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Innovation in Wind Energy

By the end of 2015, globally installed wind power capacity reached an impressive figure of about 433 GW; newly installed capacity deployed in 2015 alone was 63 GW, which is the highest annual figure ever in the history of wind technology (figures from Global Wind Energy Council). This fast growing pace is widely expected to be maintained in the coming years, while the electricity-generation scenario is rapidly evolving in a way that will continue to impact the business and reshape the energy industry, with renewable energies continuing to have the lion's share of investments and opportunities.

Enel is at the forefront of this new era of the electric industry, being also a pioneer and one of the leading worldwide players in the field of renewable energies. The net installed capacity of the Enel Group is today more than 89 GW; 37 GW of those are renewable installed capacity (data as of 31 December 2015).

Just to give a snapshot of the future, considering the whole Enel Group, about 53 % of CAPEX growth in the 2016 to 2019 timeframe will be invested in the growth of renewables.

In this scenario of still-growing renewables and increasing penetration of wind energy, innovation can play a major role and open untapped opportunities for Enel and all the other players, in an effort to make renewable energies more reliable, sustainable and competitive.

To this extent, in the coming years we will face not only increasing levels of new wind capacity being installed worldwide, but the wind energy sector could also take advantage of innovation opportunities coming from ageing wind farms in "mature" markets; as a matter of fact, Europe could be regarded as the cradle of the wind energy market, having started with turbine deployments many years ago. That's why today a large portion of the European wind fleet is approaching (or has already come to) the end of its useful life.

This scenario will lead in the coming years to a wide range of major interventions on the "old" wind fleet, opening the door to life extensions and repowering of the ageing wind turbines, thus broadening the wind capacity that would be eligible for the deployment of innovative technologies.

Let's now try to envision some of the main innovation areas that can play a fundamental role in the future of wind energy. Two macro-categories can be identified:

- Wind energy LCOE reduction, through:
    - Innovation on the wind turbine systems: Although wind turbines are often referred to as a mature technology, incremental innovation is surely expected to come and go on raising the bar of their technological content. Let's just think about the latest progress made in material sciences or software simulation tools (fluid dynamic +

aeroelastic codes, simulation tools at turbine system level, etc.) in the recent years, and how they've improved (and will continue to improve) design and performance of the wind turbines;

- Improved control: from the "hardware" side, innovative instrumentation is envisioned to be deployed in order to accurately measure the wind conditions in operating wind farms and even to directly steer wind turbines (e.g. LIDAR can be an option for both of these issues); on the "software" side, new control strategies/algorithms are likely to be developed, not only at wind turbine level, but at a farm level as well;
- Predictive maintenance through big data: Big data/data mining techniques will pave the way to switching more and more from reactive to predictive/condition-based maintenance, thus enabling early failure detection/anticipation and reducing failure rates and entity, O&M costs, failure-driven lost production and, ultimately, lowering the final cost of energy;
- Sensors/monitoring tools: Our knowledge of wind turbines' behavior and health status will take advantage of the deployment of a new generation of low-cost sensors. Condition monitoring systems (CMS) will be enhanced and brought to the next level by innovative sensors/configurations and improved data elaboration tools. Moreover, drones/ROVs are expected to make a significant leap forward in terms of wind turbine inspections;
- Ice detection, anti-icing and de-icing techniques are another issue that will have a role in the future and that has also been addressed in recent meetings of the VGB Technical Committee "Wind Energy".

- Integration and production/demand profiles matching and optimisation, through:
  - Forecasting/nowcasting tools: These are basically software tools that are able to provide predictions of the power that could be produced by non-programmable renewable energy power plants, that are inherently intermittent (typical look-ahead time horizon is 72 hours for forecasting). In a scenario of ever increasing renewables penetration, these tools will gain a paramount role as supporting tools;
  - Energy storage: If forecasting tools can be considered as the "software" side of the answer to the challenge of making renewables fully programmable and dispatchable, the "hardware" part of the solution surely consists of utility-scale energy storage, that will certainly play a fundamental role not only regarding wind energy, but in the overall renewable energy scenario in the future;
  - Hybridisation of wind farms with solar or other renewable technologies: Putting together different renewable technologies based on different resources could be a way to reduce the effect of intermittency, identifying the best mix to meet the system requirements/needs.