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Joint use of hydrological modeling and large-scale stochastic optimization techniques applied to the Nordic power system

5th International Workshop on Hydro Scheduling in Competitive Electricity Markets

Joint use of hydrological modeling and large-scale stochastic optimization techniques applied to the Nordic power system

Torjus Folsland Bolkesjø* Bjørn Sønju-Moltzau** Joachim D. Jensen ***

**Norwegian University of Life Sciences (NMBU) / Thomson Reuters Point Carbon, Oslo Norway*

***Thomson Reuters Point Carbon / Norwegian University of Life Sciences (NMBU) Oslo Norway*

****Thomson Reuters Point Carbon, Oslo Norway*



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I'm Bjørn Sønju-Moltzau

Name: Bjørn Sønju-Moltzau

Company: NMBU (20%) / Thomson Reuters

About :

Bjørn Sønju-Moltzau holds a Ph.D in Hydrology from the University of Oslo, and has been involved within the hydro power, meteorology and hydrology field throughout the professional career, with special competence in modeling of hydrological systems, operative hydrology and analysis of the fundamental conditions for the power markets in the Nordic countries, Europe, Asia and USA.

He has also worked as a trader and portfolio manager in the power market. Bjørn is also a member of the of the election committee who election representatives to the board of directors for Thomson Reuters Norway.

He has working experience from Europe, Asia, USA and Latin- and South America.



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UiO : Universitetet i Oslo



Statistisk sentralbyrå
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Renewable energy at NMBU

Studenter fra kurset FORN300: Vind – og vannkraft: Ressursgrunnlag, lønnsomhet og valg av løsninger



Bjørn Sønju-Moltzau @BjrnSnjuMoltzau - Aug 21

Masterstudenter, i fornybar [#energi](#) fra [#NMBU](#), har hatt noen fantastiske dager (25 gr C) på [#Smøla](#) Vindpark [#NVES](#)

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Renewable energy at NMBU

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Bjørn Sønju-Moltzau @BjrnSnjuMoltzau · Aug 21

Masterstudenter, i fornybar [#energi](#) fra [#NMBU](#), på besøk hos [#Aura](#) kr.v ([#besøkskraftverk](#)) til [#Statkraft](#).

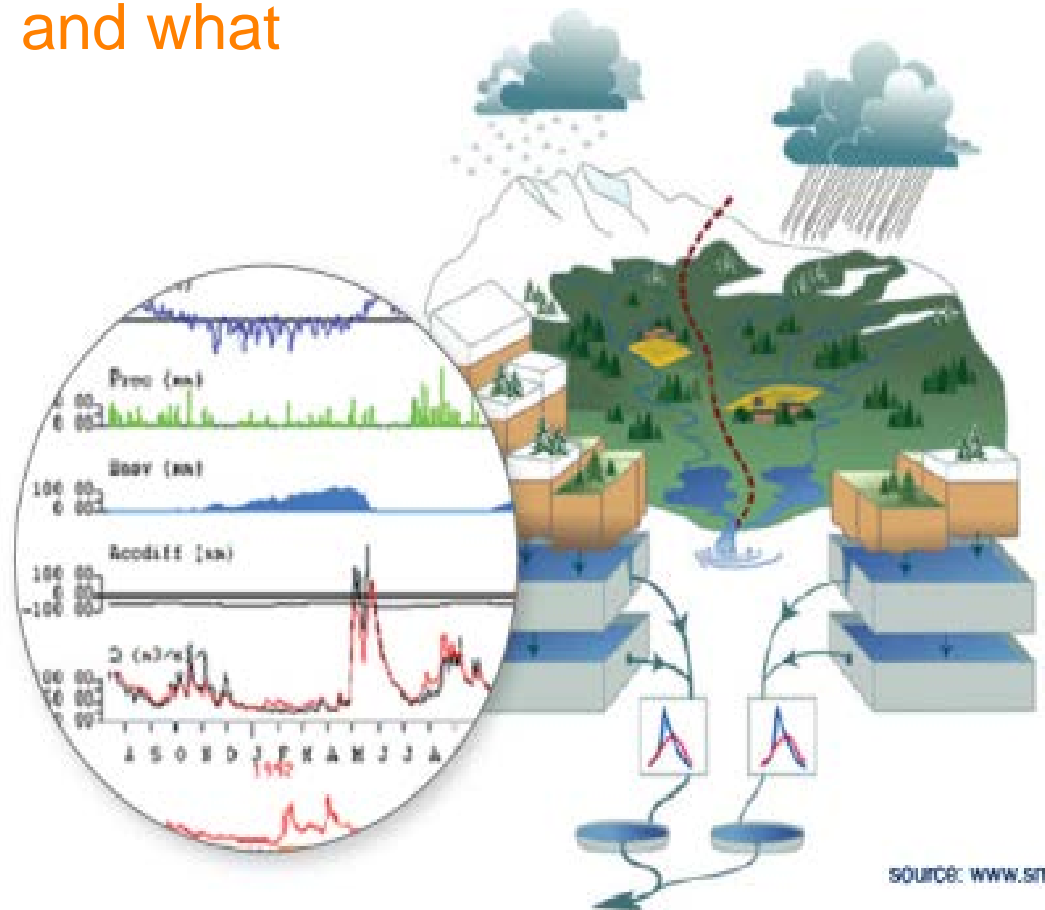
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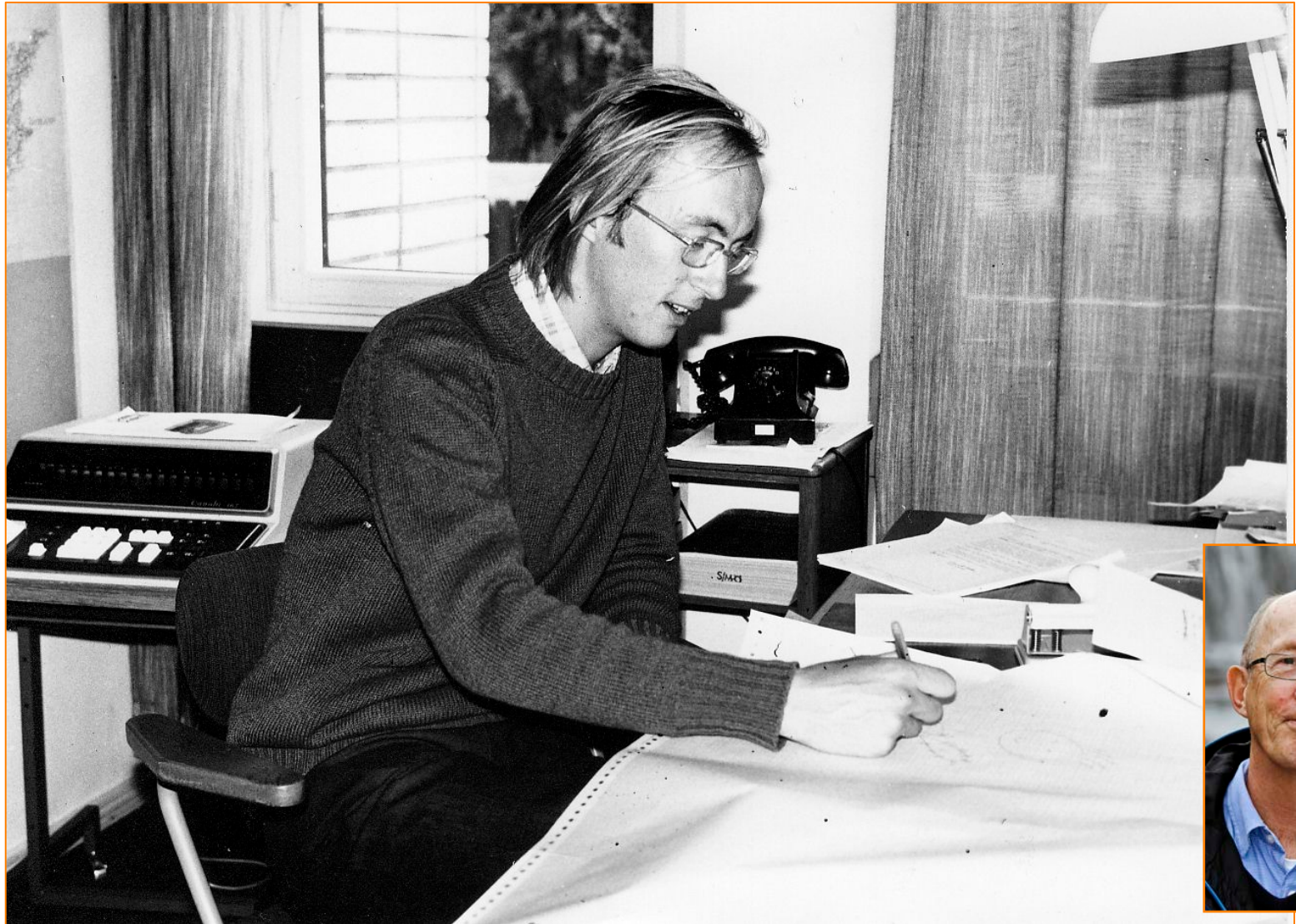
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Agenda

