

A high-speed photograph of water splashing, creating a dynamic, blue-toned background. The water is captured in mid-air, with various droplets and streams visible against a light blue sky.

E-CO Energi as

Role of the Hydropower responding to Variable Renewable Energies

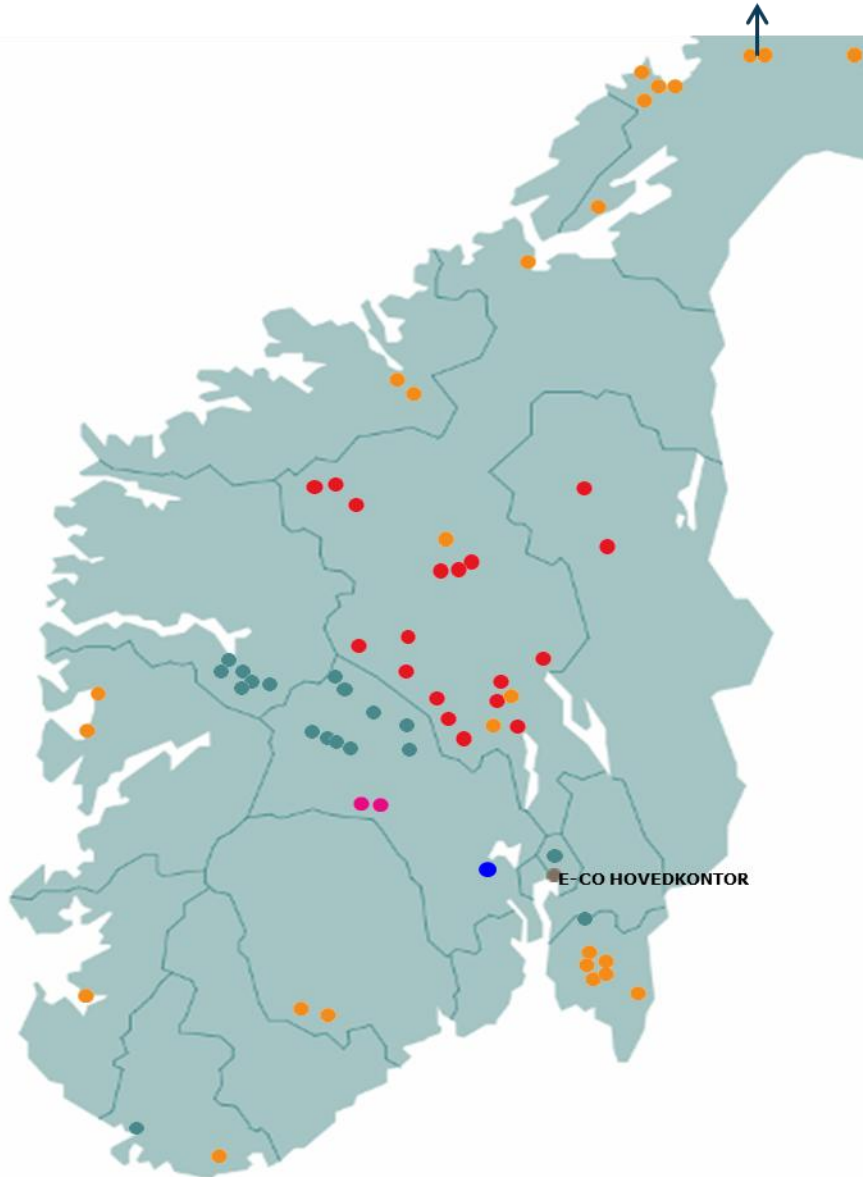
*Introducing a Pump Storage Power plant in an
existing regulated river system in Aurland
Norway.*

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VP Business Development
Oslo, Norway**

Agenda

- About E-CO
- The Power Market
- The existing regulated system in Aurland
- The Vesterdalen hydro pump storage project
- Conclusions

