

Comparison of environmental impacts from small-scale hydropower, large hydropower and wind power projects

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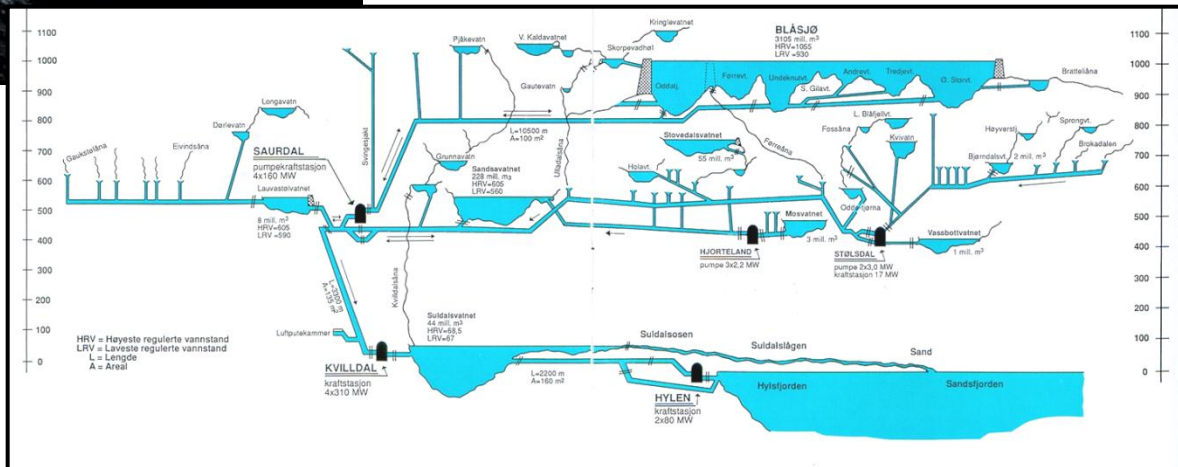
Norwegian University of Science & Technology

Large plants – large impacts?



Long history of conflicts

Resistance formed the environmental movement



Source: Statkraft

Development of Alta-Kautokeino river basin, Norway



Three Gorges project, China

China's dam busters protest controversial resettlement project

It is the world's largest building site, a showcase for the 'new' China. But rising around the Three Gorges Dam project

By Calum MacLeod and Lijia MacLeod

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WATER WORLD

Farmers protest over Three Gorges Dam relocation: residents

by Staff Writers
Beijing (AFP) March 4, 2009

Farmers relocated to make way for the Three Gorges Dam, the world's biggest [hydroelectric power](#) project, clashed with police in a protest over alleged corruption, locals said Wednesday.



Between 1,000 and 2,000 people protested in Jiangnan township in central China's Chongqing municipality on Monday and Tuesday, leading to clashes with police, they said.





Photo: Norsk Grønnkraft



Photo: BKK



Photo: Statkraft



Small plants – small impacts?

Accumulated effects?



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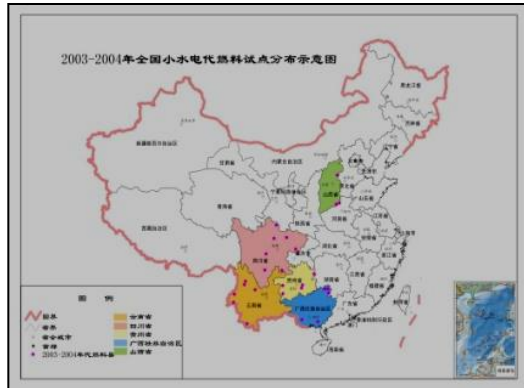




An extreme example from China

Small hydropower (< 50 MW):

- More than **1000** plants built
- Producing **2.5 TWh/a**



Large (enormous) Three Gorges:

- **1** huge plant
- Producing **96 TWh/a**



In order to produce the same energy output from Three Gorges project, approximately **40 000 small** hydropower plants (< 50 MW) must be constructed.

What are the accumulated environmental (and social) impacts?

Climate change asks for development of renewable energy

How to realise the EU Renewable Energy Sources (RES) Directive?

Large hydropower?



Many small-scale?



Wind power farms?



