

An aerial photograph of a large, curved concrete dam situated in a deep, rocky canyon. The water behind the dam is a vibrant blue. In the foreground, a white stick figure stands in the water with its arms raised. The surrounding cliffs are covered in green vegetation.

Hydro Power and Pumped Storage Hydroelectricity

CEDREN Conference
11th Septembre 2012

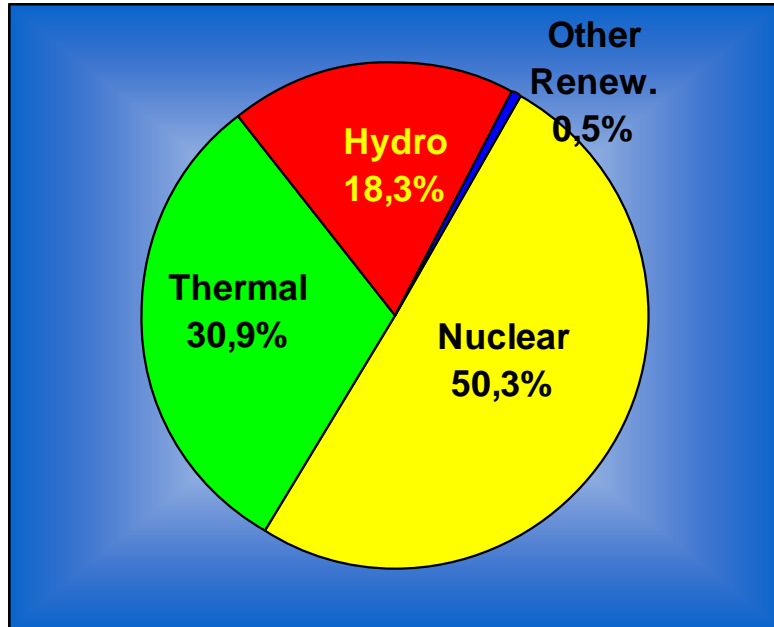


LEADING THE ENERGY CHANGE

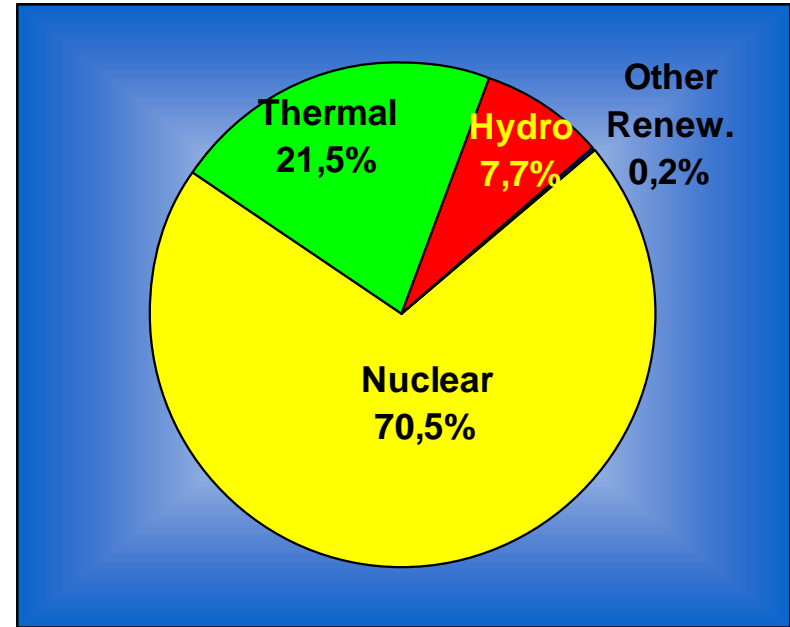
Part 1

Presentation of EDF Generation and storage capacity

EDF's Generation Capacity Worldwide (2011)



Installed Capacity: 126.7 GW



Annual Generation: 630.4 TWh

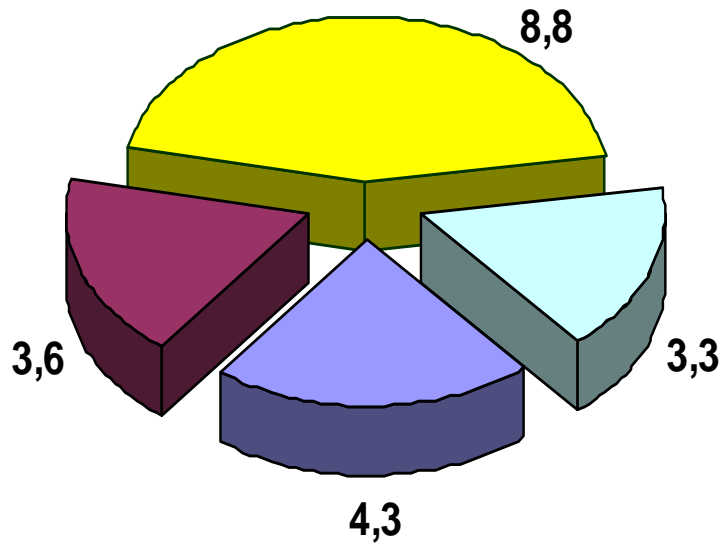
EDF WORLD HYDRO INSTALLED CAPACITY: 23 200 MW

