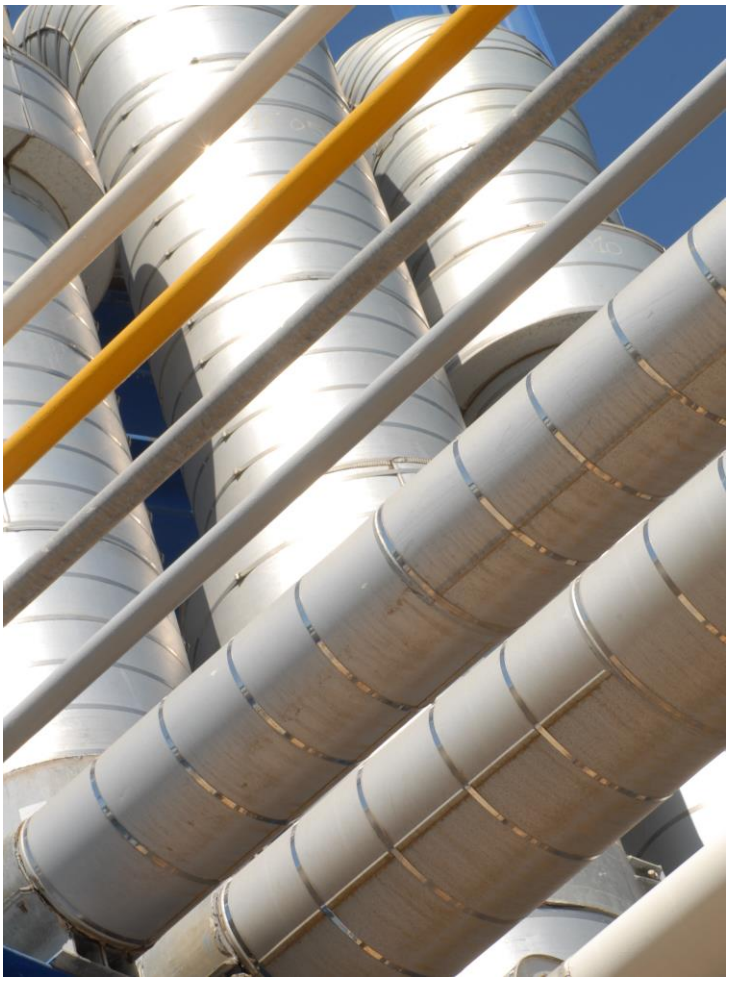

Development Study 2018-2027

Amendment of Chapter 3

October 2017

DESFA
Hellenic Gas Transmission System Operator S.A.

The English translation is not binding. In the event of discrepancies between the Greek and English version, the Greek text prevails.

Significant fluctuations in the data/assumptions, used to implement simulation models of the wholesale electricity market, have led to significant deviations from the market in recent months.

In order to better anticipate the demand for the Development Study 2018-2027, the forecast of the demand regarding the electricity sector, which is the most volatile sector, is updated. The study conducted by the Aristotle University of Thessaloniki was updated taking into account new market conditions and the simulations were performed on two of the four scenarios (high and basic), taking into account the new data.

This update results to the amendment of Chapter 3 and the related part of the executive summary chapter, the amendments of which are set out below.

AMENDMENT OF EXECUTIVE SUMMARY

DESFA drafted a study regarding the forecast of demand and allocation for the reference period 2018-2027 taking into consideration:

i. The latest developments in electricity market
ii. The most recent historical data of gas demand
iii. The latest forecasts regarding the Gross Domestic Product
iv. The latest forecasts regarding the development on crude oil and CO2 emission allowances prices
v. Data and estimations from Gas Distribution Companies, as established in January 2017, and as expected to be formed in the future

The demand scenario of the abovementioned study is based on two distinct sections and constitutes Chapter 3.1. of the Development Study 2018-2027.

- Section A: "Gas consumption forecast for electricity production provided in the wholesale market during the next decade (2018-2027)", as performed by the School of Electrical and Computer Engineering of the Aristotle University of Thessaloniki (AUTH)

- Section B: "Annual Demand Forecast and geographical-daily allocation of other consumers' demand for the period 2018-2027", performed by DESFA.

The study conducted by the Aristotle University of Thessaloniki led to two possible scenarios (1st high demand scenario, 2nd medium demand scenario). DESFA in collaboration with AUTH and taking into account the latest data of the market considered that the 2nd scenario (medium demand scenario) is the most likely scenario to be realized, which combined with the results of the study for Other Consumers, constitutes the basic scenario of the reference period 2018-2027. The key assumptions for this scenario are presented below.

Key assumptions of the Study

The key assumptions used for the drafting of the study are summarized below:

- In the study performed by AUTH the correlation of the estimated GDP with the demand and the peak of the system was done and the expected increase of the system load (consumption) and the peak load of the electricity sector for years 2018-2027 is estimated. Thus, the total power production over the reference period is estimated to range from 51,92 TWh (in 2017) to 58,78TWh (in 2027).
- The assumption regarding the CO_2 emission allowances will be kept at low levels. AUTH's estimate is that the prices will range from 6,5 €/tn CO_2 for year 2018 – 11 €/tn CO_2 (in 2027).
- The procurement price of natural gas is the main parameter for the determination of the variable cost of n.g. thermal units. AUTH's forecast for Brent prices are equal to 51 $/barrel for year 2017, 55 $/barrel for year 2018, and of 60 $/barrel for years 2019 and onwards.
- RES injections are calculated by AUTH based taking into account the target at a national level as well as historical data from both ADMIE website and Monthly RES reports of LAGIE.

