Hydropower: la feuille de route de l'AIE

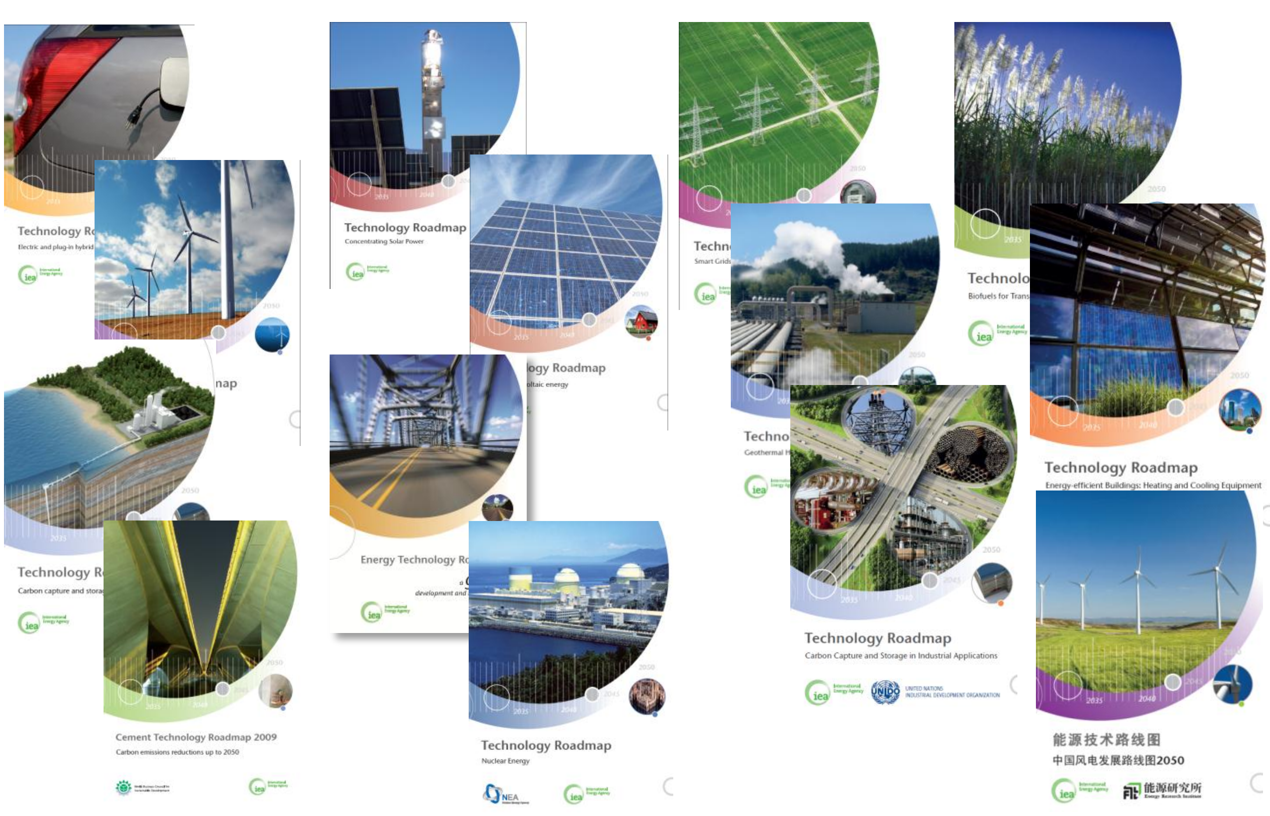
ADEME

Agence de l'Environnement et de la Maîtrise de l'Energie

Hydro 21 – Grenoble – 21 nov. 2012

Technology roadmaps status

2009 **2010** **2011** **2012**



2012 / 2013

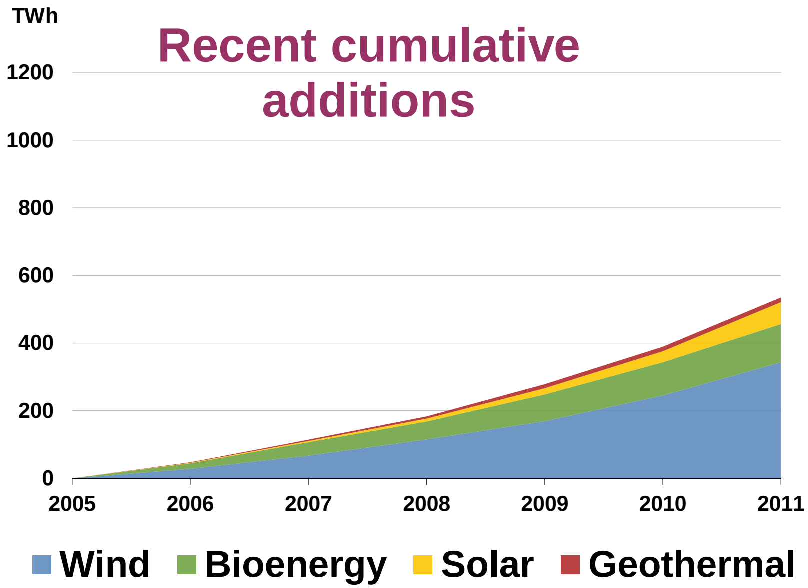
- **Hydropower**
- **High efficiency coal power**
- **Chemical catalysis**
- **Building envelopes**
- **Energy Storage**

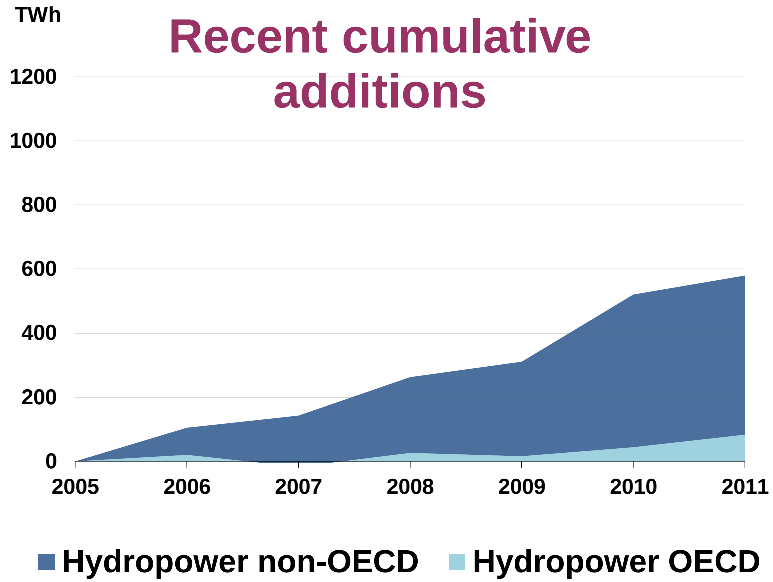
Introducing the IEA Technology Roadmap: Hydropower

- **Co-authored with Brazil's Ministry of Mines and Energy**
- **Workshops in Paris, Rio-de-Janeiro, Washington**
- **Reviewers from agencies, academia, governments, industry, NGOs**
- **Support from CEPEL, ADEME, Iberdrola**

Recent Trends

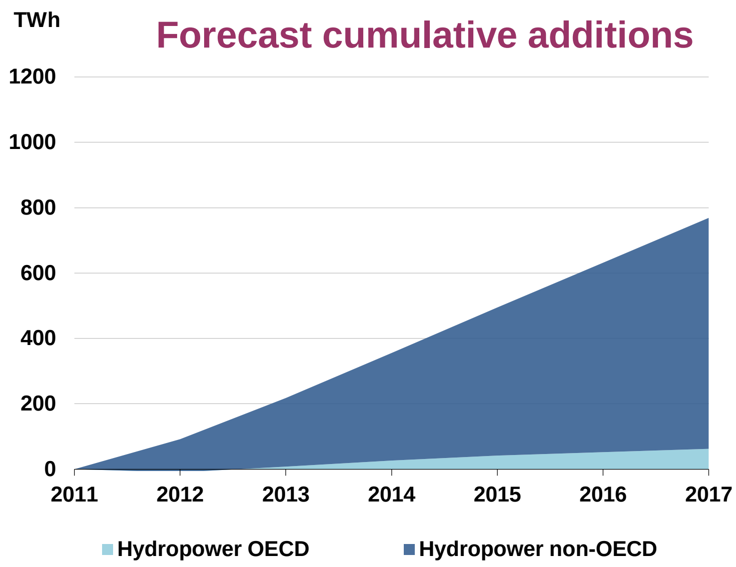
- New capacity additions in hydropower since 2005 have generated more electricity than all other renewables combined

