

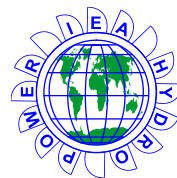


# ROLE OF HYDROPOWER IN RESPONSE TO VARIABLE RENEWABLES: ENERGY STORAGE IN EUROPE & ZOOM IN FRANCE

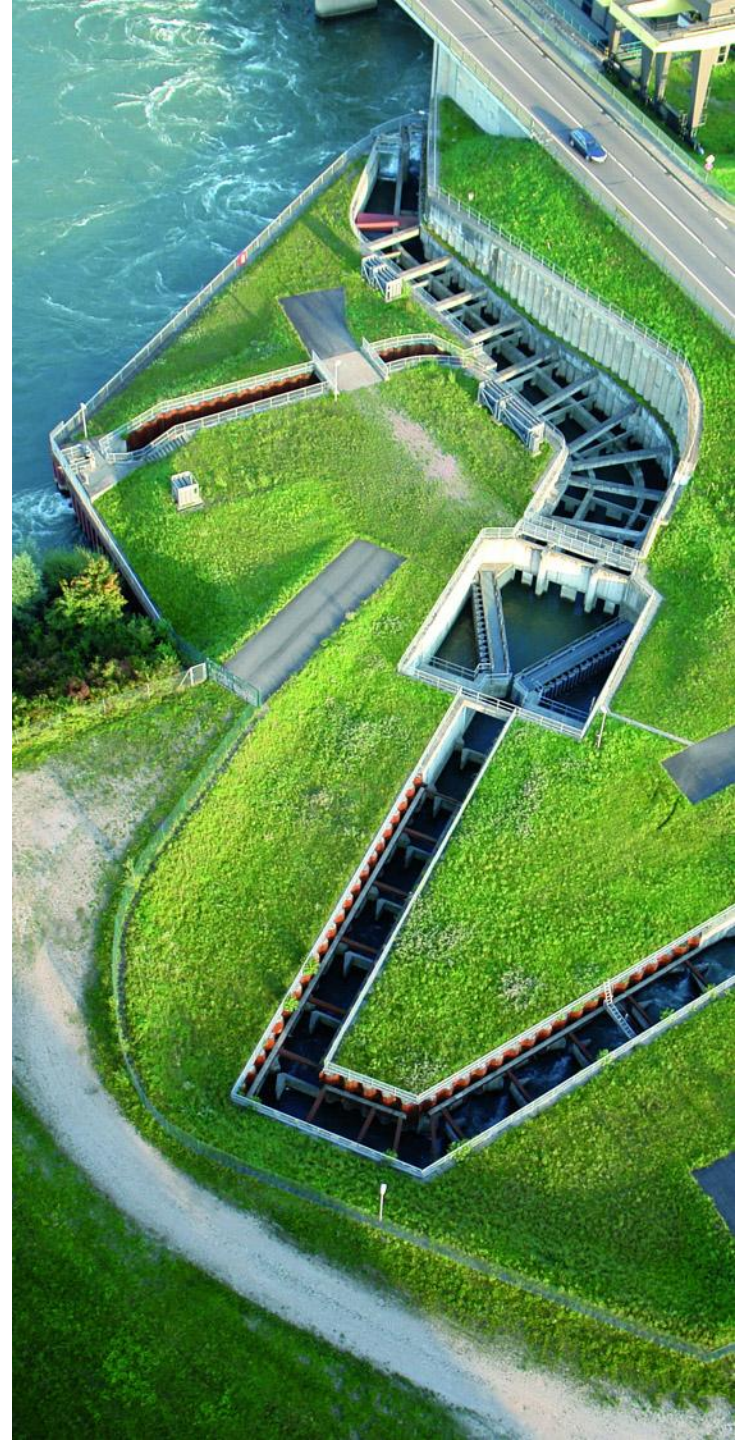
IEA Hydropower Implementing Agreement

*IEA Hydro 28<sup>th</sup> ExCo meeting*

Emmanuel BRANCHE



Tokyo, Japan – 4 February 2013



# ENERGY STORAGE WILL PLAY A KEY ROLE IN ENABLING THE EU TO DEVELOP A LOW-CARBON ELECTRICITY SYSTEM



EUROPEAN COMMISSION  
DIRECTORATE-GENERAL FOR ENERGY

“ Currently, there is limited storage in the EU energy system (**around 5% of total installed capacity**) almost exclusively from **pumped hydro storage**, mainly in mountainous areas (Alps, Pyrenees, Scottish Highlands, Ardennes, Carpathians)”

“ In a low-carbon system, intermittent renewable energy (RES) makes it more difficult to vary output, and rises in demand do not necessarily correspond to rises in RES generation. Higher levels of energy storage are required for grid flexibility and grid stability and to cope with the increasing use of intermittent wind and solar electricity”

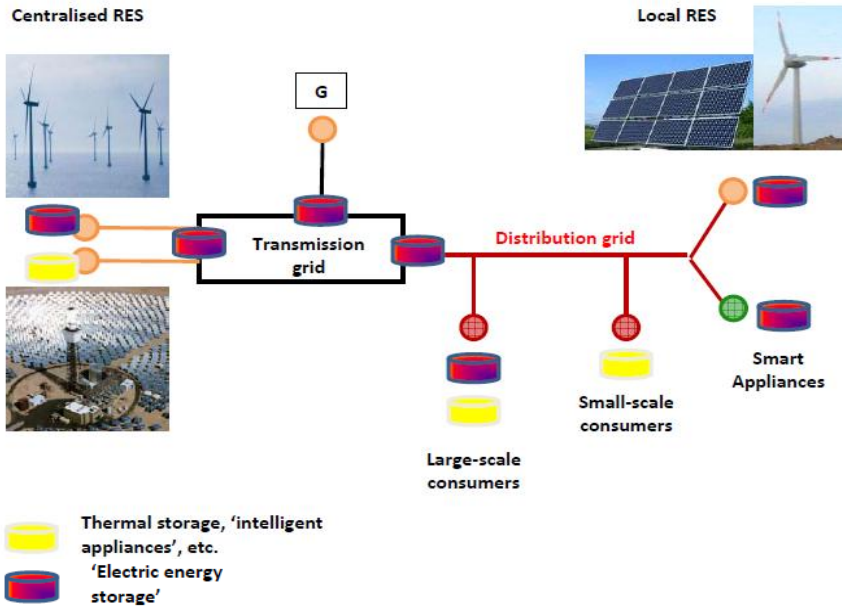
- **Fossil fuel based power plants (mainly CCGT) provide reliable & flexible back-up plants ...**
  - *Gas storage is closely linked to electricity storage.*
  
- **... Electricity storage needs to fill the gap between the ramping down time of wind and solar and the ramping up time of these back-up plants**
  - ***Pumped Hydro Storage Power Plant*** for large scale electricity storage represents almost 99 % of current worldwide storage capacity. *Pumped Hydro was attractive, and essential, when Europe's networks were mainly composed of a large number of regional grids with very weak interconnections.*

Source: EC /DG-ENER, 2013

# ENERGY STORAGE IS ESSENTIAL TO BALANCE SUPPLY AND DEMAND

Storage serves several purposes in today's power system ...

