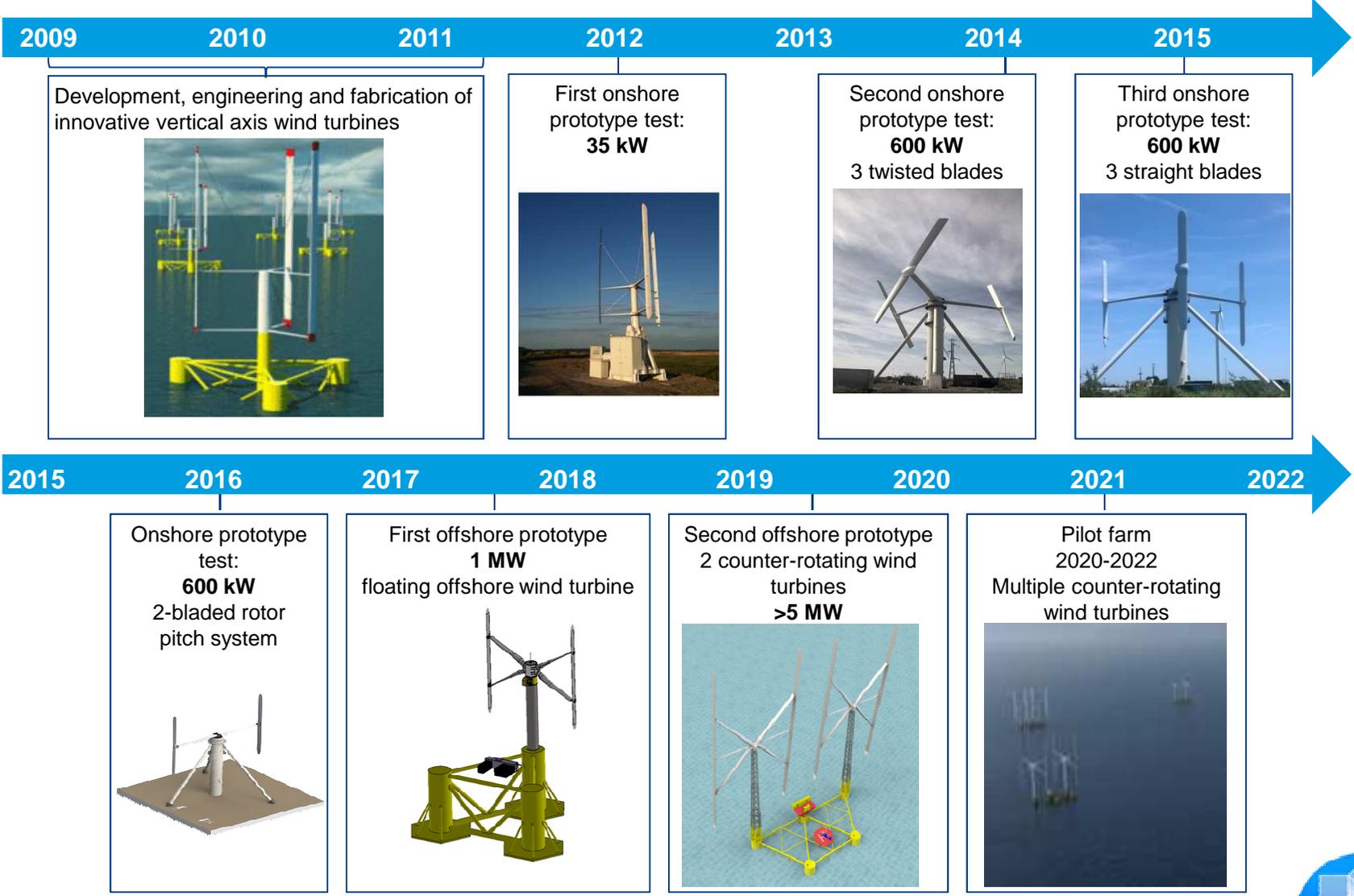


NENUPHAR develops floating vertical axis wind turbines



CONFIDENTIAL



Alain Lacaze

Short resume

▶ Education

- ◆ Diplomed engineer in Physics
- ◆ PhD in cryogenics (magnetic refrigeration)

▶ 10 years experience in cryogenics and superconductors with Alstom

- ◆ Superconducting AC electrotechnics (generator, transformer, current limiter...)
- ◆ MRI magnets, electromagnetic launcher...

▶ 15 years as a R&D manager for Alstom turbogenerator:

- ◆ Desynchronised power generation :
- ◆ Direct AC/AC conversion, 99.4% efficiency, several MW, cost efficient
- ◆ Fully adapted generator/converter solution

▶ Since 2010 : power chain, auxiliaries and control responsible for Nenuphar



Power electronics

▶ **Most widely used solution for wind turbine: PMG + full power conversion**

- ◆ IGBT based LV converter
- ◆ Efficiently manages the operation of the PMG
- ◆ Copes with LVRT

▶ **Drawbacks :**

- ◆ Costly
- ◆ Unconvenient to fit in the available space due to large dimensions
- ◆ Losses (30 kW/MW) => auxiliaries needed for cooling
- ◆ Unexpected shut down
- ◆ No access to internal control software
- ◆ Very low overload and surge capability

▶ **Alternative to power converters**

- ◆ Hydraulic transmission: cost, efficiency, maintenance and response time...
- ◆ Magnetic gearbox : ?



Power electronics

- ▶ **Each energy conversion stage (from wind to grid) brings unefficiency**
 - ◆ Reminder : ABB powerformer concept to avoid transformer
 - ◆ LV->MV to avoid the first step-up transformer (attn: skill of maintenance personal)
 - ◆ AC/DC/AC vs direct AC/AC conversion

- ▶ **Increasing penetration of renewables :**
 - ◆ dynamic response, spinning reserve, LVRT...
 - ◆ reactive power management
 - ◆ Combination with energy storage
 - ◆ Introduce hydrogen production to manage load leveling or produce hydrogen-fuel
 - ◆ Optimised generator to directly produce DC

- ▶ **Ideal switch for direct AC/AC conversion or DC generator :**
 - High surge capability
 - Able to withstand reverse voltages
 - True bidirectionnal switches

