How to handle unbalance in a wind-farm, using the market or your own hydropower-plants?

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Development of wind power within TEK

Phase 1: 1986 – 1990

- Astrid 55 kW 1986
- Big brother 400 kW 1990

Phase 2: 2000 – 2012

- Valsneset wind farm : 11,5 MW/ 30 GWh : 2006
- Bessakerfjellet wind farm : 57,5 MW/170 GWh : 2008
- Ytre Vikna wind farm (50 %) : 39.0 MW/115 GWh : 2012

Phase 3: 2013 –

- Valid licence : 80 MW
- Licence given, but appealed : 265 MW
- Work in progress to submit applications for new licences.

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Hypothesis

Is it possible to use one or several hydropower-plants to balance wind-farms

- Test this hypothesis on one specific hydropower-plant
- Us data from Valsneset and Bessaker wind-farm
- Limit time-period of analysis to 2011 and 2012
- Analysis is based on hourly data
- Historical water-values are used for calculation of marginal-cost

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Description selected hydropower plant

Søa

Pmax	: 36 MW
Popt	: 24 MW(approx.)
Pmin	: 15 MW
Full load hours	: 5300
Annual production	: 192 GWh
Qmax	: 17 m^3/s
Qmin	: 5 m^3/s
FNR	: 1.2 MW/(0.1* HZ) (R = 6 % constant)
Max. reservoir head	: 279.83 m.a.s.l.
Min. reservoir head	: 260.00 m.a.s.l.
Reservoir volume	: 67 Mm^3
Tail water level	: 0 m.a.s.l. (release directly to sea)

No restriction on how to operate the plant. Only restriction is a minimum water-level during summer months.

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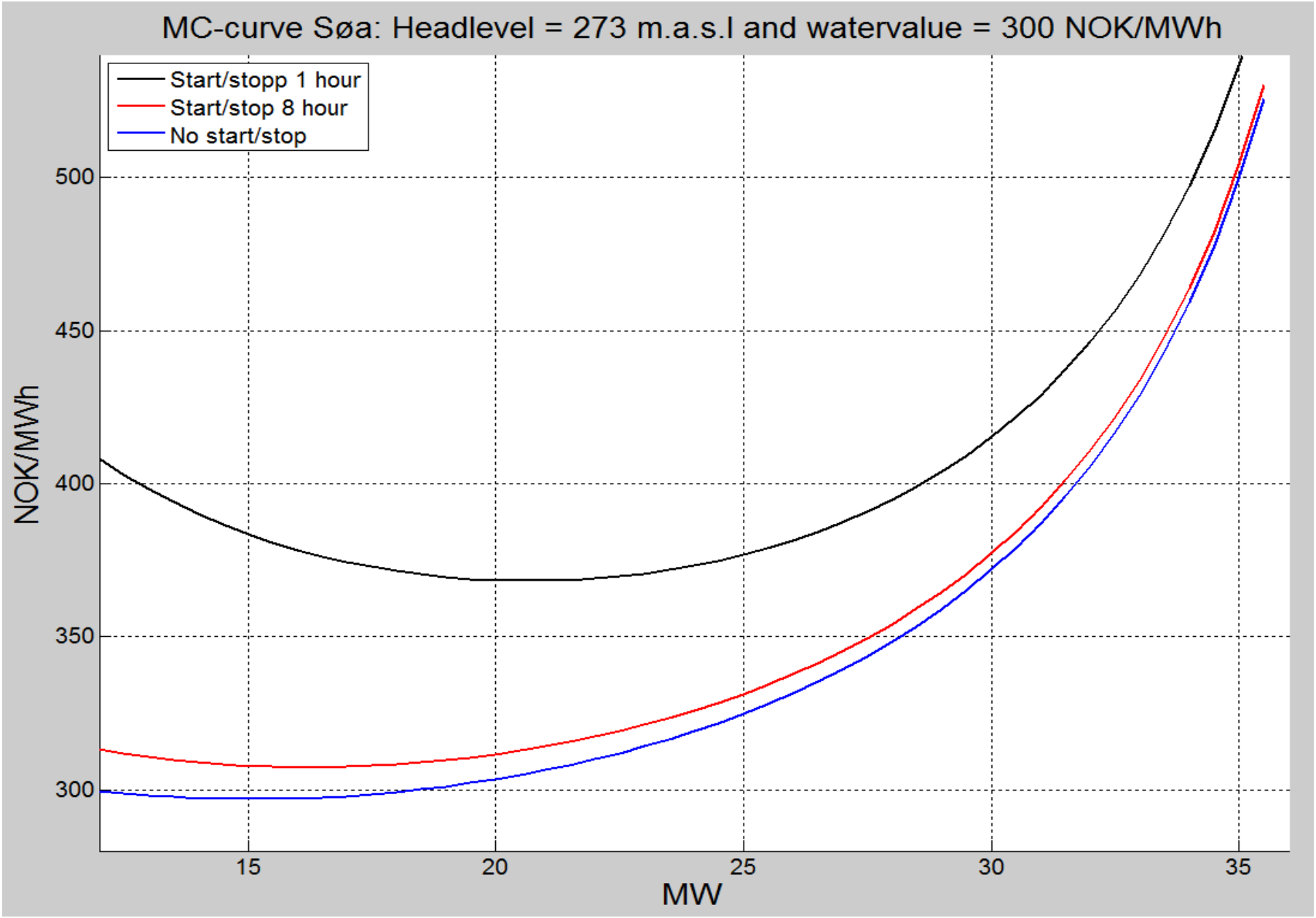

