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Review of the Expansion Plans of the Greek Natural Gas Grid

November 2024

This work has been carried out in conjunction with GREENPEACE Hellas and with the support of the European Climate Foundation under contract DG-2311-67240.

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1. Introduction

In 1987 the Minister of Industry, Energy and Technology Anastasios Peponis signed two Decrees that were destined to have large and lasting repercussions: the agreement between Greece and the Soviet Union for the provision of natural gas (NG) and the founding of the Greek National Center for Renewable Energy and Energy Efficiency (CRES). An agreement with Algeria for provision of LNG followed next year. By 1996, the pipeline from the Bulgarian border (Sidirokastro) to the greater Athens region was finished and filled and in 2000 the Revithousa Storage and Regasification Unit (SRU) received the first liquified natural gas (LNG) load; two years earlier the first NG power plant, converted from oil, commenced operation.

Since then, inland NG consumption has reached a high of 69.65TWh in 2021 from 3.2TWh in 1997, with the majority going to electricity production (48,05TWh) followed by sales to the distribution grid (13,2TWh) and industry (8.78TWh). Inland consumption in 2022 was lower by 19.04% from the 69.95TWh of 2021 (and 63.1TWh of 2020). This reduction was mostly due to a drop of NG electricity generation (down 6.69TWh) due to high NG prices which affected the mix as lignite production became competitive, and industry (down 5.98TWh). Household and other tertiary sector customers reduced their consumption by only 0.98TWh. In 2023, the inland consumption was lower still at 50.93TWh[1] with the decrease due to even lower use in electricity production which went from 20.87TWh in 2021 to 17.45TWh in 2022 and 14.62TWh in 2023[2].

The entry points of the total NG volume imbued in the Greek Natural NG Grid System is shown in Figure 1. Until 2020, NG was provided by imports through the Sidirokastro entry point connection to the Bulgarian grid and the Trans Balkan pipeline from Russia, through the Kipoi interconnection to TANAP in Türkiye and as LNG through the Revithousa SRU (see Figure 2). In addition, a very small amount (from a maximum of 0.14TWh in 2018 to less than 0.04TWh in 2020) was also provided by the Prinos natural gas field. Starting in 2021, an additional amount was provided through the TAP pipeline (Ajeri gas) with Nea Mesimvria as the entry point.

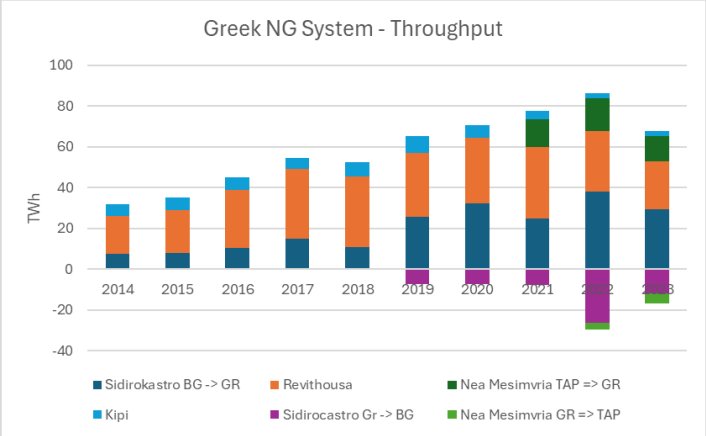

Figure 1: Use of entry/exit points of the Greek National NG Grid

[1] https://www.statistics.gr/documents/20181/bc9cc2cc-d02f-939b-c825-cb0aded645e2
[2] https://www.admie.gr/agora/enimerotika-deltia/miniaia-deltia-energeias

In 2019, Greece imported more NG (65.2TWh) than it consumed with the remaining 7.8TWh (11.8%) exported utilizing the reverse flow capability of the Greece-Bulgaria pipeline. These export amounts increased in the following years to 29.5TWh (34.1%) in 2022 as the new IGB pipeline (commencement of operation in October 2022) became operational and demand was high because of the war in Ukraine and down to 16.7TWh (24.7%) in 2023.

In view of this increasing activity, it is of interest to examine the status of the Greek National NG Grid, to review plans for its upgrading and expansion, to analyze projections for inland demand and to provide technical information on whether the demand in the years to 2050, which is within the lifetime of new planned facilities, can be covered safely and thus whether there is a solid basis for additional expansion.

2. The Greek NG Transport Grid

The Greek NG main Transmission Grid at national level comprises two main branches, one running East to West from Turkey to the Adriatic in northern Greece and a second running North to South from Thessaloniki to Athens and then to Peloponnese[3] as shown in Figure 2.

Figure 2: Map of the Greek National NG Transmission Grid and its connections

The National Grid shown in Figure 2 is owned and run by DESFA S.A. and provides the backbone from which local distribution systems supply NG to residential and tertiary sector customers. It comprises a main high-pressure part of 954km in length and an additional feeder part of 512km. DESFA S.A., the operator of the National NG Transmission Grid is owned by the Greek State (33.3%) and SENFLUGA Energy Holdings S.A. (66.6%), which in turn is owned by Snam (54%), Enagás (18%), Fluxys (18%) and DAMCO (10%). DESFA also owns and operates the Revithousa Storage and Regasification Unit (SRU).