SUSTAINABLE DEVELOPMENT: EDF has a low CO2 emission profile

- EDF (France) : 42.5 g/kWh
 - EDF Group in Europe : 108.9 g/kWh
- ⇒ **3 times lower than European energy sector average**

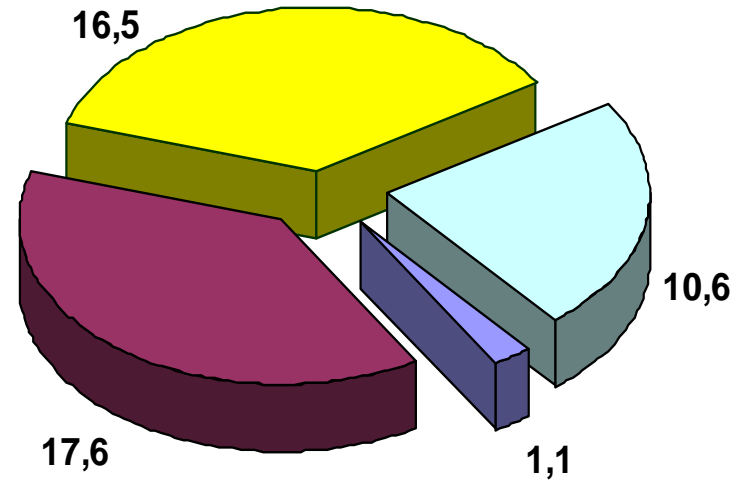
EDF Hydro Generation In France in Figures

Installed Capacity 20 GW



(\approx 20 % of EDF mix in France)