... in a future low-carbon energy system, storage will be needed at all points of the electricity system

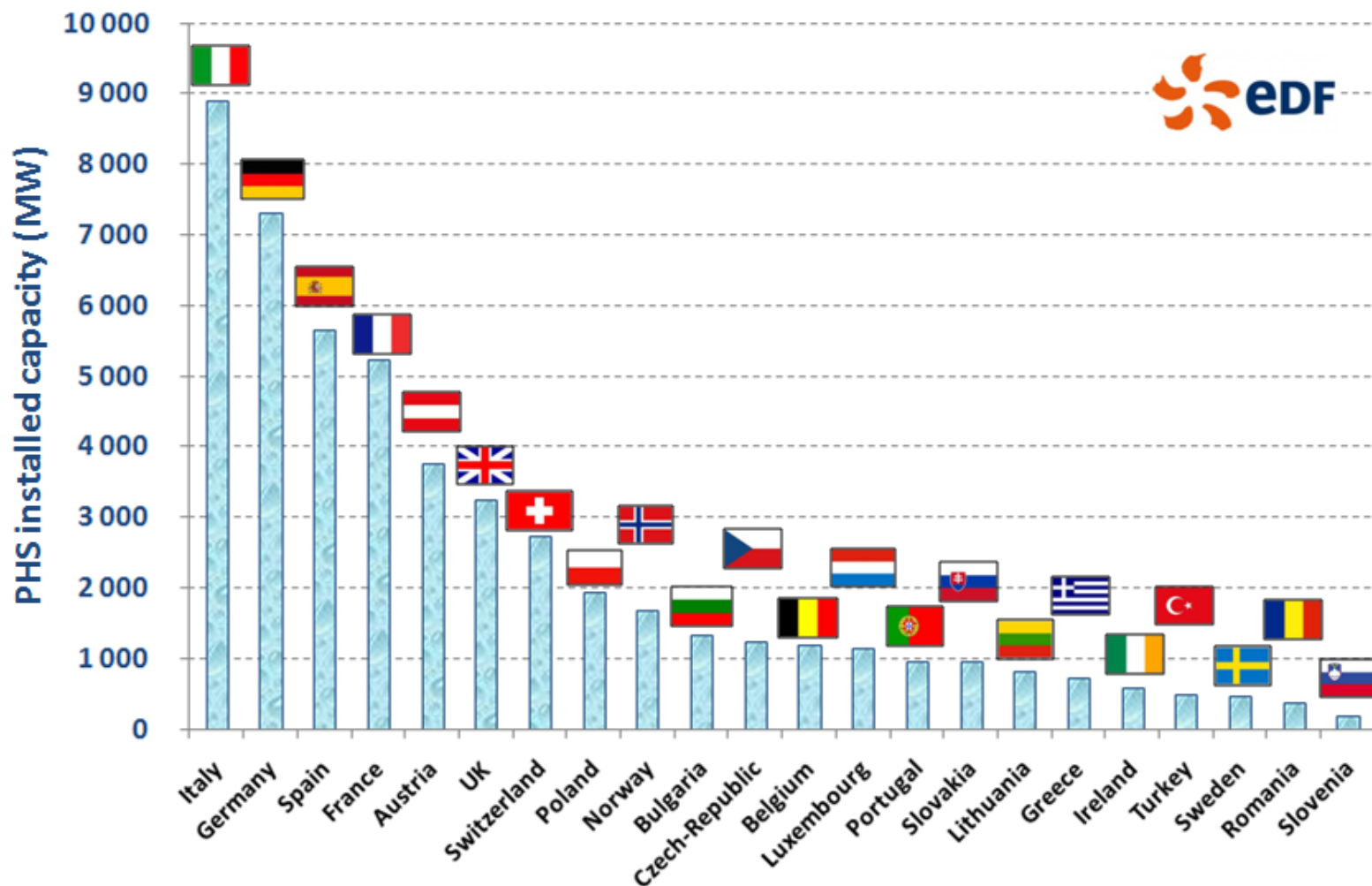


Source: EC /DG-ENER, 2013

Application in power system	Transmission grid-central storage	Distribution grid storage	End-user Storage
<b>Functionalities of storage</b>	(national and European level)	(city level)	(household level)
<b>Balancing demand and supply</b>	Seasonal / weekly fluctuations  Large geographical unbalances  Strong variability of wind and solar  (electricity and gas storage need to be integrated)	Daily / hourly variations  Peak shaving  (electricity and heat/cold storage need to be integrated)	Daily variations  (electricity and heat/cold storage need to be integrated)
<b>Grid management</b>	Voltage and frequency regulation  Complement to classic power plants for peak generation  Participate in balancing markets  Cross-border trading	Voltage and frequency regulation  Substitute existing ancillary services (at lower CO2)  Participate in balancing markets	Aggregation of small storage systems providing grid services
<b>Energy Efficiency</b>	Better efficiency of the global mix, with time-shift of off-peak into peak energy	Demand side management  Interactions grid-end user	Local production and consumption  Behaviour change  Increase value of PV and local wind  Efficient buildings  Integration with district heating /cooling and CHP

