     

Large scale balancing and storage from Norwegian hydropower

ETIP-SNET Northern Region workshop 3-4 October, Otaniemi, Finland

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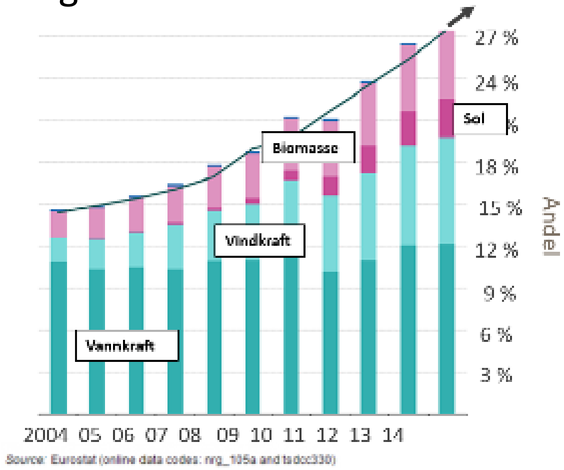
Norwegian hydropower for balancing

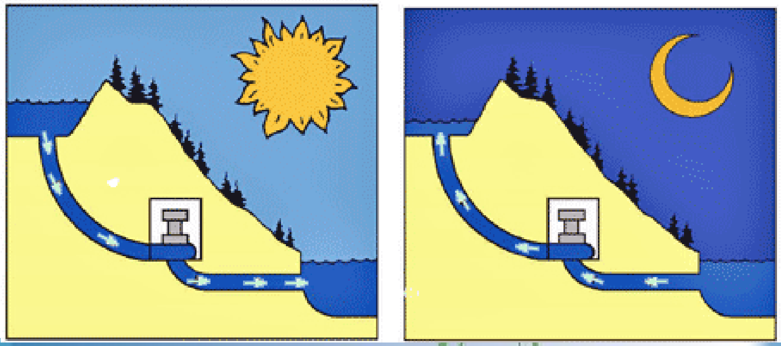
Reservoirs are natural lakes

- Multi-year reservoirs
- Largest lake stores 8 TWh
- **Total 84 TWh reservoir capacity**
- **32 GW installed with max load 25 GW**

Increasing share of renewable power in EU. **Intermittent power from wind solar** with need for balancing



Huge possibilities for **more capacity** including **pump-storage** in existing reservoirs - Requires more transmission capacity



