Naturvernforbundet

Assessment of environmental impacts from small versus large hydro-power developments

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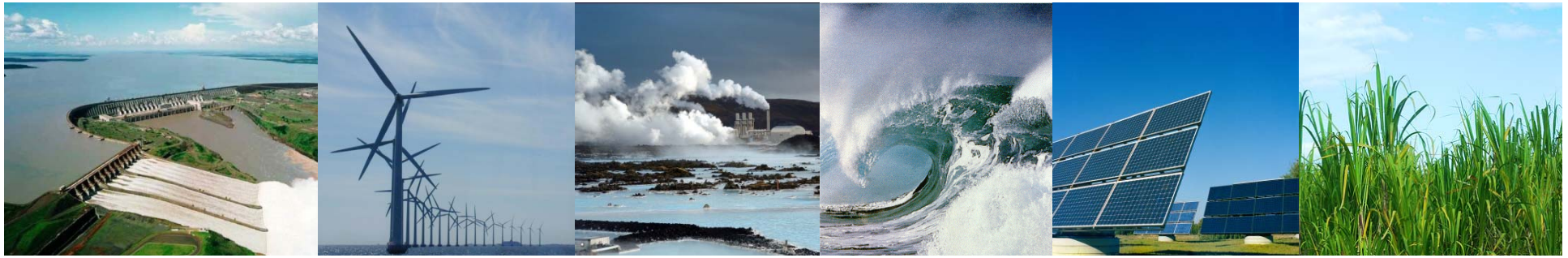
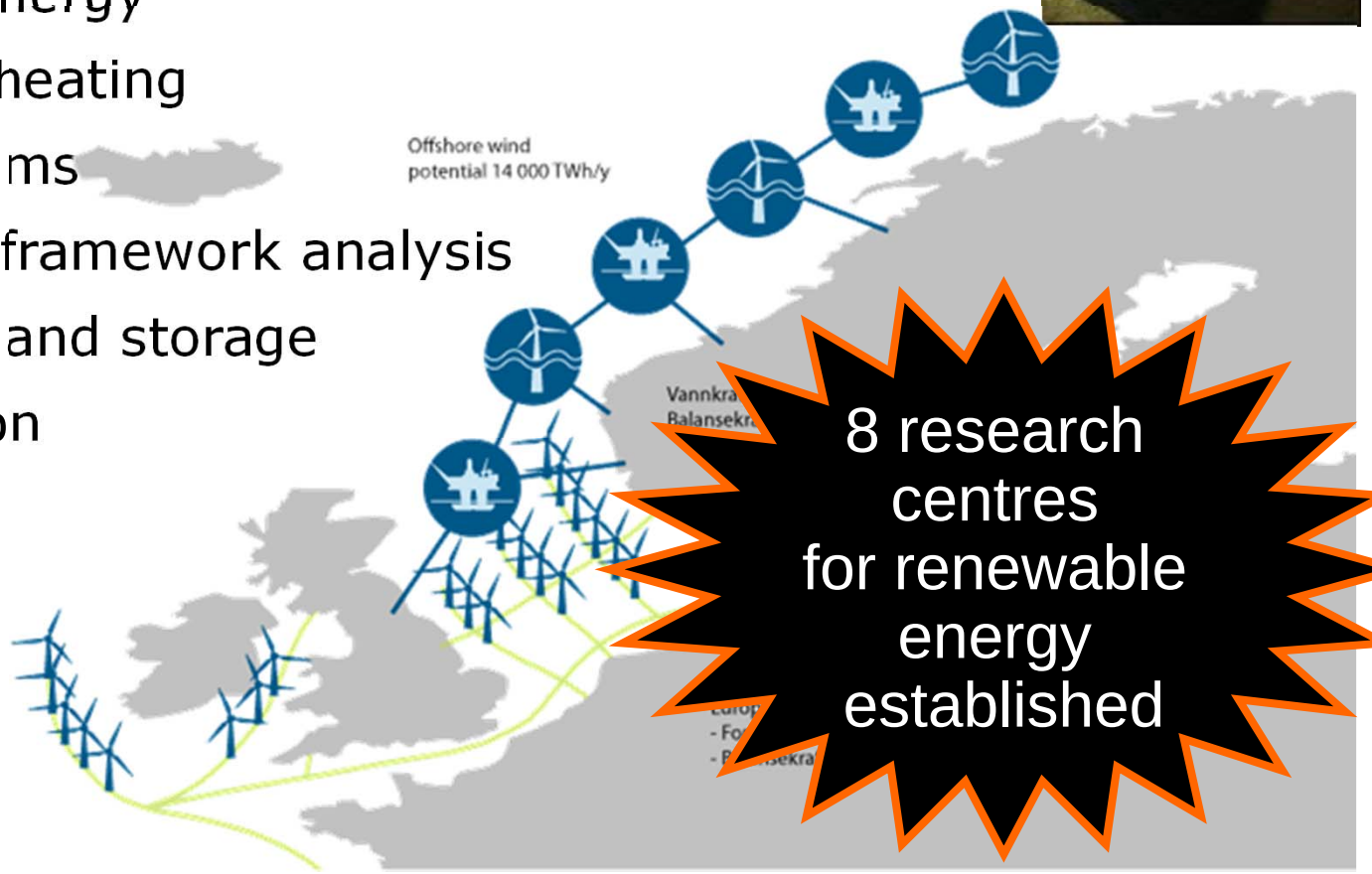


