Hydropower

Mats Leijon

Results and Perspective in Particle Physics... La Thuile 3 mars 2005

Content

Background

Market for Hydro

Capacity for Hydro

Technology development

Pro's and con's with hydro

Hydropower and the climate

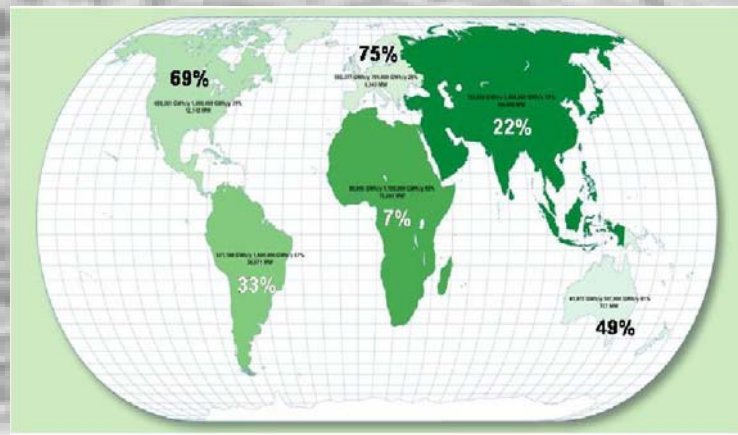
Hydropower and the environment

Hydropower in Europe

Background

Hydropower;

- produces cost-effective electricity, worldwide 19 %
- operates with success on regulated as well as on highly deregulated markets, such as the Nordic
- has been developed to a fairly large degree within the OECD-countries (50-80% of potential)



Source: World Atlas of Hydropower & Dams, 2002

- does not in general significantly contribute to GHG-emissions compared to natural environment (background emissions)
- GHG-emissions comparable to wind mills and solar, PV

Market for Hydro

Today´s market:

base-load, peak-load, grid-connected electricity generation, ancillary services

small hydro in combination with other renewables

secures distributed power needs

Niche markets:

combined hydro and other renewables for green energy marketing within OECD

combined hydro and wind for base-load and optimal use of existing grids

Planned Capacity (TWh)

Large hydro contributes to electricity production in more than 80 countries

Small hydro contributes in principle in every country world wide except in desert areas

Present capacity worldwide - 2 500 TWh

Projected capacity by 2020 - 4000 TWh (WEO)

Potential more than 8000 TWh

Planned Capacity (TWh)

***Examples*:** Planned new production 2020

- China 110 GW - 420 TWh
- India 30 GW - 100 TWh
- Brazil 50 GW - 250 TWh
- Africa 10 GW - 30 TWh

These figures includes all hydro.
Small hydro will play a significant role especially in areas with local power demand, as in Africa

Note: The definition “Small hydro” is by no way definite. It varies between every country; Sweden 1.5 MW - Canada 25 MW - China 50 MW. Even within the E. U. it varies between 1-15 MW

Pro's and con's with hydro

ADVANTAGES	DISADVANTAGES
Economic Aspects	
Low operating and maintenance costs	High upfront investment
Long life span (50 to 100 years and more)	Precipitation dependent
Flexible to meet load (for hydro with reservoir)	
Reliable Service	
Proven technology	
Instigates and fosters regional development	
Highest energy efficiency rate (pay-back ration and conversion process)	
Generates revenues to sustain other water uses	
Creates employment opportunities	
Fuel Saver	
Provides energy independence by exploiting national resources	
Optimizes power supply of other generating options (thermal and intermittent renewables)	

Pro's and con's with hydro

Social Aspects	
Leaves water available for other uses	In many cases – inundation of land requiring involuntary displacement
Provides flood protection - in many cases	In many cases - river passage restrictions
Enhances navigation conditions – in some cases	Modification of land use patterns
Enhances recreational facilities – in many cases	In some cases – may facilitate propagation of waterborne disease vectors
Enhances accessibility of the territory and its resources (access roads and ramps, bridges)	Requires management of competing water usages
Built and operated with a high percentage of local manpower	Affects livelihoods of impacted people
Improves living conditions	
Sustains livelihoods (freshwater, food supply)	

Pro's and con's with hydro

Environmental Aspects	
No atmospheric pollutants and only very few GHG emissions	In many cases – inundation of habitats, loss or modification of biodiversity
No waste	In many cases – loss or modification of fish habitat
No depletion of non renewable resources (i.e. coal, gas, oil)	In some cases – changes in reservoir and stream water quality
Creates in many cases new freshwater ecosystems with increased productivity	In some cases – temporary introduction of methyl-mercury into the food chain
Study results enhance knowledge and improve management of valued species	In many cases – modification of hydrological regimes
Helps to slow down climate changes	Barriers for fish migration, fish entrainment
Enhances air quality	In some cases – reservoir sedimentation requires control measures

Hydropower and the climate

Table 8.1:
Today's hydropower utilization in Europe.