CEDREN HydroBalance: Work Packages

Feasibility of **large scale** development of energy **balancing and storage** from **Norwegian** hydropower in the **future European** electricity market with respect to the **power system**, **environmental** aspects, **economic** viability and **social acceptance**.

WP 2
Demand for energy balancing storage

WP4
Environmental impact of operation schemes for balancing

WP 1
Roadmap for balancing from Norwegian hydropower

WP 3
Analyses to develop relevant business models

WP 5
Social acceptance and regulatory framework

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SFE

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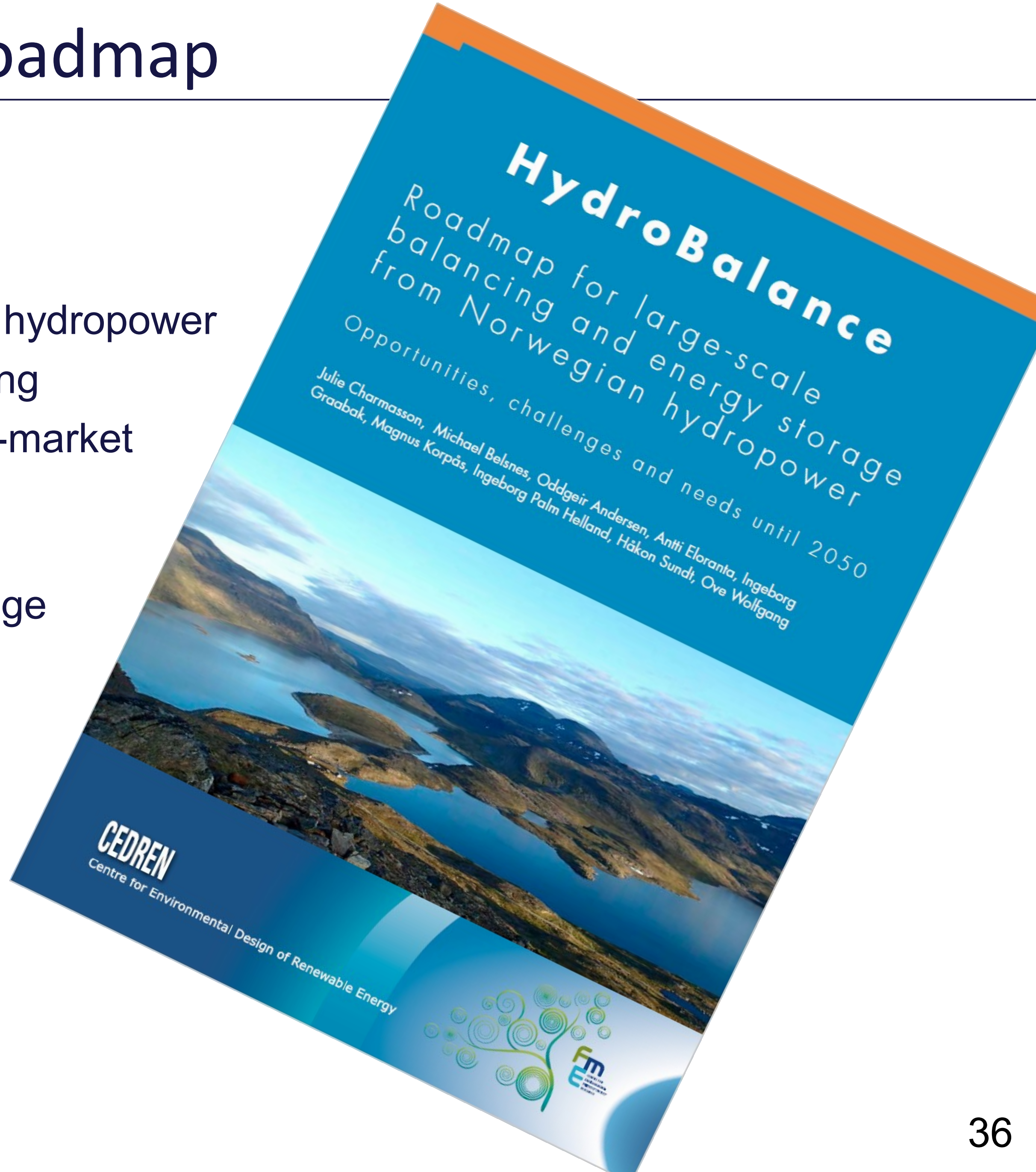
e·on

