



Small Hydro Going Smart – Small hydro pumped storage and its contribution to smart grids

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2011-04-13

Small hydro: definition

Hydropower plants with an installed capacity up to 10 MW



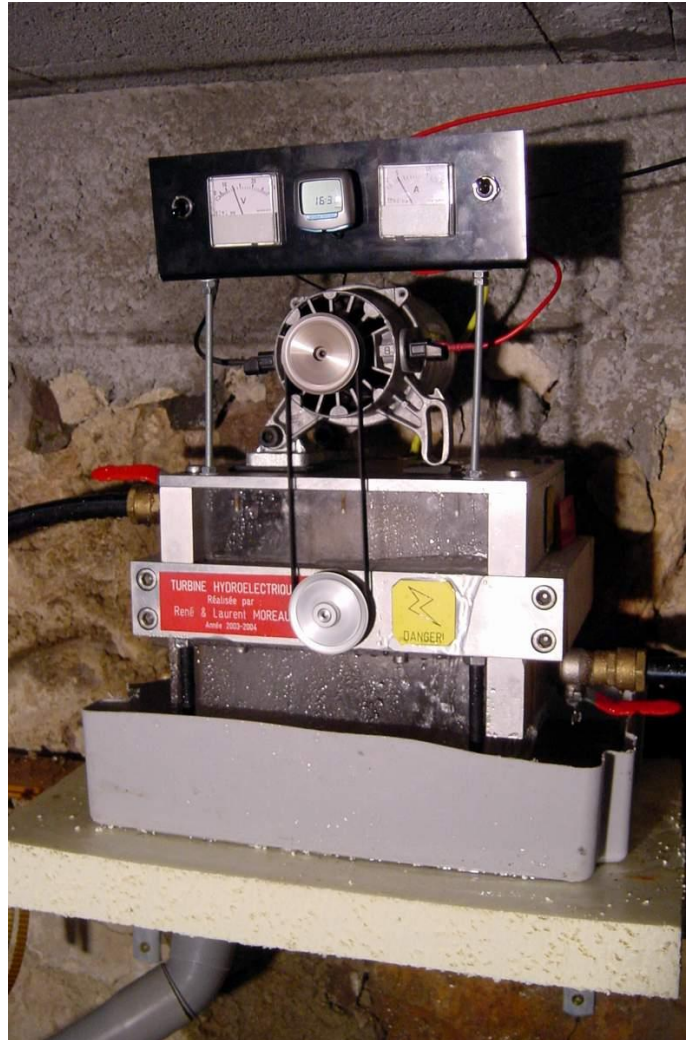
A small hydro plant (6,7 MW)



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Another small hydro plant (600 W)



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What about **Sustainable** hydro?

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Well known hydropower features