	Energy Union	Annual generation of hydroelectricity[1]		Installed capacity for generation of hydroelectricity[2]				
				in total		by category		
		TWh	% of total electricity generation	GW	% of total capacity for electricity generation[3]	Run-of-river, incl. pondage GW	Reservoir and mixed pumped GW	Pure pumped storage GW
Austria	UCTE	42.2	78.0	10.9	67.7	5.5	5.4	0.0
Belgium	UCTE	1.7	2.1	1.4	8.9	0.1	0.0	1.3
Croatia	UCTE	5.8	59.0	2.0	57.0	n.a.	n.a.	n.a.
France	UCTE	66.9	13.3	24.3	22.1	10.8	11.6	1.9
Germany	UCTE	23.6	4.8	8.3	8.3	2.7	1.4	4.2
Greece	UCTE	4.1	9.0	3.0	32.9	0.7	2.3	0.0
Italy	UCTE	50.3	19.2	19.8	27.5	8.2	7.4	4.2
Luxembourg	UCTE	0.9	77.1	1.1	93.2	0.0	0.0	1.1
The Netherlands	UCTE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Portugal	UCTE	11.6	30.9	4.2	45.5	2.1	2.1	0.0
Slovenia	UCTE	3.5	28.0	0.8	32.1	n.a.	n.a.	n.a.
Spain	UCTE	31.4	16.1	16.3	35.4	6.1	7.7	2.5
Switzerland	UCTE	37.8	57.9	13.8	77.2	4.0	9.5	0.3
Yugoslavia, Macedonia, Bosnia-Herzegovina	UCTE	13.2	32.0	4.6	36.6	1.9	2.0	0.7
Czech Republic	CENTREL	2.3	3.4	2.0	14.3	0.2	0.7	1.1
Hungary	CENTREL	0.2	0.5	0.1	0.7	0.1	0.0	0.0
Poland	CENTREL	4.0	2.8	2.0	6.4	0.4	1.4	0.2
Slovakia	CENTREL	5.0	17.5	2.4	35.1	0.8	0.9	0.7
Denmark	NORDEL	0.0	0.1	0.0	0.1	n.a.	n.a.	n.a.
Finland	NORDEL	12.6	18.9	2.9	17.8	n.a.	n.a.	n.a.
Iceland	NORDEL	6.0	84.1	1.0	77.8	n.a.	n.a.	n.a.
Norway	NORDEL	122.1	99.4	27.6	98.9	n.a.	n.a.	n.a.
Sweden	NORDEL	70.4	46.8	16.2	48.5	n.a.	n.a.	n.a.
Albania	others	5	96	n.a.	n.a.	n.a.	n.a.	n.a.
Belarus	others	0	0	0	0	n.a.	n.a.	n.a.
Bulgaria	others	3	9	2	17	n.a.	n.a.	n.a.
Cyprus	others	0	0	n.a.	n.a.	n.a.	n.a.	n.a.
Estonia	others	0	0	0	0	n.a.	n.a.	n.a.
Ireland	others	1	5	0	0	n.a.	n.a.	n.a.
Latvia	others	4	77	n.a.	n.a.	n.a.	n.a.	n.a.
Lithuania	others	1	3	0	0	n.a.	n.a.	n.a.
Malta	others	0	0	n.a.	n.a.	n.a.	n.a.	n.a.
Moldova	others	0	7	n.a.	n.a.	n.a.	n.a.	n.a.
Romania	others	19	37	6	27	n.a.	n.a.	n.a.
Russian Federation (Europe and Asia)	others	158	20	44	22	n.a.	n.a.	n.a.
Turkey	others	42	39	10	44	n.a.	n.a.	n.a.
Ukraine	others	16	10	5	9	n.a.	n.a.	n.a.
United Kingdom	others	5	2	1	1	n.a.	n.a.	n.a.