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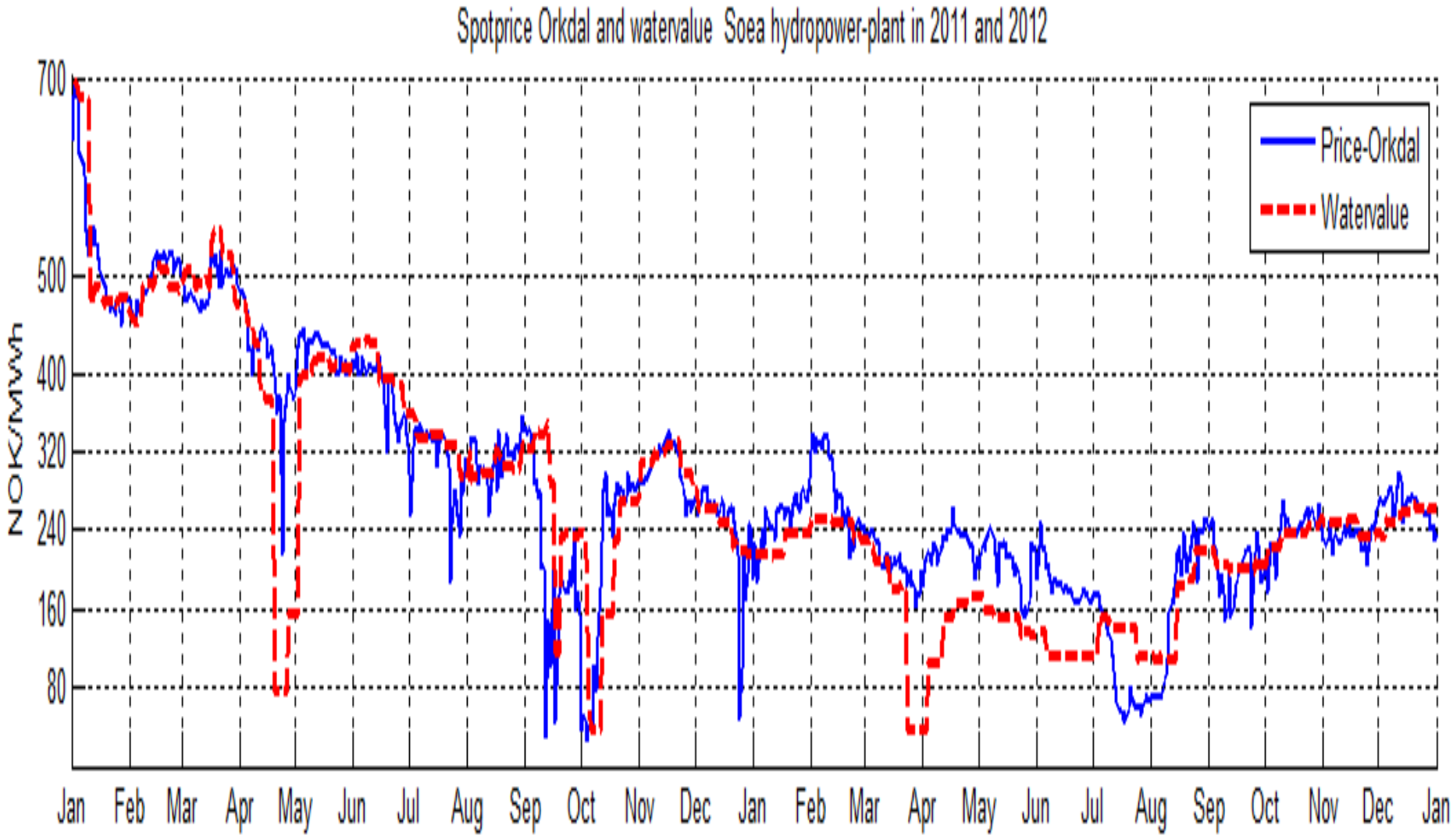

