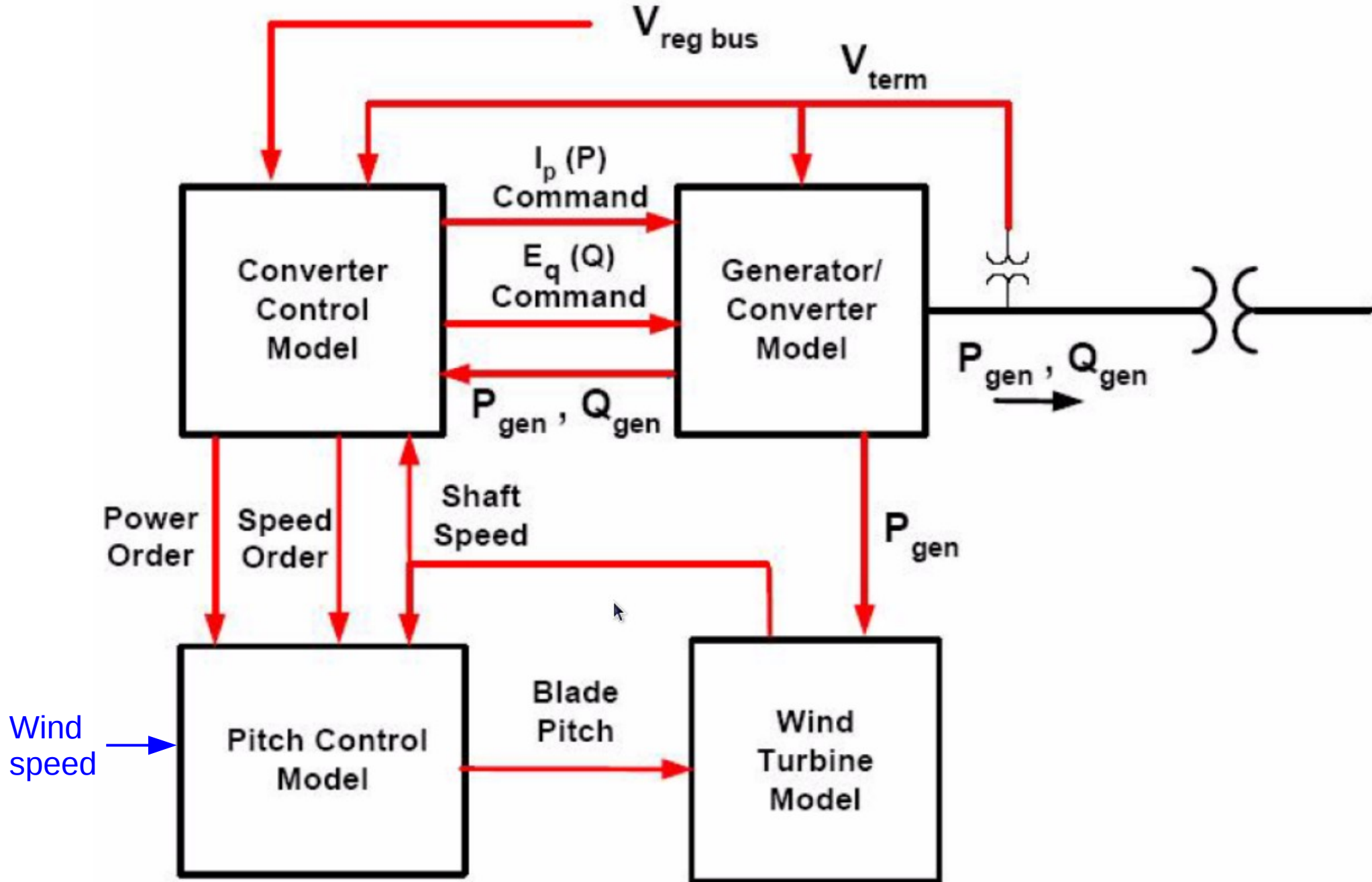
EPRI Battery Energy Storage (CBEST) Efficiency