High reliability

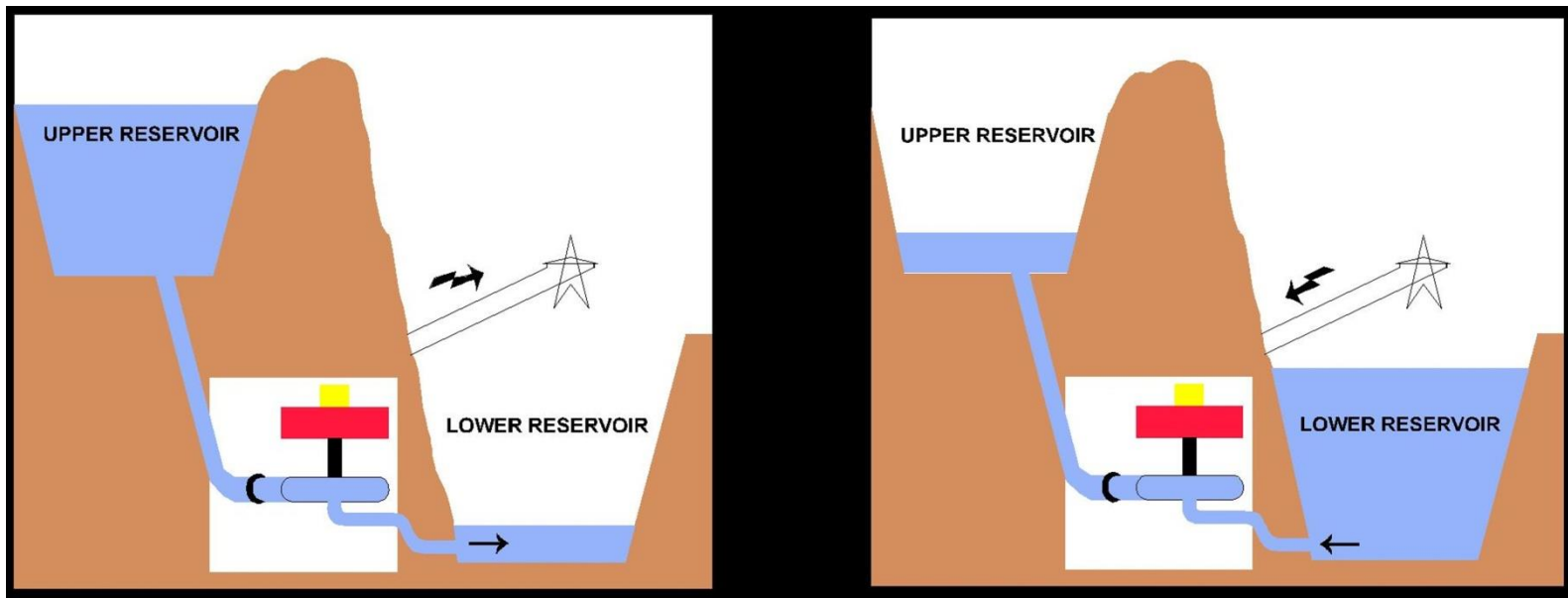
High predictability

Quick response to load changes 



Pumped storage - definition

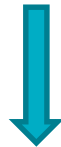
“A pumped storage power station, or power station with contributory pumping is one in which water may be raised to one or several upper reservoirs by means of pumps and stored for later use for the production of electrical energy” (Unipede-Eurelectric definition)



Pumped storage - definition

Pure pumped storage: no significant Natural Cumulative Flows (NCF) into the upper reservoir (NCF permits a utilisation period of the Maximum Electrical Capacity [MEC] in the turbine mode less than 250 hours/year)

Mixed pumped storage: significant NCF permits a utilisation period of MEC in the turbine mode ≥ 250 hrs/yr



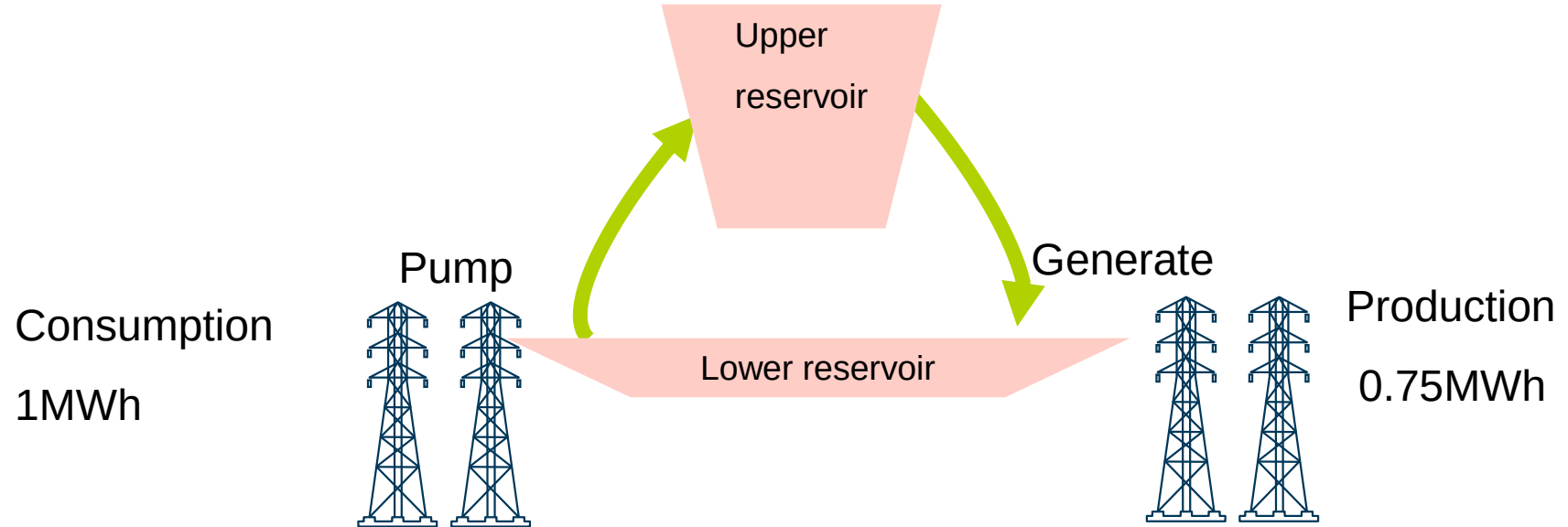
Mixed pumped storage if $Q_{avg} > 3 \% Q(MCE)$