HydroBalance Roadmap

Contents

- Key Findings
  1. Cost comparizon of hydropower
  2. Demand for balancing
  3. Flexibility as a multi-market commodity
  4. Sustainable storage
  5. Acceptance of storage
- Innovations
- Key Actions
- Research needs

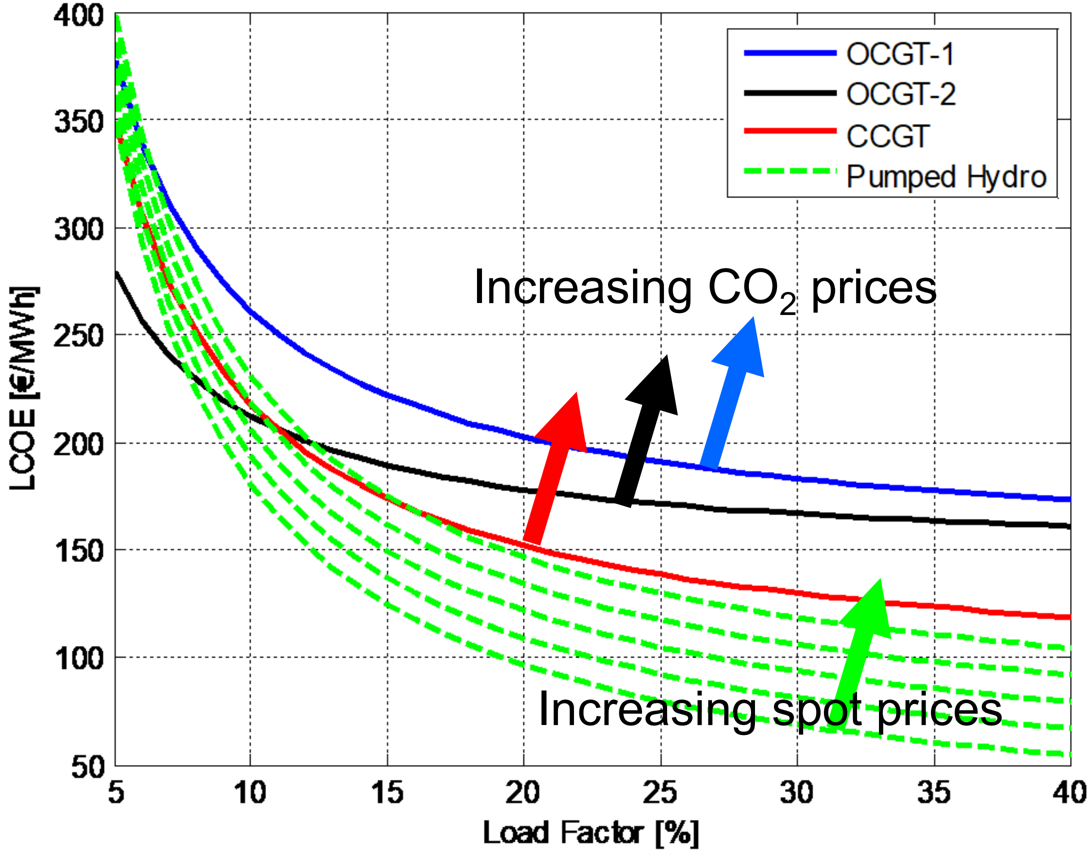


1. Tech. competition: gass power vs. pump-storage

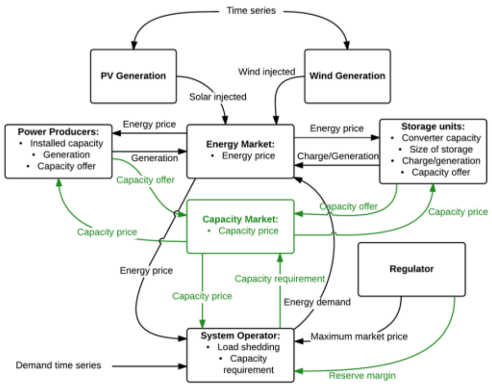
"Levelized Cost Of Energy (LCOE) incl HVDC cables"

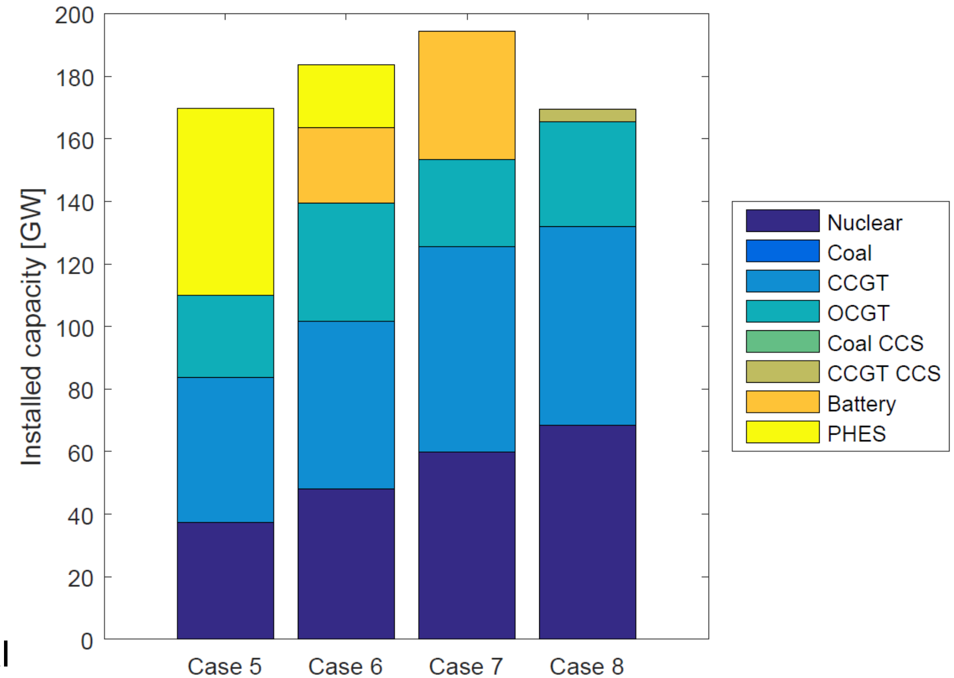
Input data ref: 2040

- Based on IEA WEO scenarios and figures
- Gas plant models and costs according to report for UK Dept. of Energy and Climate Change
- Pumped hydro storage and grid data based on Norwegian figures; Producers, Regulator, TSO, Univ.