# 51 GW OF PSP WERE IN OPERATION IN 2011 IN EUROPE

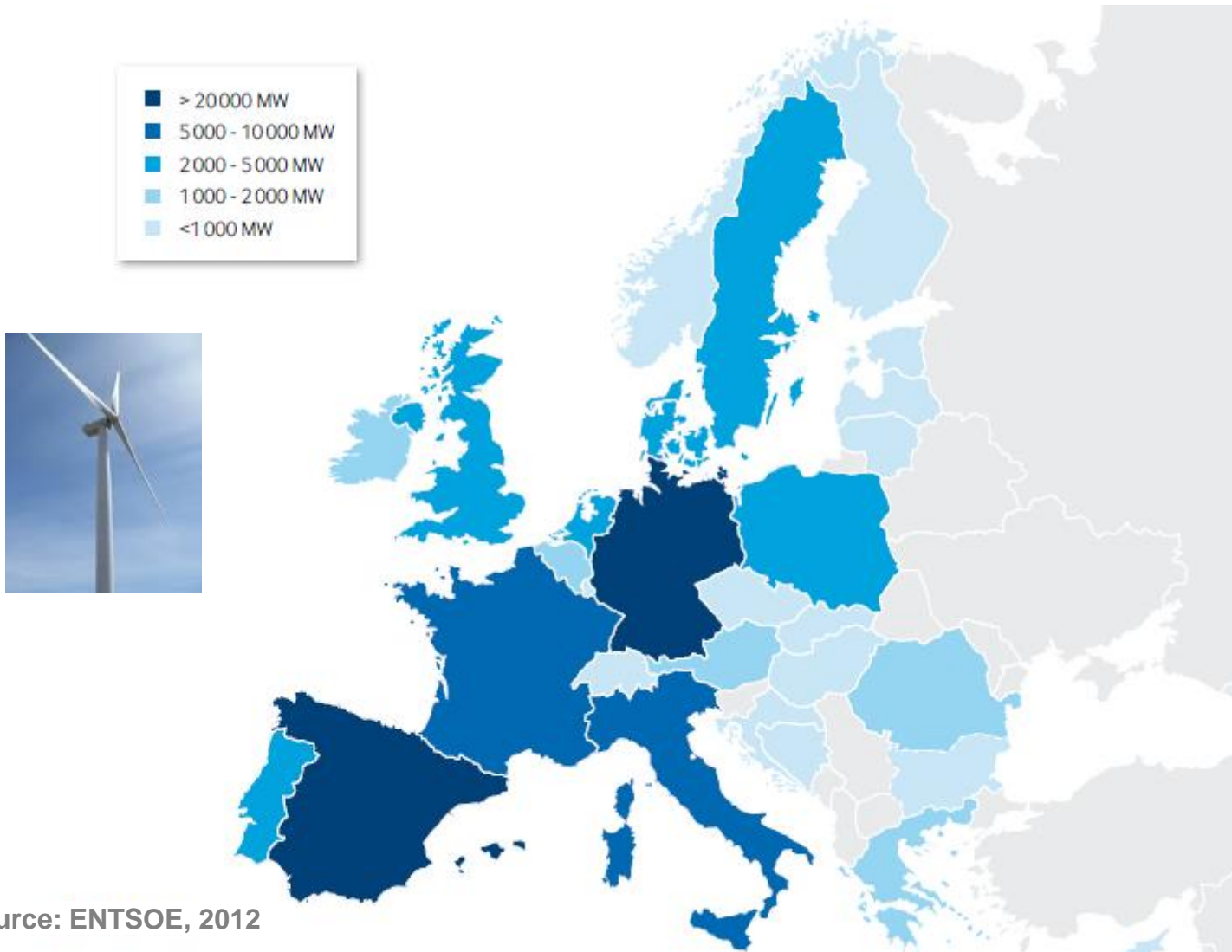
Installed capacity of pumped hydro storage power plants in EU-27 , Norway, Switzerland and Turkey - end 2010 (source HEA, 2012) ; EDF analysis



Source: HEA, 2012 ; EDF analysis 2013

# WIND CAPACITY HAS INCREASED A LOT IN EUROPE ...

Wind power (installed capacity in MW) - status January, 1<sup>st</sup> 2012



Source: ENTSOE, 2012

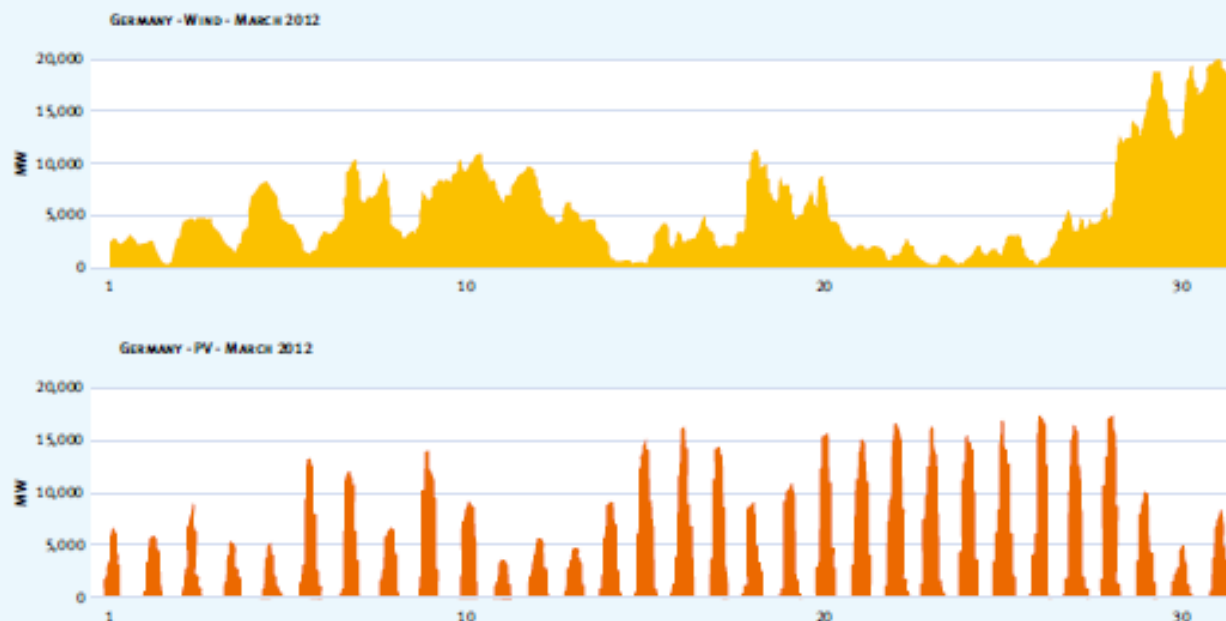
# ... GENERATION FROM THOSE RENEWABLE ARE HIGHLY VARIABLE ...