Approach for comparison

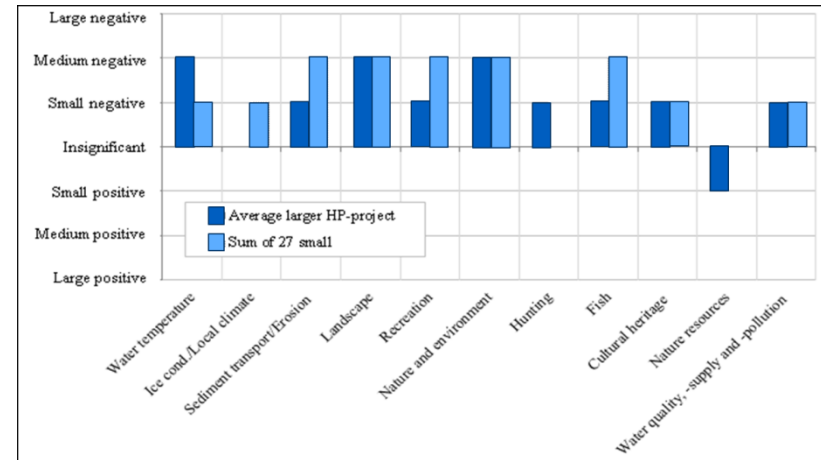
Similar volumes of energy production



**Environmental impacts from one large
plant compared to accumulated impacts
from many small**

Results phase 1 – Comparison based on EIAs

- Small-scale HP scores 'worse' (more negative/less positive) on the following topics:
 - Ice conditions/local climate
 - Erosion/sedimentation
 - Recreation
 - Fish
 - Nature resources



- ▶ Large HP scores 'worse' (more negative) in the category water temperature
- ▶ The scores differ with only one impact level

Conclusions from phase 1

- The results show a slight tendency that large hydropower has a lower degree of impacts than many small-scale projects.
- The results are, however, marginal in the favour of large hydropower.
- Lack of precision in the data and weak methodological foundation introduce uncertainty in the results.
- Taking into account other benefits such as the provision of regulated power, it is reasonable to assume that a few large hydropower projects will produce electricity to a lower environmental cost compared to many small projects.
- The study raises a more fundamental question on valuation of environmental qualities.

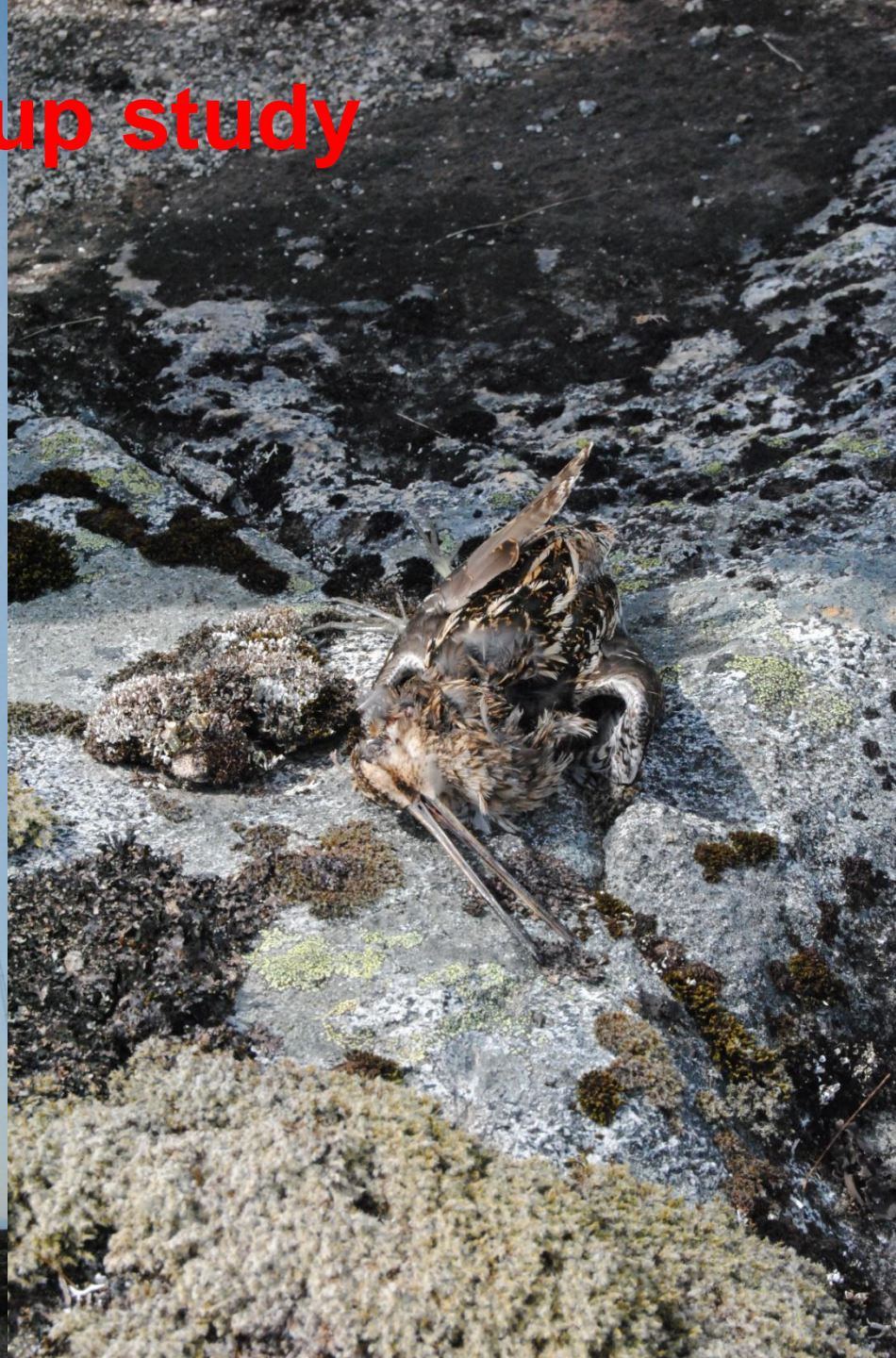
Is salmon more important than moss?



