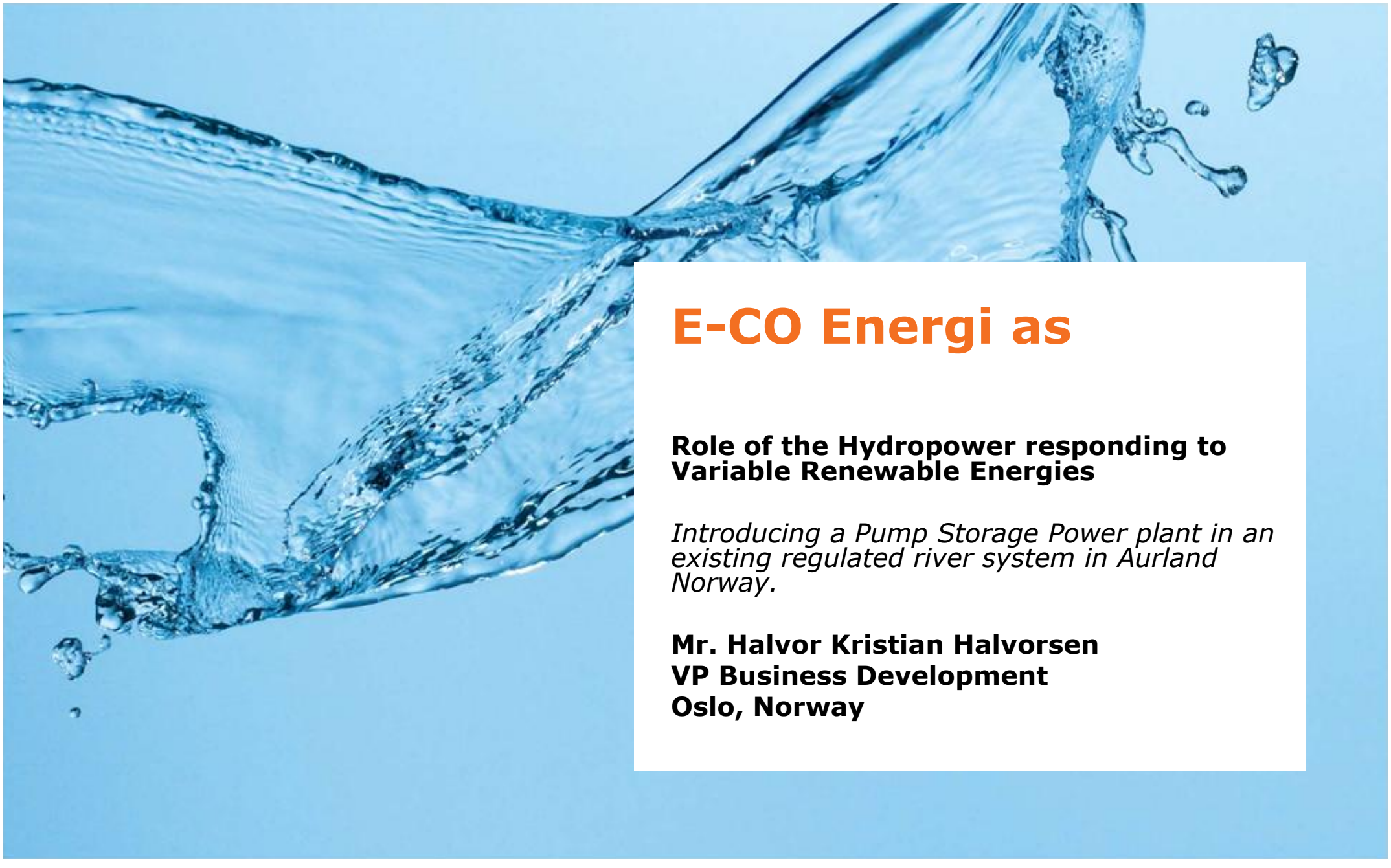


E-CO Energi as

Role of the Hydropower responding to Variable Renewable Energies

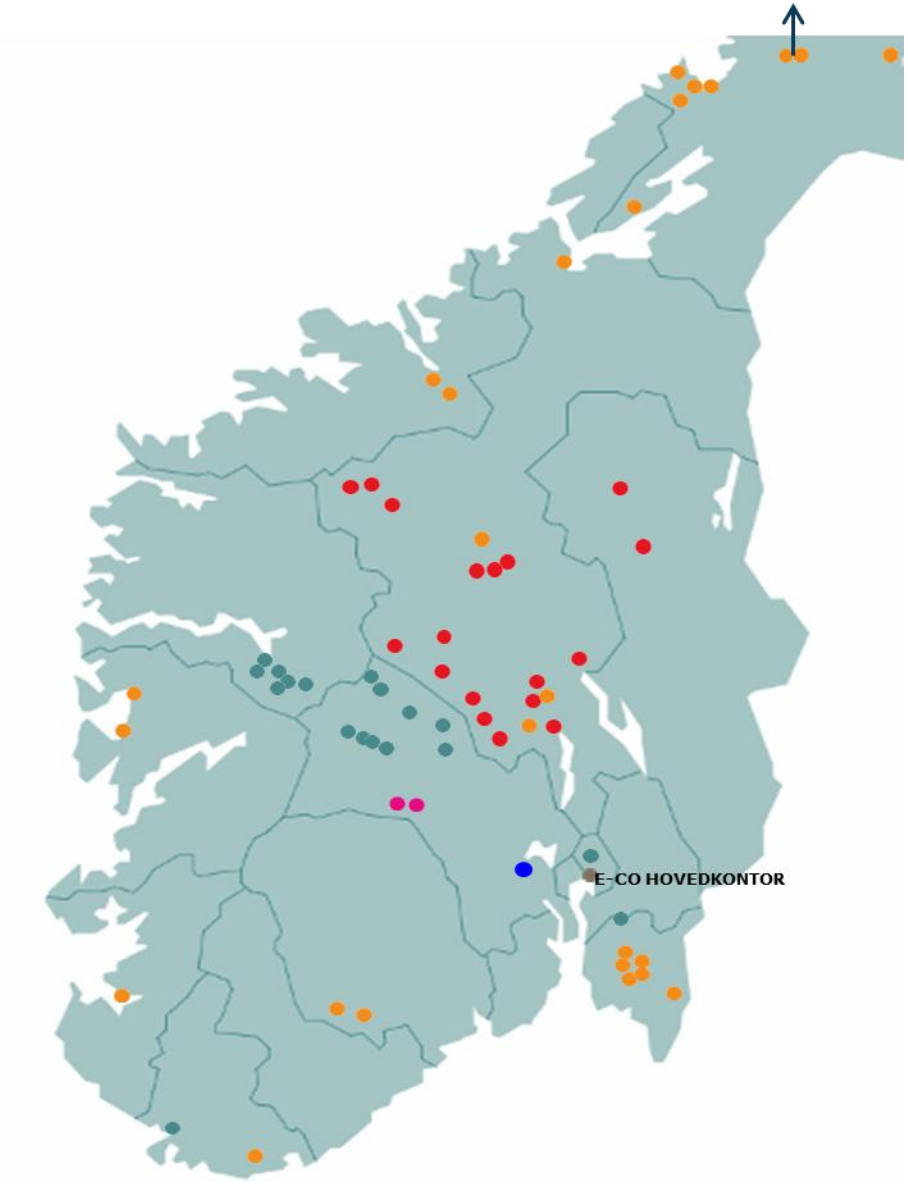
Introducing a Pump Storage Power plant in an existing regulated river system in Aurland Norway.

Mr. Halvor Kristian Halvorsen
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