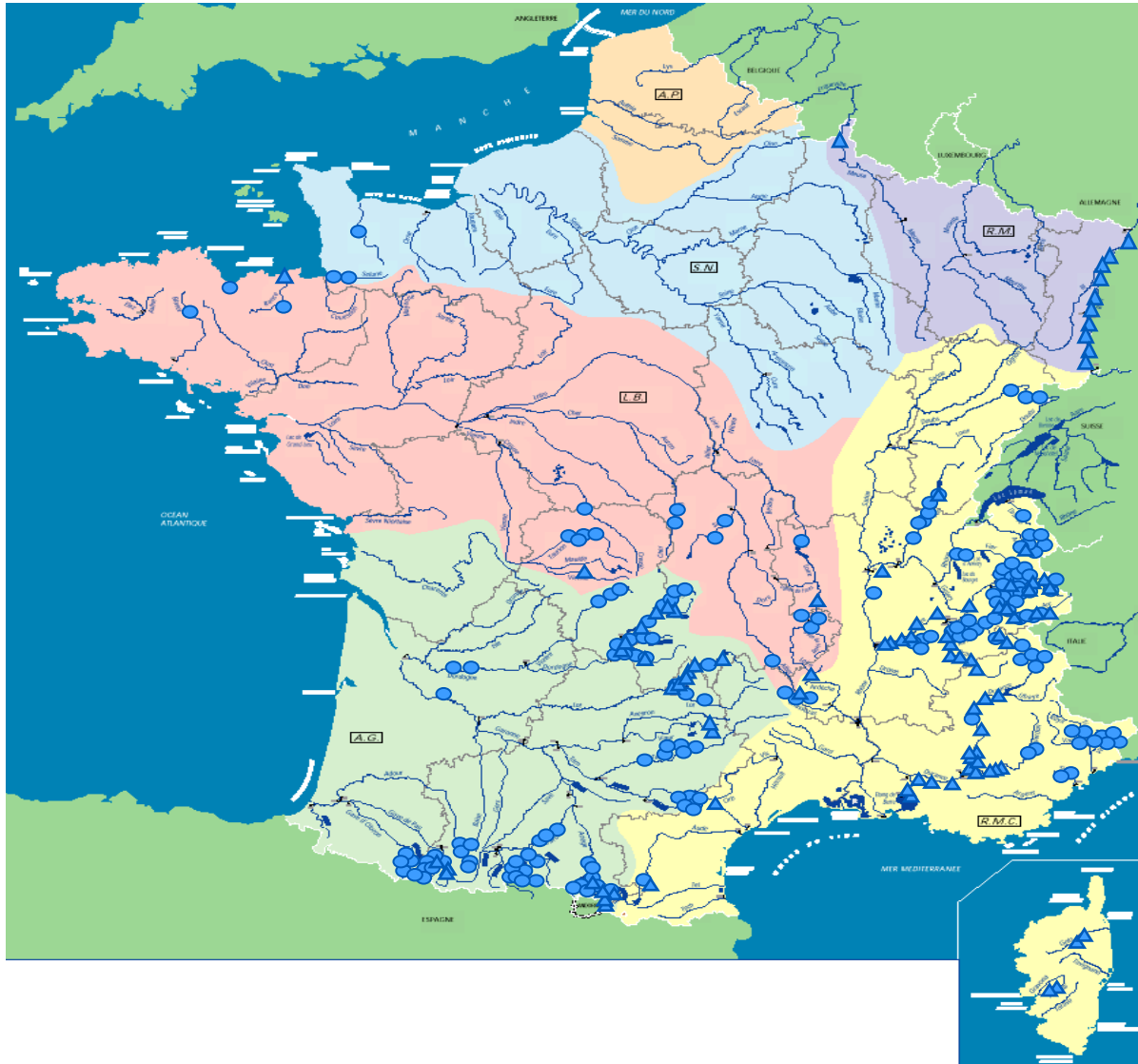
Generation 39 TWh



(\approx 10 % of EDF in 2010)

- Pumped storage
- Run of river
- Reservoir
- Daily Storage

Overview of EDF Hydro Fleet in France



Total installed capacity: 20 GW

Average generation : 46 TWh/y

⇒ 439 Hydro Power Plants

- from 100 kW to 1800 MW
- automated or remote controlled
- built between 1896 and 1996

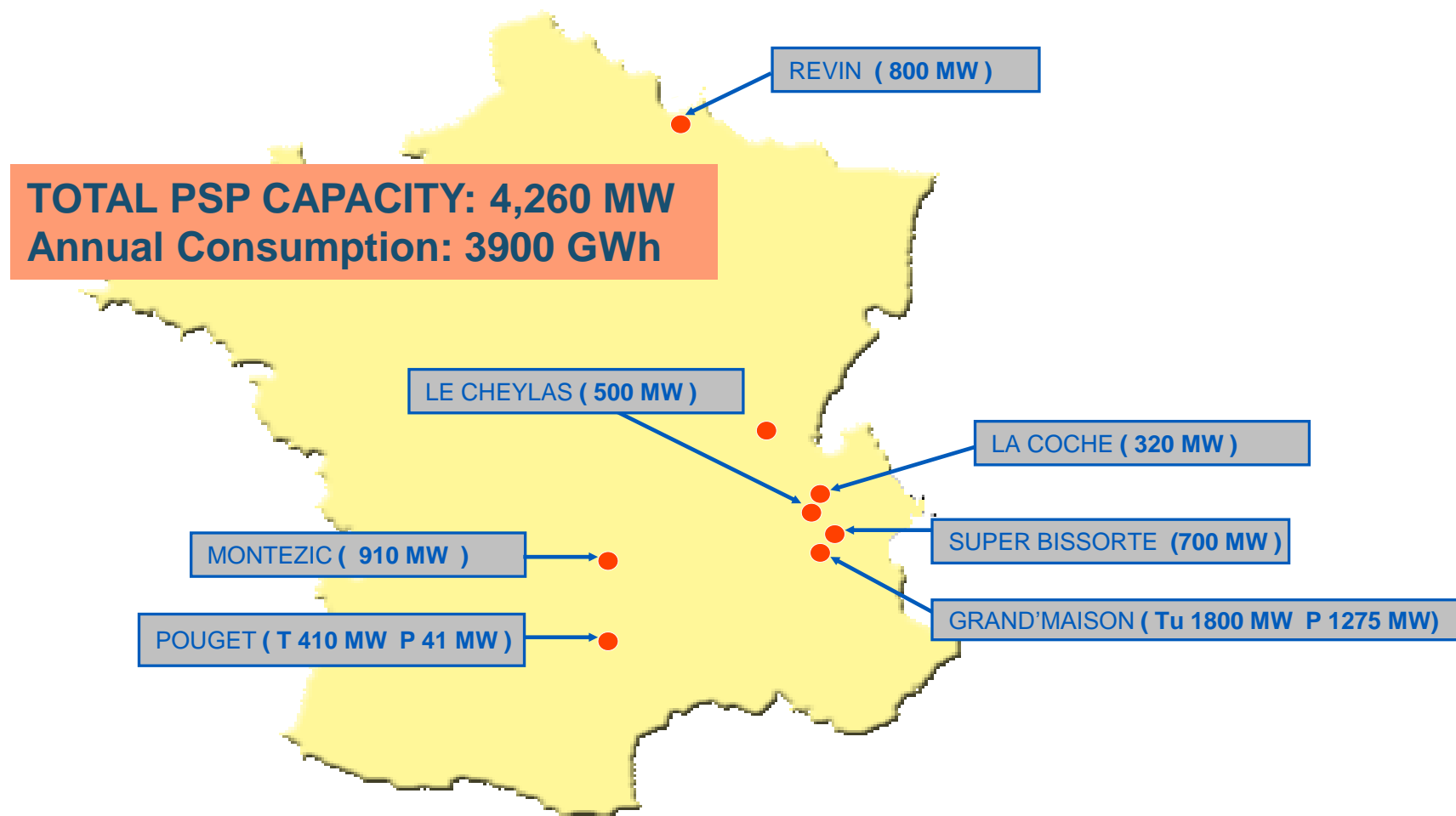
⇒ 220 dams (3500 gates)

