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POSSIBILITIES AND CHALLENGES FOR BALANCING FROM HYDROPOWER

Coordinator Michael M. Belsnes with help from the project group








Highlights and results from...

CEDREN HydroBalance

(2013-2017)

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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

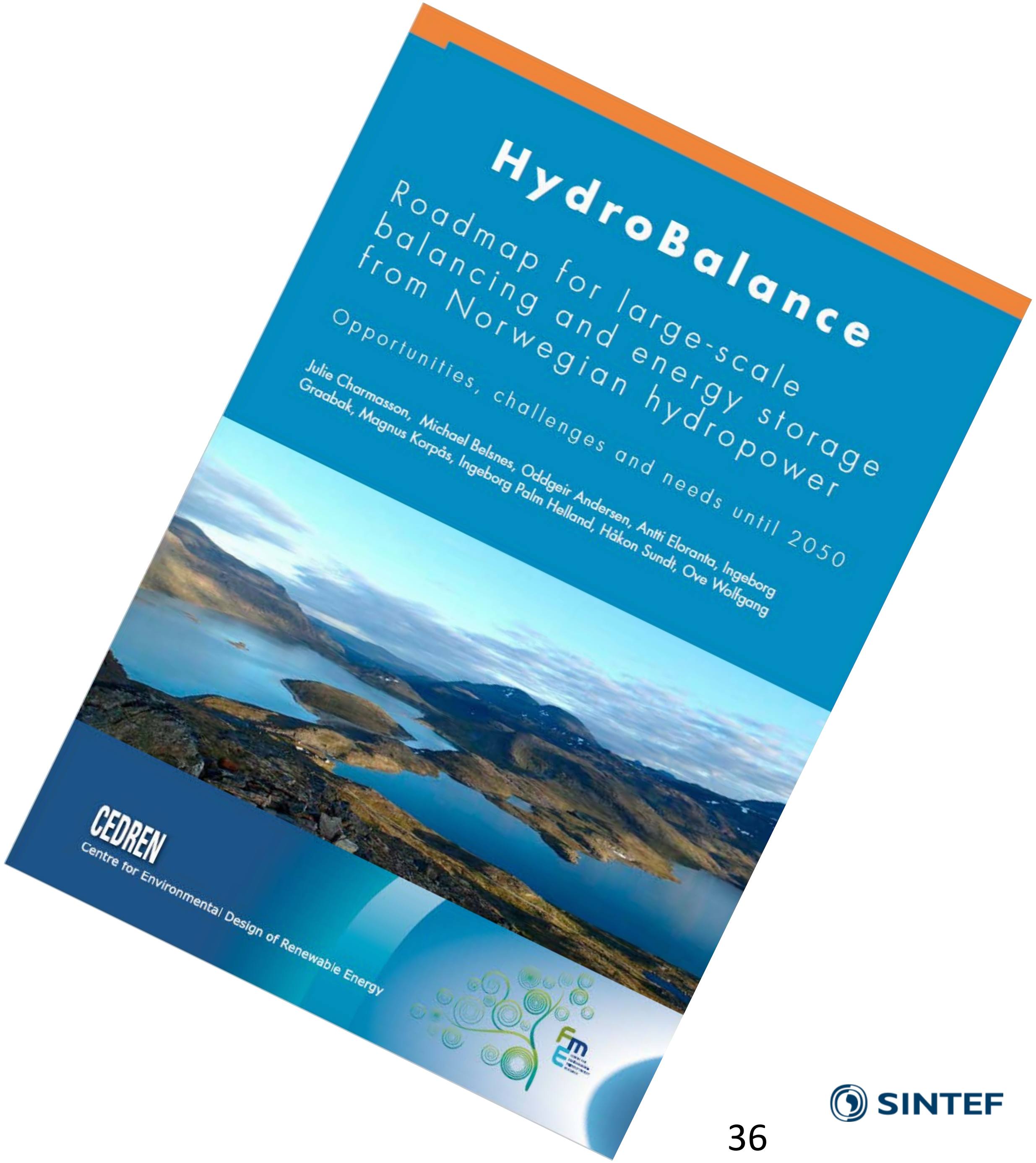
WP 3
Analyses to develop relevant business models

WP 5
Social acceptance and regulatory framework

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
- Key Actions



Main findings

Cost comparison of hydropower	✓	Pumped-storage incl. HVDC line cheaper than gas
Demand for balancing	✓	25 TWH and 300 GW needed for North-Europe
Flexibility as a multi-market commodity	✓	Pumped-storage in a multi-market setting gives 300% more revenue and 32% more compared to before expansion in the case study
Sustainable storage	✓	Sustainable flexibility from hydro is obtainable
Acceptance of pumped-storage	✓	Yes, if it gives something back