1. Tech. competition: Optimal energy system

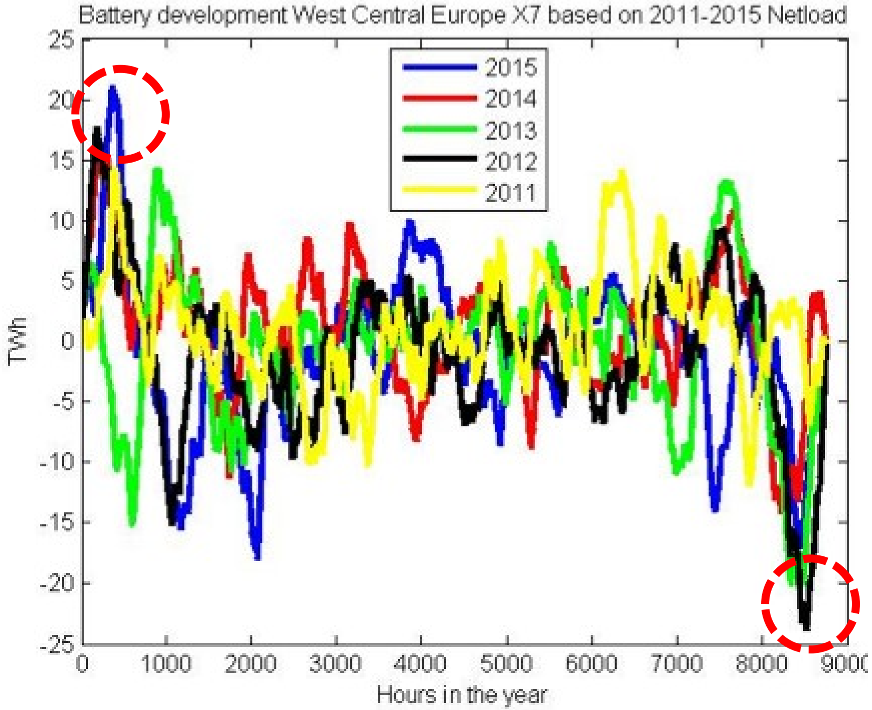


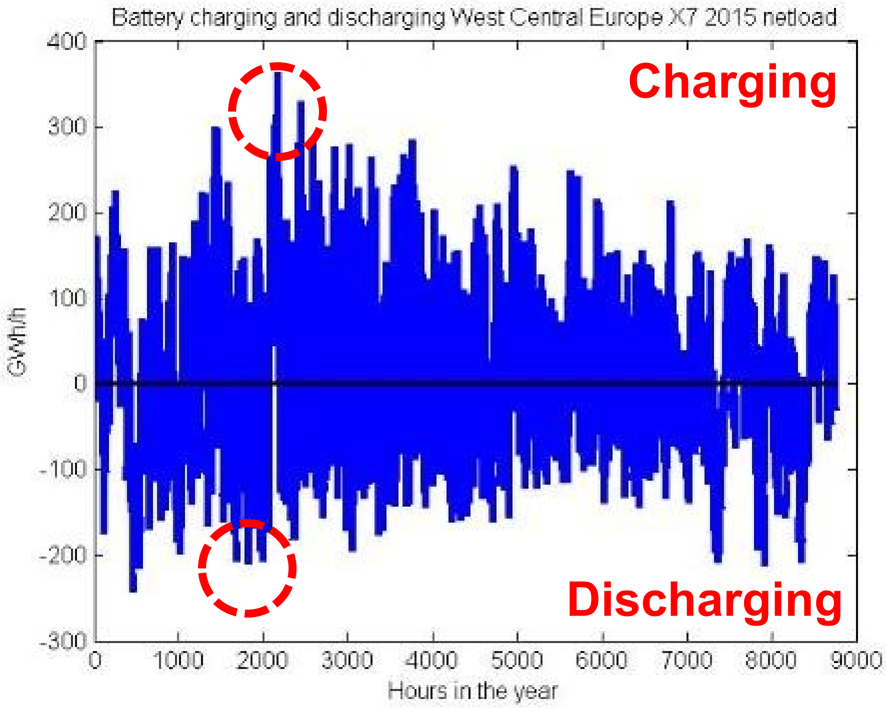


- Uses data from ENTSO-E and e-Highway assuming 80% RES in 2050
- Investment cost and variable cost for thermal units included
- Investment cost and cycle cost for energy storage included.
- **With a fixed C02 quata, what is the consequences with different use of energy storage.**

	Case 5 All	Case 6 Limited PHES	Case 7 No PHES	Case 8 No storage
Wind[MW]	372 618	345 922	332 852	372 495
Solar[MW]	146 091	220 570	257 036	146 435
Thermal[MW]	109 953	139 318	153 426	169 546
Battery[MW]	0	24 224	40 964	0
PHES[MW]	59 811	20 000	0	0
RES curt.[GWh]	45 021	84 178	116 394	159 666
Emissions[kton]	32 335	32 335	32 335	32 335
Tax[EUR/ton]	76	92	115	126

2. Need for balancing 2050 West Central Europe





20-25 TWH storage needed

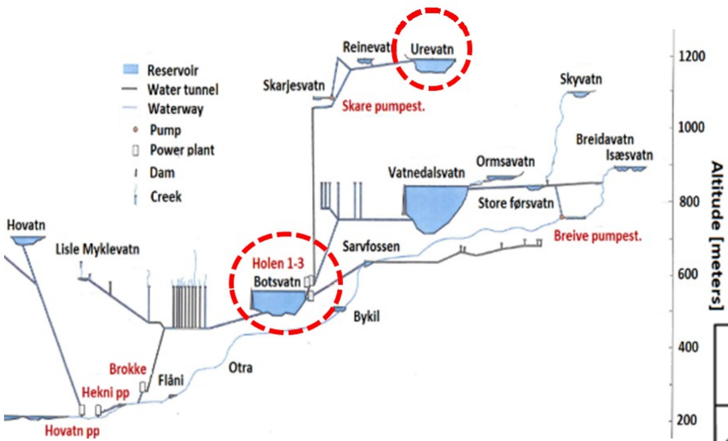
2-300 GW capacity needed

Includes: UK, Ireland, France, Benelux, Germany, West Denmark, Switzerland, Austria, Check Republic, Slovenia

