



# Increasing the share of renewable energy in the global energy mix



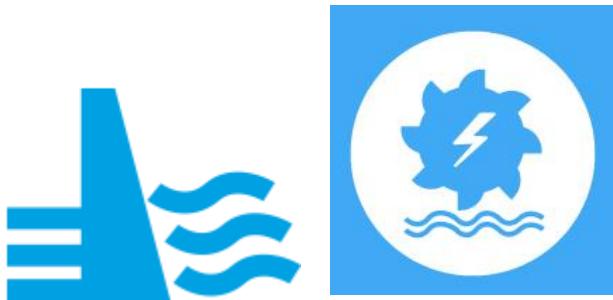
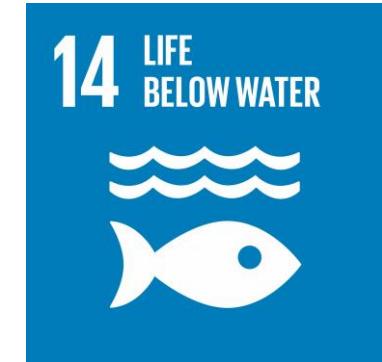
NATURHISTORISK MUSEUM  
UNIVERSITETET I OSLO



*Atle Harby, SINTEF Energy Research  
Centre for environmental design of renewable energy*



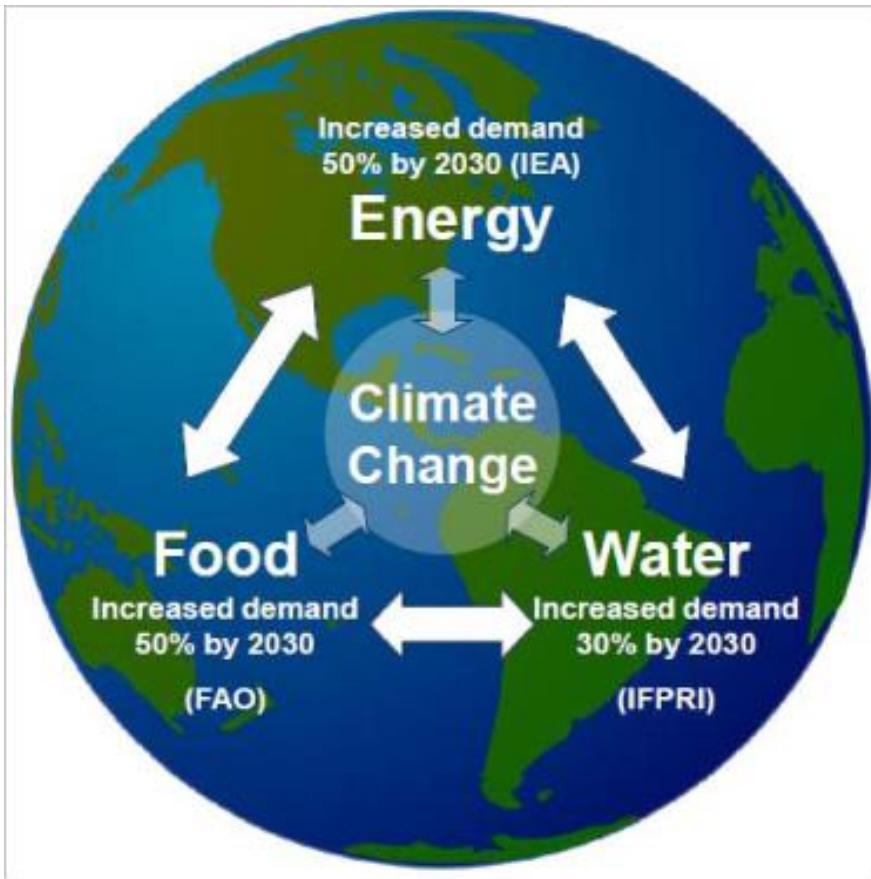
# Ensure access to affordable, reliable, sustainable and modern energy for all



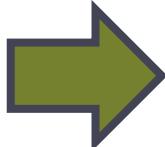
## The role of hydropower

# Energy-water-food nexus

## - development versus environment?

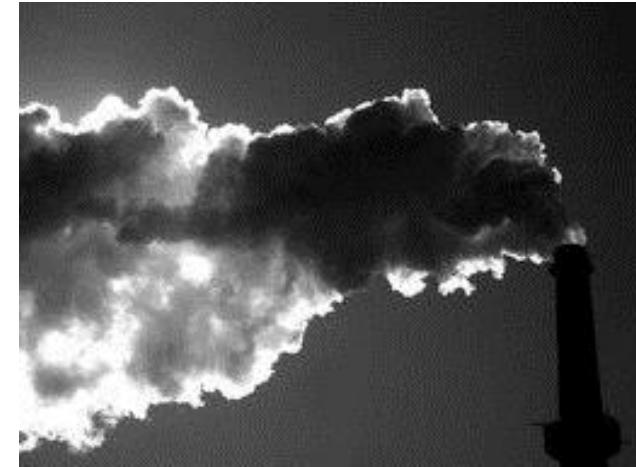
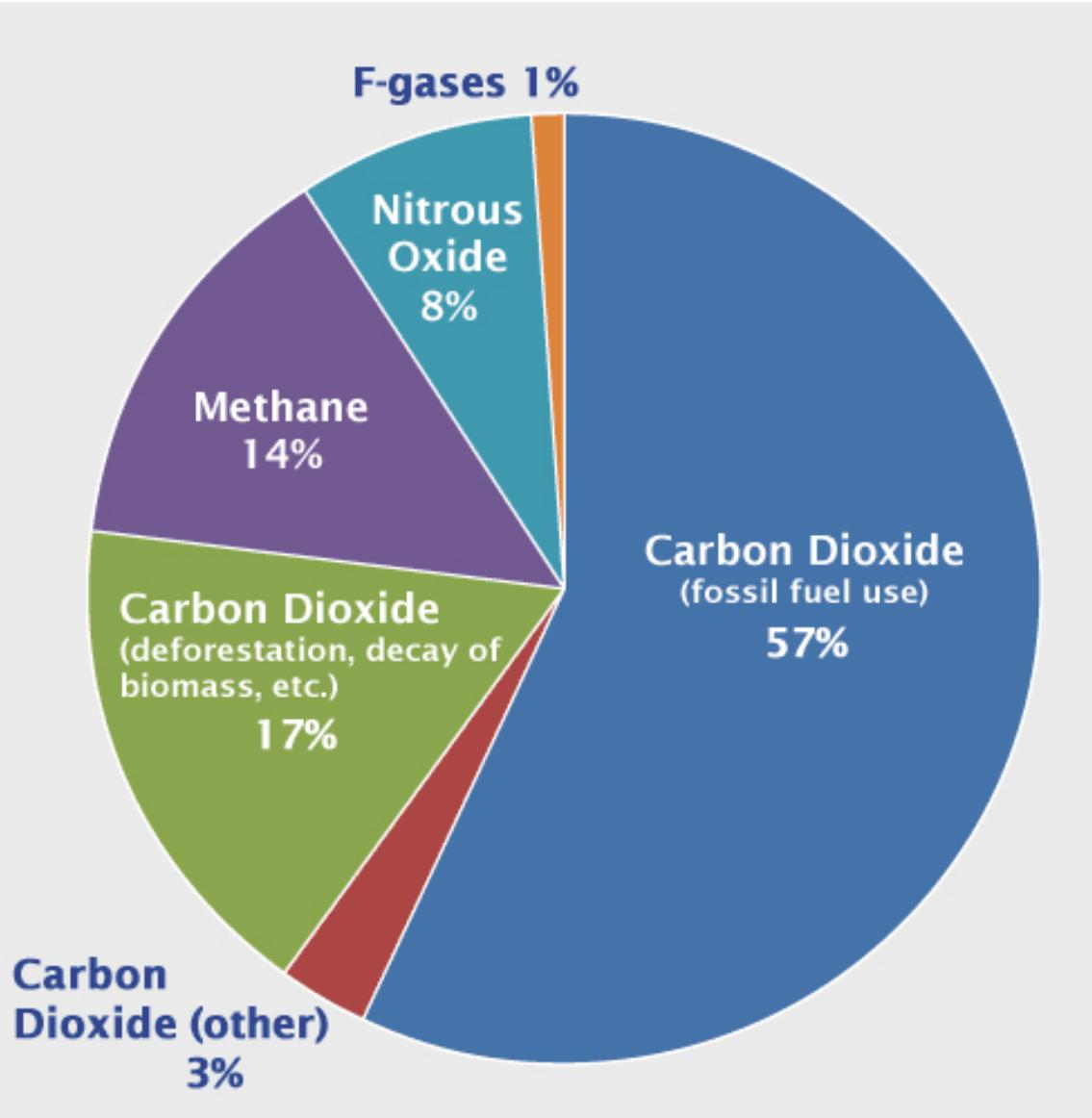


