Report 2021
Italy

Beleolico Wind Farm. *Source: Renexia*

Authors *Laura Serri, Ricerca sul Sistema Energetico (RSE S.p.A) and National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)*
Luca Greco, National Research Council (CNR), Italy

In 2021 the effects of the COVID pandemic decreased, and the new capacity increased at the levels of 2018-2019: 470 MW, the total installed capacity surpassing 11 GW.

The year 2021 has seen the closure of many relevant research projects, the proposal and start of new ones, and an increasing number of participants in the IEA WIND Tasks.

Highlight(s)

- The new installed capacity increased at the levels of 2018-2019: 470 MW.
- Installation of the first offshore wind turbine started in December 2021.
- 64 expressions of interest for offshore wind projects (at least 40 floating ones!) have been received by the Ministry of Ecologic Transition.

Table 1. Key National Statistics 2021: Italy

Total (net) installed wind power capacity	11.1 GW
Total offshore capacity	0 GW
New wind power capacity installed	0.47 GW
Decommissioned capacity (in 2021)	0 GW
Total electrical energy output from wind	20.6 TWh
Wind-generated electricity as percent of national electricity demand	6.5%
Average national capacity factor	22.1%
Target	19.3 GW installed capacity @2030
National wind energy R&D budget	n.a.

Market Development

Targets and Policy

The final version of the Integrated National Energy and Climate Action Plan (INECP), published in December 2019, sets a target of 30% of overall annual energy consumption from renewable energy sources (RES) for the year 2030. The contribution of wind energy is fixed in a total installed capacity of 19.3 GW (including 0.9 GW offshore), producing 41.5 TWh/y, including revamping and repowering interventions. In line with "Next Generation EU" actions, in 2021, Italy published the National Recovery and Resilience Plans (NRRPs), which outlines a future update of the objectives of the INECP. Pending this update, the Ministry of Ecological Transition has adopted the Ecological Transition Plan, which provides a framework of environmental and energy policies integrated with the objectives already outlined in the NRRP.

Progress and Operational Details

According to the National Wind Energy Association (ANEV), Italy installed a new net wind power capacity of 471 MW in 2021. Cumulative installed capacity at the end of 2021 reached 11.1 GW - all land-based, including decommissioning and repowering. The trend of annual and cumulative capacity in 2010-2021 is shown in Figure 1. According to the national TSO, TERNA, around 240 MW of small wind plants (plant size lower than 200 KW) should be added to the cumulated capacity.

In 2021, 32 new wind farms were grid-connected (21 with a size greater than 5 MW). The maximum plant size was 43.2 MW. One hundred fifty new turbines were installed, bringing the country's total to around 7,300 operating units. The wind turbines installed during the year averaged 3,1 MW (maximum 4,2 MW). The average size of all wind turbines installed in Italy is 1.5 MW. 77% of the new turbines are Vestas. In the second half of the year, the construction of the first offshore wind farm in Italy, Beleolico park, has started [1]. It consists of ten 3 MW wind turbines to be installed close to Taranto harbor in the Apulian region.

New wind power capacity was mainly installed in Basilicata (28%), followed by Sicily (26%) and Apulian region (24%). 90% of the cumulated capacity is concentrated in six Southern regions: Apulian (24%), Sicily (18%), Campania (15%), Basilicata (12%), and Calabria (10%), and Sardinia (10%).

The overall wind electricity production in 2021, according to TERNA data [2], was 20.6 TWh, corresponding to 6.5% of Italy's total electricity demand (total consumption plus grid losses). The trend of annual wind energy production and percentage of the electricity demand in 2010-2021 is shown in Figure 2. The curtailments reached 4.4% (preliminary data). The 2021 average national capacity factor was 22,1%.

The estimated average capital cost of the 2021 new capacity was 1,200 EUR/kW (1,467 USD/kW).

According to ANEV [3], three operators manage around 24% of the total installed capacity: Gruppo ERG with 9.9% of the share, Enel Green Power with 7.3%, and E2i Energie Speciali with 7.1%. Other 20 operators have a shear greater than 1%.