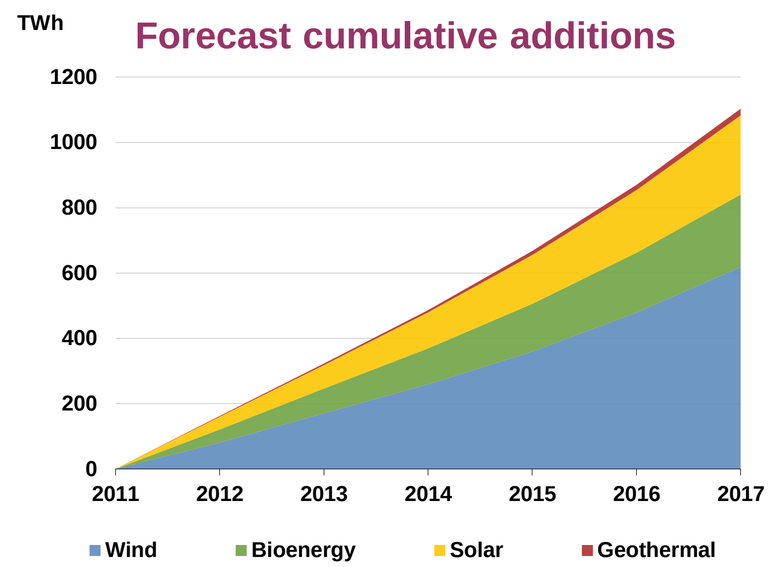




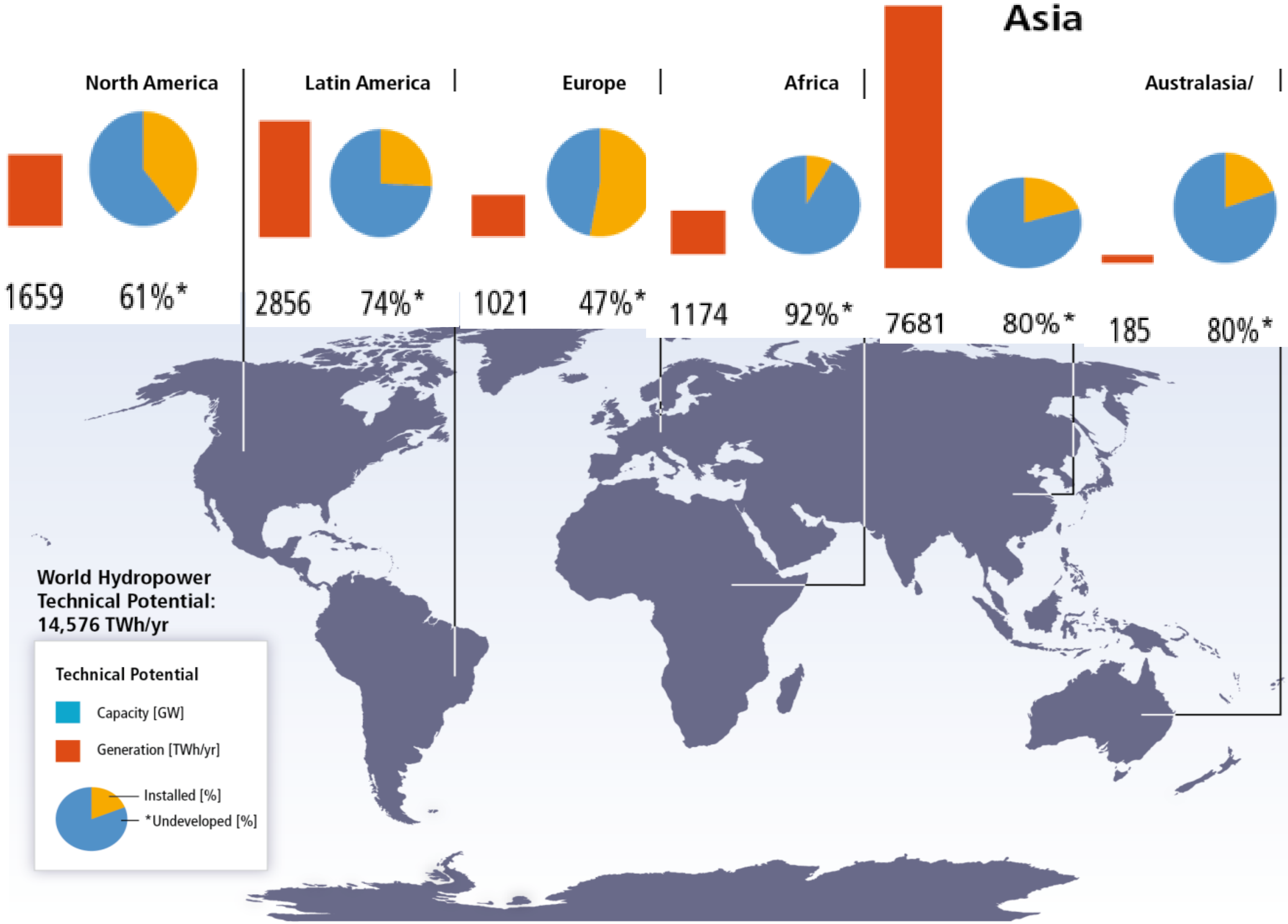
Short term forecast

- Hydropower remains the largest but its share declines
- The bulk of its growth comes from emerging economies and developing countries