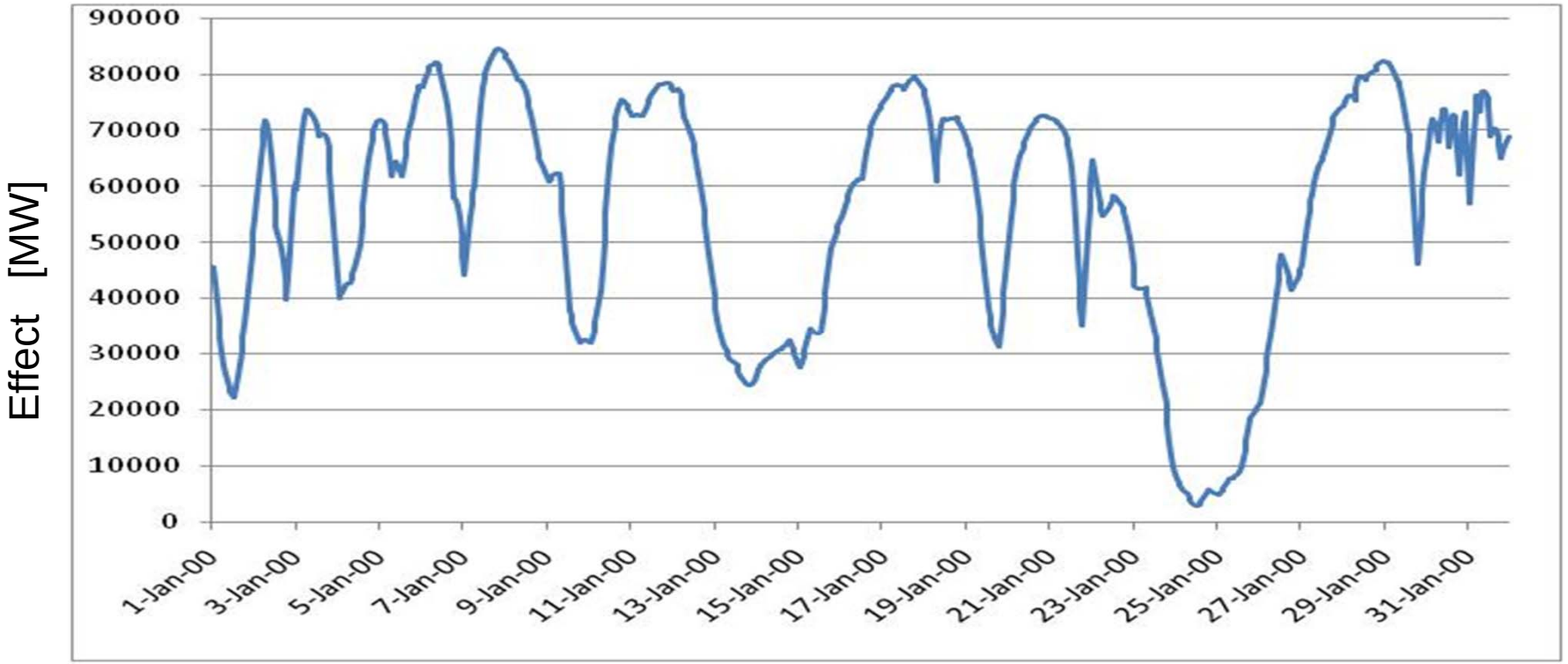
Energi21 and Climate agreement in Parlament pointed out:

- Energy efficiency
- Renewable energy
- CO_2-neutral heating
- Energy systems
- Institutional framework analysis
- CO_2-capture and storage
- Transportation