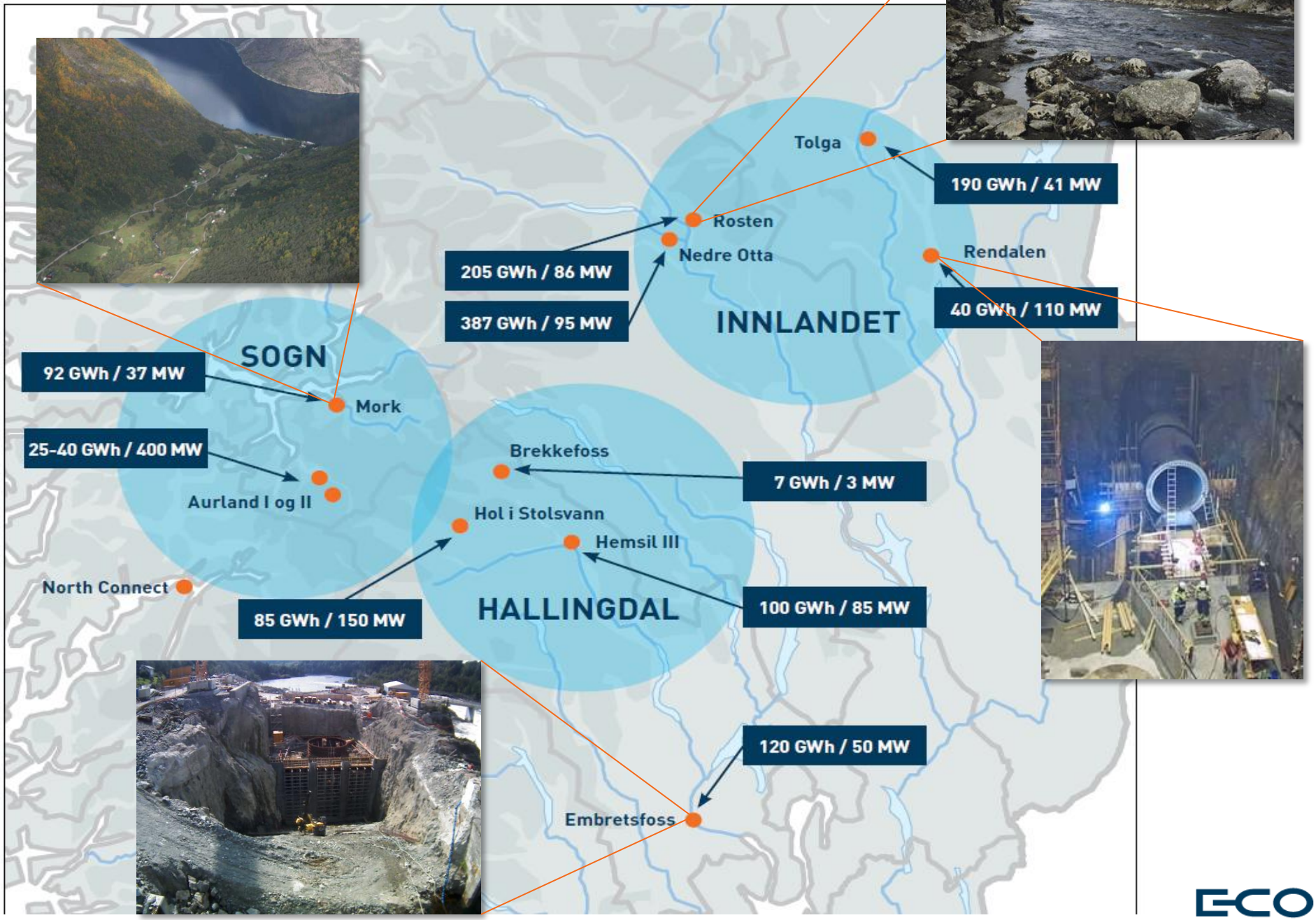


~10 TWh in production
~1 TWh under development

- 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)

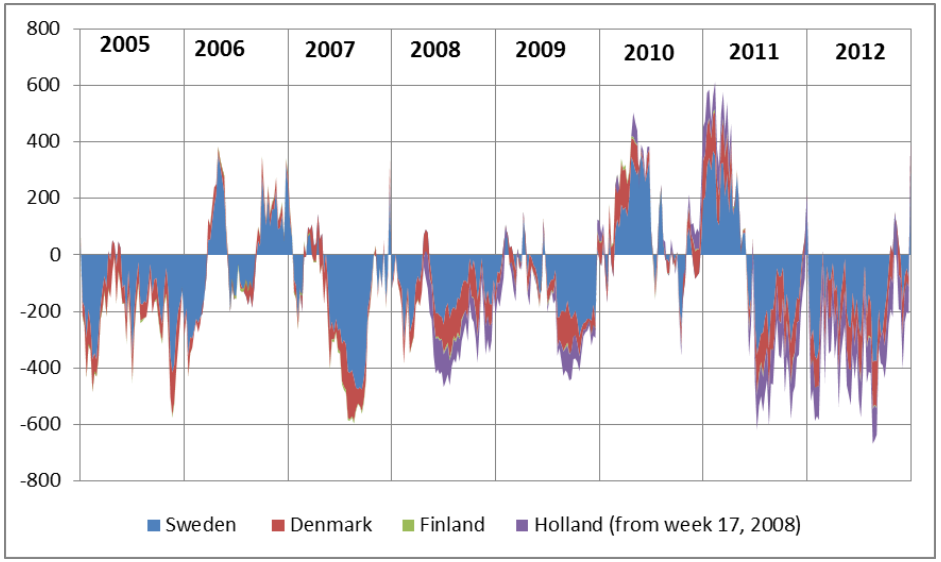
- **E-CO**
  E-CO Energi Holding owns E-CO Energi and Oslo Lysverker 100 %
- **Oppland / Hedmark**
  E-CO owns Oppland Energi 61,4 %, Vinstra Kraftselskap 66,7 % and Opplandskraft 40 %
- **Norsk Grønnkraft**
  E-CO owns 25 %
- **Uvdal I og II**
  E-CO owns 10%
- **Embretsfossverkene DA**
  E-CO owns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