TABLE 2: VARIABLE RES INDICATORS IN GERMANY (YEAR-END 2011)

	WIND <sup>5</sup>	PHOTOVOLTAIC <sup>7</sup>	WIND + PV <sup>7</sup>
Total installed capacity	29,075 MW	24,990 MW	54,065 MW
Maximum generation <sup>4</sup>	22,795 MW (78%)	13,939 MW (56%)	26,479 MW (49%)
Minimum generation <sup>6</sup>	266 MW (0.9%)	0 MW (0%)	402 MW (0.7%)
Average generation <sup>8,7</sup>	5,145 MW (18%)	4,390 MW (18%)	7,374 MW (14%)
Maximum increase within 1 hour	4,348 MW	3,319 MW	4,348 MW
Maximum increase within 5 hours	7,744 MW	12,228 MW	13,907 MW
Maximum decrease within 1 hour	-4,723 MW	-3,299 MW	-4,723 MW
Maximum decrease within 5 hours	-8,507 MW	-11,863 MW	-14,966 MW

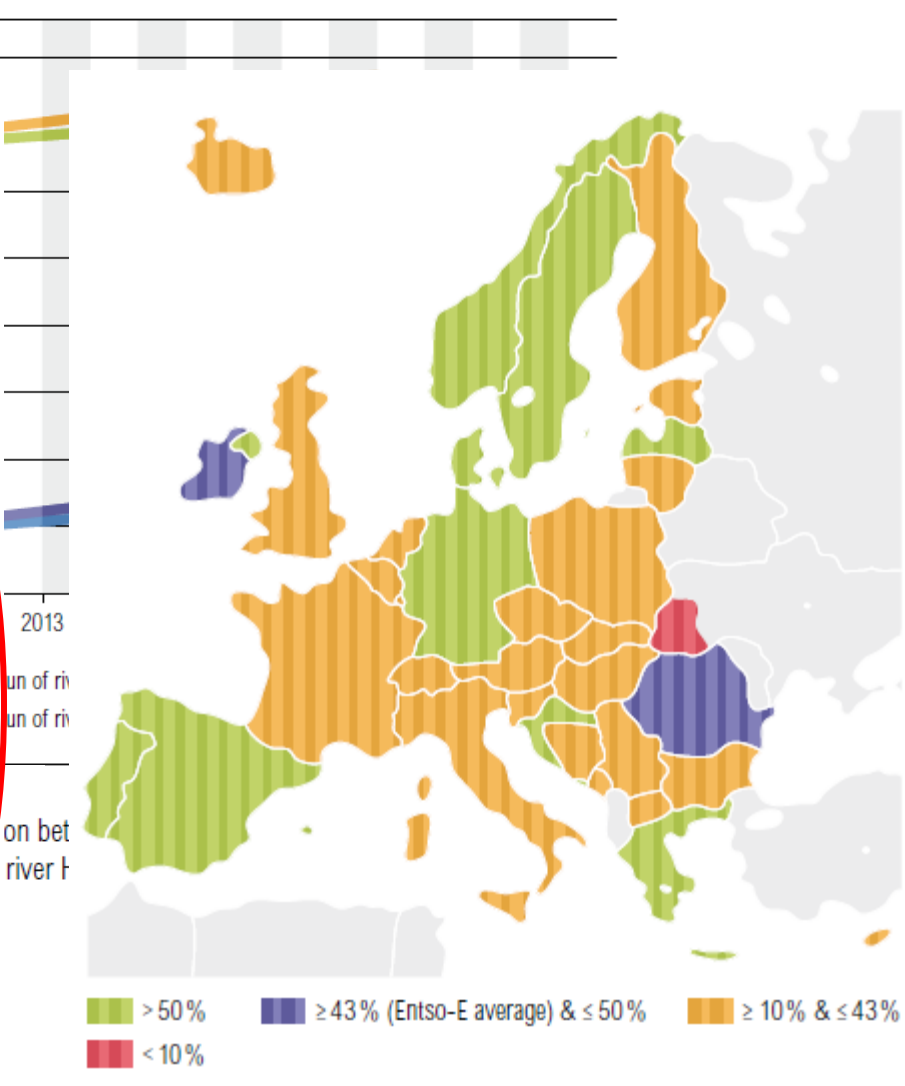
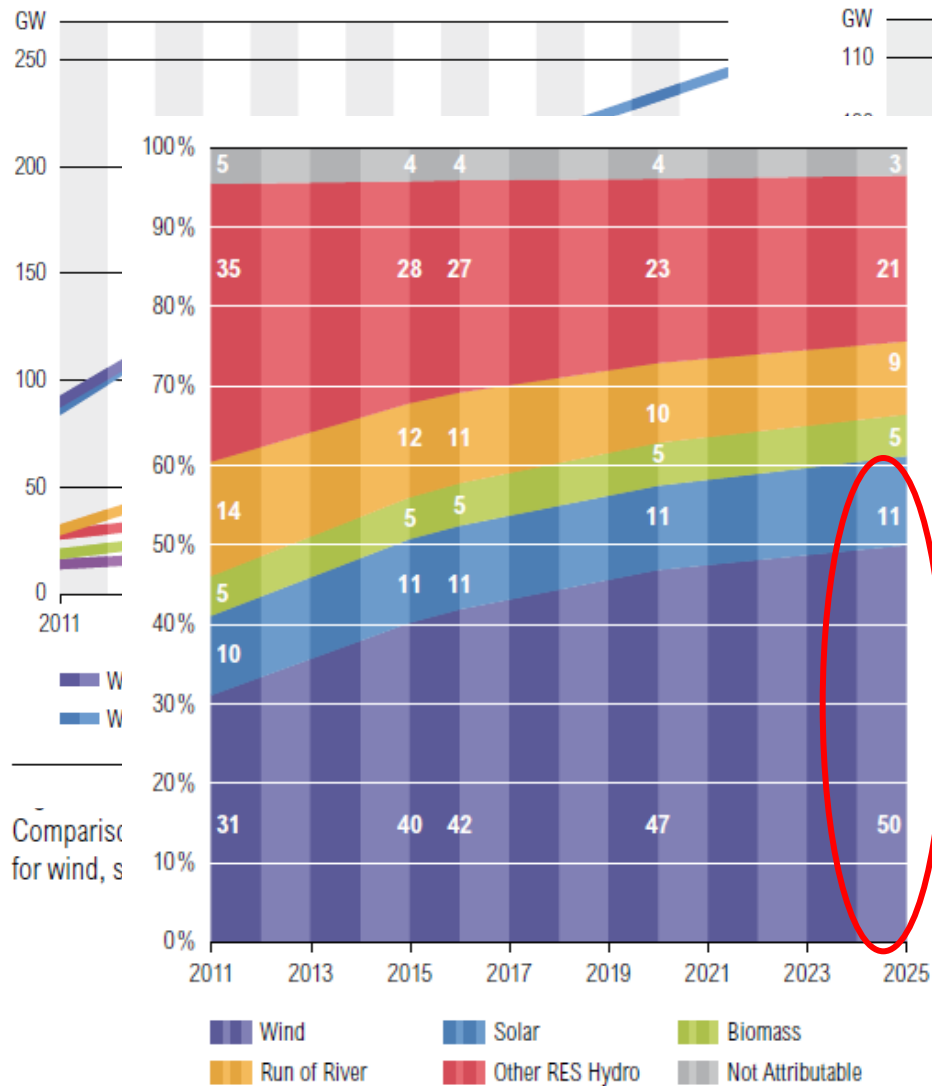
Source: BDEW