After a decade of vacillation, the NG Grid is now also connected to Bulgaria with the new IGB pipeline as shown in Figure 2. Furthermore at least four enterprises have sought permits to

[3] Greek Draft NECP, August 2024

build and operate floating SRUs (FSRU) to be connected to the National Grid. Of those, the Alexandroupolis FSRU, owned by GASTRADE, S.A. has been constructed, received operating license in August 2024 and started commercial operation on 1 October 2024. A second one, Dioryga FSRU in Corinth is well on its way to be fully permitted with the latest in-situ inspection from Ministry of Environment and Energy inspectors having taken place on 8 November 2024. According to Dioryga GAS S.A. the owner of the project and a subsidiary of MOTOR OIL S.A., the final decision of the €340Milllion investment needed, is awaiting the consent of the European Commission for co-financing from Greek State funds at a level and terms close to the €270Million assistance provided[4] to the Alexandroupolis FSRU. At the same time, In March 2024, the necessary permits for the construction of the connecting link from the planned site in Corinth to the National NG grid by DESFA were approved and DESFA has included this construction in its 10-year plan to 2033. The other projects for the construction of FSRUs, by Elpedison S.A. in Thessaloniki and by Mediterranean Gas, S.A. in Volos are further behind in permitting and market tests.

All four FSRU projects are associated with NG electricity plants with the new one of 840MW at Alexandroupolis already under construction and the ones, of similar power rating, in Thessaloniki and possibly Corinth are planned to be constructed at the sites of their existing NG power plants.

Yet, to accommodate this increased import capacity to be provided by the additional planned FSRU, a number of bottlenecks in the existing National NG Grid need to be removed. These bottlenecks are clearly depicted in Figure 3 below (without the Volos FSRU).

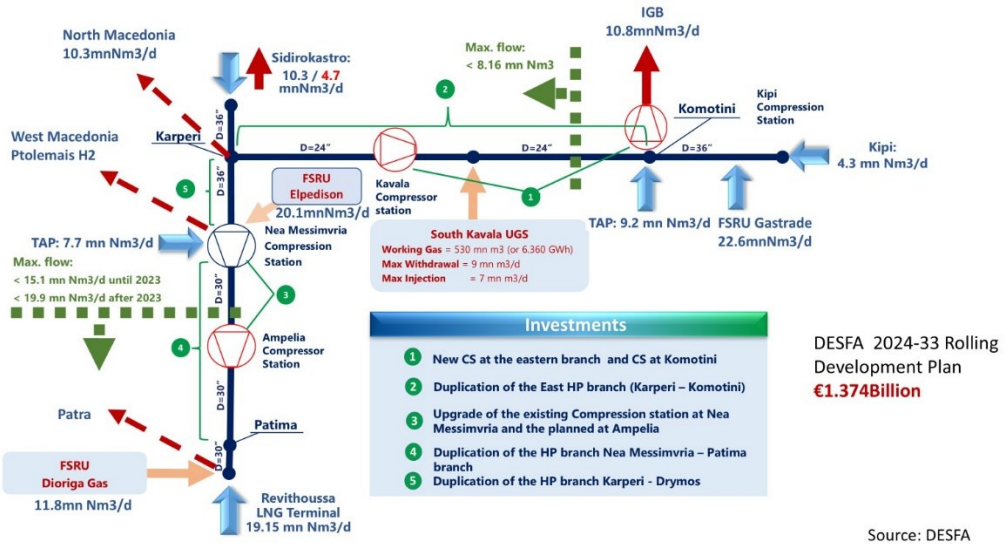

Figure 3: A detailed presentation of capacities and bottlenecks of the Greek NG Grid

The diameters, and hence their carrying capacity, and compression facilities in the sections from Revithousa to Patima and Nea Mesimvria can barely handle the Revithousa daily

[4] https://www.gastrade.gr/en/2023/10/02/european-commission-approves-e106-million-to-support-completion-of-lng-terminal-in-alexandroupolis/

throughput and need to be upgraded to be able to handle the additional import from the planned Dioryga FSRU. The same is true for the segment from Komotini to Karperi which may be called to handle part of the additional NG from the Alexandroupolis FSRU and to which the planned underground storage facility (UGS) at the exhausted oil fields outside Kavala is to be possibly connected. Figure 3 does not depict some hydraulic mis-match issues that might temporarily curtail flows such as the one between Kipoi and Komotini[5]

3. DESFA 10 year Rolling Development Plan

This seems to be the strategic target of DESFA as seen from its latest (September 2024) draft 10-year Rolling Plan[6]. The draft Plan calls for a total amount of €1374Million for the 10-year period 2024-2033 in investments (up from €1275Million in the previous one for 2023-2032) to be spent as follows:

1. Grid enhancement and expansion (€820.7Mil)
    - €92.1Mil for HP pipeline from Nea Mesimvria to the North Macedonia border (FID taken, planned operating date Jan 2025)
    - €124.9Mil for a new compressor and regulation station in Komotini (FID taken, planned operating date Feb 2025)
    - €73.9Mil for a new compressor and regulation station in Ampelia, Farsala (FID taken, planned operating date May 2025)
    - €47.9Mil for additional Booster compressor for connection to TAP (FID taken, planned operating date Oct 2025)
    - €310.6Mil for a 2nd HP connection from Karperi to Komotini (pending FID in Jun 2025, planned operating date Dec 2026)
    - €150.6Mil for a 2nd HP connection from Patima to Livadeia (pending FID in Oct 2025 planned operating date Dec 2026). The cost for a 2nd HP extension from Livadeia to Karperi is under evaluation.
    - €20.7Mil for metering and regulation station to the connection of Dioryga Gas FSRU (pending FID Feb2025, planned operating date Oct 2026)
2. Connections to existing power plants and industrial units(€31.4Mil)
    - €19.3Mil for the HP pipeline and connection of the LARKO installations (in operation Dec 2024)
    - €6.7Mil for the connection of the new NG power stations at Komotini (in operation Dec 2024)
    - €5.4Mil for the connection of the ELVAL installations (FID taken, planned operating date Dec 2026)
3. Extensions to service planned power plants (€24.2Mil)
    - €3.9Mil for the connection to a planned NG power station in Thessaloniki (FID taken, planned operating date Oct 2025)
    - €7.5Mil for the connection to planned NG power station in Larissa (pending FID Jun 2025, planned operating date Jun 2027)

