AlternaFuture:
Extreme upgrading of existing hydropower systems

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NORWEGIAN RESEARCH CENTRE FOR HYDRO POWER TECHNOLOGY

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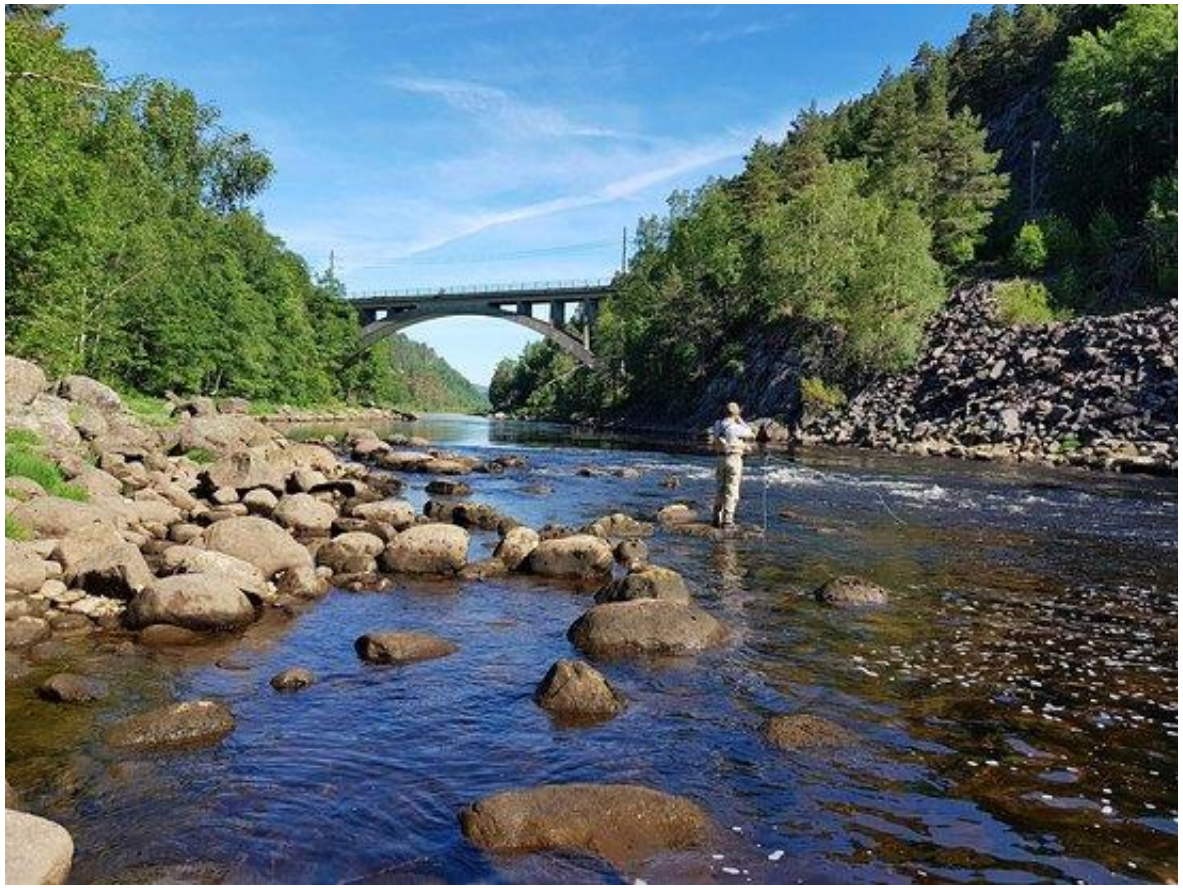
The Research Council of Norway

Disposition

1. Scope
2. Methodology
3. Results



Scope
- AlternaFuture

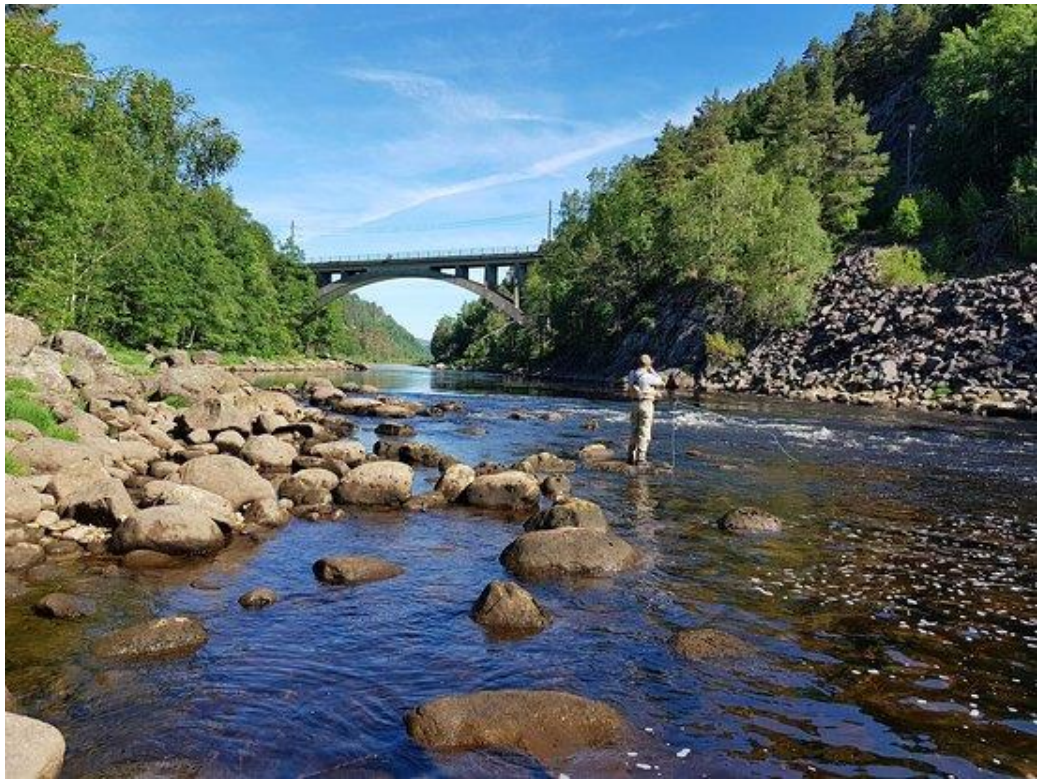
Scope:

1. Strengthen multidissiplinary cooperation in HydroCen
2. Develop and test scenarios for extreme upgrading of hydropower systems
3. Stress-test innovations from HydroCen
4. Generate new research projects

Scope
- AlternaFuture

Scope:

AlternaFuture shall study extreme upgrading of existing hydropower systems that also improves the environmental conditions. We need such a desk study to highligh potential challenges and the need for research to enable such upgrading in the future.



Methodology

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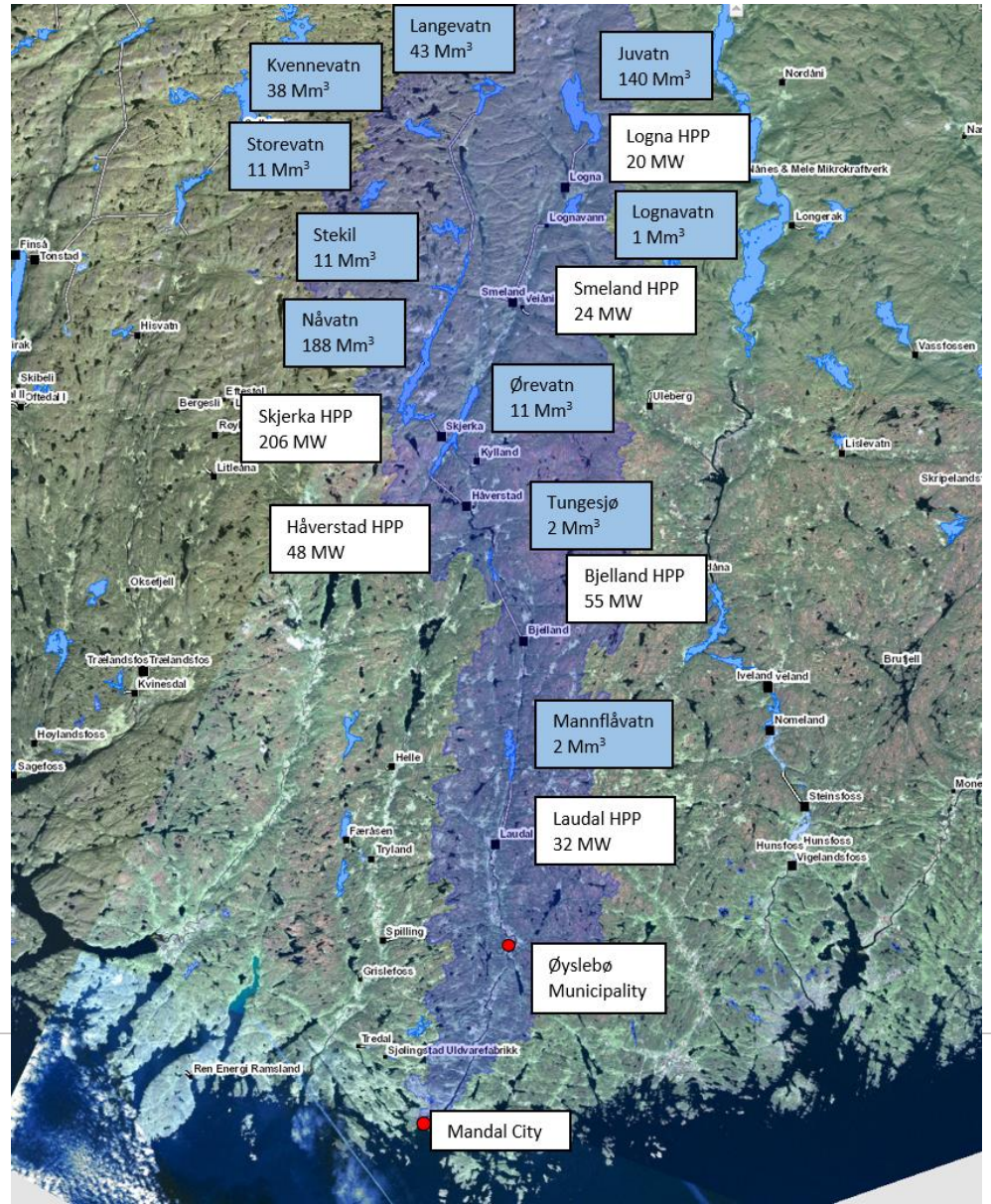
Case-study: Mandal hydropower system - Characteristics