The pumped storage principle

Buy electricity overnight - pump water to top reservoir

Release water to generate at times of peak price



Overall cycle efficiency ~75%

pumped storage plants
are net users of
electrical energy

The pumped storage principle

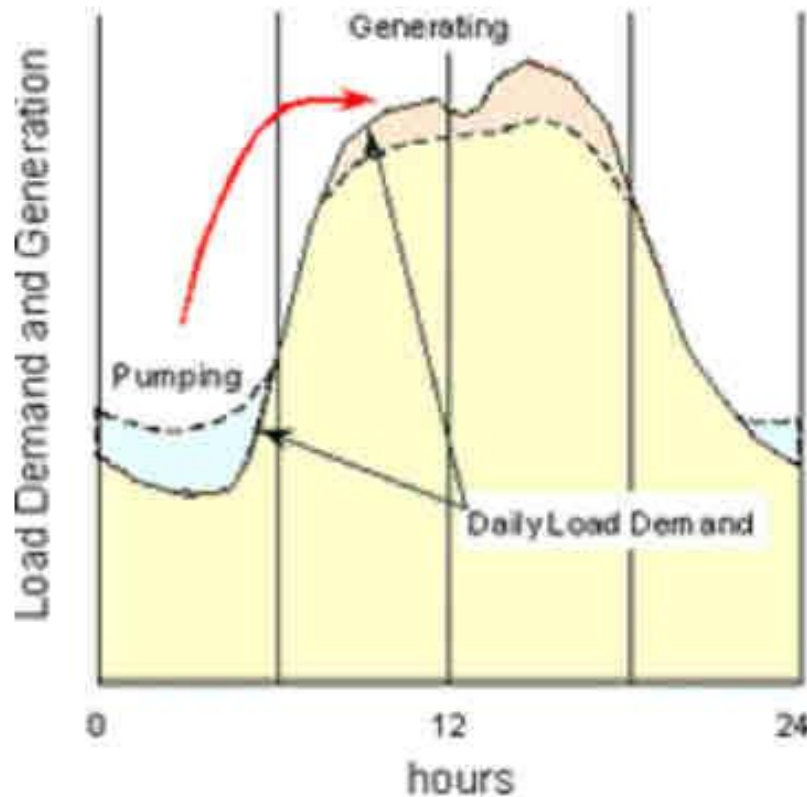
Conclusion:

Pumped storage plants are harmful to the environment because of this energy waste and consequent dump of gaseous emissions

Hasty conclusion



Pumped storage functions (I)



Basic function: **load leveling**

It absorbs the surplus power from the supply grid during the off-peak period to pump water to an upper reservoir.

Then in a peak period, it generates power using the water and thus it levels the load for other generating plants



Pumped storage functions (I)

Conventional hydropower plants can store energy, and release it when the supply grid needs it

Why bother with pumped storage plants?

1. Conventional hydro would usually require considerable water storage and thus larger reservoirs → Environmental issues: use of land, hydropeaking
2. They have no ability to absorb power from the grid like pumped storage → No load leveling

Feature vital to nuclear generation plants (NGPs)

NGPs can only change load very slowly and pumped storage plants can be used to absorb their output at night.

The maintenance costs of certain types of gas-fired power stations (GFPs) increase sharply if they are forced to reduce load at night

GFPs also benefit from storage plant attached to the grid

Oil and coal-fired stations can be operated closer to their optimum efficiency (and thus **reduced gaseous emissions**)



Pumped storage functions (I)