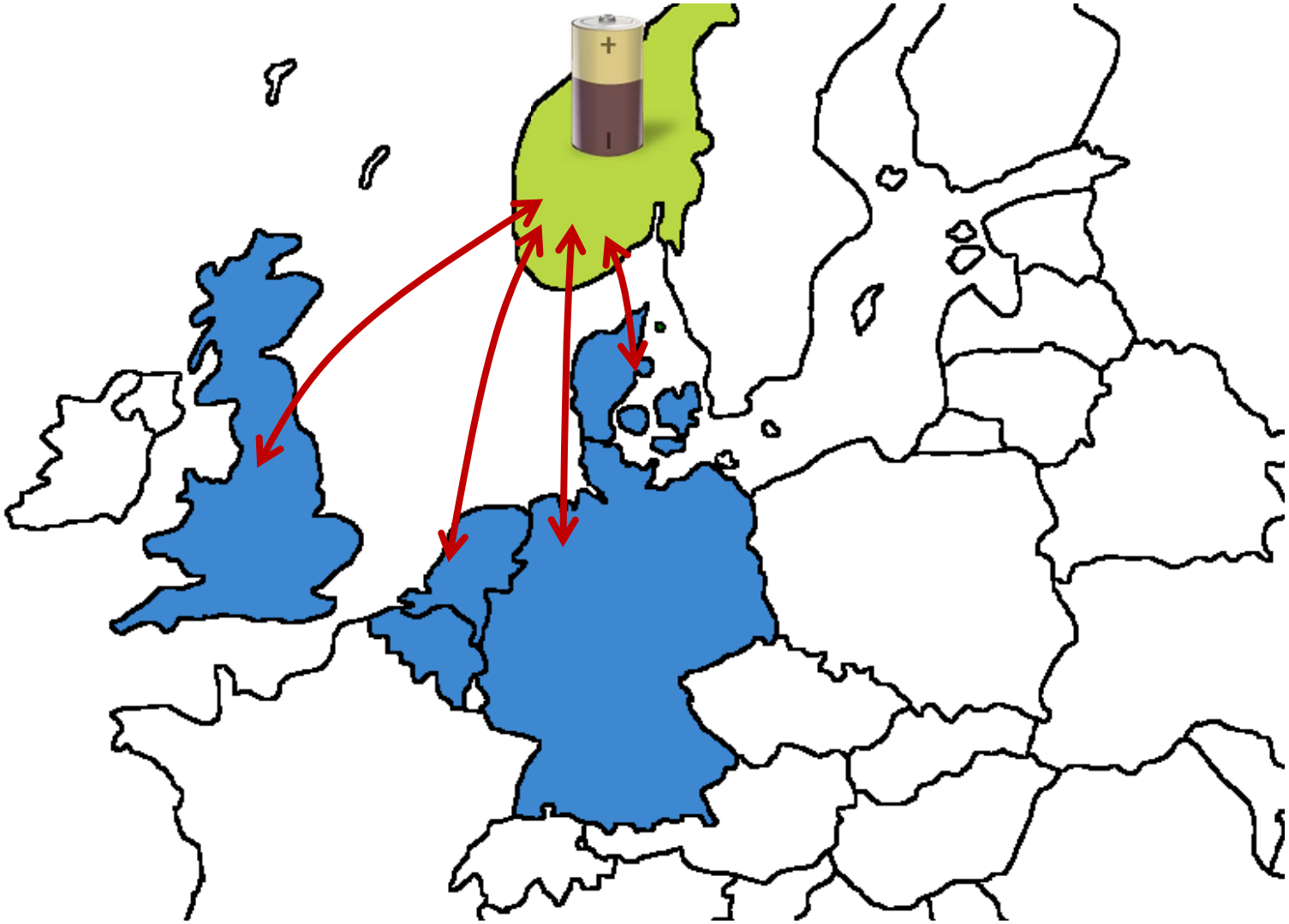


8 research centres for renewable energy established

Future wind power production in the North Sea Area



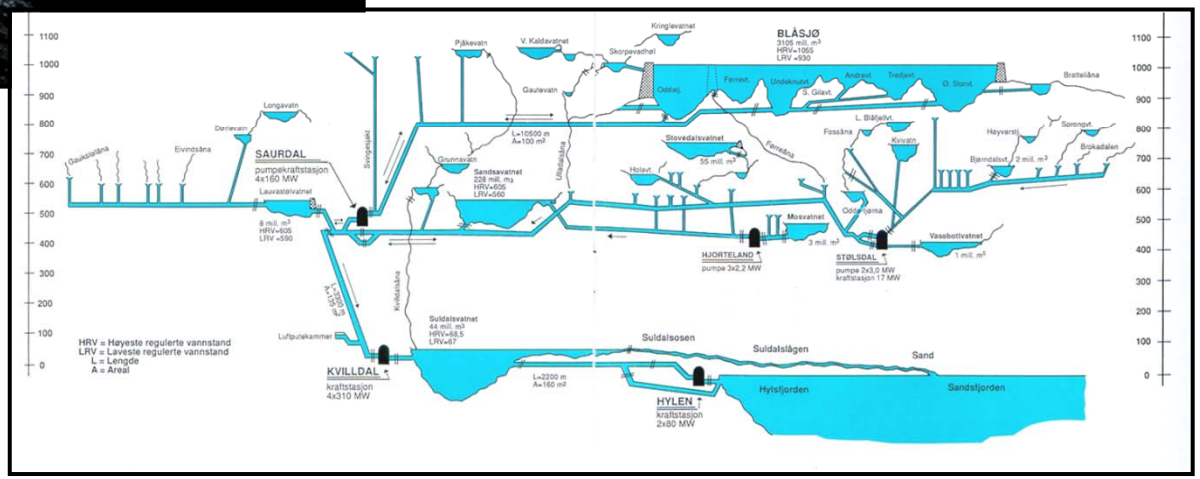
Norway – A green battery for Europe?



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

THE INDEPENDENT

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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.

Theun-Hinboun hydropower project, Laos

Ruined rivers, damaged lives

« ...most people admitted they did not understand the implications and were afraid to ask questions.»

«Nyom! Bor mee pba leua!
– I accept defeat! There are no fish left!»

THPC

Expansion Project

After a decade of successful operations, THPC had decided to expand its project to a new total capacity of 500 MW. The Project (THXP) involves a 70m high upstream dam and reservoir on the Nam Gnouang River and a new 60MW power stat dam, 230MW expansion of the existing THPC capacity, and 150 km of 115kV and 230kV transmission lines.

Small plants – small impacts?

Accumulated effects?


Small plants – small impacts?
Accumulated effects?

Small plants – small impacts?

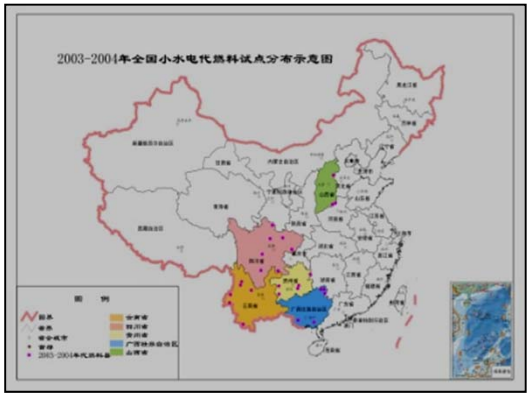
Accumulated effects?


DAEWOO

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?

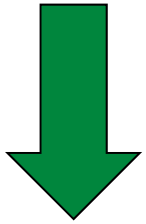
Large hydropower?

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

Approaches for comparison

Comparison of environmental impacts across types of energy (electricity) production technologies:

- Few studies published
- Lack of mature and well-proven methodological frameworks
- IPCC SRREN-report (2011) suffers from lack of studies

The quality of the energy production should also be considered:

- Regulated versus non-regulated
- Security/reliability of supply / hydrological risk
- Access to grid with sufficient capacity

Comparison of environmental impacts (1)

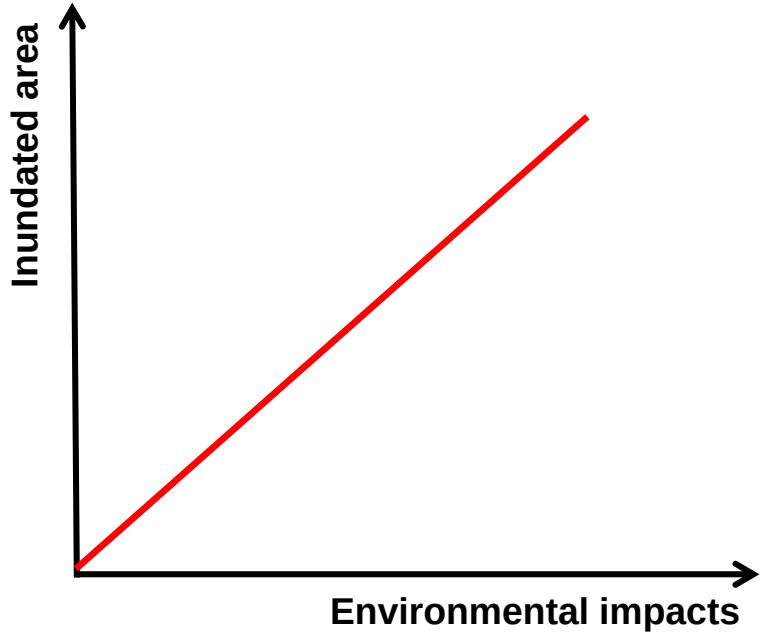
Rule of thumb; environmental impacts are roughly proportional to area inundated, (e.g. Egre & Milewski (2002))

<u>Outcome:</u>

Small-scale plants without reservoirs come out better than large reservoir plants

Developed for reservoir plants?

What about large run-of-the-river plants?