- incl. 150 over 20 m
- incl. 67 over 15hm³

⇒ 1480 km tunnels, 267 km penstocks

⇒ 100 HPP controlled from 4 Hydro Control Centres ⇒ 14,000 MW ready to start in 20 min

Major pumped storage power stations operated by EDF in France



Example of PSPP: Grand'Maison



- The two power stations at Grand'Maison have total installed capacity of **1800 MW in turbine, 1275 MW in pump operation.**
- The above ground powerhouse has four 5-jet Pelton units with unit capacity 158.5 MW running under 922 m head and with total discharge of 78 m³/s.
- The underground power house measures 161 x 16 x 40 m and has eight 4-stage pump-turbines, with unit capacity 152.5 MW (turbine) and 157 MW (pump), running under 955 m head and with total discharge of 144 m³/s (turbine) and 138 m³/s (pump).

GRAND'MAISON Pumped Storage Power Station includes:

- The Grand'Maison dam (head work),
- The Verney dam which is the lower reservoir,
- Two power stations and the headrace works.



Part 2

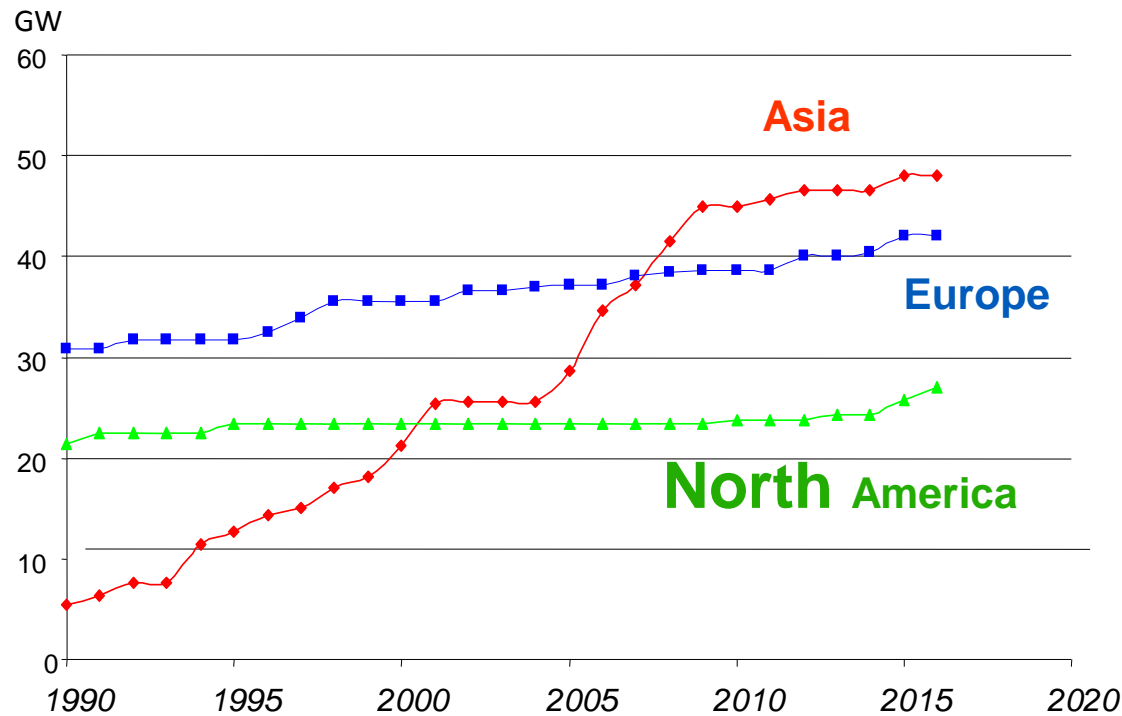
Worldwide PSPP overview



1 - Brief history of PSP development

- Well proven technology
- PSP massively developed in mature power systems
- Massive development of PSP as complement to the nuclear investment program

PSPs development trends



Source : EDF R&D

Total storage capacity in the world (end 2010)