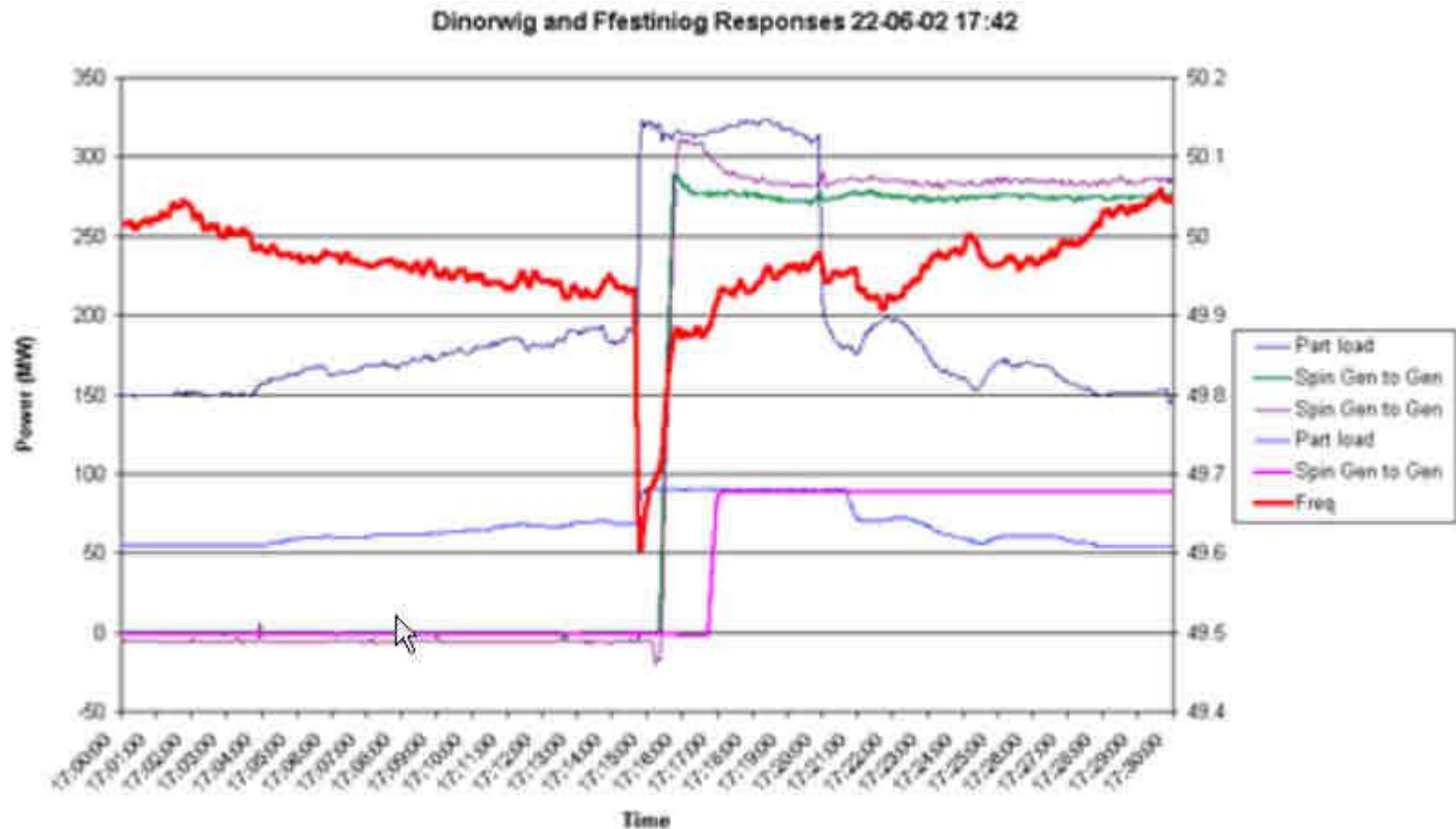
It is no coincidence that some of the larger pumped storage have been built where NGPs largely contribute to energy production

Country	PSPs > 1.000 MW	Total Capacity >1.000 MW	%Nuclear / Total
Japan	9	13.413	24,0%
USA	12	17.166	19,3%
China	17	23.060	2,0%
Ukraine	2	3.762	46,7%
France	1	4280*	77,0%
Italy	3	3.060	0,0%