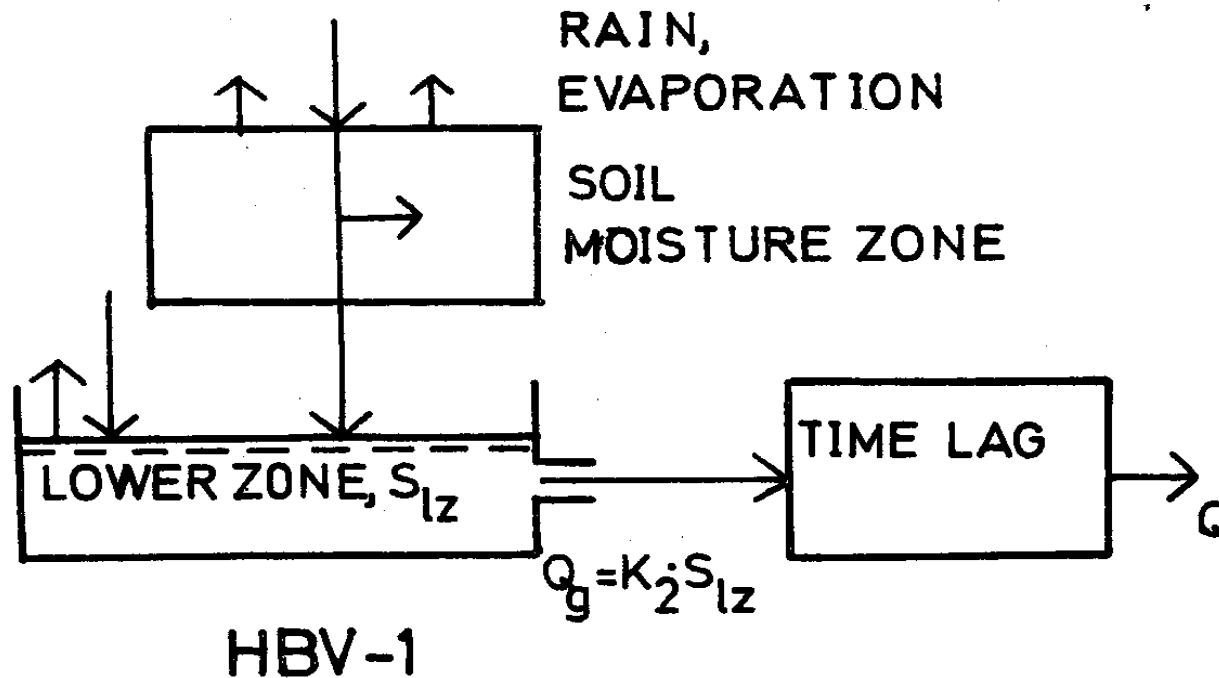
- Hydrological modelling: Theory and practice
- Forecast – How often and what
- HBV link to SDDP
- Benchmark
- Scenario Explorer



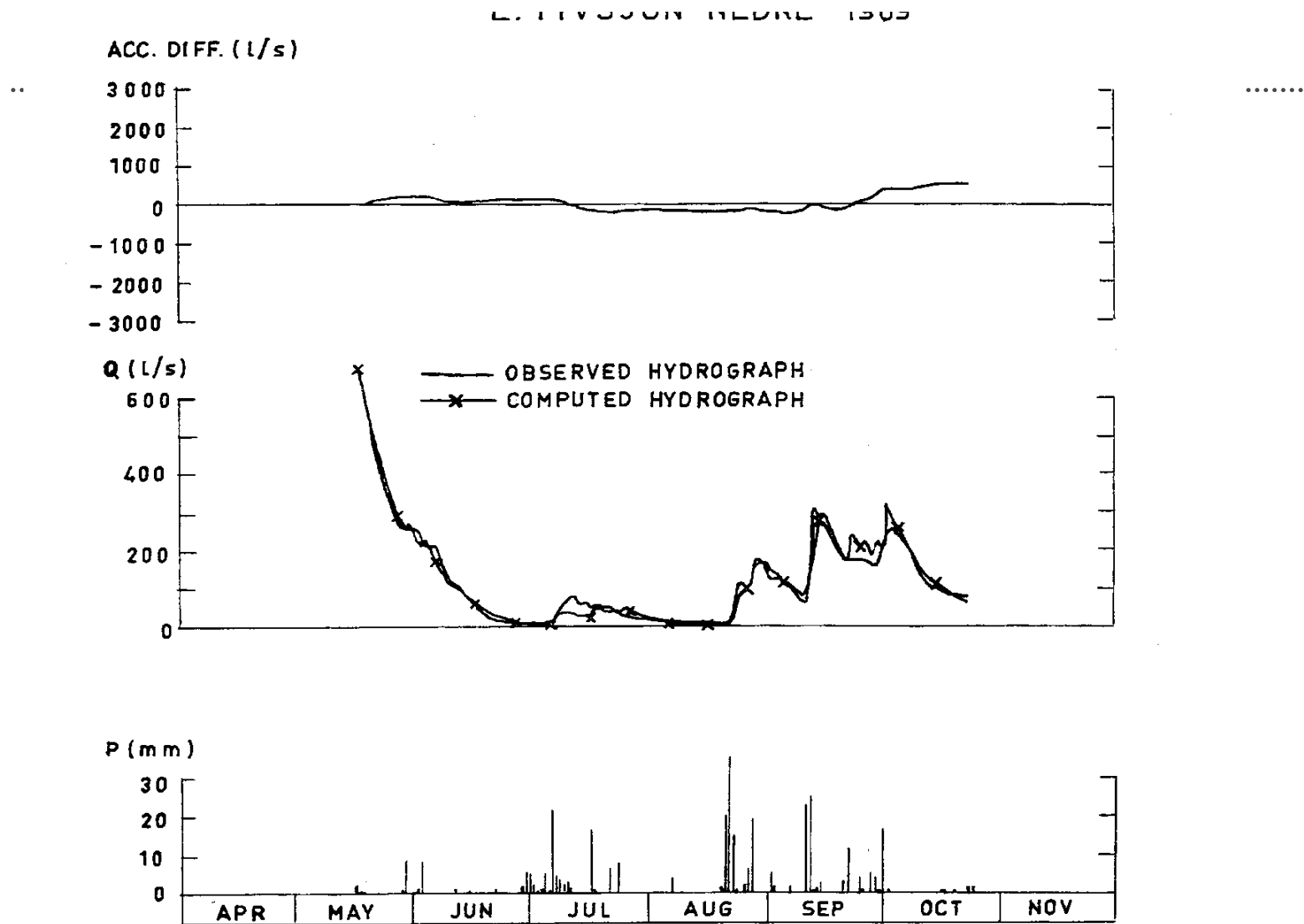
The HBV model story...



The very first HBV model from early 1972



The first successful run...



Eikon



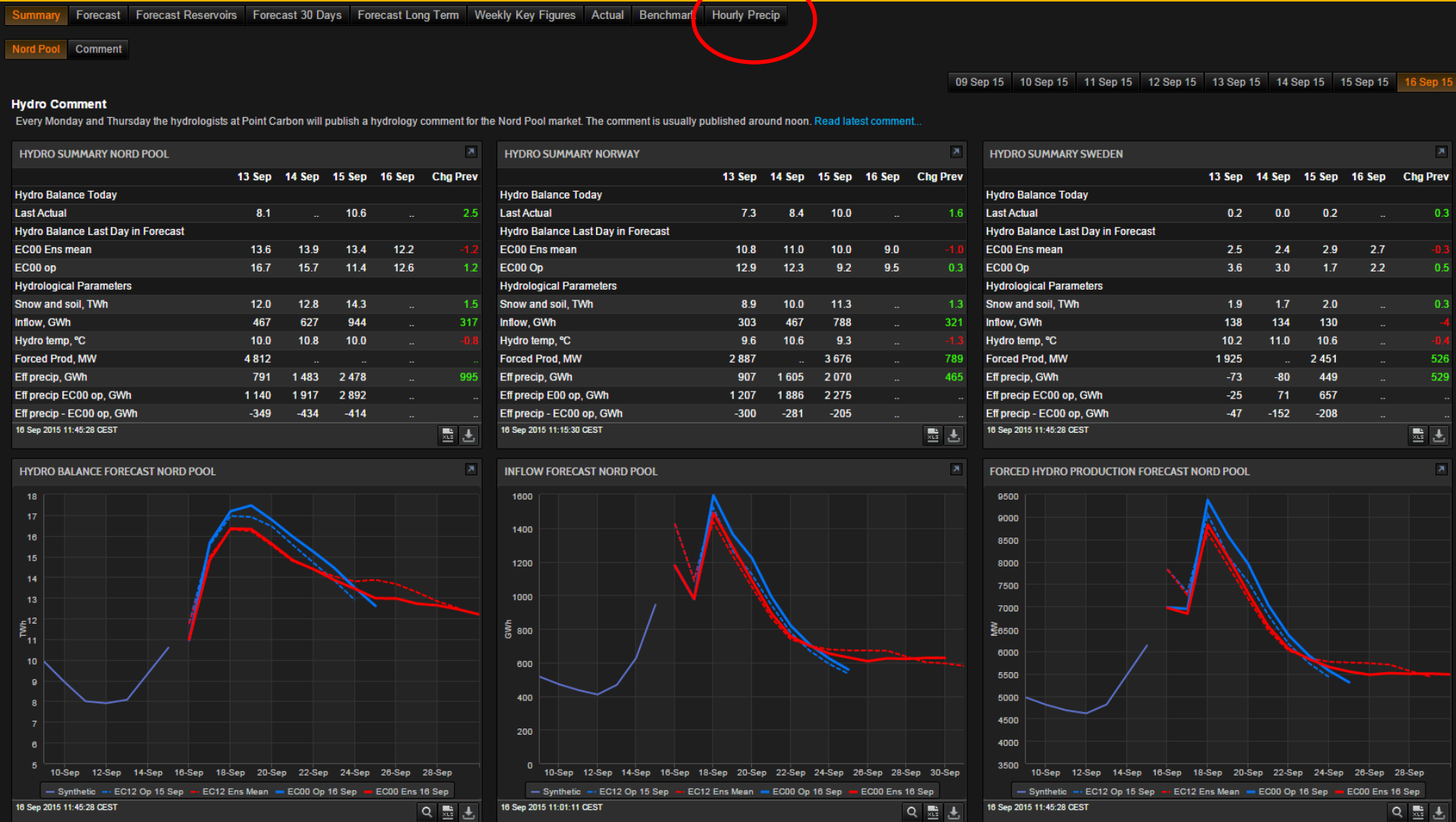
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Commodities Research & Forecasts – Power Nordic



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Commodities Research & Forecasts – Power Nordic Hydrology Front Page



“Petra” is coming...