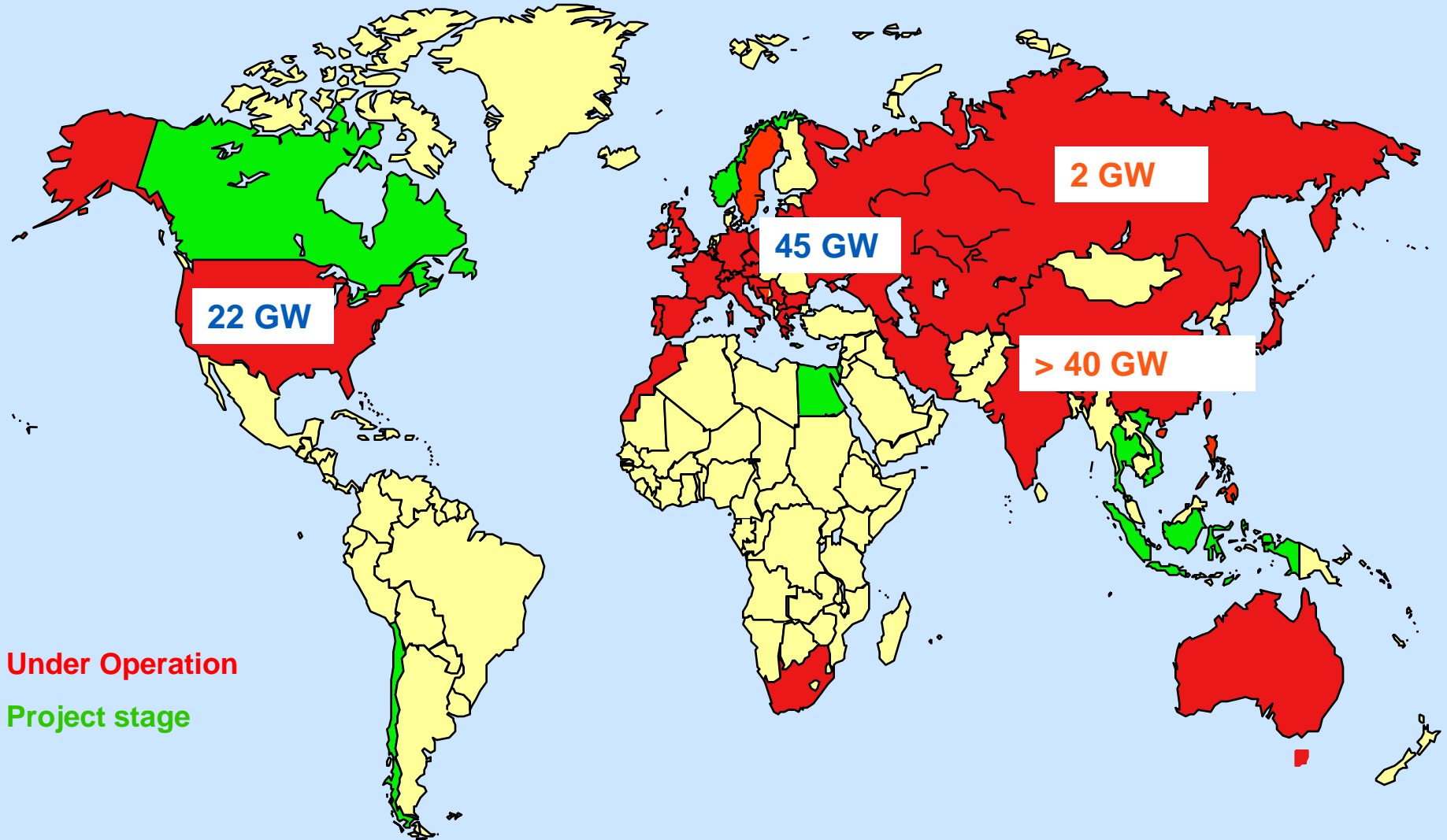
Pumped Storage : **140** GW

CAES & Gas Turbine : 0,5 GW

Batteries : < 0,3 GW

Source : Fraunhofer Institute, EPRI, EDF R&D

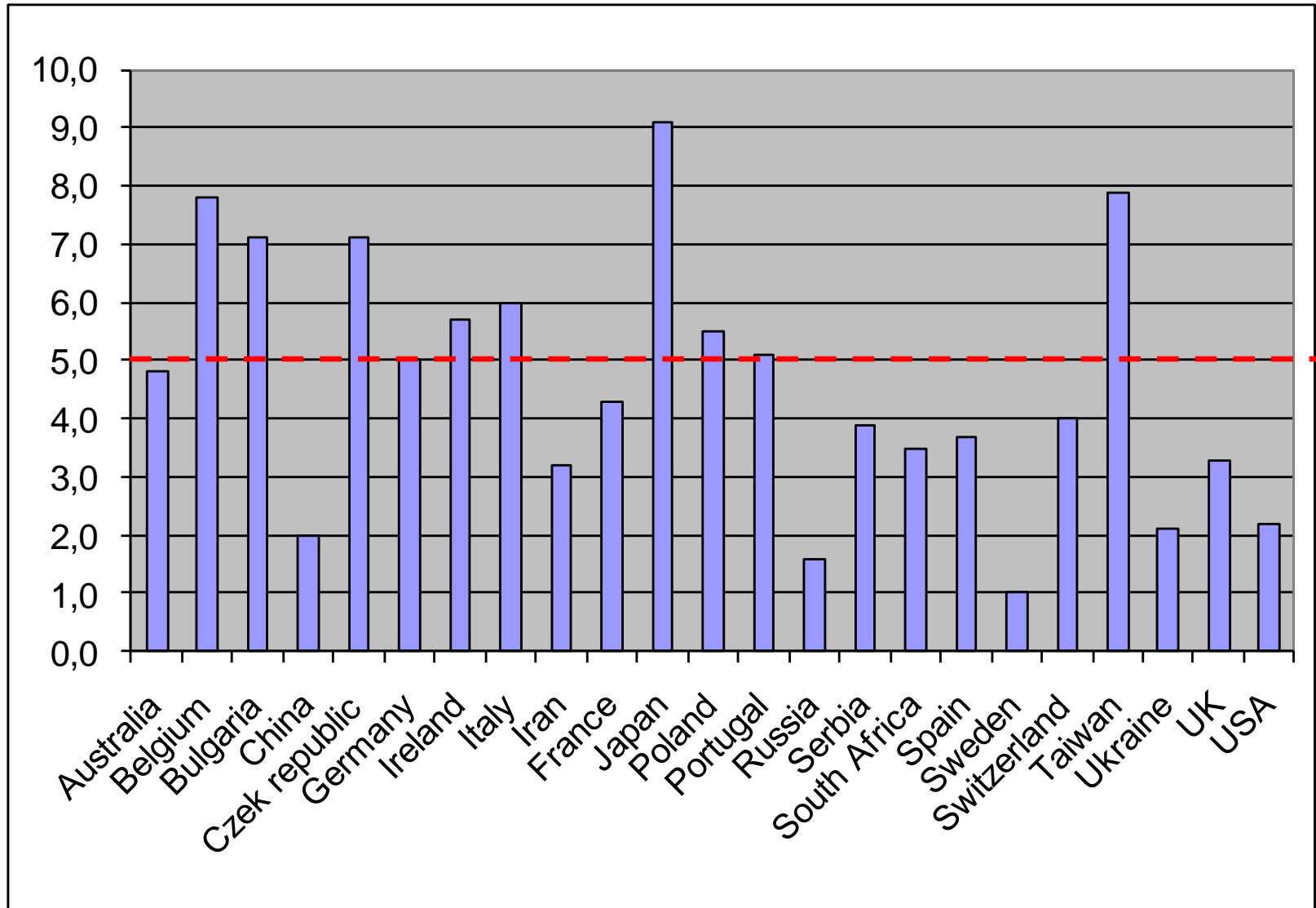
Where to find Pumped Storage Facilities



Under Operation

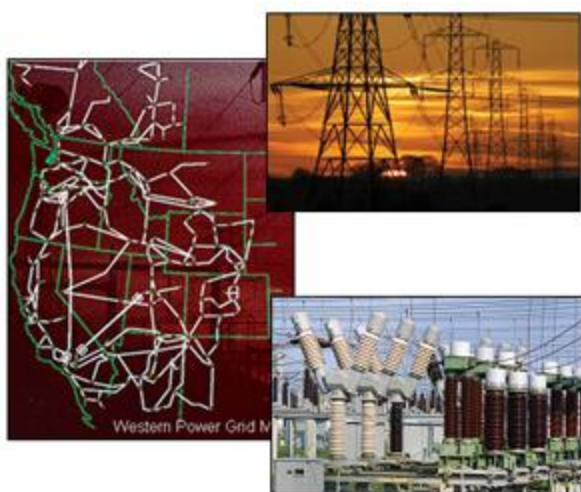
Project stage

Percentage of PSP per installed capacity



The evolving uses of PSP

- ▶ **Institutional evolutions : from a regulated to a deregulated power market**