Norway's second largest power producer

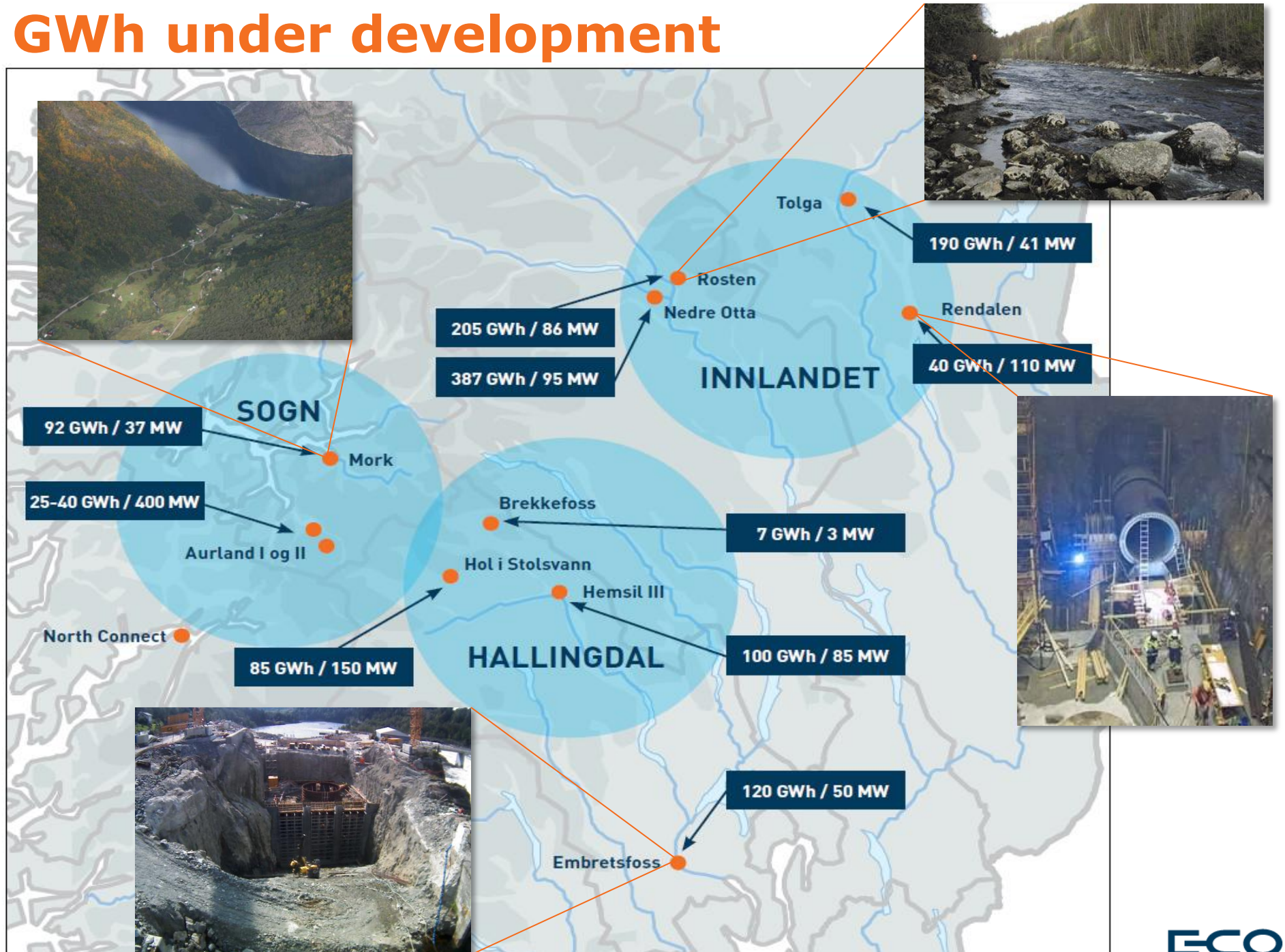


~10 TWh in production
~1 TWh under development

- Owned by the City of Oslo
- E-CO owns and/or operates more than 60 power plants throughout southern Norway
- 170 employees
- Net profit MEuro 130 (2011)

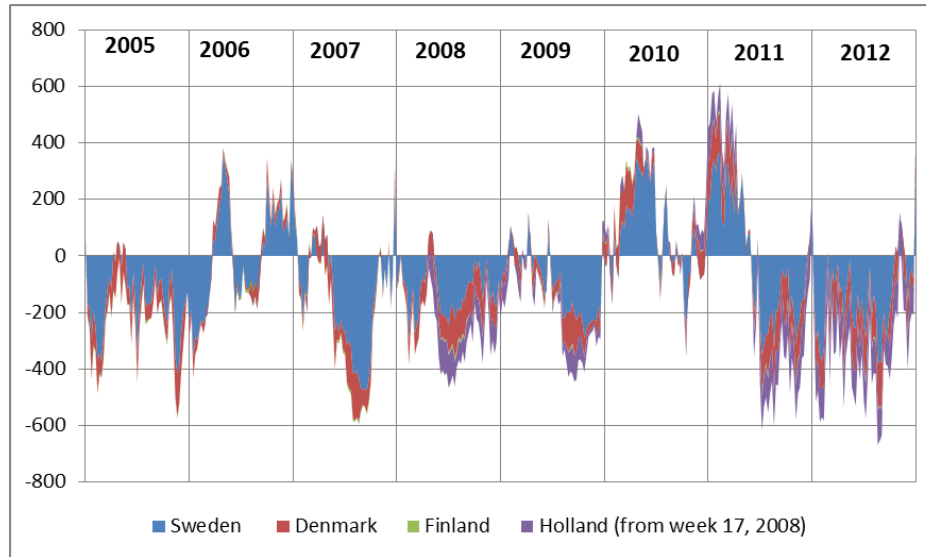
- **E-CO**
E-CO Energi Holding owns E-CO Energi and Oslo Lysverker 100 %
- **Oppland / Hedmark**
E-CO owns Oppland Energi 61,4 %, Vinstra Kraftselskap 66,7 % and Opplandskraft 40 %
- **Norsk Grønnkraft**
E-CO owns 25 %
- **Uvdal I og II**
E-CO owns 10%
- **Embretsfossverkene DA**
E-CO owns 50%