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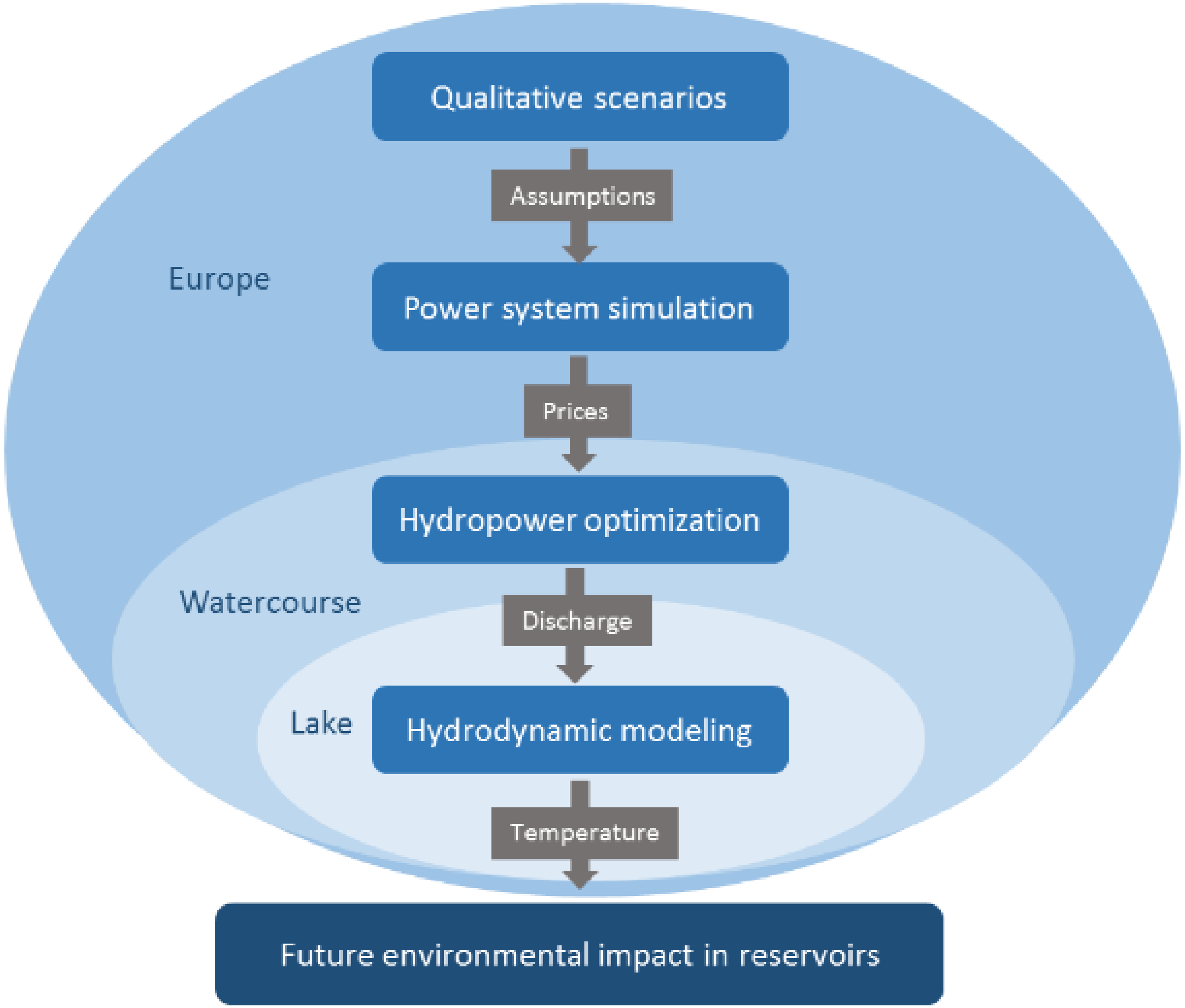
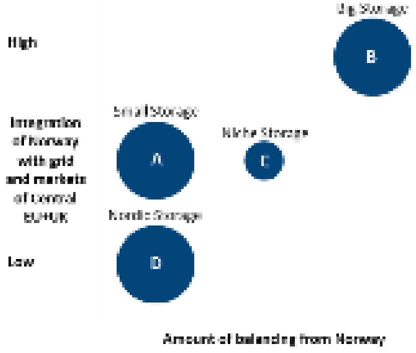
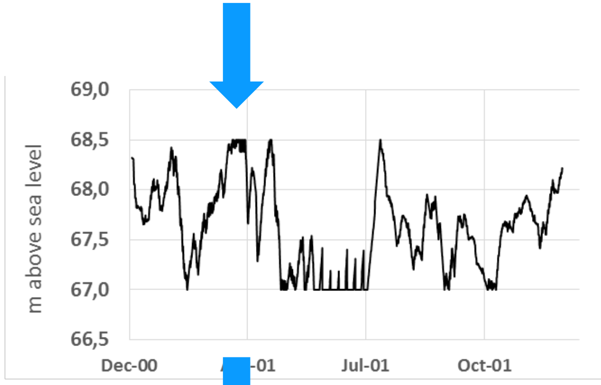
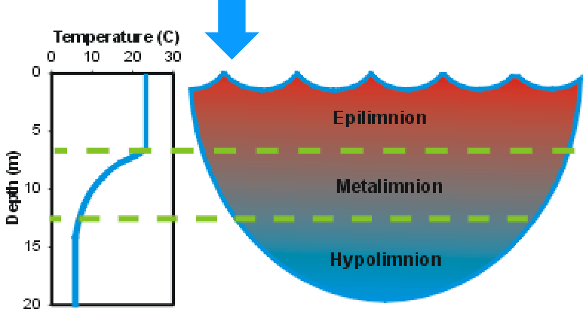
Must look at the big picture to find the right solutions









Key actions: National policy makers

Priority 1: Promote a transnational and level playing field for flexibility

Priority 2: Establish an multi-disciplinary advisory board on how to best develop Norwegian hydropower, including transmission lines and interconnectors.

Priority 3: Develop a benefit sharing scheme

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Key actions:National authorities (OED, NVE)

Priority 1: Create an overall plan for how to identify which lakes and watercourses that are most suitable for balancing services, and which that are not.