Assumes no bottlenecks in transmission system in and between countries

eHighway Scenario X7: ~100% res, ~70% from wind and solar

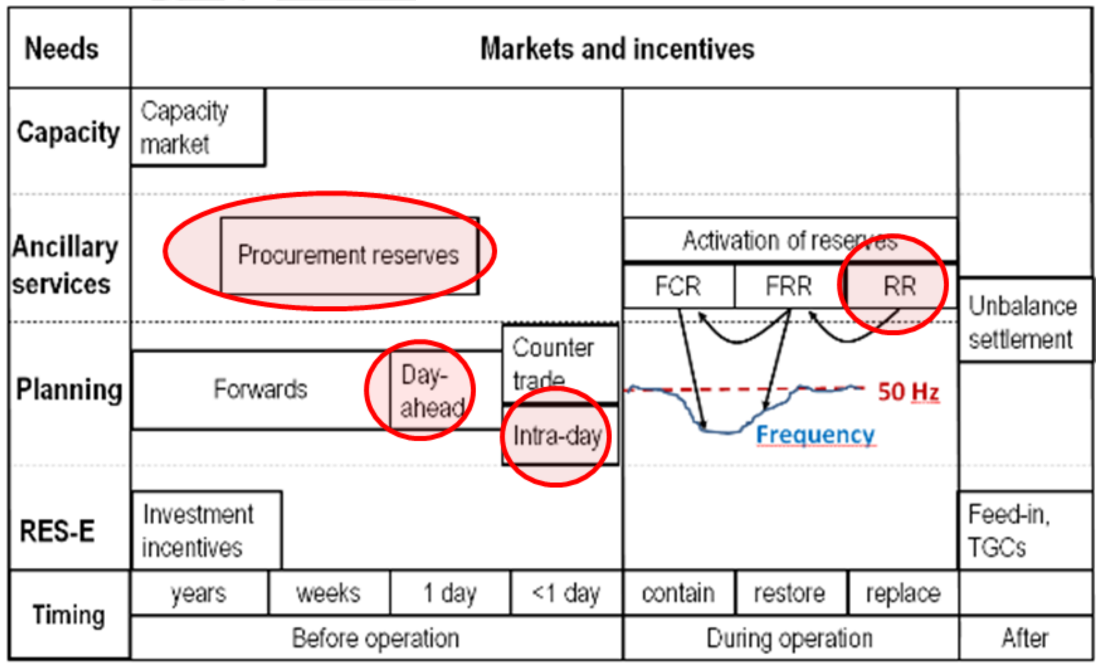
3. Business models: Revenues multiple markets



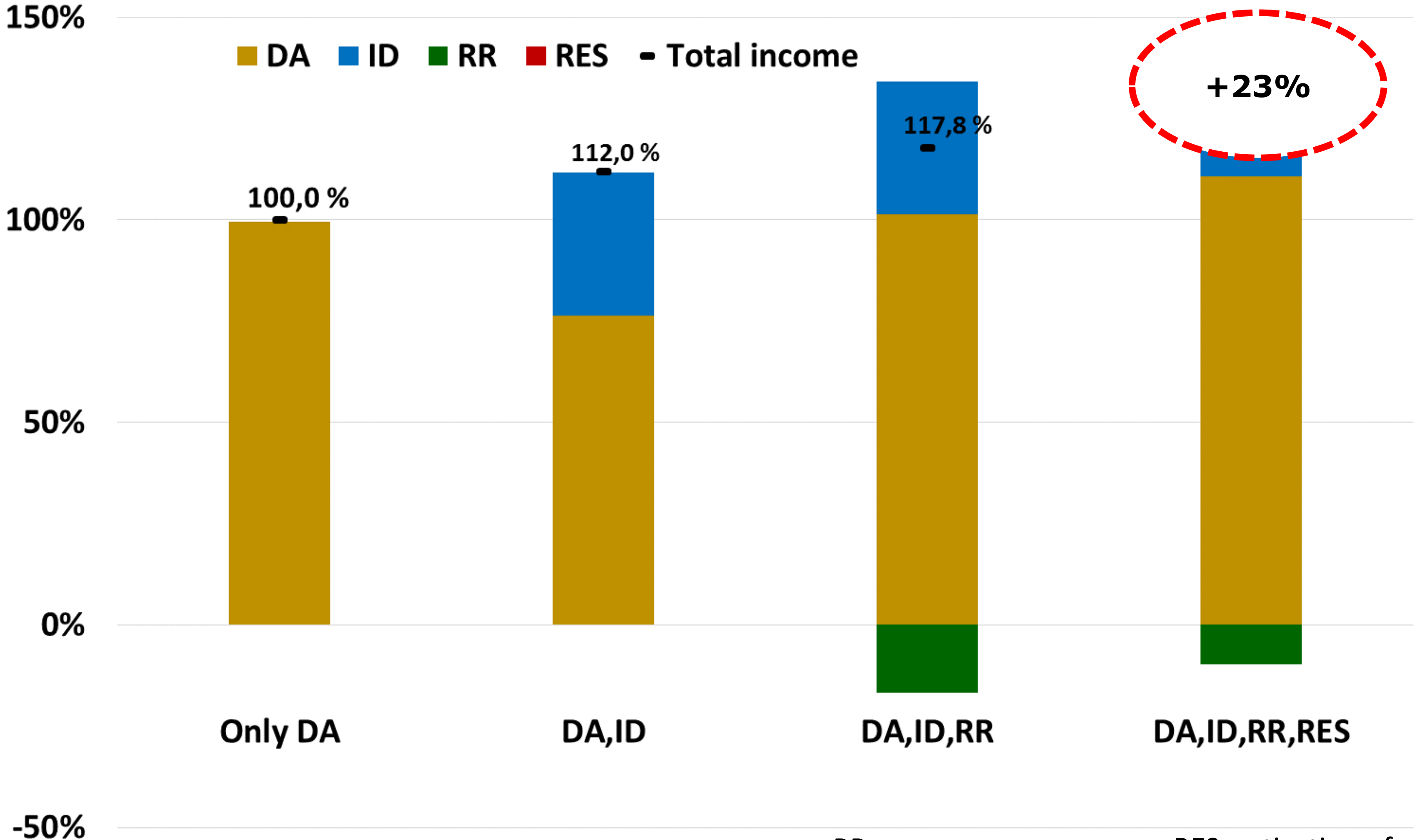
Case study:

1 GW pump-storage

24 M€/year annuity with 5% interest



3. Case study: Revenues from flexible hydropower assets



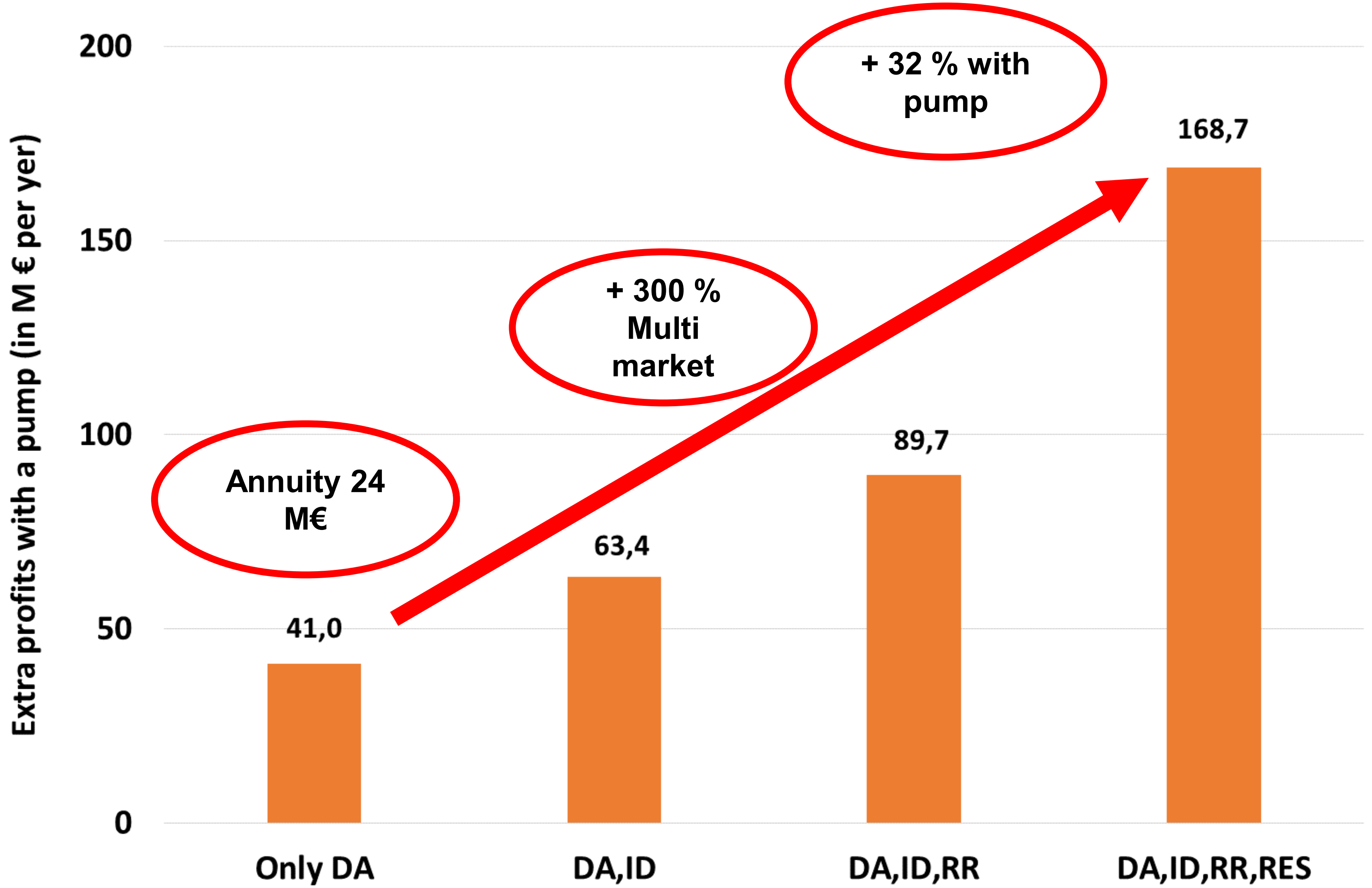
DA: Day-ahead

ID: Intra-day

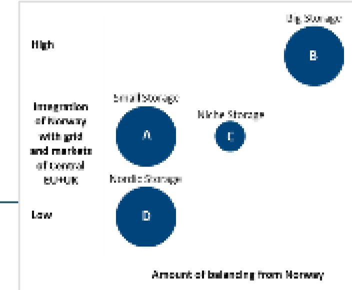
RR: procurement of reserves

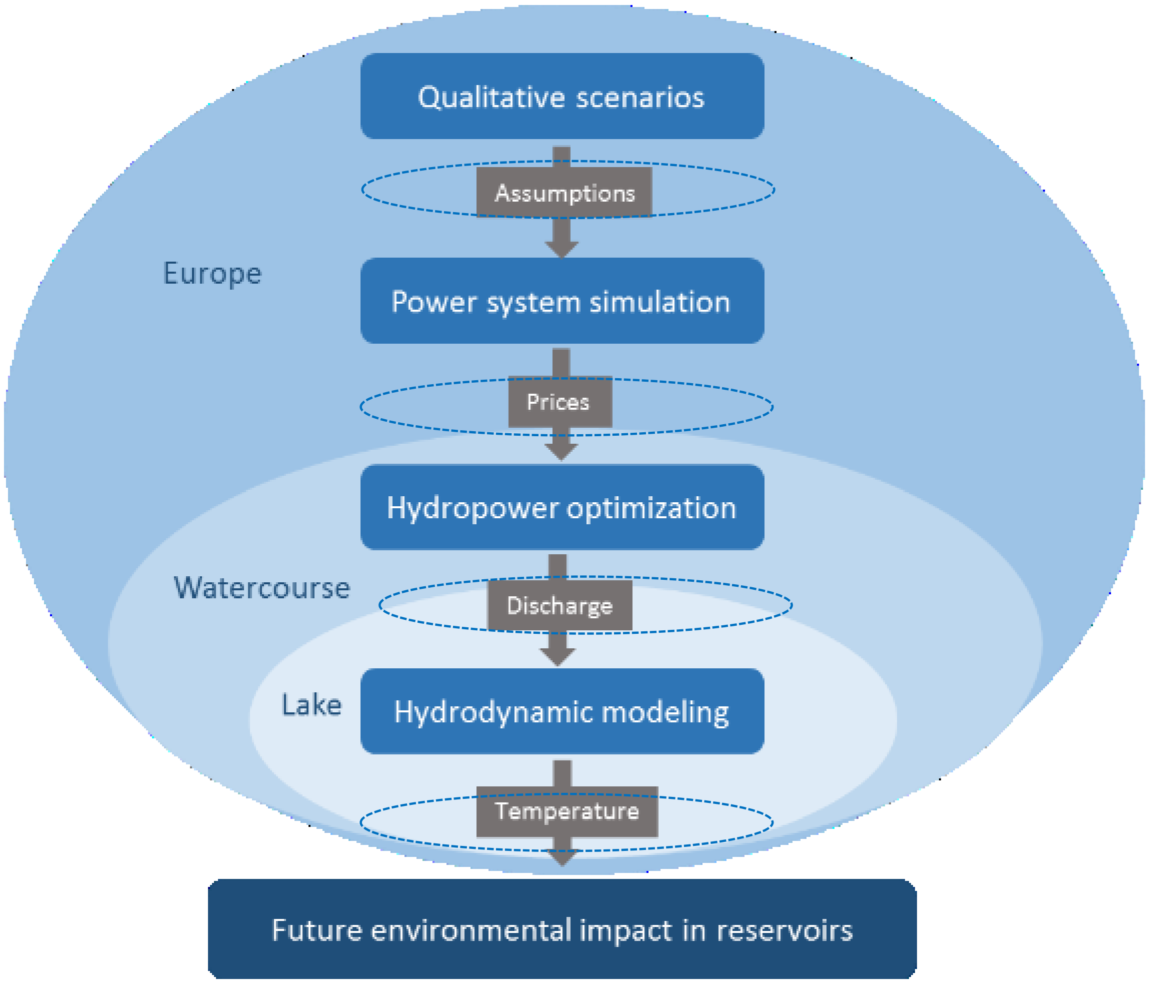
RES: activation of reserves

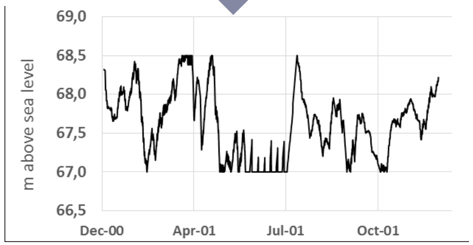
3. Case study: Revenues from pump

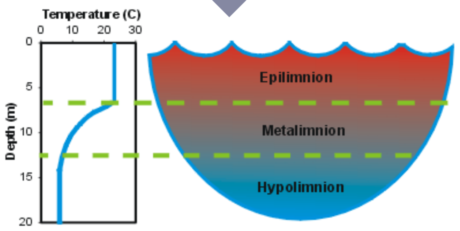


4. Modelling potential impacts of water level fluctuations in reservoirs





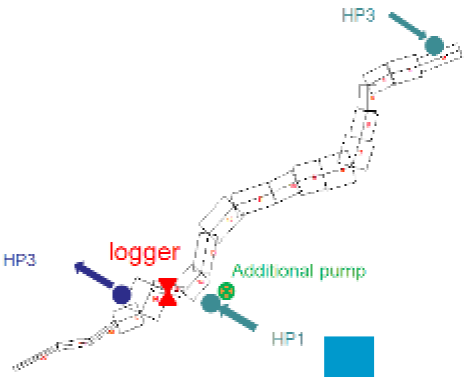




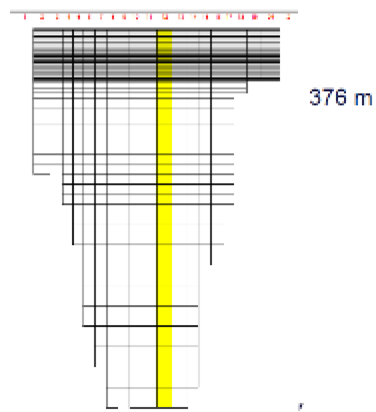
4. Case study: Change in water temperature

Hydrodynamic modelling
CE-QUAL-W2

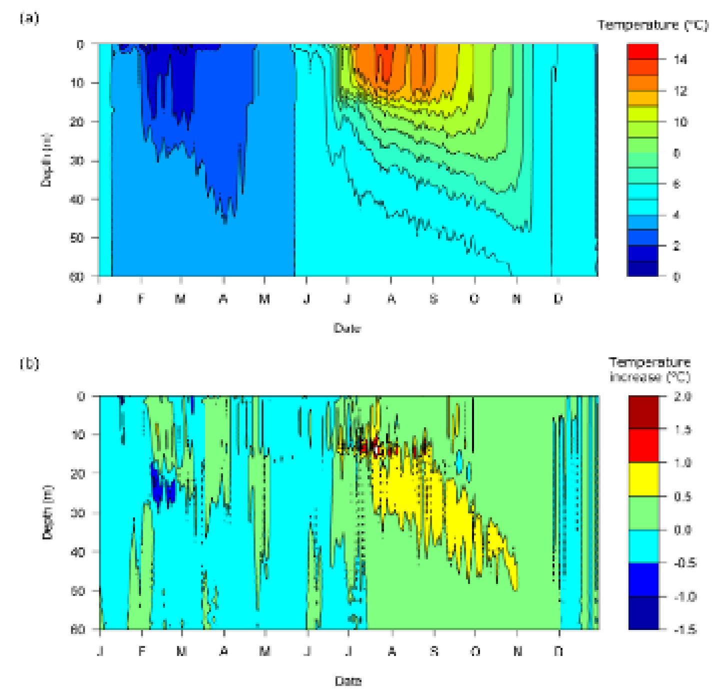
Arial view



Side view



Simulated temperature changes



5. Barriers and drivers for large-scale balancing

<u>Method</u>

Informants where:

- National authorities
- Members of Parliament
- Environmental NGO`s
- Energy intensive industry
- Hydro power companies

Topics for the interviews:

- Current legislation
- Infrastructure/grid lines
- Commercial potential
- Societal legitimacy
- Environmental impacts

<u>Main findings</u>

Key actions: National policy makers