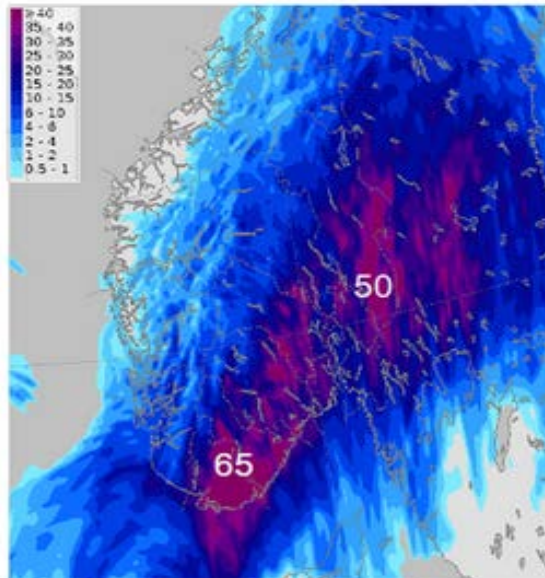
Meteorologene @Meteorologene · 1d



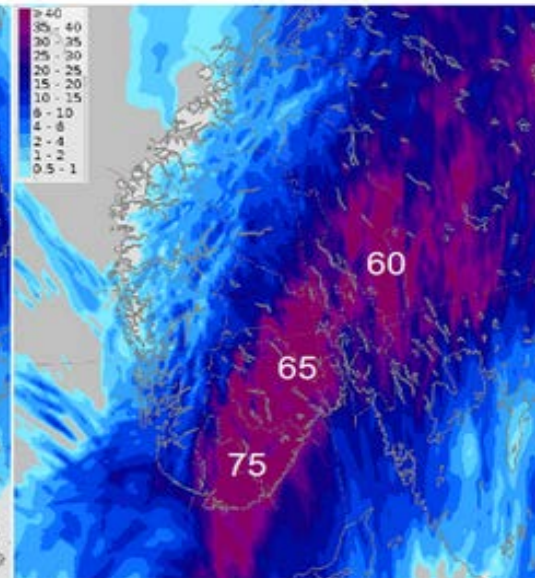
Mye nedbør neste 24 timer, mest fra 02.00 til 14.00 torsdag #Østafjells #Petra #ekstremvær

[View translation](#)

Hovedtyngden av nedbøren kommer mellom 02.00-14.00 torsdag



12 timers nedbør fra 02.00 til 14.00 torsdag



24 timers nedbør
fra 20.00 onsdag til 20.00 torsdag



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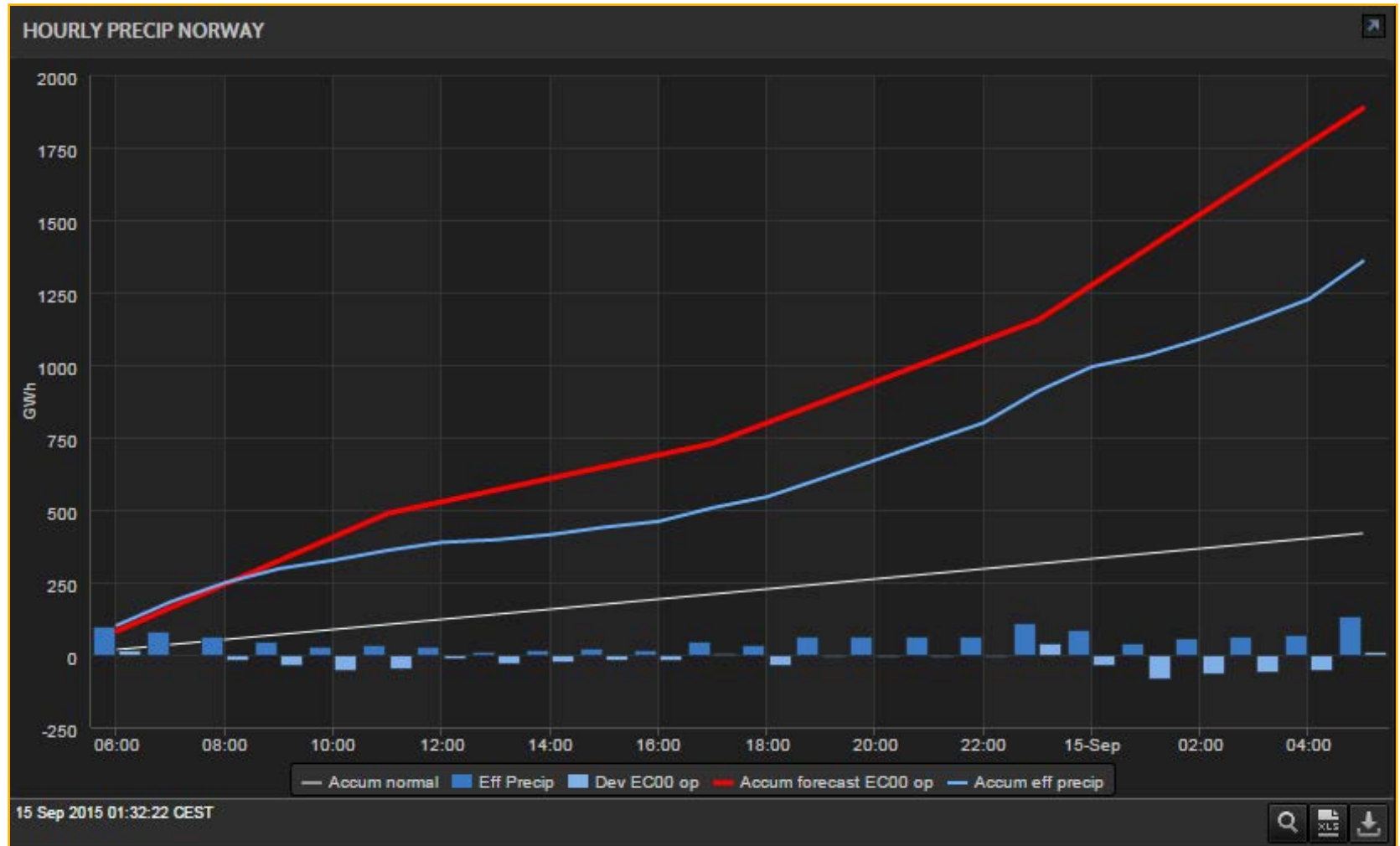
“Petra” is coming...



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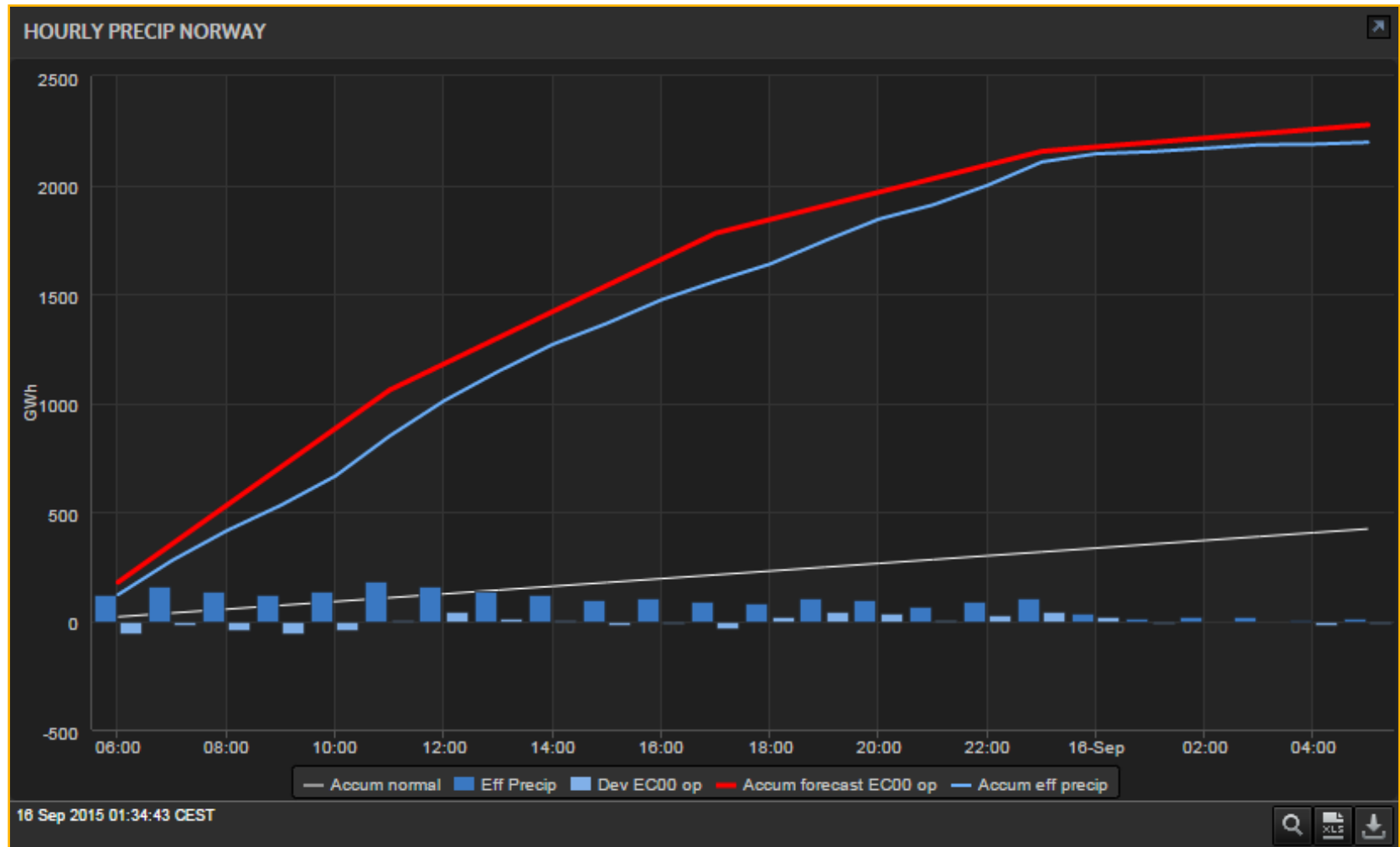
Commodities Research & Forecasts – 15.09.2015