Priority 2: Integrate the concept of environmental design of hydropower in license revisions and implementation of the water framework directive but adapted to flexible services that hydro needs to provide in the future

Priority 3: Develop a coherent and comprehensive planning framework concerning the potential for balancing services and related grid development.

Key actions: Producers

Priority 1: Make a strategy to increase the flexibility and prepare for a changed role

Priority 2: Use environmental design from the very beginning and collect information data such as bathymetric maps and temperature.

Priority 3: Give local groups the opportunity to provide direct input during the planning and construction phase and, specify how community benefits and costs are allocated.

Thanks for your attention!

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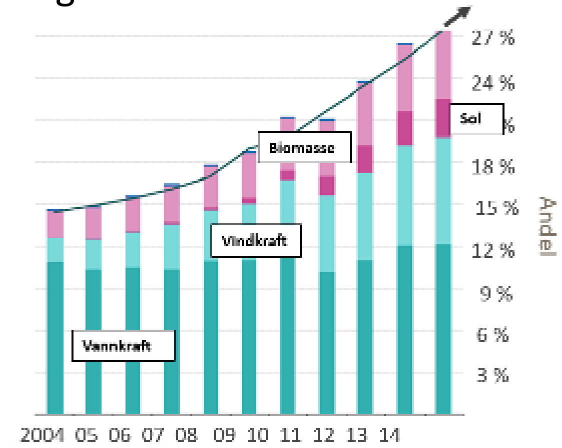
Technology for a better society

Norwegian hydropower for balancing

Reservoirs are natural lakes

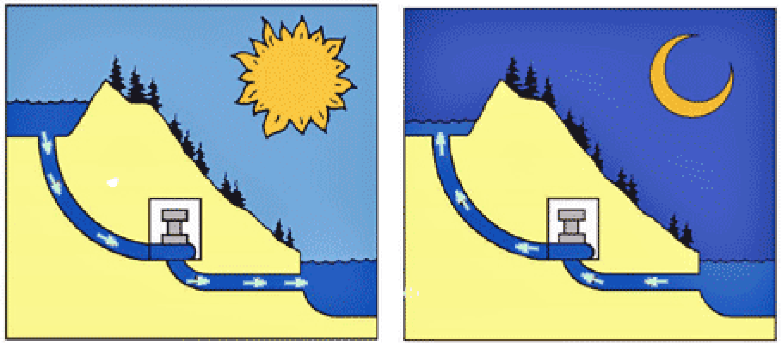
- Multi-year reservoirs
- Largest lake stores 8 TWh
- **Total 84 TWh reservoir capacity**
- **32 GW installed with max load 25 GW**

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



Source: Eurostat (online data codes: nrg_105a and tsdcc330)

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



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Key actions: Norwegian TSO

- Make and maintain a rolling plan for realizing the next cables from Norway.

- Coordinate plans with neighboring 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.

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SFE

International partners:

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

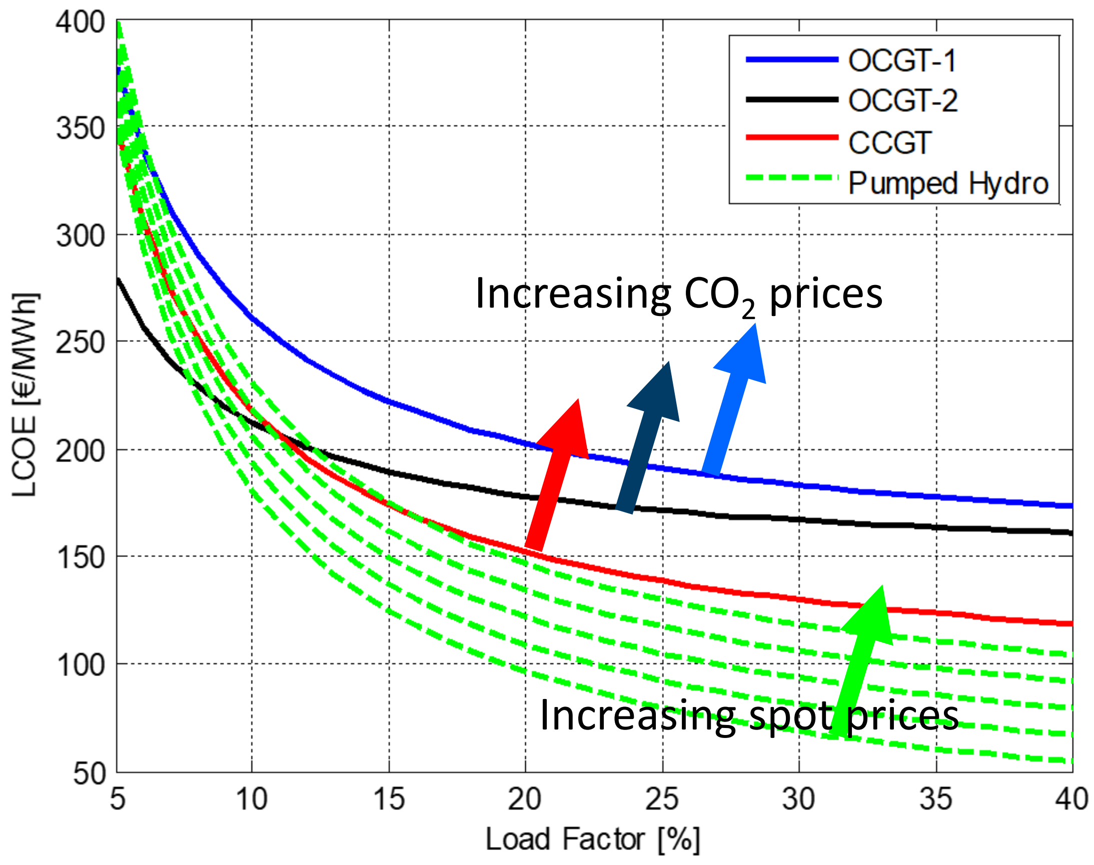
"Levelized Cost Of Energy (LCOE) incl HVDC cables"

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.