- ▶ **Associated with large nuclear / thermal capacity**
- ▶ **Development of intermittent renewable energy**



Different forms of PSP

- ▶ PSP with or without natural inflows
- ▶ Daily, weekly or seasonal reservoir



Tom Sauk PSP - USA



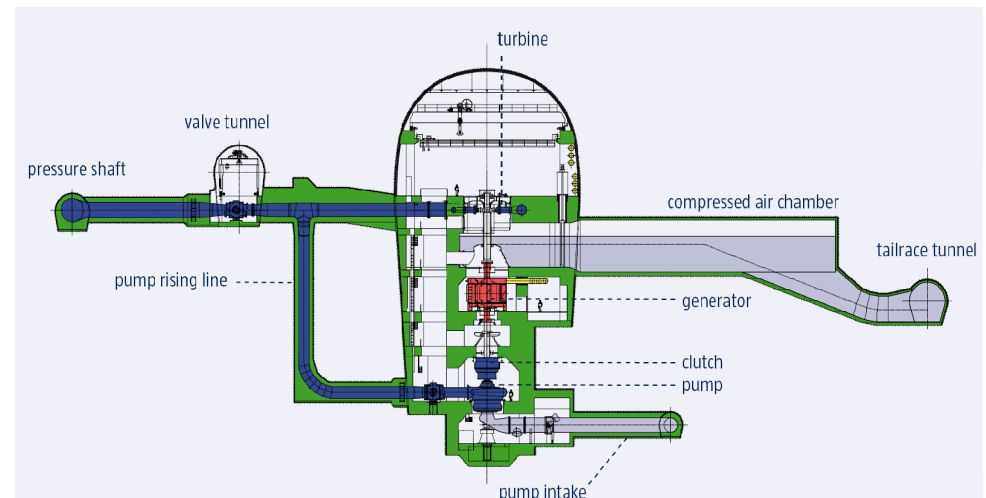
Okinawa PSP - Japan



Tehri PSP Project - India

A wide range of technologies

- ▶ Reversible pump-turbines without variable speed equipment
- ▶ Reversible pump-turbines with adjustable speed
- ▶ Ternary block
- ▶ Totally separated machines