1000 GWh under development



Nordic Power Market

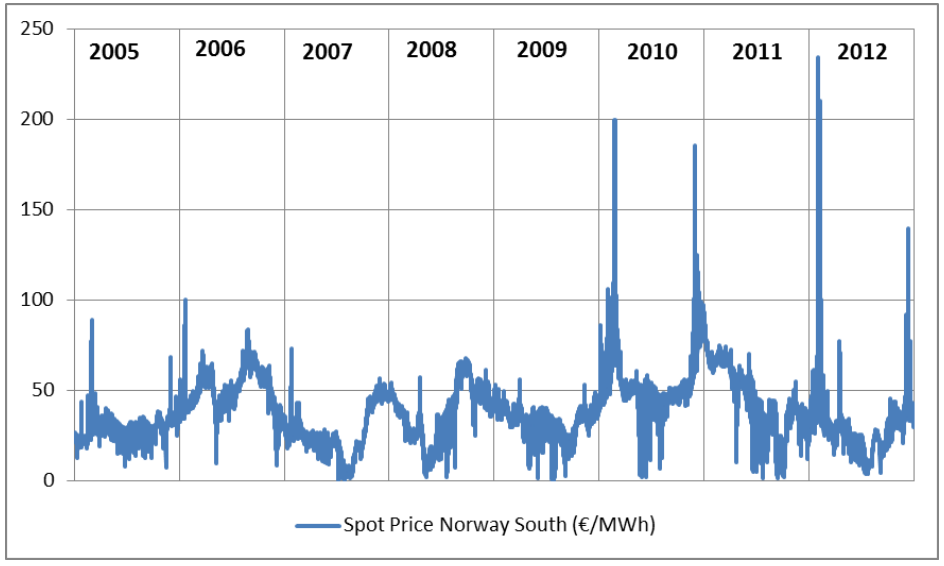
Exchange in accordance with price

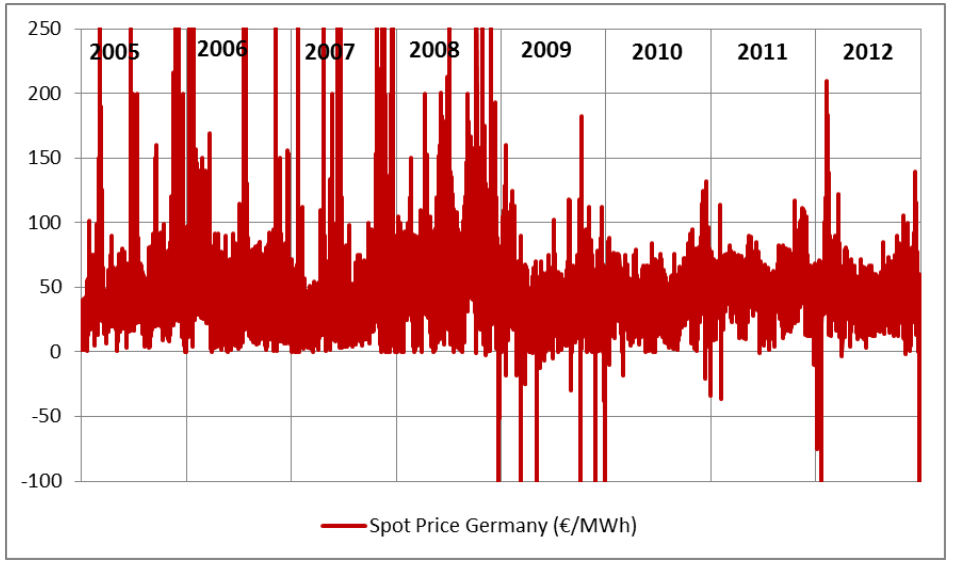


General picture:

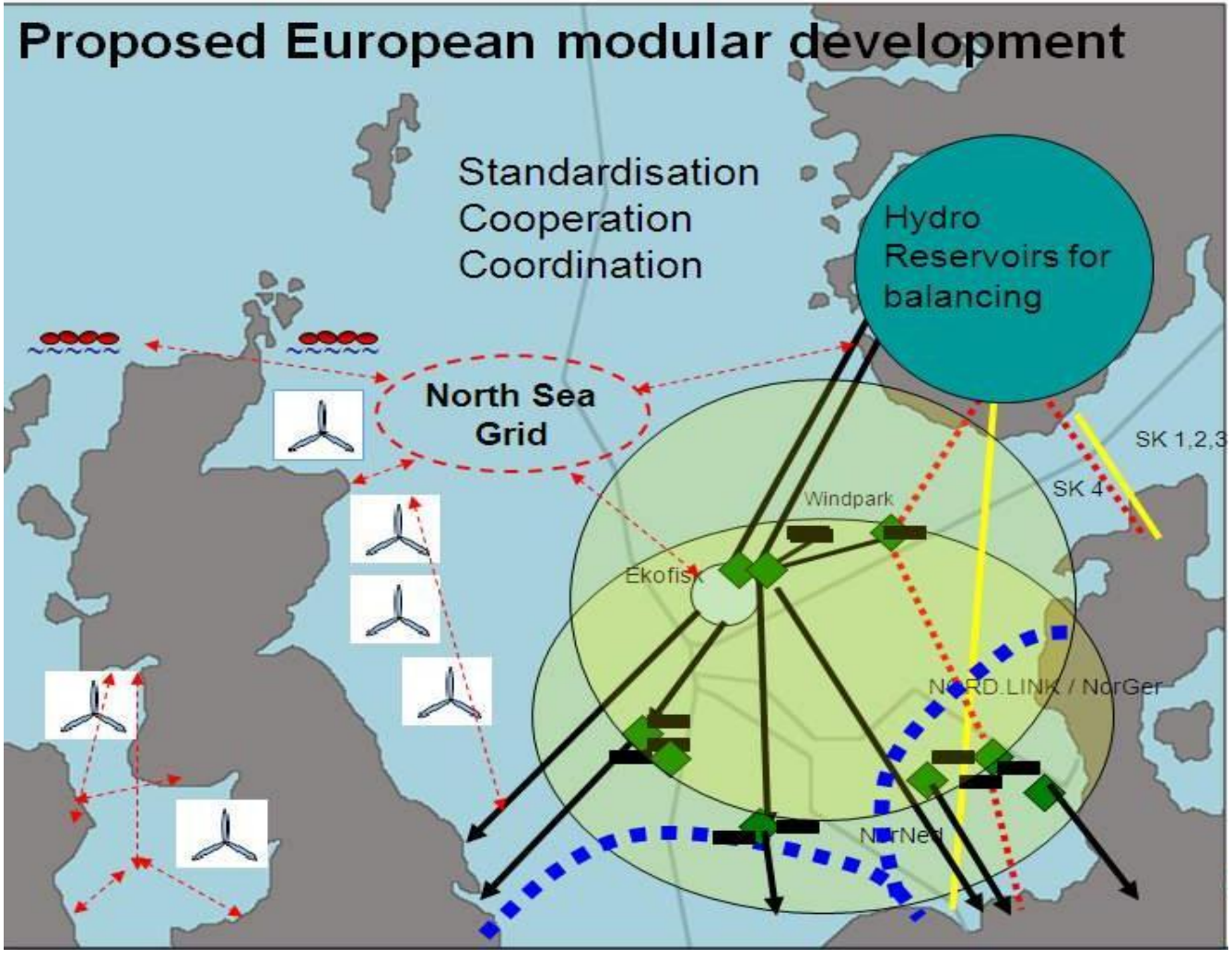
High price i Norway:
Import (+)