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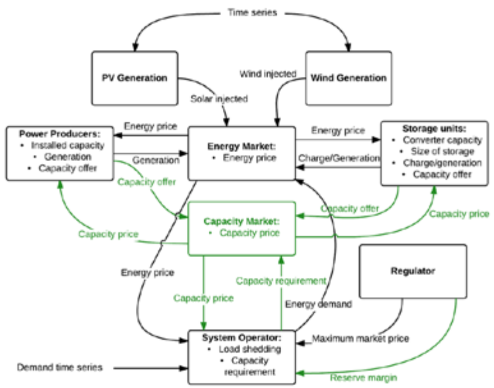
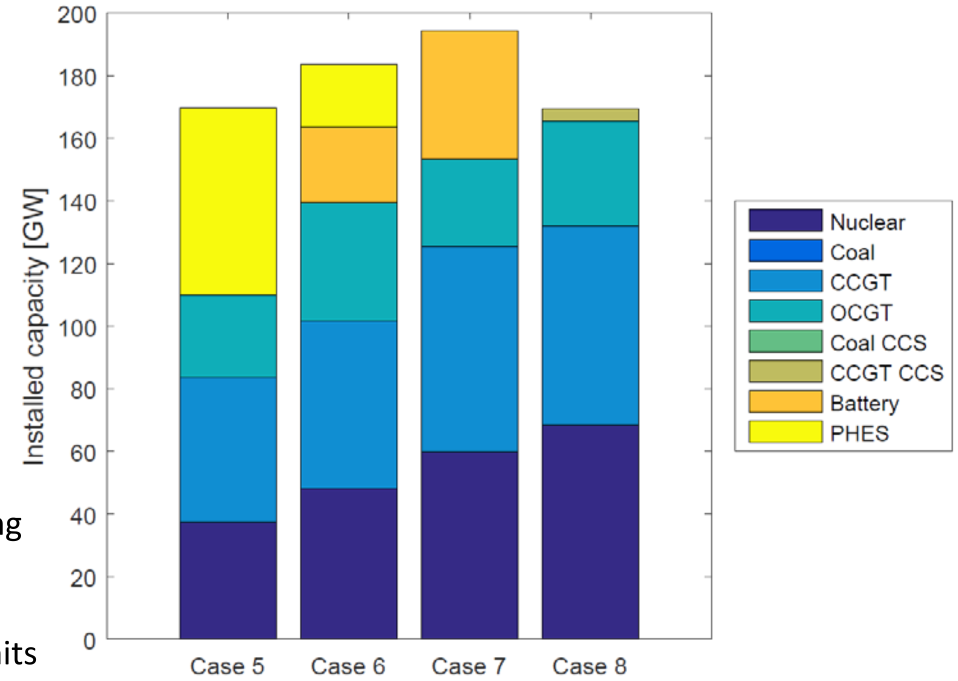
1. Tech. competition: Optimal energy system





