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Abstract

In order for Greece to contribute its due share to the European energy and climate targets for 2030, as laid down by the Clean Energy Package texts and commitments, a true energy "renaissance" has to take place during the coming decade. This "renaissance" is urgently needed, in order to substantially upgrade and decarbonise an antiquated, highly inefficient and polluting national energy system, still relying heavily on domestic low-quality lignite and on imported oil. The scale of the required energy transformation that has to take place in the country, in the 2021-2030 period, if Greece is to meet its 2030 EU goals and international commitments is impressive: according to the Greek National Energy and Climate Plan (NECP, 2021-2030), investments totaling 35 billion euros have to materialise by 2030 in the Greek energy sector alone, two thirds of which will have to be channeled to energy efficiency, renewables and electricity transmission infrastructure/storage. The present paper explores key challenges posed on the Greek energy sector by the EU Energy Transition process and the application of the Clean Energy Package provisions and commitments, in the 2020-2030 period. In the crucial direction of securing the required green energy and the proper infrastructure needed for Greece's energy transformation process, the paper discusses core energy issues, concerns and persisting obstacles that hinder or considerably slow down the required transformation (legislative, administrative, financial, etc.). Based on this analysis, the paper proposes specific policies, measures and top developmental priorities for the Greek energy sector in the coming decade, hopefully providing, as well, useful considerations for other South Eastern European countries.

Keywords

EU energy transition, Clean Energy Package, National Energy and Climate Plans, Greek energy sector, development priorities, investment needs, renewables, electricity transmission, storage, energy financing

1. In pursuit of the Clean Energy Package targets and commitments

In order for Greece to contribute its due share to the European energy and climate targets for 2030, as laid down by the Clean Energy Package texts and commitments, a true energy "renaissance" has to take place during the coming decade. This "renaissance" is urgently needed, in order to substantially upgrade and decarbonise an antiquated, highly inefficient and polluting national energy system, still relying heavily on domestic low-quality lignite and on imported oil. The Greek National Energy and Climate Plan (NECP), officially submitted to the European Commission on 6.2.2019[1], is very clear about the very large scale of the required energy transformation that has to take place in the country, in the 2021-2030 period, if Greece is to meet its 2030 EU goals and international commitments (p. 309 of the NECP, Table 51): investments totaling 35 billion euros have to materialise in the Greek energy sector alone, by 2030, distributed as follows:

Energy subsector		Total required investments (million €) in the 2020-2030 period
1.	**New RES electricity generation units**	8,500
2.	**New and upgraded electricity transmission infrastructure/storage**	5,500
3.	**New conventional (fossil fuel-based) electricity generation units and upgrading of existing ones**	1,900
4.	**New and upgraded electricity distribution networks Digitalisation**	3,300
5.	**Cross-border natural gas pipelines**	2,200
6.	**Natural gas networks and storage**	2,000
7.	**Research and Innovation**	800
8.	**Energy efficiency**	9,000
9.	**Investments in the Oil Refinery sector**	1,500
	TOTAL INVESTMENTS 2020-2030	**34,700**

It is evident from the above table that the three (3) basic investment pillars in the Greek energy system, necessary to comply with the country's EU commitments and targets for 2030, are: a) renewables (25% of total required investment), b) energy efficiency (26%) and c) electricity transmission infrastructure/storage (16%). These three sectors together comprise two thirds (2/3) of the total required investment in the Greek energy sector for the coming decade. More specifically, according to the official NECP (p.275), the energy transformation commitments of the Greek energy system by 2030 require, among others, the installation of about 8500 MW of new renewable (RES) electricity units, out of which 3800 MW will be new wind parks and 4100 MW will be new photovoltaic units. In addition, the NECP identifies the need for massive investment (5.5 billion euros till 2030) in the upgrading and extension of the country's electricity transmission infrastructure, particularly in the interconnection of the autonomous islands of the Aegean Sea to the mainland grid, as well as sizable investments in electricity storage.

According to the latest European Investment Bank strategic paper on Energy Lending Policy[2] (January 2019, p.8):

> "…Integrating variable generation has a number of profound implications on electricity systems and requires greater flexibility over the short term…Renewables can reduce dependence on imported

> fuel but integrating high shares of wind and solar power raises energy security issues. In particular, given seasonal weather patterns across Europe, the electricity system will also need to be able to cope potentially with weeks or months of lower production from wind and solar and meeting peak demand will also remain a challenge, exacerbated by the increasing electrification of heat. This will require continued investments to ensure an adequate infrastructure...Modern economies rely on an uninterrupted and abundant energy and ensuring a high level of security of supply is a necessary condition for the success of the energy transformation."