- Energy is vital for eradicating poverty, 2,5 billion without reliable access to electricity
- 2,8 billion live in areas with high water stress
- Use of resources, degradation of habitats, pollution and emissions
- Water for food production
- Climate change impacts on draughts, floods, water for energy and food



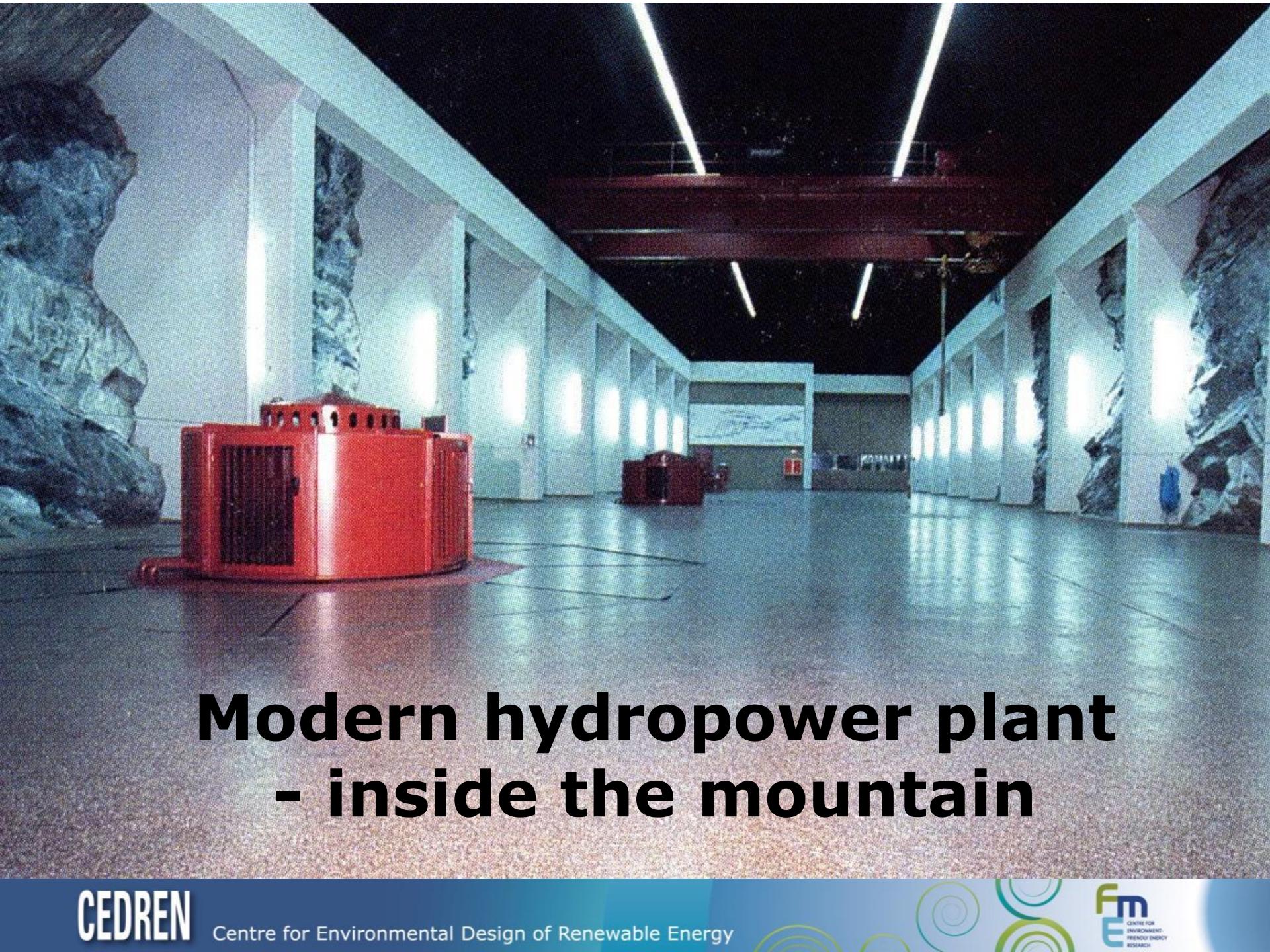
More reservoirs and potential impacts on rivers and lakes