- 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

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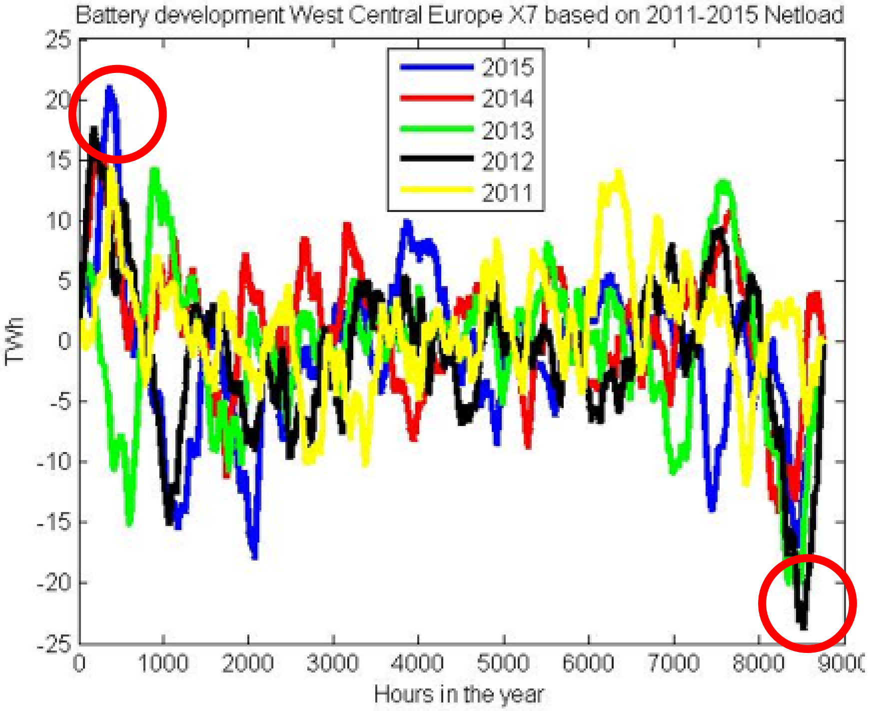
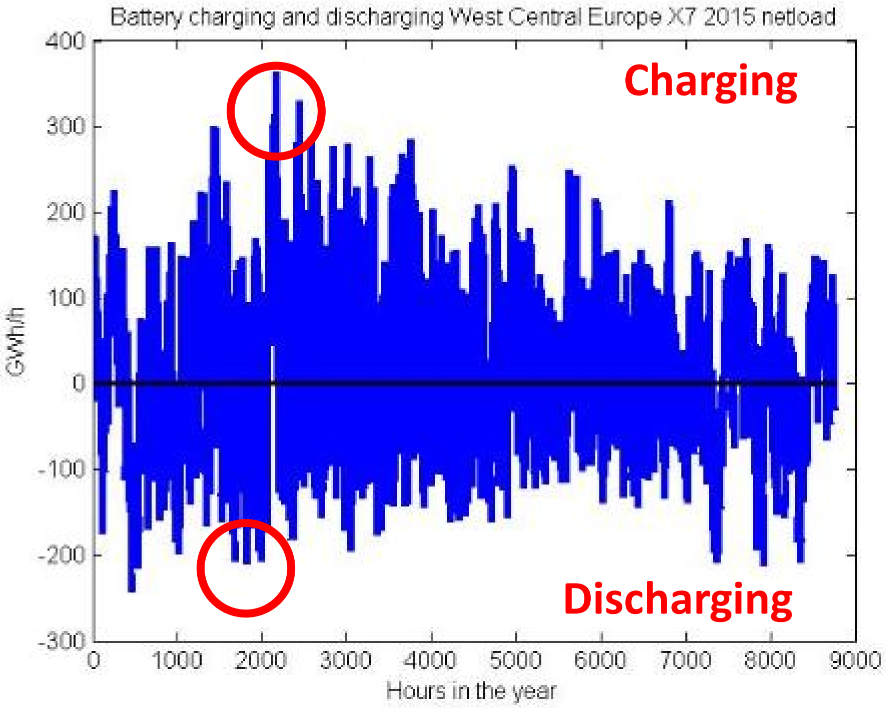
2. Need for balancing 2050 West Central Europe



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

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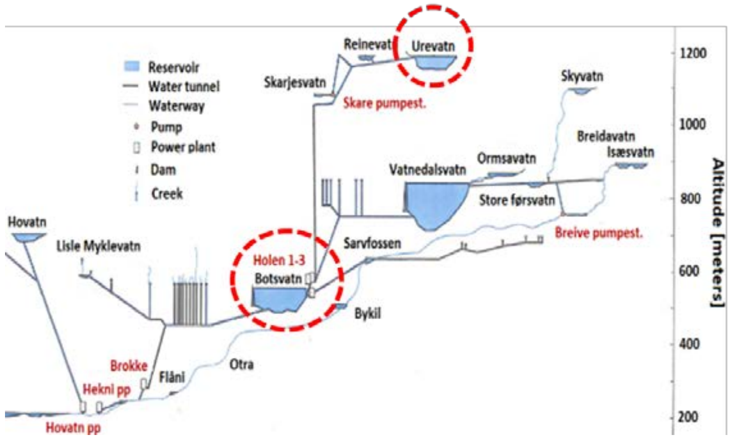
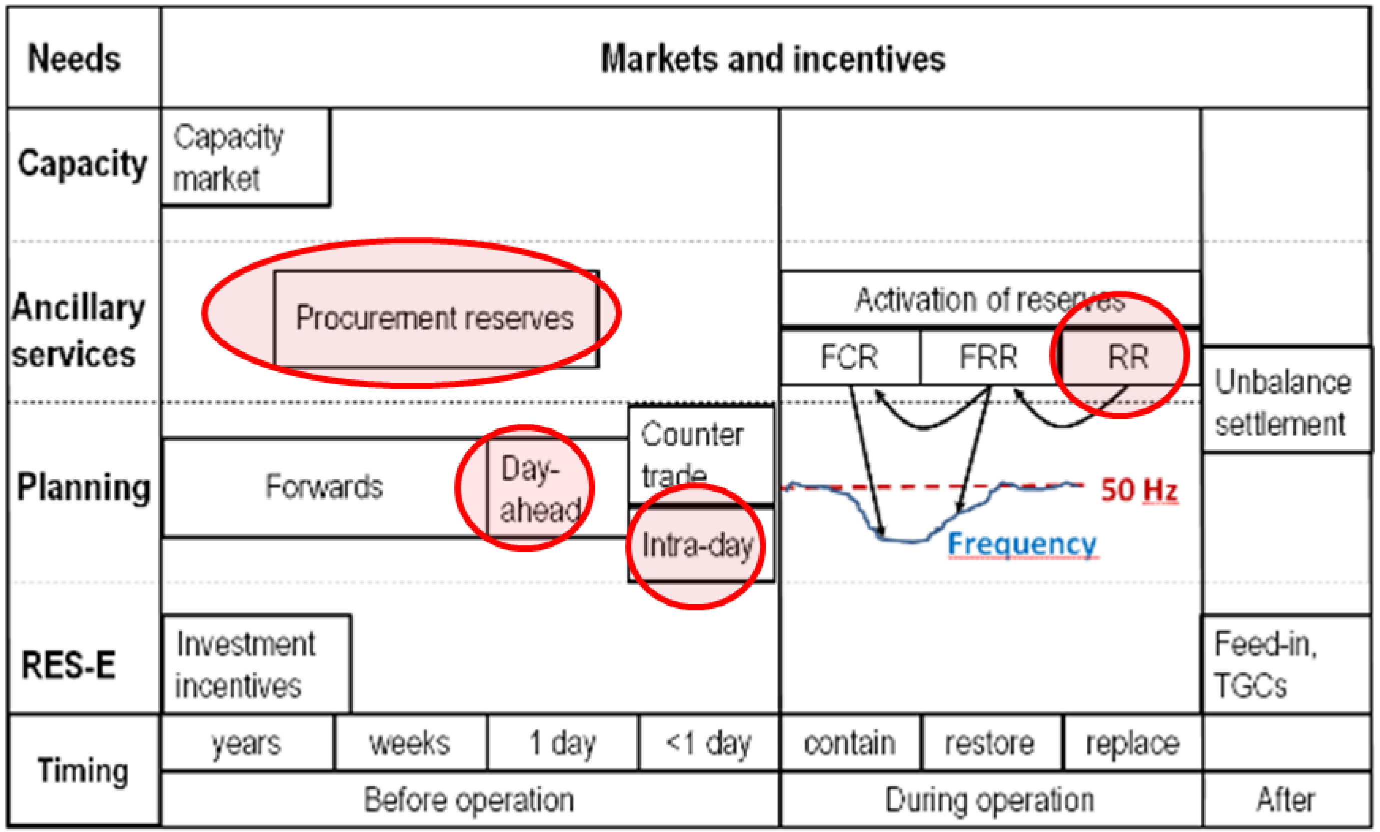
3. Business models: Revenues in multiple markets