- 140 km long river
- Highest point 1160 masl, outlet in the sea
- 6 power plants
- Total capacity = 384 MW
- Annual production = 1.7 TWh



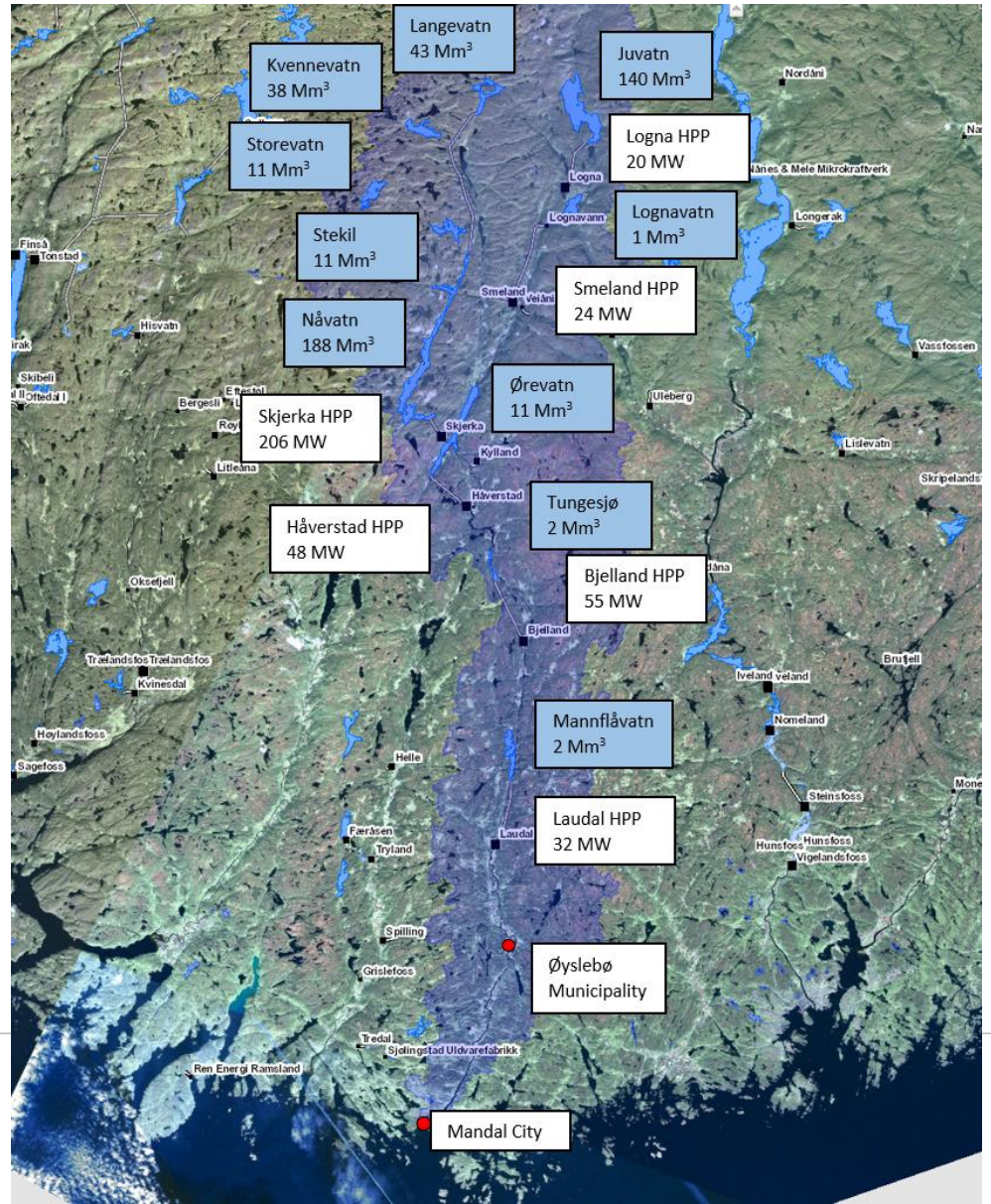
Case-study: Mandal hydropower system - Challenges

- National parks
- Population in the best reservoir locations
- Protected side rivers
- Important salmon population