1000 GWh under development



Nordic Power Market

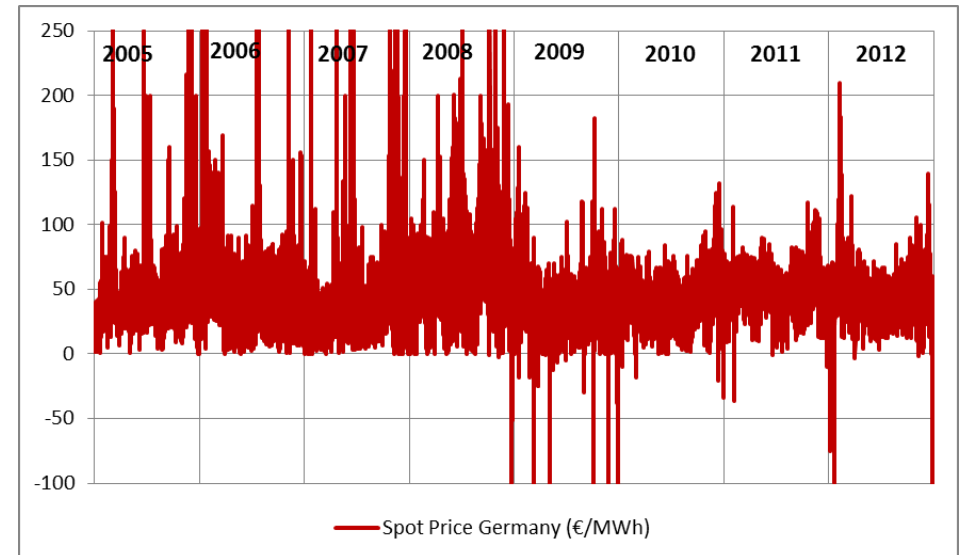
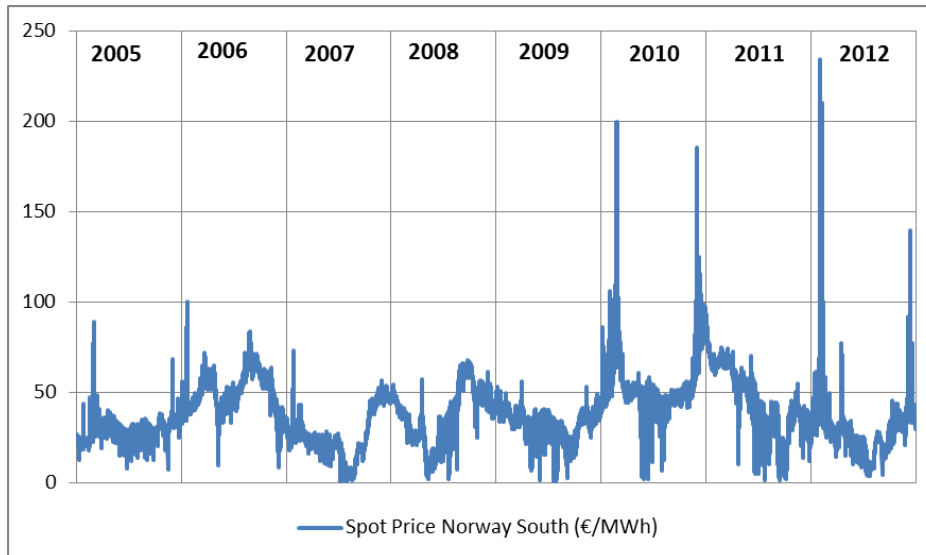
Exchange in accordance with price



