Hydro Power and Pumped Storage Hydroelectricity

CEDREN Conference
11<sup>th</sup> Septembre 2012
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

- Pumped storage: 3.6
- Run of river: 4.3
- Reservoir: 3.3
- Daily Storage: 8.8
(≈ 20% of EDF mix in France)

Generation 39 TWh

- Pumped storage: 10.6
- Run of river: 16.5
- Reservoir: 17.6
- Daily Storage: 1.1
(≈ 10% of EDF in 2010)
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 15 m³

- **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

TOTAL PSP CAPACITY: 4,260 MW
Annual Consumption: 3900 GWh

- GRAND’MAISON (Tu 1800 MW P 1275 MW)
- MONTEZIC (910 MW)
- POUGET (T 410 MW P 41 MW)
- LE CHEYLAS (500 MW)
- LA COCHE (320 MW)
- SUPER BISSORTE (700 MW)
- GRAND’MAISON (Tu 1800 MW P 1275 MW)

EDF Presentation - CEDREN Conference- 12th September 2012
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

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

Source: EDF R&D
Where to find Pumped Storage Facilities

Under Operation

Project stage

45 GW

> 40 GW

2 GW
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 seasonnal 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
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

TOTAL PSP CAPACITY > 23,000 MW
Thank you for your attention