Matters Affecting Growth and Work to Remove Barriers

The main incentive mechanism supporting renewables (6th July 2012

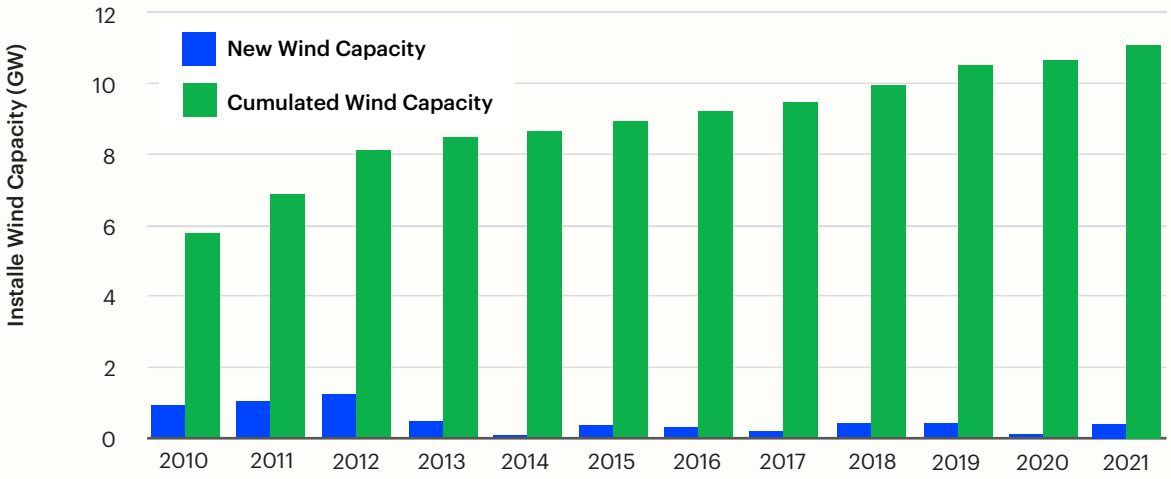

Figure 1: Trend of annual and cumulative wind capacity in the period 2010-2021.

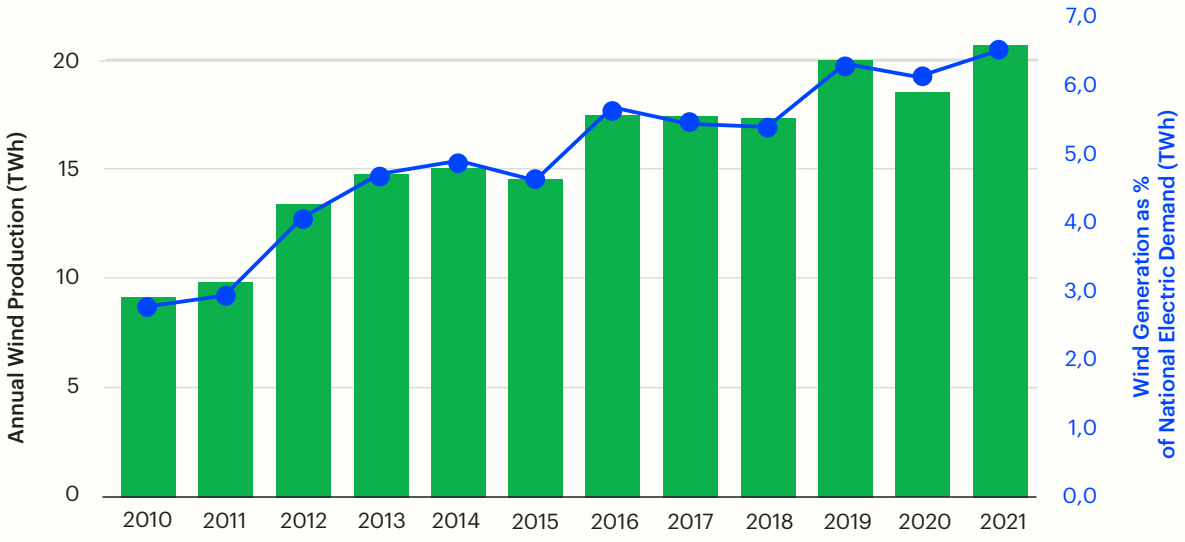

Figure 2: Trend of annual wind energy production and percentage of the electricity demand in the period 2010-2021.

decree) is fixed energy purchase prices for RES plants, depending on technology and size. The tariffs depend on the plant size: for sizes greater than 1 MW, the tariff is 70 €/MWh (86 $/MWh), whilst tariffs increase lower sizes.