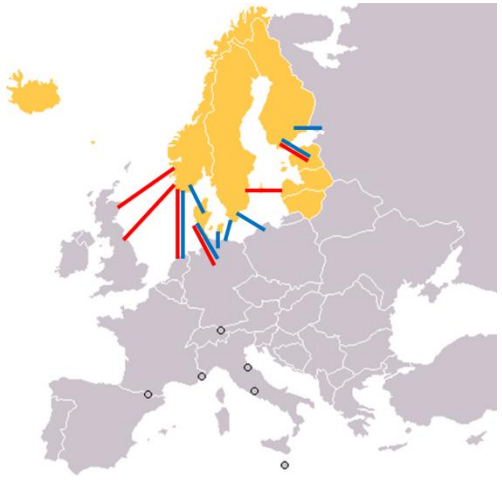
Low price in Norway:
Export (-)





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

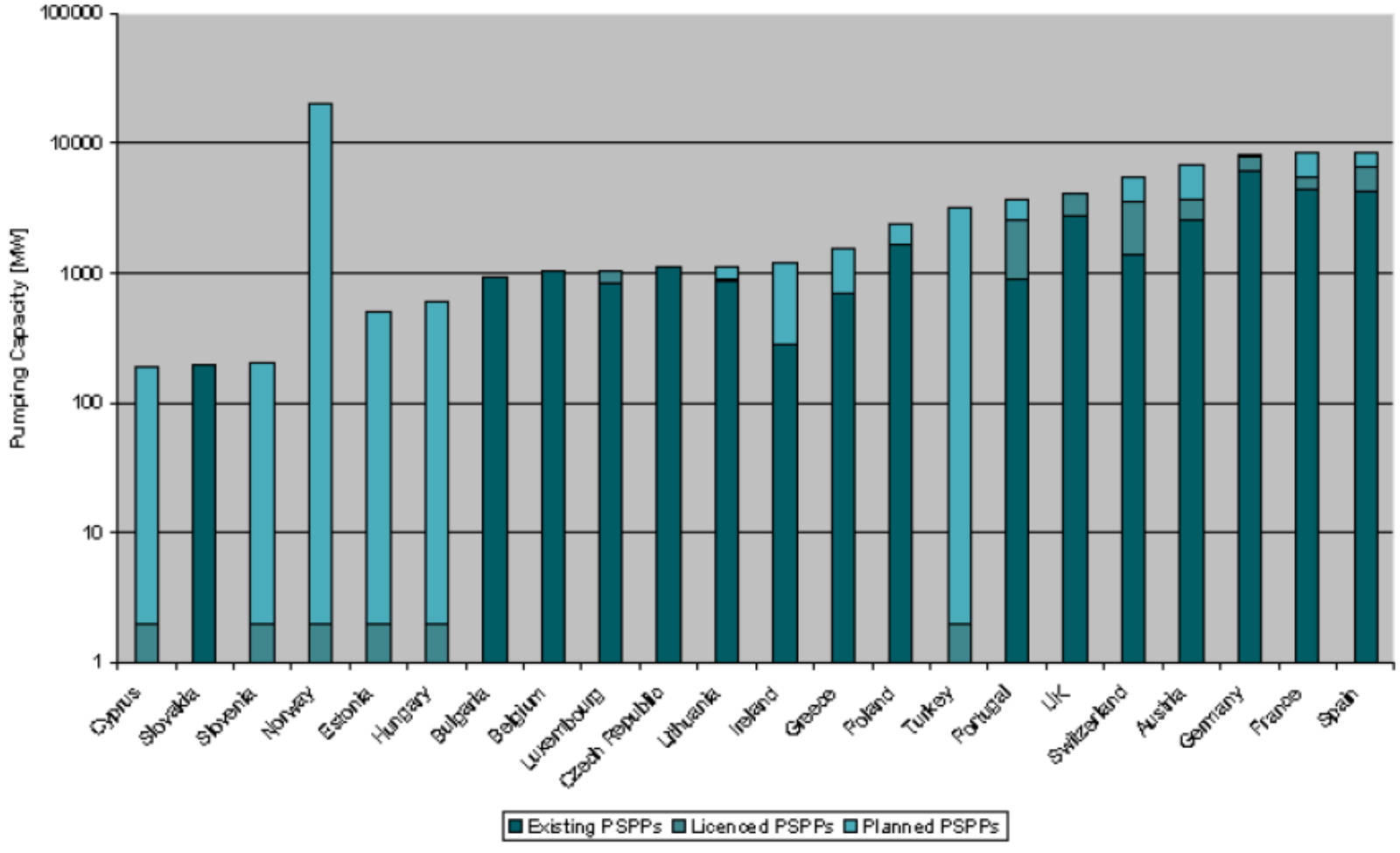


Fig. 7 Installed pumped storage capacities, licensed pumped storage capacities and capacities of pumped storage projects in early planning stage (LOGARITHMIC SCALE), MW