In this crucial direction, of securing the required green energy and the proper infrastructure needed for Greece's energy transformation process, the top developmental priorities that emerge in the Greek energy sector for the coming decade, apart from energy efficiency, are new RES investments and investments in new electricity interconnections and storage. These top priorities are analysed in the chapters to follow.

2. New RES investments

A point of concern needs to be addressed first, in relation to the Greek NECP's target of 17,700 MW of installed RES electricity units by 2030, out of which 13,400 MW will be variable (wind and PV; NECP, p.302). This RES target is directly linked and relies decisively on the corresponding energy efficiency target that is adopted by the NECP for 2030, which appears to be highly ambitious, if not unrealistic: according to the NECP, the gross national energy consumption in 2030 is to be slightly lower than the one projected for 2020 (23,9 Mtoe in 2020 vs. 23,0 Mtoe in 2030), while the final national energy consumption in 2030 is to increase slightly, compared to the one in 2020 (17,5 Mtoe in 2020 vs. 18,0 Mtoe in 2030). Such a prospect presupposes a true energy-efficiency "revolution" in Greece, in relation to today's total stagnation of the sector. This "revolution" would entail, on the one hand, the rapid and generalised introduction/implementation of relevant new and innovative technologies and, on the other, the provision of substantial financial incentives over the next decade, from budgetary resources that, simply, do not exist. And all these, supposedly would take place under the low GDP growth (<2%) and low energy (and especially electricity) demand rebound rates, assumed by the NECP throughout this period.

Thus, the projected by the NECP evolution of RES towards 2030 turns out, after all, to be "conservative", and is unrelated to the respective RES development of the previous National Energy Plan (2011-2020). The aforementioned, very optimistic target for energy efficiency, supports decisively, by reducing the denominator, i.e. the gross domestic consumption in 2030, the RES penetration target in the gross final energy consumption (31% in 2030). A more realistic target for energy efficiency would obviously require a higher, overall, RES target for 2030.

In any case, even if one adopts the Greek NECP's target of 17,700 MW of RES electricity capacity (mainly wind and PV) by 2030, achieving it will require an annual rate of installation/operation of about 650-700 MW of new RES projects every year for the next 12 years (NECP, p.277), a rate which is almost three times greater than the current rate (200-250 MW/year). Unfortunately, the chronic problems plaguing the implementation of RES projects in Greece for more than two decades now, still persist, and in several cases they are getting worse, problems such as[3]:

- the very long and tortuous RES licensing procedures,
- the hostile RES Space Planning regulations and practices, especially at the regional and local levels (see separate paragraph below),
- the uncertain future of the Special RES Account and its resources that financially support the RES growth,
- the lack of electrical interconnections with RES-rich regions, such as islands, etc.

In addition to those problems, new challenges for renewables have emerged, such as:

- the new auction-based Feed-in-Premium (FiP) system, which still requires significant improvements in its design and operation,
- the continuously postponed application of the Target Model and the regional electricity market coupling, which prevent the full and equitable participation of new RES projects in the electricity market,
- the rapid and very significant changes that many RES technologies and integrated RES schemes are undergoing worldwide, for which a coherent regulatory and space planning framework is missing in Greece (e.g. for energy storage, for offshore/floating wind, etc.).

While all these problems and obstacles impose additional difficulties and requirements for the successful implementation of new RES projects, the policies and measures presented in the Greek NECP, to support its targeted, spectacular increase in RES penetration by 2030, are sketchy and insufficient - at best. For example, extreme space planning restrictions for RES projects, especially for wind farms, have been recently adopted by a number of Greek Regional Authorities, in the context of formulating their new Regional Space Plans, and have been rushed to governmental approval (through Ministerial Decrees), without the necessary prior public deliberation. This development undermines the existing priority of the National Space Plan for RES over the Regional Space Plans, and threatens to ostracise RES - especially wind farms - from most areas of high renewable potential in the mainland. Extensive mountain, touristic and Natura areas are now characterised in these Regional Plans as No-Go areas for wind farms and other RES projects, thus jeopardising the implementation of many RES projects already under development, or new ones in the planning stage. Immediate action should be taken to avoid the adoption of such provisions in the National RES Space Plan, currently under revision, and to reinforce its legal priority over Regional Plans, in case of conflicting provisions.