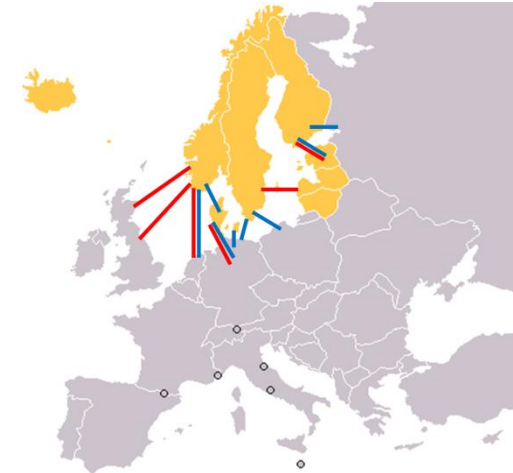
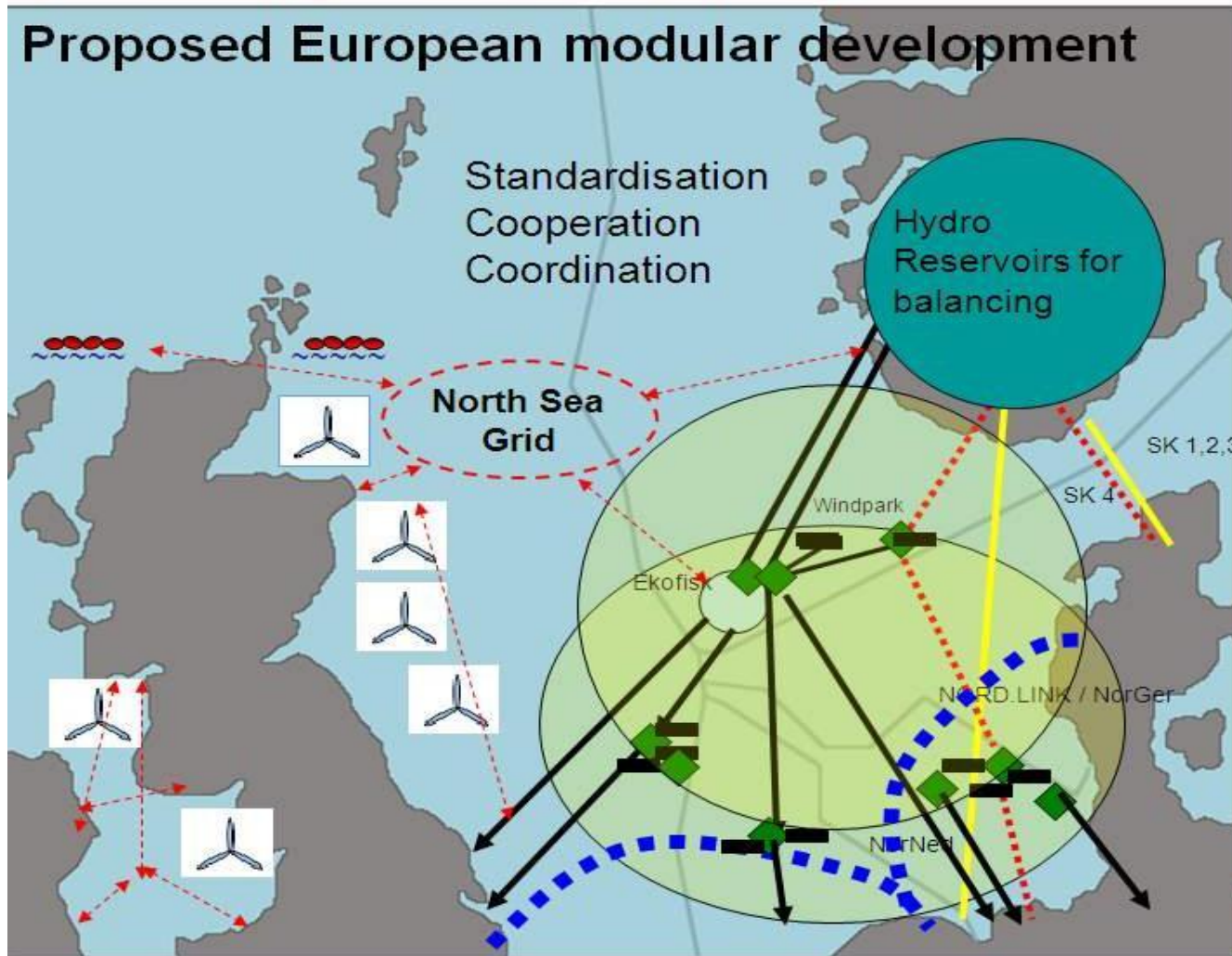
General picture:

High price i Norway:
Import (+)

Low price in Norway:
Export (-)