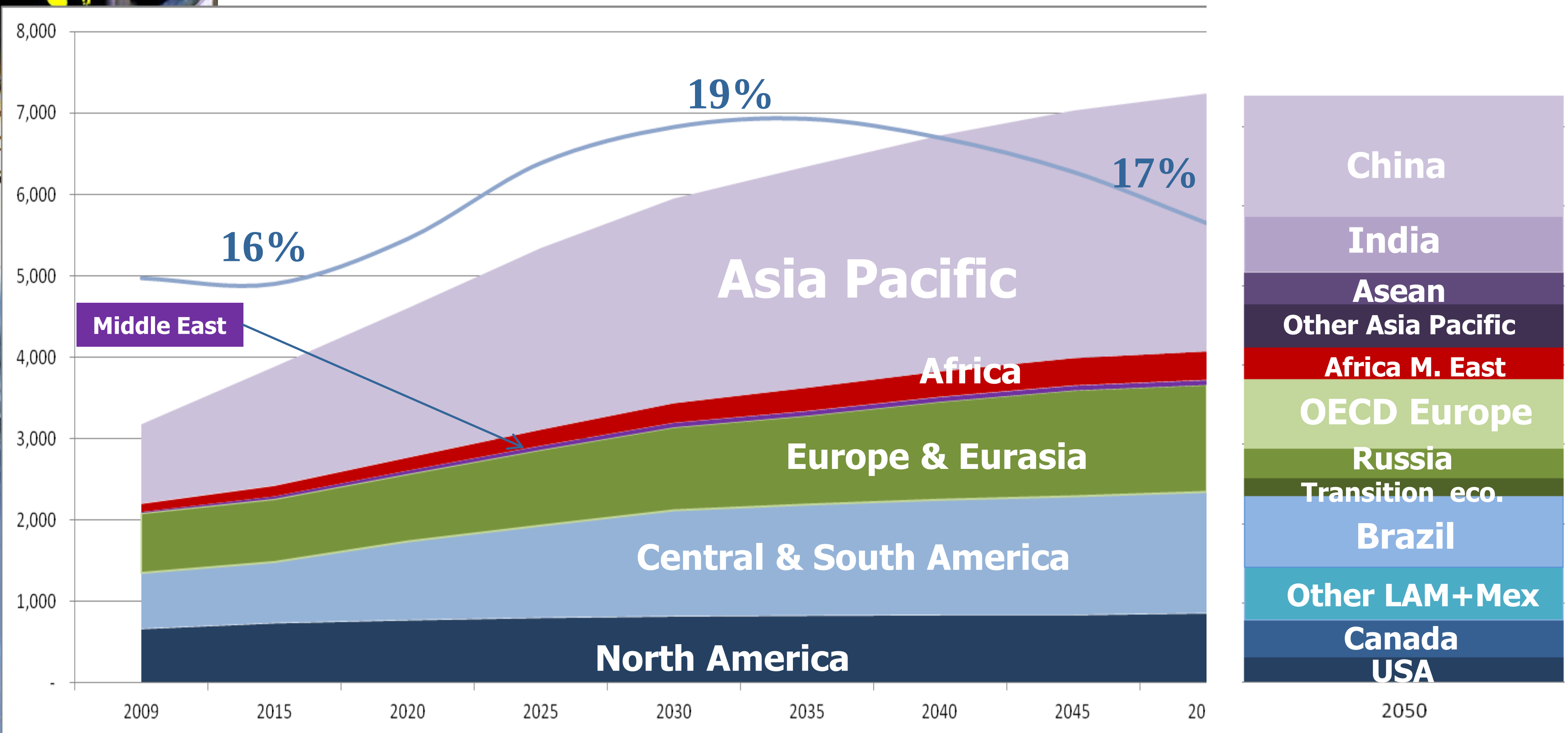


A large HP potential remains



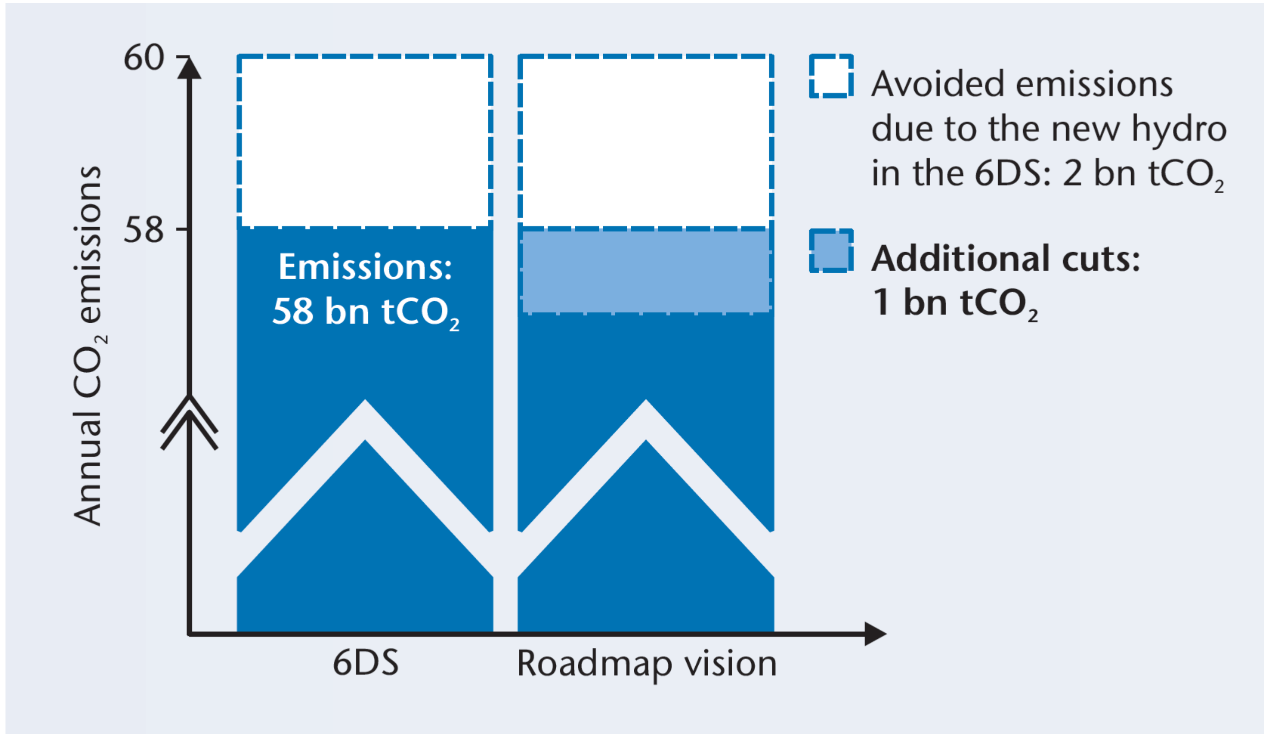
Source: Kumar *et al,* IPCC SRREN 2011

Vision for Hydropower IEA Roadmap



Hydropower generation will double by 2050 and reach 2 000 GW and 7 000 TWh, mostly from large plants in emerging/developing economies

Hydropower and CO_2 emission reductions

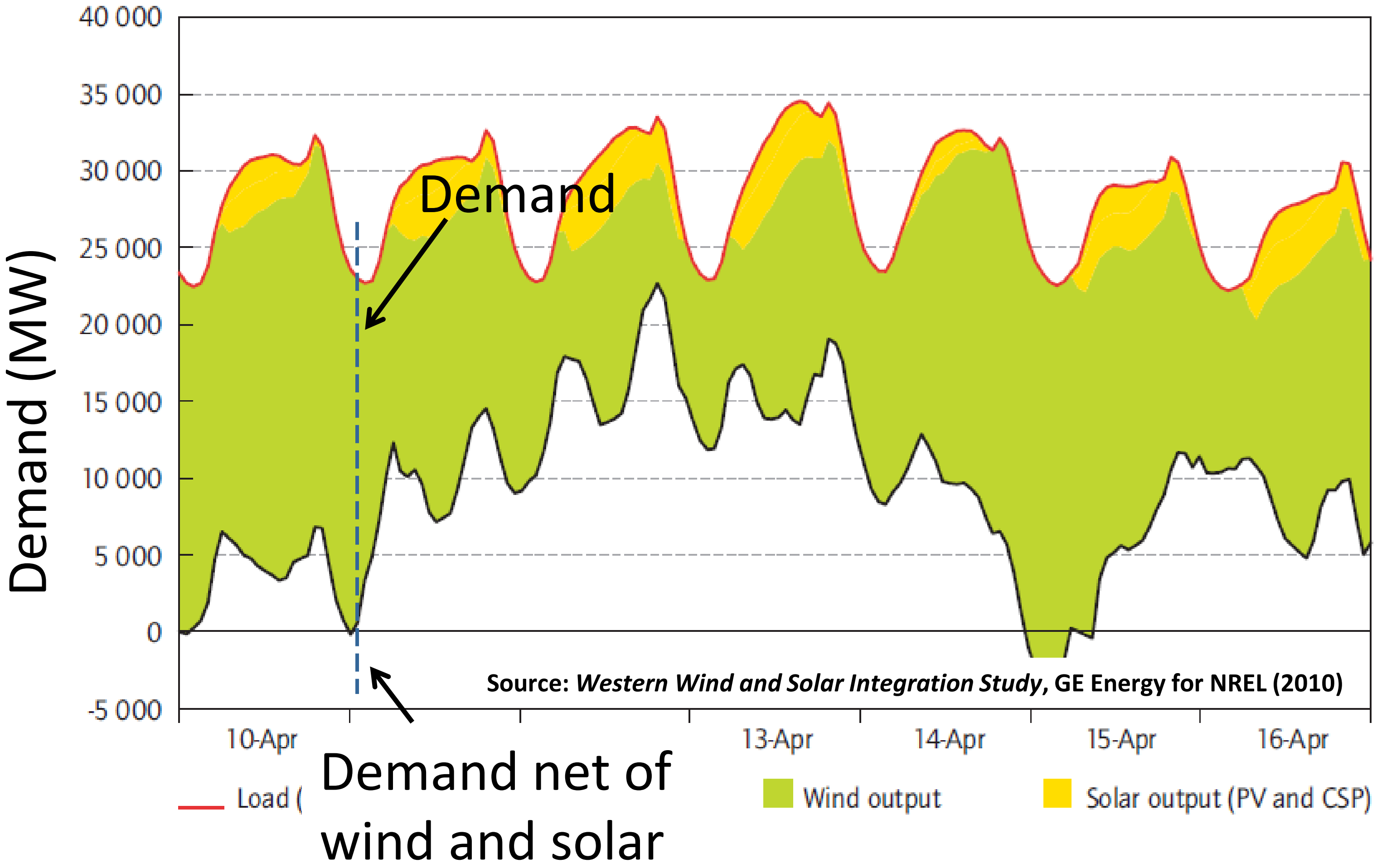


- **Compared with the laissez-faire scenario (6DS) of *Energy Technology Perspectives 2012*, hydropower in this roadmap would cut 1 bn tCO_2 emissions per year by 2050**
- **New hydropower plants developed under this vision would total 3 bn tCO_2 emission cuts per year by 2050**
  - **Assuming they replace a mix of fossil fuel plants**

Hydropower drivers

- Affordable energy, security of supply
- Multipurpose water resource management
  - Irrigation, freshwater supply
  - flood protection
  - Navigation
  - Recreation
  - Climate change mitigation
- Flexible capacities, help integrate wind and solar PV