→Will respect all of the above

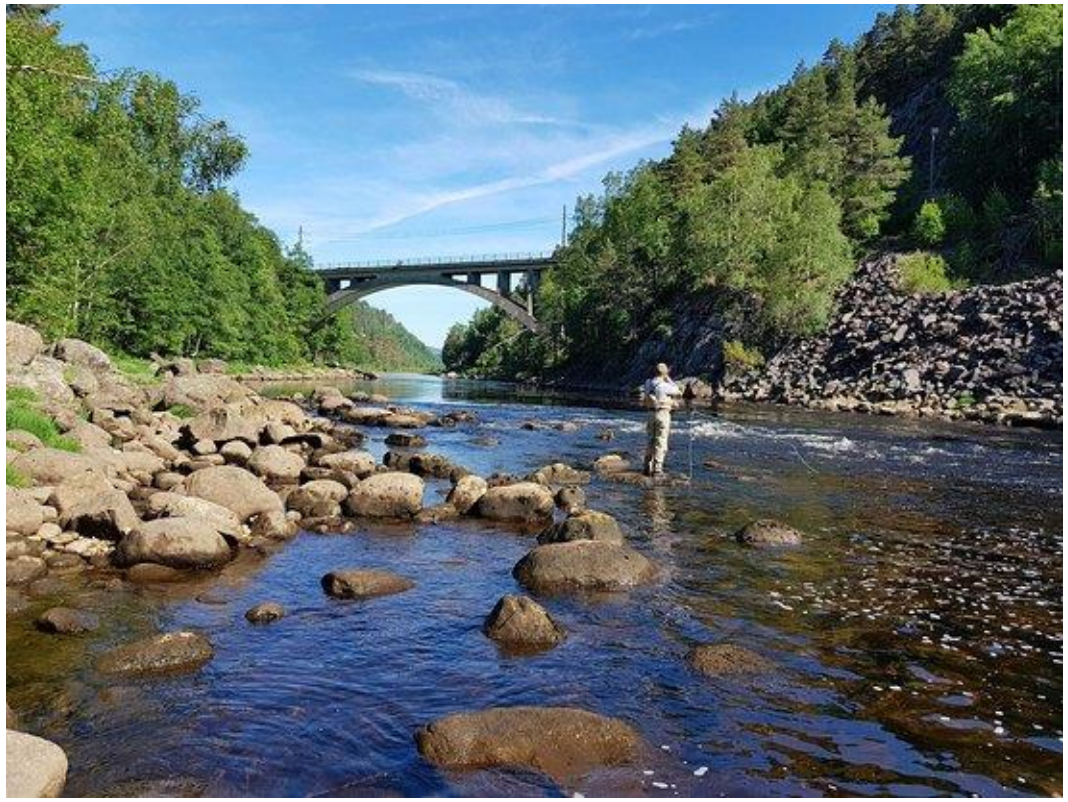
→Have made the task difficult for ourselves!

- But if we find solutions here, they will work also elsewhere



AlternaFuture
- Work breakdown

- Activity 1 : Map the current situation
- Activity 2: Develop scenarios for reconstruction
- Activity 3: Quantify the effects of reconstruction



HydroCen

Results

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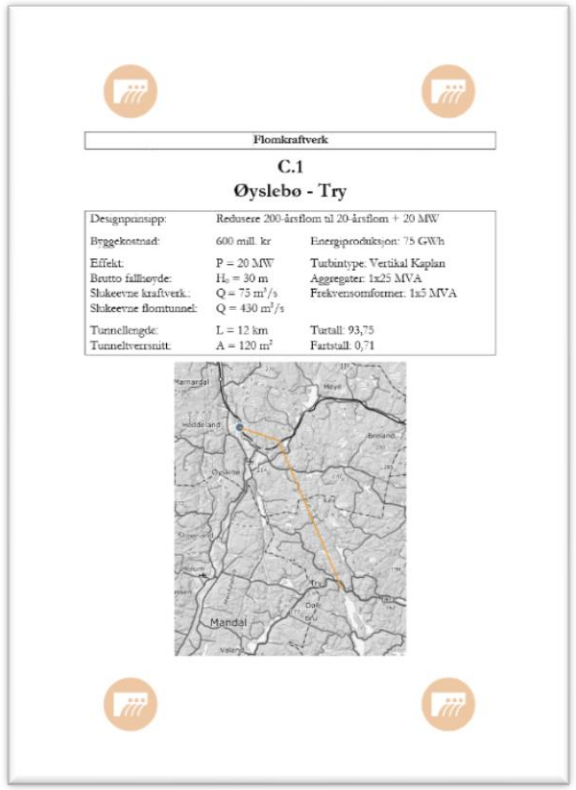
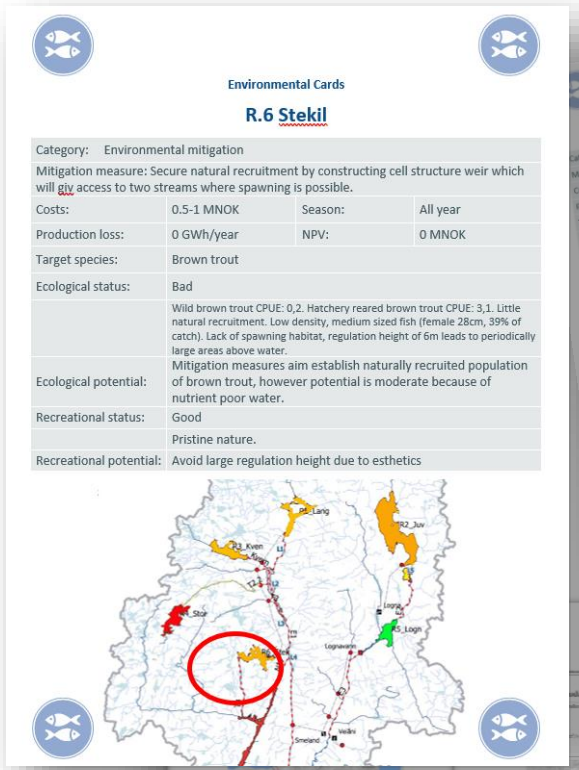
Results
- «Deck-of-cards» method