Power Nordic Hourly Precipitation Norway



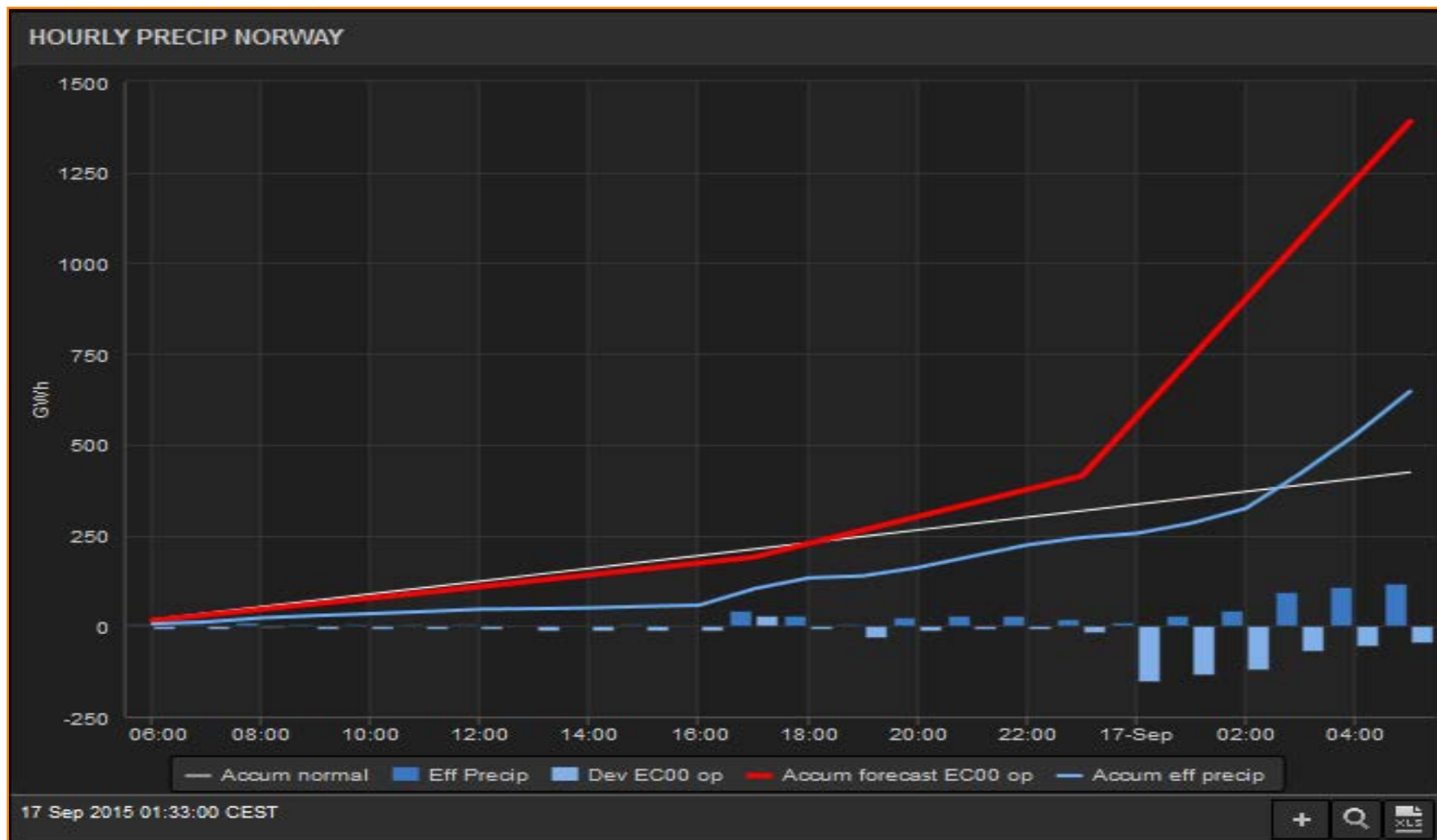
Commodities Research & Forecasts – 16.09.2015

Power Nordic Hourly Precipitation Norway



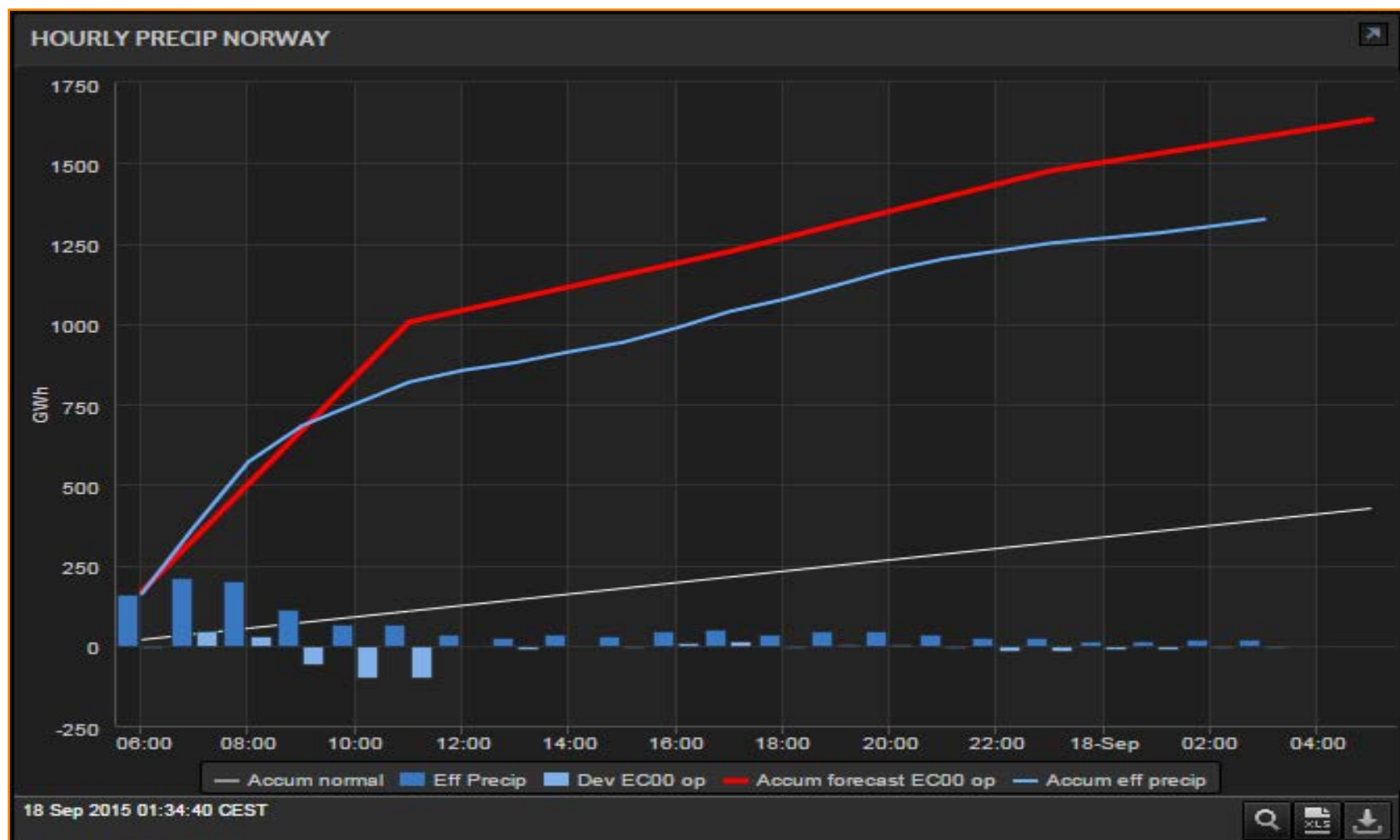
Commodities Research & Forecasts – 17.09.2015