A vision: Norway as a battery for Europe



Existing and planned interconnectors

Large degree of wind power will result in price fluctuations

Wind power can be balanced with Norwegian hydro power or local gas power

Potential – Hydro pump storage plants

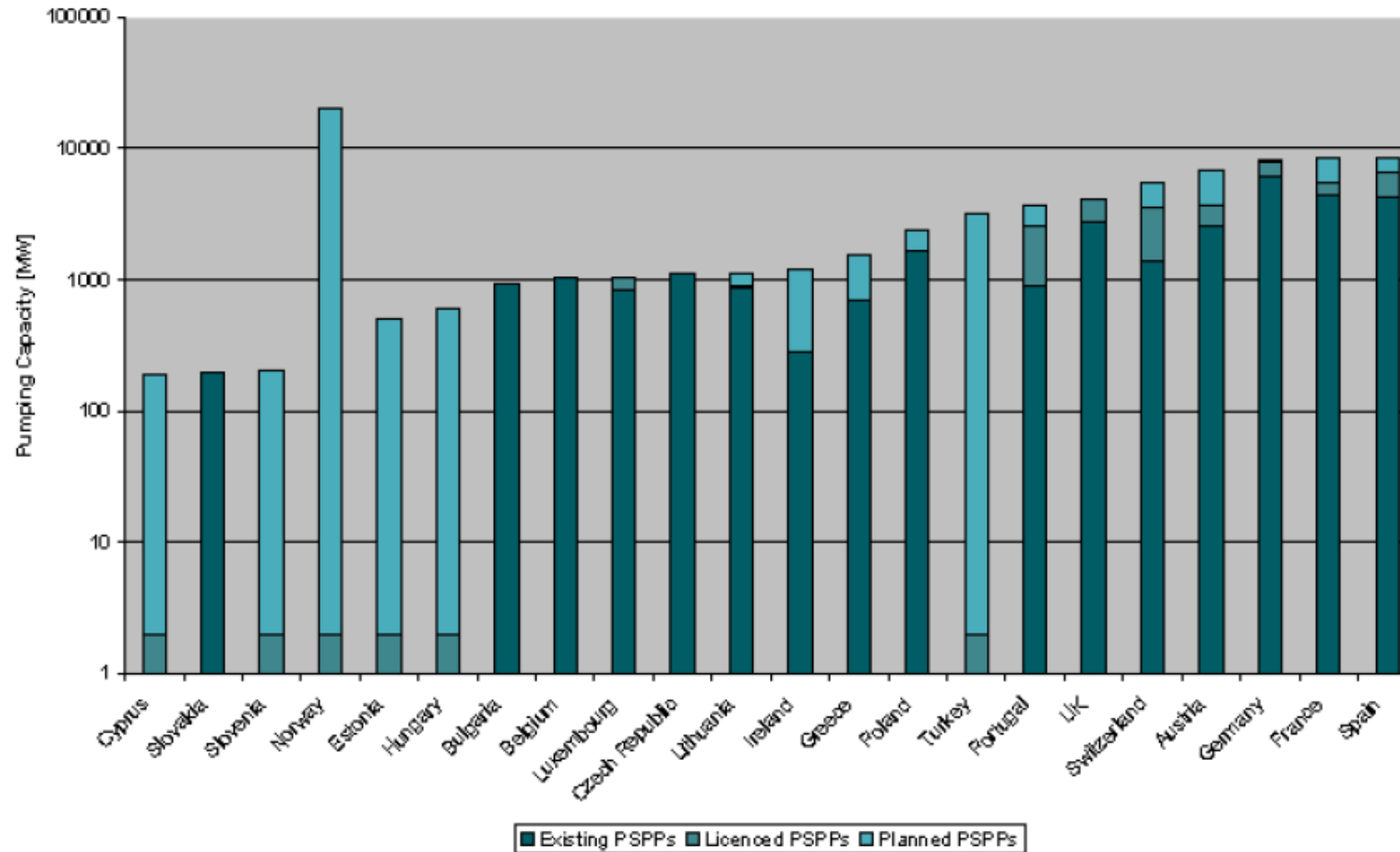


Fig. 7 Installed pumped storage capacities, licensed pumped storage capacities and capacities of pumped storage projects in early planning stage (LOGARITHMIC SCALE), MW

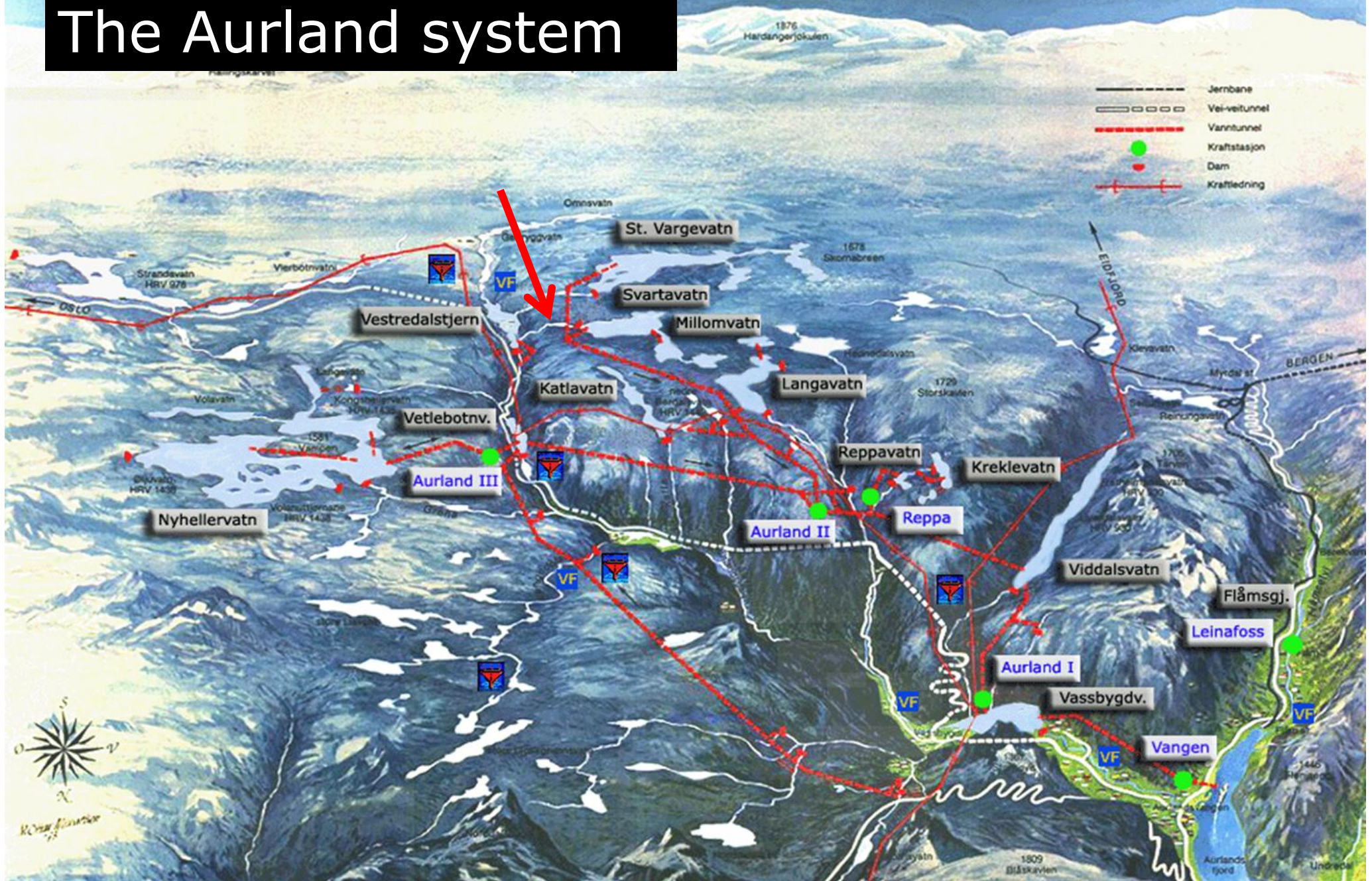
Source: EURELECTRIC¹⁸

Why Hydro Pump Storage Plants?