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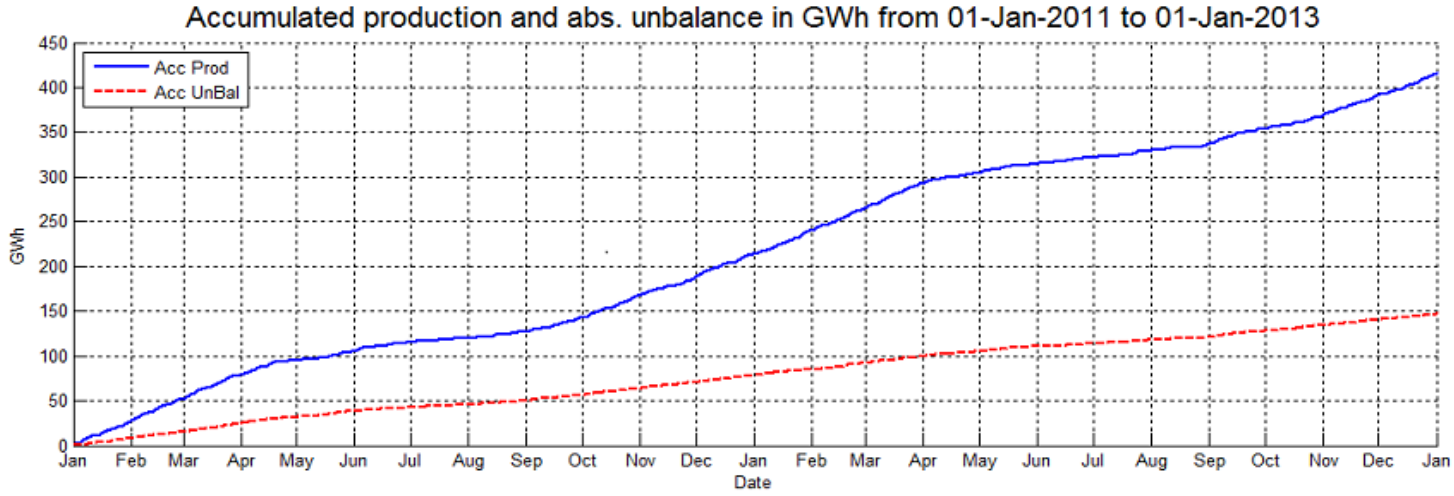
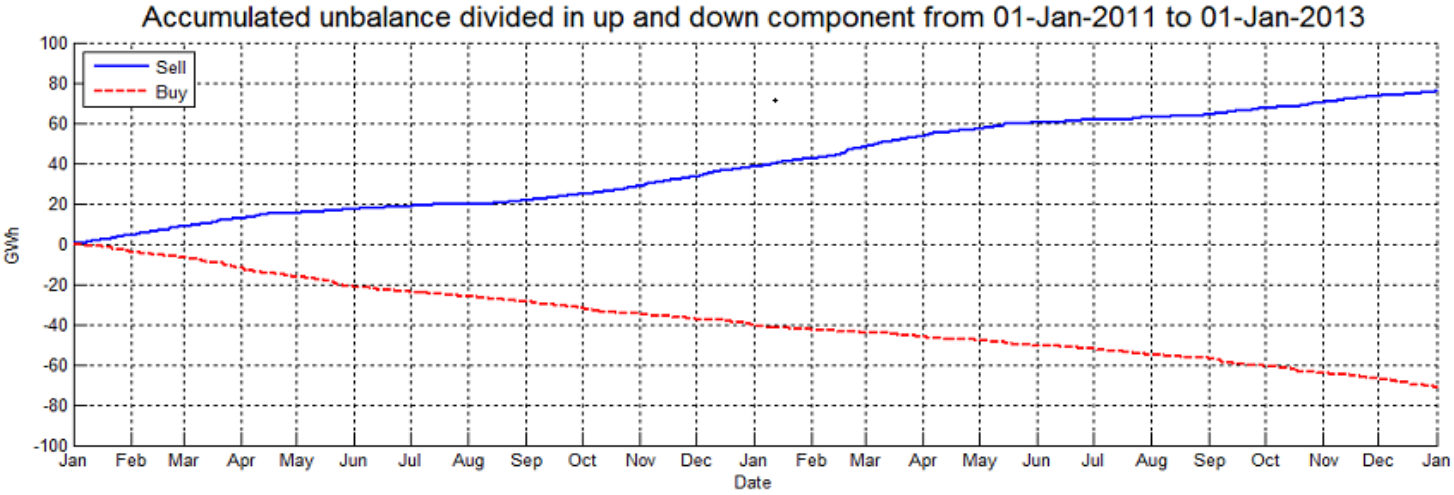
Production and unbalance in GWh
Bessaker and Valsneset





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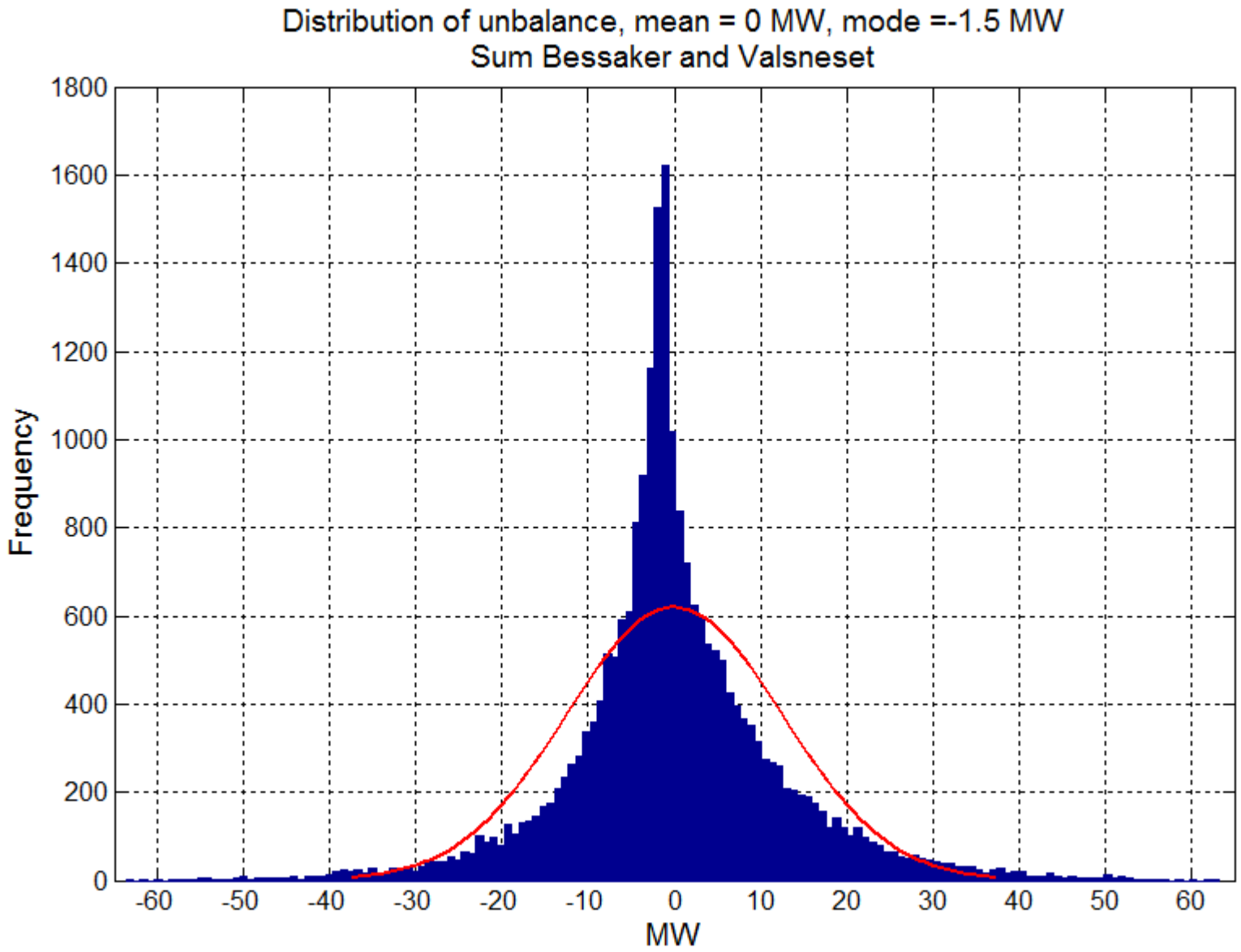

