

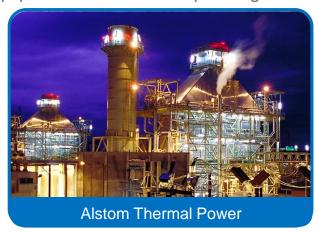
Pumped Hydro Storage Plants

Olivier Teller
Grenoble
19 November 2014



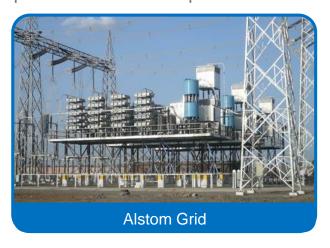
Three main activities in four sectors

Equipment & services for power generation





Equipment & services for power transmission



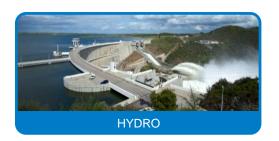
Equipment & services for rail transport





Presentation title - 20/11/2014 - P 2

Alstom Renewable Power Technologies adapted to all renewable energy sources















...for new plants and the installed base



Alstom, the leading supplier in hydropower for over 100 years

A global leader

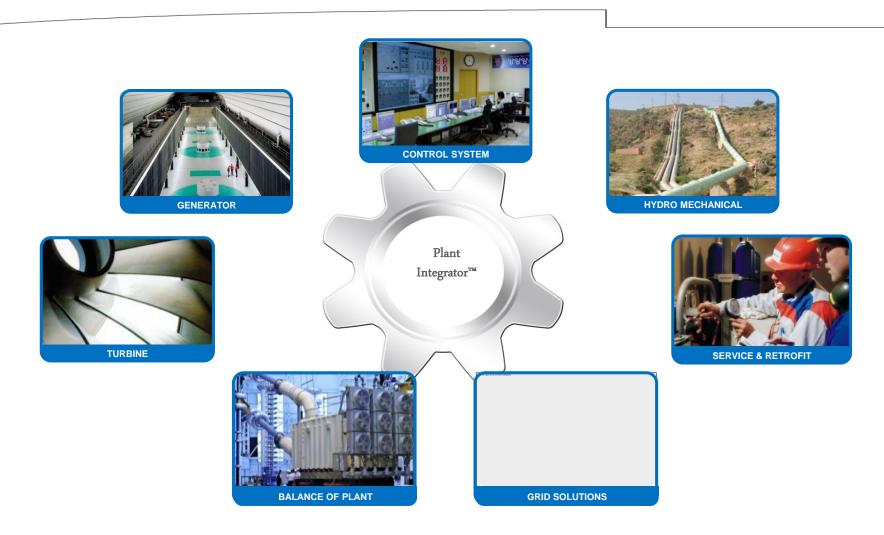
- from water to wire
- for new plants& the installed base
- for service & retrofit