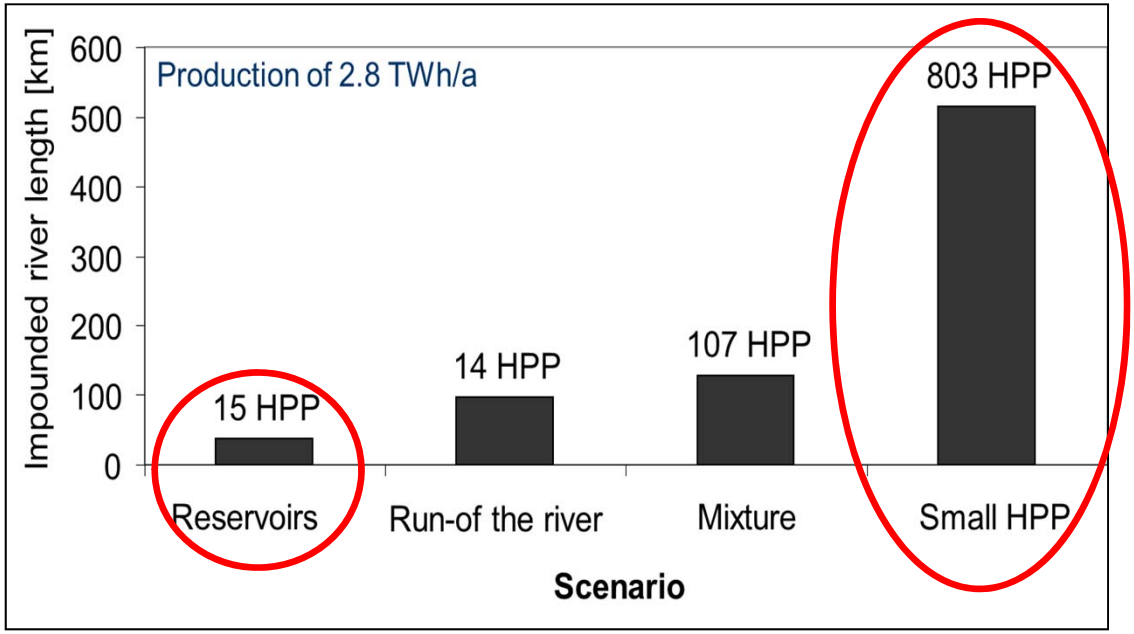
Comparison of environmental impacts (2)

Comparison of impounded river lengths, given the need to produce 2.8 TWh/a (Schmutz et al. 2010):

<u>Outcome:</u>

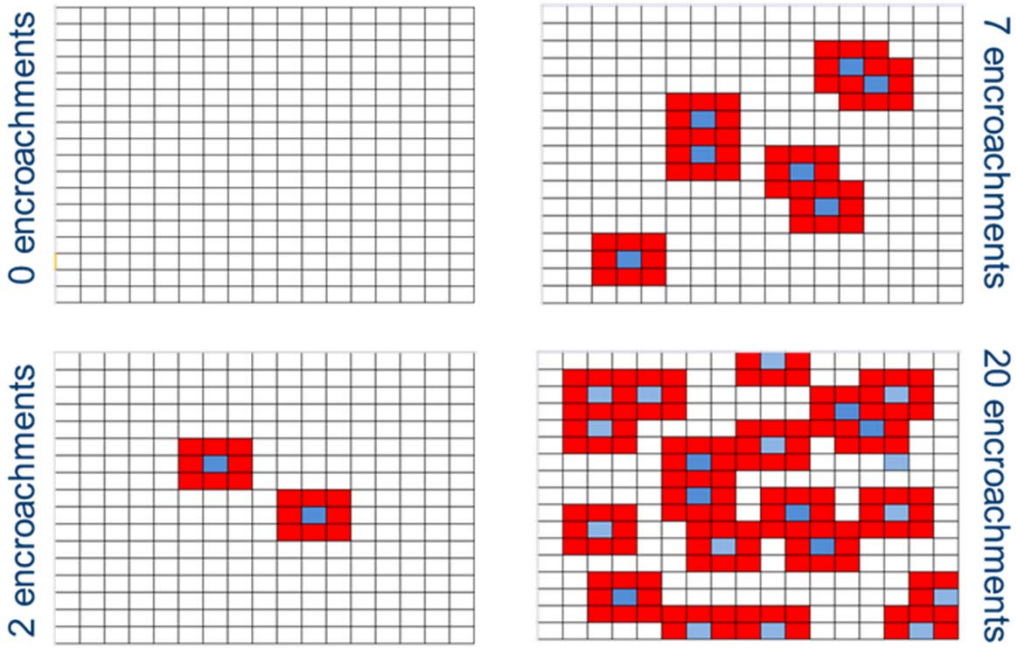
Reservoir plants better than all other strategies

Simplified to include only impounded rivers as the impact



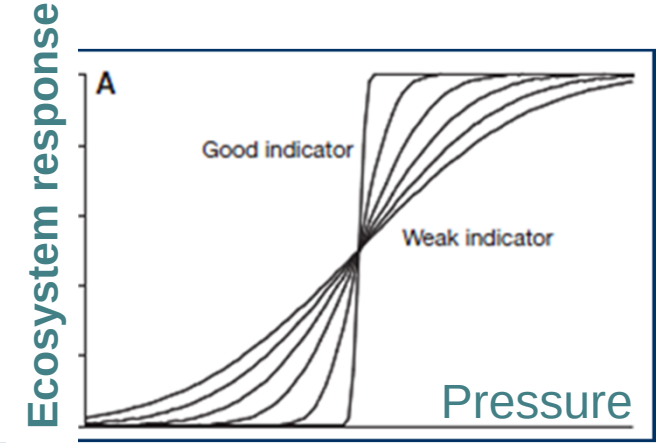
Comparison of environmental impacts (3)

Reduction in areas with no prior or major encroachments (INON-areas);
(Directorate for Nature Management (DN))



Outcome:

- Better to develop new energy resources in already exploited areas?
- Selective exploitation of nature types (Erikstad et al., 2009).