Power Nordic Hourly Precipitation Norway



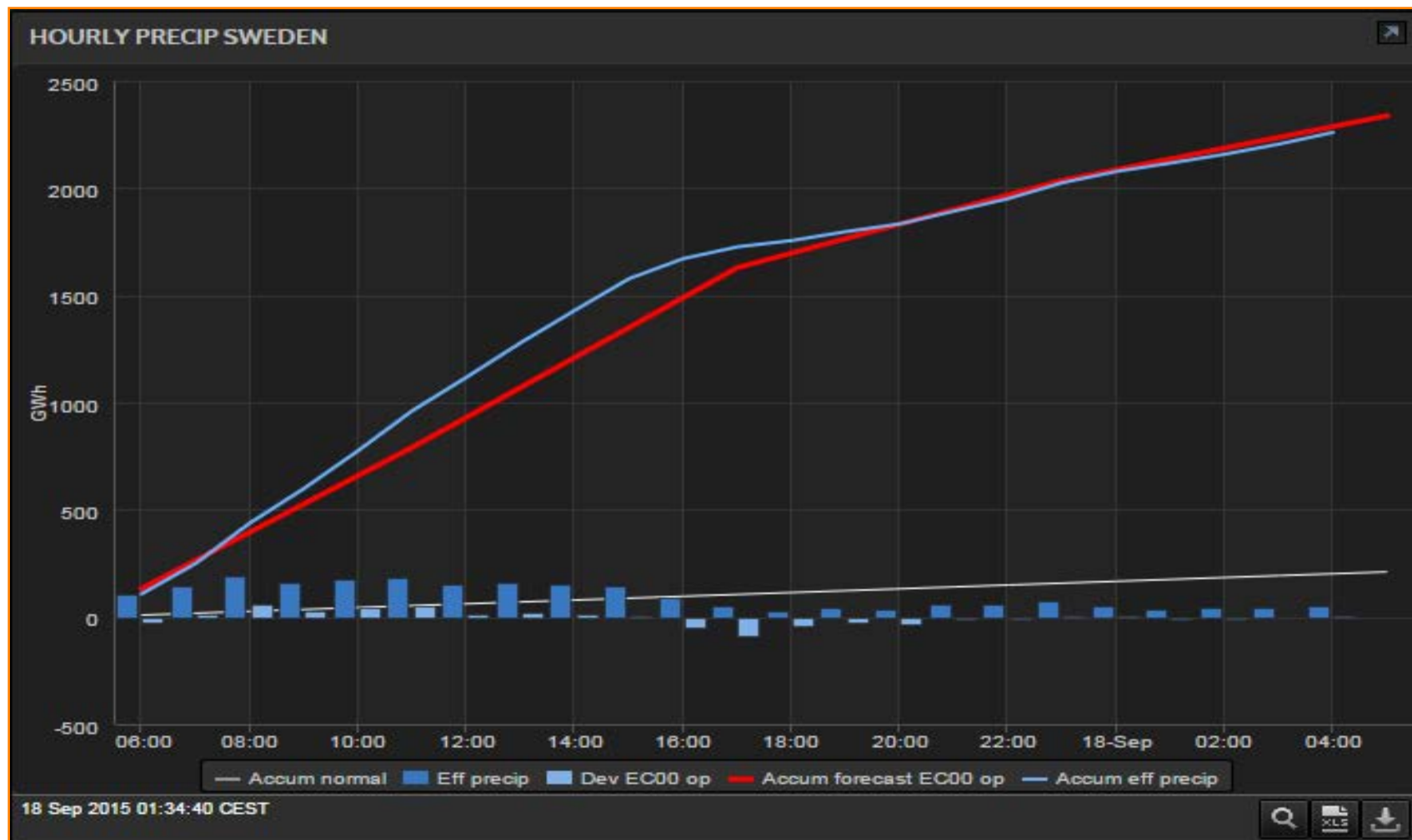
Commodities Research & Forecasts – 18.09.2015

Power Nordic Hourly Precipitation Norway



Commodities Research & Forecasts – 18.09.2015

Power Nordic Hourly Precipitation Sweden



Commodities Research & Forecasts – 18.09.2015

Power Nordic - Totally for week 38 2015

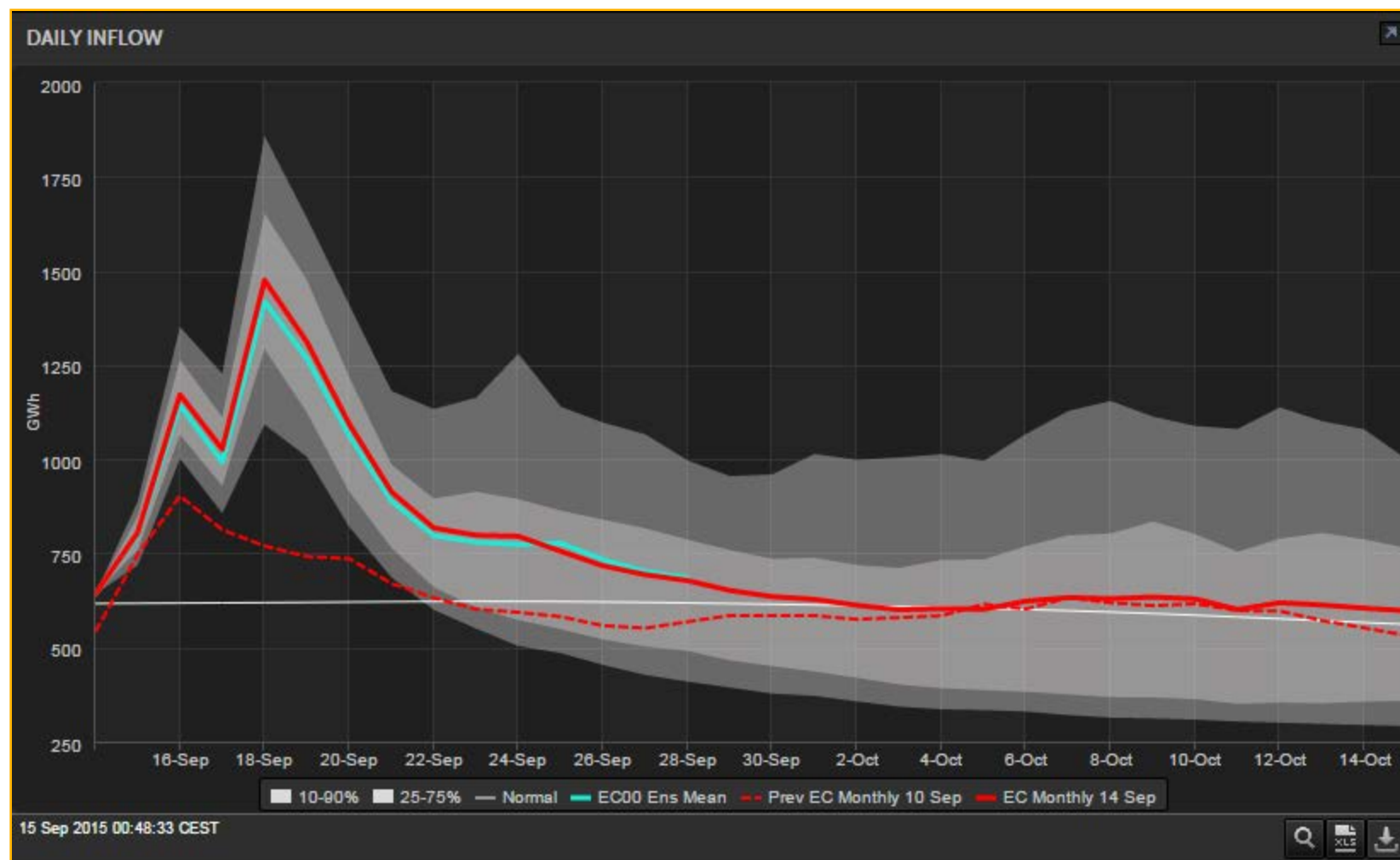
WEEKLY KEY FIGURES, NORD POOL, TWH					
		Eff Precip	Dev Norm	Net Inflow	Dev Norm
Actual	34 2015	-3.1	-6.9	5.32	0.8
Actual	35 2015	10.2	6.1	6.77	2.4
Actual	36 2015	5.4	1.1	5.03	0.7
Actual	37 2015	0.2	-4.3	2.94	-1.4
Forecast	38 2015	12.2	7.5	7.10	2.8
Forecast	39 2015	3.3	-1.6	4.84	0.5
Forecast	40 2015	4.3	-0.8	4.30	0.0
Forecast	41 2015	5.7	0.5	4.62	0.5
Forecast	42 2015	4.7	-0.7	4.05	0.1
Forecast	43 2015	5.2	-0.2	3.66	0.0
Forecast	44 2015	6.4	1.0	3.69	0.2
17 Sep 2015 11:27:03 CEST					



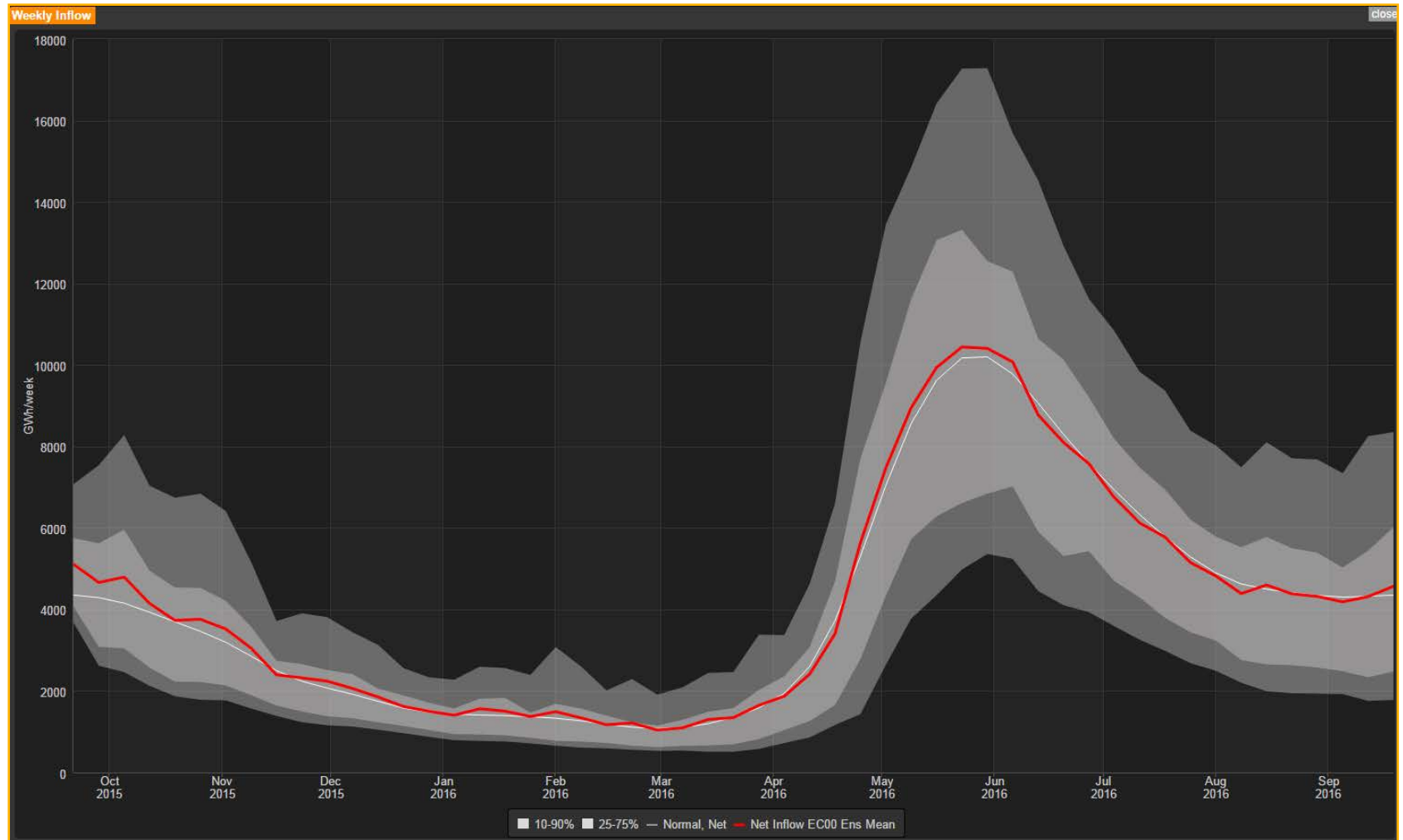
Input: 128 unique weather stations



Commodities Research & Forecasts – Daily Inflow Nordic Forecast 30 Days



Commodities Research & Forecasts – Daily Inflow Nordic Forecast Long Term 52 weeks



