Acknowledgement

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Overview of the Greek electricity market

Up to 2011, lignite coal was the dominant source of electricity generation in Greece, contributing to almost 49% of the domestic generation mix, with natural gas following with 27%, large hydro with roughly 9%, oil with 7%, and renewable energy sources (RES) with almost 9%. Since then, the lignite coal generation has substantially dropped and the grid is being supported by natural gas and high voltage, and medium and low voltage RES.

In 2020, the most significant source of energy production was natural gas (36% - 17815 GWh) with interconnections (18% - 8863 GWh) and System RES following (18% - 9263 GWh). The energy produced by lignite was 5722 GWh (11%) and by Network RES was 5536 GWh (11%), while hydro’s market share was 6% (2901 GWh) for 2020.

The National Energy and Climate Plan (NECP) 2030 serves as Greece’s energy strategy for the next decade. It lays down energy and climate objectives for 2030 to address climate change, integrating the European Commission recommendations and the U.N. Sustainable Development Goals. Renewable energy in particular, will be the major domestic source of power by the middle of the following decade, with a share exceeding 65% of the domestic power generation by 2030. Another key objective is ending lignite-based power generation in Greece by 2028. All lignite power plants will be decommissioned by 2023 except one which will change fuel and continue to operate after 2028.

According to the country’s NECP, the most important challenges of the energy market are those related to electricity demand, RES penetration, and decarbonisation.

1 The energy production values correspond to the energy injected in the Transmission system. The “System RES” refer to energy produced by RES injected in the Transmission system (High Voltage - HV), while “Network RES” refer to certified measurements on the Medium Voltage (MV) and estimates on the Low Voltage (LV).

To achieve high penetration of variable RES plants in an economically rational way and preventing curtailment, there is a general need for energy storage. For several decades, pumped storage hydropower has been the most widespread international method for large-scale electricity storage. Today, other forms of storage are rapidly being used for large or small installations, especially batteries of different kinds. The coupling of markets via interconnectors in accordance with the provisions of the new electricity market model is important for achieving high levels of penetration of renewables. There is also interest in power-to-gas (e.g., hydrogen) storage applications, which are also being investigated via interconnection of electricity and gas networks as they are of high interest.

Moreover, given the international interconnections of the Greek mainland system, investigating the needs for storage and coverage at a regional level may also prove cost-effective.

The development of new financial instruments compatible with the new market environment will contribute to required investments in Greece’s long duration storage. We should also refer to the proposed change to the regulatory framework for incentives for implementing such projects, e.g., payment of an additional rate of return on capital costs and/or setting minimum performance indicators to attain actions and targets.

Current status of pumped storage & development potential

Two pump storage power plants are currently in operation in Greece, and both are owned by Public Power Corporation S.A.

- Thissavros PSH: 3 Hydro Turbines, installed capacity for generation 3x128MW, pumping capacity 3x125MW
- Sfikia PSH: 3 Hydro Turbines, installed capacity for generation: 3x110MW, pumping capacity 3x110MW

Currently, PSH plants participate in the Greek electricity market under the provisions of the Target Model (DAM & IDM Trading Rulebook and the Balancing Market Rulebook).

Expert studies on the implementation of new pump storage hydropower, show that the revenues attained from the price differentials (arbitrage) between the off-peak and peak hours within a day, along with the low revenues from the provision of previously mentioned ancillary services stipulated in the Target Model, are insufficient to cover the unit’s fixed investment and administrative costs.

In Greece, the electricity market is deregulated, allowing different promoters to invest in projects and participate in the market, according to European legislation. There is no specific legislation applied to storage at the moment. However, law 4819/2021 introduces an authorizing provision for the issuance of a Ministerial Decision, following the opinion of the Regulatory Authority, which will determine the required actions as well as a binding timetable for implementing the relevant obligations by the competent bodies (Transmission Operator, Market Operator, Network Operator, Exchange Stock market).

PSH installations are remunerated either as consumption or generation entities, and no special provisions exist for PSH. Based on the new “target model” market operation, PSH units can participate in the balancing capacity market by offering ancillary services (FCR, mFRR and aFRR).³

In the near future, PSH systems may be able to participate alternatively under the demand response market framework with more favourable conditions (e.g., special provisions for less strict imbalance tolerances).

The only pumped storage with mature licensing status is Amfilochia (PCI 3.24), which has an installed capacity of 680 MW. As of now, there are two PSH projects (680 MW PCI project in Amfilochia and 180 MW in Amari,

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³ FCR: Frequency Containment Reserves
mFRR: manual Frequency Restoration Reserves
aFRR: automatic Frequency restoration reserves
Crete) in the pipeline, owned by the company Terna S.A. They have been designed but have not yet begun construction due to the absence of a relevant regulatory compensation framework. It is worth mentioning that the incorporation of the relevant regulation will be the trigger for their immediate construction.

According to Greece’s NECP, the total energy transmitted to storage systems for 2030 is estimated to be up to 2.2 TWh. The common finding for Greece is that the increase and possibility of storing electricity, such as using pump storage hydropower, will be required to mitigate the effects of variable production from RES. The Independent Power Transmission Operator (IPTO) for Greece submitted its Ten-year Network Development Plan for 2021–2030, which notes the importance of integrating new storage systems, especially from pumped storage hydropower, to enable the energy transition.

Challenges, barriers and emerging opportunities for pumped storage development

For the challenges and barriers that PSH faces in Greece, two issues seem the most important:

a) Lack of regulatory framework to ensure the feasibility of the investments, since they are capital intensive and require stability of the relevant business plans

b) Because energy prices fluctuate sharply with great uncertainty (even daily, let alone long-term), the markets do not currently offer adequate services remuneration, which leads to the absence of compensation for pumping hydro operations.

The Ministry of Environment and Energy, the National Regulatory Authority for Energy in collaboration with the Independent Power Transmission Operator, are the institutional bodies for addressing the issues. Policy measures to promote the installation of electricity storage systems may vary depending on the technology and type (centralised, dispersed) of the storage system (such as pumped storage projects in Amfilochia and Amari). In particular, the promotion of centralised electricity storage systems is possible by implementing an appropriate purchasing mechanism, which will motivate the construction of storage systems over other electricity generation plants.

In terms of the need for storage/PSH, the IPTO has evaluated the Greek generation system adequacy on a periodic basis, and taking into account existing or mature storage projects. Additionally, the Greek National Energy Climate Plan (NECP) describes a scenario to achieve 2030 climate targets with significant storage capacities, including PSH. The IPTO participates in the NECP monitoring mechanism of the Greek Ministry of Energy, which monitors the evolution of the Greek energy system with respect to the 2030 climate targets and updates relevant studies in order to assess and propose policies and measures to be applied for achieving the climate targets in a cost-optimal way.

In December 2020, the Ministry of Environment & Energy established a Committee to develop a legislative and regulatory proposal for the participation of different storage technologies (including pumped storage) in the electricity market. The Committee has an obligation to submit its proposal within the semester of the year.

Recommendations

Any policy and market framework solutions for Greece should align with those recommendations of the IFPSH’s Policy and Markets Working Group European Regional Paper.

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4 The regulation is in process, following the outcome of a Committee that was established for delivering proposals
5 To achieve its 2020-2030 RES goals, Greece will depend especially on the integration of new storage systems, mainly pumping hydroelectric stations to enable greater variant renewables. See more from: https://www.admie.gr/en/grid/development/ten-year-development-plan