FIGURE 9: WIND AND PV PATTERNS IN GERMANY, MARCH 2012



Source: <http://www.theoil Drum.com/node/9205>, retrieved 5 October 2012

# ... AND FUTURE DEPLOYMENT PROJECTIONS WILL INCREASE THIS PHENOMENON ...



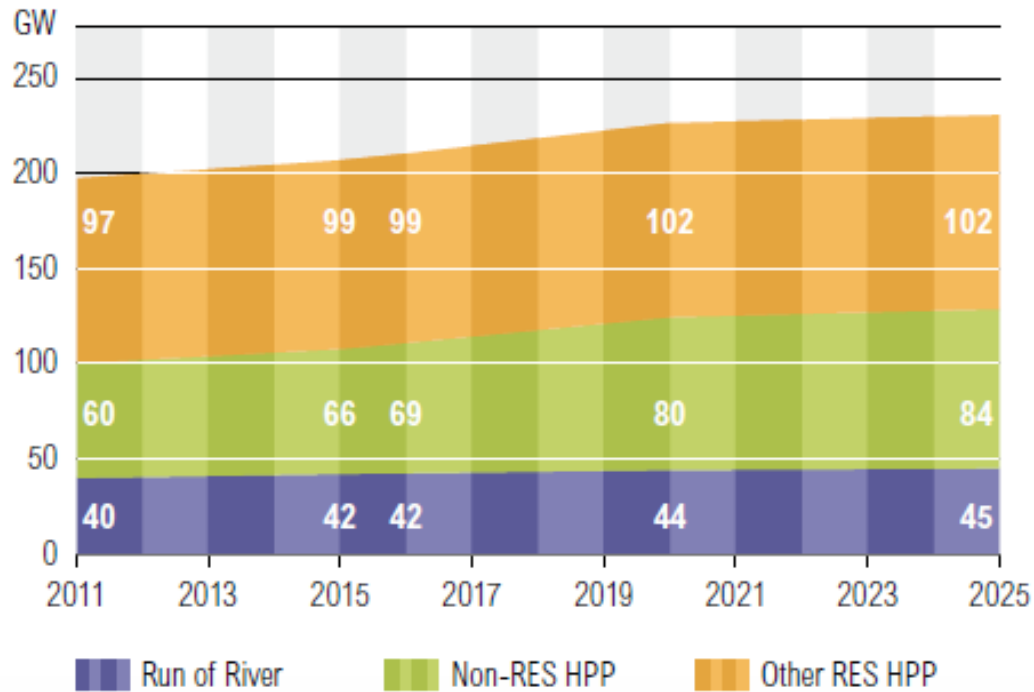
Source: ENTSOE, 2012



ENTSO-E total RES generating capacity mix, January 7 p.m.: Scenario B

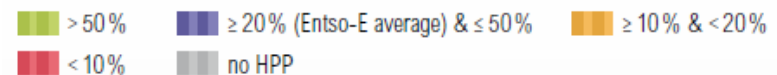
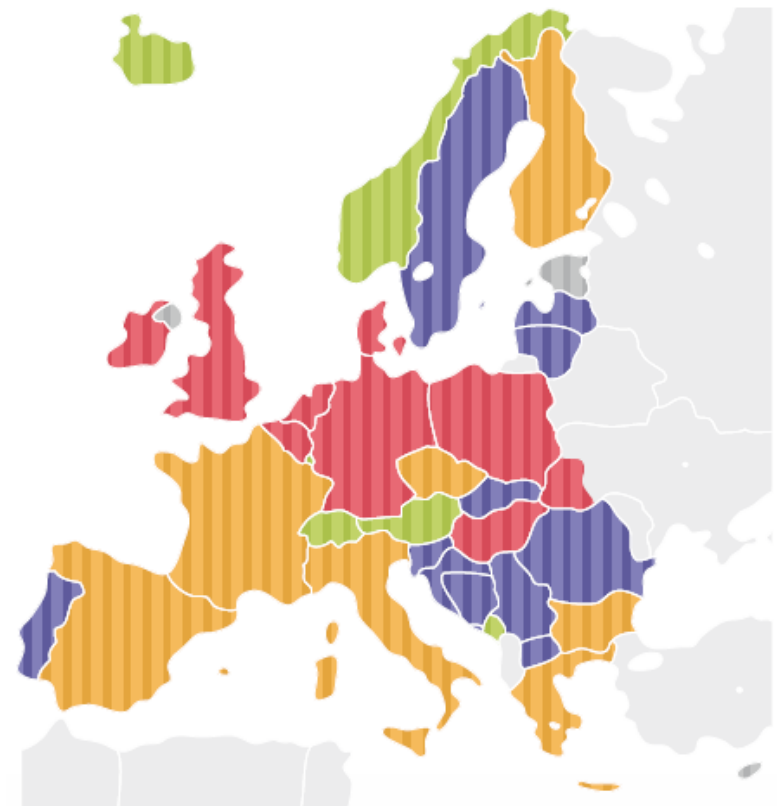
Share of total RES in net generating capacity per country in 2020, Scenario EU 2020

# ... HOWEVER HYDROPOWER GENERATION IS ALSO EXPECTED TO INCREASE, BUT AT A LOWER RATE



ENTSO-E HPP installed capacity mix, Scenario B, January 7 p.m.