Flomkraftverk

C.1

Øyslebø - Try

Designprinsipp:	Redusere 200-årsflom til 20-årsflom + 20 MW		
Byggekostnad:	600 mill. kr	Energiproduksjon: 75 GWh	
Effekt:	P = 20 MW	Turbintype: Vertikal Kaplan	
Brutto fallhøyde:	H_b = 30 m	Aggregater: 1x25 MVA	
Slukeevne kraftverk.:	Q = 75 m³/s	Frekvensomformer: 1x5 MVA	
Slukeevne flomtunnel:	Q = 430 m³/s		
Tunnellengde:	L = 12 km	Tverfall: 93,75	
Tunneltverrsnitt:	A = 120 m²	Fartsfall: 0,71	

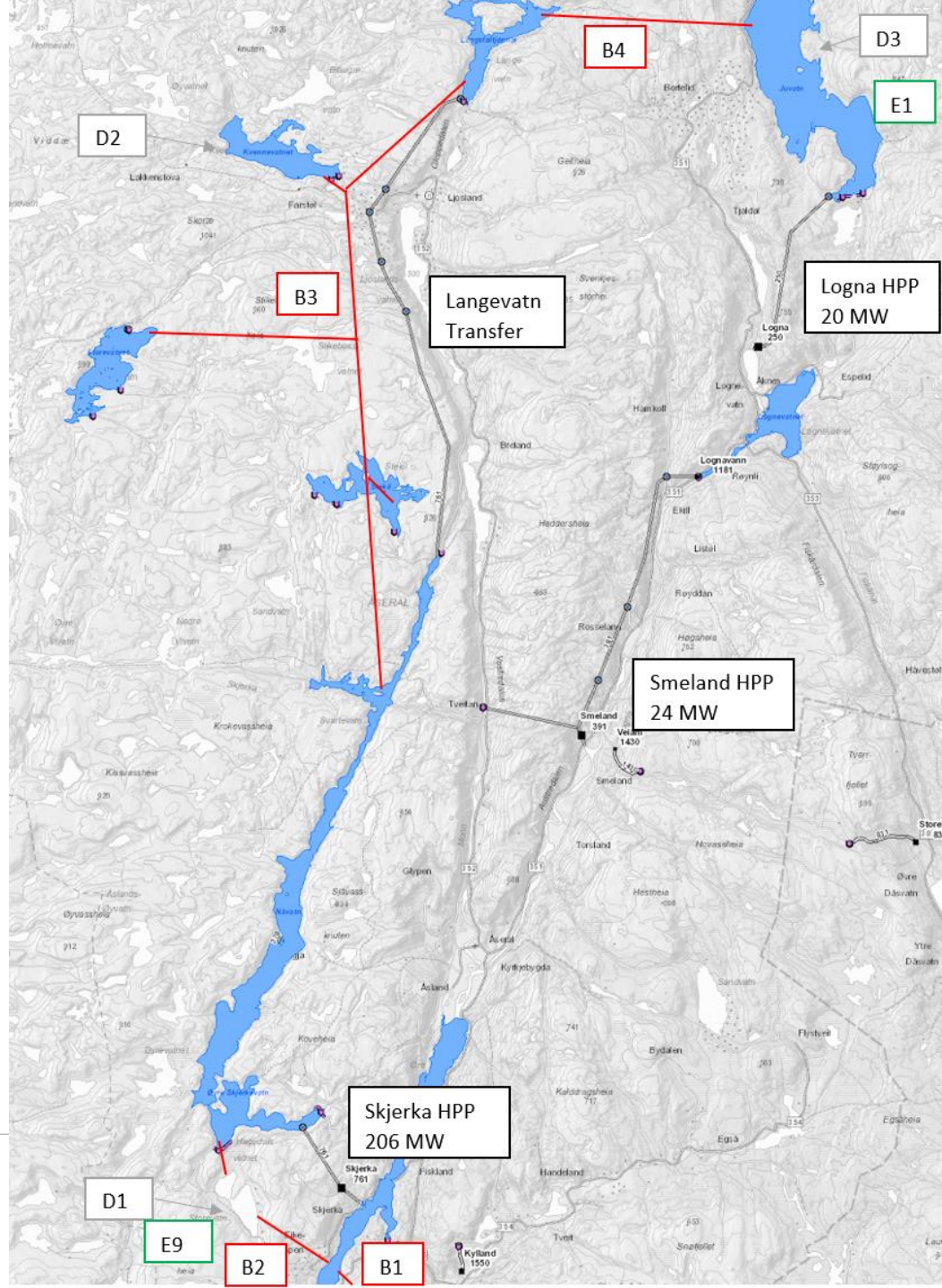

Environmental Cards

R.6 Stekil

Category:	Environmental mitigation		
Mitigation measure:	Secure natural recruitment by constructing cell structure weir which will giv access to two streams where spawning is possible.		
Costs:	0.5-1 MNOK	Season:	All year
Production loss:	0 GWh/year	NPV:	0 MNOK
Target species:	Brown trout		
Ecological status:	Bad		