Moreover, the progressive saturation of viable RES sites on the Greek mainland, primarily for wind but, also, for photovoltaics, will necessitate for a sizeable portion of the new RES electricity capacity projected for 2030 (8.5-9 GW) to be developed either offshore, as near-shore or floating wind parks in the Aegean and Ionian Seas, or as floating PVs on water reservoirs of hydro and pumped storage units. The prospects of significant growth of the offshore/floating wind and PV sectors in Greece, especially in the second half of the coming decade, is of particular importance for the country, due to the multiple advantages and the high added value that these sectors can bring to the Greek economy (very favourable wind/wave and water- reservoir characteristics, activation of the local manufacturing/assembly/installation potential, such as island shipyards for the construction of the floating platforms, installation of the electric substations on rock islets, manufacturing of dedicated subsea cables, etc.). Unfortunately, the Greek NECP is inadequate in clearly outlining these exciting prospects, let alone quantifying them, although they will certainly constitute an integral part of Greece's energy transformation process towards 2030. And, as usual, no solid provision is made for an appropriate legislative framework that will effectively foster and support the rapid development of these technologies and investment opportunities.

In summary, if renewables are to have any serious chance for substantial further development in Greece, the relevant policy support measures -only roughly sketched in the NECP- need to be clearly defined, quantified and prioritised, content- and time-wise. All-the-more so, in case the possible, downward revision of the (overambitious and rather unrealistic) national energy efficiency/conservation targets for 2030, lead to the need for further increase in the (directly related) RES targets.

3. Electricity interconnections and RES hybrid stations in remote regions and islands of Greece

Mountainous remote regions in the Greek mainland, as well as non-interconnected islands, especially in the Aegean Sea, possess a very high RES potential that still remains largely unexploited, due to their weak local grids that cannot handle substantial penetration of variable renewables (wind, photovoltaics).

As a consequence, electricity generation on those remote and island regions is mostly based on antiquated, heavily polluting and energy inefficient fuel-based power plants, which are as unreliable as the local electricity grids, often causing pollution incidents and blackouts in the midst of heavy-tourism periods. Thus, the lack of a) sufficient electricity interconnections with the mainland, in those geographically isolated regions, and b) local RES hybrid stations (e.g. wind/hydro) that can effectively support the weak local grids and increase penetration of locally generated RES electricity, finally ends up depriving the Greek consumers from access to abundant domestic green energy, currently in heavy demand all over Europe, and, thus, from actively participating in the EU energy transition process.

According to the Greek NECP, important and absolutely necessary interconnections of the (electrically autonomous) Aegean islands with the mainland Greece, such as those of the Dodecanese islands and the islands of the North Aegean, are pushed, timewise, towards the end of the 2020 decade, and even later (for the Dodecanese islands in 2029, for the islands of the North Aegean in 2031). The final phase (Phase IV) of the Cyclades interconnection is planned for 2025, so there is an unnecessary gap of at least four (4) years for the next interconnection of the Dodecanese islands and, then, two more years for the North Aegean islands. By delaying the interconnection of the Dodecanese islands with Crete (or directly with Attica), which could be implemented in parallel with the so-called "large" interconnection of Crete, and could be ready in 2023, and not in 2029 (as the NECP foresees), €130 million will be wasted each year from the limited financial resources of the National Budget, in order to pay for the Dodecanese PSO (Public Service Obligation) levies. In total, 6 x 130 = €780 million will be wasted in the 6-year delay of implementation of this interconnection alone.

Since interconnection of the autonomous Aegean islands is declared "a top priority" by the Greek NECP (for reasons of energy security, further RES development, etc.), the relevant timetable should be promptly revised. In fact, the ambitious national targets for RES in 2030 (i.e. 31% penetration of RES in the gross final energy consumption and 56% of RES in the gross electricity consumption), and the ensuing need to integrate thousands of MW of new (mostly variable) RES capacity within the next 12 years, necessitate a complete change in the structure and mode of operation of the country's electricity grids. This enormous task must be preceded by:

i. Studies and tenders for works to upgrade the transmission network in the mainland, especially since the authorisation and implementation schedules of such land-based projects (e.g. the new 400kV Peloponnese Transmission Line) deviate substantially from contracted schedules and, often, incur very significant delays due to increasing local reactions, in comparison to the respective subsea interconnection schedules.

ii. Studies, detailed outline and legislative enactment of a viable and effective institutional/financial framework for electricity storage (which is correctly reported and correlated, by the NECP, with the flexibility of the System), so as to promptly launch the implementation of key storage projects, especially those already included in the European PCI list.

iii. Strengthening of the (weak and insufficient) international interconnections of the country, beyond the construction of the 2nd 400kV Transmission Line, currently being realised with Bulgaria. Rapid promotion and completion of relevant negotiations for the construction of additional 400kV lines with Albania, FYROM and Italy, most likely.