Who to assign values/priorities to the environment?

- Researchers?
- Management authorities?
- The majority?
- Other stakeholders?

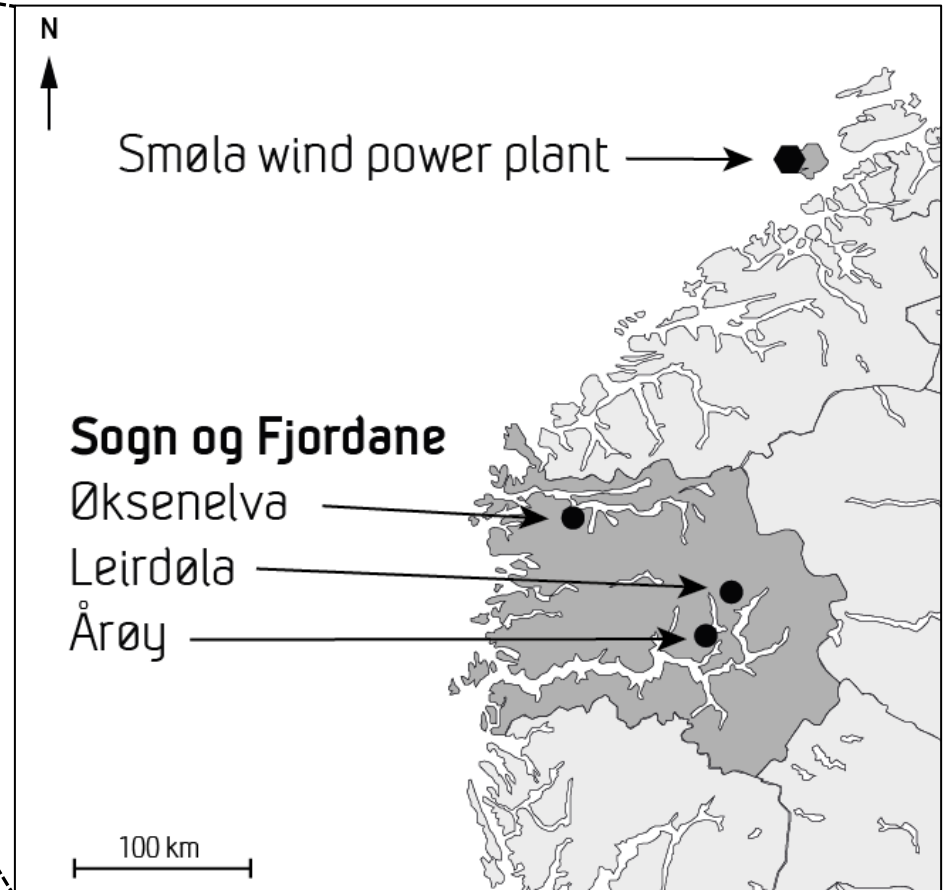
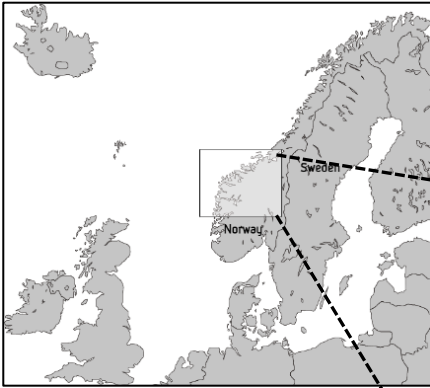
Follow-up study