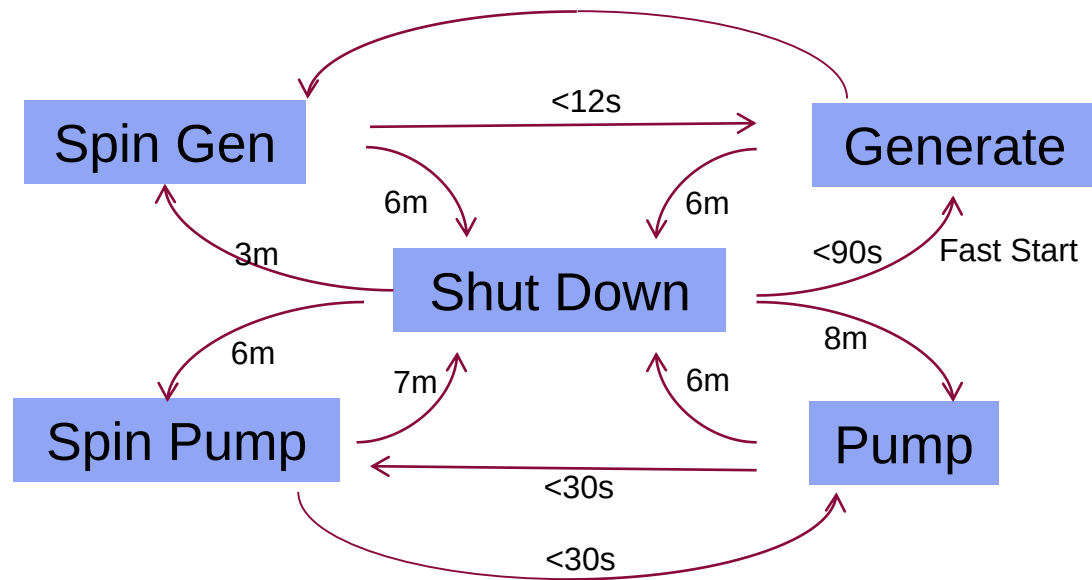
Pumped storage functions (II)

To guarantee and maintain the quality of the electric power



Pumped storage functions (III)

- Speed of response
- In principle hundreds or thousands of mode changes per year
- Extremely high reliability and availability
- Originally designed and built to support grid system management



Pumped storage functions (IV)

Critical back-up facility during periods of excessive demand on the grid

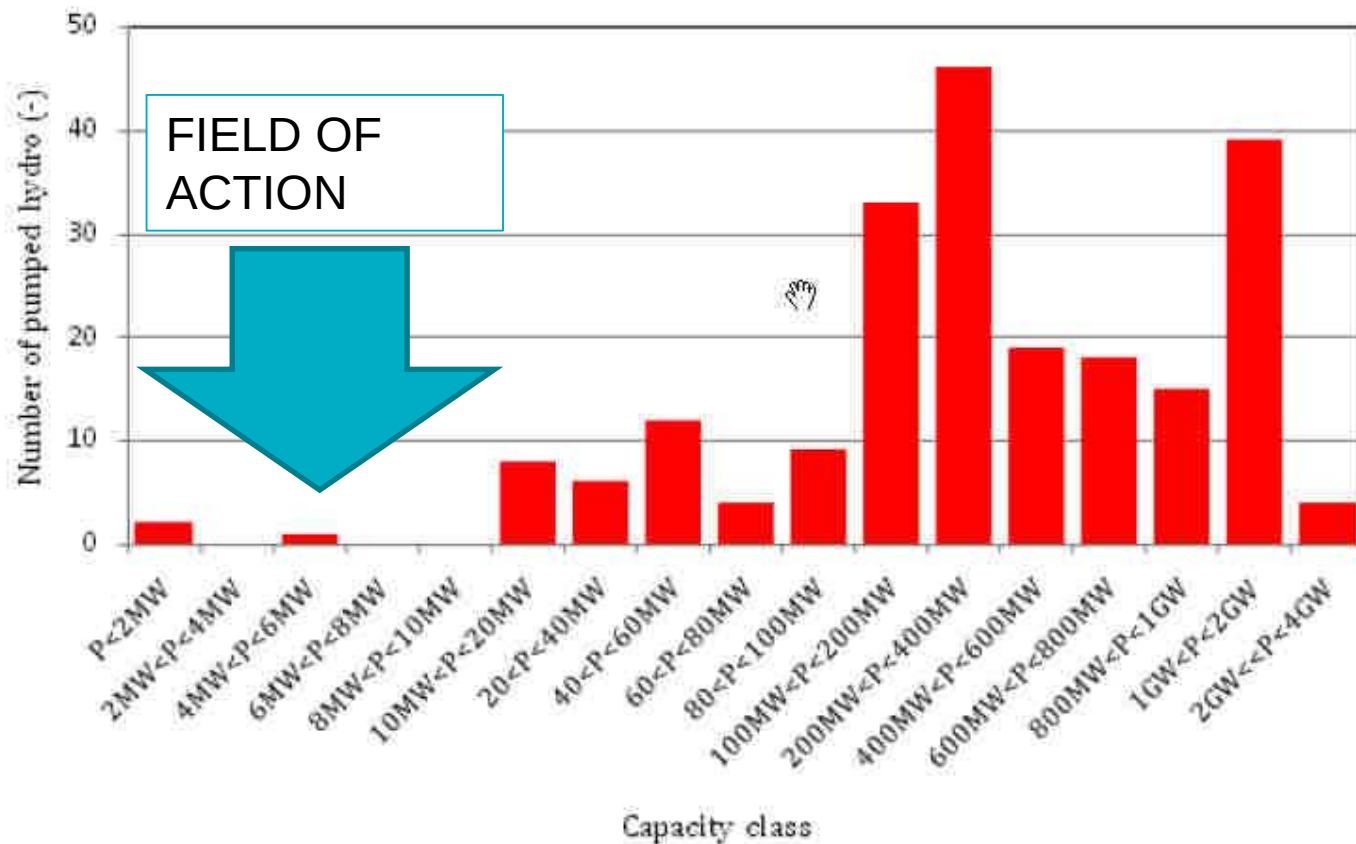
Increasing role played by new, but highly variable renewables