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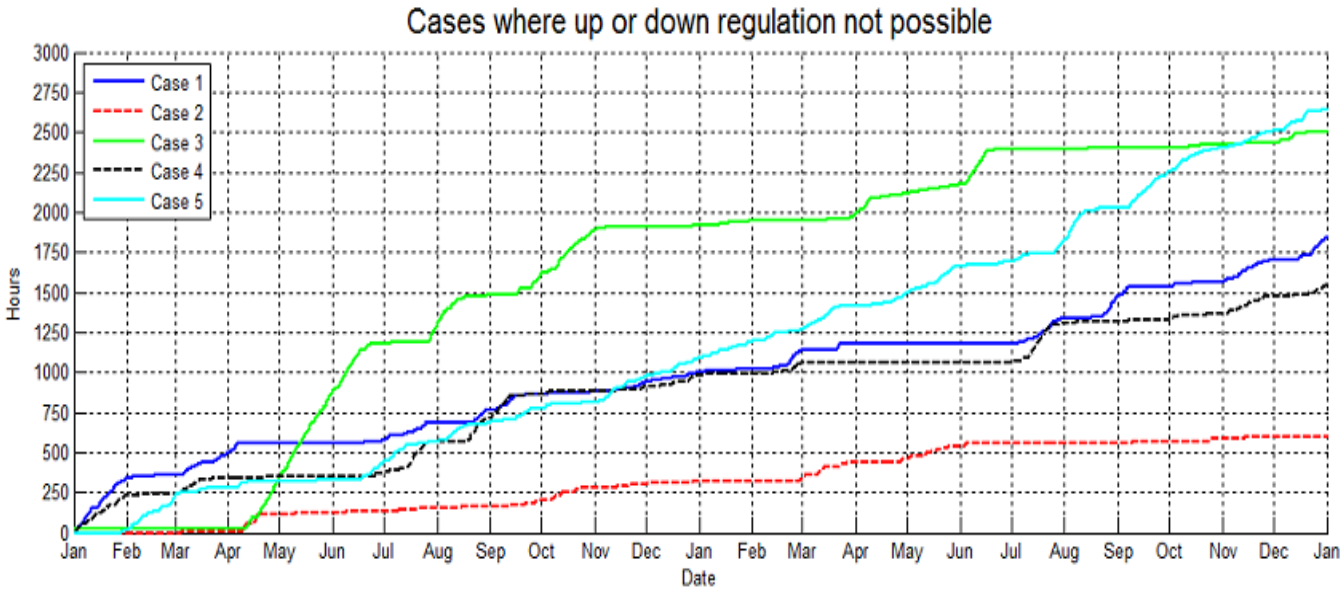