[5] https://www.rae.gr › ΣΠΔ-Απόφαση 163/2023

[6] https://www.desfa.gr/userfiles/consultations/DRAFT_TYDP2024-2033.pdf f

- €12.8Mil for the connection to a planned NG power station in Alexandroupolis (pending FID Jun 2025, planned operating date May 2027)

4. Extensions of the Grid to provide services to new regions (€314.9Mil)
   - €194.1Mil for HP pipeline to the Ptolemais area and measuring/regulating stations to feed the towns of the old lignite plants and the converted Ptolemais V to NG after 2028 (FID taken, planned operating date May 2025)
   - €5.9Mil for measuring/regulating stations to distribution networks to towns East Peloponnese (FID taken, planned operating date Jun 2025)
   - €13.5Mil for measuring/regulation stations to distribution networks in Central Macedonia (FID taken, planned operating date Jul 2025)
   - €101.4Mil for HP pipeline to feed Patra area (pending FID May 2025, planned operating date Dec 2026)
5. Infrastructure improvements (152.6Mil)
   - €39.2Mil for the Revithousa installations upgrading to handle small scale LNG and trucks (FID taken, planned operating date Dec 2025)
   - €13.9Mil for compression of fugitive methane gas in compressors (pending FID Mar 2025, planned operating date Dec 2025)
   - €99.5Mil Various miscellaneous infrastructure improvements (FID taken, in planned operating date for most in 2025, for the rest few in 2026)
6. Investments in New works (€30.4Mil)
   - €8.3Mil for a new measuring/regulating station for the connection to the Kavala UGS
   - €8.3Mil for a new measuring/regulating station for the connection to the EastMed
   - €13.8Mil for a new H2 pipeline and mixing station from Amyntaio to Komnina

From the list above, a number of conclusions as to DESFA strategic priorities can be made, namely:

a. This 10-year 2024-2033 Rolling Plan is for all intents and purposes a 3-year Plan as only 3 works totaling 35.82Mil i.e. a miniscule 2.5% of the budget are scheduled for after the 3-year period.
b. The lion's share (€820.4Mil or 60%) will go to the enhancement of the main NG Grid, increasing its capacity to both import and export larger quantities. This includes works to lift the choke points that might arise because of the smaller pipeline capacities west of Komotini and south of Ampelia (see Figure 3). This enhancement is foreseen in two phases, one of boosting compressor capacity and a second of enlarging carrying capacity. Both are scheduled to take place in the next one to two years with the first phase of €246.7Mil having already secured positive final investment decision (FID) and with expected completion date in 2025. The FID for the second phase of €461.2 is expected to be taken in early 2025 with a planned completion date in 2026.
c. The connection to supply North Macedonia with NG (at least the part of the infrastructure in Greece) is to be ready in 2025. Note that North Macedonia has only one other minimal connection to the Bulgarian grid.
d. DESFA expects that the Dioryga GAS S.A. (a subsidiary of MOTOR OIL, S.A.) FSRU will probably be built (even though MOTOR OIL, S.A, its ultimate owner has hinted strongly that it expects State assistance of the same order as that given to the Alexandroupolis

one before making its FID. The Dioryga FSRU has secured environmental permits and a site visit by Ministry of Environment and Energy staff to issue an installation license took place on 8 Nov 2024. On the other hand, no provisions are included in the 10-year Plan for connections of the other two FSRUs in Thessaloniki and Volos.

e. The second largest tranche of €314.7Mil or 38% is for grid extensions to cover needs of some large industrial units (€31.4Mil) and of the industrial/residential/tertiary sectors in three regions, Nafplio/Argos and Patra in the Peloponnese, the Edessa/Naousa/Veroia corridor in Central Macedonia and the Ptolemais/Amyntaio/Kastoria corridor in Western Macedonia where the Ptolemais V lignite would most likely be converted to NG after 2028, and after 2030 substantial Hydrogen production is expected to take place.

f. The funds for the works are to come from DESFA own capital and loans and possibly subsidies. The only source for the loans mentioned is EIB for the North Macedonia pipeline (€92.1Mil). Three projects, the Western Macedonia pipeline and associated works (€194.1Mil), the upgrading of Revithousa installation to handle small scale LNG tracks (€39.2Mil) and the fugitive CH_4 emissions recompression facility (€14.4Mil) have submitted requests for or have secured approval of subsidies from the 2014-2020 and 2021-2027 ESPA Funds of the order of 50% of the investment costs. The investments are expected to be recovered from fees for the use of the system.

The upshot of these works, most to be completed by 2025-2026, is to double the capacity of the main trunk of the HP grid and eliminate bottlenecks, and to expand the Medium Pressure (MP) and Low Pressure (LP) grids to cover more populated areas for the NG distribution enterprises to increase retail connections from ca 600,000 currently to over 1,000,000.

It would also enable an increase of entry points capacity as imports from the proposed FSRUs in Corinth by Dioryga Gas as well as the ones less advanced in Thessaloniki and Volos can be handled by the pipeline increased capacities.

Table 1: Import & Export Capacity

	Import		Export	
	MWh/d	TWh/yr	MWh/d	TWh/yr
Sidirokastro	117493	42.30	66285	23.86
Revithousa	224592	80.85	0	0
Kipi	48592	17.49	0	0
Nea Mesimvria	53368	19.21	53368	19.21
IGB Komotini	124760	44.91	124760	44.91
Alexandroupolis *	172811	62.21	0	0
Total	**741616**	**266.98**	**244413**	**87.99**
Total w/o IGB input	**616856**	**222.07**		
North Macedonia	0	0	118664	42.72
Dioriga	135946	48.94	0	0
Total w/o IGB input plus Dioriga	**752802**	**271.01**	**363077**	**130.71**

* The import capacity of the Alexandroupolis connection is larger at 94.5TWh/yr but limited by regasification capacity of the FSRU. In view of the

grid technical limitations the capacity until the Komotini compressor upgrade is finished is restricted to 46,000MWh/d

In Table1 above the current and foreseen in the next two years import capacities[7] at each entry point to the NG Grid are shown. It should be noted that the import/export capacities of Table 1 do not include the carry- through capacity of TAP which does not involve the National NG Grid but is for transit to Italy.