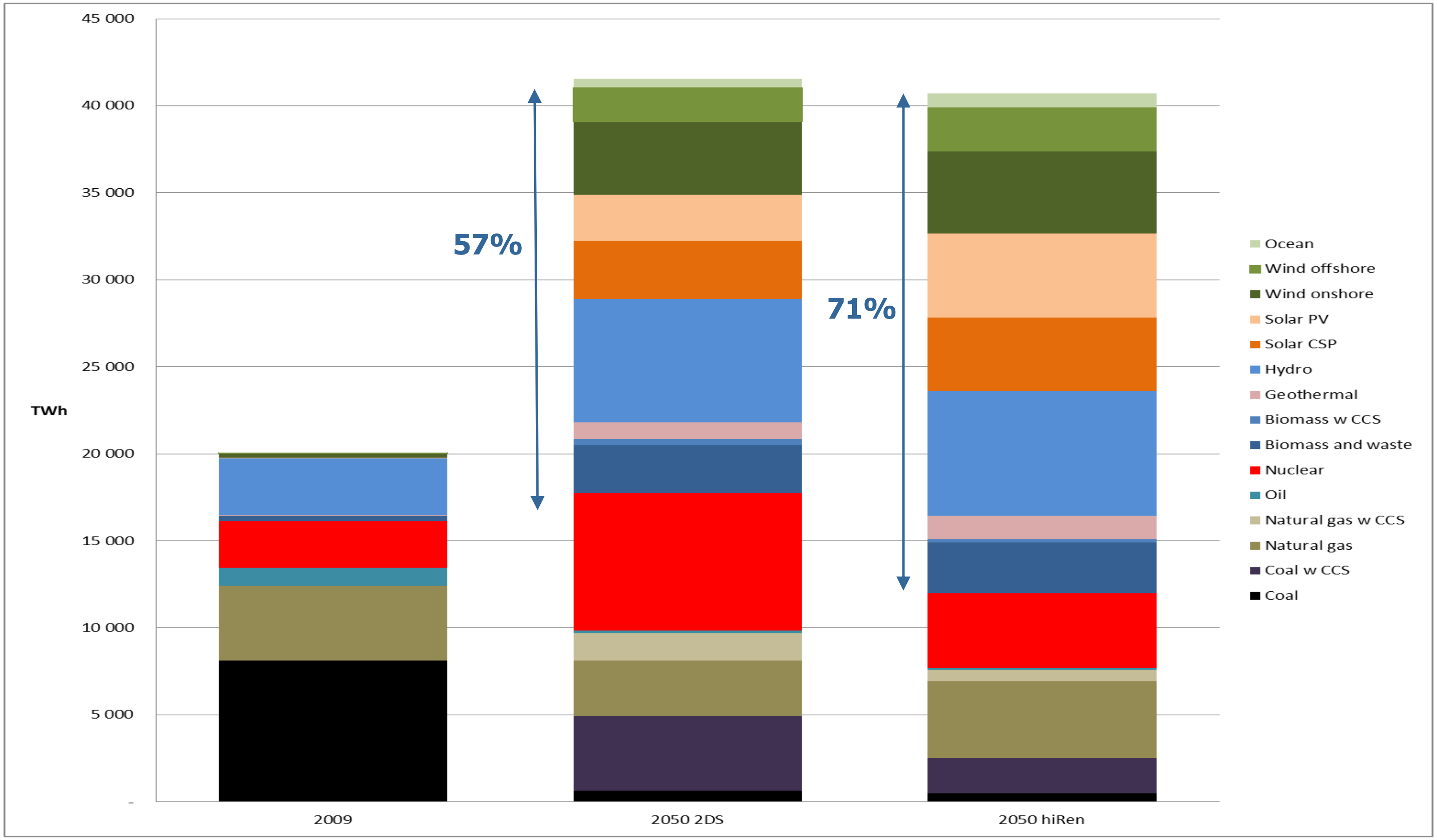
The need for flexibility increases



Source: *Western Wind and Solar Integration Study*, GE Energy for NREL (2010)

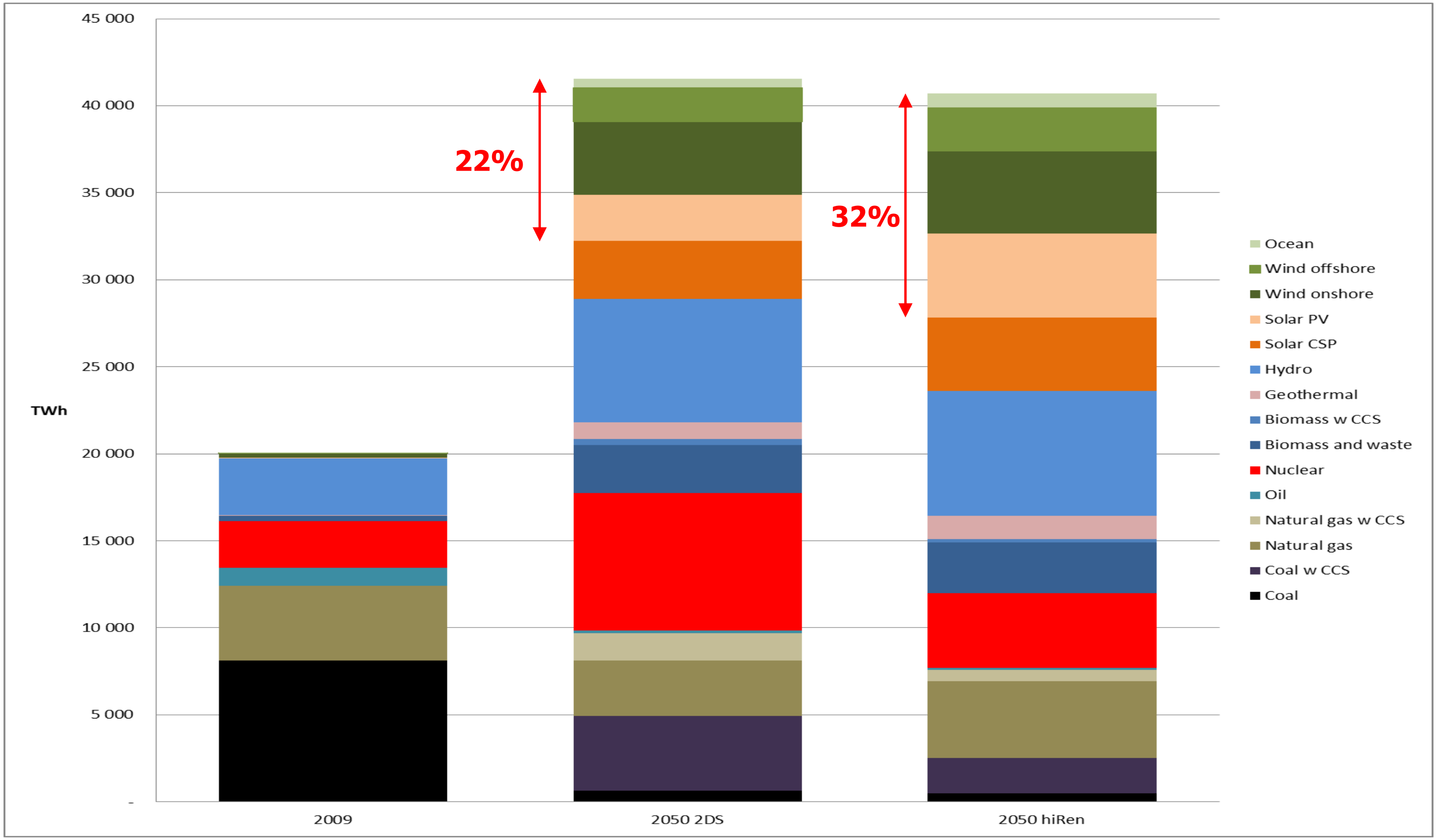
Variability is not new, but it does get bigger with variable renewables (wind power, solar PV)

Renouvelables: rôle dominant à terme (2050)