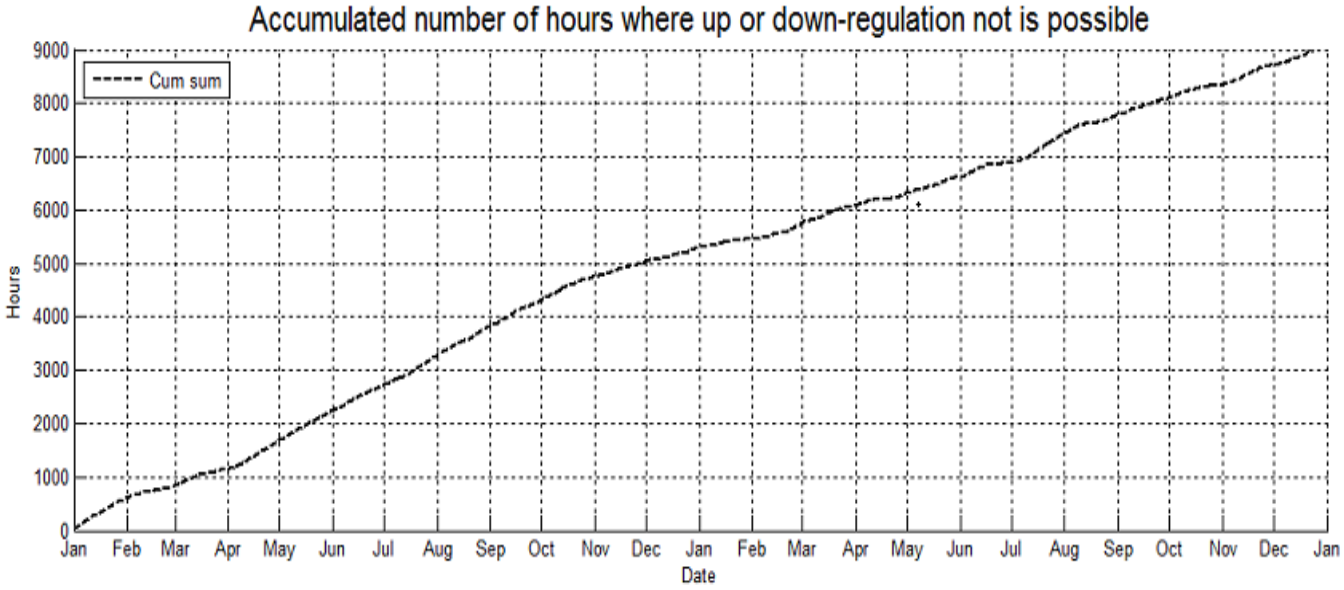

- Case 1 : Hydro-power plant is not running and wind-farm must regulate down.
- Case 2 : High inflow etc, down regulation of hydropower-plant is not feasible.
- Case 3: Hydro-power plant is running at maximum effect, up-regulation is not feasible.
- Case 4: Hydro-power plant is not producing, and up-regulation volume is less than Pmin.
- Case 5: Hydro-power plant is running at MC > regulation-price and upward regulation is not economic.

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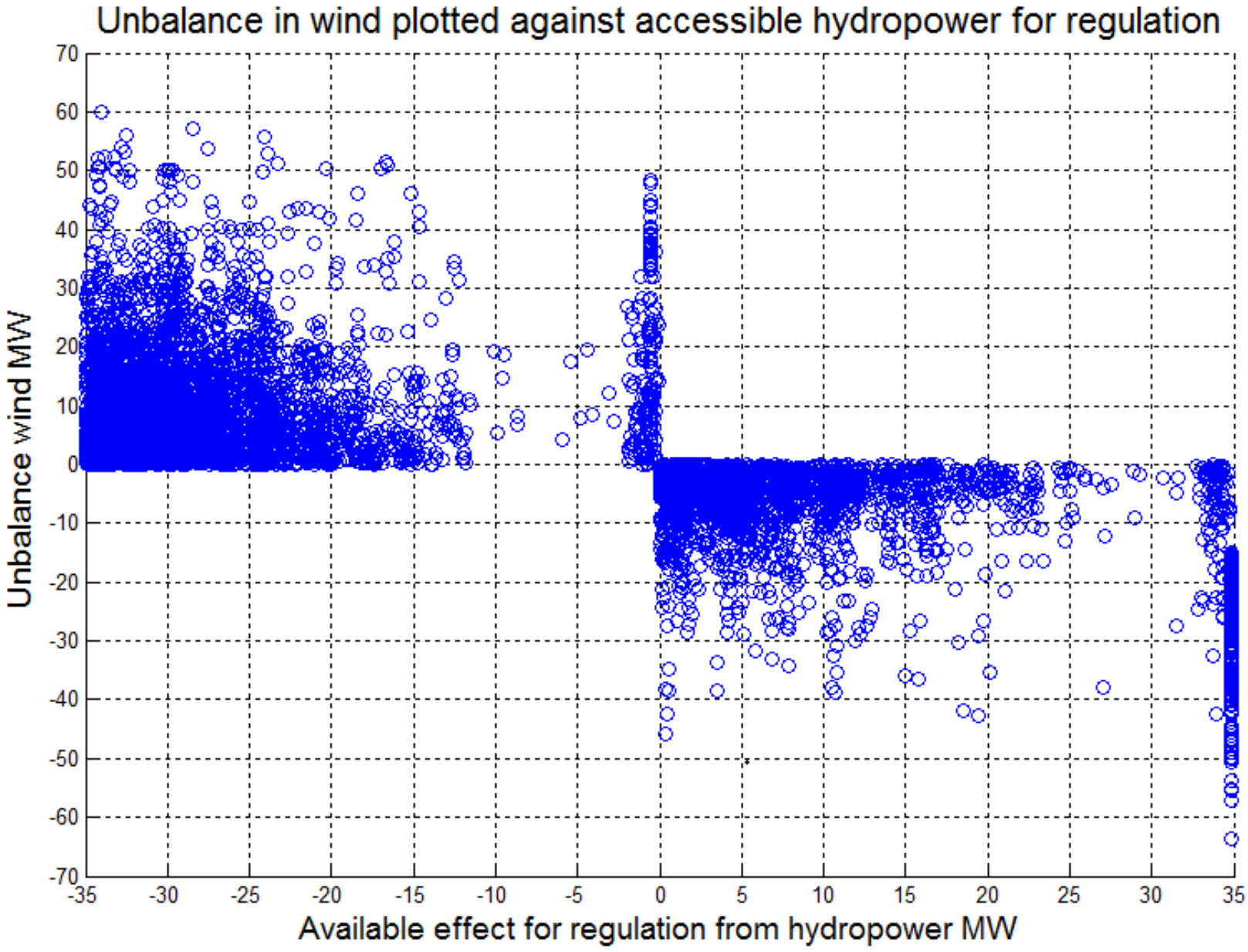