Kops II - Austria

Advantages of PSP

- ▶ Mature Technology
- ▶ Very flexible
- ▶ Fast acting plant
- ▶ Performances
- ▶ **Grid services**
- ▶ Load balancing
- ▶ Limited impact on the environment
- ▶ Service life of 50 year +



Tehri PSP Project - India

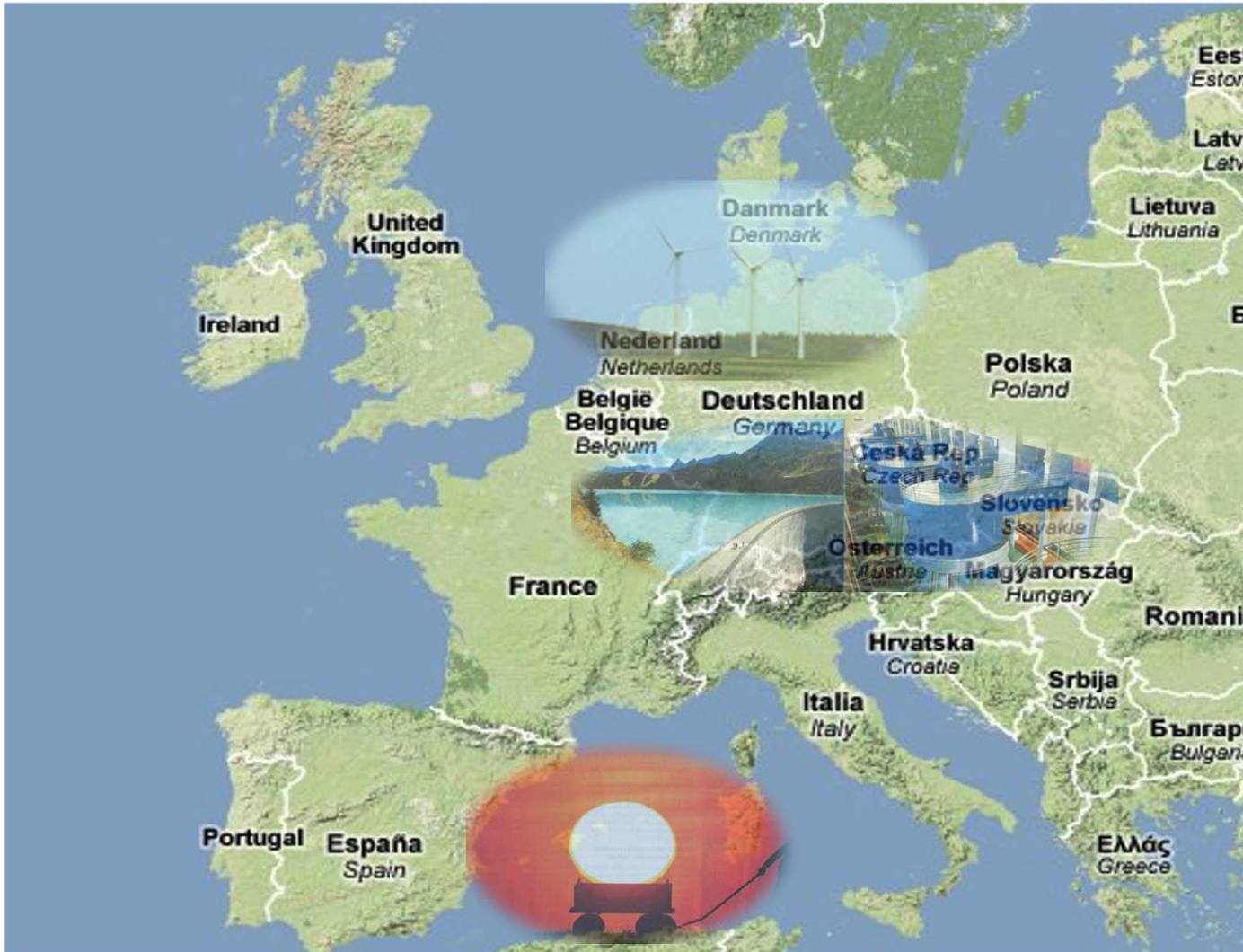
Wind & Solar Issues

- ▶ Intermittent Variable
- ▶ Difficult to predict
- ▶ Cannot meet fluctuating demand
- ▶ No inertia



New and large electrical storage options are needed to compensate for fluctuating generation.

