Report 2022
Italy

Beleolico Wind Farm: The first offshore wind farm in the Mediterranean Sea started production in 2022. *Courtesy: Renexia.*

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In 2022, Italy installed 0.5 GW of new capacity, which is consistent with the growth rate of the previous year. The country also installed record-sized onshore wind turbines at 5.7 MW.

Additionally, the first 30 MW offshore wind farm, located in Taranto harbour, started production on the 21st of April 2022. Many offshore wind projects are currently at different authorisation stages, collectively totalling more than 100 GW. To facilitate their development, a new accelerated authorisation process for wind plants has been introduced. In addition to this, three neutral wind and PV auctions were held, with wind plants securing 28% of the total capacity. Following the election of the new Government in October 2022, the Ministry for Ecological Transition was renamed the Ministry for Environmental and Energy Security. Furthermore, the renewable targets for 2030, set by the National Integrated Climate and Energy Plan, are under review, and a significant increase in the offshore wind energy target is expected. Finally, the R&D outlook showed an increase in the number of national projects funded in 2022 through the National Fund for Electric System Research (RdS) and the National Recovery and Resilience Plan (NRPP) supporting actions.

Table 1. Key National Statistics 2022: Italy

Total (net) installed wind power capacity	11.5 GW
Total offshore capacity	0.03 GW
New wind power capacity installed	0.46 GW
Decommissioned capacity (in 2022)	- GW
Total electrical energy output from wind	20.4 TWh
Wind-generated electricity as percent of national electricity demand	6.4%
Average national capacity factor	21.0%
Target	19.3 GW installed capacity at 2030
National wind energy RD&D budget	N/A

Highlights

- Record large onshore wind turbines, 5.7 MW size, were installed.
- The first offshore wind farm, Beleolico Park, started production in April 2022.
- Uptick in offshore wind projects at different authorisation stages.
- Increase in support for wind-related research activities.

Market Development

Targets and Policy

Published in December 2019, the National Integrated Energy and Climate Action Plan (NIECAP) established a target of deriving 30% of overall annual energy consumption from Renewable Energy Sources (RES) by 2030. In this framework, wind energy is projected to constitute a total installed capacity of 19.3 GW (including 0.9 GW offshore), producing 41.5 TWh per year. This goal includes revamping and repowering initiatives.

In 2022, the actuation of the National Recovery and Resilience Plans (NRRPs) started. Initially published in 2021, the plans outline future updates of the objectives of the NIECAP, hereby assisting the "Next Generation EU" actions.

The new Ministry of Environment and Energy Security is in charge of managing RES growth. A new accelerated authorisation process for onshore and offshore wind plants was adopted. However, as of the end of 2022, some policies and regulations remained unpublished and unimplemented. These include the implementation policy for renewable incentive mechanisms, which define auction quotas and base tariffs, furthermore the identification of suitable areas for onshore and offshore wind deployment, and the Maritime Spatial Plan.

Progress and Operational Details

According to the National Wind Energy Association (ANEV), Italy installed a new net wind power capacity of 459 MW in 2022, including the first offshore capacity, consisting of 30 MW at Beleolico Park. This brings the cumulative installed capacity at the end of 2022 to 11.5 GW, including decommissioning and repowering. The trend of annual and cumulative capacity between the years 2010-2022 is depicted in Figure 1. Around 300 MW of small wind plants (plant size lower than 200 KW) should be added to the cumulated capacity.

In 2022, a total of 42 new wind farms were connected to the grid. 16 of which had capacities greater than 5 MW, where the maximum plant size constituted a capacity of 43 MW. 140 new turbines were installed, bringing the country's total to around 7,450 operating units. The installed turbines had an average capacity of 3.3 MW and a maximum of 5.7 MW. In Italy, the average size of all wind turbines installed is 1.5 MW. Of the new turbines, 46% are Vestas, 20% Nordex and 17% Siemens Gamesa. The offshore Beleolico Park consists of ten 3 MW Ming Yang wind turbines.