Improvements of methodology

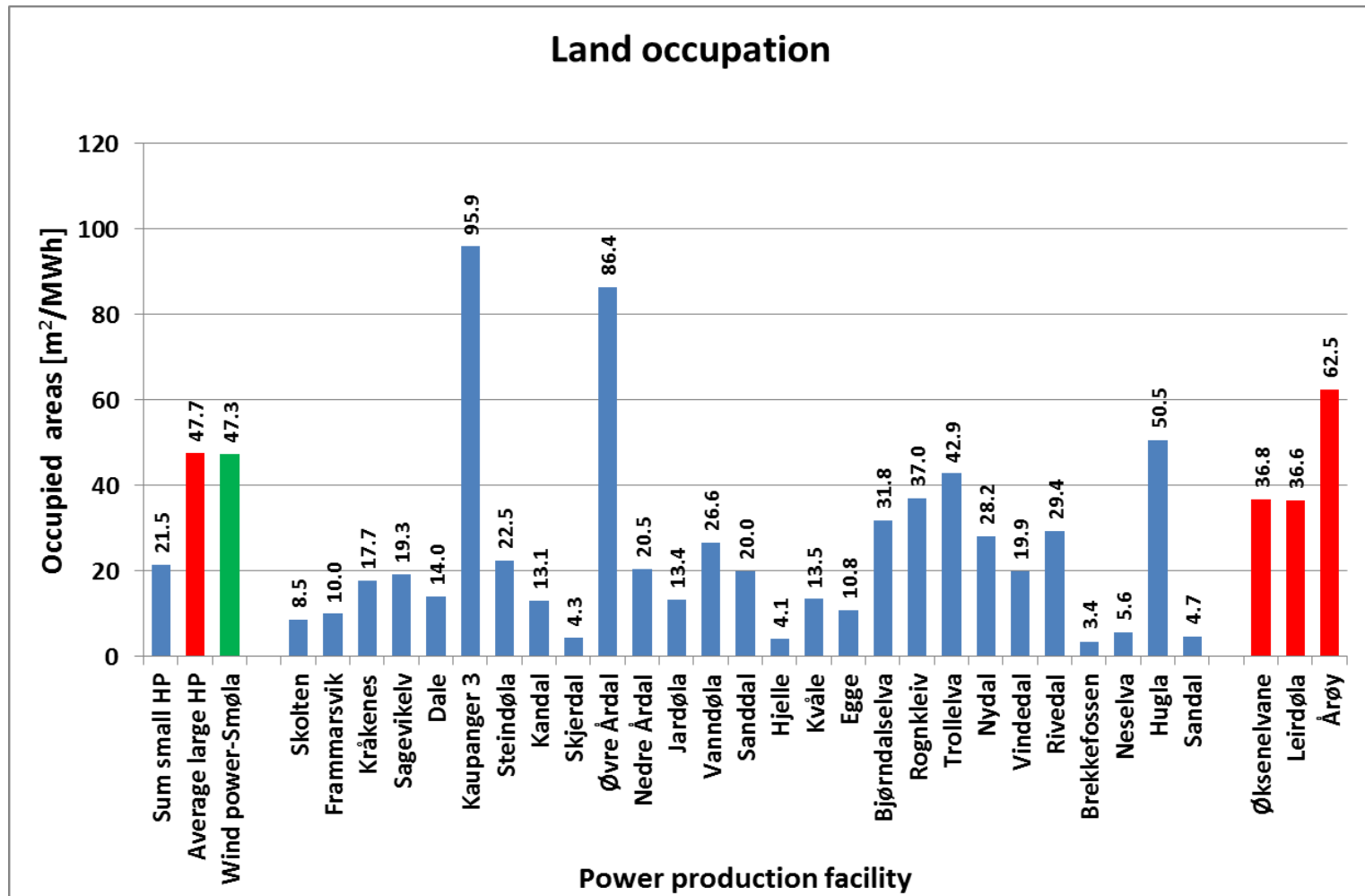
- Includes also wind power
- Uses a standardized set of parameters relevant for all production technologies:
 - areas directly affected by the projects
 - reduction in untouched nature (INON)
 - visibility
 - impacts on red-listed species