Big plants receive special energy purchase prices through calls for tenders (until the annual quota is reached), which are granted over the average conventional lifetime of plants (20-25 years). During 2021 three joint tenders for onshore wind and PV were published, but the available quota was not saturated. The winning wind capacity was 41.4 MW, 23.1 MW and 392.5 MW equal to 56%, 40%, and 40% of the total winning capacity, respectively. In addition, 97.5 MW of small plants signed up in registers. The total amount of the winning wind capacity resulted in a fairly good market size of almost 500 MW, even if most of the 2021 winning capacity was assigned to PV plants.

According to the large wind energy operators, the main issues affecting

Photo: Andrea Proietti/Unsplash

growth are the long and complex permitting processes. Associations, operators, and policy makers are working together to improve it. Within the NRRP (Mission 2C2.1), a simplification of the authorisation process for onshore and offshore renewable energy farms is planned and will be implemented in the following years.

R,D&D Activities

Italian Research Institutes and Universities carry on several activities in the field of wind energy both at the basic science and technological level. They are funded by national and international projects, consultancy activities for private enterprises as well as, especially for the fundamental physics aspects, self-financed.

According to the present institutional organisation, the ministries mainly supporting and promoting R&D are the Ministry of Economic Development (MiSE), and the Ministry of Education, Universities, and Research (MIUR).

National R,D&D Priorities and Budget

The national energy system priorities for 2030-2050 are envisaged in the INECP underlying the importance of RES contribution to the energy mix also through specific actions for offshore wind R&D tailored to the Mediterranean Sea. The 2021-2027 National Research Programme (NRP), published by MIUR, highlights the fundamental role of the technologies for the sustainable use of renewable sources from the sea (such as wind offshore). Moreover, the NRRP will support research efforts toward innovative offshore integrated RES technologies, including offshore wind and tailored storage systems. Within this scenario, most research organisations set their own budgets for wind energy R&D, and, in many cases, the activities are funded in a bigger umbrella concerning renewables. For these reasons, it is difficult to give a representative value for the national wind energy R&D budget or to evaluate trends.

The most important R&D support program is the "National Fund for Electric System Research" (RdS), promoted by MiSE. It aims at the scientific and technological innovation for the electricity system to enhance competitiveness, security, and environmental compatibility, as

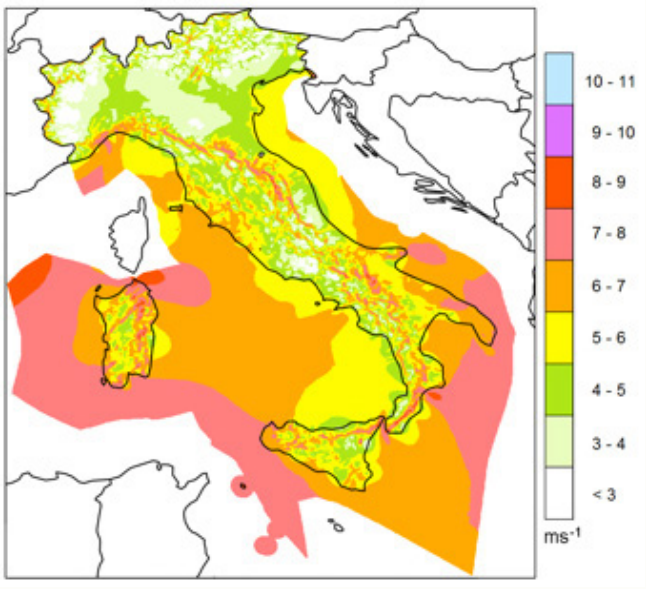

Figure 3: Mean wind speed at 100 m a.s.l./a.g.l. (m/s)

Figure 4: The MaRELab site with the installed FOWT Hexafloat

well as ensure conditions for sustainable development. RdS projects are implemented by R&D institutions, namely Ricerca sul Sistema Energetico (RSE SpA), the National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), and the National Research Council (CNR). In 2021 a 3-years term including wind energy related research activities within different projects totaling a budget of around 3.5 M€ reached its closure. Finally, under the umbrella of the National Technology clusters, Blue Italian Growth is funding projects dealing with offshore renewable energy sources.