Renewables provide 57% (2DS) to 71% (Hi-REN) of World's electricity

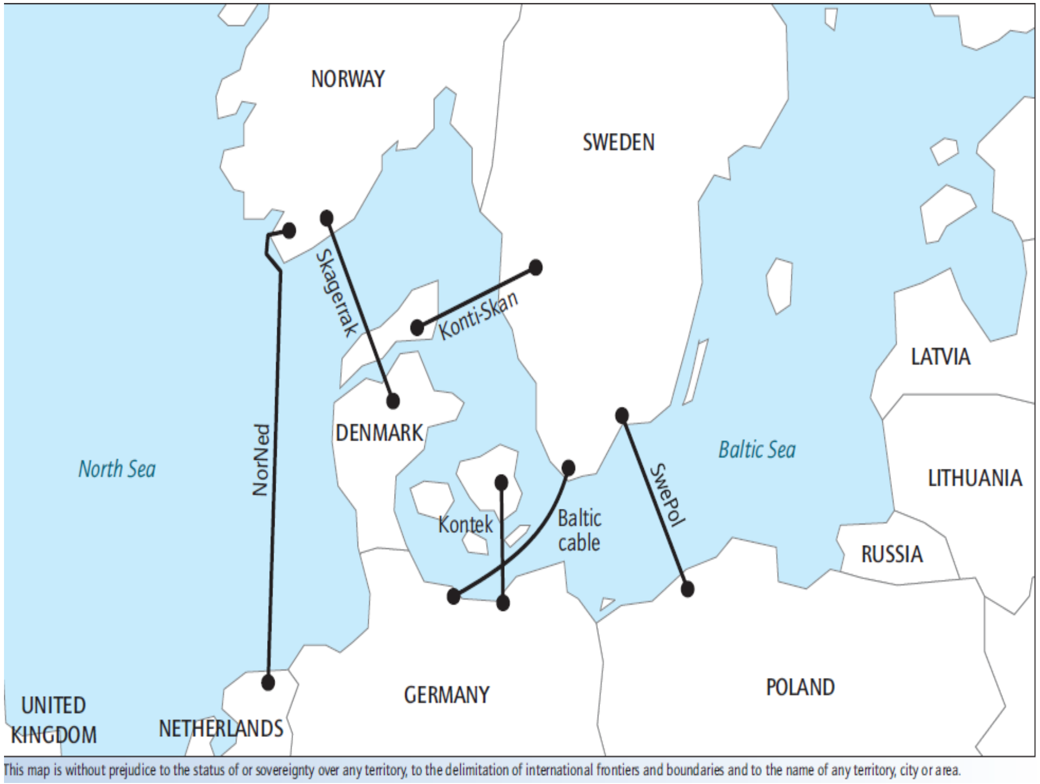
Forte pénétration des énergies variables



Variable renewables provide 22% (2DS) to 32% (Hi-REN) of World's electricity

Reservoir hydropower, an excellent asset for integrating wind and PV

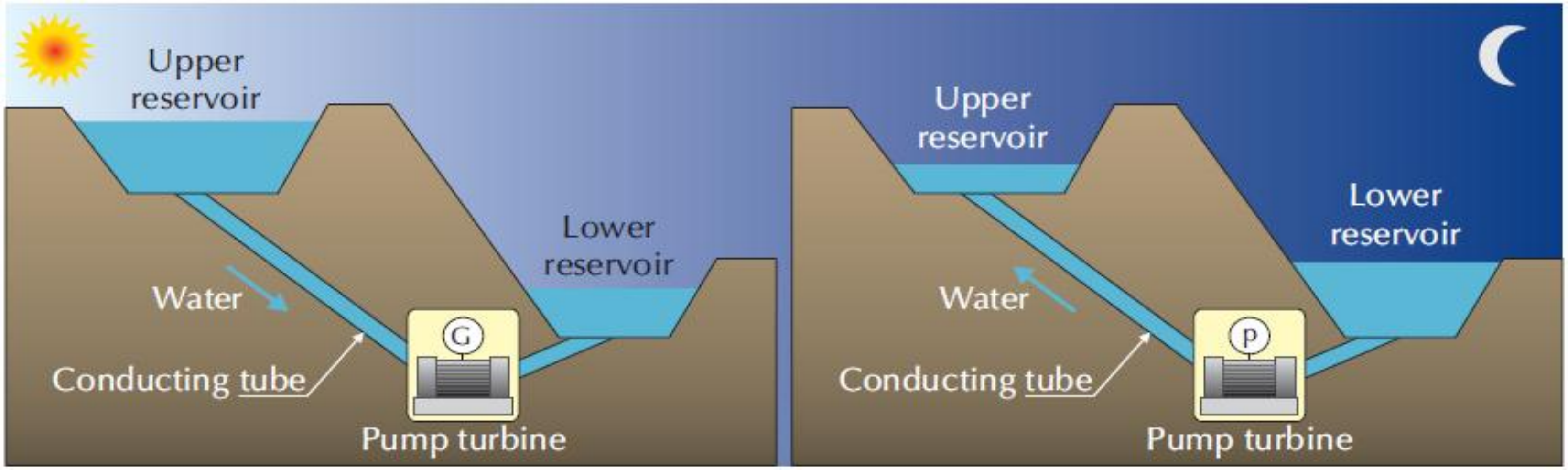
- In Europe and the US, hydro is increasingly providing flexibility, helping integrating variable renewables



- Increased electric capacity of existing HPP
- Pump-storage hydro:
  - 140 GW in service, 50GW in development
  - By 2050: 400 to 700 GW

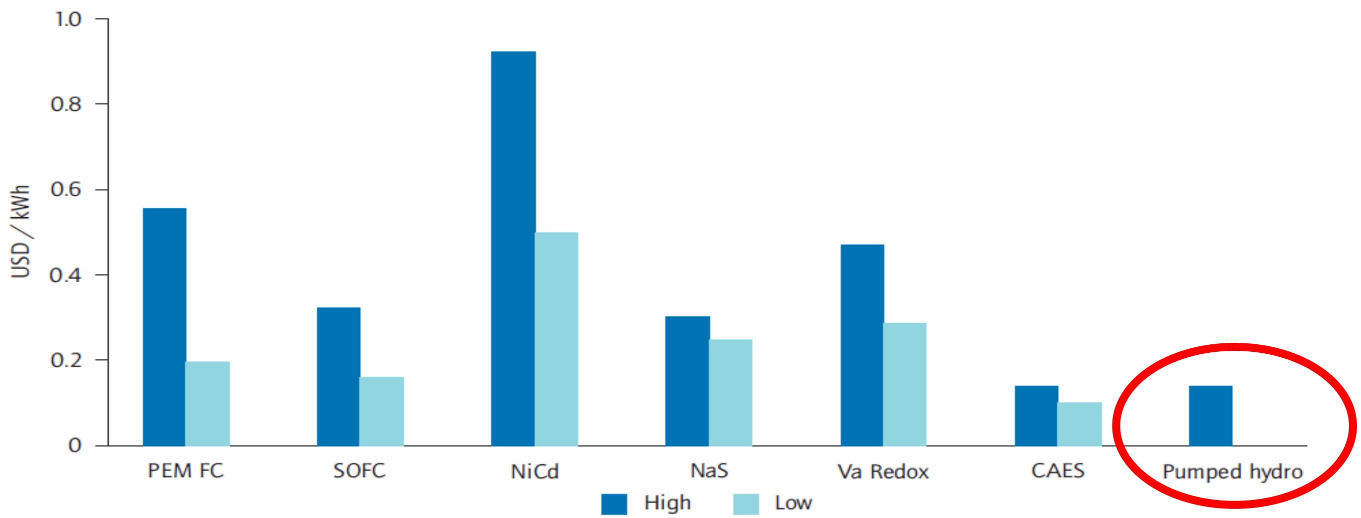
PSP: 99% of current on-grid storage

- **Pumped-hydro plants the reference solution**
  - **140 GW in service, 50 GW in development**
- **PSP developed from existing hydro plants**
  - **“off-stream” or “pumped-back” schemes**
  - **Small energy volumes but large power capacities**
  - **Daily/weekly storage does not require large areas**

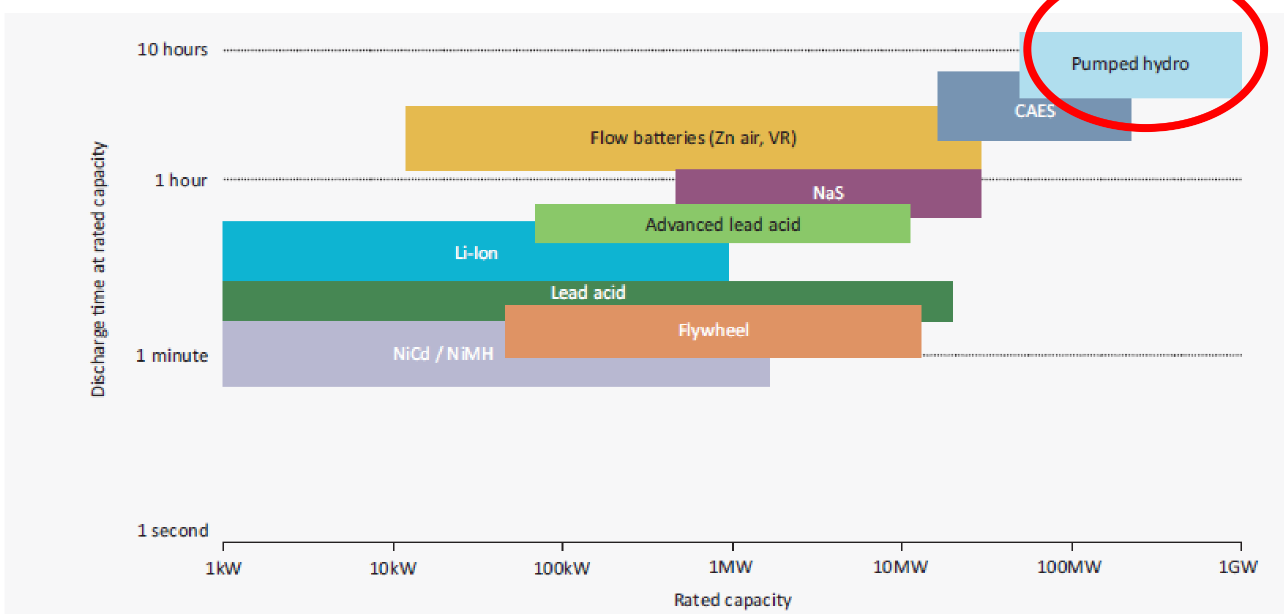


Source: Inage 2009.