# Sources of Greenhouse Gas (GHG) emissions



# Why talk about hydropower?

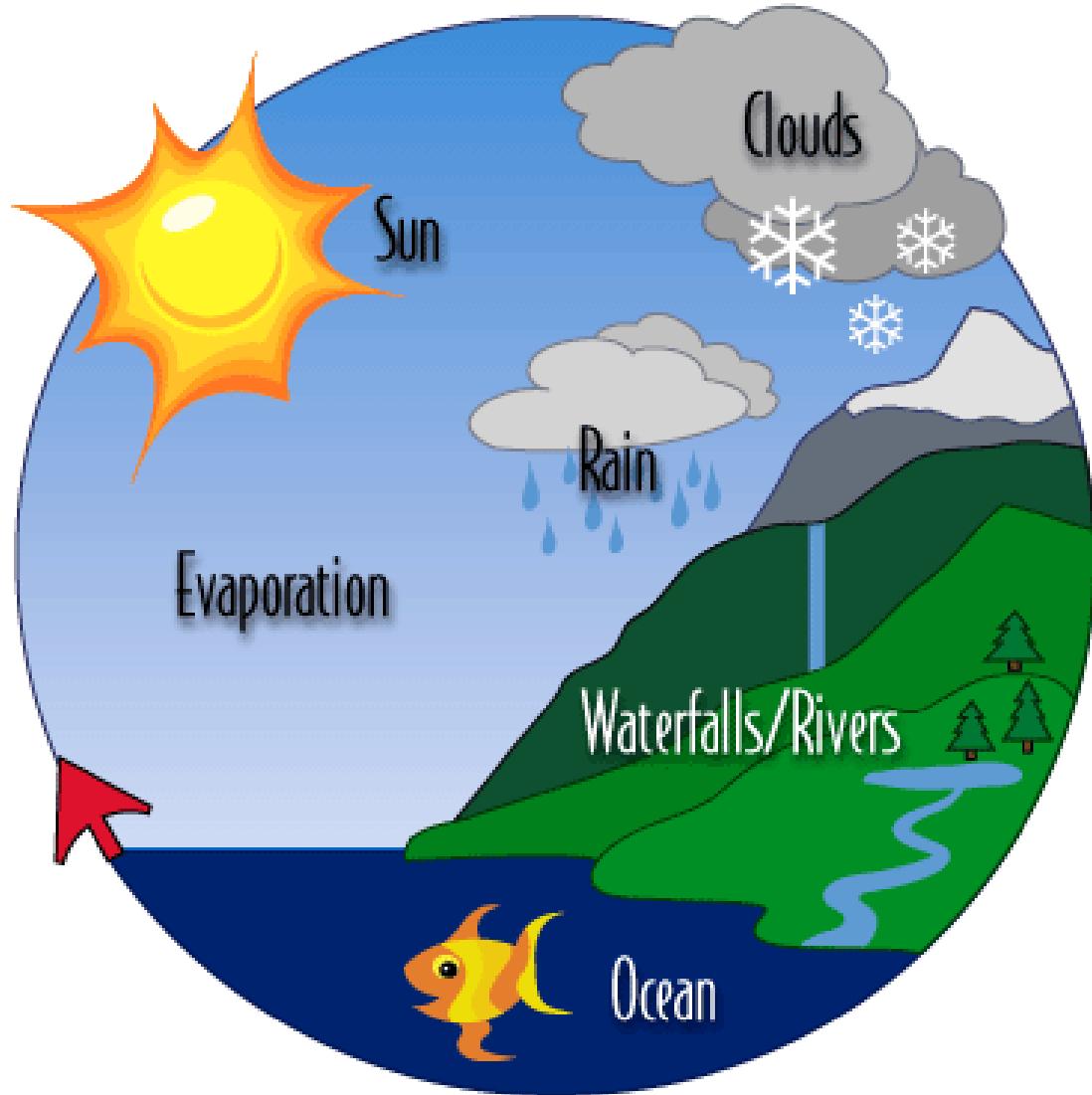




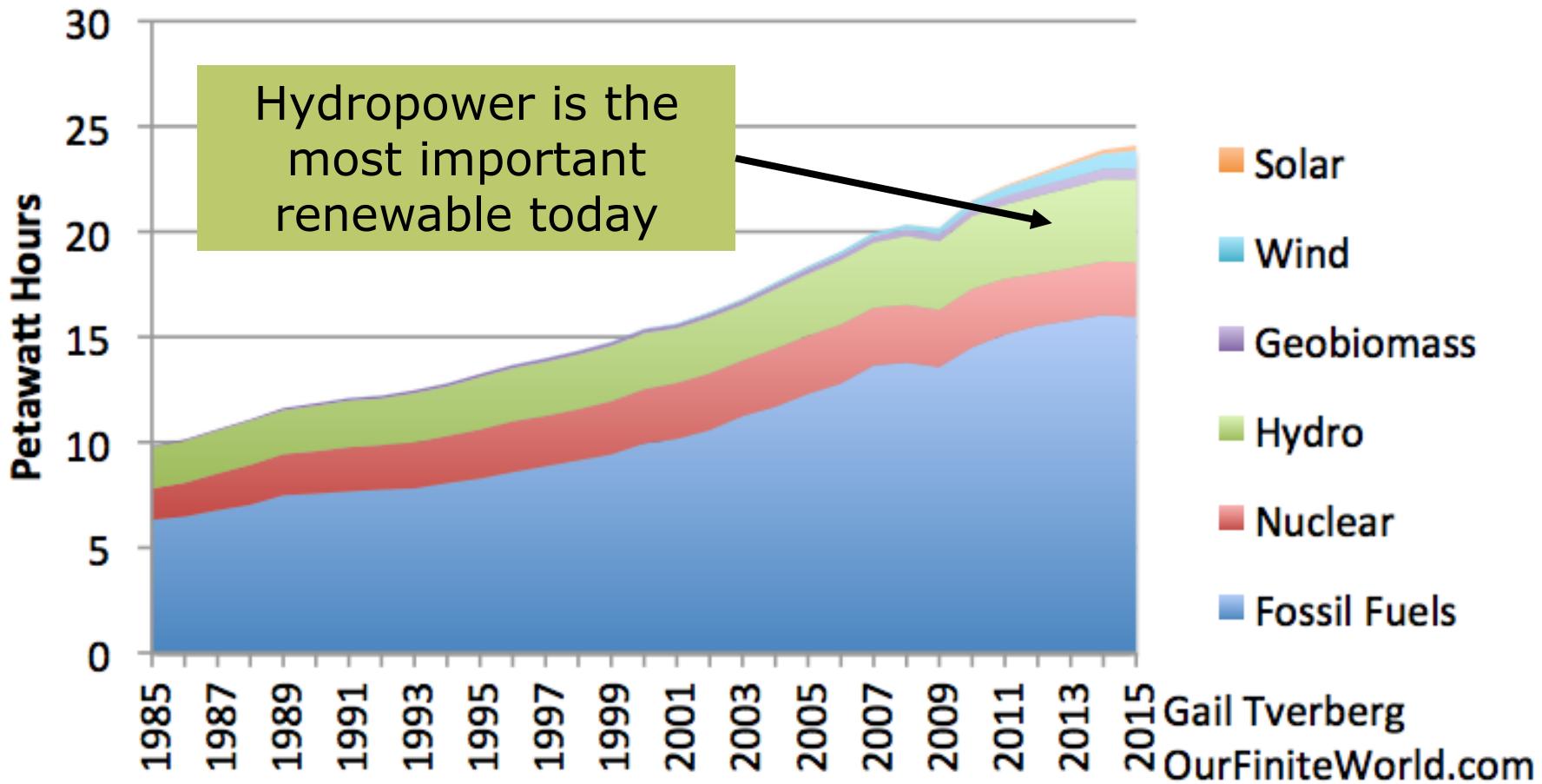
# Modern hydropower plant - inside the mountain

# Hydrological circle

- Powered by the sun
- About 50 % of solar energy used to drive the hydro circle
- Hydropower = solar power