	Wild brown trout CPUE: 0,2. Hatchery reared brown trout CPUE: 3,1. Little natural recruitment. Low density, medium sized fish (female 28cm, 39% of catch). Lack of spawning habitat, regulation height of 6m leads to periodically large areas above water.		
Ecological potential:	Mitigation measures aim establish naturally recruited population of brown trout, however potential is moderate because of nutrient poor water.		
Recreational status:	Good		
	Pristine nature.		
Recreational potential:	Avoid large regulation height due to esthetics		

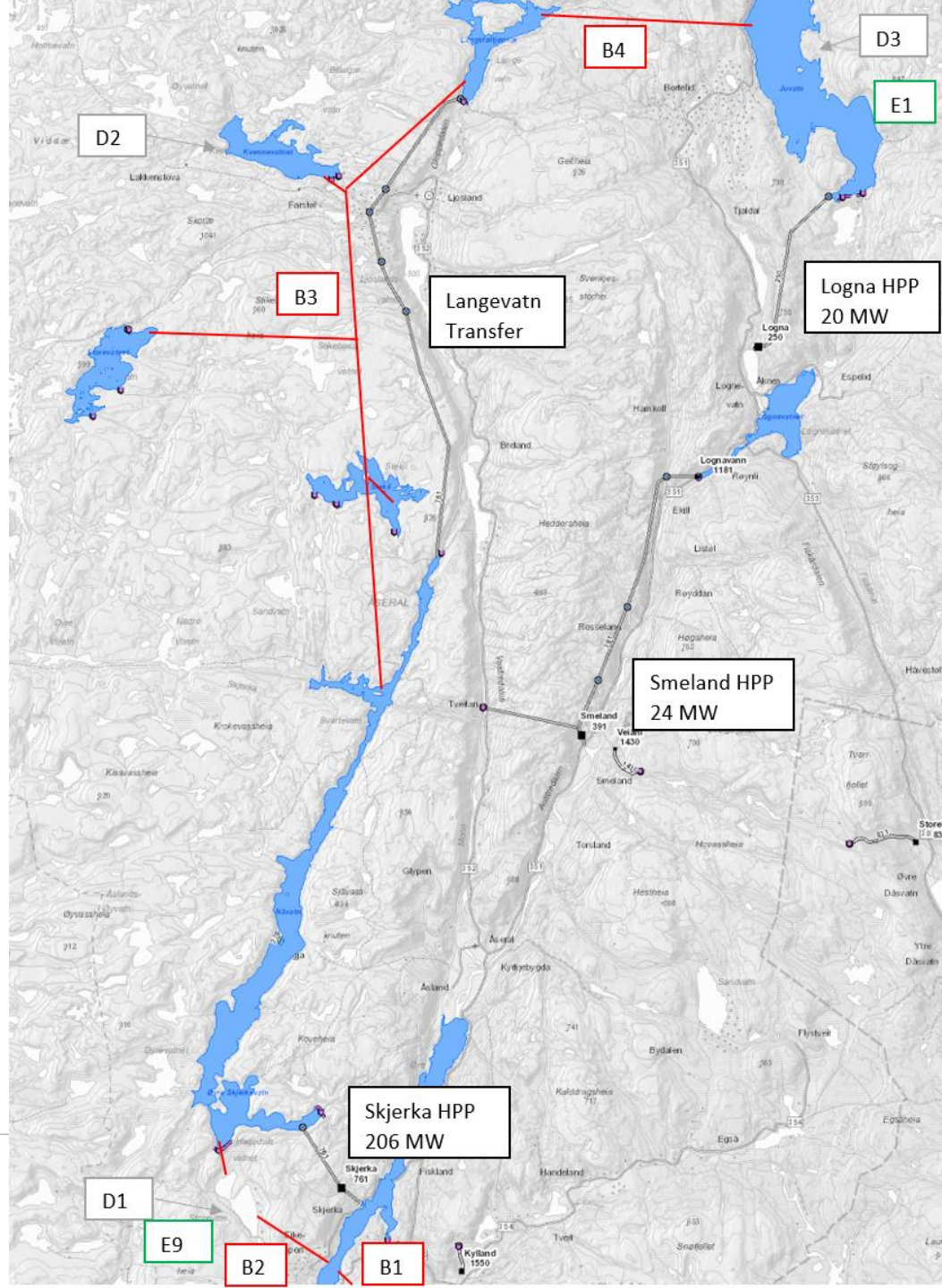
Results
- Three scenarios

Scenario	Installed capacities	Characteristics
Tripple installed capacity	385 + 745 MW + 20 MW FPP	Construction of new parallell power plants for most cost-efficient power upgrade.
Maximum flexibility	385 + 750 MW PSP	Construction of new pumped storage plants for maximum utilization of reservoirs
Flood protection	385 + 655 MW PSP + 20 MW FPP	Construction of pumped storage and flood power plants for maximum flood dampening