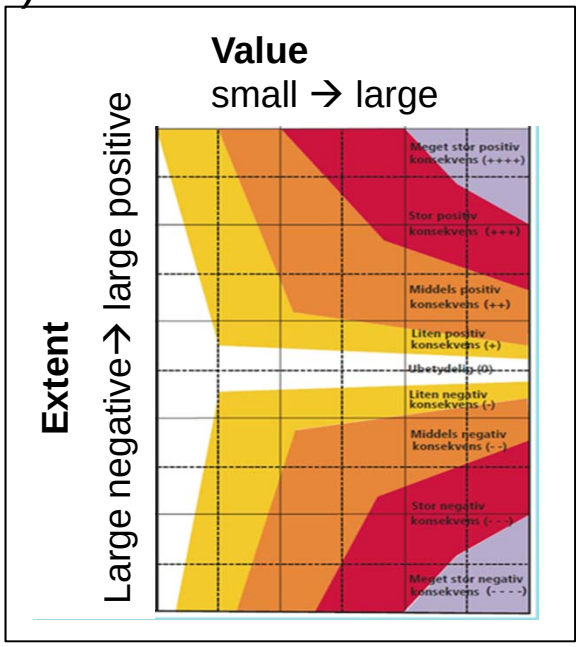
Source: from Carstensen & Heiskanen, 2007

Comparison of environmental impacts (EIAs)

Use of standardised Environmental Impact Assessments (EIA) for comparison (Bakken et al. 2012):

EIAs in Norway and internationally: A standardised and complete set of environmental topics to investigated (given by guidelines)

- Landscape
- Biodiversity
- Fish
- Water quality etc.



A standardised way to classify impact level (Statens Vegvesen, 2006)

Data 27 on small-scale HPPs

- Accumulation of impacts
- Interpretation of qualitative data
- Expert judgments

	Loc 1	Loc 2	Loc 3
Ice, water temp	2	3	1
Local climate	1	1	1
Water quality	1	1	1
Fish & Invertebrates	1	4	5
Biodiversity	3	3	3
Landscape	3	3	5
Agriculture & forestry	4	1	4
SUMMED (*)	2	2	1

Identified impact / Small-scale hydropower project	Areas with no prior & major encroachments (INON)	Area protected due to landscape values	Anadromous fish present	Fish fauna affected	Withdrawn water anadromous river stretch	Changed water quality	Cultural heritage affected	Changed water temp.
Bjåstad	Yes	No	No	Yes	No		Yes	
Duvedalen	Yes	No	No	No	No	No	No	
Eitreelvi	Yes	No	Yes	Yes	No		No	
Eitreneselvi	Yes	No	No	No	No		No	
Engeseteelva	Yes	No	Yes	Yes	No	No	Yes	
Hatlestad	Yes	No	No	No	No		Yes	
Holsen	Yes	No	No	Yes	No		Yes	Yes
Hopland	No	No	No	No	No	No	Yes	
Jordal	No	No	Yes	Yes	No		Yes	
Kjørstad	No	No	Yes	Yes	Yes	Yes[c]	No	Yes
Kvamselva	No	No	Yes	Yes	Yes	No		
Kvernhuselva	Yes	No	Yes	Yes	No		Yes	
Lidal	Yes	No	Yes	Yes	No		Yes	
Mjølsvik	Yes	No	Yes	Yes	No			
Romøyri	Yes	No	No	No	No		Yes	
Røneid	No	No	Yes	Yes	Yes	No	No	
Sandalselva	No	No	No	No	No		No	
Selselva	Yes	Yes	Yes	Yes	No	Yes[d]	No	
Senneset	No	No	Yes	Yes	No	No	No	
Storelva kraft	Yes	No	No	Yes	No		No	
Storelva	No	No	Yes	Yes	No		No	
Strupen	Yes	Yes		Yes	No		Yes	
Sætredalen	Yes	No	No	Yes	No		Yes	
Timbra	Yes	No	No	Yes	No		No	
Torvikelva	No	No	Yes	Yes	No		Yes	
Ygleelvi	Yes	No	Yes	Yes	No		No	
Øyni	Yes	No	Yes	Yes	Yes	Yes	No	

Sum inst. capacity: 112 MW

Sum production: 390 GWh/a

Data on large HPP

'Average HP plant'

	Loc 1	Loc 2	Loc 3
Ice, water temp	2	3	1
Local climate	1	1	1
Water quality	1	1	1
Fish & Invertebrates	1	4	5
Biodiversity	3	3	3
Landscape	3	3	5
Agriculture & forestry	4	1	4
SUMMED (*)	2	2	1

EIA

	Loc 1	Loc 2	Loc 3
Ice, water temp	2	3	1
Local climate	1	1	1
Water quality	1	1	1
Fish & Invertebrates	1	4	5
Biodiversity	3	3	3
Landscape	3	3	5
Agriculture & forestry	4	1	4
SUMMED (*)	2	2	1

Vestsideelvane

EIA

	Loc 1	Loc 2	Loc 3
Ice, water temp	2	3	1
Local climate	1	1	1
Water quality	1	1	1
Fish & Invertebrates	1	4	5
Biodiversity	3	3	3
Landscape	3	3	5
Agriculture & forestry	4	1	4
SUMMED (*)	2	2	1

Vigdøla

'EIA'

	Loc 1	Loc 2	Loc 3
Ice, water temp	2	3	1
Local climate	1	1	1
Water quality	1	1	1
Fish & Invertebrates	1	4	5
Biodiversity	3	3	3
Landscape	3	3	5
Agriculture & forestry	4	1	4
SUMMED (*)	2	2	1

Trollheim

<u>Average plant:</u>
Installed cap.: 54 MW
Production: 350 GWh

Scientific reports

Comparison of impacts

Large

54 MW
350 GWh

Average large HPP

	Loc 1	Loc 2	Loc 3
Ice, water temp	2	3	1
Local climate	1	1	1
Water quality	1	1	1
Fish & Invertebrates	1	4	5
Biodiversity	3	3	3
Landscape	3	3	5
Agriculture & forestry	4	1	4
SUMMED (*)	2	2	1