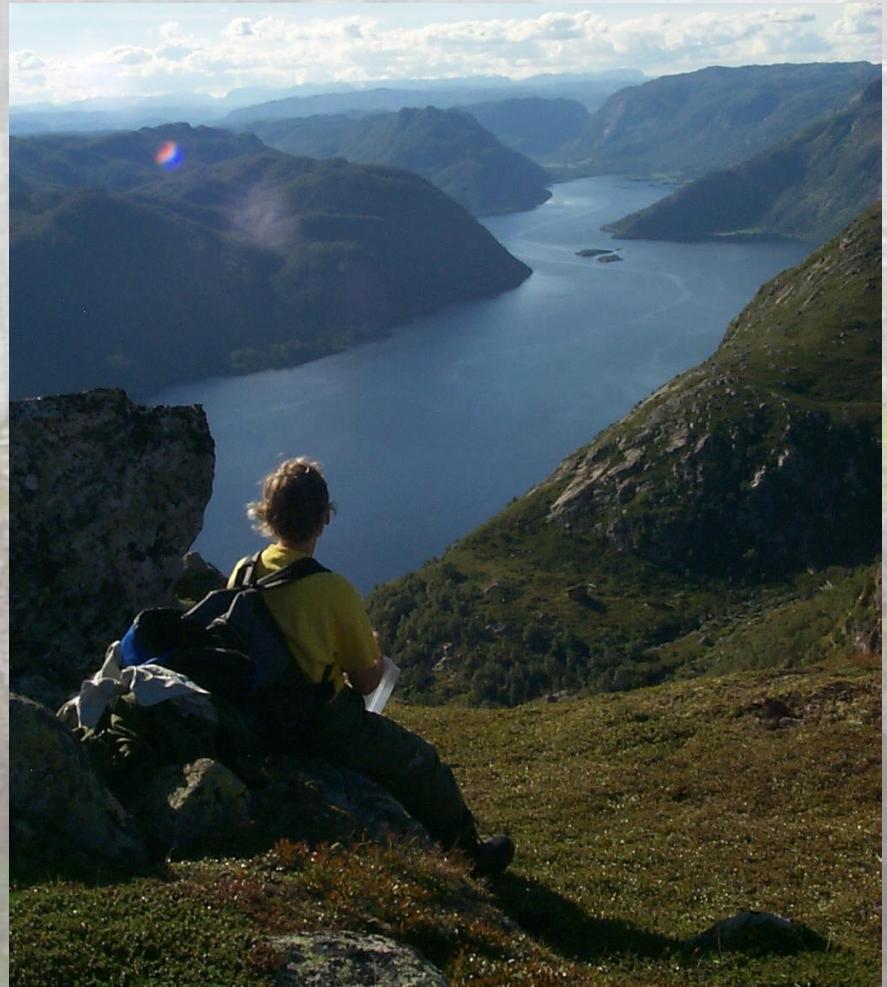


# World Electricity Generation



# Hydropower – Resource base

Abundance of water, high head, large natural reservoirs





**CEDREN**

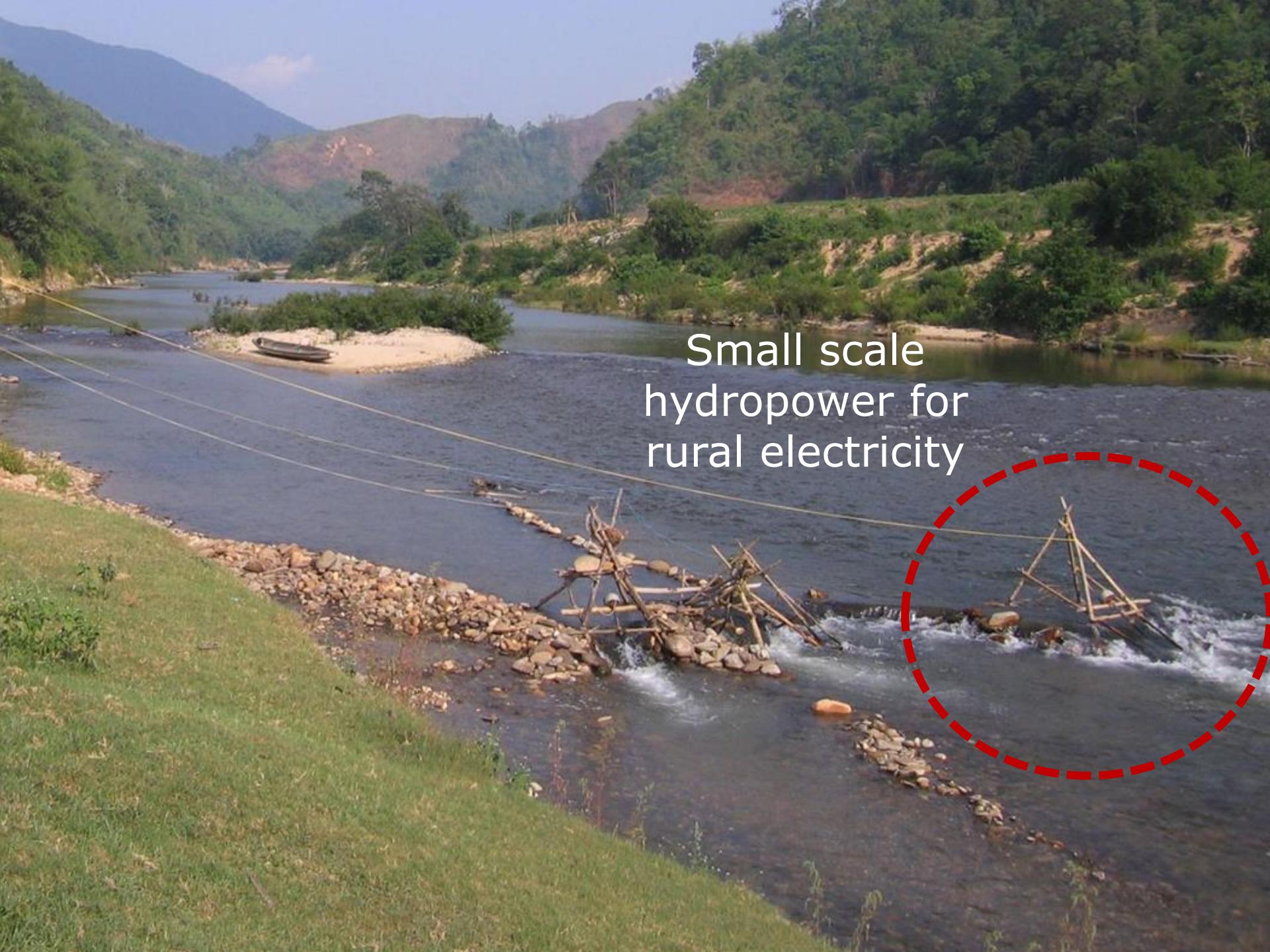
Centre for Environmental Design of Renewable Energy



**CE**  
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RESEARCH

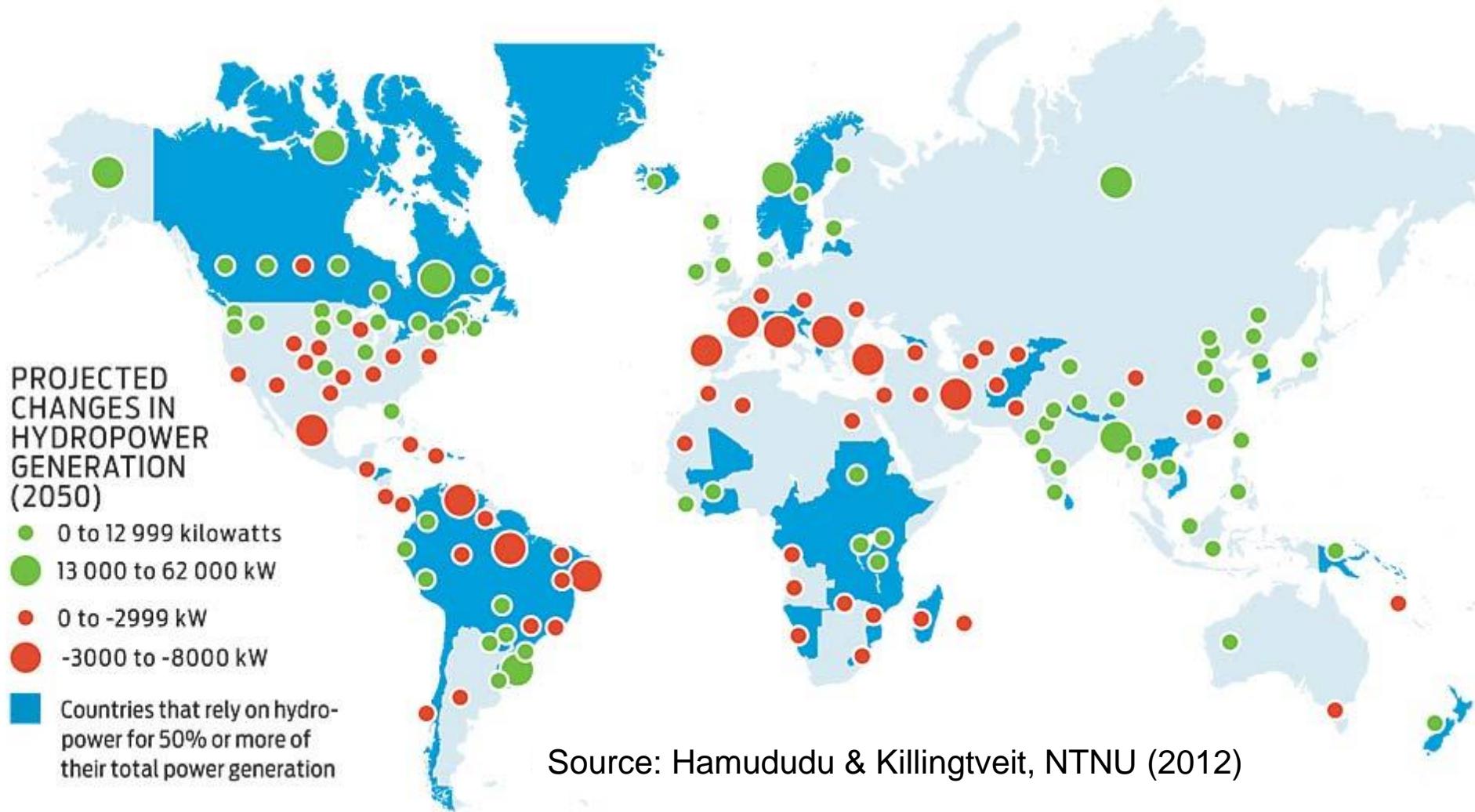


China, USA, Russia, Canada, Brazil, India, Norway

A photograph of a river flowing through a lush, green, mountainous region. In the foreground, a grassy bank meets the water. A small, temporary-looking hydropower structure made of bamboo and stones is visible in the river, with several yellow cables running across the water from it. A red dashed circle highlights this structure. The background shows more mountains and hills under a clear blue sky.