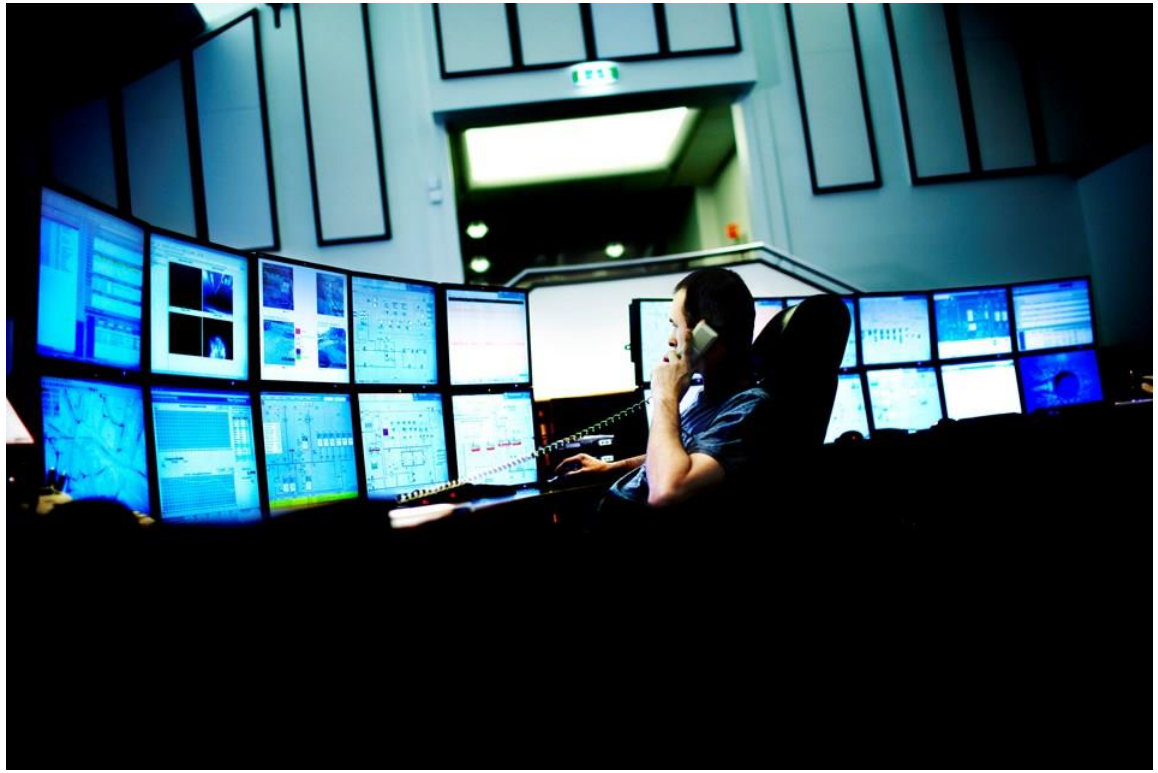
Results
- Environmentally friendly?

- Environmentally friendly extreme upgrading is possible for all three scenarios
- Disclaimer: Final evaluation is not complete!



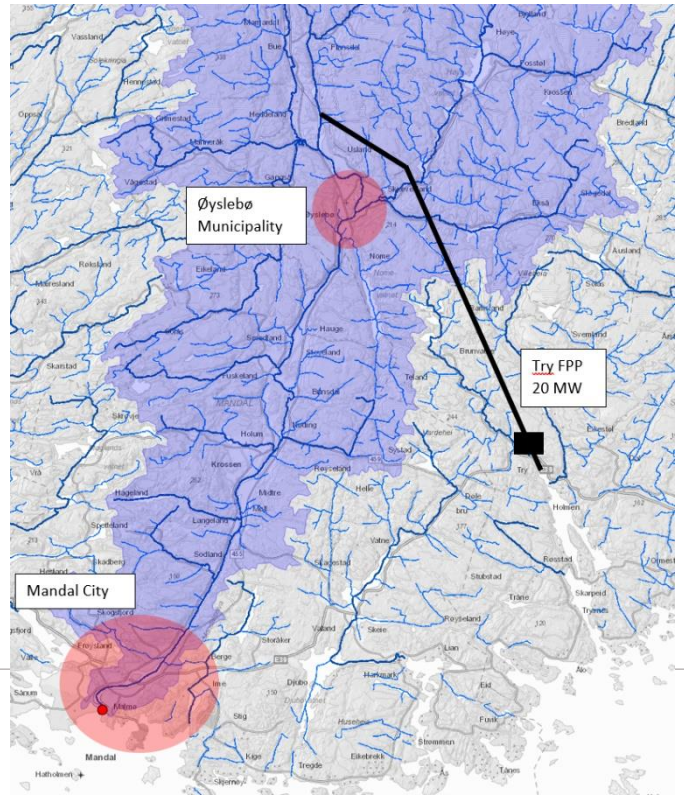
Results
- Economic feasibility?