Measuring "Power Energy"



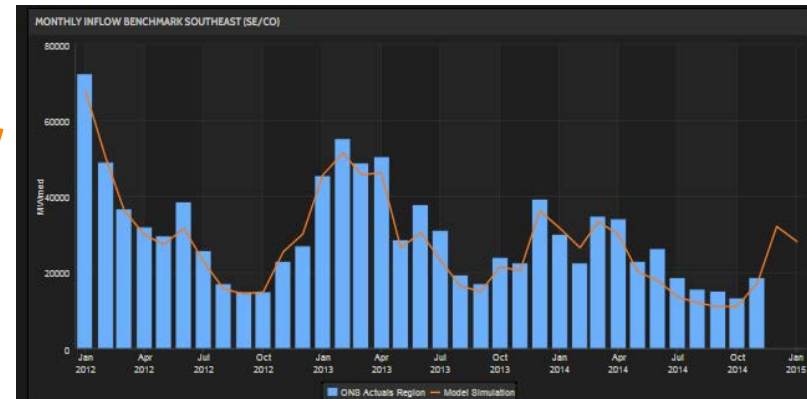
How target series are generated

- Building target values (series) for the hydro model to be calibrated on is one of the most **important** and in many cases most difficult and time consuming part (50%).
- Relevant GWh number being officially presented (weekly/daily):
 - For instance Sweden, Norway, Finland and Switzerland
 - Inflow numbers broken down into daily numbers using discharges profiles
- Some energy numbers can be calculated using information collected from (several) official sites of the individual power plants.
- If very little (energy) data available we use of official yearly or monthly production numbers and make numerous of assumption



Hydrological Model Results

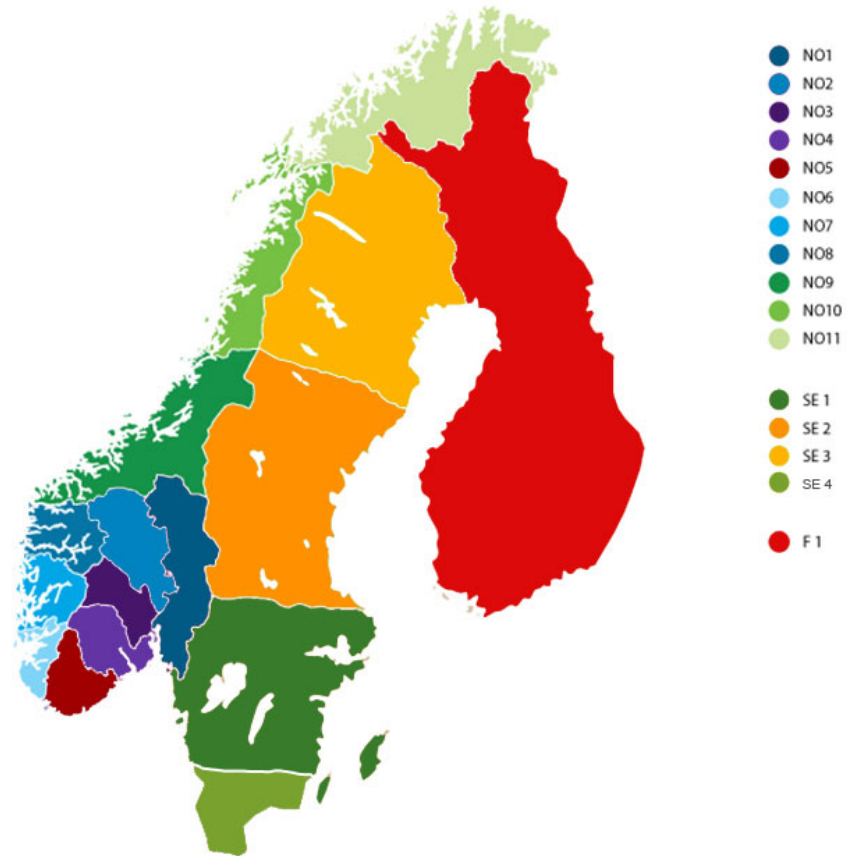
- All Results In Energy (GWh & MWh)
- Hydro Balance, Inflow, Precipitation, Evapotranspiration, Soil Water...
- Simulations from 1981 with Daily Resolution
- Forecasts for Short and Long term (1 yr)
- Ensemble Forecasting
- Models the Natural Inflow



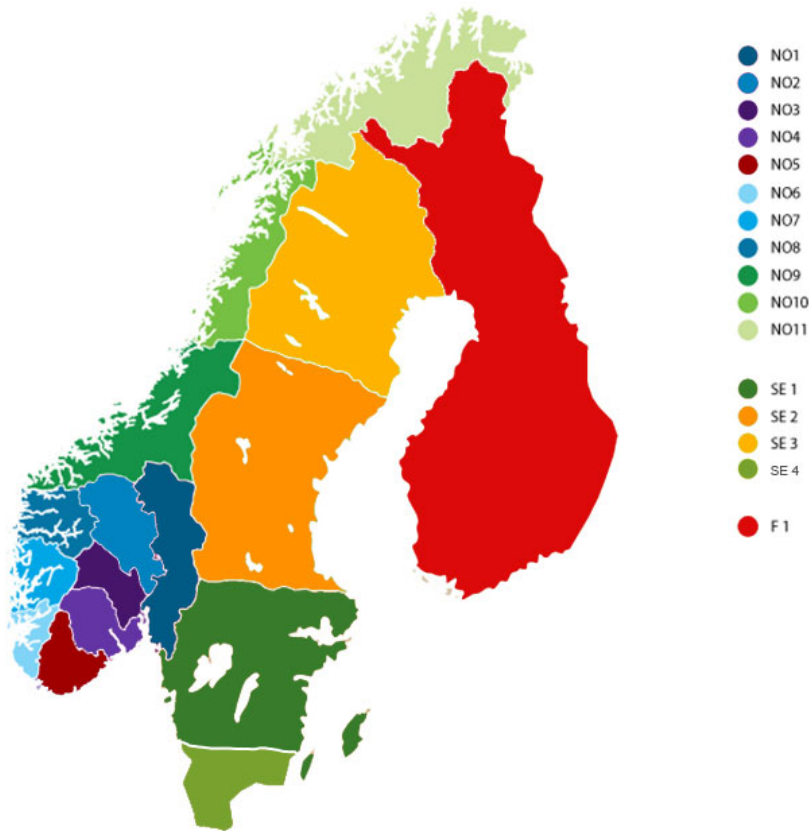
SDDP

A fundamental market model for the Nord Pool area

- SDDP calculates optimal hydro power generation in 16 different areas given:
 - Stochastic future inflow
 - Expected power consumption
 - Thermal production capacity
 - Fuel prices
 - Interconnection capacities
 - etc
- Output:
 - Power prices in different areas
 - Production
 - Exchange (imp/exp)
 - Reservoir levels
 - etc