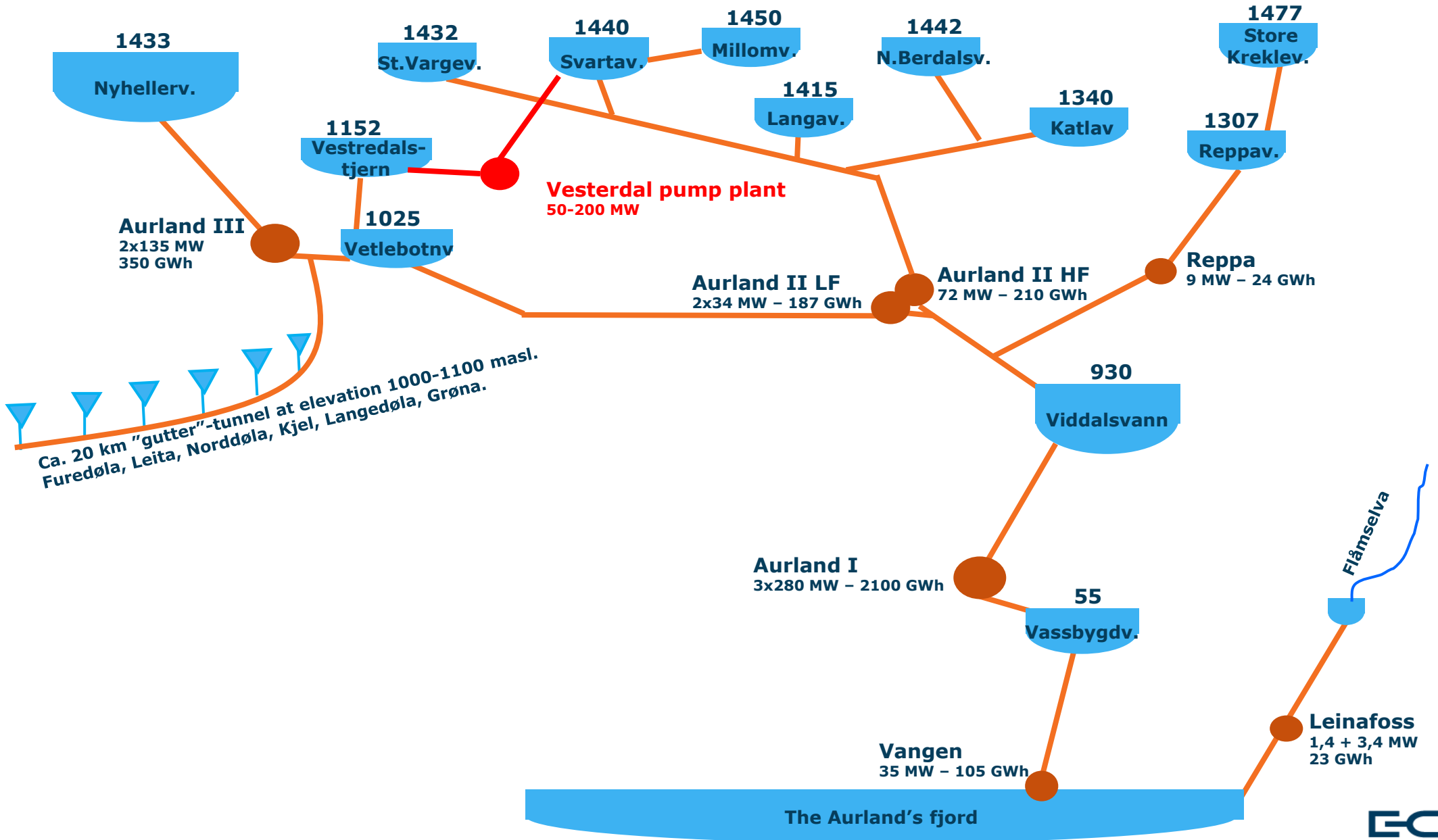
- Market development
 - Stronger interconnectors
 - More intermittent renewables in Europe – wind and solar
 - Higher price variations is expected
 - An increasing need for balancing power in neighboring countries
- Development of hydro pump storage plant will take long time
 - Long term view – 10-25 years
 - Thorough concession process
 - Option strategy