National Research Initiatives and Results

- Within the RdS projects on "Electric Energy from the Sea," RSE has developed the new Italian Wind Atlas -Atlante EOLico ItaliANo AEOLIAN- to describe wind conditions from 1990 to 2019. It has a spatial resolution of about 1 km for heights ranging from 50 to 150 m a.s.l/a.g.l. and is based on a novel approach combining the Weather Research and Forecasting (WRF) numerical modeling with the Analog Ensemble (AnEn) statistical technique. In Figure 3, the mean wind speed map at 100 m a.s.l./a.g.l. is shown. Moreover, a preliminary techno-economic assessment of combined wind and wave production at a site of the Sicily Channel has been carried out [4].

- Within the same project, CNR has coordinated the construction of MaRELab (Marine Renewable Energy LABoratory), a laboratory at sea managed in cooperation with the University of Campania "Luigi Vanvitelli" for the testing of novel marine energy harvesting systems. Since 2021, the first prototype at sea of Hexafloat (patented by Saipem SpA), an innovative platform concept for floating wind turbines, has been installed at MaRELab by CNR in cooperation with Saipem. The prototype, with a scale factor of 1:6.8 of a 5 MW machine, hosts a 10kW turbine provided by Tozzi Green SpA (see Figure 4) and is moored with three synthetic lines reducing the environmental footprint: this is the first FOWT installed in the Mediterranean Sea for research purposes. Energy production, platform motions, and loads on the mooring lines, as well as local meteo/ocean conditions, have been measured, generating a valuable set of experimental data.

- Within the RdS projects on "Energy and Electric Scenarios," GIS-based analyses have been performed by RSE to assess the actual wind turbine distribution on the national territory and to plan the future wind energy share, also considering the contribution of repowering old wind farms [5].

- The Sustainable Energy Research Group of the Department of Mechanical and Aerospace Engineering from "Sapienza" the University of Rome works on the topics of rain erosion damage, AI-driven models for multi-MW machines, floating offshore farms wake effects, and rotor aeroelasticity. In 2021 they finalised a fast and reliable numerical tool for the prediction of rain erosion on blades by coupling high fidelity computational fluid and particle dynamics methods with machine learning regression. Predictions of the rain erosion damage's incubation, shape, and depth (see Figure 5) on a 5MW wind turbine blade section after a year of power production regime

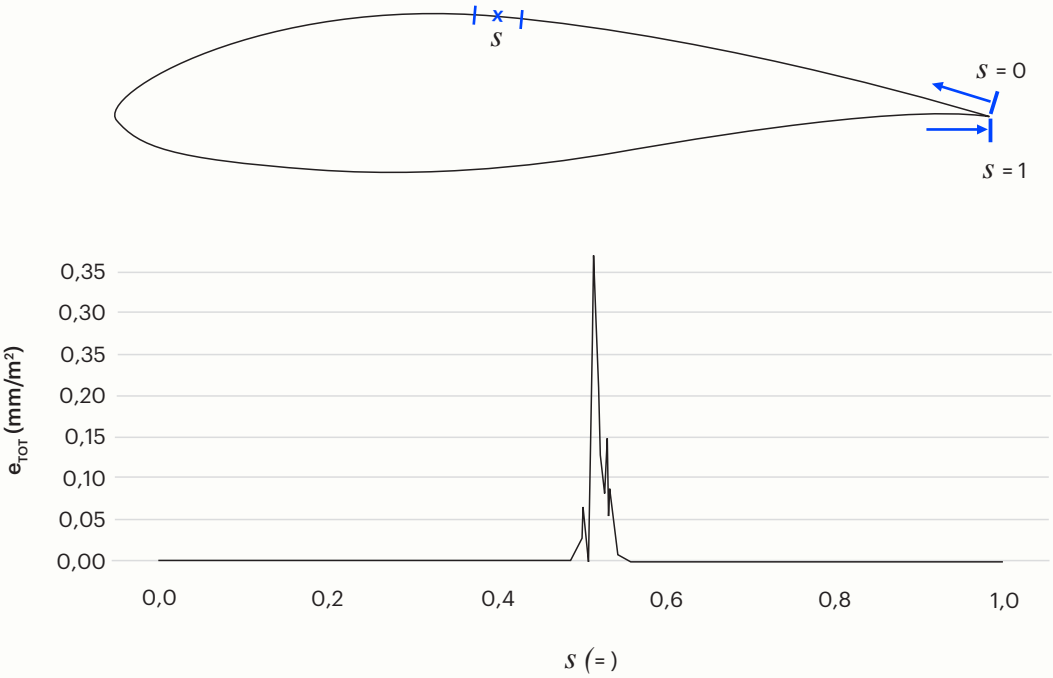

Figure 5: Depth of erosion damage predicted for an outboard section of a 5MW wind turbine, considering one year of operation at a site with 2000 mm of annual rain flow and 7 m/s of average wind speed