New wind power capacity was mainly installed in the Apulian region (46%), followed by Campania (19%) and Sicily (15%). 90% of the cumulated capacity is concentrated in six Southern regions: Apulian (25%), Sicily (18%), Campania (16%), Basilicata (12%), and Calabria (10%), and Sardinia (9%).

According to the National Transmission Operator TERNA [1], the overall wind electricity production in 2022, was 20.4 TWh, corresponding to 6.4% of Italy's total electricity

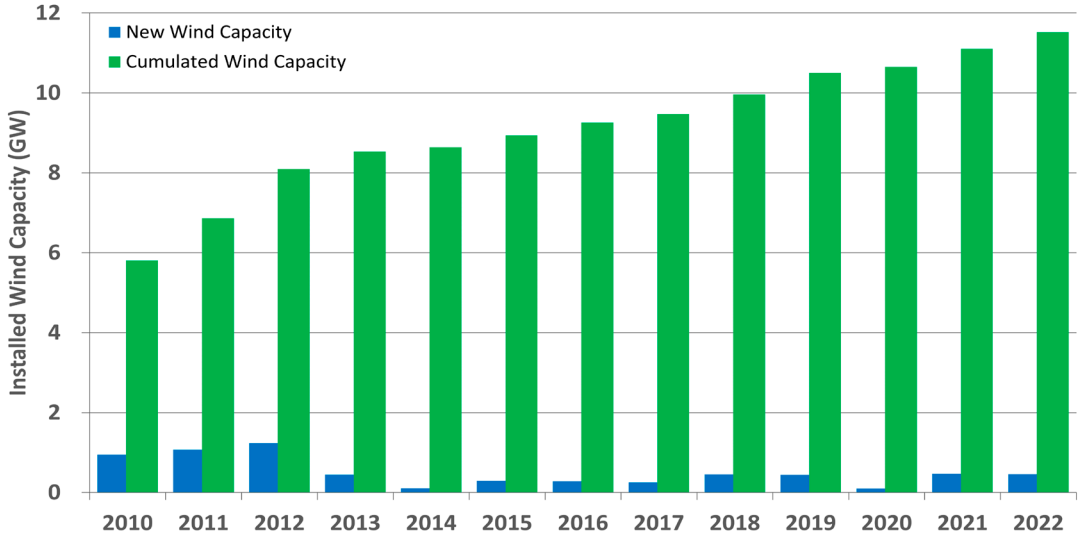

Figure 1: Annual and cumulative wind capacity trend from 2010-2022.

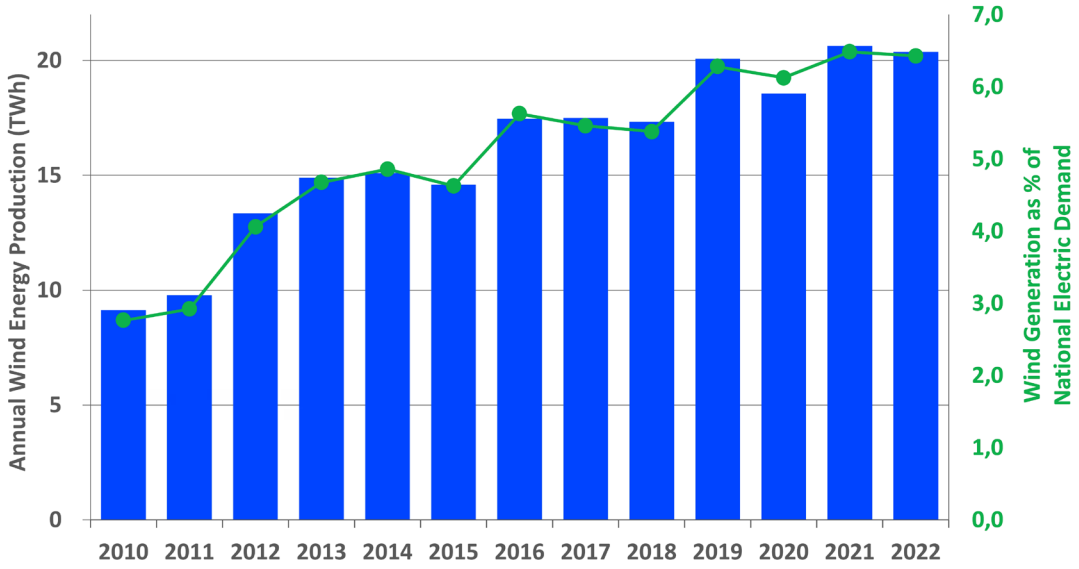

Figure 2: Trend of annual wind energy production and percentage of the electricity demand in the period 2010-2022.