Storage options: costs and availability



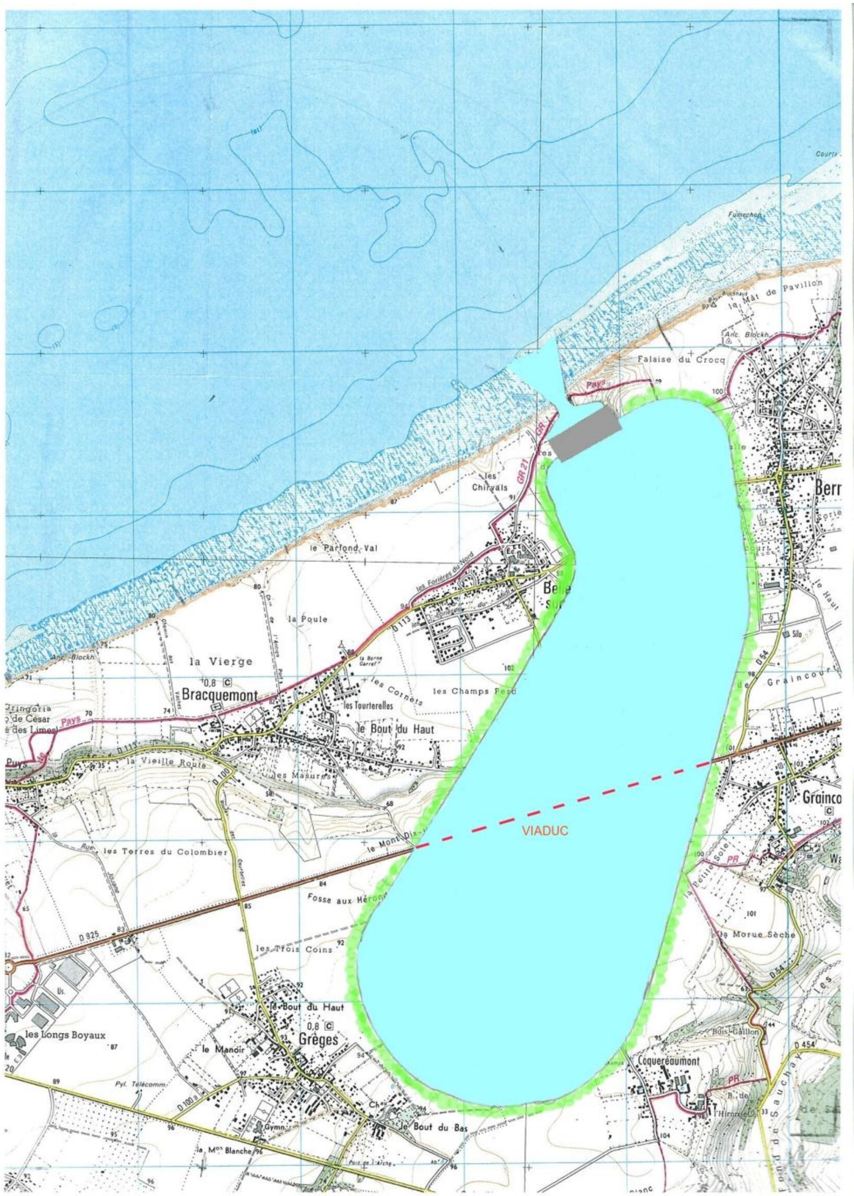
Note: PEM FC = Proton exchange membrane fuel cell; SOFC = Solid oxide fuel cell; NiCd = Nickel cadmium battery; NaS = Sodium-sulphur battery; Va Redox = Vanadium redox flow battery; CAES = Compressed air energy storage. For the high case the assumed price for electricity is USD 0.06 per kWh; for the low case USD 0.04/kWh.



New options for pumped-hydro plants

- **Closed-loop plants**
  - **Using natural declivity**
  - **Possibly using the sea as lower reservoir (Okinawa-style)**

One possible site in Normandy near Dieppe, head 95m, area 6 km², storage 65 GWh, capacity 2 to 6 GW



Source: Lempérière 2011

Options for flat countries exist

- **Artificial energy islands combining pumped-hydro, wind power and possibly tidal are being considered**

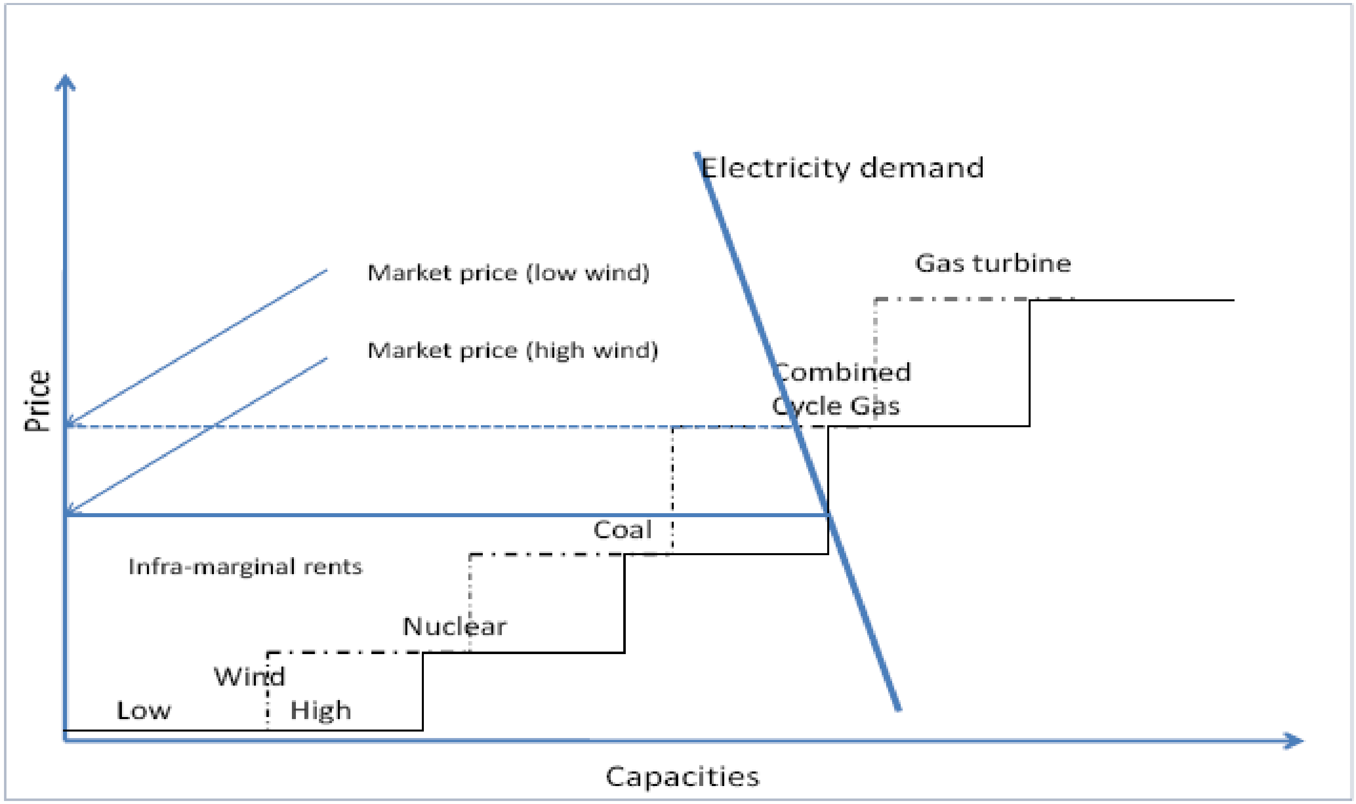
Source: Kema 2007.