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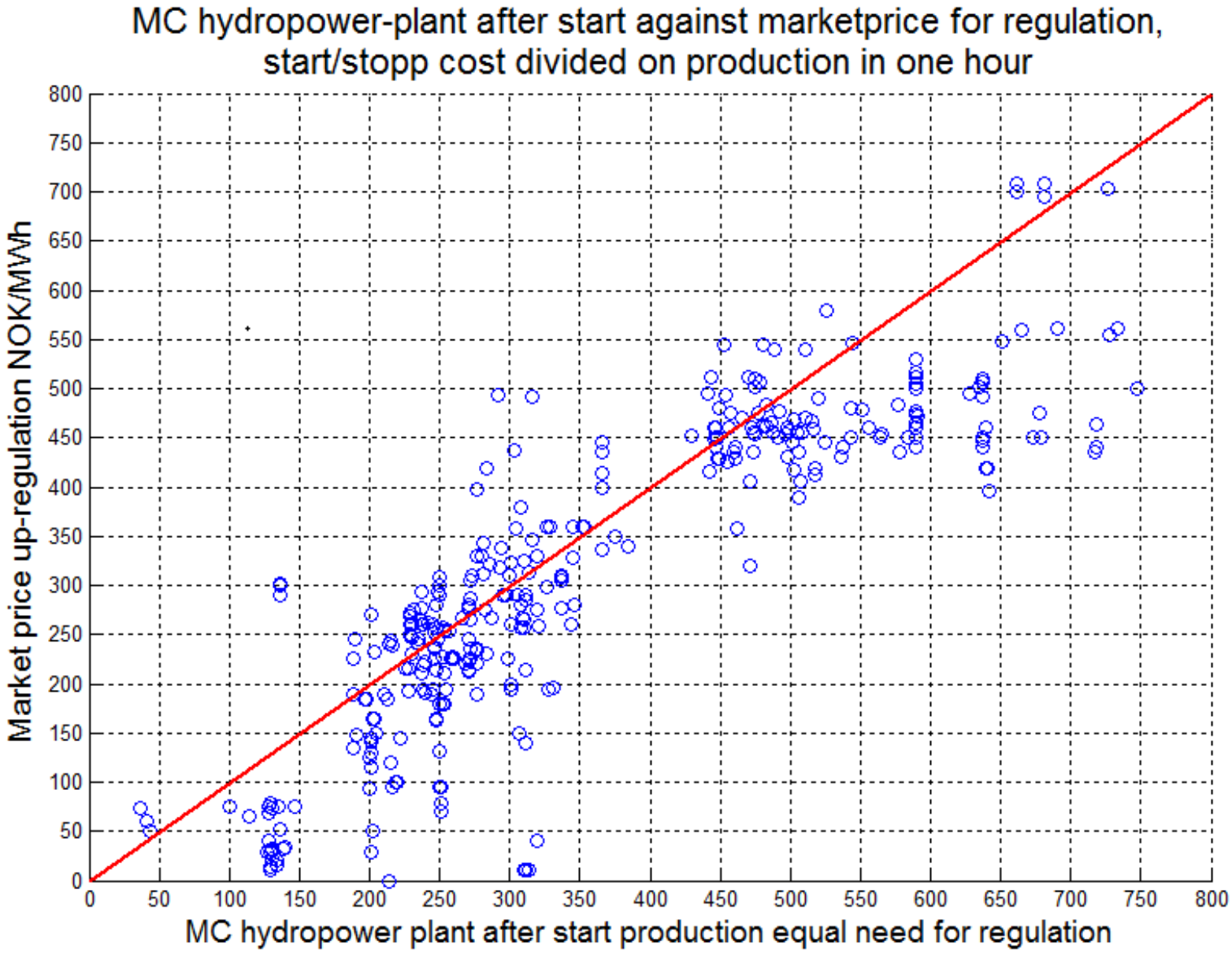

