



Wind turbine and PV panels at the Hybrid complex in Agios Efstratios island, North Aegean, Greece. Photo: CRES.

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The total installed wind power capacity in Greece at the end of 2023 reached 5,226 MW, [1] (11.6% increase compared to end of 2022). The total new capacity installed in Greece in 2023 was 543 MW, well above the 10-year average (336 MW).

A total of 153 new wind turbines with an average nameplate capacity of 3.5 MW were installed, continuing the trend of **increasing average WT capacity** (from 2.6 MW in 2020-2021, to **3.4** and **3.5 MW** in 2022 and 2023 respectively). **Wind energy remains the biggest domestic energy source** for the Greek Electricity system. Wind energy covered 21% of total demand. Combined with PV, hydro and smaller shares from biomass and small hydro, the total renewable

share in the electricity mix exceeded 50%, bringing Greece to the top-10 globally, on what regards the RES penetration to electricity production. Also notable for 2023 is a continuing decline in the annual electrical energy consumption (estimated at 3% compared to 2022).

Table 1. Key National Statistics 2023: Greece

Total (net) installed wind power capacity	5.2GW
Total offshore capacity	0 GW
New wind power capacity installed	0.543 GW
Decommissioned capacity (in 2023)	- GW
Total electrical energy output from wind	11 TWh
Wind-generated electricity as percent of national electricity demand	21%
Average national capacity factor	25.4%
Target	9.5 GW
National wind energy R&D budget	-

Highlight(s)

- The national RES target significantly increased to 37% RES contribution in energy consumption and from 7.0 to 9.5 GW for installed wind capacity.
- The National Plan for the deployment of Offshore Wind Farms released for consultation foresees an additional 1.9 to 2.5 GW of offshore wind by 2030.
- Wind energy continues as major domestic energy source, where the share of wind surpassed 20% of demand.

Market Development

Targets and Policy

The national targets for renewable energy for 2030 were increased in the revision of the National Plan for the Energy and the Climate which is currently under consultation. The new target for the total RES share in energy consumption is 37%, which translates into an 80% share in RES in electricity production by 2030. Following this increase, the estimated wind capacity needed by the end

of 2030 has increased to 9.5 GW (up from 7.0 GW). Offshore wind is estimated to provide 1.9 to 2.5 GW, while the remaining will be covered by onshore wind. Regarding onshore wind, a mean annual installation rate of 250-300 MW per year is needed, which is comparable to the average rate of new installations achieved in the last three years. Targets for offshore wind, which is a completely new field for Greece, may have greater uncertainty regarding its fulfilment by 2030.

An auction system for a guaranteed feed-in price for wind farms and PV systems has been in effect in Greece since 2018. The auction system applies to wind farms with an installed capacity greater than 3 MW competing for eligibility in a "Contract for Difference" payment scheme. In 2022, one auction round was run, common for PV (>1 MW) and wind (3 MW – 50 MW), for 1,000 MW of combined capacity. A minimum technology quota of 30% per technology was applied, aiming to balance the energy mix. A total capacity of 538 MW was finally awarded, of which 382 MW were PV projects and 166 MW were wind farms. The mean price offered by wind farms (57.7 €/MWh) was 1% higher than in 2021. Since the

beginning of the auction system in 2018, a total of 1,585 MW of new wind farms and 1,680 MW of PV systems have been awarded. No auctions for wind nor PV plants were run in 2023 (national election year). The auction system is planned to continue until 2024, with no specific guidance for the successor plan.

Offshore: The **National Plan for the deployment of Offshore Wind farms** was released for consultation in October 2023. The Plan foresees 4,900 MW of potential for medium term development (from 2030-2032) and 6,900 MW for long term development. Due to the large depth of the Greek seas, 80% of the planned capacity is expected to be floating. A national target of 1,900-2,500 MW of offshore wind by 2030-2032 is to be included in the revised NECP. The first batch of 600 MW pilot projects (up to 250 MW each) at preselected areas are planned to start under a feed-in tariff scheme. Within 2023, the first permits for field studies were granted to developers with production licenses for the pilot offshore wind projects.

Progress and Operational Details

The **total installed wind power capacity** in Greece at the end of 2023 reached 5,226 MW, [1] (an 11.6% increase compared to end of 2022). The total new capacity installed in Greece in 2021 was 543 MW, well above the 10-year average (335 MW).

During the year, wind and other non-dispatchable RES penetration to the electricity system reached high values. The maximum 1-hour average wind energy penetration on the main electricity grid was 86%. Wind penetration was above 30% for 2,117 hours in 2023, while the total non-dispatchable RES penetration was higher than 60% for 1,717 hours. Also notable, the total RES penetration exceeded total demand for 120 hours, making Greece a net exporter of RES electricity.

Matters Affecting Growth and Work to Remove Barriers

Licensing: A major review of the licensing framework has been in progress in recent years, aiming to reduce the typical time needed for a wind farm to pass through the licensing procedure in Greece. Currently, this takes eight to ten years and aims to be reduced to the target set by the EU which is two years. The main legislative documents were passed through the parliament in two phases in 2021 and 2022, including the framework for offshore wind development. The effect of the licensing revision will be seen in the coming years.