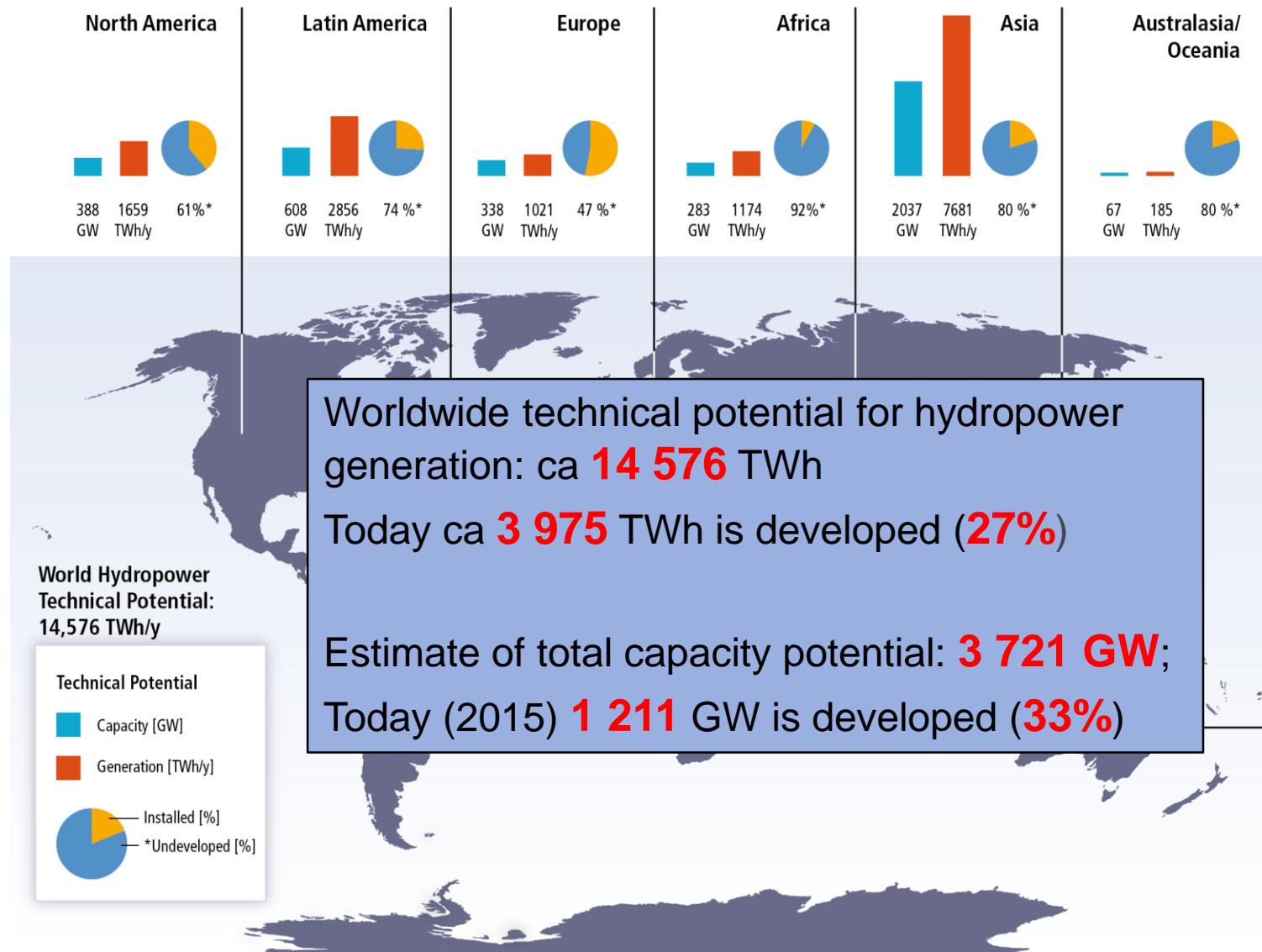
Small scale  
hydropower for  
rural electricity

# Hydropower and Climate Change – A Global view



Source: Hamududu & Killingtveit, NTNU (2012)

# Hydropower Potential – A Global overview (IPCC-SRREN)



# Hydropower development

- Increase capacity in existing reservoir hydro
- Retrofit non-hydro dams



# Environmental design



Constructing habitats

- Build the right reservoir in the right place the right way
- Operate the hydropower the right way



Adapting downstream flow



Increasing power production

An aerial photograph of a deep fjord surrounded by rugged, snow-capped mountains. The water is dark blue, and the sky is filled with soft, white clouds.

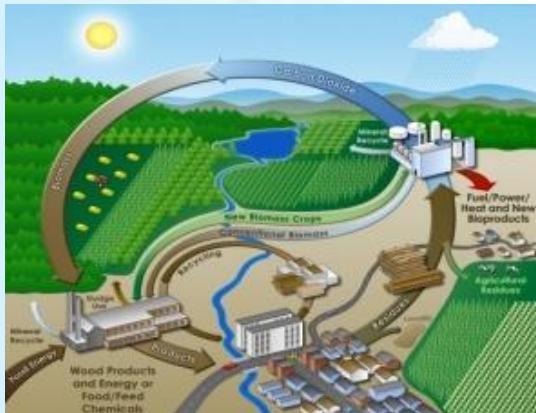
**Need to keep some undisturbed nature**