Alstom accounts for over 25% of world's hydro power plants



The broadest hydropower portfolio



Turnkey plant or individual products



Product Portfolio Hydro Business

Turbines and Generators



Low Speed



Low Speed



Medium Speed



MotorGenerator



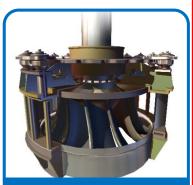
High Speed



Bulb



Kaplan



Francis



Pump Turbine

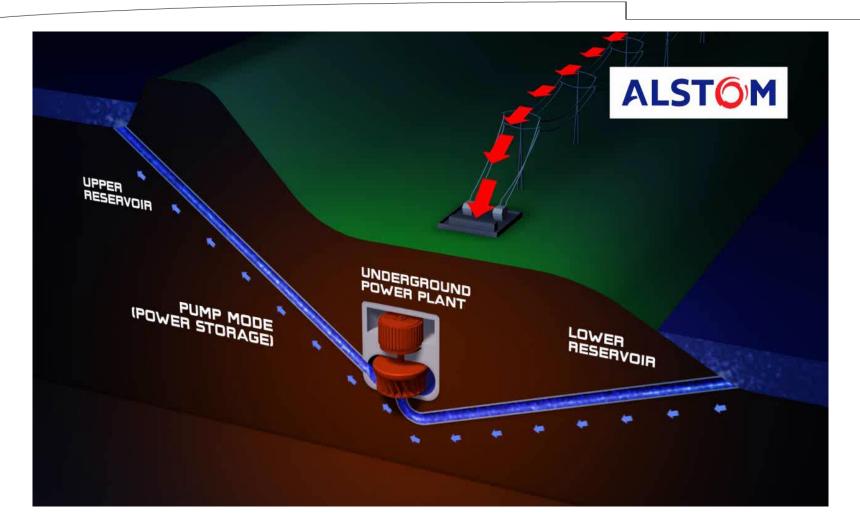


Pelton

ALSTOM

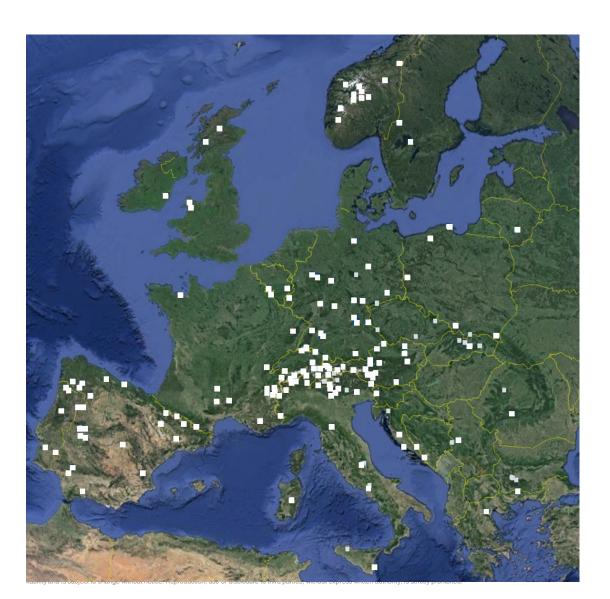


A reliable large-scale storage solution: Pumped Hydro Storage Plants (PSPs)





PSP in Europe



199 plants,
48,8 GW turbine capacity
537 machines with a pumping mode (representing a turbine capacity of 46,6 GW)



Alstom ongoing PSP Projects Worldwide

SWITZERLAND FRANCE NANT DE DRANCE **REVIN** 6 units of 150 MW 4 units of 200 MW Variable Speed ■ 305 m – 428.6 rpm Rehabilitation ■ 240 m - 300 rpm LINTH-LIMMERN LE CHEYLAS 4 units of 250 MW ■ 1 units of 256 MW Variable Speed ■ 613 m – 500 rpm Upgrade to variable speed ■ 254 m – 300 rpm **CHINA ZHANGHEWAN** ■ 4 units of 255 MW ■ 305 m – 333.3 rpm **PORTUGAL** НОННОТ ALQUEVA II 4 units of 306 MW 2 units of 130 MW ■ 521 m - 500 rpm ■ 72 m – 428.6 rpm **PUSHIHE** 4 units of 306MW SALAMONDE II ■ 308m-333.3 rpm 1 unit of 209 MW ISRAEL **INDIA** ■ 115 m – 166,7 rpm **TEHRI** GILBOA 2 units of 150 MW 4 units of 250 MW Variable speed ■ 430 m - 750 rpm ■ 188 m - 233 rpm Equipment + O&M