4. DESFA 10-year Demand Forecasts

In September 2024, DESFA published[8] its Demand Forecast Study 2025-2034 as the basis for its 2025-2034 10-year Rolling Development Plan. The baseline scenario (see Figure 4) assumes that inland NG demand will continue to grow to 2034 at which point it would reach 76.68 from a high of 77.75TWh in 2030, with 63.58TWh in 2025 and 50.39TWh in 2023. The increase according to DESFA is due to a large increase in electricity demand in 2024-2026 as the lignite plants are phased out and a smaller in absolute numbers but not percentage wise (50%) increase in industrial use.

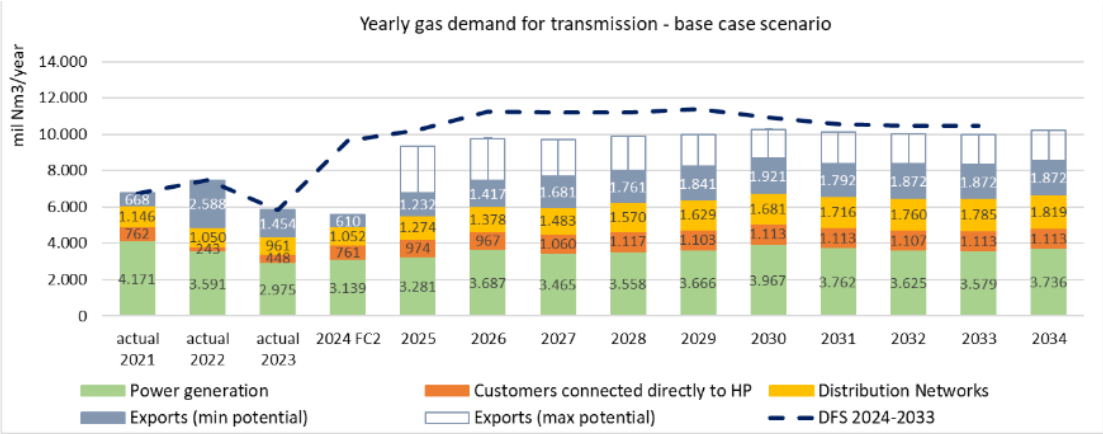

Figure 4: The DESFA projections for inland and export demand on an annual basis

At the same time, exports are, according to DESFA, on the way to almost double, from 16.69TWh in 2023 to as much as 42.71TWh in 2025 and 38.6TWh in 2030, and almost the same (40.25Wh) in 2034. These values are almost equal to 56% of the inland consumption in 2030-2034 from 33% in 2023.

Of interest is also the forecast daily peak demand[9] for transmission base case values (see Figure 5) to be compared with existing and expected capacity at entry and exit points of the National Grid.

[7] https://www.rae.gr › ΣΠΔ-Απόφαση 163/2023

[8] https://www.raaey.gr/energeia/wp-content/uploads/2024/12/demand-forecast-study-2025-2034_final_638688146187462373.pdf

[9] https://www.raaey.gr/energeia/wp-content/uploads/2024/12/demand-forecast-study-2025-2034_final_638688146187462373.pdf

The daily peak inland demand is seen to reach 47.80MilNm3/d (549.70GWh/d) in 2034 and 43.15MilNm^3/d (496.32GWh/d) in 2030 from 30.7MilNm^3/d (353.7GWh/d) in 2023. These peak demands are lower than the values shown in Table 1 of the 617.1GWh/d current import capacity to be boosted up to 734.7GWh/d if the Dioryga FSRU is built. The current capacities can accommodate easily even the high scenario daily peak values of 505.98GWh/d and 558.56GWh/d for 2030 and 2034 respectively leaving an additional 10% safety factor.

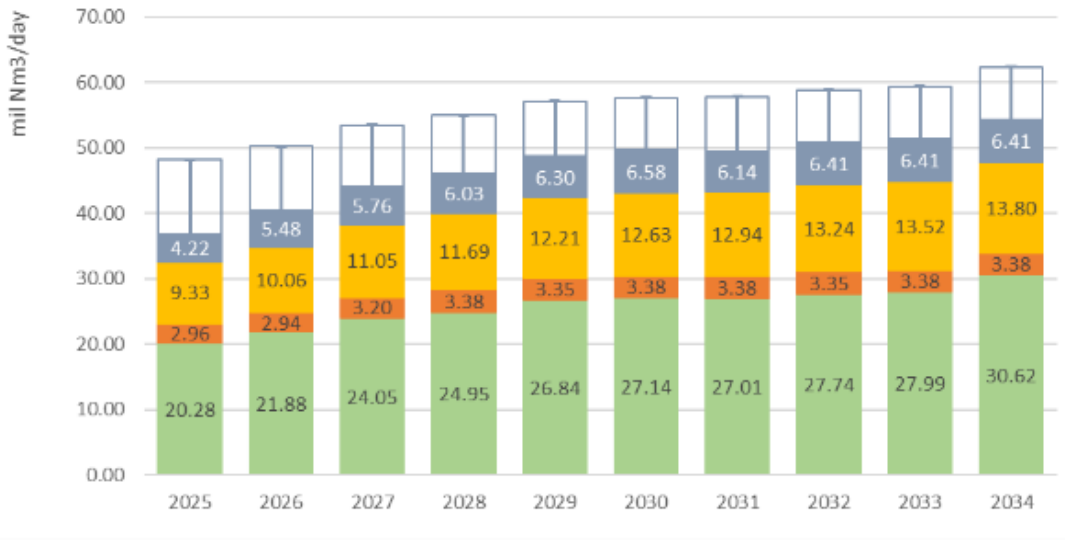

Figure 5: The DESFA peak daily projections for inland and export demand Green indicates power generation demand, red industrial demand, orange distribution network demand, gray minimum export demand and white maximum export capacity.