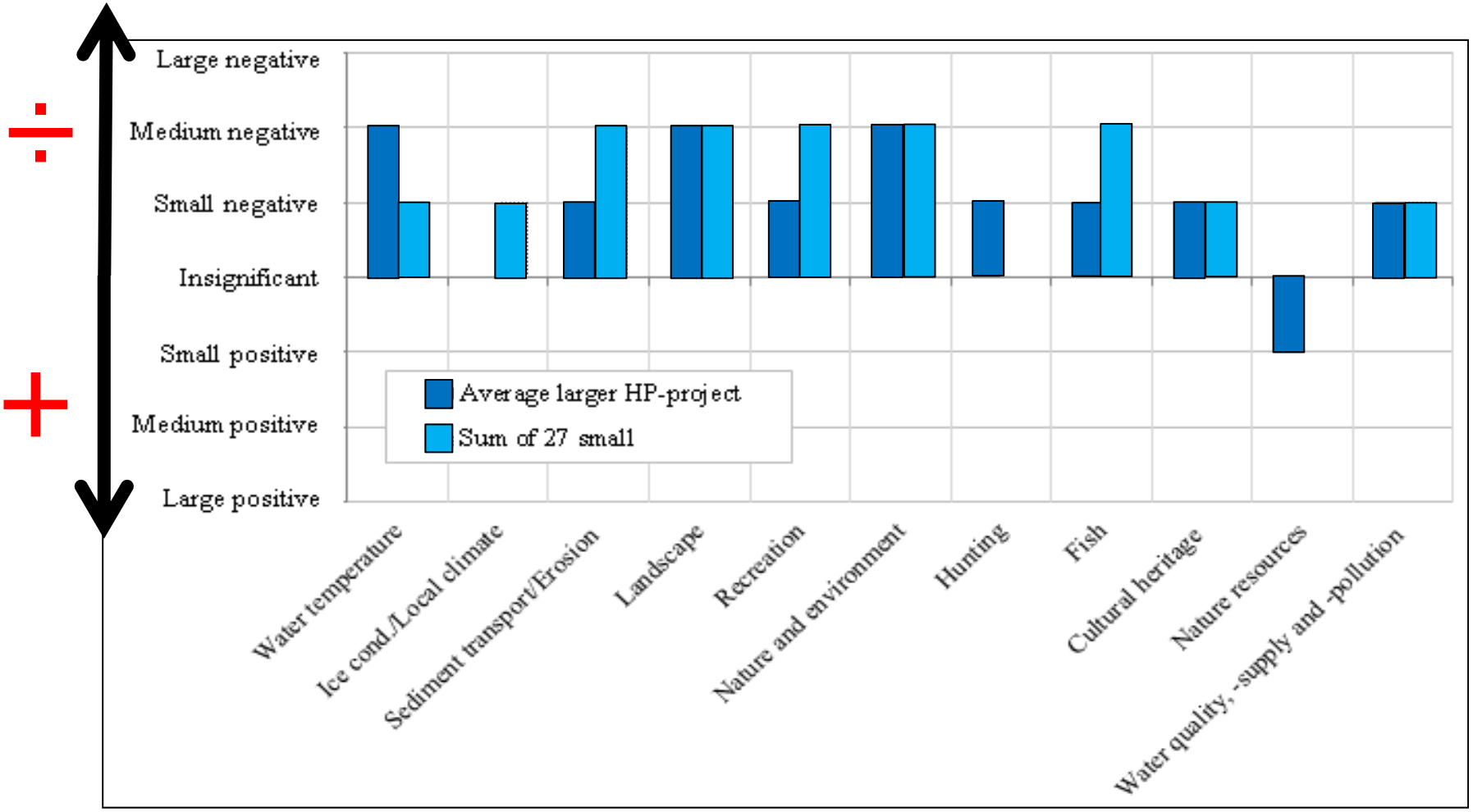
Many small

112 MW
390 GWh

Accumulated impacts from 27 small HPPs

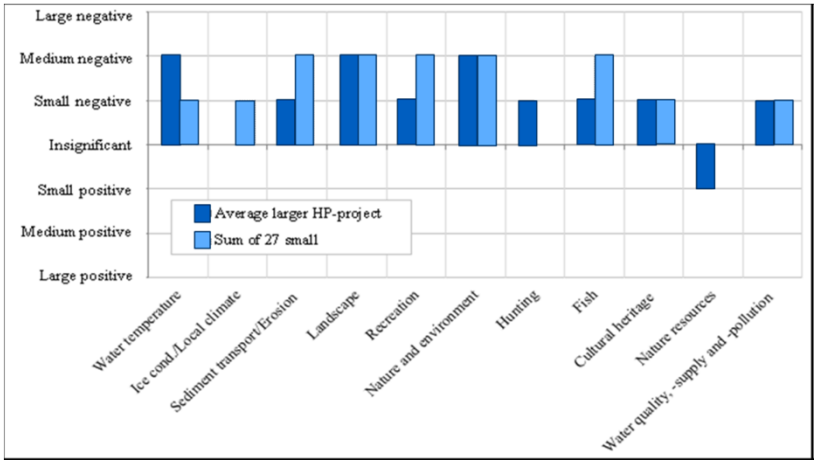
	Loc 1	Loc 2	Loc 3
Ice, water temp	2	3	1
Local climate	1	1	1
Water quality	1	1	1
Fish & Invertebrates	1	4	5
Biodiversity	3	3	3
Landscape	3	3	5
Agriculture & forestry	4	1	4
SUMMED (*)	2	2	1

Results: Comparison of impacts



Comments to the results

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



- Large HP scores 'worse' (more negative) in the category water temperature

- The scores differ with only one impact level

Points of discussion from our study

- Quality of available information; completeness, precision.
- Accumulation of impacts from many small projects
- How to compare 'non-comparable environmental qualities'?
- Other aspects affecting the environmental performance; professionalism/competence in developer's organization, monitoring/control, corporate responsibility (CR)
- Qualities of the energy production

Conclusions from our study

- 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 recently started

Improvements of methodology

- MSc-study started up this Fall, finalized Summer 2013
- 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
  - main problem of concern