for different rainfall characteristics are described in [6].

- The Energy Department, "Galileo Ferraris" from Politecnico di Torino, has developed an innovative Statistical Method (SM) to evaluate wind turbine efficiency by estimating the incoming wind speed. This method relies on the manufacturer's power curve and the data measured by the turbine anemometer only, thus being convenient also in wind farms without a meteorological station. The method has been assessed by comparing it to the standard techniques implemented on the turbines of two wind power plants in Southern Italy and Mauritania [7].

Collaborative Research

- The Department of Aerospace Science and Technology of Politecnico di Milano is partner of the FLOAting Wind Energy netwoRk (FLOAWER), an Innovative Training Network funded by the EU within the framework of Marie Skłodowska-Curie Actions (H2020 ITN-MSCA). This 4-years project brings together academic and industry partners with the goal of training Early Stage Researchers on the topics of floating offshore wind turbines. Within this context, the Institute of Marine Engineering of the National Research Council (CNR-INM) is an associate partner of Politecnico di Milano.

- The University of Florence participates in the EU project FLOATECH, a Horizon 2020 project funded under the call LC-SC3-RES-31-2020. This 3-years project aims at increasing the technical maturity and the cost competitiveness of floating offshore wind energy through the development of effective design engineering tools and innovative control techniques.

- Terna SpA is the leader of the Italian demonstrator of the OSMOSE (Optimal System-Mix Of flexibility Solutions for European electricity) project, a Horizon 2020 funded program under the call H2020-LCE-2017-SGS involving six TSOs (France, Spain, Italy, Slovenia, Portugal, and Belgium) as well as market players. Terna conducted tests between the Puglia and Basilicata regions to explore the technical and economic feasibility of innovative flexibility solutions to enable a high share of renewables [8].

- Politecnico di Milano is the full participant in EERA's joint program on wind energy, while CNR and RSE are associate participants.

- The number of Italian participants in the IEA Wind TCP Tasks has increased significantly: in 2021, Italy participated in Tasks 11, 25, 30, 34, 41, 47, 48, and 49

Impact of Wind Energy

Environmental Impact

According to the Gestore dei Servizi Energetici (GSE), substituting one MWh produced by fossil fuels with

one produced by wind energy avoids 536 kg in CO2 emissions [9]. In 2021, Italy's wind-generated electricity avoided around 11 million tons of CO2 emissions.

Economic Benefits and Industry Development

In 2021, the economic impact of wind energy in Italy was estimated at around 4.3 billion EUR (4.8 billion USD). This value represents the overall contribution of three different business areas, estimated as follows: new installations (565 million EUR – 638 million USD), operation and maintenance of the online plants (412 million EUR – 466 million USD), and energy production and commercialization (3.3 billion EUR – 3.7 billion USD). The number of jobs in the wind energy sector was estimated to be 16,000 units, including direct and indirect involvement.

Leitwind, the only Italian manufacturer of large-sized wind turbines, accounted for around 1% of the overall installed capacity. In 2021 Leitwind launched wind generators with innovative blades able to withstand typhoons [10]. Vestas has two production facilities in Taranto. Vestas installed 114 over 150 new wind turbines in 2021.

Next Term

Within the NRRP (Mission 2C2.1), a simplification of the authorisation process for onshore and offshore renewable energy farms is planned and will be implemented in the next years.

The Italian Ministry of Ecologic Transition received in 2021 64 expressions of interest for offshore wind projects from companies and business associations [11]. In total, 40 floating offshore wind farm projects were examined, mainly located off the coast of Sicily and Sardinia (more than 20), along the Adriatic coast (more than 10), and for the remainder, distributed between the Ionian and Tyrrhenian.

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