demand (total consumption plus grid losses). The trend of annual wind energy production and percentage of the electricity demand in 2010-2022 is shown in Figure 2. According to the Italian Regulation Authority (ARERA), 2022 curtailments were 1.5% of the total wind energy production. Their reduction is due to National Transmission Grid reinforcements, capital-light interventions (e.g., Dynamic Thermal Rating) and optimisation of the use of assets in real-time to ensure the maximum possible withdrawal of safely produced wind energy. The 2022 national average capacity factor was 21%. The estimated average capital cost of new onshore capacity from 2022 is 1,200 EUR/kW (1,288 USD/kW). Concerning owners/operators, the 2022 installations do not substantially affect the 2021 framework in which, according to ANEV [2], 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%. Additionally, another 20 operators have a share greater than 1%.

Matters Affecting Growth and Work to Remove Barriers

The main incentive mechanism supporting renewables, established by the policy of the 6th of July 2012, relies on fixed energy purchase prices for RES plants. Rates vary depending on technology and size. Specifically, plants larger than 1 MW have a tariff of 70 EUR/MWh (75 USD/MWh), while tariffs increase for smaller-sized plants. Plants with a capacity greater than 1 MW secure fixed energy purchase prices through calls for tenders, provided the annual quota is met. The

prices are granted over the average conventional lifetime of plants. In 2022, three joint tenders for onshore wind and PV were published. The total secured wind capacity was 231 MW (126 MW for new constructions and 105 MW for integral reconstruction). In addition, a range of smaller plants (Capacity < 1 MW), accounting for 105 MW, registered for tenders. The total amount of the secured wind capacity resulted in 28% of the ranked capacity. As of the end of 2022, the implementation policy for the incentive mechanism for the upcoming years had not yet been published.

According to large wind energy operators, the main issues affecting growth are uncertainty regarding future regulations for incentives (mechanisms, quotas, tariffs, etc.) as well as the long and complex permitting process. Concerning the latter, a new accelerated authorisation process for onshore and offshore wind plants was defined in 2022 and will be implemented in 2023.

RD&D Activities

Italian Research Institutes and Universities engage in several activities in the field of wind energy at both basic science and technological levels. These efforts are funded by national and international projects, consultancies for private enterprises as well as self-financing, especially regarding topics concerning fundamental physics.

According to the current institutional organisation, the primary ministries supporting R&D are the Ministry of Universities and Research (MUR) and the Ministry of Environment and Energy Security (MASE).

National RD&D Priorities and Budget

The NIECAP outlines the national energy system priorities for 2030-2050, emphasising the importance of RES contribution to the energy mix. Furthermore, emphasising specific capabilities of offshore wind R&D tailored to Mediterranean conditions. Additionally, the National Recovery and Resilience Plan (NRPP), published in 2021, supports innovative offshore integrated RES technology research efforts, including wind. In 2022, it began to produce its first tangible results.

In 2022, an increase in the number of funded national projects on wind energy topics was observed. Specifically, the two major pillars supporting research are the "National Fund for Electric System Research" (RdS) and the NRPP.

MASE promotes the RdS R&D support programme. It supports scientific and technological innovation in the electricity system to enhance competitiveness, security, and environmental compatibility, as well as ensure conditions for sustainable development. In 2022, a new 3-year programme to support various wind-related research activities started with an allocated budget of around 5 million EUR (5.2 million USD). Under this project, CNR is testing at the MaRELab sea test site, the Hexafloat (Saipem patent) floating offshore wind turbine prototype. Different mooring configurations and materials, including synthetic chains, will be tested. It has a scale factor of 1:6.8 relative to a 5 MW machine and is equipped with a 10 kW TN535 turbine. This is the first FOWT installed in the Mediterranean Sea for research purposes. RSE continues activities concerning the development of wind plants in the Italian territory. Moreover, studies concerning the future deployment of offshore wind are underway, including offshore renewable hybrid systems.