Locations & characteristics



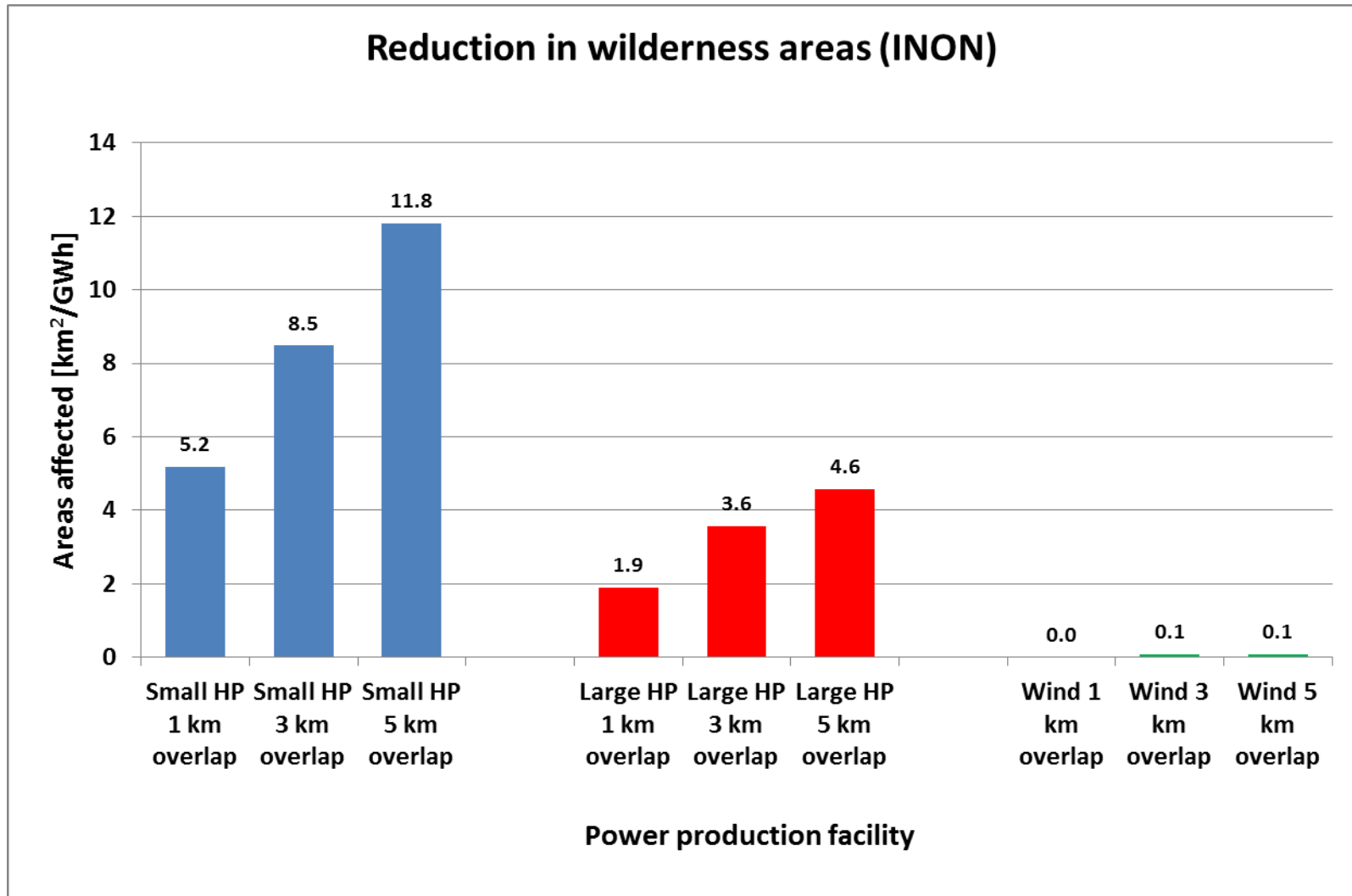
	Installed cap. [MW]	Energy prod. [GWh]
Sum small HP	89	350
Large HP	76	347
Wind power	150	356