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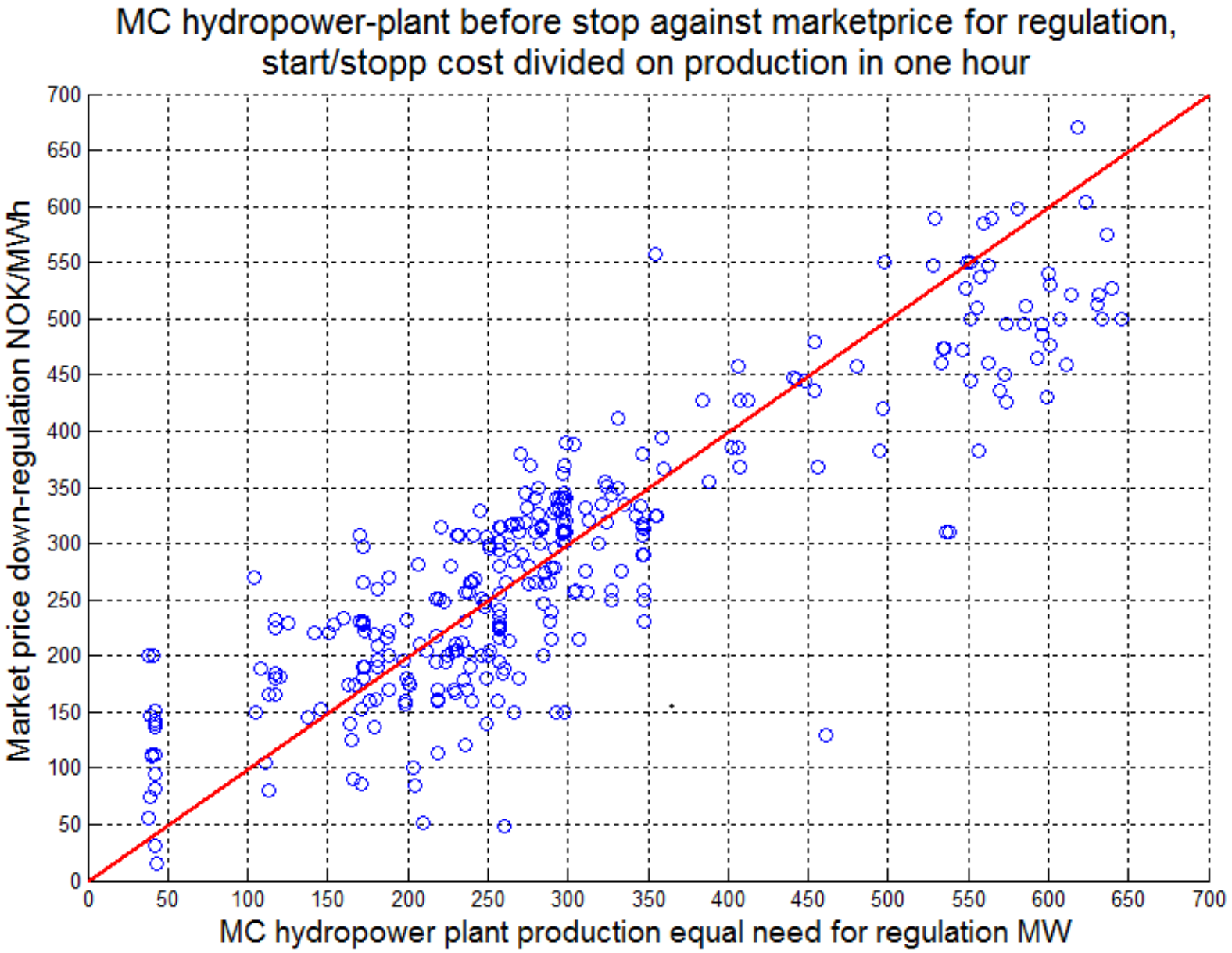

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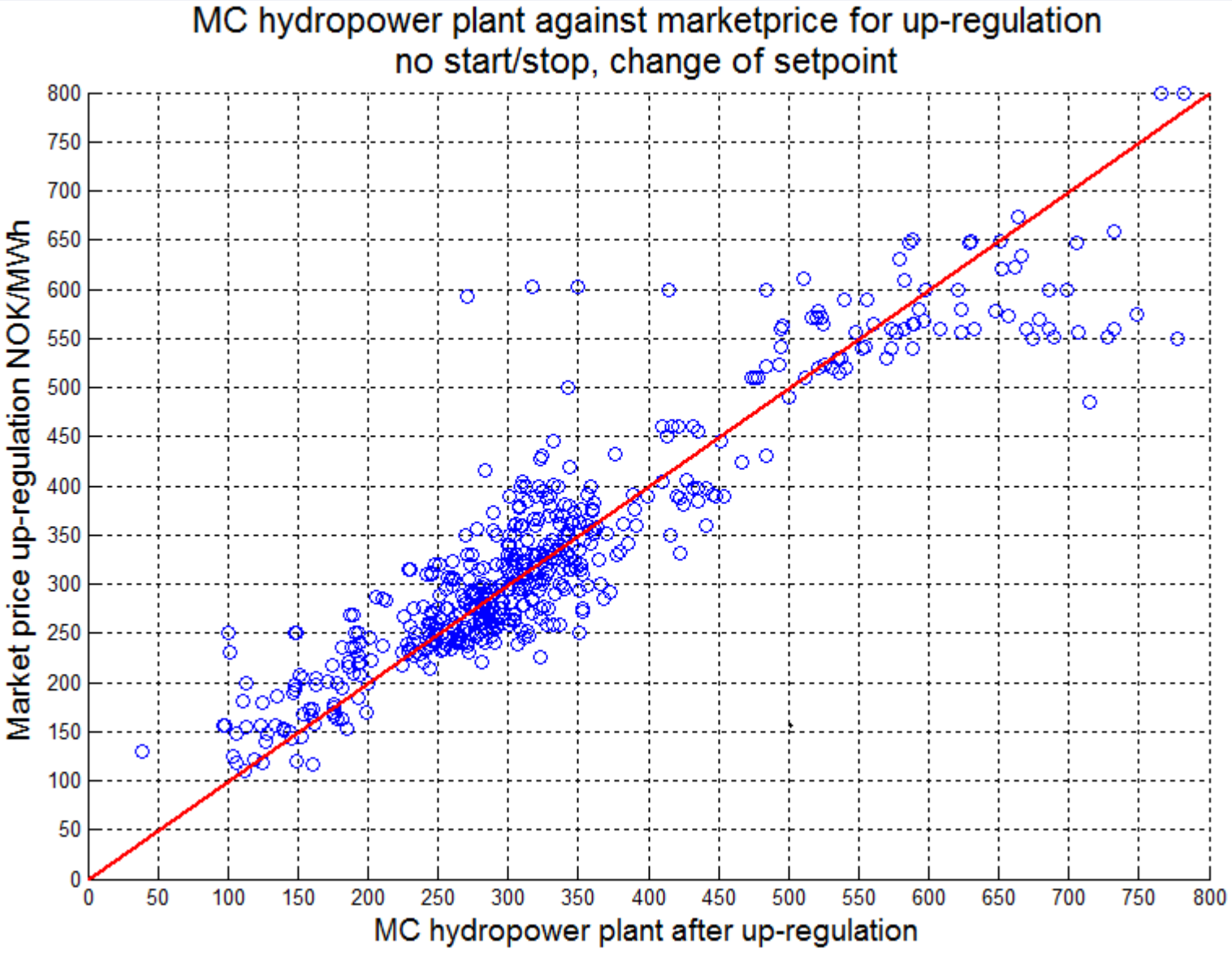