Increasing importance of Pumped Storage as backup facility



Small hydro pumped storage

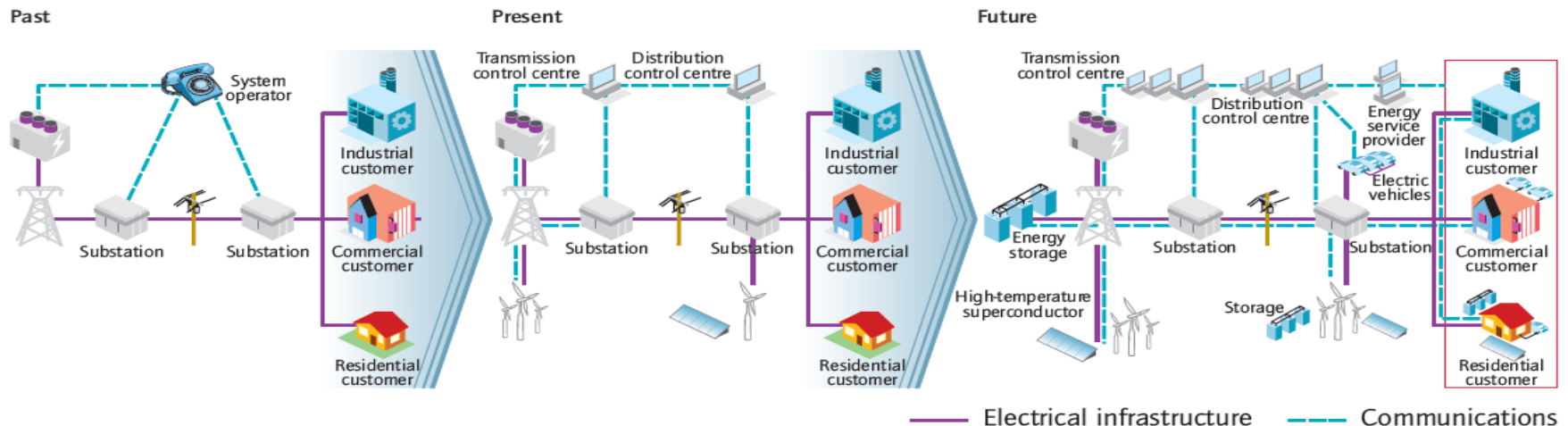
Figure A.2: Relationship between number of pumped hydro systems and capacities



Source: IEA, based on data from Mc COY report 2008, (2008).

Smart grids: IEA definition

“A smart grid is an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users. Smart grids co-ordinate the needs and capabilities of all generators, grid operators, end-users and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimising costs and environmental impacts while maximising system reliability, resilience and stability.”



Smart grids benefits (US DOE)

1. Be able to heal itself
2. Motivate consumers to actively participate in operations of the grid
3. Resist attack
4. Provide higher quality power that will save money wasted from outages
5. Accommodate all generation and storage options
6. Enable electricity markets to flourish
7. Run more efficiently
8. Enable higher penetration of intermittent power generation sources (wind, solar...)

Are smart grids the panacea, the solution to all our problems?