The third FSRU (in Thessaloniki) also awaiting FID but fully licensed by the Regulatory Agency for Waste, Energy and Water (RAAEY) - if it goes ahead - will add an additional ca 58.5TWh/yr bringing the total LNG import capacity to 169.6TWh/yr by 2025-2026. A further 59.9TWh/yr may be added later from the fourth planned FSRU in Volos. Furthermore, very short-term spikes can be addressed through the recent addition of at least 155,000m^3 of LNG storage to the 130,000m^3 of Revithousa and the 153,000m^3 of LNG of the Alexandroupolis FSRU, without counting the possibility of the Kavala oil field being converted to NG storage (although recently the possibility of it being used as a CO_2 storage facility instead has surfaced). On top of the three planned FSRUs, lately Gastrade, the owner of the Alexandroupolis FSRU announced plans for a fourth planned FSRU[10], "Thrace FSRU", also near Alexandroupolis with LNG storage capacity of 170,000m3 and regasification capacity of 22.7MNm3/d (258.2GWh/d). This raises the question of whether the three planned FSRUs are indeed needed and would be financially viable, a question already raised in the press[11].

[10] https://www.gastrade.gr/en/the-company/

[11] https://www.dw.com/el/%CE%AC%CF%83%CE%BA%CE%BF%CF%80%CE%B5%CF%82-%CE%BF%CE%B9-%CE%B4%CE%B1%CF%80%CE%AC%CE%BD%CE%B5%CF%82-%CE%B5%CE%BA%CE%B1%CF%84%CE%BF%CE%BC%CE%BC%CF%85%CF%81%CE%AF%CF%89%CE%BD-%CE%B3%CE%B9%CE%B1-%CF%84%CE%BF-lng-%CF%83%CF%84%CE%B7%CE%BD-%CE%B5%CE%BB%CE%BB%CE%AC%CE%B4%CE%B1/a-65367364

In November 2023, DESFA published[12] the results of a market test call for non-binding requests for capacity in all entry and exit points of the National NG Grid. The results for entry points are summarized in Table 2. Interested parties submitted non-binding firm requests as shown in Table 2 where the maximum requests submitted are seen to be fully covered by the capacity of all existing entry points except Nea Mesimvria (connection to TAP).

Table 2: Results of non-binding requests for DESFA entry capacity		
(GWh/d annual basis)	Techical capacity (GWh/d)	Maximum annual Request (GWh/d)
Sidirokastro	117.49	73
Nea Mesimvria	53.37	150
Kipoi	46	72
Revithousa	224.59	90.5
Alexandroupolis	172.81	118.5
Dioryga	135.9	15
Thessaloniki FSRU	162.6-235.3	100
Argo (Volos) FSRU	N/A	68.9

The Thessaloniki and Volos FRSUs have no definite capacity values yet, but the range of the Thessaloniki one as inscribed in their operating permit also covers fully the demand. Furthermore, requests for all exit points (disregarding those to export imports from the Volos FSRU) are also covered by the existing exit points capacity.

5. The 2023 RAAEY System Adequacy Exercise

The works included in the 10-year Rolling Plan are in line with the results of a system adequacy exercise[13] carried out by Greek Regulatory Agency for Energy (RAE) in July 2022 to determine whether the Greek National Grid can cope with a complete cut-off of Russian NG supply for very short terms of operation (hours and days up to a month) focusing in the period 1/1/2023 to 31/3/2023 and aiming at analyzing impacts of the war in Ukraine. The Adequacy Exercise was repeated and upgraded in 2023[14]. The 2023 Study examined the period up to and including the winter 2025-2026. It took into account the characteristics and supply requirements of the Balkan region and especially those of Bulgaria and was based on a number of assumptions for the situation in Greece that have changed in the meantime, and specifically that the Komotini NG power plant will be in operation at the end of 2025 whereas it is already conducting acceptance trials and that the Amphilochia pumped storage hydro plant will come online in by the end of 2025 which is unrealistic.

The basic scenarios examined were five with 16 sub-scenarios (one 7-day periods with extreme temperatures and with and without Russian gas & 3 subs-scenarios, a second with 2-weeks with a cold snap with and without Russian gas & 2 sub-scenarios, a third with 30 days of normal temperatures and disruption of the largest entry facility & 6 sub-scenarios, a fourth with 30 days of high demand & 4 sub-scenarios, and a fifth with 150 days without Russian gas. All include export of 3 levels (13,500, 25,000 and 65,000MWh/day) to Bulgaria to cover obligations to crucial costumers and vital facilities there. The impacts were estimated for four

[12] *https://www.desfa.gr/userfiles/5fd9503d-e7c5-4ed8-9993-a84700d05071/%ce%9c%ce%a4%20DAR-%20vf.pdf*

[13] https://www.rae.gr › ΣΠΔ-2022_22072022

[14] https://www.rae.gr › ΣΠΔ-Απόφαση 163/2023

user classes, NG power stations, industrial units, protected consumers of high importance (public and medical facilities, schools, airports, etc) and exports.

The results were for the 3 winter periods 2023/24, 2024/25 and 2025/26. Focusing on the 2025/26 period in particular, in view of the fact that the other winters are already past or on us, the results showed that:

- There was negligible impact to protected costumers in all scenarios
- Industrial customers will be affected at a manageable level only in the sub-scenario of a month with normal temperatures but with Revithousa out of line for the duration
- Electricity production will be affected at a manageable level in all sub-scenarios of the disruption of service at Revithousa for a month. It will suffer undesirable impacts which will call for close surveillance and even pro-active measures in a week of extreme temperatures and no import of Russian gas.
- Exports will be impacted at a not-acceptable level for the sub-scenario of both cut-off of Russian gas and Revithousa off-line for a month, and at an undesirable level for the sub-scenario of very high inland demand and cut-off of Russian gas.