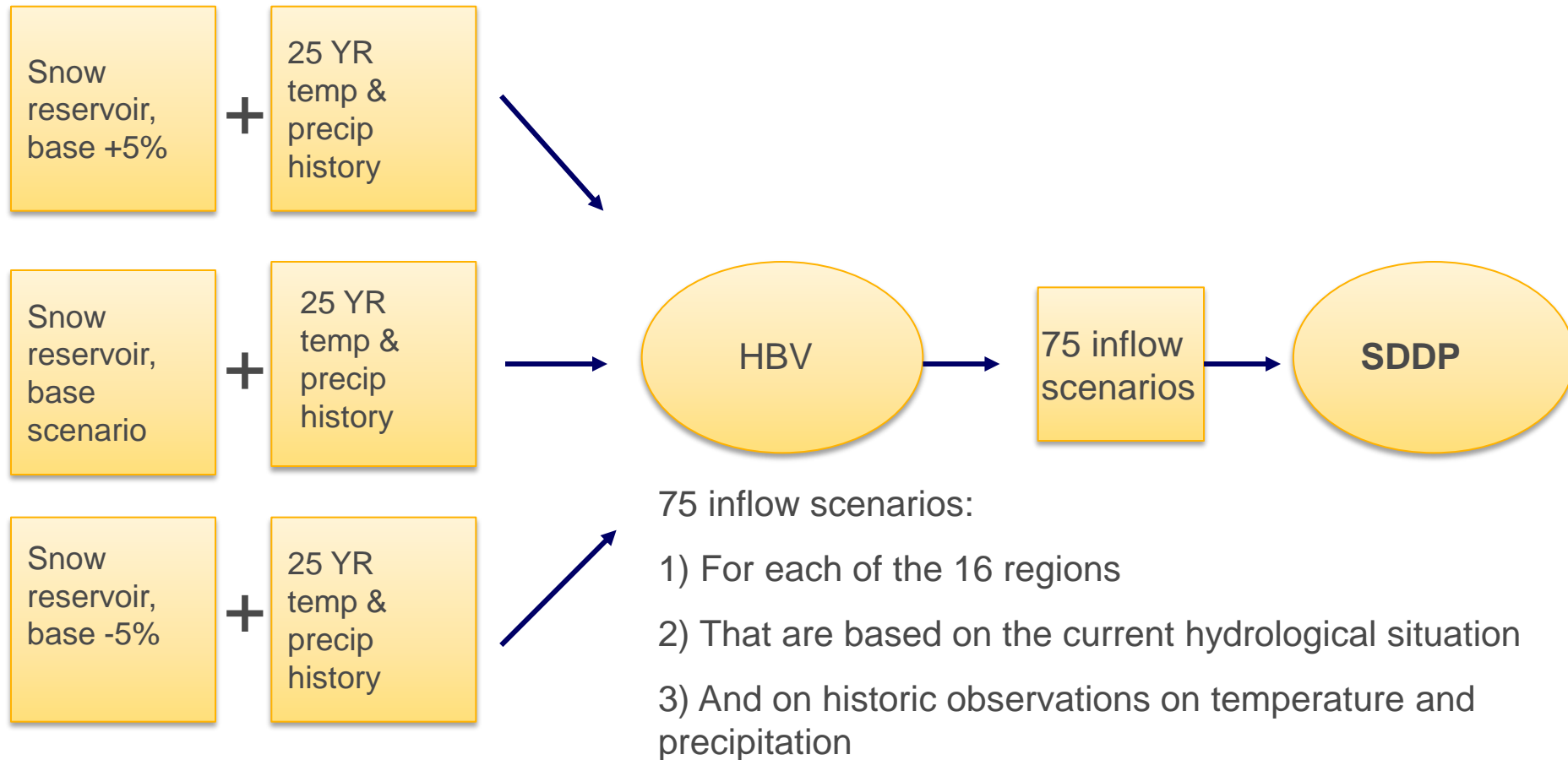


SDDP hydrology modelling



- 16 hydrological regions
 - 11 regions in Norway
 - 4 in Sweden,
 - 1 in Finland
- Inflow:
 - 75 inflow scenarios generated from HBV modelling system used for the first months
 - Thereafter historic inflow series 1931-2005

Linking HBV and SDDP



Publication Schedule

	Mon	Tue	Wed	Thu	Fri
Quarter and Year Ahead comment	07:35	07:35	07:35	07:35	07:35
Day Ahead comment	07:55	07:55	07:55	07:55	07:55
Afternoon comment	14:00	14:00	14:00	14:00	14:00
Week ahead comment	14:30	14:30	14:30	14:30	14:30
Weekly Report				14:30	
SDDP report		12:00		12:00	
Cross commodity report	12:00				
Hydrology comment	14:00			14:00	
Met comment morning Georg Müller	07:45	07:45	07:45	07:45	07:45
Met comment afternoon Georg Müller	14:00	14:00	14:00	14:00	14:00
Met comment SMHI	09:30	09:30	09:30	09:30	09:30
Georg Müller Live	11:00	11:00	11:00	11:00	11:00

Quarterly benchmark reports are published approx 2 weeks after the quarter has ended.

Long term price reports are published twice a year.

Seasonal weather forecast is published around the 9th every month.



Other SDDP assumptions

- Consumption
 - 4 load levels for each week
 - Based on normal (1981-2005) temperatures
 - Consumption slightly price elastic for prices above €70/MWh
- Other supply
 - Complete stack for the Nordic region
 - Coal, Gas, Oil, CHP, Nuclear, Wind
 - Using forward curves for fuel prices
- Import/export outside Nord Pool
 - Direction determined by price difference
 - Using forward curves for EEX and APX



The SDDP mid-term price forecast

- Published twice per week
- Covers **front week, month, quarter** and **year**
- Fundamental optimization model
- Reflects state of hydrologic and thermal situation
- Produces 160 scenario paths



Mr Gekko vs SDDP



"It's not about the money - It's about the game." -
Gordon Gekko



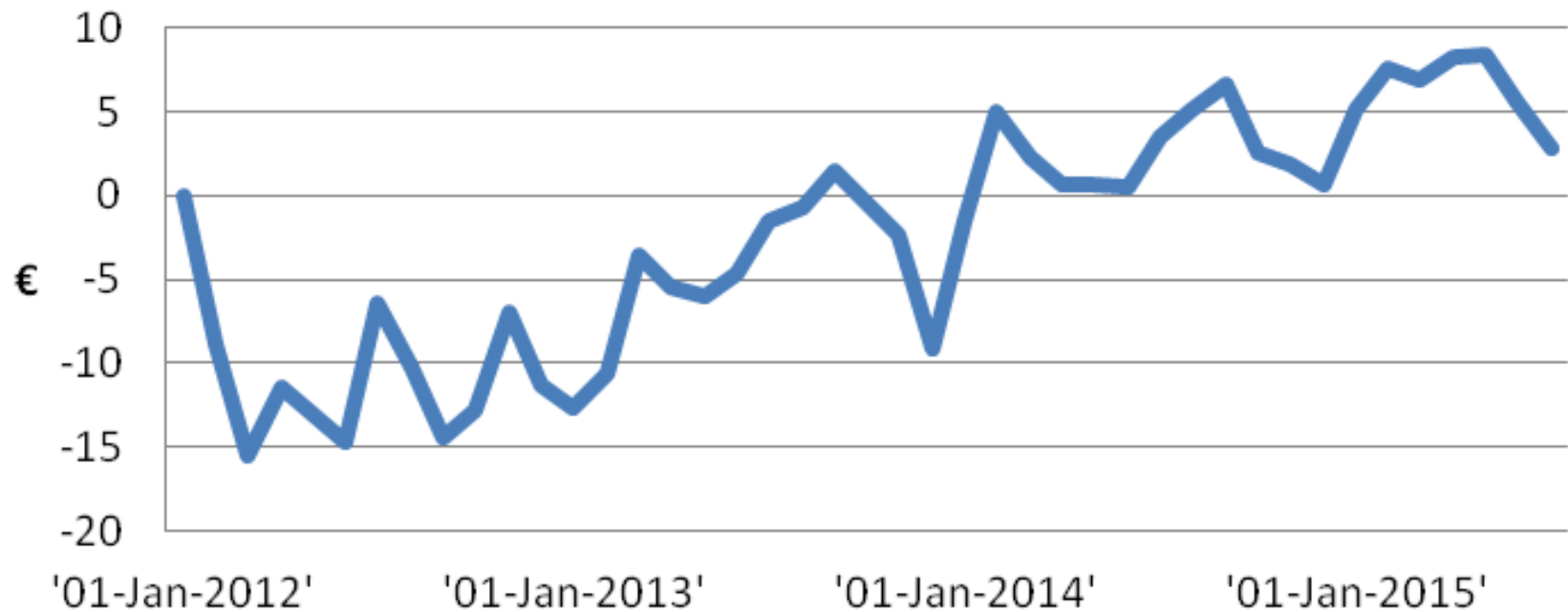
SDDP Benchmark Methodology

- Compares the results of the model at some point in time before a traded contract delivery period to the market prices for that contract at the time and the actual delivery prices for the contract period.
- If the **model indicates the correct direction of the actual**, delivered prices relative to the market, it is recorded as a positive gain and the difference between the market and the delivery is added to a cumulative measure of profit and loss (P'n'L).
- It is assumed that a **position of 1 MWh** is made in the market based on the signal provided by the SDDP model in the last model run before delivery.