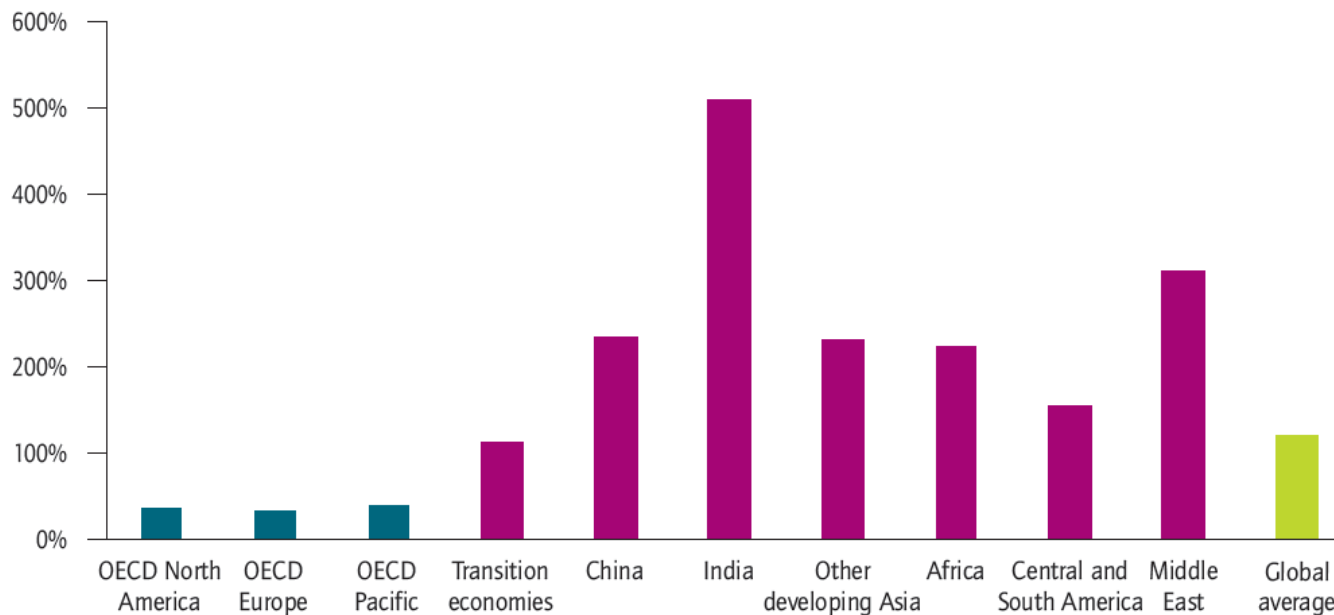


Smart grids benefits (IEA)

Peak demand will increase between 2010 and 2050 in all regions of the world.

Smart grids deployment could reduce projected peak demand increases by 13% to 24% over this frame

Figure 3. Electricity consumption growth 2007-50 (BLUE Map Scenario)