Vision for PSP deployment by 2050

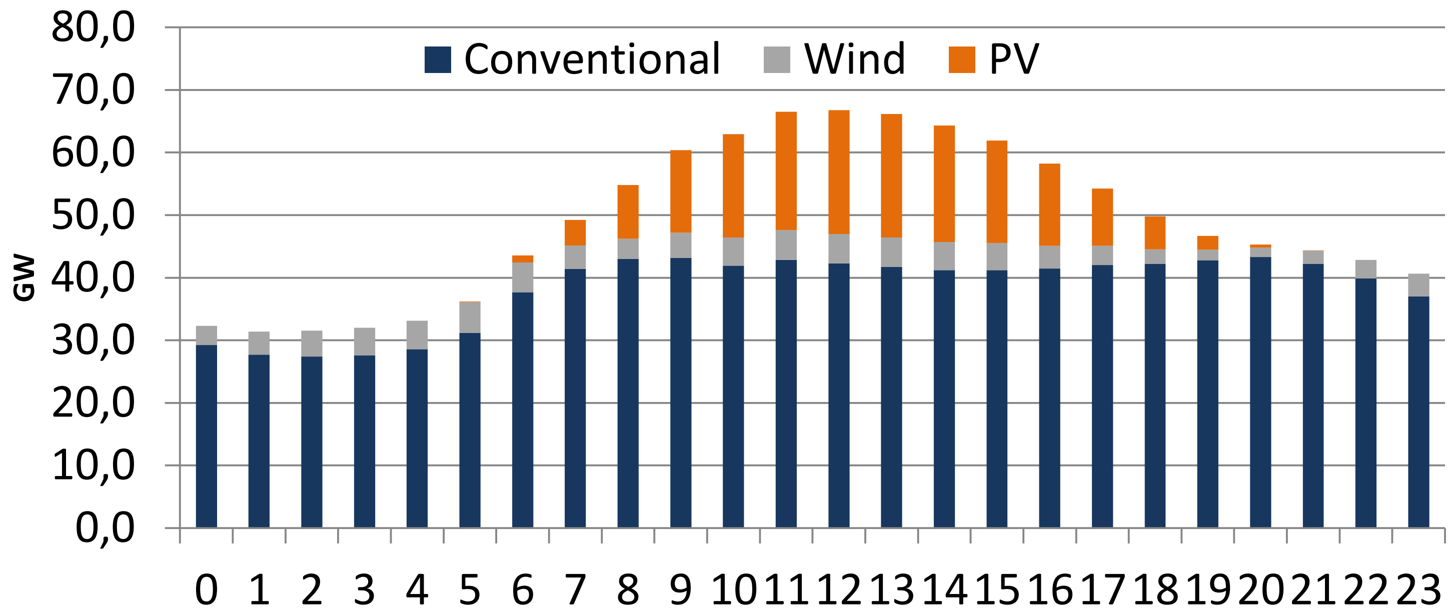
		China	USA	Europe	Japan	RoW	Total
Low	*vRE/total energy*	*21%*	*24%*	*43%*	*18%*		
	Hydro/total energy	*14%*	*6%*	*13%*	*12%*		
	PSP/total capacity	4%	4%	6%	11%	2%	
	GW	**119**	**58**	**91**	**35**	**109**	**412**
High	*vRE/total energy*	*34%*	*37%*	*48%*	*33%*		
	Hydro/total energy	*15%*	*6%*	*11%*	*13%*		
	PSP/total capacity	5%	8%	10%	12%	3%	
	GW	**179**	**139**	**188**	**39**	**164**	**700**

But economic challenges appear…

- **The merit order effect reduces spot market prices, and the peak-base spread…**



… undermining storage economics…

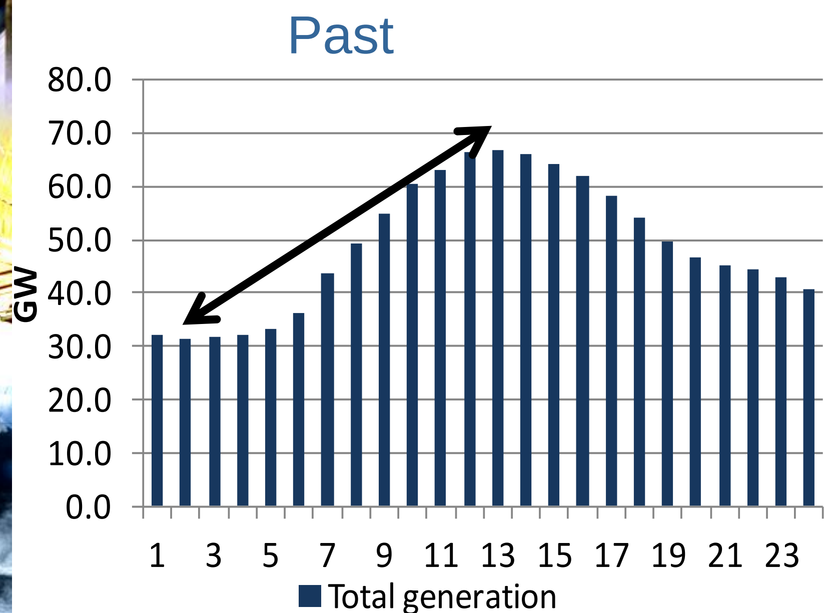


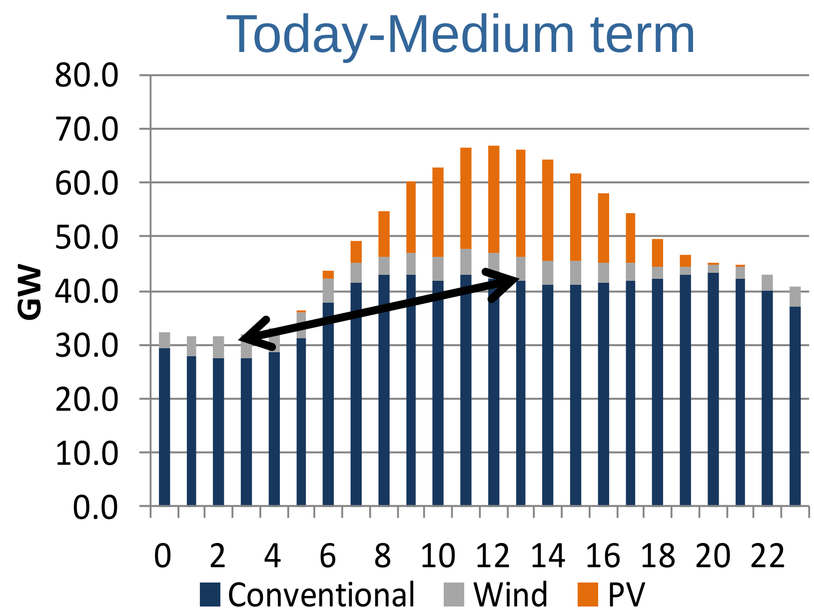
Power generation in Germany, 14 May 2012

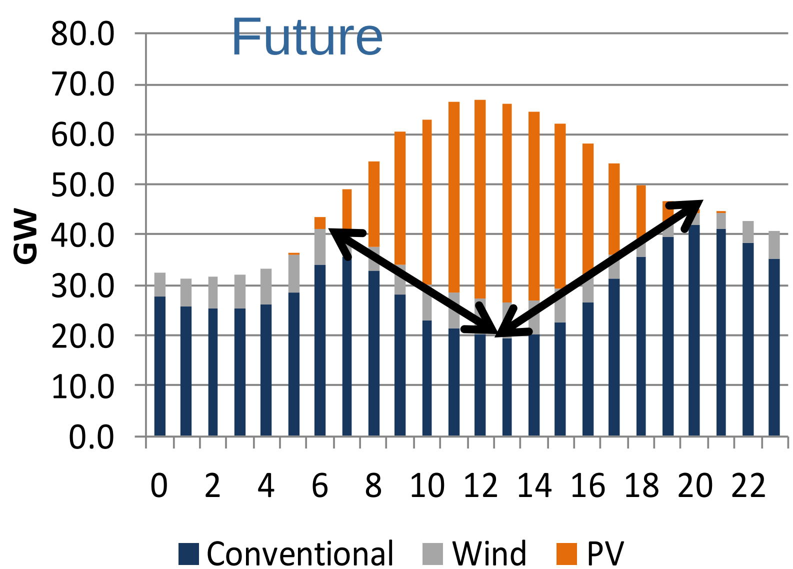
	2007	2008	2009	2010	2011
Phelix Base [EUR/MWh]	37.99	66.76	38.85	44.49	51.12
Phelix Peak [EUR/MWh]	56.16	88.07	51.15	55.02	58.95
Spread [%]	149	134	132	124	115

Source: Top, EEX Transparency Platform; Bottom EEX cited as in http://www.agora-energiewende.de/fileadmin/downloads/Agora_Energiewende_Impulse_Kapazitaetsmarkte.pdf