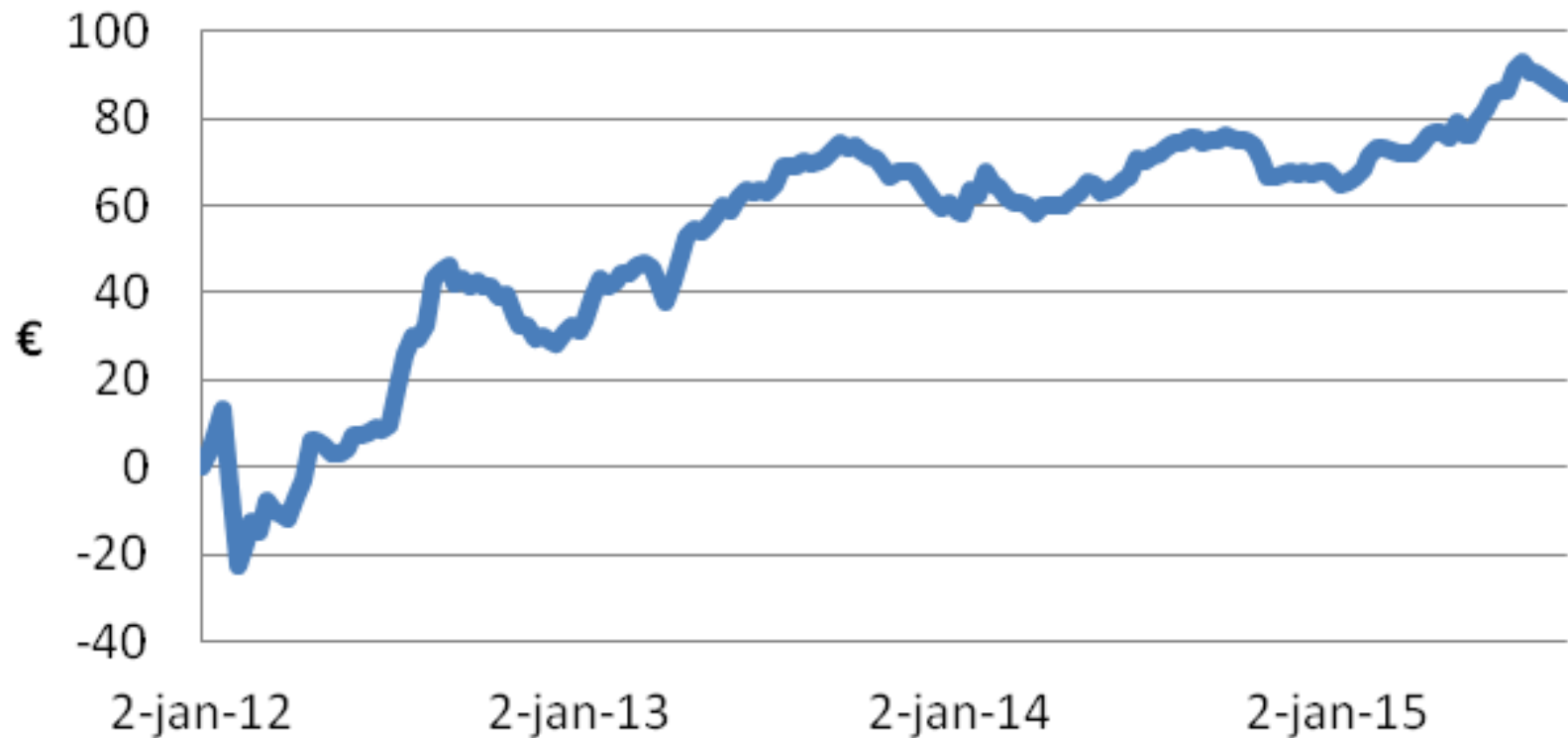
SDDP Front Month Benchmark

Cumulative P'n'L



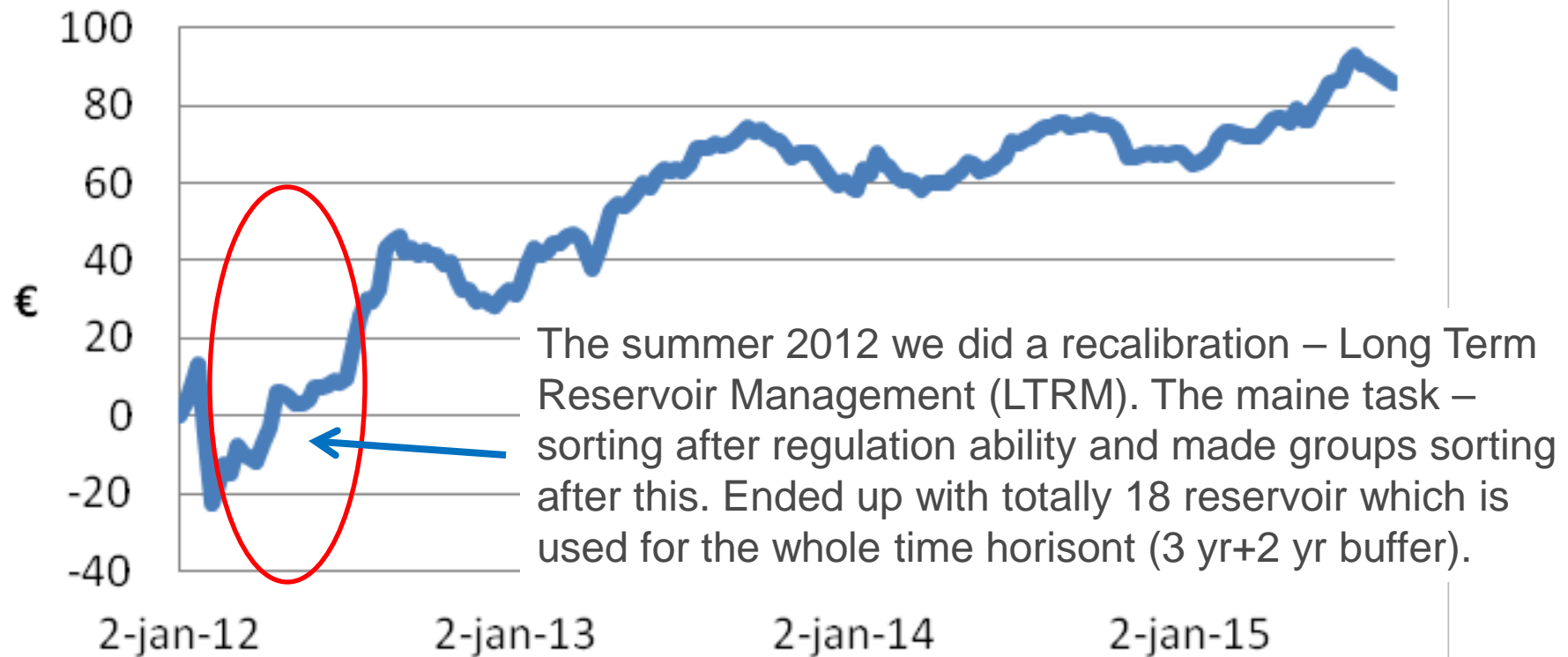
SDDP Front Week Benchmark

Cumulative P'n'L



SDDP Front Week Benchmark

Cumulative P'n'L



SDDP Performance

- It can be argued that for the shorter contracts (week, month), this does not show the long-term predictability, but we are comparing to the market price – so it's a fair measure of the accuracy.
- These results are achieved without any manual adjustments of results
 - Results presented are raw model output
 - No re-runs
 - No reservoir guidelines
 - Follows calculated optimal dispatch



Scenario Explorer Explained

- Key Concepts
 - The SDDP mid-term price forecast
 - SDDP Performance
 - Scenario Paths
 - Correlations and Sensitivities
- How does it work?
 - It show correlations and sensitivities in our forecast data in a simple and intuitive way

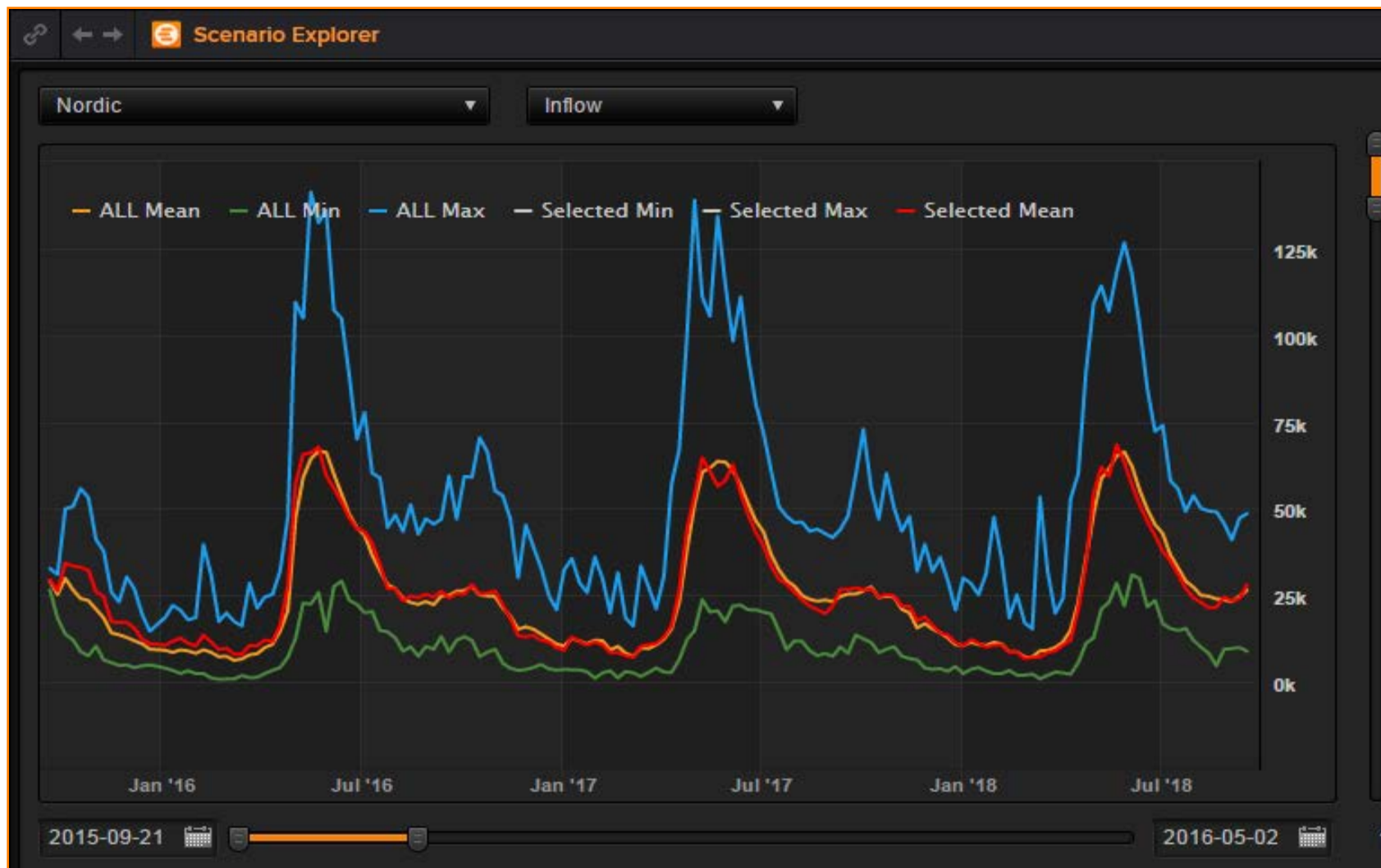
SCENARIO EXPLORER



SCENARIO EXPLORER



SCENARIO EXPLORER



SCENARIO EXPLORER



SCENARIO EXPLORER Help overlay





REUTERS/Yves Herman

CONCLUSION

- The SDDP benchmark has a strong record in general for the Nordic power market
- The Scenario Explorer is a strong tool for doing “What if...” analysis



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Today's quote:

"All models are wrong, but some models are useful"

George Box, 1979



Thank You...



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Thank you

Bjørn Sønju-Moltzau

Manager of Dept. Hydrology and Meteorology - Point Carbon
Commodities Research & Forecasts

Thomson Reuters

Office: +47 23 31 64 82

Mobile: +47 97 78 10 10

bjorn.sonju-moltzau@thomsonreuters.com

thomsonreuters.com