- Establish an multi-diciplinary advisory board on how to best develop Norwegian hydropower, including transmission lines and interconnectors.
- Develop plans and strategies for Norwegian hydropower in the common integrated European electricity.
- Develop a benefit sharing schemes
- Create a transnational level playing field for flexibility
- Implement a new regulatory framework for hydropower production with updated restrictions adapted to flexible services in future markets.

Key actions: Norwegian TSO

- Make and maintain a rolling plan for realizing the next cables from Norway.
- Coordinate plans with neighbouring countries to remove local bottlenecks and agree on sharing of investments, profits, and risks. (ACER is also a component)
- Ensure that new domestic and international transmission cables are constructed with minimal impact on landscape and biodiversity.

Key actions: National authorities (OED, NVE)

- Develop a coherent and comprehensive planning framework concerning the potential for balancing services and related grid development.
- Create an overall plan for how to identify which hydropower plants that are the most suitable for balancing services, and which that are not.
- Integrate the concept of environmental design of hydropower in license revisions and implementation of the water framework directive but keeping in mind impact on available flexibility from hydro.
- Initiate a dialogue including politicians, authorities, and public and private stakeholders, with the aim of formulating common goals that encompass and balance different societal interests and concerns related to further hydropower development.

Key actions: Producers

- Make a strategy to increase the ability to provide balancing services.
- Replace fish stockings with habitat improvements and water level regulation patterns that facilitate natural recruitment and improved ecological status of the reservoirs
- Collect data such as bathymetric maps and spatial and temporal water temperature variations enabling improved modelling of future operation patterns.
- Give local groups the opportunity to provide direct input during the planning and construction phase and, specify how community benefits and costs are allocated.

Thank you for your attention!

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www.cedren.no/Projects/HydroBalance