What PSP Does



Provide flexibility to balance base load generation



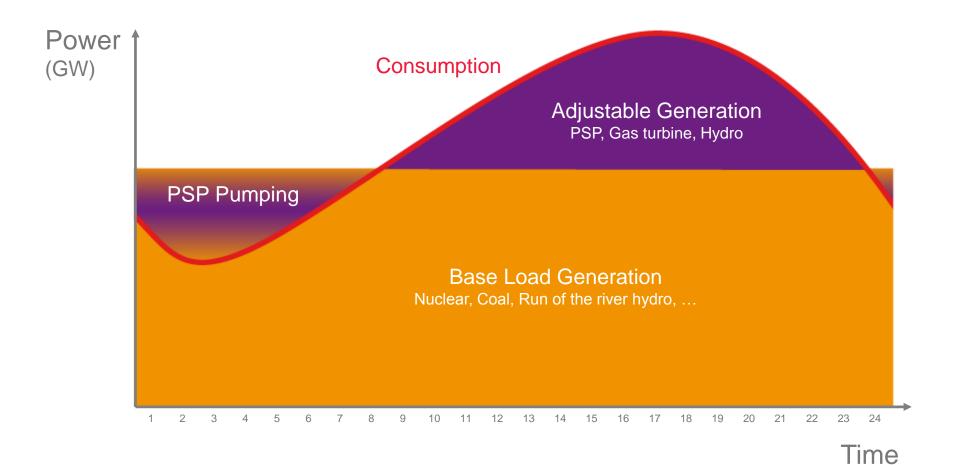
Complement intermittent renewable energies