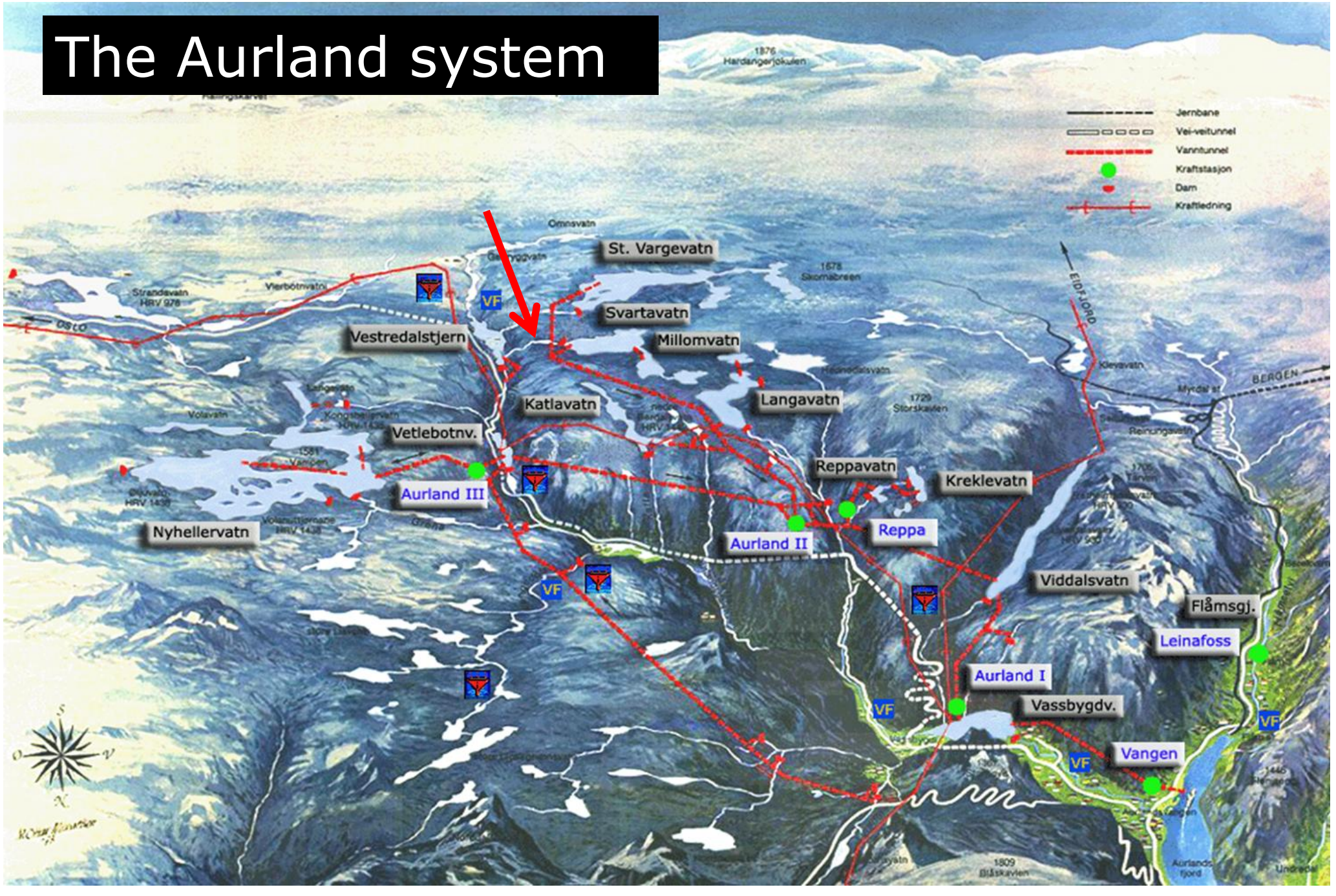
Source: EURELECTRIC[18]

Why Hydro Pump Storage Plants?