The Aurland system



Power facilities in Aurland



Vesterdalen Hydro Pump Storage Plant

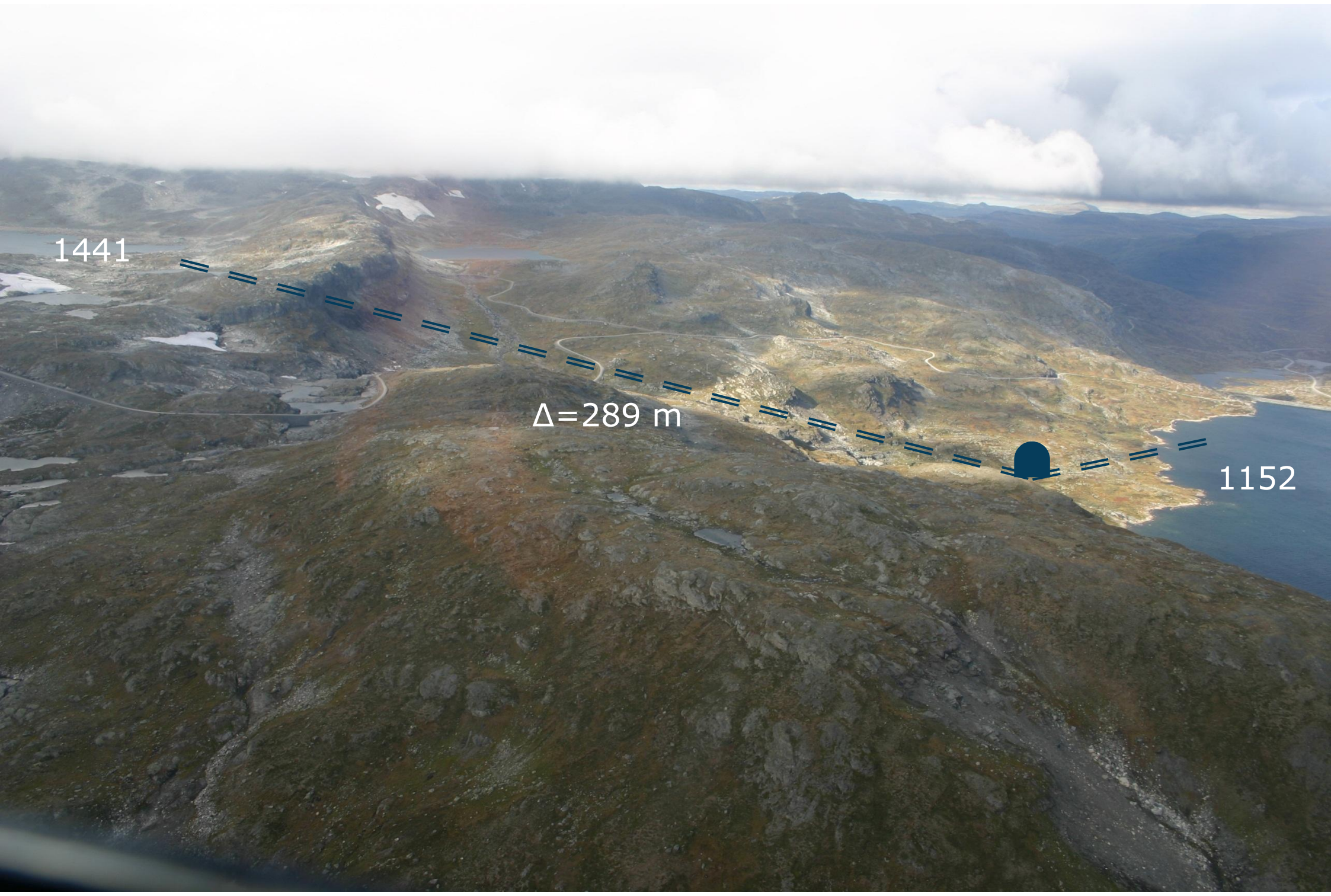
- Existing
 - Upper reservoir Svartvatn: 58 Mm³
 - Yearly inflow 15 Mm³
 - Lower reservoir Vesterdalstjern: 37 Mm³
 - Yearly inflow: 110 Mm³
- Future?
 - Pump station in mountain with installed power between 50 to 200 MW
 - 2910 m waterway (tunnels)
 - Investment estimate (excl. financing/design)
 - 50 MW: 250 MNOK (5 mill kr/MW)
 - 100 MW: 300 MNOK (3 mill kr/MW)
 - 200 MW: 500 MNOK (2,5 mill kr/MW)