Results



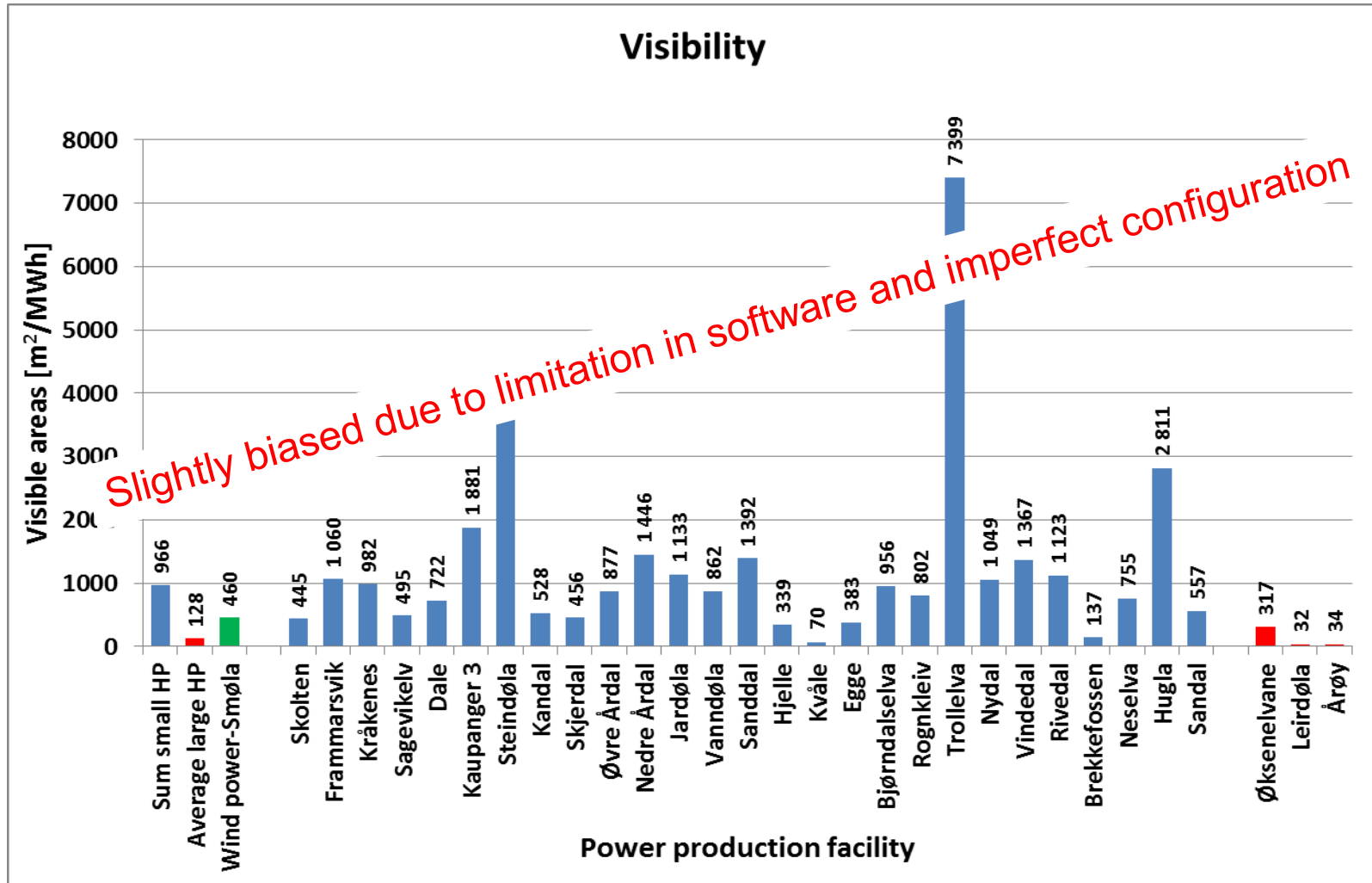
Accepted: Bakken et al. *J. of Environmental Management*