In summary, the appropriate conditions must be created and promptly put in place, at least in terms of the electricity network, that will allow the 8500-9000 MW of new RES projects, forecasted in the NECP by 2030, to be implemented, especially given that their majority will be located in the RES-rich regions of the central and southern mainland, as well as in the southern Aegean Sea (Crete and offshore parks).

For all the above reasons, there is an urgent need for the relevant EU institutions and instruments (EIB, CEF, Commission Initiative on Clean Energy for the EU Islands, Structural Funds, etc.), to place top priority on the sufficient financing of: i) key electricity interconnections of remote and island Greek regions with the mainland, in the 2020-2030 period, such as, for example, the interconnection of the RES-rich Aegean islands (Crete, Dodecanese, North Aegean) with the mainland Greece, and ii) the

construction of local RES hybrid stations in isolated regions with weak electricity grids, for example wind/pumped hydro plants on large Greek islands, and wind/PV/batteries stations on smaller ones. This is the **only way** to provide an export outlet for their huge wind and solar power potential, while, at the same time, solving the islands' acute energy-supply and (energy-related) environmental problems and, most importantly, relieving the Greek consumers from the huge financial burden of billions of Euros each year, that they are currently paying for electricity-related PSO levies.

4. Electricity storage projects, particularly those based on large-scale, mature technologies with very high European and local value

The EU needs to actively support and secure sufficient financing, of energy storage projects, hydro-pumped storage in particular, which is a technologically mature, promptly available, European solution for the Union's accelerating drive towards a Clean Energy Future. It is a well known and well documented fact, for many decades now, that hydro-pumped storage schemes play a key role in enabling energy systems to develop low-carbon electricity production. They supply more flexibility and balancing to the grid, providing a back up to intermittent renewable energy and facilitating its entrance to the energy market. They are also accelerating the decarbonisation of the electricity grid, improving the security and efficiency of electricity transmission and distribution (reducing unplanned loop flows, grid congestion and voltage and frequency variations). They are also stabilising market prices for electricity, while also ensuring a higher security of energy supply.

Europe, and particularly its relatively isolated peripheral regions, such as the South Eastern European countries and, especially, Greece**,** need to find a way to boost energy storage and supplement power grid during peak hours. Hydropower storage is the only large-scale and cost-efficient storage technology available today. Despite promising developments in other energy storage technologies, hydropower is still the only technology offering economically viable large-scale storage. It is also an efficient energy storage option. The system integration capabilities of hydropower are, therefore, particularly useful for allowing the large-scale penetration of wind, photovoltaic and other variable power sources. Systems with significant shares of large-scale hydro with significant reservoir storage will, therefore, be able to integrate higher levels of variable renewables at low cost, than systems without the benefit of hydropower storage.

In this context, it is important to provide a level-playing field for hydro-pumped storage in the European electricity market, and to remove all legislative obstacles that currently hamper the realisation and efficient operation of these systems. In addition to promptly removing such obstacles, the EU (as well as individual Member States) must establish a proper, dedicated and effective legal/technical/financial framework for pumped storage that will allow it to be viable and competitive, on the road to the EU's Clean Energy Transition. In essence, this means that pumped storage should not only be allowed to participate fully in the electricity market, on equal footing with the other electricity service providers, but also to be fairly and equitably rewarded for the multiplicity of crucial services it can offer to the electricity system (flexibility, balancing, congestion management, voltage and frequency stabilisation, increased renewables integration, security of energy supply, decarbonisation of other economic sectors, such as transport and chemical industry, etc.).

The conditions and needs described in the previous paragraph require the launching of two (2) urgently needed and time-consuming actions in Greece, as a matter of top priority:

- The nationwide upgrading and expansion of the country's interconnection infrastructure, particularly in the high-RES areas of the Aegean Sea (analysis given in previous paragraphs); and
- The installation of a sufficient number of new large-scale electricity storage units, and more specifically: (i) Pumped storage stations -as it is by far the most mature and widespread storage technology worldwide- on the mainland and in the large interconnected (or under interconnection) Aegean islands, and (ii) PV-wind-batteries stations in the smaller ones.

Unfortunately, without the necessary documentation and dynamic analysis of the adequacy and stability of the country's electrical system, the Greek NECP adopts the assumption that, besides the already constructed PPC pumped storage hydros of Sfikia (315 MW) and Thesaurus (384 MW), which, however, remain inactive as such, due to the lack of a regulatory framework for storage in Greece, only some rather limited, undefined in nature, energy storage capacity of about 700 MW total will materialise, and this towards the end of the coming decade (beyond 2025). So, while throughout Europe there is a true revolution and extremely rapid pace of investments going on in the electricity storage area, its coverage in the Greek NECP is totally insufficient and vague. The NECP's main assumption, which is deemed unrealistic, is that a 62.5 % RES share in domestic electricity production by 2030, comprising 17,700 MW of RES (of which 13,400 MW variable wind and PV), will be handled smoothly and efficiently by a mere 1400 MW of total storage capacity.