1441

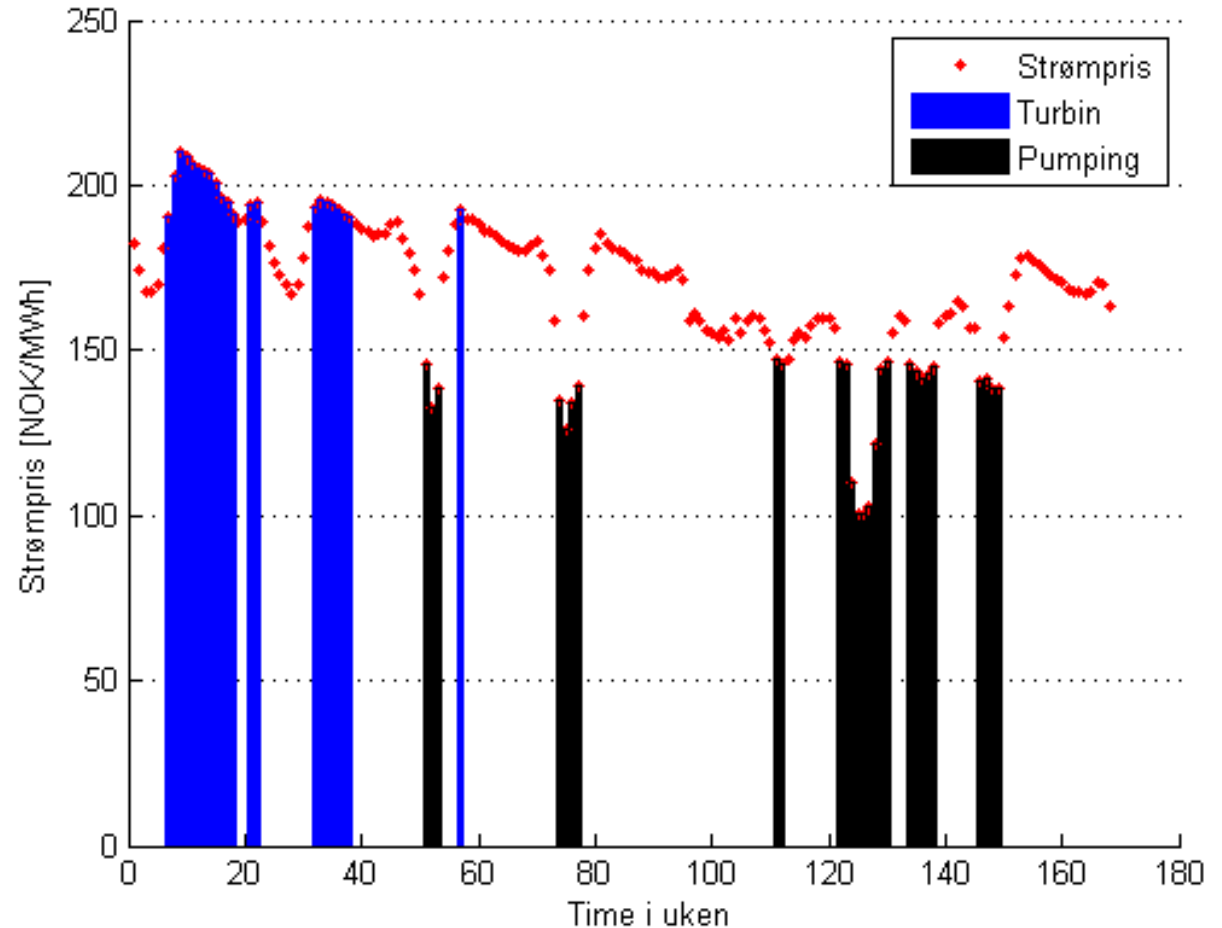
$\Delta=289$ m

1152



Income

- Price difference between periods with pumping and production
 - Long term (months)
 - Short term (daily/weekly)
- Less water loss in the regulated river system
- Savings in pumping in downstream hydro power pump plant (AU 3)
- Increased production in AU 2 HF power plant (existing station)



Week 17, 2009

Profits of this case

$$\frac{p_t}{p_p} > \frac{1 + \frac{h_f}{H}}{\eta_p \cdot \eta_p \cdot (1 - \frac{h_f}{H})}$$

f	50 MW	75 MW	100 MW	150 MW	200 MW
1.0	-12.7	-57.2	-96.4	-161.7	-219.0
1.5	12.4	-19.6	-46.1	-86.1	-177.7
2.0	41.0	26.0	16.3	10.5	13.0
2.5	72.5	76.7	86.3	118.9	159.9

$$NPV = -I + \sum_{i=0}^n \frac{CF_i}{(1+r)^{i'}}$$

- There must be a necessary price difference for pump mode and production mode ...
- Table shows example result from simulations. Year 2009. NPV in MNOK.
- f = price variation
 - f=1,0 this years variation, e.g. 2009
 - f=1,5 means 50% more variation in prices than in 2009
- Overall learnings from simulations for this project
 - NPV increases with higher prices
 - NPV increases with higher price variations
- We need major increased price variations in power price to get an acceptable profit

Conclusions

- Norway has a hydro power system in southern Norway which can be a part of the solution of the challenges in the European power system
- The power market does not bring the necessary incentives to invest in pump storage plants now
- Aurland is good location for building a hydro power pump plant
- We need major increased price variations in power price to get an acceptable profitability
- E-CO may seek to come in the position to invest in the Vesterdalen pump plant within a 10-15 year period



Hydro power is a part of the climate solution

Thank you for your attention!



BE A SUPPORTER OF HYDRO POWER

I tillegg av kull i tillegg til at dette betyr at vi reduserer størst utslipp og et klimautslipp og global oppvarming. Av raskest brent som olje, gass og kull fører til at temperaturen øker. Heldigvis finnes det energi som ikke belastar klimaet. Produksjon av vannkraft gir ikke CO₂-utslipp. Jo mer ren kraft vi produserer i Norge, desto mindre miljøbelastende kraft må det produseres, i Norge og i utlandet. På den måten kan lille Norge bidra til mindre CO₂-utslipp i den store verden.

E-CO er Norges største rene vannkraftprodusent. For hver gigawatttime E-CO øker kraftproduksjonen med, reduseres de globale CO₂-utslippene med 526 tonn (SINTEF). Vi er involvert i prosjekter som vil gi mer enn 600 GWh ny kraft. Det vil redusere CO₂-utslippene med over 300 000 tonn per år.

REN KRAFT. REN VERDISKAPING.

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