Habitat, biodiversity

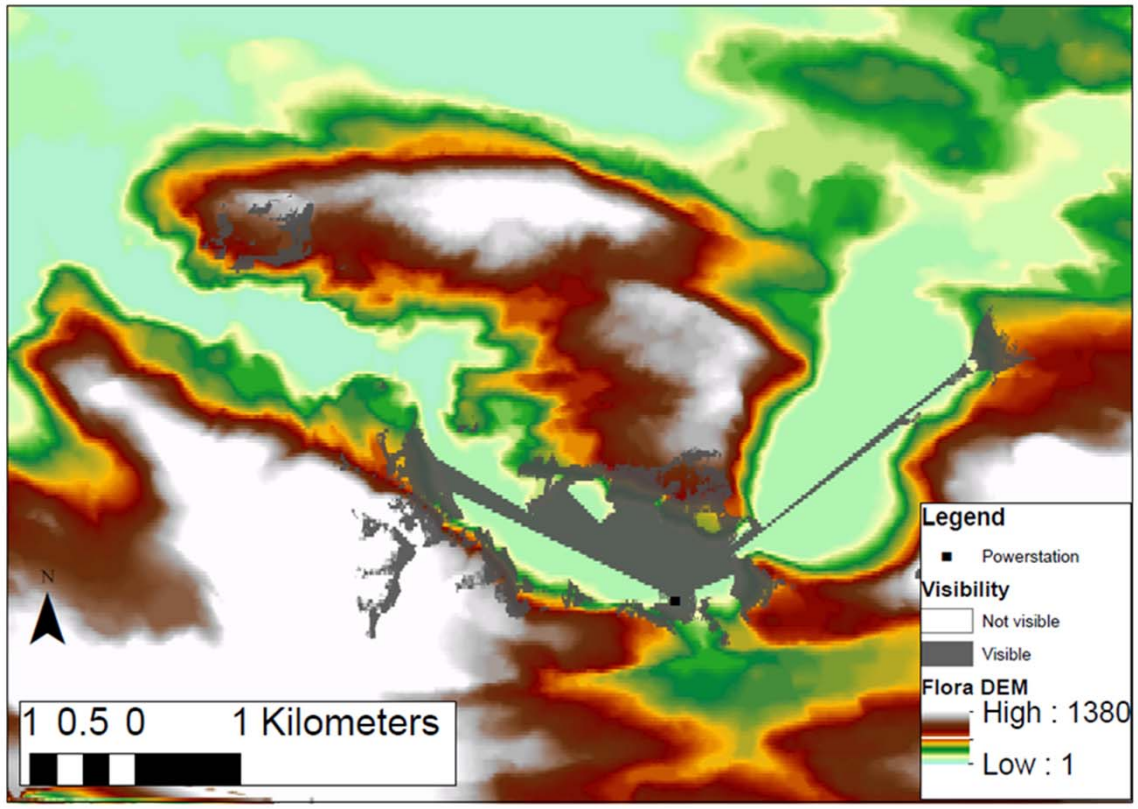
Landscape

Biodiversity ('Party-stopper')

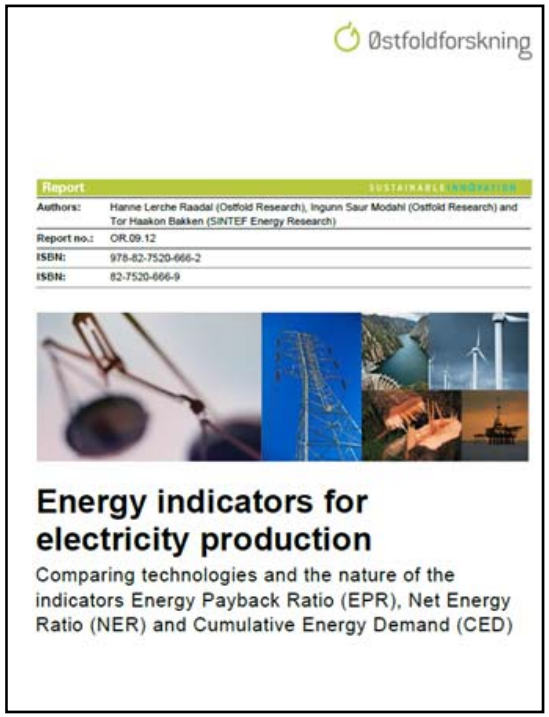
Conflict

Improvements of methodology

- Based on GIS-data and tools
- Preliminary testing promising



Some details from the EPR-study


Østfoldforskning

Report

Authors: Hanne Lerche Raadal (Ostfold Research), Ingunn Saur Modahl (Ostfold Research) and Tor Haakon Bakken (SINTEF Energy Research)

Report no.: OR.09.12

ISBN: 978-82-7520-666-2

ISBN: 82-7520-666-9

Energy indicators for electricity production

Comparing technologies and the nature of the indicators Energy Payback Ratio (EPR), Net Energy Ratio (NER) and Cumulative Energy Demand (CED)

Report


CEDREN

Centre for Environmental Design of Renewable Energy

POLICY BRIEF

Energieffektiv elektrisitetsproduksjon

Analyse av energieffektiviteten til ulike former for elektrisitetsproduksjon i Norge ved hjelp av internasjonalt etablerte indikatorer

www.cedren.no

Policy memo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Energy Procedia

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Renewable Energy Research Conference - 2012

Development of small versus large hydropower in Norway– comparison of environmental impacts

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Abstract

This study has compared the accumulated environmental impacts from 27 small-scale with 3 large hydropower projects in the Western Norway. The results show a small tendency that large hydropower has a lower degree of impacts than many small-scale per GWh. 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 more valuable electricity services to a lower environmental cost compared to many small projects. This should be taken into account when small-scale hydropower projects are promoted in realizing renewable energy policy objectives.

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Keywords: small-scale hydropower, large hydropower, environmental impacts, accumulated impacts, comparison