… at least for the time being







- **Medium-term:**
  PV *reduces* value of flexible resources (e.g gas, storage)
- **Long-term:**
  Mutual *increase* of market value

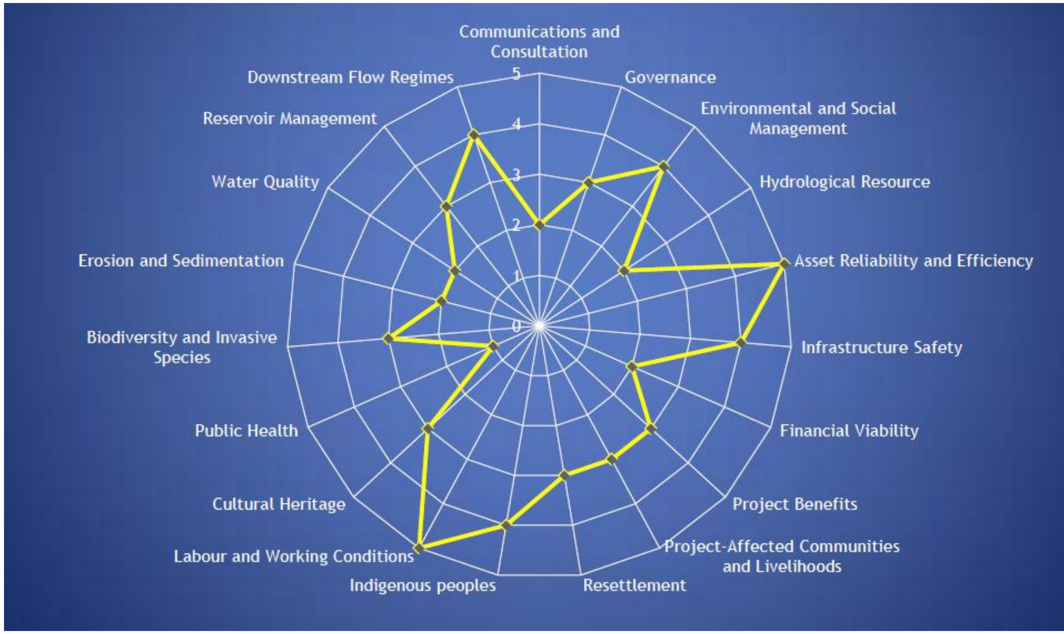
Overview Actions

- **Sustainability and public acceptance**
- **Technology development**
- **Financial challenges**
- **Policy and Market Design**

Sustainability challenges

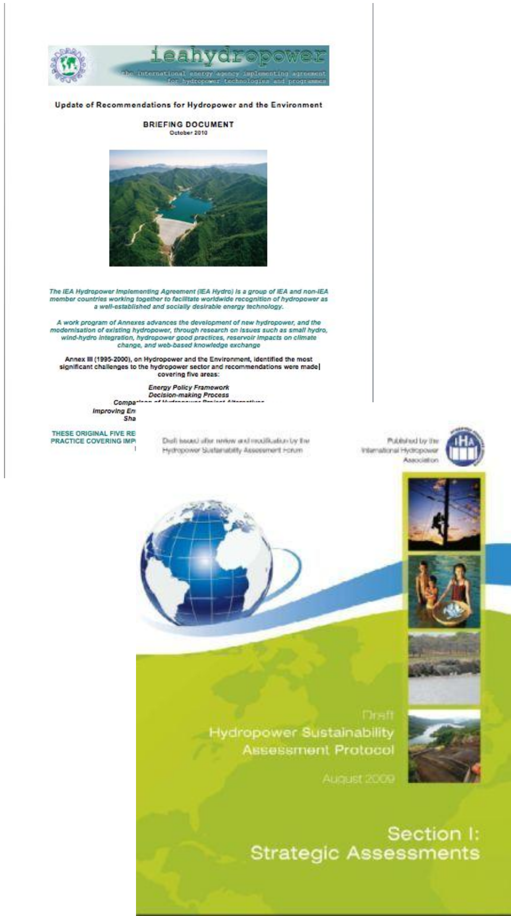
- Dam safety
- Wildlife, biodiversity
- Water quality
- Impacts of civil works
- Population resettlement
- GHG emissions

An example of a sustainability profile using IHA's Operations tool. Source: IHA



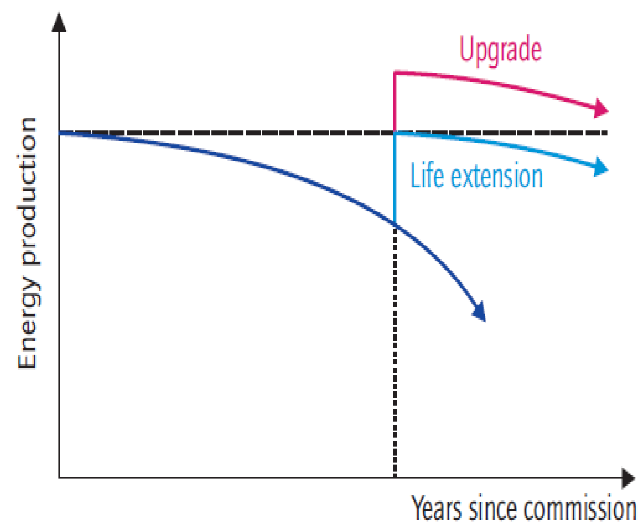
Environmental benefits and mitigation

- **Considerable environmental benefits: reduced GHG emissions, air pollution, etc.**
- **Sustainable resource and various benefits**
- **Mitigation of negative impacts**
  - ***<u>Improving procedures:</u>* protocols and best practices**
  - ***<u>Improving technology</u>*: fish steps, fish-friendly turbines, aerating turbines, oil-free turbines,**
  - ***<u>Improving management:</u>* land and forest restoration, flow requirements, etc…**



Technical improvements

- **Strengthened environmental requirements may reduce hydropower output and potential**
  - **E.g. water framework directive in the EU**
- **Technical improvements allow to increase or maintain performance and output, and reduce environmental impacts**



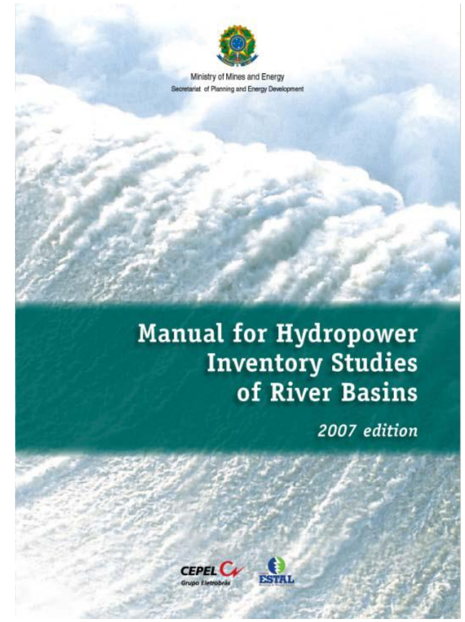
Source: Lier, 2011.

Financial challenges

Technology	Bioenergy	Bioenergy co-firing	Geothermal	Solar PV	CSP	Hydro	Wind onshore	Wind offshore	New coal	New gas CCGT	Micro hydro	Small-scale Solar PV	Small-scale Biogas
min USD/ MWh	80	80	35	155	160	**20**	50	140	40	40	**35**	185	110
max USD/ MWh	250	140	200	350	300	**230**	140	300	90	120	**230**	600	155

- **Although cost-effective, hydropower faces financial challenges**
  - **Large projects, capital intensive, long building times**
  - **Returns on investment vary from year to year**
  - **Long tenures from commercial banks difficult to get**
  - **Flexibility under-valued on most markets**
  - **Market design based on marginal running costs may not deliver the right incentives**

Policy and market design



- Governments and stakeholders should establish/ update inventories, at river basin level where appropriate, incl. options for upgrading/redeveloping existing plants or non-hydroelectric dams
- Set targets and track progress
- Promote policy framework and market design for HP
- Check that developers document their approach to sustainability, mitigate or compensate negative effects
- Develop effective financial models to support HP in developing countries

Policy action is needed for reservoir/PSP

- **Reservoir hydro and PSP priceless…**
  - **Beyond HP electricity generation, to support wind and solar PV deployment addressing variability**
- **…but must be priced!**
  - **Market designs must be completed or changed**
  - **Reconsidering grid fees can be pragmatic first step**
- **PV and PSP have very different lead times and markets cannot easily handle the gap**
  - **Especially as they are based on marginal run costs**
- **Long term planning is required**

Source: Inage 2009.