It should be noted that large-scale electricity storage in Greece (pumped hydro in particular) has been put into public debate in the past, and there are enlightening studies simulating its potential operation at the national level, for a series of scenarios of increased RES penetration. In such a detailed and fully documented study[4], carried out by the National Technical University of Athens (NTUA, 2013), the operation of the national electricity system was simulated in 2025, based on the following assumptions: i) an estimated electricity demand in the interconnected system of 68 TWh (compared to ~ 52 TWh today), ii) an annual peak load demand of 12.5 GW (compared to ~ 9.5 GW today), iii) an installed thermal-based power capacity of 10.1 GW (compared to ~ 8.8 GW today), and iv) an installed RES power capacity -together with the capacity of large hydros- of 14.5 GW (compared to ~ 8.6 GW today). The lignite power capacity in the NTUA study was projected at 5 GW and the corresponding natural gas capacity also at 5 GW. Regarding overall RES capacity in 2025, large hydroelectric power plants were projected at 3.1 GW, wind parks at 7 GW, PV stations at 3.5 GW and other RES at 0.85 GW overall.

The mix of the above installed power would yield an overall RES penetration in the country's final electricity demand of about 37% in 2025. Under conditions of lack of storage for such an energy mix and estimated load and peak demand, the NTUA study predicted a 20% curtailment (forced cuts) in wind generation in the system, while with the addition of about 1 GW/1 TWh of pumped storage capacity, the percentage of curtailment would be reduced to 14%, and the wind energy stored in the hydro reservoirs would reach 7.5%.

It is obvious that the above results - illustrating the high value of pumped storage for the national electricity system - become even more impressive, **and the need for such units even more urgent,** under the declared RES targets of the NECP (p.258), namely to reach 41% RES share in the country's gross electricity consumption by 2025 and 56% by 2030 (equivalent to 47.3% and 62.5, respectively, of RES share in the domestic electricity production, to be achieved by 9.3 GW of variable RES in 2025 and 13.4 GW in 2030). The Greek TSO, ADMIE, could not be more clear in its concluding statement, in the latest national TYNDP 2019-2028, approved by the Regulator in late 2018[5] (p. 136):

> "The absorption, of course, of the RES power in the country, envisaged to meet the 2020 and 2030 national targets, is not only dependent upon the capacity to transfer this power through the Transmission System, but also imposes the change in the composition of the national production mix and, above all, the incorporation of new storage systems (**mainly pumped hydro stations**, but also batteries), in line with the evolution of available technologies".

We note that the electricity storage, and any need it faces to support its economic viability (in terms of fair and equitable coverage of its capital and operating costs), should be treated as a System infrastructure and, hence, should be covered by TSO/DSO revenues. This is so, because the country's electrical system is the recipient and user of the multiple support services offered by storage: arbitrage time shift, load balancing, flexibility, voltage and frequency regulation, spinning reserves, prevention of RES production cuts/curtailment, etc.

5. Access to EU financing for the Greek electricity sector

Access to sufficient EU financing, EIB lending in particular[2], is not only a prerequisite, but a condition sine qua non for the rapid promotion and efficient implementation of these important projects (interconnections, hybrid stations and storage), that constitute a central pillar in Europe's Clean Energy Drive and Green Future. Especially for Greece, EIB lending criteria should take into consideration the challenging economic conditions that the country faces, as well as the status of its banking sector. The latter currently focuses mainly on reducing the NPL stock based on aggressive and front loaded targets, an effort that as a result drains management time and energy and limits room for credit expansion initiatives. The limited number of banking institutions operating in Greece (currently four core local banks following the consolidation wave of the past few years) has restricted access to long term financing, which in turn hampers their ability to provide long term financing, an issue that should be factored in EIB's energy financing policy.

In this context, it should also be noted that foreign financial institutions maintain an extremely limited presence in Greece and that their strategy focuses on short-term financings limiting in effect access to alternative financing sources. Concluding, we strongly argue that EIB lending criteria should take into consideration, not only the energy infrastructure areas that represent a priority to achieve medium term targets in Europe's Energy Future, but also the specific conditions of each country. In this aspect, EIB support should be further extended to financing tools with specific characteristics (such as a long term tenors) and guarantee programs that can facilitate local joint lenders support.

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