Case study:

1 GW pump-storage

24 M€/year annuity with 5% interest

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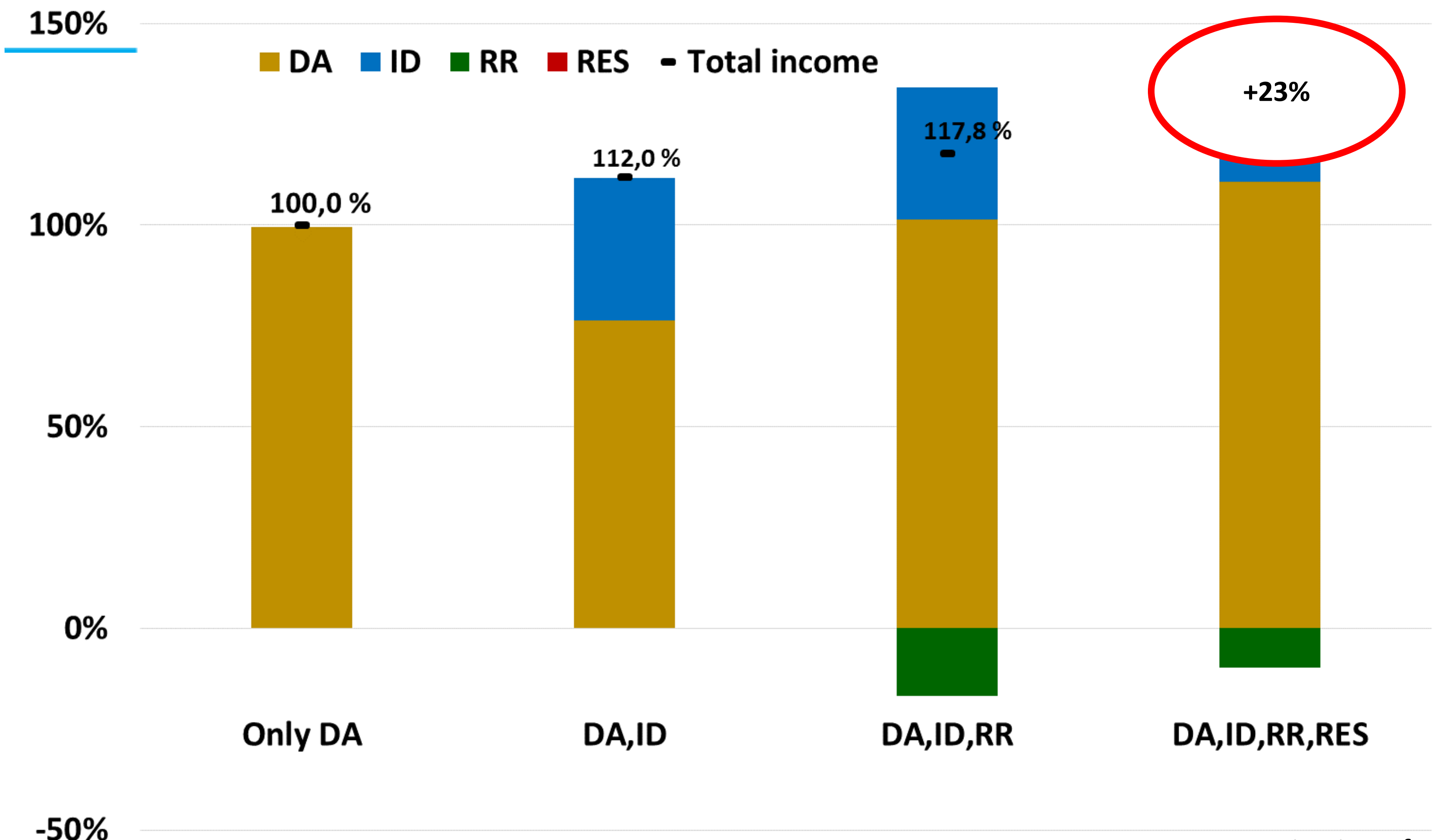
3. Case study: Revenues from flexible hydropower assets