New projects in Europe



Switzerland

- Nant de Drance (600 MW)
- Linth Limmern (1200 MW)
- Hongrin Léman (240 MW)
- Fah Sera (50 MW)

Austria

- Kops 2(2008) (450 MW)
- Limberg (480 MW)
- Feldsee (70 MW)

Spain

- La Muela 2 (852 MW)

Portugal

- Baixo Sabor (171 MW)
- Alqueva 2 (240 MW)
- Alto Tamega (600 MW)

Slovenia

- Avce (185 MW)

United Kingdom

- Great Glen (600 MW)
- Sloy (60 MW)

Conclusion

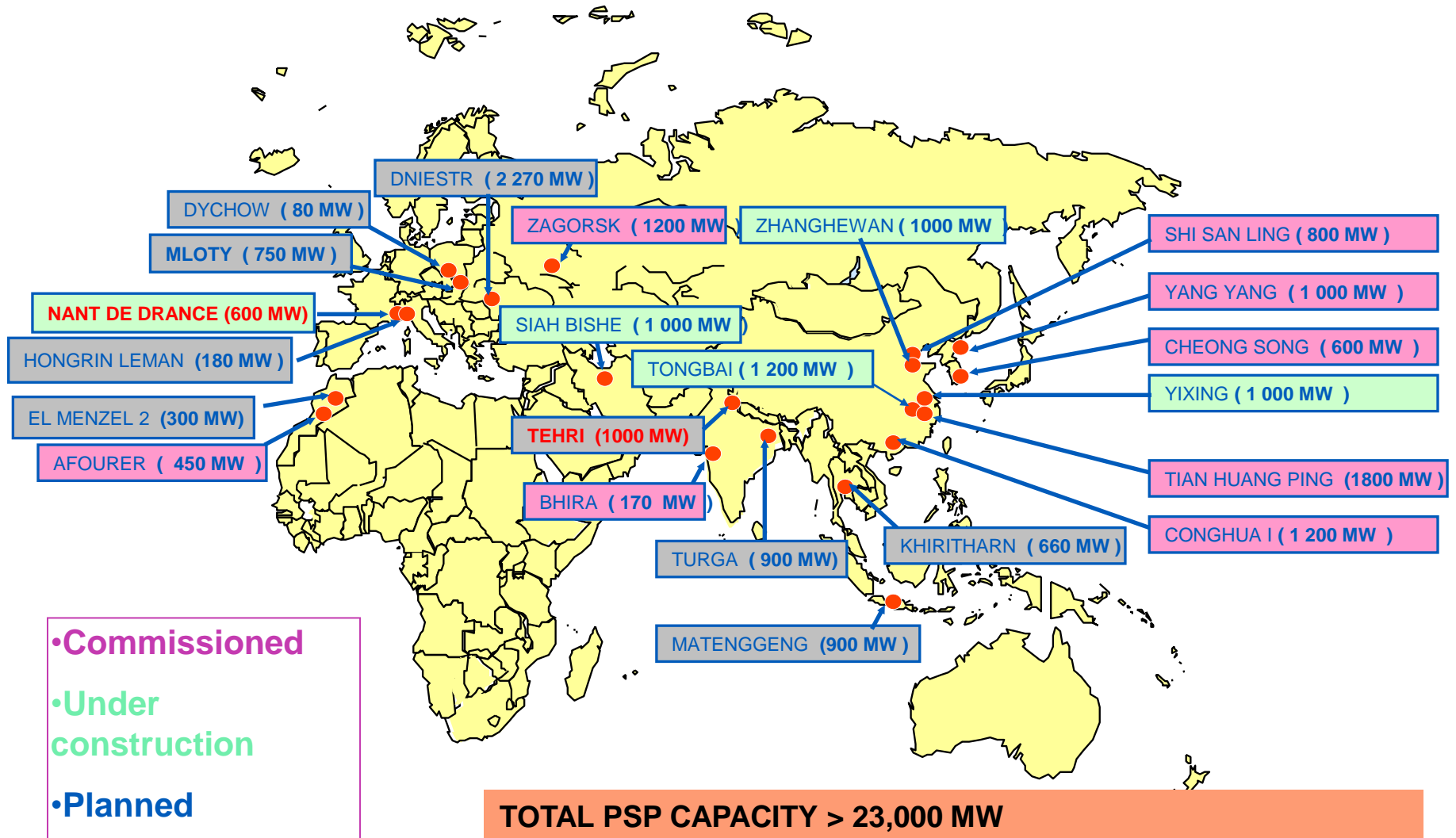
Large development of renewable intermittent energy sources

➡ Need for new balancing facility

Opportunity for PSP development

Challenge for new PSP development is contractual arrangement & financing

EDF CIH's international experience with PSPP



- Commissioned
- Under construction
- Planned
- Variable Speed

Thank you for your attention

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