Based on the above it recommended enhancement of a number of NG facilities for longer term security that included the construction of the FSRUs in Alexandroupolis and Corinth, the upgrading of the major compression stations and the completion of the IGB pipeline enhancement. Of those four, three, namely upgrading compressor capacity, duplicating the main pipelines, and the operation of IGB and the Alexandroupolis FSRU are already under way or planned in the 10-year Plan for the next 3-year period. The fourth, the Dioryga FSRU in Corinth will most likely go ahead pending a FID in Spring 2025 aiming to go into operation in 2026. In addition, it included in the works that would be able to improve the performance of the system under extraordinary circumstances, the construction and operation of the Kavala UGS which would add to the system a 11.5TWh storage capacity to be inputted at a 46GWh/d rate.

It also proposed a number of corrective measures for handling extraordinary conditions. These include (i) capacity to plan entry point availability and SRU unloading schedules (ii) plans for provision of vital industries (specified a priori), (iii) strengthening of business continuity assurance for industrial facilities and other core installations (iv) making obligatory the storage of alternate fuel in NG dual-fuel power stations, (v) keeping lignite stations on standby for the next three years, (vi) DESFA to compile an estimate of expected upcoming winter demand by April of each year and others.

So, at first glance, the Greek NG system seems able not only to cover fully its inland demand under stressful conditions but also export sizable amounts to the rest of the Balkan countries and Italy.

6. The August 2024 Greek NECP

On 22 August 2024 the Greek government, after a long delay, announced the latest final draft of the National Energy and Climate Plan (NECP) and posted it for public consultation with a deadline of 16 September 2024. Even though the updated Draft NECP should have been

submitted to the European Commission by 1 July 2024, the final draft, which should have taken into account the results of the public consultation, has not yet been released.

The Gross Inland Consumption of NG for the period to 2050 according to the August 2024 version of the NECP is shown in Table 3. It also calls for slightly higher net imports of which the extra amount is used in bunkering. Going toward the net zero emissions target in 2050, all sectors show a decrease in final energy NG consumption, as does NG consumption for electricity generation which most likely is only for electricity grid stability purposes. As a result, by 2030, yearly NG Gross Inland Consumption is projected to be 3790ktoe (44.1TWh) down by 14% from 4404ktoe (51.2TWh) in 2022. Sectoral total FEC does not change much (i.e. by only ca 1%) between 2022 and 2030, but the consumption immediately afterwards in the residential and tertiary sectors drops substantially so that by 2050 from 575ktoe in 2022 and 620ktoe in 2030 is down to 145ktoe in 2040 and 88ktoe in 2050. By 2050, NG FEC from all sectors is as low as 120ktoe down by 70% from 2022.

This leads to a much lower value to be imported as evidenced also from the net import projections shown in Table 3.

Table 3: NECP 2024 NG consumption (ktoe)

	2023 balance	2022	2025	2030	2035	2040	2045	2050
Industrial (Table 32 NECP24)	569	569	512	425	392	124	96	80
Transport (Table 33 NECP24)	27	14	30	129	169	173	103	90
Residential (Table 34 NECP24)	466	466	541	513	300	135	89	71
Tertiary (Table 37 NECP24)	109	109	145	107	67	10	10	17
Agriculture (Table 38 NECP24)	10,2	10	0	0	0	0	0	0
Total FEC (all above)	1181	1168	1228	1174	928	442	298	258
NG Net Elec generation Table 31		1642	1049	894	370	378	378	413
NG installed capacity (GW) Table 31		6,3	7	7,9	6,4	6,4	6,4	6,4
Plant effective efficiency (assumed)		0,52	0,55	0,55	0,55	0,55	0,55	0,55
Estimated NG used	3154	3158	1907	1626	672	688	688	750
Total FEC & elect NECP2024	4335	4326	3135	2800	1600	1130	986	1008
Gross Inland Consumption NECP24 (Table 29)	4404	4647	4007	3790	2585	1758	1608	1396
NG net import (Table 29 NECP24)	4464	4626	3986	3973	2905	2191	2104	1955

It is interesting to compare (see Table 4) the NECP projections for NG Gross inland Consumption (GIC) and net NG imports, with the DESFA projections. DESFA projections are higher for the whole period from 2025 to 2032. A reason for this is the overestimation of the NG demand for electricity production which is expected according to DESFA's projection to go from 19.9TWh in 2023 to 22.6TWh in 2032 whereas NECP calls for substantially lower NG fired electricity production of 12.2TWh in 2022 to 10.4TWh in 2025, 4.3TWh in 2030 and 4.4TWh in 2035. The difference is partially due to the assumption in DESFA projections - but not in NECP - of the construction and operation of the planned fully permitted new 826MW Elpedison NG power plant in Thessaloniki.

Table 4: NECP vs. DESFA NG inland consumption projections (TWh)

	2022 act	2022	2023	2025	2028	2030	2032
NECP24 GIC	4404	4647		4007	3877	3790	3308
NECP24 net imports	4404	4626		3986	3980	3973	3546
DESFA 2023-32	4404		3585	4304	4319	4205	3953

The draft 2024 NECP also calls for the production of 1.0TWh of H_2 by 2030 increasing to 6.7TWh by 2040 and reaching 20.2TWh by 2050 with 90% going to the production of synthetic fuels and ammonia. A preferred location for the electrolysis plants is West Macedonia where almost all the lignite plants including the Ptolemais V plant to be converted to NG after 2028 are located. To this purpose, the new €190Million HP pipeline to the Ptolemais area is designed to be 100% H_2-ready, as are the other major planned pipeline additions listed above. DESFA hopes to have a 1000km parallel H_2-ready pipeline grid by 2030. The Alexandroupolis FSRU connection is also 50% H_2-ready as is the planned Dioryga one. The amount of H_2 though to be inputted into the National NG Grid is planned to start in 2035 at ca 1.8% by volume and is not to exceed 2.4% by 2050.

