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Regionalization of water consumption and the effect on water footprint results for hydropower

A part of the EcoManage project:

Improved development and management of energy and water resources

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Centre for Environmental Design of Renewable Energy



The EcoManage project

Improved development and management of energy and water resources

Test, evaluate and adapt new concepts and indicators.

Enhance the governance of energy and water recources.

Active involvement of the users (Agder Energy, Statkraft, the Norwegian Environmental Agency etc)





Key subjects

- What is the life cycle water consumption of Norwegian hydropower?
- How important is evaporation from the dam/waterways?
- What would the result have been if the evaporation took place in another region?



Background

Water consumption from energy generation: Source: IPCC SRREN, 2011



Weak methodology

- Limited number of cases
- Unclear definition of spatial and temporal boundaries of the study area
 - Only the operational phase is included (evaporation)
 - Calculations based on gross evaporation rates





Water footprint of hydropower dominated by the operative phase (evaporation from dam and waterways)?

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Methodological approach: evaporation calculations



Evaporation/evapotranspiration based on the Penman-Monteith model on daily time steps for one year:

- Precipitation, tempetarure, wind speed, relative humidity, global radiation
- Vegetation type, vegetation height and season (leafes)



Inventory results





2009

al. 2011

al. 2012

⊢4

2014

Scarcity

2006

2009

al. 2011

Trollheim

al. 2012

2014

Scarcity

2006

How important is evaporation from the dam/waterways? Water footprint results Low or Low or zero zero 100% 90% **25-45%** 80% 70% 60% 50% Infrastructure, reinvestments, 6**5**-75% maintenance and 40% operation Evaporation from 30% reservoir 20% 10% 0% LCI Pfister et al. Boulay et Hoekstra et Berger et al. Ecological LCI Pfister et al. Boulay et Hoekstra et Berger et al. Ecological

What would the result be if this evaporation happened in another region?

Virtually «moving» Trollheim (Follsjøen reservoir) power plant to another region.

Consequences:

- Evaporation will most probably increase.
- If constant evaporation; how much will the scarcity issue affect the total results?



Water scarcity results for hydropower from Trollheim Boulay 2011, using evaporation characterisation factors for Canada, China, Ethiopia, New Zealand and USA



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Conclusions

- Water footprint of hydropower is not always dominated by evaporation from reservoir and waterways. Infrastructure, maintenance and reinvestment can also contribute in some cases/countries.
- More detailed regionalisation would enhance the results.
- LCI results from Norway: in the lower range compared to the IPCC results.

Further work

- Calculate the evaporation rates in the actual countries.
- Re-calculate the water footprint results, using regional evaporation rates and several water footprint methods.
- Scarcity issue (characterisation factors) vs increased evaporation



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RESEARCH



Thank you!

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