DA: Day-ahead

ID: Intra-day

RR: procurement of reserves

RES: activation of reserves

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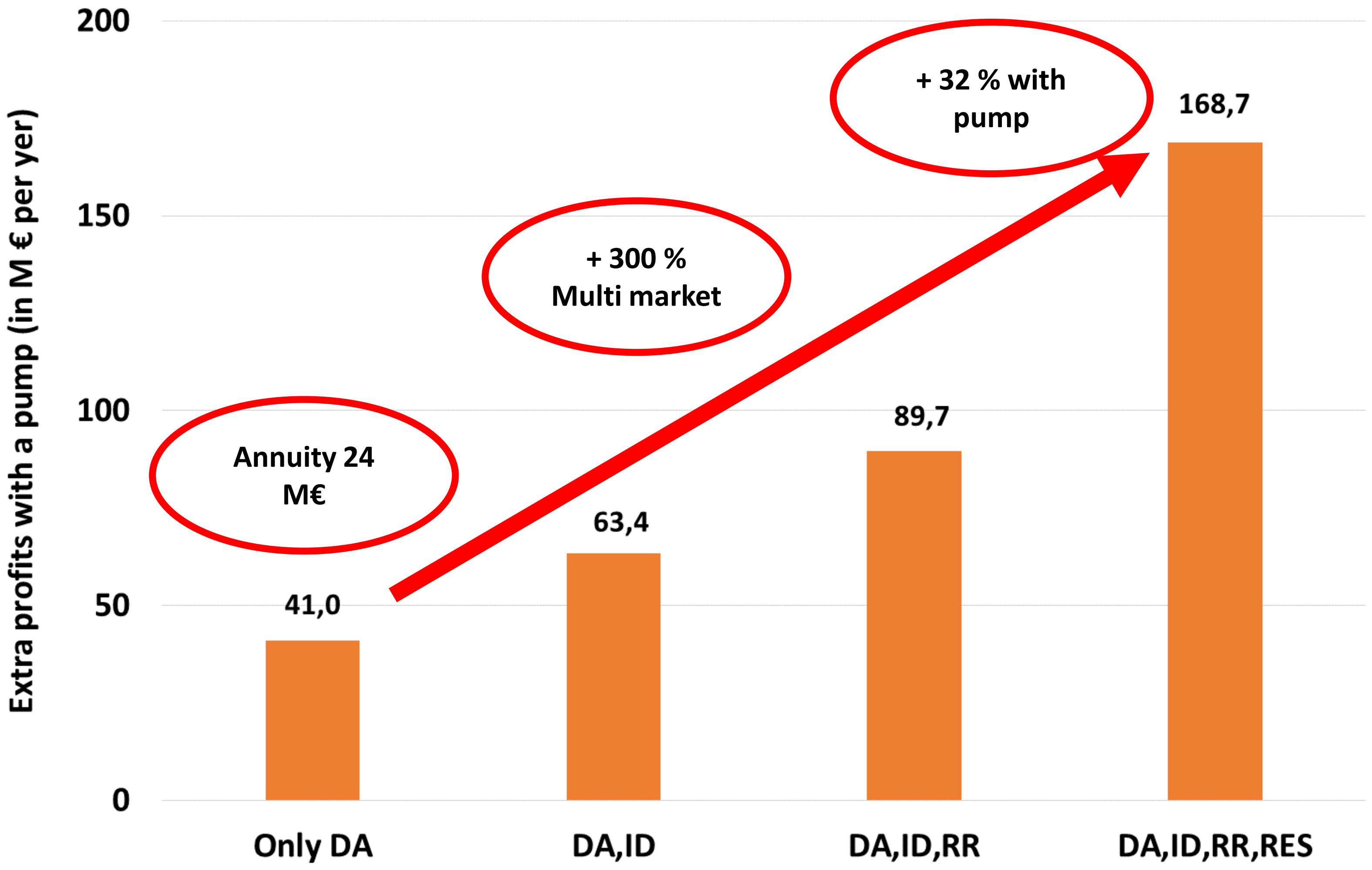
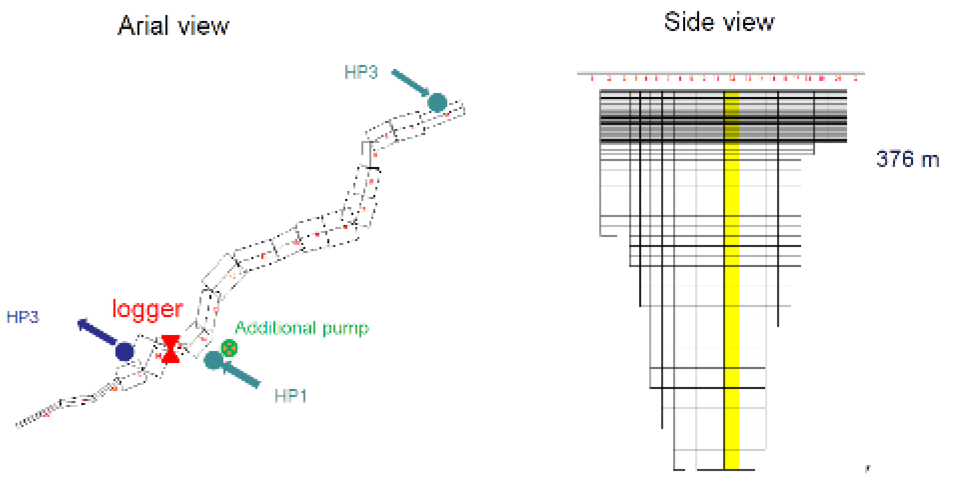
3. Case study: Revenues from pump