Optimise *electrical grids*

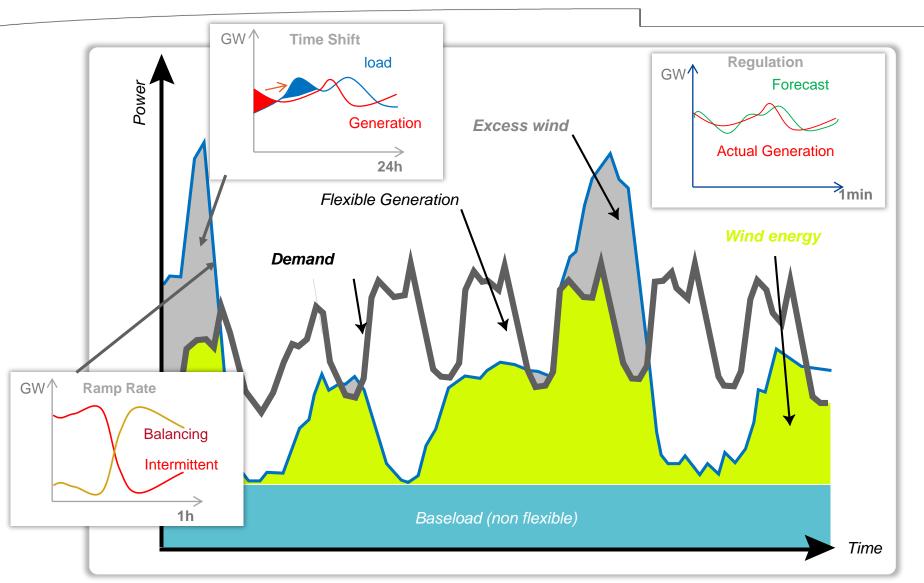


Thermal & Nuclear plants optimisation



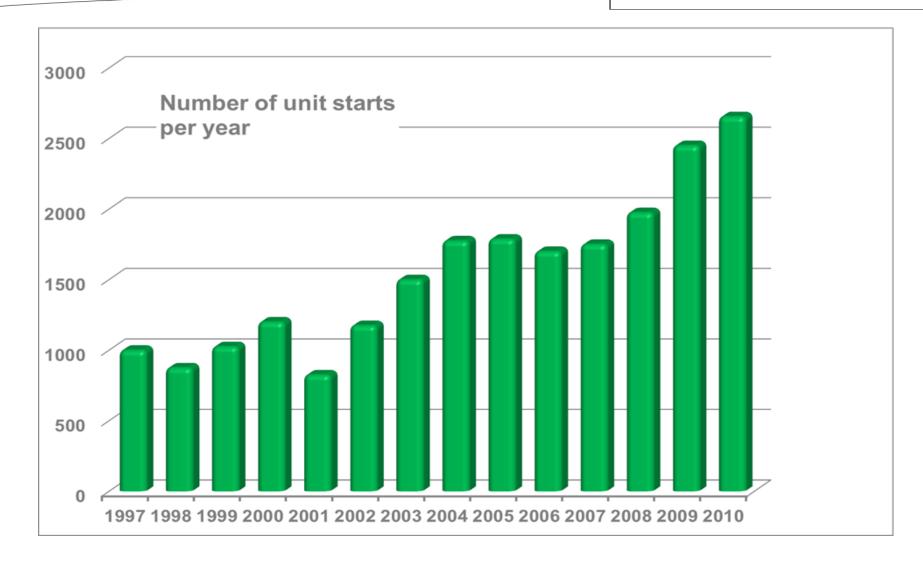


New need for flexibility



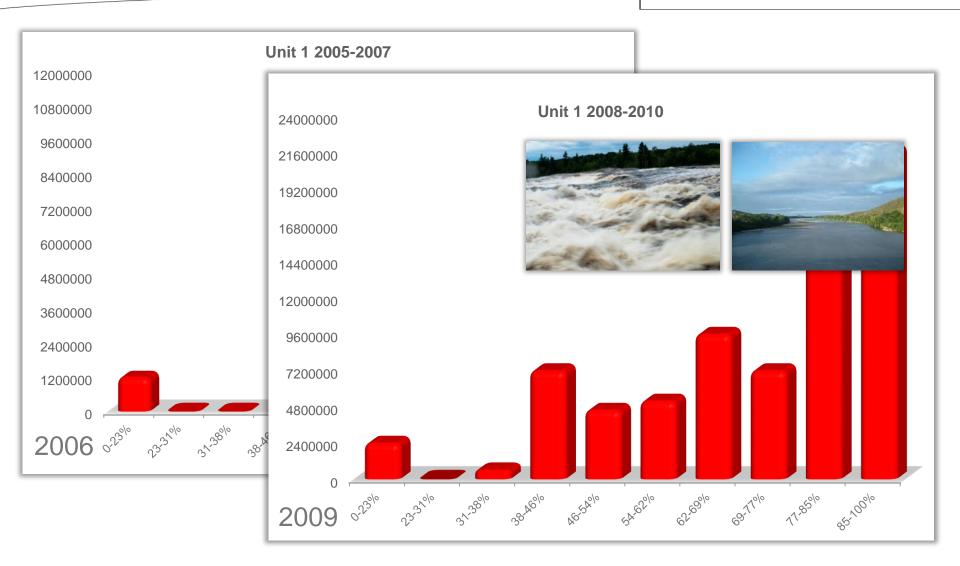


Increase of unit cycling



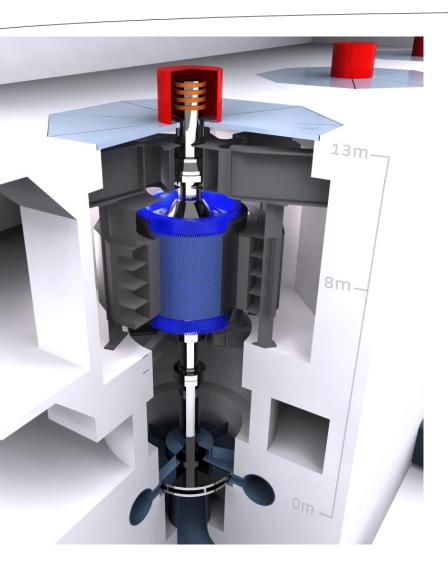


Increased partial load operation





PSP Development Trends



Performance improvement

- Efficiency: 70 to 80% in 40 y.
- Availability, Reliability, Cycling

Overcoming topological limitation

- · Very High or Very Low Head
- Head range increase
- Underground reservoir
- Sea water operation

Maximising flexibility

- · Variable Speed offering
- Power range increase
- Reaction time reduction



Variable speed PSP

Double Fed Asynchronous Motor Generator

- Adjustable pumping power
- Compatible with larger head variation
- Faster power adjustment
- Pump Turbine global efficiency (+ ~ 1%)





PSP allows Renewable to remain Renewable

Customised solutions for each application

Economical feasibility highly depends on regulatory framework