**Perfect for  
hydropower**

*from Lars Haltbrekken*

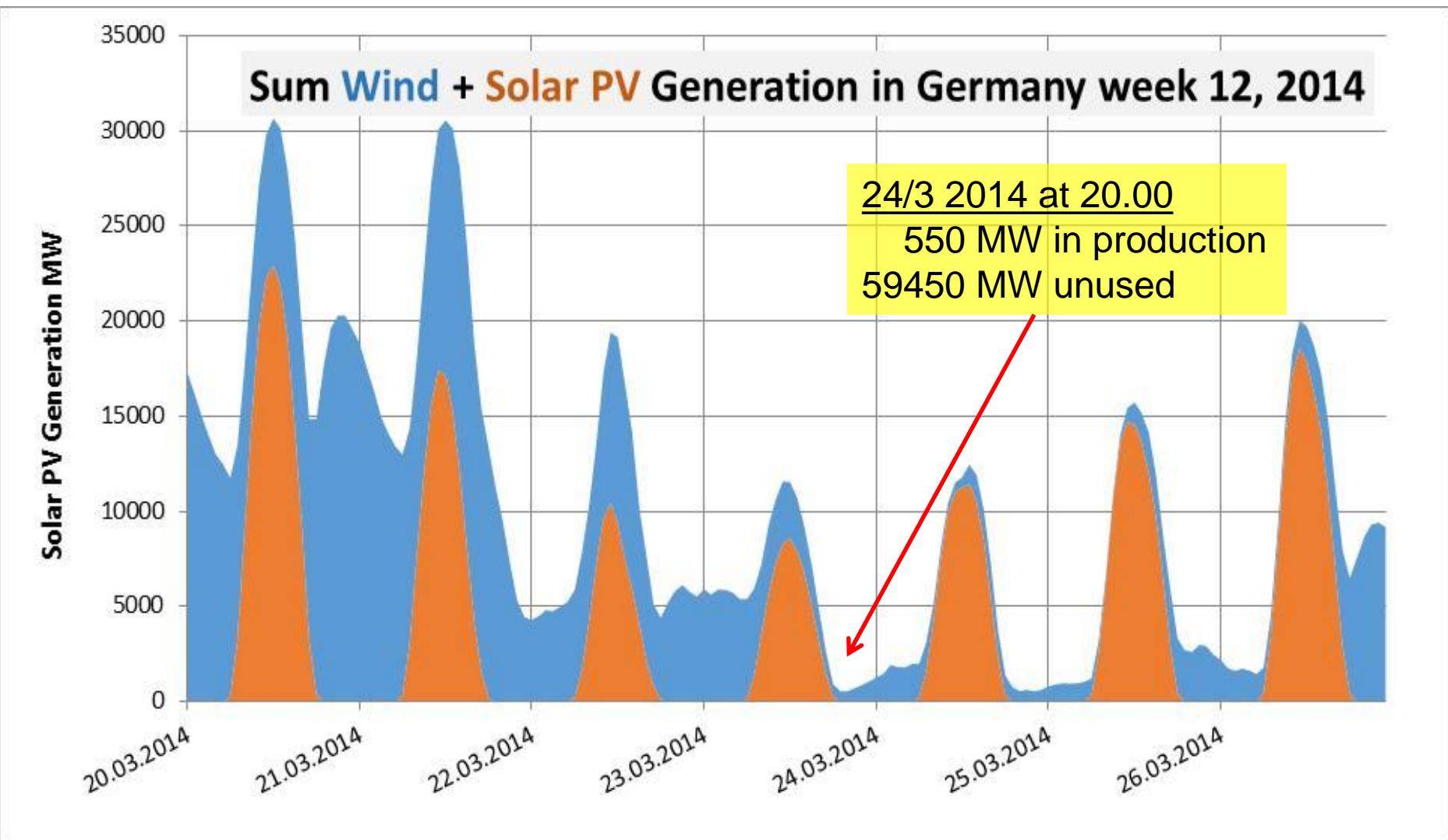


## Hydropower – supporting other renewables

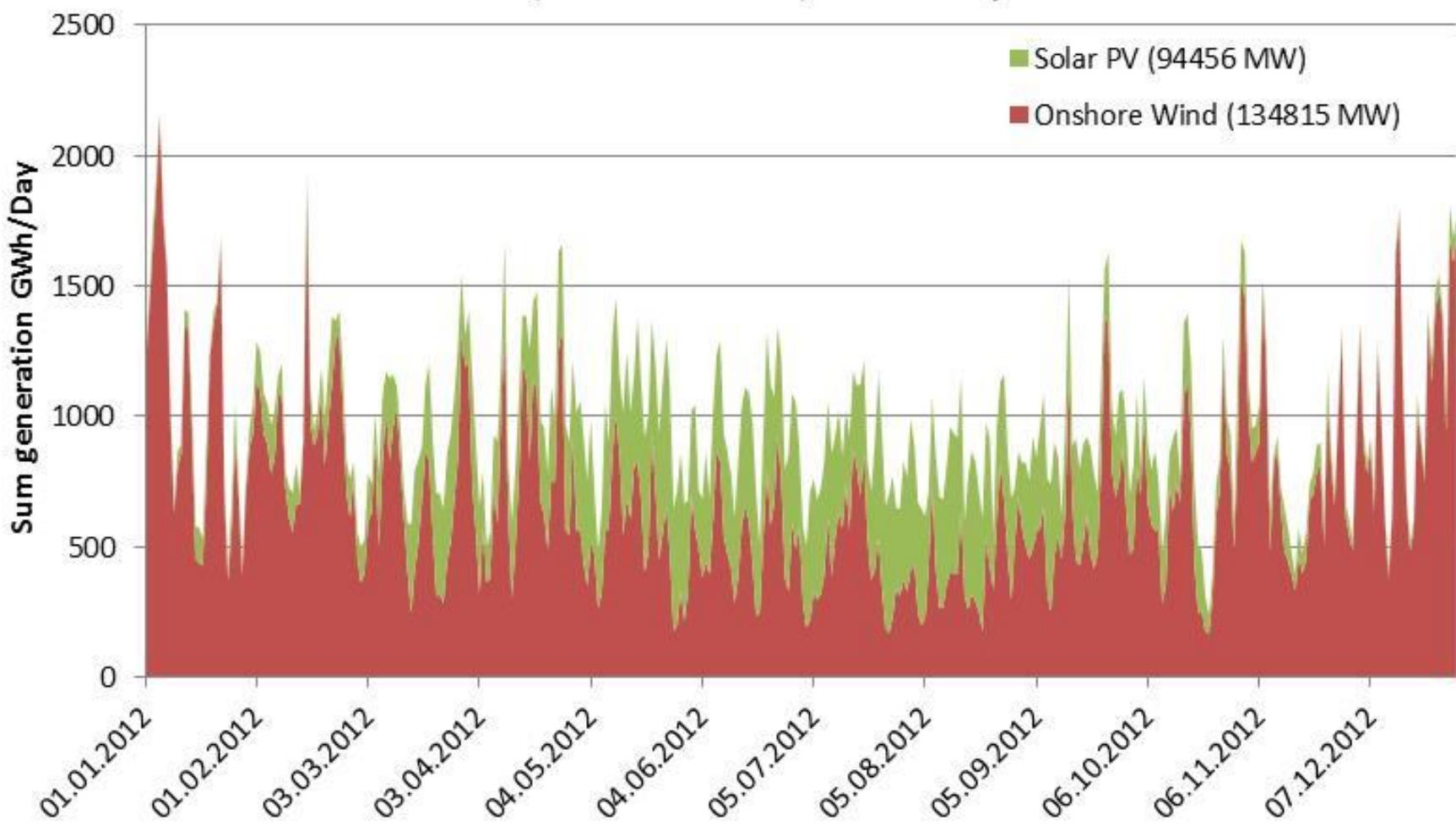


# Wind + Solar energy in Germany week 12 2014

Capacity ~30 000 MW Wind + 30 000 MW PV

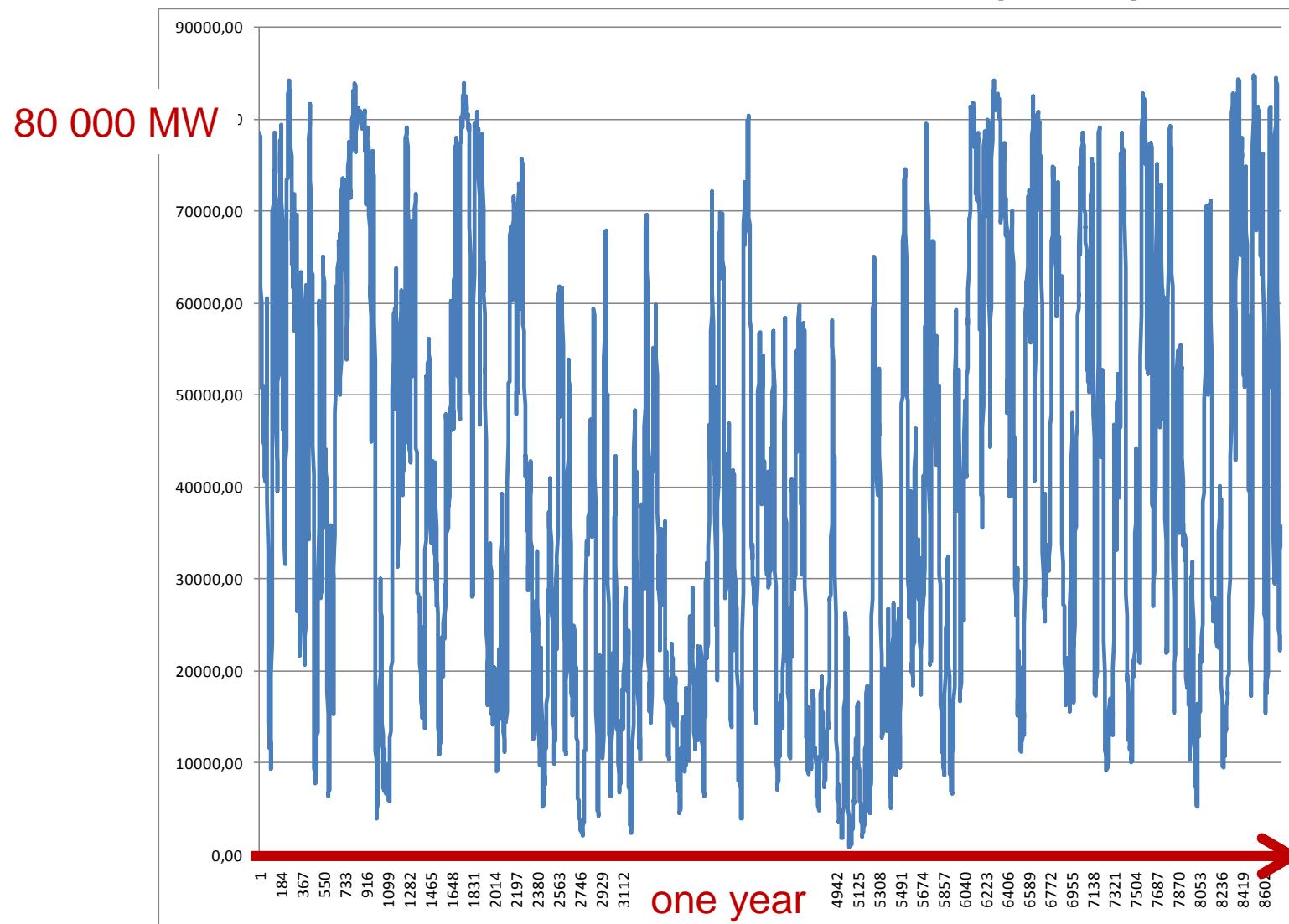