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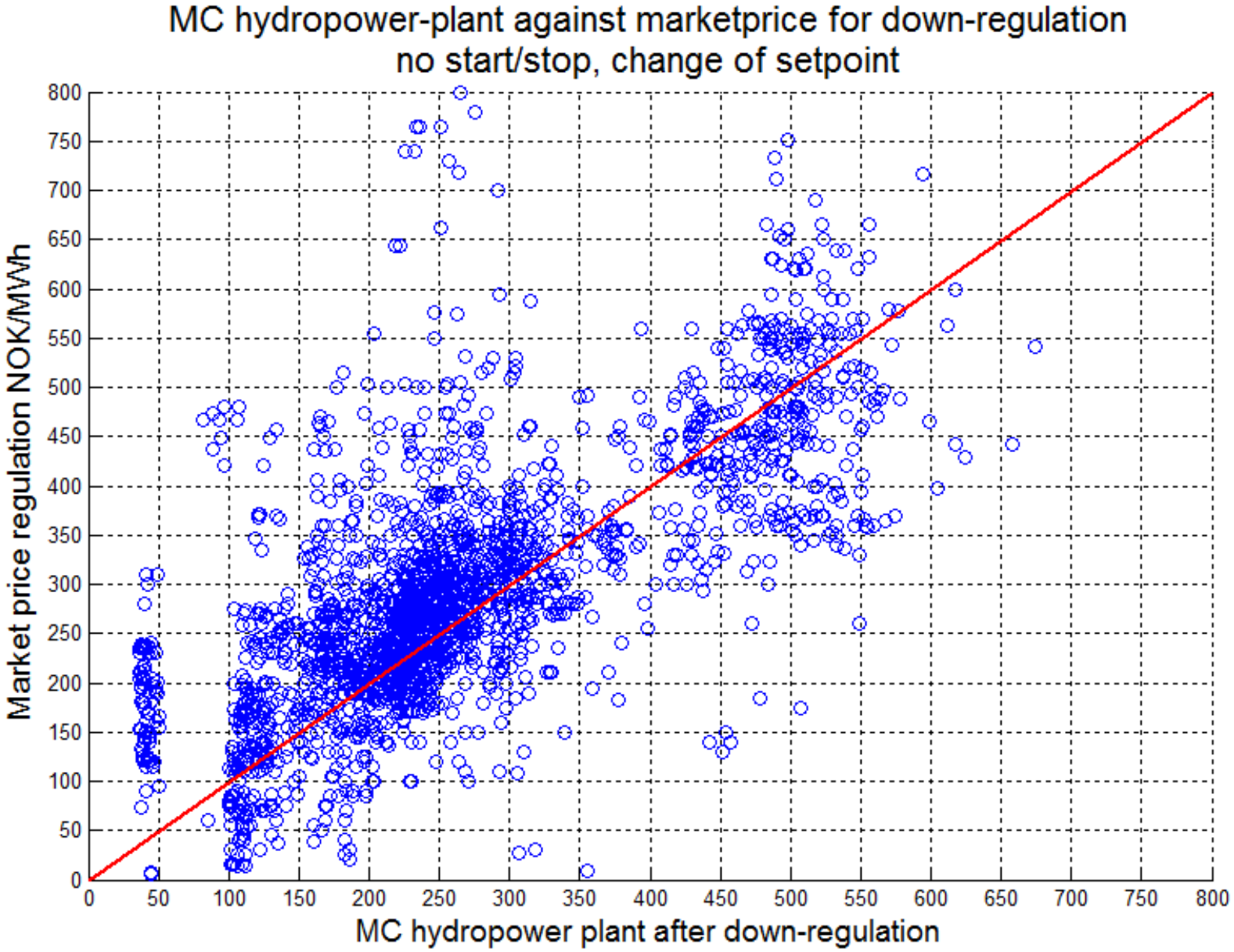

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Summary analysis

- Available for down regulation : 47/2 GWh
- Available for up regulation : 16/2 GWh
- Annual production in Søa : 192 GWh
- Volume for down regulation is questionable since it can lead to an increase in loss of water.
- Cost for regulation up tends to be above market prices
- Cost for down regulation is evenly distribute above and under market prices in our sample

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Summary analysis

For

- Development in wind-unbalance is symmetric even in short-run and will therefore not affect water-values
- Minor volumes can probably be regulated cheaper than in the market
- Minor unbalance can probably regulated automatically

Against

- Concurrent effect significant reduce the number of hours available for regulation with use of hydro-power
- A small sample shows that using the market will be preferred in many hours.
- Calculation of cost is essential and challenging in an operative environment
- Will for sure increase the number for start/stop
- Need several hydro-power plants to balance even a small wind-farm, assuming medium-sized plants used for this purpose
- Investment must be done in automation solutions
- Return on investment is hard to estimate

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Conclusion

Just now, don’t do it.

If you want to do it, you probably need to do an in-depth study on the hydro-power plants singled out for this purpose.

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