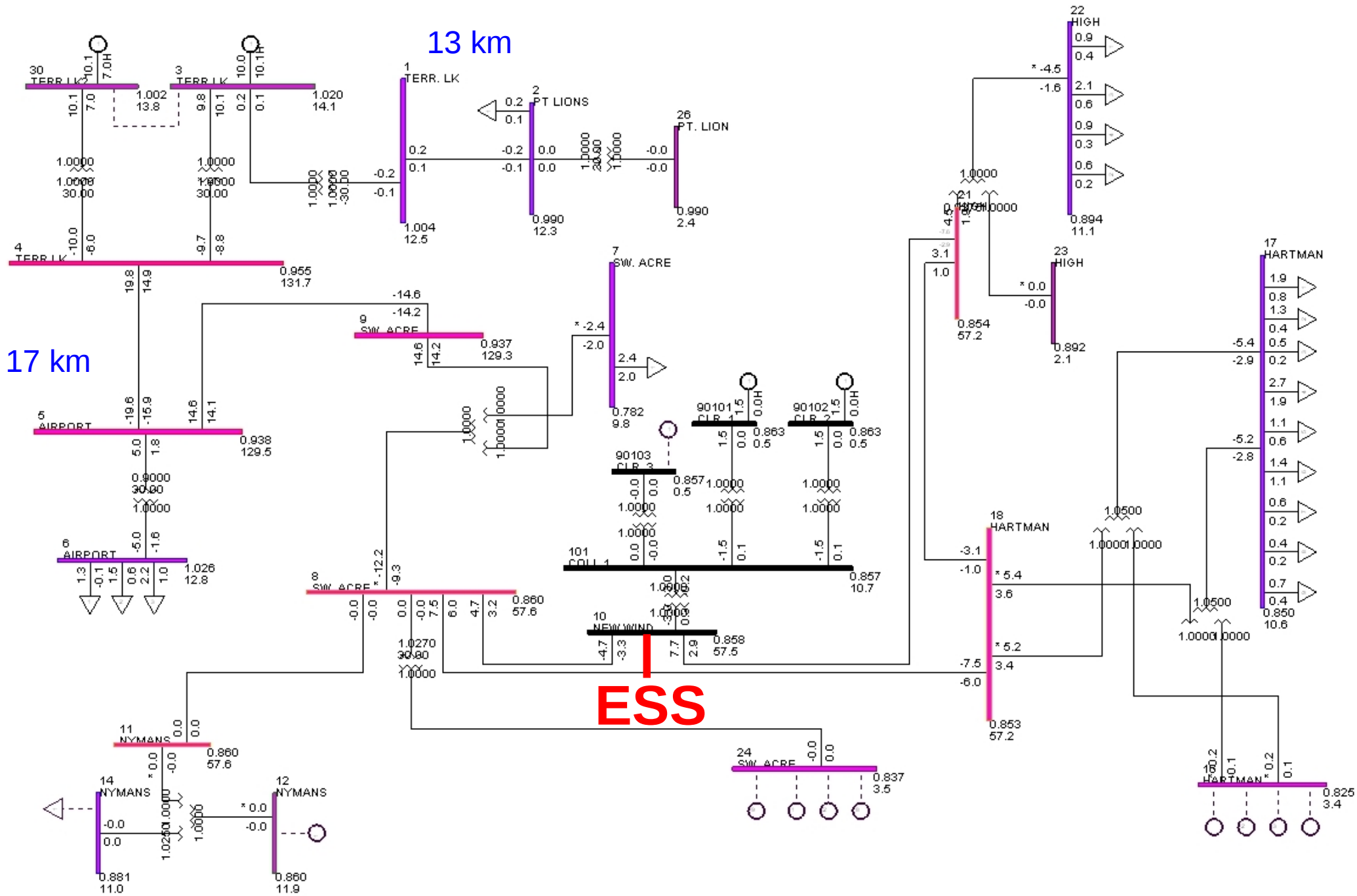
EPRI Battery Energy Storage (CBEST) Efficiency



Wind Turbine Block Diagram



KEA One Line



“Shorter-term” Storage Options

- Battery
 - Proven: Lead-acid, Sodium, Lithium
 - Newer: Flow, Lead-carbon
- Flywheel
 - PSS/E modules do not exist
 - Seismic issues
- SMES
 - EPRI CMEST module does exist

Road Ahead

- Wind gust simulations with new PSS/E model
- Addition of CBEST battery module to model
- Investigation of CBEST module constants *
- Look at different & distributed storage locations

*Kook, KS, McKenzie KJ, Liu, Y, Atcitty, S (2006) A study on applications of energy storage for the wind power operations in power systems, IEEE J.