- Not profitable with current power prices
- Scenario 2&3 are profitable in the “extreme 2030” price forecast



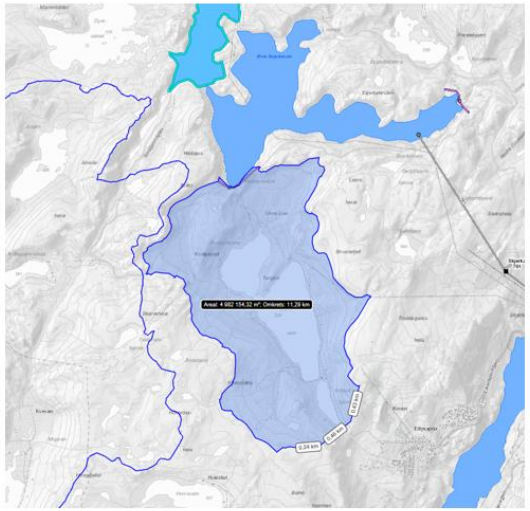
Results
- Remaining potential?

- New and interesting hydropower projects can still be found in existing schemes



D.1: Storevatn

Formål: Nytt magasin		
Eksisterende	**Potensial**	
Navn: Storavatn Vannstand: 529 moh A = 0,8 km² Årstilsig = 13 mill. m³	HRV = 580 moh A = 2,7 km² V = 120 Mill. m³ Årstilsig = 13 mill. m³	HRV = 627 moh A = 4,9 km² V = 280 Mill. m³ Årstilsig = 13 mill. m³
	Dam	
	Volum: 1,3 mill. m³ Kostnad: 400 mill. kr.	Volum: 6,6 mill. m³ Kostnad: 1,6 mrd. kr.



Results

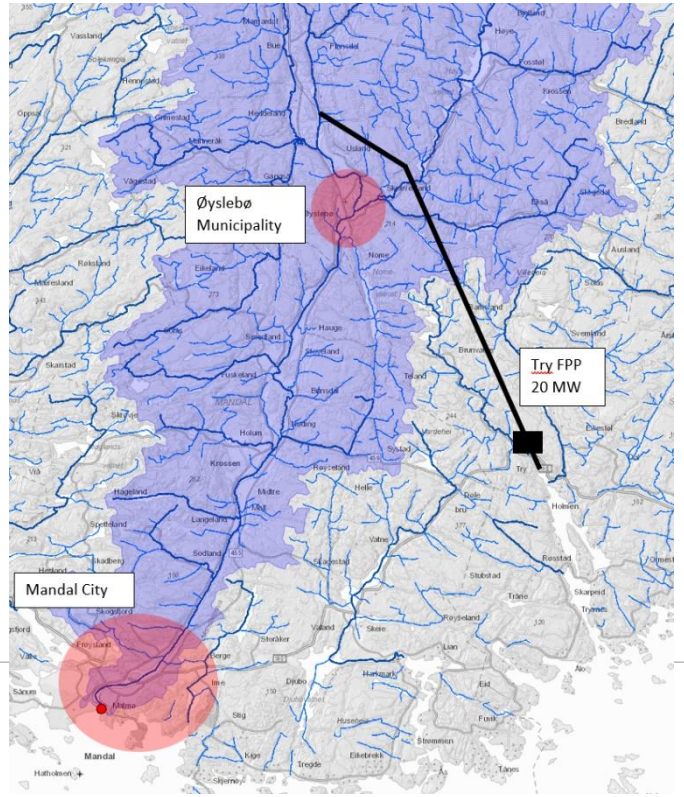
- Many interesting multidissiplinary discussions

- New ideas and concepts have been conceived
- 18 research projects are proposed

Research Project Cards

RP.1 Fish Friendly Intakes for Pumping

Relevance:	Bjelland PSP	Previous research:	Limited
Necessary funding:	4 MNOK	Discipline:	Fish/hydraulics
Environment:	Very positive/**Positive**/Neutral/Negative/Very negative		
Power production:	Very positive/Positive/Neutral/**Negative**/Very negative		
Scope:	Avoid spreading species when pumping water.		
Short description:	Develop a fish friendly intake for pumping plants and pumped storage plants		
Overall assessment:	Unexplored field of research. Potential for new innovations.		



Research Project Cards

RP.16 Fish Friendly Hydropower Tunnels

Relevance:	All HPP	Previous research:	Limited
Necessary funding:	4 MNOK	Discipline	Fish/Civil
Environment:	Very positive/**Positive**/Neutral/Negative/Very negative		
Power production:	Very positive/Positive/Neutral/**Negative**/Very negative		
Short description:	Adapt unlined hydropower tunnels to enable fish habitats		
Overall assessment:	Potential large-scale environmental gains at limited costs		

Thank you for the attention!

- Final report due in March!