Source: ENTSOE, 2012



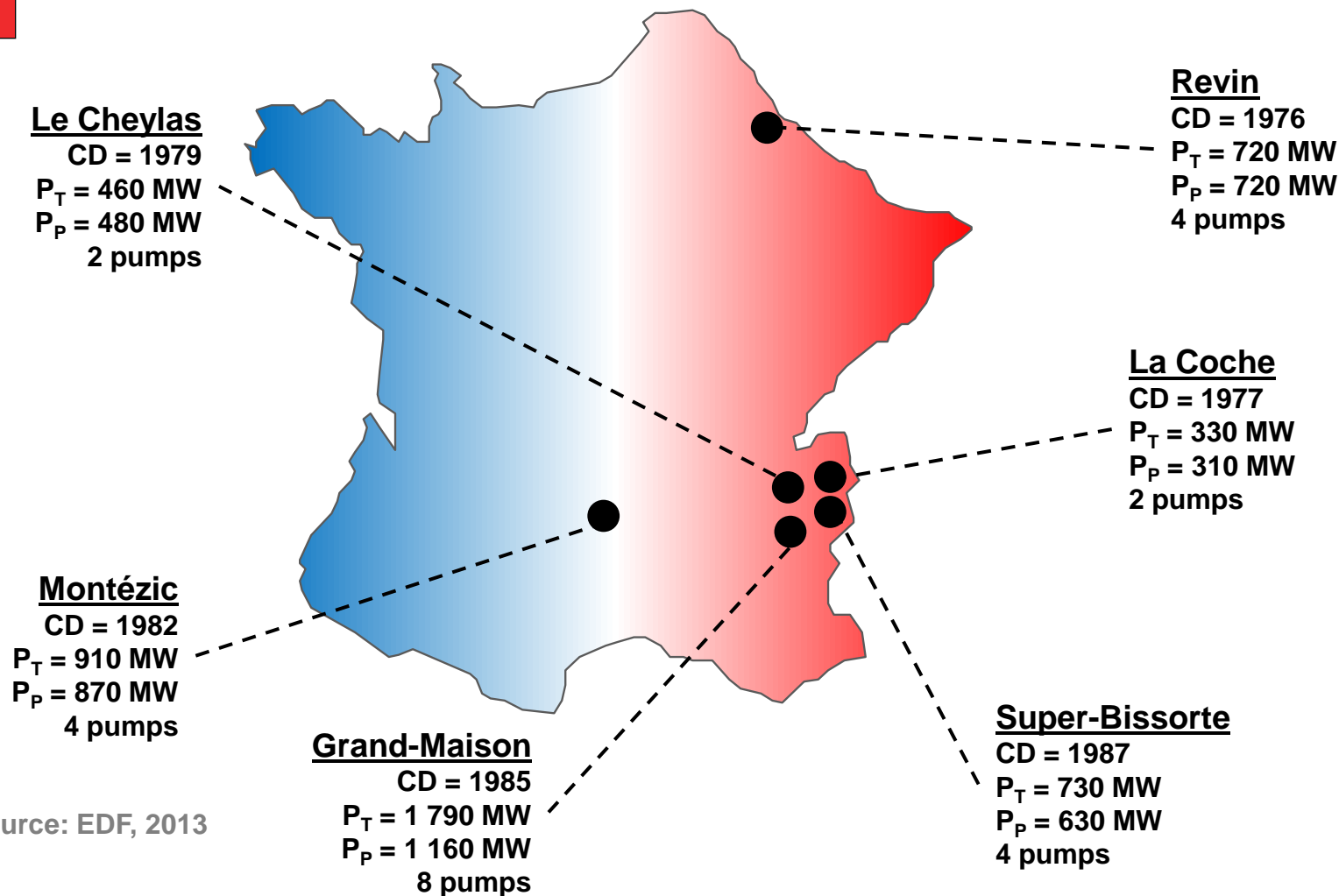
Share of total HPP in net generating capacity per country in 2020, Scenario EU 2020