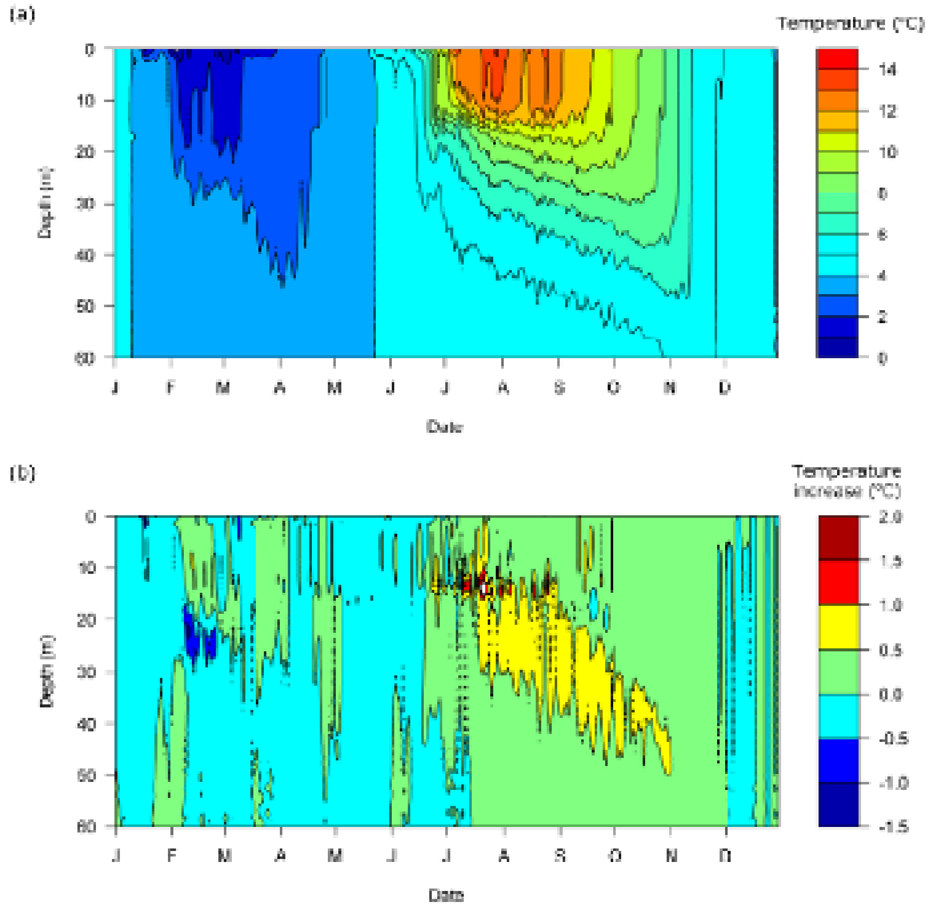


4. Case study: Change in water temperature

Hydrodynamic modelling
CE-QUAL-W2



Simulated temperature changes



5. Barriers and drivers for large-scale balancing

Method

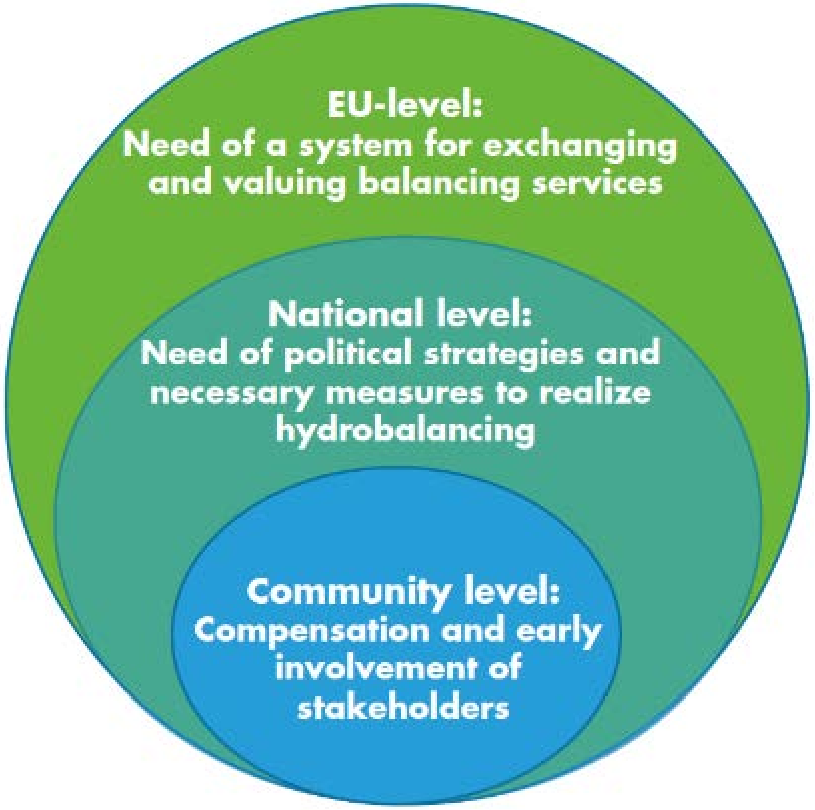
Informants where:

- 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

Main findings



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