Hydropower and the climate

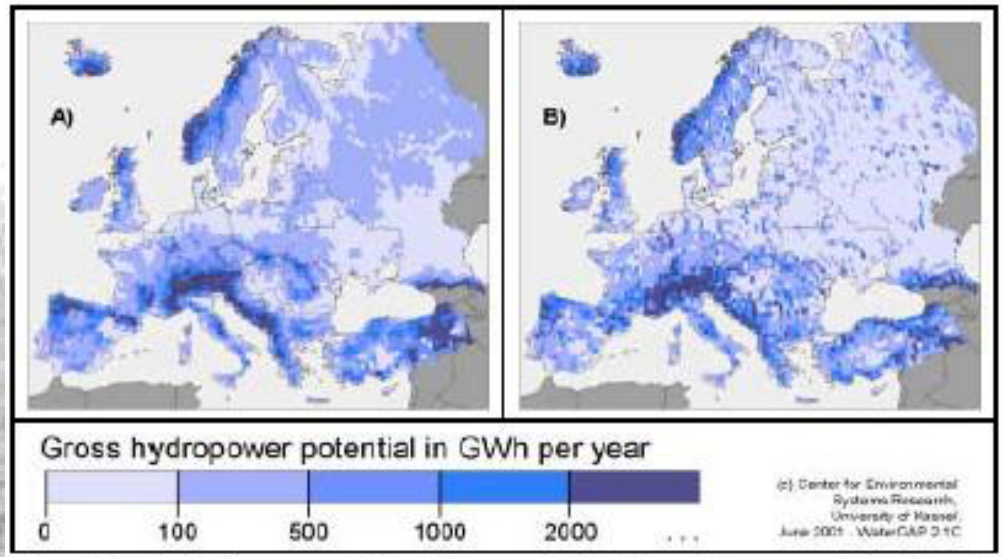


Figure 8.1: Gross hydropower potentials for Europe, calculated by applying average (1961-90) runoff and discharge values of WaterGAP 2.1. A) Each cell is assigned its total gross hydropower potential down to sea level. B) Only the portion of the gross hydropower potential that can be locally utilized down to the next downstream cell is allocated to each cell.

Gross hydropower potential

$GP = m \cdot g \cdot h$

m: Mass of runoff

g: Gravitational acceleration

h: Height (elevation above sea level)

Hydropower and the climate

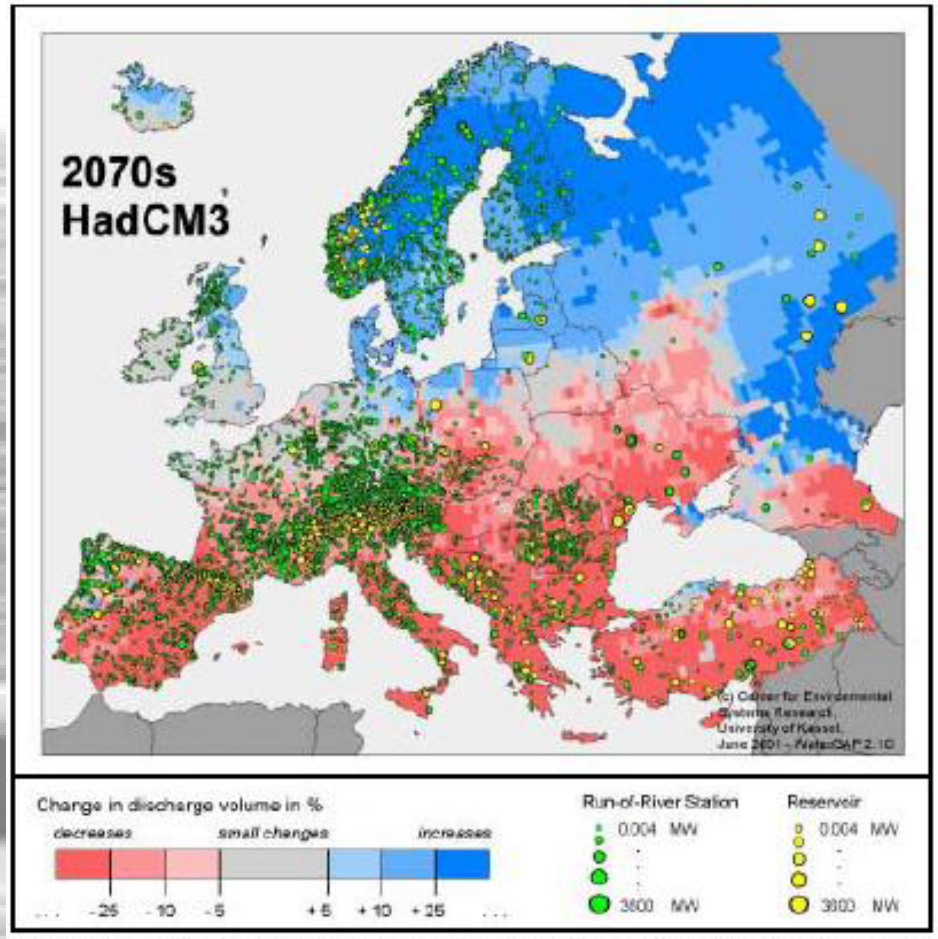


Figure 8.2: Relative change of average (1961-90) total discharge volumes calculated with WaterGAP 2.1 for the 2070s (HadCM3 climate model and Baseline-A water use scenario), superimposed by geo-referenced European hydropower plants, classified according to their type and capacity.