Grid restrictions: Significant grid reinforcing works are either in progress or planned for the near future. These aim to connect the mainland with all major islands of the Greek archipelagos, which currently operate as isolated, diesel-powered grids. The first interconnection line for Crete (400 MVA) has been fully operational since 2021, while the second line (1,000 MW) is under construction and expected to be fully

operational by 2025. In addition to significant savings in electricity cost, the second line will increase security and improve the quality of electricity provided to the island, and will allow 2,000 MW additional RES capacity to be added in the system when it is in operation. Targeted grid strengthening projects are in progress on the Greek mainland as well.

RES power curtailment: Due to the lack of storage capacity and load management mechanisms, RES power curtailment and “near zero” market prices were experienced in mid-day PV production peak hours. The occurrence of power curtailment events is still low, the total non-dispatchable RES production lost due to curtailments is estimated at 228 GWh (1.2% of total non-dispatchable RES production), but is expected to increase rapidly in the near future.

Public opposition: As the recently revised licensing framework has still not produced any effect on the actual planning and development of wind farms, more positive interaction between the local public and developers and licensing authorities is necessary.

RD&D Activities

R&D activities in wind energy in Greece are funded mainly through EU and national programs. A major funding tool for applied research in Greece is the Program for Research, Technological Development and Innovation “EREVNO” (co-funded by the Greek state and the European Regional Development Fund) whose total budget for the period 2016-2023 is EUR 510 million (all areas). A non-exhaustive review of R&D proposals oriented mainly in wind energy, that were active in 2023 is given in the following [3]:

- AIOLIKOS: Development of an innovative lidar scanning system for wind energy applications.
- PARALOS2: Redesign and operational evaluation of a 50 KW

wind turbine suitable for near shore applications.

- ASSURE: Automated specialised surveillance radar application technologies for the accurate estimation and mitigation of electromagnetic waves emitted from wind turbines.
- AIOLOS: Development of multifunctional fibre-reinforced nano-composites for structural wind turbine parts.

The total budget of the projects above is EUR 3.8 million.

The next major round of national funding for applied research projects is expected to be launched in 2024. The total national funding for all research areas for the period between 2023 and 2030 is estimated at EUR 300 million.

Test Facilities and Demonstration Projects

- **GREEN ISLAND – Agios Efstratios:** The project, managed by CRES, deals with the conversion of a small isolated island grid into a RES powered system. Main power sources on the island will be an 800-900 kW wind turbine and 100-200 kW PV array. A 2.5 MWh Li-Ion battery bank is also foreseen for short term energy storage, while thermal storage for district heating will provide load balancing to limit power shredding and medium-term storage. Diesel generators, currently covering the total electricity demand on the island, will be limited to back-up operation only. **The target value for mean annual RES penetration of 85%, makes the project a small-scale test bench for the electricity networks of the future, where RES will be the major contributor.** Construction work started in 2022, the plant is expected to be fully operational in Q2 2024. (Total budget EUR 8.5 million, co-funded by the by the Greek state and the European Regional Development

Fund, <http://aistratis.agenso.gr/>)

activity in the global offshore wind supply chain.

Impact of Wind Energy

Wind energy produced 11,000 GWh of electricity in 2023 covering 21% of the annual electricity demand in Greece, while offsetting the equivalent of 2.3 million tons of CO₂ emissions. The volume of avoided CO₂ emissions is equal to the emissions of 80% of private cars circulating in Greece.

Wind energy, being the largest domestic energy source, greatly contributes to the reduction of natural gas imports. Additionally, as all other RES, it is to a great extent immune to fossil fuel price volatility, and feeds electrical energy to the grid at stable competitive prices.

On the local level, 3% of electricity sales by all wind farms returns to the local communities as extra funding to the local administration bodies and direct subsidies to the electricity bills of consumers in the communities hosting wind farms. From 2020-2021, a total of EUR 54 million was distributed to local communities through this mechanism.

The total investment value of new wind capacity set in operation within the year in Greece is estimated to be EUR 600 million. By the end of 2023, 300 MW of new wind energy plants were under construction, most of which are expected to be operational within the next 12 months [3]. On the employment field, wind energy is estimated to support the equivalent of 6,500 full time jobs.

Greece has a strong maritime industry and substantial shipbuilding infrastructure and knowhow. Although these are currently underused, they could be exploited for offshore wind, further increasing the local impact of wind energy. It is worth noting that although offshore wind development in Greece is in its early planning stage, three companies based in Greece already have substantial

Next Term

In the revision of the NCEP for 2030 which is under discussion, wind energy is recognised as one of the major pillars for the zero-emission, resilient and independent energy system in Greece. For wind energy to fulfil these expectations, the following challenges must be addressed, as outlined by all members of wind industry in Greece:

- Implementation of the revised licensing framework to allow for fast deployment.
- Deployment of storage capacity.
- Application of load demand management procedures.
- Offshore wind development.
- Local supply chain strengthening and improvement.
- End of life issues.

References

[1] Hellenic Wind Energy Association: <http://eletaen.gr/>

[2] National Plan for the Energy and the Climate (NPEC) <http://www.opengov.gr/minenv/?p=10155>

[3] <http://www.eyde-etak.gr/central.aspx?sid=10614951127416461439523>