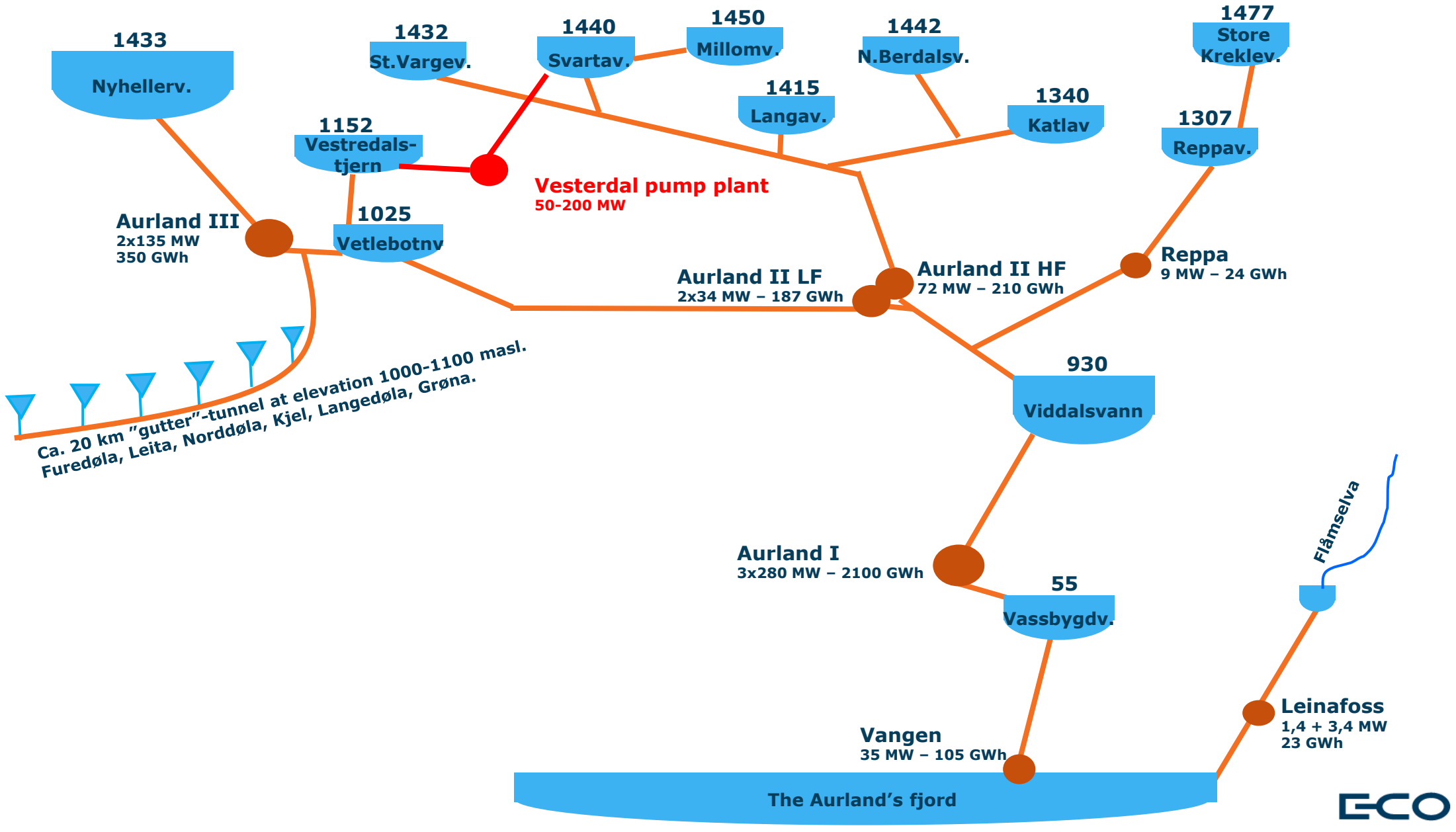
- Market development
  - Stronger interconnectors
  - More intermittent renewables in Europe – wind and solar
  - Higher price variations is expected
  - An increasing need for balancing power in neighboring countries

- Development of hydro pump storage plant will take long time
  - Long term view – 10-25 years
  - Thorough concession process
  - Option strategy