7. The Medium and Low-Pressure Distribution System

Beyond NG use for electricity production, of interest is the expectations of NG penetration in the other sectors and in particular the residential and tertiary ones serviced through mostly the low pressure distribution networks of Enaon EDA and HENGAS. The November 2024 projected expansion[15] is shown in Figure 6 below.

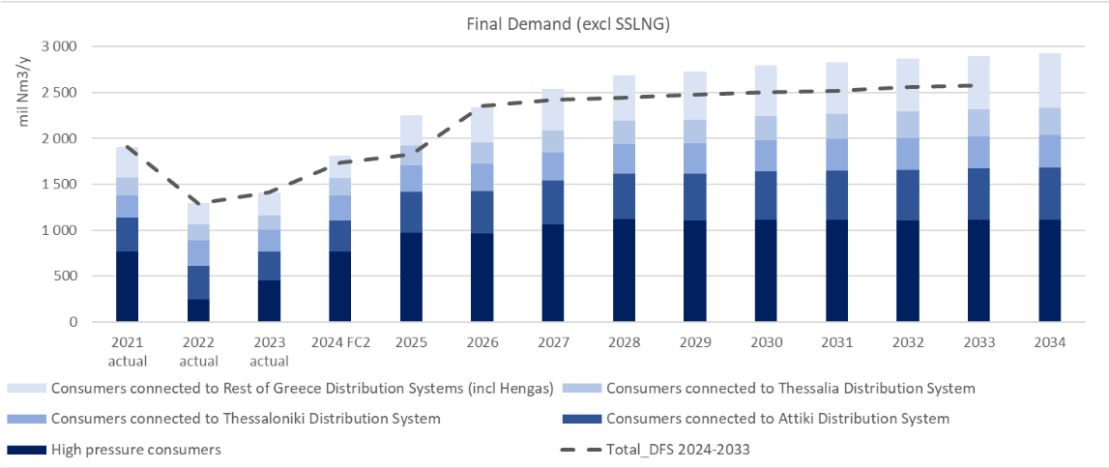

Figure 6: The projections of regional demand to be serviced by the MP and LP grids. The SSLNG not included refers to CNG-LNG substations supplied by trucks for local networks

The expected demand increase of almost 45% between 2023 and 2027 reflects the planned expansion of the distribution networks in towns of West and Central Macedonia (Grevena, Kastoria, Florina, Livadeia, Giannitsa, Amfissa, Veroia, Karpenisi, Orestiada, Alexandria)[16] and Patra to be based on the HP pipelines included in the 10-year DESFA Rolling Plan above. This would result in more than 920,000 retail customer connections by 2029 for Enaon EDA alone[17].

[15] https://www.raaey.gr/energeia/wp-content/uploads/2024/12/demand-forecast-study-2025-2034_final_638688146187462373.pdf
[16] https://www.energygame.gr/synentefkseis/416670/morgkante-se-30-000-nees-syndeseis-fysikou-aeriou-fetos-stochevei-enaon/
[17] https://energypress.gr/index.php/news/enaon-eda-emfasi-se-nea-kai-prasina-diktya-sto-neo-pentaetes-2025-2029-analytika-oi-ependyseis

To these new markets one should add the ones of Ioannina and Kastoria to be serviced initially by local LNG Hubs (SSLNG) supplied by trucks for which the investments for the necessary increase in loading facilities are already inscribed in the 10-year Rolling Plan. These are to be replaced in due course by future grid expansions.

8. The need for more public investment into NG infrastructure

An analytical overview of the current capacity and planned expansion of the Greek National NG Grid and the projections of the inland NG consumption demand in the next decade and on to 2050 presented above leads to a number of conclusions, namely:

1. An analysis of the DESFA demand estimates in the medium term to 2032 coupled with the data on the current status of NG import facilities capacities (222.17TWh) Sidirokastro, Revithousa, Nea Mesimvria, Kipoi and Alexandroupolis FSRU), leads to the conclusion that all inland NG consumption needs (maximum 69.96Twh in 2021 down to 56.64TWh in 2022 and 50.93TWh in 2023, even the maximum DESFA projected one of 77.75TWh in 2030) can be fully covered even in the event of service disruption to one of them. This provides a satisfactory safety margin and in addition ample room for re-exporting. The full coverage of inland needs is still accomplished even after both Sidirokastro and Nea Mesimvria entry capacity is subtracted to make room for export at full reverse flow capacity there. The possible addition of the Dioryga FSRU will further enhance the ability of the National Grid to meet the demand for the next decade.
2. The existing facilities already provide enough import capacity to satisfy both inland consumption and existing export capacity demand as stated in the offers for capacity reserve.
3. The excess capacity, after inland needs are satisfied, will increase in the future if one or more of the planned FSRUs (Dioryga, Thessaloniki and Volos) and especially the Dioryga one is added and demand for electricity production continues to decrease.
4. The existing facilities can also cope with high peak daily needs and extreme circumstances as the 2023 RAAEY Adequacy Study has documented.
5. The existing LNG storage facilities (Revithousa 260,000m^3 LNG, Alexandroupolis 135,000m^3), if full, can cover the average inland needs by themselves for at least 15 days without any imports from any source, thus providing some security of supply in cases of emergency.
6. The demand projections of DESFA for the next decade are higher than the ones of the Greek draft NECP. This is based on a larger projection of needs for electricity production and for final energy demand in the industrial, residential and tertiary sectors. DESFA and the distribution grid owners Enaon EDA plus HENGAS project a large increase (almost double, from ca 530,000 in 2023 to ca 1,000,000 in 2029) in customer connections, especially in the next 3-5 years. On the contrary, NECP envisions lower needs as the building stock is renovated and assumes a larger use of electricity in heating (as well as other uses) in the residential and tertiary sectors.
7. The Greek NECP projects large decreases of NG use in the 2030-2050 period especially for electricity production. By 2050, the projected inland use of NG would be 1396ktoe

(16.23TWh) down by 70% from the current 4647ktoe (54.05TWh). This would lead to increased overcapacity and stranded investments in view of the long lifetime of the facilities.