# PSPP PLAY AN IMPORTANT ROLE FOR THE GENERATION MIX IN FRANCE



## Location and characteristics of the 6 main EDF's pumped-storage hydro power plants in operation in France

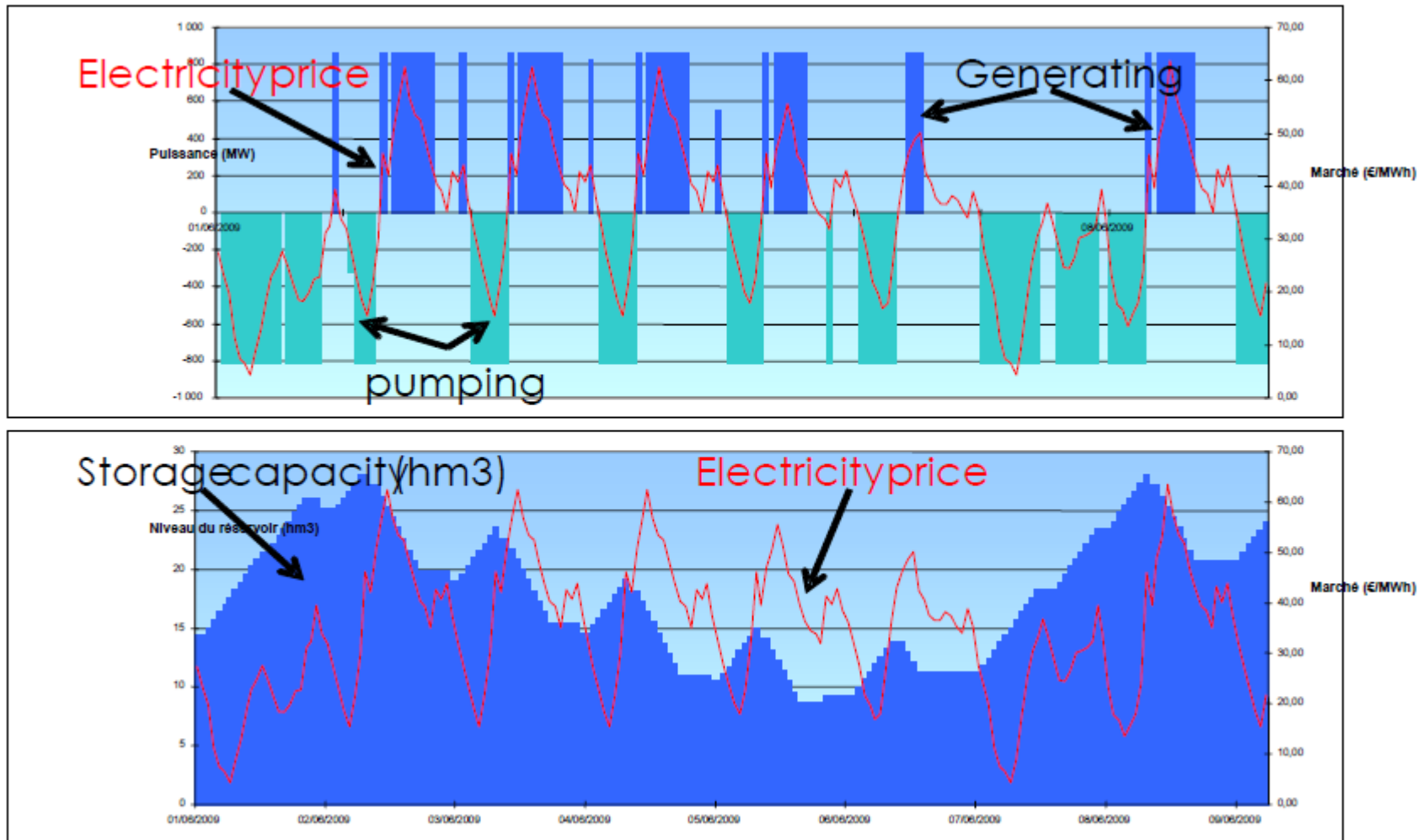


Source: EDF, 2013

# ACCORDING TO THE RESERVOIR CAPACITY, THEY ARE OPERATED ON A DAILY OR WEEKLY CYCLE



## Typical operation of a weekly pumped-storage hydro power plant

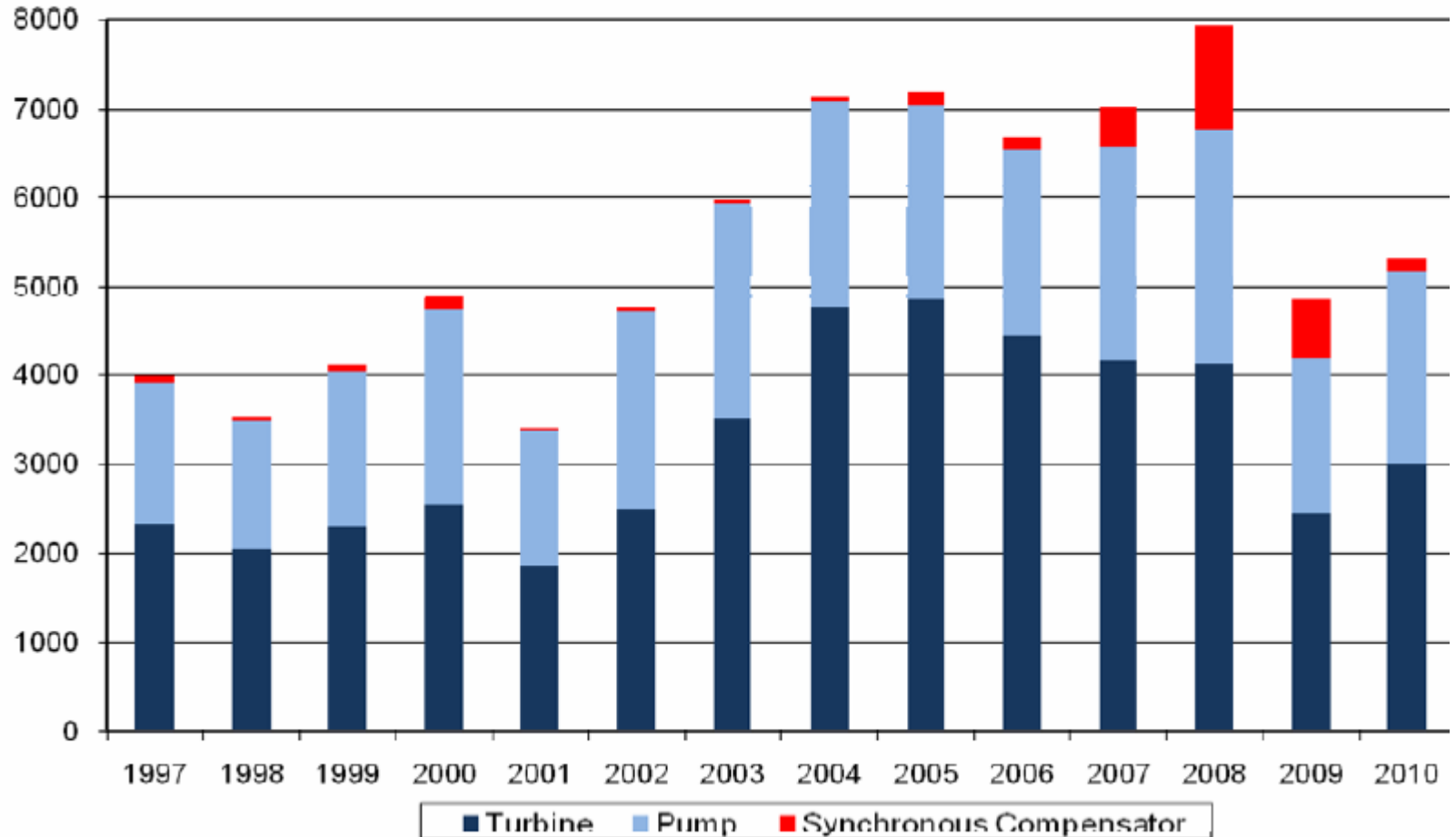


Source: EDF, 2011

# THIS DYNAMIC BEHAVIOR OF EXISTING STORAGE WILL INCREASINGLY MOVE IN THE DIRECTION OF QUICK AND POWERFUL RESPONSE TO THE NEEDS OF THE GRID

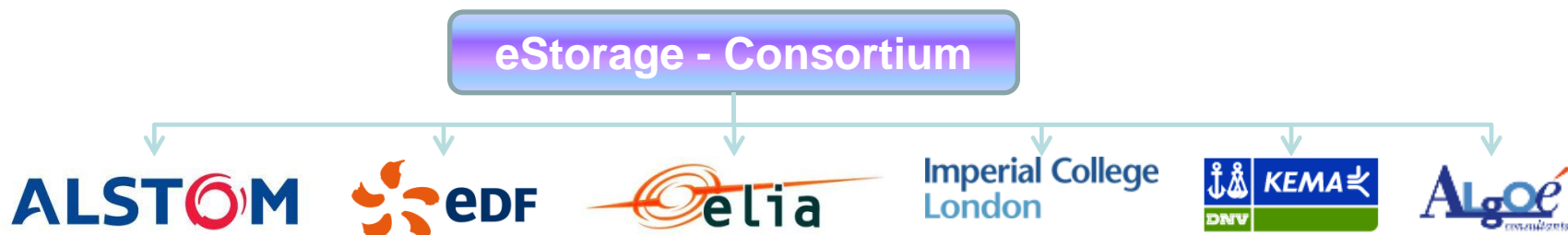


*Revin : number of startings*



Source: EDF, 2011

# EXAMPLE: ESTORAGE PROJECT



- eStorage, which represents electric power value chain from Europe, will utilize the fund to develop solutions for the deployment of GWh-scale energy storage and to enhance grid management systems.

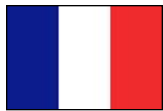
- The eStorage project is expected to **upgrade EDF's Le Cheylas fixed-speed pumped hydro storage power plant** (PSP) in France to **a variable-speed PSP**. Following the completion, Le Cheylas plant will provide 70MW of additional night-time regulation capacity, allowing the integration of several hundred megawatts of intermittent renewable generation.