According to the NRPP, large projects in wind energy involving academia, research institutes, and private entities have been funded in 2022. These are organised into groups (named "Spokes") dealing with specific topics. Within this supporting action, the National Research Centre on High-Performance Computing (HPC), Big Data, and Quantum Computing (CN1) has been established. It is coordinated by the National Institute for Nuclear Physics (INFN) and, within Spoke 6 (Multiscale Modelling and Engineering Applications), "Sapienza" University of Rome is actively working on HPC simulations applied to wind energy. Additionally, the 3-year project, NEST (Network 4 Energy Sustainable Transition), is coordinated by the Politecnico of Bari and involves eleven universities, five research centres and nine private companies. Within this project, two Spokes deal with wind energy topics. Spoke 2 (Energy Harvesting and Offshore Renewables) focuses on offshore wind (among other RES). Specifically, research efforts related to floating wind turbines suitable for the Mediterranean area (with breakthrough technologies on platform, turbine, and electric machine) and the integration with wave energy converters. Spoke 5 (Energy Conversion) investigates the development of innovative materials, components, devices, and digital tools. The goal is to improve the efficiency and flexibility of conversion devices, including wind turbines, to reduce CO2 emissions and costs while optimising the exploitation of primary sources.

National Research Initiatives and Results

- Within the RdS R&D project, RSE has conducted a techno-economic analysis of offshore wind plants paired with onshore hydrogen production within a medium-term scenario. The levelised cost of green hydrogen ranged from 0.5 to 5 EUR/kg (0.52 – 5.2 USD/kg) depending on the wind farm site, the curtailment percentage, specific characteristics of the electrolyser, and different incentive hypotheses. The most probable value was found to be around 3 EUR/kg (3.15 USD/kg) [3].
- The Sustainable Energy Research Group of the Department of Mechanical and Aerospace Engineering from "Sapienza"

University of Rome collaborated with Lancaster University, University of Basilicata, and CNR-IMAA (Institute of Methodologies for Environmental Analysis), to develop novel technologies for the fast assessment of wind turbine blade performance degradation caused by leading-edge erosion [4]. Furthermore, to develop multiscale prediction frameworks for offshore wind fields based on numerical weather predictions and high-resolution CFD methods [5].

- Within the framework of the RdS R&D support program, Roma Tre University, in cooperation with the University of Trento, developed an Economic Nonlinear Model Predictive Controller (ENMPC) designed for onshore and offshore wind turbines. The ENMPC is capable of more than real-time computations on standard hardware. Its use has given a notable advantage in power production, with increases ranging from +1% to +5%, depending on load case. The improvement is attributed to the capability of exploiting wind shifts above the rated value (see Fig. 3). The controller, which is also capable of multi-objective functioning, has also been tested for power maximisation/ platform motion reduction on floating offshore wind turbines [6].

- Within the EU project FLOATECH, the University of Florence contributed to the release, verification, and accuracy assessment of the new open-source offshore wind turbine simulation tool, QBlade-Ocean [www.qblade.org]. This software features a highly advanced multi-physics model covering the complete range of aspects required for the aero-servo-hydro-elastic design, prototyping, simulation, and certification of wind turbines.

- Similarly, Politecnico of Turin has released the software MOST (Matlab for OFWT Simulation Tool), a comprehensive model for planning and designing floating offshore wind turbines. It is a wind-to-power tool that includes floating platform hydrodynamics, rotor aerodynamics, mooring dynamics, an electric generator, and controller. MOST features an intuitive and user-friendly structure based on MATLAB-Simulink™ and has accurately reproduced outcomes from the NREL FAST code applied to the IEA 15 MW Reference Wind Turbine sheared turbulent inflow. This replication occurs if the blade aeroelasticity and wave forces acting on the platform are neglected [7, 8].