These conclusions bring up three quandaries that need to be answered as a matter of policy: (a) should the three proposed FSRUs and especially the most advanced that of Dioryga Gas in Corinth be supported by public funds as Dioryga already seems to be asking for in order to come to a positive FID, (ii) should increases in rates for users, in view of the monopolistic nature of the TSO in which the State already has a 33% stake, be granted by RAAEY to repay commercial loans for the expansion and (iii) should public support be provided to DESFA for the expansion of the HP grid and the distribution companies for the extension of the MP and LP grids in view of the NECP implied policies for the reduction of fossil fuels to meet the 80% (wrt to 1990) GHG emission reduction target inscribed in the Greek Climate Law and the net zero EU target by 2050.

Answers to the first quandary seem to include, from the State's point of view, non-financial considerations which though open the door to the debates on policy choices. These are clearly summarized in the "Vertical Natural Gas Corridor" concept. According to the Greek Ministry of Foreign Affairs[18], "The **Vertical Natural Gas Corridor"** is a network of existing and future natural gas infrastructure projects (natural gas interconnecting pipelines, LNG terminals, natural gas storage facilities) that will significantly enhance energy security conditions in the SE and Central regions of Europe, but also in Europe as a whole". An overview of the grid and companies involved is shown in Figure 7.

Its purpose is "The transport / transit of Azeri natural gas from the "Trans-Adriatic Pipeline" (TAP) and Liquefied Natural Gas (LNG) from various sources, through Greece (entry point) and Bulgaria (transit country), to the countries of Central, Eastern and SE Europe, for whose markets it is estimated that the demand for natural gas will strengthen significantly in the coming years". An unstated purpose in the above definition is providing an alternative to these countries to the low-price Russian gas from which EU is trying to wean itself.

[18] https://www.mfa.gr/en/foreign-policy/economic-diplomacy/energy-diplomacy/

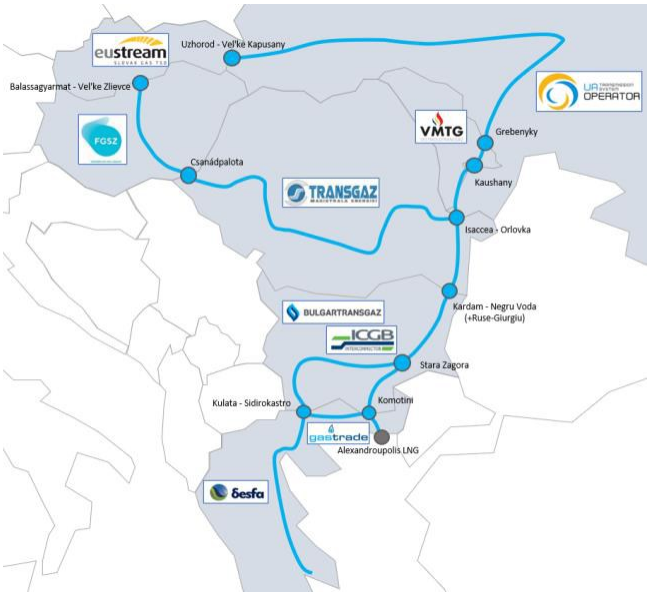

Figure 7: Map of the "Vertical NG Corridor" with the NG enterprises involved

This political choice, which seems to override economic considerations, provides an answer to the second quandary as well, although a question of transparency and inadequate information to the public arises at a time of high energy prices and their effect on household budgets and enterprise competitiveness.

From the economic point of view, the danger of stranded investments cannot be ignored as the Fit-for-55 and the Net Zero by 2050 targets fully embraced by all EU MSs clearly call for much less use of NG already in the next decade and thus will shorten the repayment period of the investments which have lifetimes beyond 2050 and, as a consequence, without State assistance or higher prices for the consumers would be non-viable. A further consideration might be the possible dual use of the grid to transport H_2. The Greek NECP though does not call for any import or export of H_2 (even though the Alexandroupolis FSRU and the proposed Dioryga one are 50% H_2 ready) as it includes enough capacity to produce all the green H_2 needed to feed the local production of synfuel and synthetic ammonia. Thus, it would need no extra import facilities and the transport of H_2 would only be local. DESFA though plans a new export "dedicated" H_2 pipeline of 24TWh/yr capacity and parallel networks for internal transport to industrial parks[19].

The answer to the third quandary should be looked for in whether the needs of households, for energy, mostly for heating, the tertiary sector and enterprises can be serviced better by other sources and in particular electricity which according to the Greek NECP would be provided almost fully by RES. In this, a number of studies such as the ones by NTUA[20] have shown that heat pumps are economically advantageous and the preferred option together with biofuels in the Greek draft NECP, so if State support is to be provided it should be in these.

In summary, the backbone of the NG infrastructure in Greece is seen to be more than adequate to service all current and anticipated demand as well as to re-export non-negligible NG

[19] DESFA presentation (Thomadakis, Head S&D) 1st Greek Turkish Energy Forum, Istanbul 25 April 2024
[20] http://www.lsbtp.mech.ntua.gr>system>files

quantities to the Balkan countries. Enhancement plans seem to be based on expectations of it becoming a strong regional NG hub, and a large gateway for LNG to the Balkans and beyond to replace Russian supply. As such, and in view of the medium-to-long term Greek and EU targets for decarbonization and RES penetration, viability on solely economic terms of additional investment is questionable and should be left to private risk-taking initiatives.