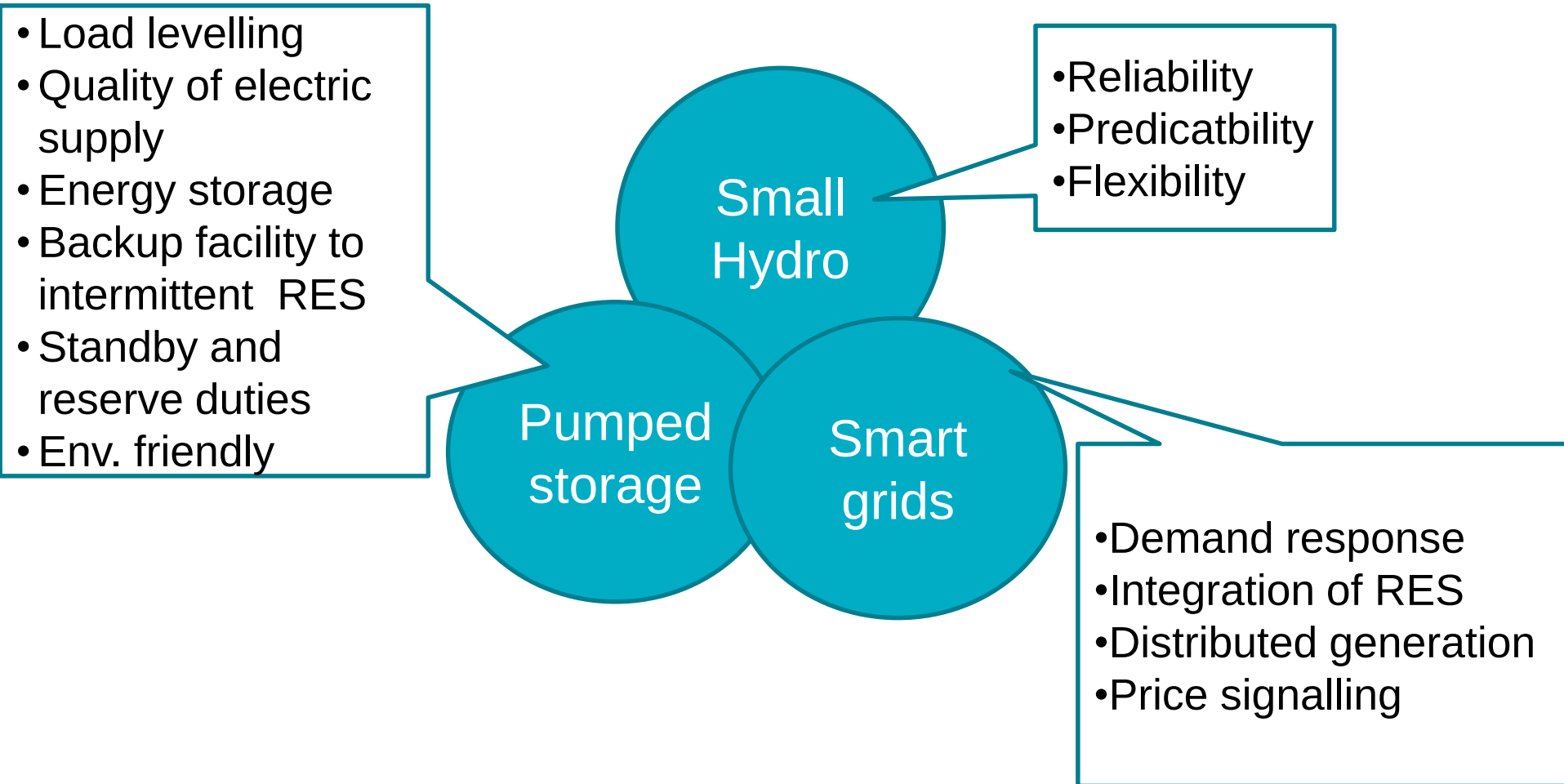


Smart grids benefits

- It is not a substitute for a real grid, but only an enhancement
- It is envisioned to overlay the ordinary electrical grid with an information and net metering system
- It is not equivalent to a distributed generation grid but
- It can be an essential tool for penetration of the distributed generation
- with special reference to the distributed generation based on RES mix



Each of them is highly desirable by itself but their joint implementation is winning



Open issues

- Location of the reservoirs to keep SHPSPs env. friendly 
- Few specific research on small hydro equipment
- Transposition of the experience acquired for large installations to small ones (e.g. *adjustable speed pumped hydro*)?
- Interaction with variable RES and optimization of small distributed generation grids (e.g. load leveling by pumping during period of high availability of intermittent RES and low energy consumption/demand)



Open issues

- Stricter technical requirements for EM equipment than conventional small hydro
- High marginal costs of production expected
- High investment costs for matching the pumping mode (e.g. transients management, air chambers needed, underground installation...)
- The price should reflect the cost of production and should offset the strategic role played by pumped storage



Conclusions

- The future development of small hydro can be highly threatened by the escalation of the ongoing conflict for the use of water
- Hydropower is looking for new opportunities of development and for a new role to play in the energy sector
- Small hydro pumped storage can represent a great opportunity for future development
- There's a lot of room for the future deeper investigation and research as many issues are still open from technical, economical and social point of view

A suitable EU energy policy is needed to support and coordinate the relevant activities



THE END

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Small hydro pumped storage ?

Upper and lower volume of the reservoirs

To have 1,2 MW available for 4 hours you need, under 250 m net head approx. 8.000 m^3 = a cube with a 20 m side....



Where the upper and lower reservoirs can be located?



Tunnels? (e.g.: a 5 m diameter requires a 400 m long tunnel...)



Small hydro pumped storage ?

Upper and lower volume of the reservoirs

If you operate under 1.000 m head the volume needed is 1/4 !



Small hydro pumped storage makes sense under high and very high heads



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