Results



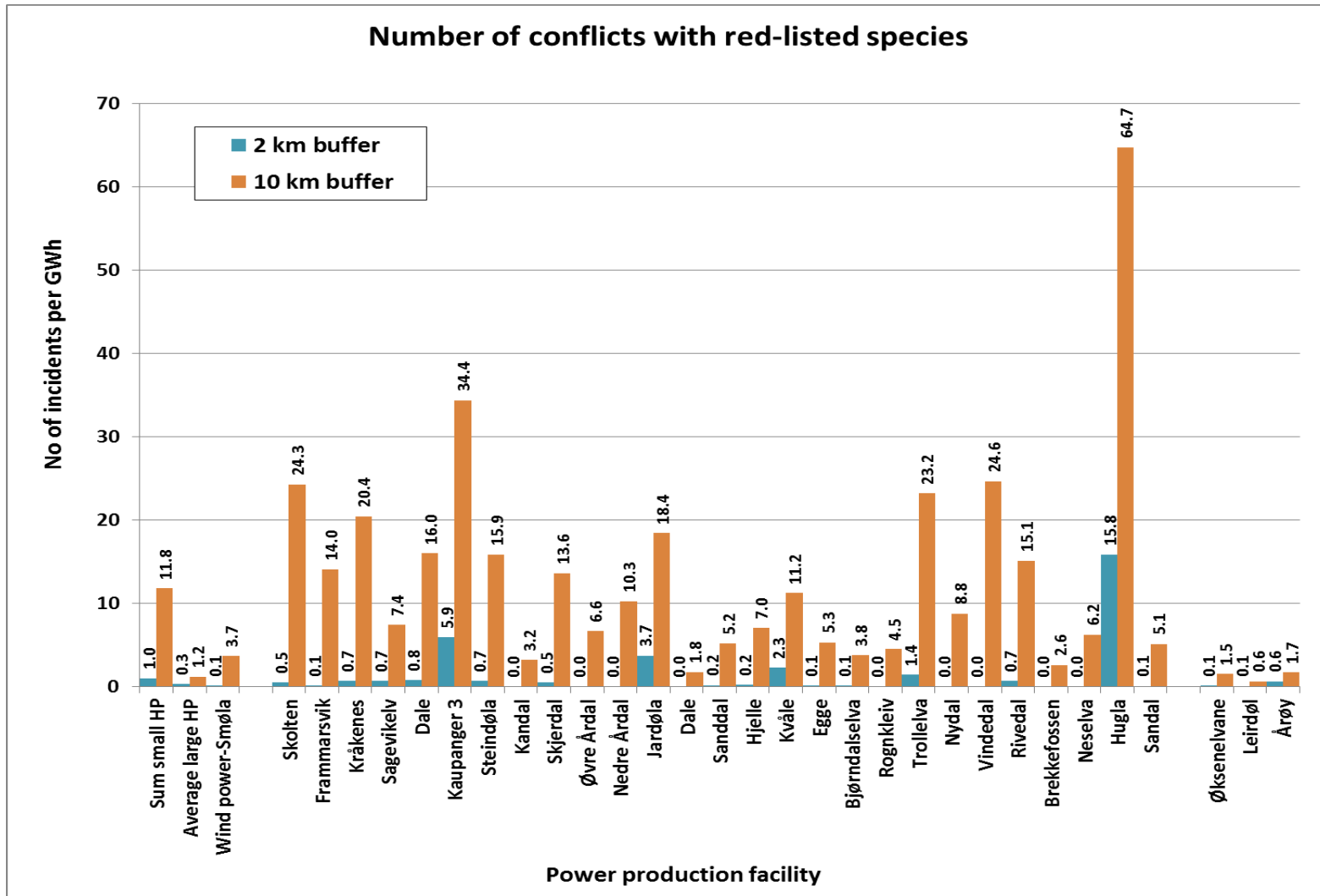
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Results



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Results



Accepted: Bakken et al. *J. of Environmental Management*

Conclusions phase 2

- Small-scale HP scores lowest on most criteria
- Large HP and wind have overall similar performance
- Results are case-specific
- Our parameters do not cover all environmental aspects
- Careful design of projects can improve performance
- Remember differences in energy qualities