Centre for environmental design of renewable energy – CEDREN
CEDREN HydroBalance: Facts

- **Budget**: 24863 MNOK, (17692 from NFR)
- **Duration**: 4 years
- **Research partners (11)**
- **Funding (10)**:
CEDREN HydroBalance: Objectives

The project will address key questions regarding use of hydropower flexibility and expansion of such flexibility including pump storage development between reservoirs.

The project will draw a picture of the future for hydropower flexibility towards 2050 and assess needs for flexibility, alternatives to hydropower and required transmission capacity. How can and should the hydropower sector respond to the power system development in Europe? The project will assess and suggest business models in a Norwegian-European perspective.

Use of hydropower flexibility must go hand in hand with environmental concerns and the project will in particular contribute with new knowledge about consequences of reservoir level changes.
CEDREN HydroBalance: Objectives

... and with CEDREN and the combined consortium = true

Generate new knowledge about balancing from hydropower in Norway
CEDREN HydroBalance: Technology

• WP 1: Roadmaps for balancing from Norwegian hydropower
  - Assess the possibility space for balancing power from Norway towards Europe
  - Timeline for when, how and where Norwegian hydropower should respond

• WP 2: Demand for energy balancing storage
  - Establish data models with
  - Time horizon for storage needs, interaction between markets
  - Includes a PhD scholarship

• WP 3: Analyses to develop relevant business models
  - Possible business models for operation in different markets for balancing, including cross border possibilities.
  - Analyses of possible capacity projects, profitability and operation
  - Includes a substantial research cooperation with ECN
CEDREN HydroBalance: WP's

- **WP4: Environmental impact of operation schemes for balancing**
  - Research task regarding environmental impact on reservoirs, size and type
  - Use CEDREN results for broad analyses of environmental impact and mitigation.
  - Includes a Postdoc scholarship.

- **WP 5: Social acceptance and regulatory framework**
  - Political barriers and success criteria for balancing power
  - Income distribution and socialization of cost, non technical challenges.
CEDREN HydroBalance: Perspective
WP 1: Pump-storage is competitive for balancing in Europe

Internal study of balancing cost alternatives in Europe towards 2050

-Performed by senior experts, Sverre Aam, Magnus Korpås, Now 2012-Feb 2013.

- Based on EIA ETP 2012 scenarios and figures.

-Gas, coal and nuclear cost from "UK Dept. of Energy and Climate Change"

-Norwegian pump-storage data from Statkraft, Statnett and NVE
WP 2: Simulated power generation from wind in the North Sea area: 2030 – 100 000 MW
WP 2: Germany is not the only with a balance request
WP 3: Business models

- Does it make sense to optimize cross-border balancing services?
- Large gains can be achieved by market integration, shared between energy, balancing and system services.
- Cross-border cooperation pays off.
WP 3: Storage capacity and cycle cost

Existing storage capacity in GWH

Comparing cycle cost

Capital cost per unit output energy per cycle [USD $ / kWh]
WP 3 & WP 2: Profitability in a larger perspective

Storage possibilities

Strategy by (SDP/SDDP)

Markets and prices

Stochastic, inflow
solar, wind etc

Simulation

Vannverdi

Supply/demand data

Simulating markets (LP)

System operation

Storage utilization

Feasible solution

Probability

CEDREN
Centre for Environmental Design of Renewable Energy
WP 4: Environmental impact

How fast can we regulate?

How much water is enough?
WP 4: Connecting environmental impact and economy

Discharges and reservoir levels

ECO tools

ECO consequence

ECO mitigation

Recalculate: Discharges and reservoir levels
WP 5: Social acceptance and regulatory framework
Workflow in CEDREN HydroBalance

1. Scenario selection
   1.1

2. Data models
   2.1

3. Identify markets
   3.1

4. Ecological consequences
   4.1

5. Barriers and drivers
   5.1

6. Dissemination and management

7. Grid bottlenecks
   1.2

8. HP alternatives
   1.3

9. Time lines
   1.4

10. Revised road map
    1.5

11. Compare solutions
    2.4

12. Model interaction
    2.3

13. Expected payback
    3.2

14. Estimate operation
    3.3

15. Hydrodynamic changes
    4.2

16. Mitigating effects
    4.3

17. Social acceptance
    5.2

18. Non-technical challenges
    5.3
Thanks for your attention

Questions?