- eStorage will also demonstrate and develop solutions for connecting the dispatch of storage plants with renewable generation, using advanced energy management systems.

- The project is expected to demonstrate a balancing market platform, corroborating IT systems that manage new types of flexible products such as PSP. A significant proportion of European PSP could be upgraded to include variable speed and thus **provide up to 10 GW of additional control**, with no impact on the environment and a much lower cost than the development of new power plants.

- The European Commission has awarded **a €13.3m grant** to eStorage in December 2012

# IN FRANCE THE ELECTRICITY RENEWABLE ENERGY ARE PLANNED TO INCREASE



Evolution of the electricity mix in France (GW and TWh) according to RTE for the long term projection scenarios – focus on renewables

Source RTE, 2012 - EDF analysis

Installed capacity (GW) Source: RTE, 2012	1 <sup>st</sup> January 2012	2030			
		Median	High demand	New mix	Low demand
Wind (on-shore)	6,7	24,5	24,5	28,0	18,5
Wind (off-shore)	0,0	5,5	5,5	12,0	1,5
PV	2,4	20,0	20,0	30,0	12,0
Ocean energy	0,0	1,5	1,5	3,0	0,0
Hydropower	25,2	25,2	25,2	28,2	25,2
including PSP	4,3	4,3	4,3	6,3	4,3

Energy generation (TWh) Source: RTE, 2012	2011	2030			
		Median	High demand	New mix	Low demand
Wind	12,1	58,2	58,2	77,5	38,8
PV	2,4	22,0	22,0	32,9	13,2
Ocean energy	0,0	4,3	4,3	8,6	0,0
Hydropower	50,0	69,4	69,4	73,9	69,4
<i>Share of renewables</i>	13,0%	26,7%	29,2%	40,2%	26,6%

“Some hydroelectric facilities can play an important role in electricity storage, very useful in situations of major intermittent productions through systems called Pumped hydro Storage Power plant”

EDF key  
figures in  
hydropower



- EDF is one of the **world largest hydropower operator**
  - ~**25,000 MW** in Europe (1<sup>st</sup> European utility) and 1,080 MW in Lao PDR
  - In France **447 power plants** (1,200 units) from 100 kW to 1,800 MW built between 1886 and 1996 fully automated or remote controlled
- CIH (Hydroelectric Engineering Centre): **integrated engineering** ensuring safe design and operation of dams
  - **900 employees** at the end of 2012
  - **438 M€** of **CAPEX** in 2011
  - Present in more **30 countries worldwide** in more than 50 contracts

# THANK YOU FOR YOUR ATTENTION!



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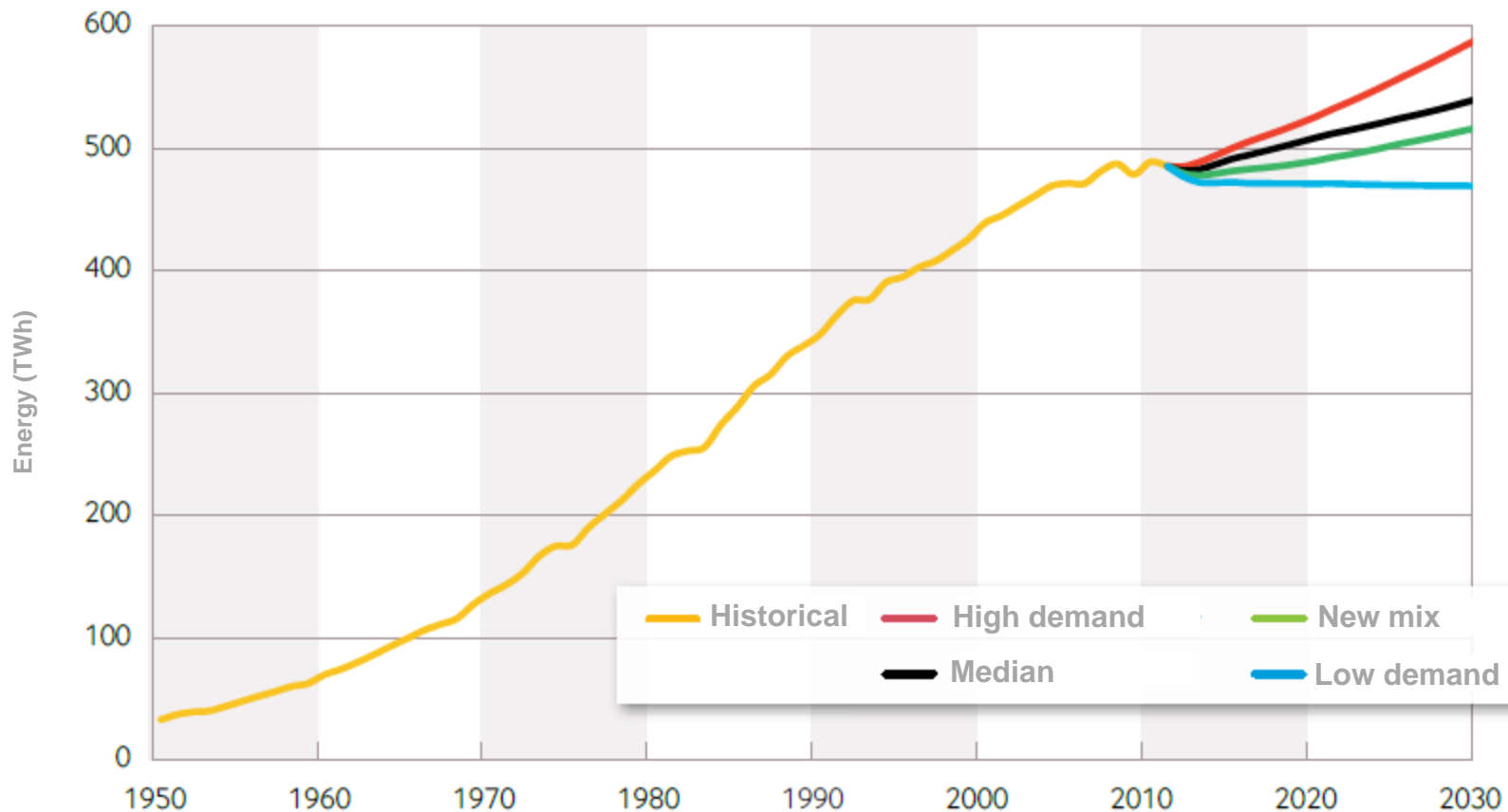
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# Back-up



## Gross electricity consumption in France (TWh) Historical data and long term projection scenarios



Source: RTE, 2012