Collaborative Research

- Italy coordinates the project MARINEWIND, which was started in 2022 and funded by the Horizon Europe programme. It aims to identify bottlenecks and potential opportunities to strengthen floating offshore wind technology FOWT role.

- Politecnico di Milano is a 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 Tasks increased significantly: In 2022, Italy participated in Tasks 11, 25, 30, 34, 41, 47, 48 and 49.

Impact of Wind Energy

According to ANEV [2], employment in the sector in 2022 consisted of 16.000 jobs. Around one-third of which are direct jobs and two-thirds are indirect jobs.

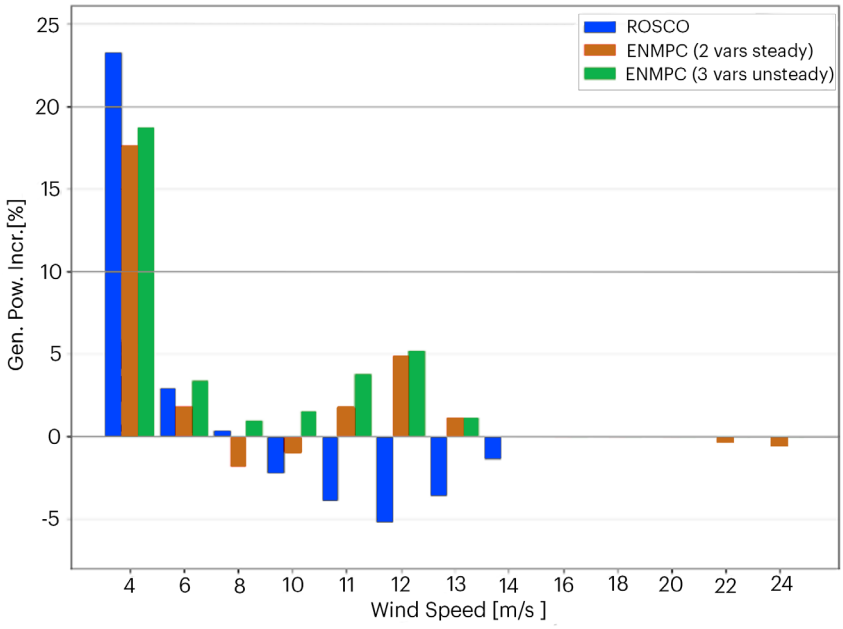

Figure 3: Increase in generated power using two different turbine models in the ENMPC.

Environmental Impact

- According to the Gestore dei Servizi Energetici (GSE), substituting one MWh produced by fossil fuels with one produced by wind energy offsets 536 kg in CO2 emissions. In 2022, Italy's wind-generated electricity offset around 11 million tons of CO2 emissions.

Economic Benefits and Industry Development

- In 2022, the economic impact of wind energy in Italy was estimated at around 4.3 billion EUR (4.5 billion USD). This value represents the overall contribution of three different business areas, estimated as follows: New installations (551 million EUR; 591 million USD), operation and maintenance of online plants (407 million EUR; 437 million USD), and energy production and commercialisation (3.3 billion EUR; 3.5 billion USD) – the latter was calculated with an average wind energy selling tariff of 160 EUR/MWh (167 USD/MWh).
- In 2022, Leitwind, the only Italian manufacturer of large-sized wind turbines, installed several wind turbines totalling 10.8 MW. Vestas announced that its Taranto facility in the Apulian Region will produce the blades of the V236-15.0 MW prototype [9].

Next Term

An increase in the new yearly capacity is expected in the coming years to reach the targets set by the National Integrated Climate and Energy Plan by 2030. Updates to these targets are ongoing and should be finalised by mid-2023. Specifically, a significant increase in offshore wind targets is expected in response to the substantial amount of new offshore wind projects in the pipeline – exceeding 100 GW. Work to identify new suitable areas for additional deployment of onshore and offshore wind areas is ongoing. Offshore wind energy areas must first be defined by the Maritime Spatial Plan strategy, which is yet to be officially published and adopted in Italy by the end of 2022. Finally, a new policy defining the renewable incentive mechanism is expected to be published and implemented in 2023.

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