Hydropower and the climate

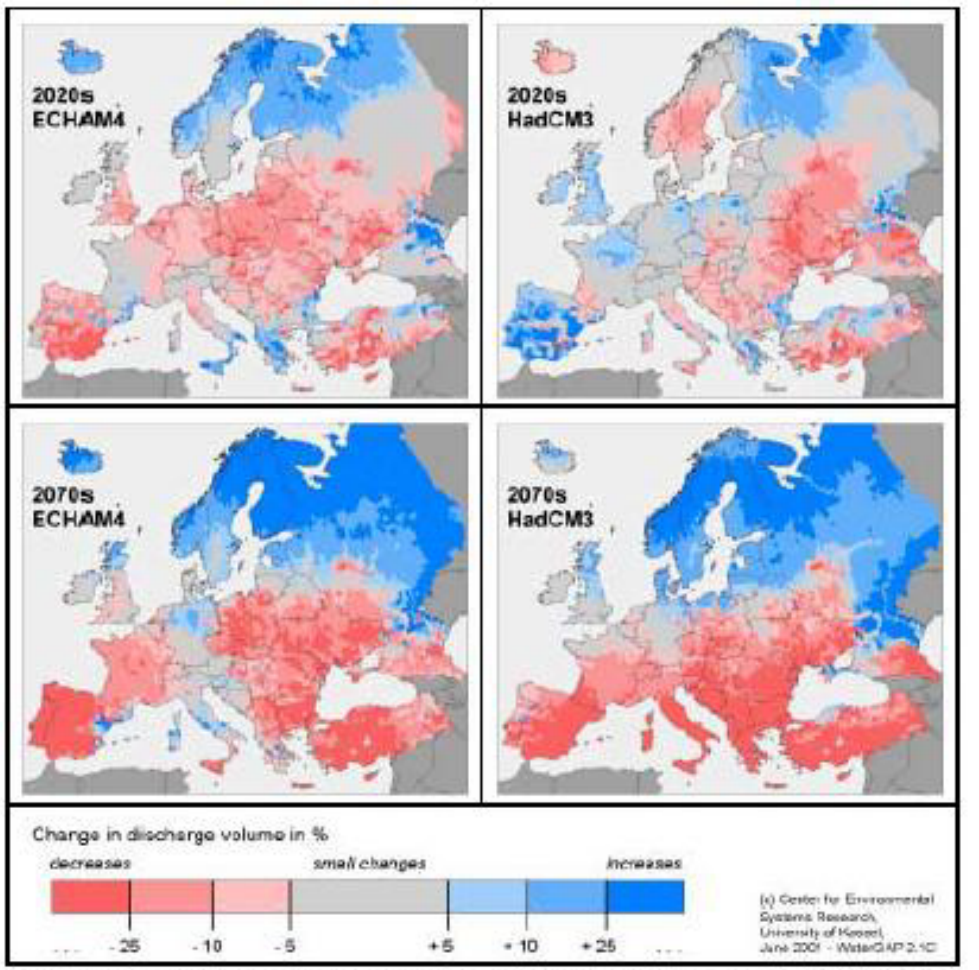


Figure 8.3: Relative change of average (1961-90) total discharge volumes calculated with WaterGAP 2.1 for the 2020s and 2070s (ECHAM4 and HadCM3 climate models and Baseline-A water use scenario).

Thank You for Your Attention

Hydropower and the environment
Swedish LCA-analysis

Category	Construction phase		Production Phase		Total	
	Vattenfall	Sydkraft	Vattenfall	Sydkraft	Vattenfall	Sydkraft
To air g/MWh el						
NO_X	4,8 -7 ,5	5,6	0,13 - 0,60	0,72	5,1 - 8,1	6,3
SO_2	1,0 - 1,6	1,1	0,06 - 0,13	0,29	1,08 - 1,72	1,37
CO	2,8 - 3,6	5,1	0,07 - 6,34	2	2,9 - 9,2	7,1
CO_2	474 - 724	4800	56 - 102	180	576 - 787	4980
CH_4		5,5		0,08		5,58
Particles		0,67		0,17		0,84
To water mg/MWh el						
Kemisk syretäring, COD	7,3 - 22,2	51	1,5 - 4,1	15	8,8 - 26,3	66
N_{tot}	1,1 - 2,3	36	0,15 - 0,4	12	1,3 - 2,6	48
P_{tot}		0,18		0,06		0,24
Oil	2,3 - 2,8	38	159 - 830	14	162 - 832	52
Waste, total, kg/MWh el	1,7 - 27,2	3,2	Ej kvant	2,3	1,7 - 27,2	5,5