## El-generation from Wind (135000 MW) and Solar (95000 MW) in Europe 2012

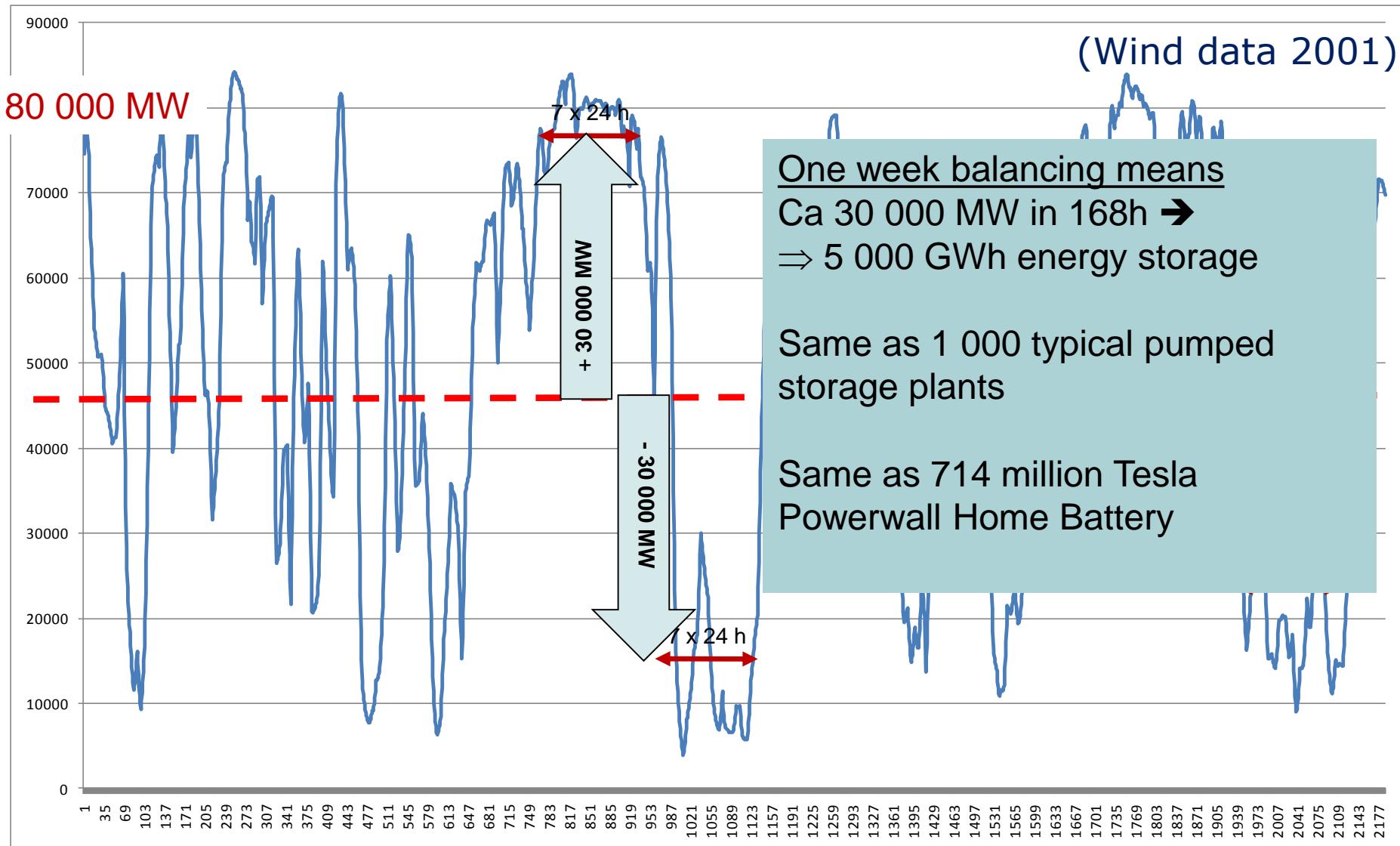


Source: JRC Emirhes data base

# Simulated wind production in the North Sea area in 2030 – 95 000 MW installed capacity



# Wind Power North-Sea Region - Jan – March

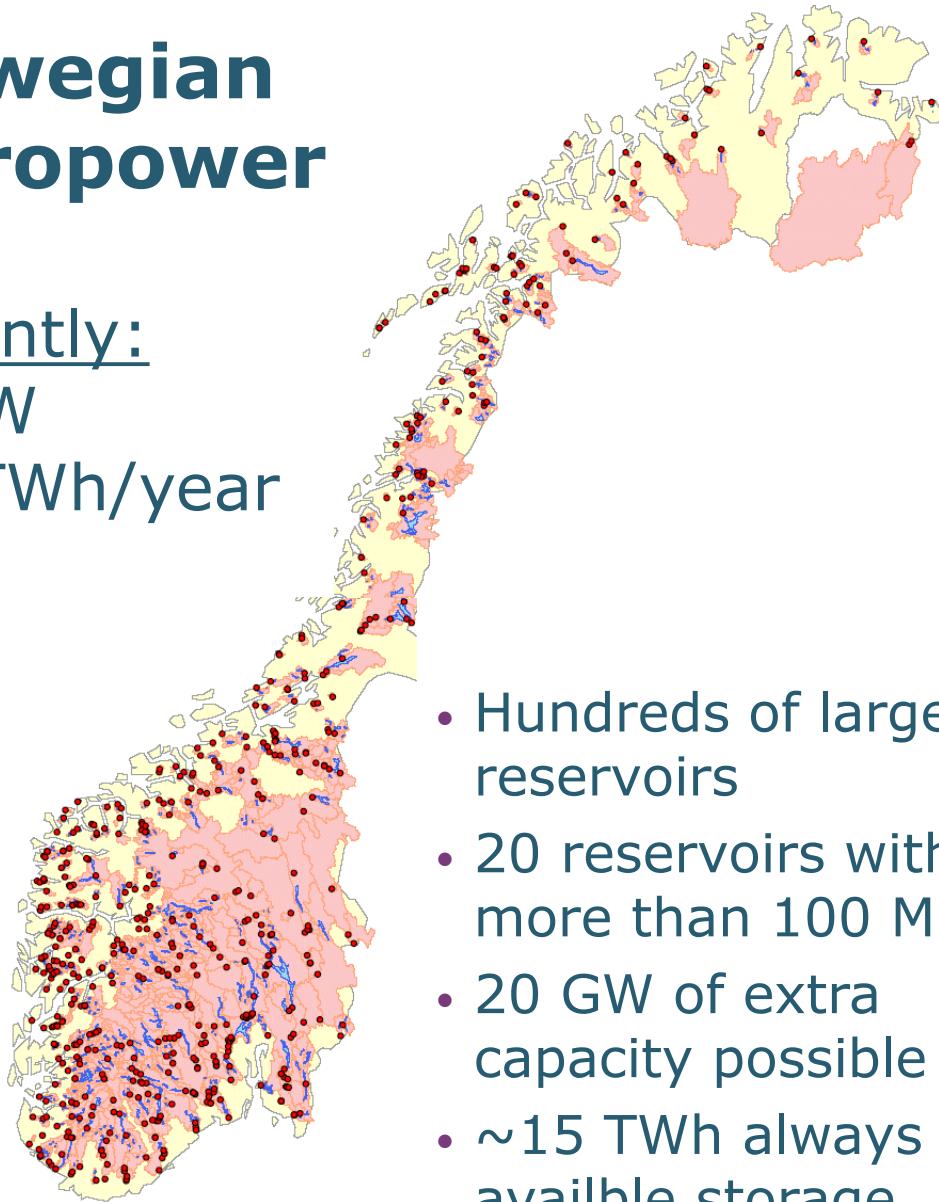


# Norwegian hydropower

Currently:

32 GW

130 TWh/year

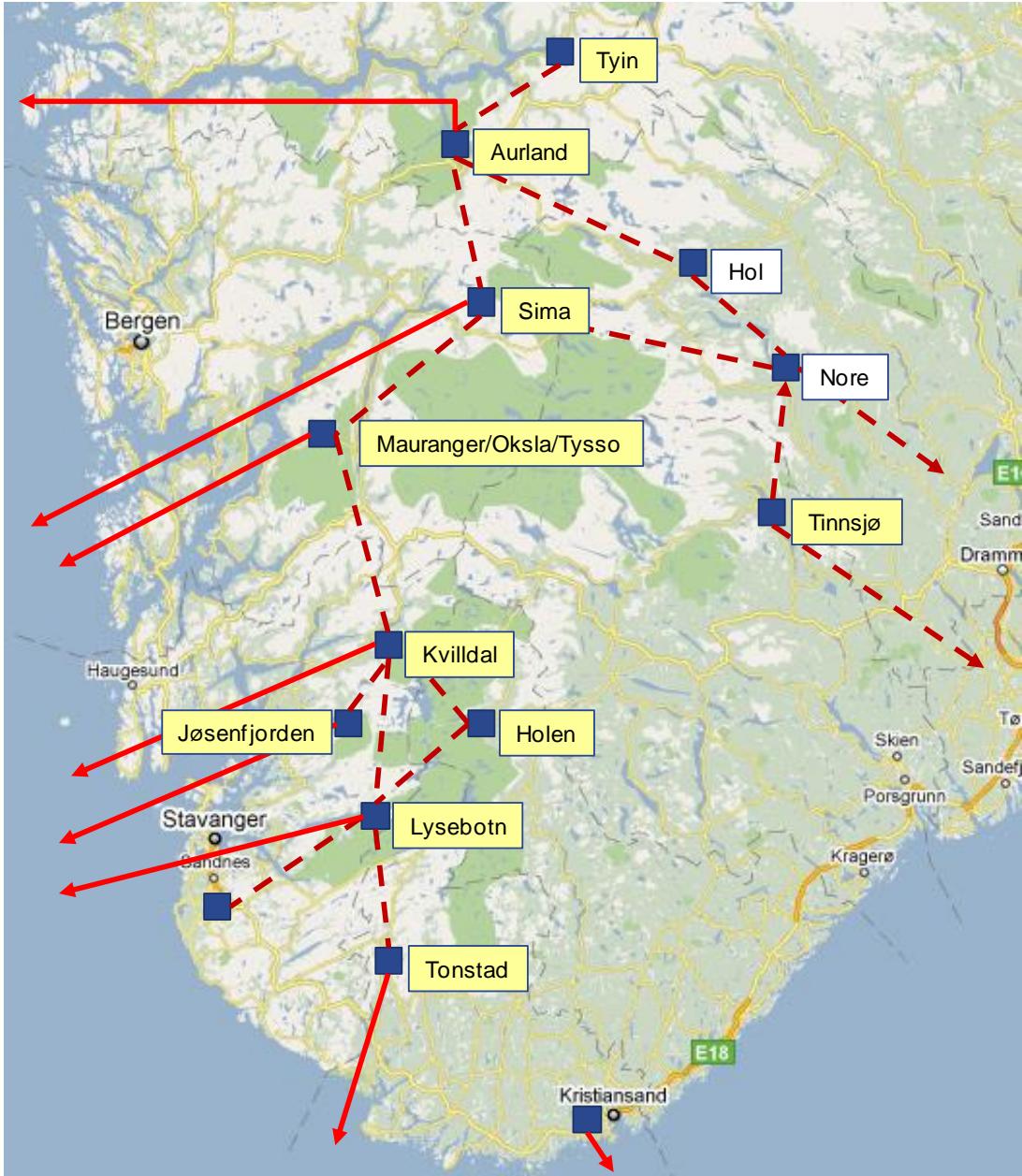


- Hundreds of large reservoirs
- 20 reservoirs with more than 100 Mm<sup>3</sup>
- 20 GW of extra capacity possible
- ~15 TWh always available storage



# CEDREN Case study 2030

## 20 000 MW possible



# Reservoirs



16:00



16:15



# Drought mitigation



# Irrigation and water supply

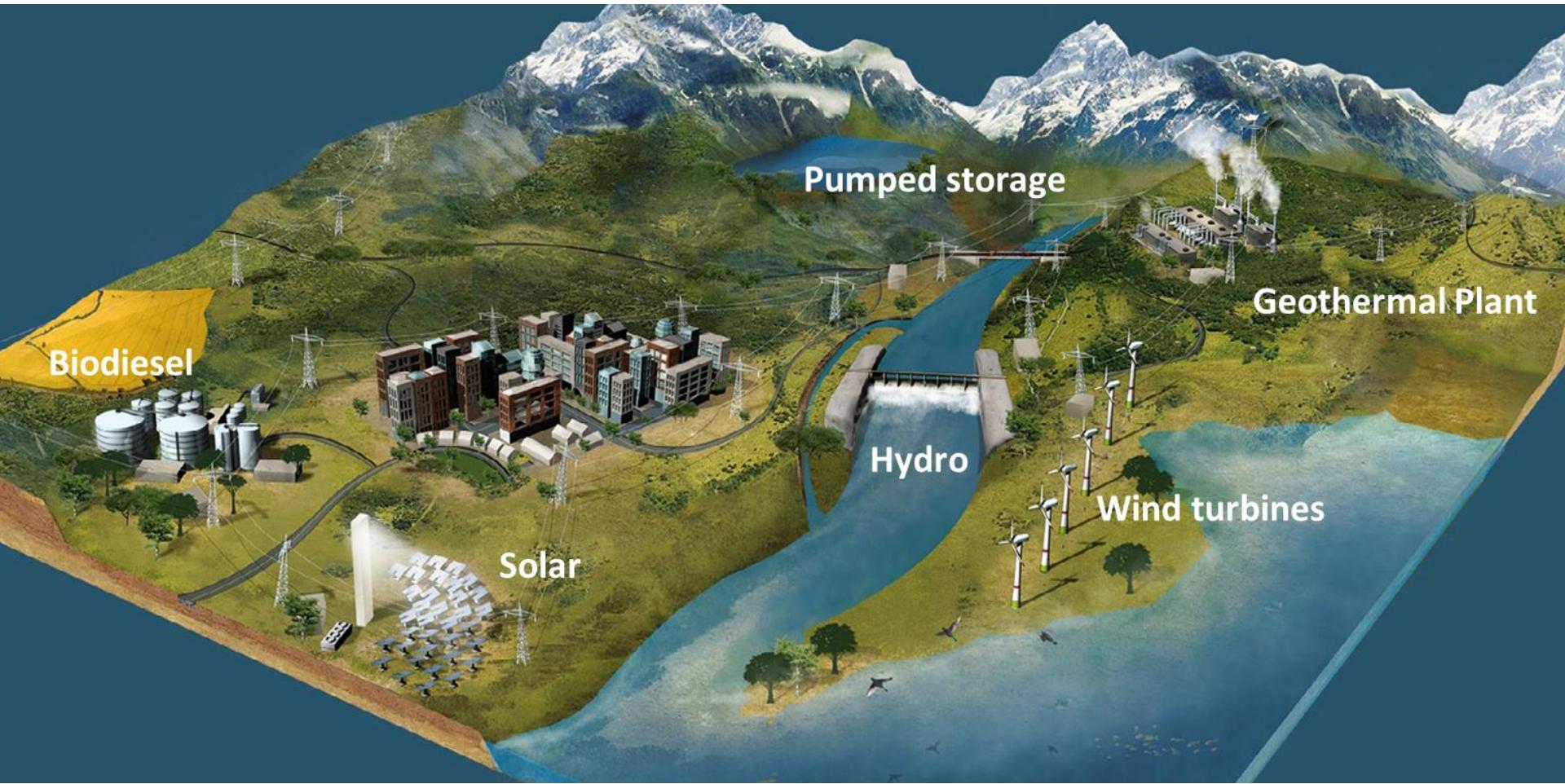


# Challenges

A wide-angle photograph of a dry, arid landscape. In the foreground, the ground is covered with light-colored sand and scattered small, dry, yellowish-brown shrubs. The middle ground shows a flat, featureless expanse that appears to be a dried-up lake bed. In the background, a range of mountains is visible under a clear blue sky with wispy white clouds. The overall scene conveys a sense of extreme dryness and desolation.

Owens Lake,  
California

# Combination of renewables



Source: IHA

# Hydropower and reservoirs are needed