The Aurland system



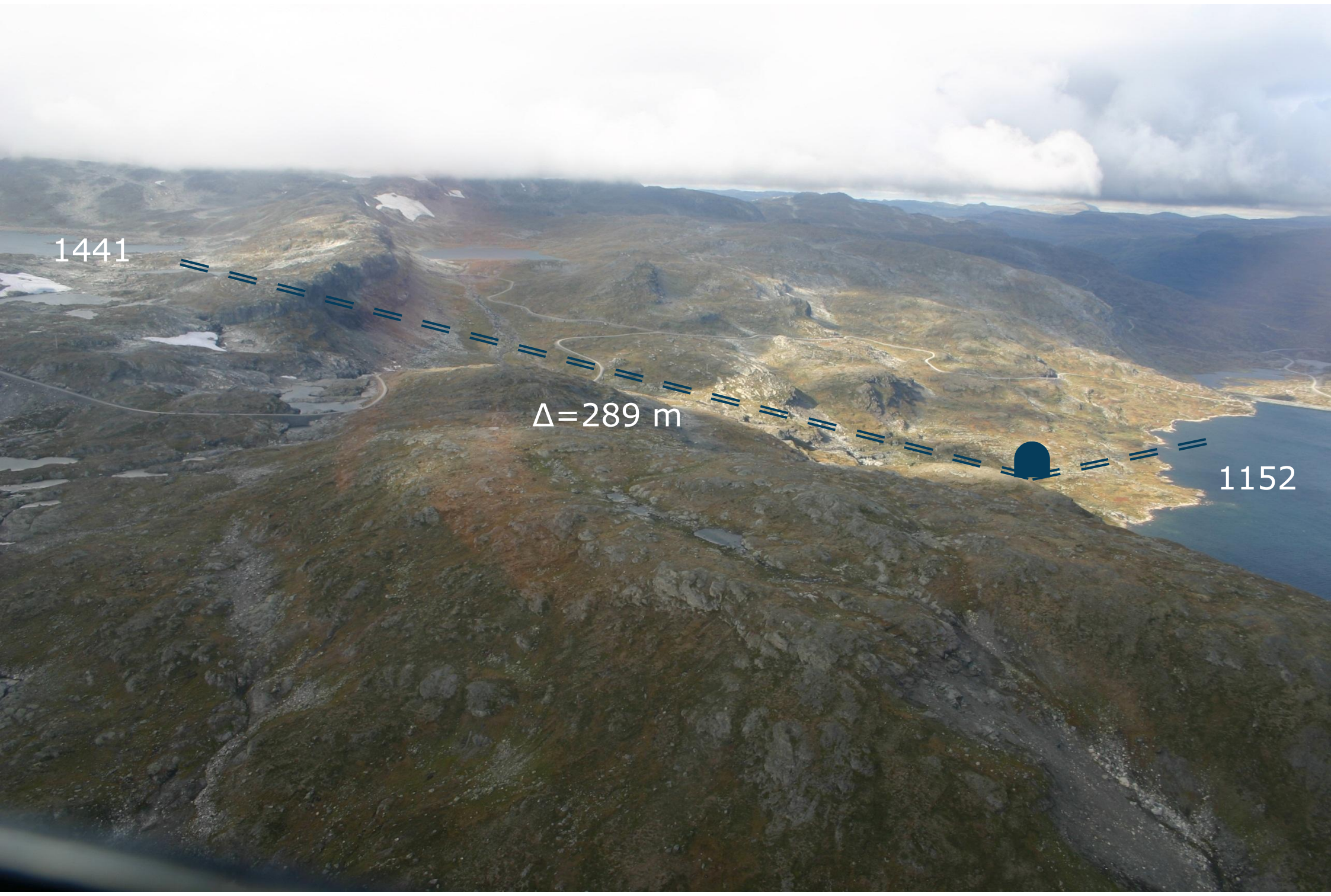
Power facilities in Aurland



Vesterdalen Hydro Pump Storage Plant

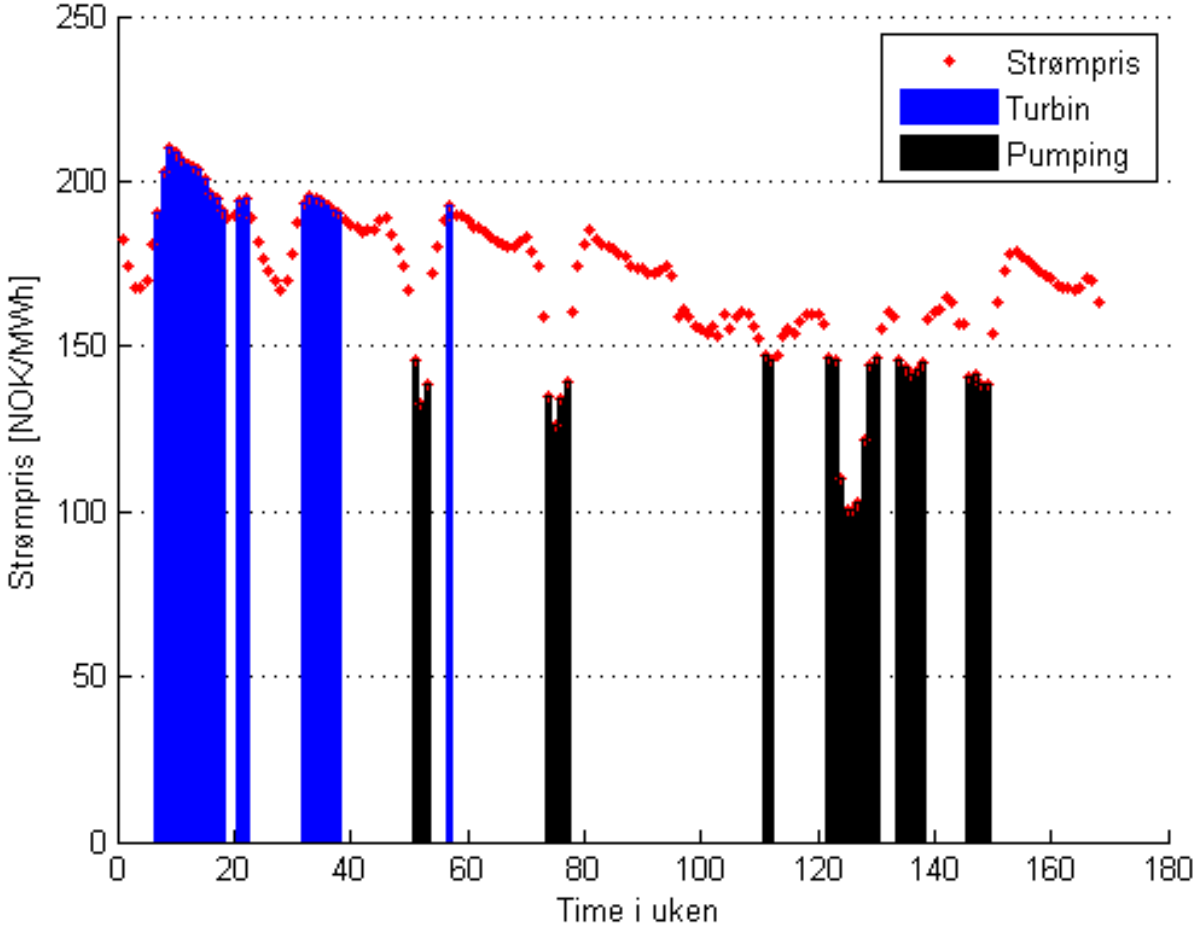
- Existing
  - Upper reservoir Svartvatn: 58 Mm3
    - Yearly inflow 15 Mm3
  - Lower reservoir Vesterdalstjern: 37 Mm3
    - Yearly inflow: 110 Mm3

- 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
Δ=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 (excisting 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!