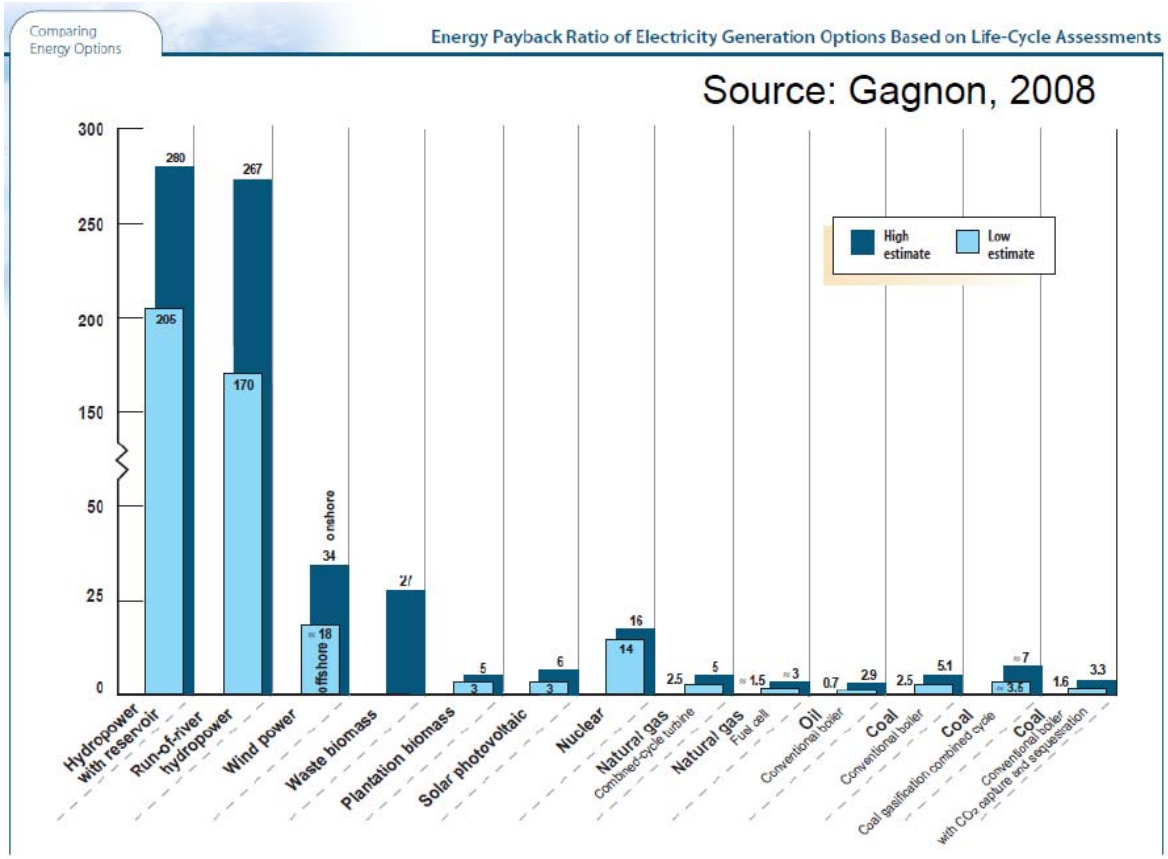
1. Introduction

1.1. Point of departure

There has been a boom in the development of small-scale hydropower (< 10 MW) in Norway during the last decade. At the same time, the development of large hydropower has been very limited. The reason for this situation is due to political priorities, subsidizing small-scale hydropower development. We believe there is a tendency in the public opinion that 'small-scale hydropower is considered green and beautiful', while large-scale hydropower projects have a reputation to cause dramatic and negative impacts to the environment. More lately, the issue concerning fragmentation of untouched nature by many small projects, however, has been raised by scientists, e.g. (Erikstad *et al.*, 2009), and environmental concerns

Article (in prep.)

Benchmarks the energy efficiency of electricity production technologies



How does Norway fit in?

- HP run-off the river
- Reservoir HP
- Smaller plants vs larger
- O/U-projects
- Wind power
- Bio-energy ("NVE-project")

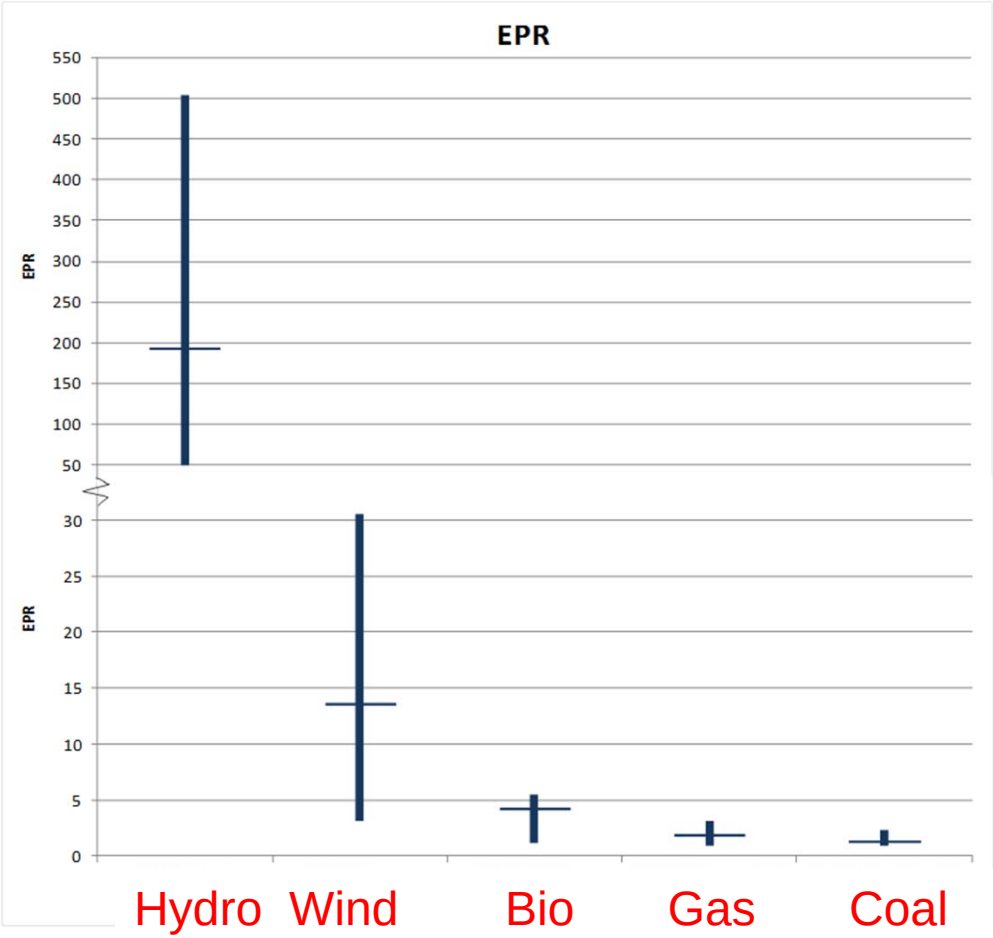
Benchmarks the energy efficiency of electricity production technologies

Energy payback ratio (EPR)

Maximum, mean and minimum presented

High values → high energy efficiency

Similar graphs for net energy ratio (NER) and cumulative energy demand (CED)



Findings

- Hydropower clearly achieves the best energy performance according to the indicators EPR, NER and CED.
- Wind power achieves the second best performance while thermal power generation technologies based on biomass and fossil fuels give the lowest energy performance.
- There are large internal variation within the technologies.
- Upgrading and extension of old, existing hydropower plants can have extremely high energy efficiency
- The different indicators answer different questions (suitable for different purpose)
- Benchmarks only energy efficiency (not 'traditional' impacts)