- Environmental constraints in a series of lignite units, with the obligation of limited operation for the following years until their full withdrawal are taking into account. These units will operate for a maximum of 17,500 hours.
- The new lignite unit "PTOLEMAIDA 5" is expected to operate commercially in June 2021. MELITI 2 unit is considered to start commercial operation in January 2025.
- Two new hydro units are expected to start commercial operation, "Metsovitiko" (29 MW) and "Mesochora" (160 MW).
- Cyclades islands are expected to be interconnected with the mainland in year 2019, while Crete is expected to be interconnected with the mainland system in year 2022 through an AC transmission line (underwater cable) at 150 kV with a maximum transmission capacity equal to 2x140 = 280 MW. In 2025, it is expected that a second underwater cable (DC) of Crete (2x350 MW) will be operational, and hence there will be no congestion anymore between the mainland transmission system and Crete.
- The expected growth of medium and low pressure distribution networks of EDA is considered to begin from 2020 onwards.

Main conclusions

a) Annual natural gas demand for year 2018 is expected to be equal to 4.284 Nm^3.

From year 2019 onwards, new Small Scale LNG projects will contribute to the annual demand quantities and from year 2018 onwards annual demand related to gas transit via reverse flow and through Greece-FYROM interconnector is taken into account.

The total estimates of gas demand per consumption category for the reference period 2018-2027, is presented in the following table.

Estimation of Natural Gas demand

Estimation of natural gas demand [mil. Nm3/year]	PP n.g. demand	Other Consumers		Transit of n.g.	Small Scale LNG	Total
		Customers connected to HP network	Distribution networks			
2018	2.814	569	891	10	-	**4.284**
2019	2.710	570	934	50	1	**4.264**
2020	2.795	572	990	100	2	**4.459**
2021	2.812	573	1.039	500	18	**4.941**
2022	2.743	573	1.085	550	29	**4.980**
2023	2.757	573	1.122	600	53	**5.104**
2024	2.750	574	1.163	620	82	**5.189**
2025	2.558	574	1.193	650	93	**5.068**
2026	2.749	574	1.225	650	122	**5.321**
2027	2.773	574	1.255	650	151	**5.404**

b) The peak daily demand for the year 2018 is expected to be equal to 20mil. Nm3/day. The expected peak of the system for the years of the reference period is presented in the following table. The notable deviation in between the forecasted following peak of year 2018 in comparison with the actual 2017 peak (23.6 mil. Nm3/day), is due to beyond the usual electricity exports from Greece to the northern neighboring countries due to the Europe-wide energy deficit, combined with the extremely unfavorable weather conditions during this winter in Greece, resulting in a much higher than expected consumption of natural gas. Such extraordinary harsh conditions are not expected to take place frequently during the years to come, especially in combination.

Estimation of Daily Peak demand

	TOTAL NNGS (Nm^3/day)					
	Power Production	Other Consumers		Transit flows	Small Scale LNG	Total
		Customers connected to HP Network	Distribution Networks			
2018	11.786.176	2.504.195	5.737.968	34.247	-	20.062.585
2019	11.988.518	2.506.330	6.059.411	171.233	49.300	20.725.492
2020	12.437.398	2.508.465	6.566.117	342.466	49.300	21.854.445
2021	14.086.506	2.512.735	7.119.238	1.579.148	94.701	25.392.327
2022	13.104.566	2.513.392	7.620.051	1.750.381	166.702	25.155.091
2023	13.755.013	2.514.059	7.990.198	1.921.613	261.403	26.442.286
2024	12.307.814	2.514.783	8.351.849	1.990.107	329.505	25.494.058
2025	13.063.880	2.515.470	8.689.004	2.092.846	374.906	26.736.106
2026	12.915.837	2.516.166	9.003.514	2.092.846	488.409	27.016.772
2027	13.203.673	2.516.166	9.281.039	2.092.846	601.912	27.695.636

c) The following table summarizes the abovementioned results:

Estimation of Natural Gas demand 2018-2027

Unit/load category	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Lignite units [MWhe]	**15.318.664,04**	**15.639.746,48**	**14.453.760,36**	**13.994.642,12**	**15.381.411,50**	**15.463.923,85**	**15.586.928,90**	**17.866.765,15**	**16.799.543,13**	**16.787.609,99**
Gas units (PPC) [MWhe]	6.086.393,66	5.866.875,91	6.000.928,56	7.309.542,74	7.547.352,87	7.443.287,69	7.562.374,49	6.956.561,58	7.468.176,45	7.552.838,20
Gas units (IPPs) [MWhe]	8.369.758,12	7.948.642,02	8.322.866,34	7.364.081,87	6.858.099,85	7.020.205,03	6.880.317,33	6.340.012,80	6.928.225,78	6.978.339,87
Gas units [MWhe]	**14.456.151,78**	**13.815.517,93**	**14.323.794,90**	**14.673.624,61**	**14.405.452,72**	**14.463.492,72**	**14.442.691,82**	**13.966.232,66**	**15.058.360,77**	**15.212.698,12**
Crete CCGT Unit [MWhe]	0,00	0,00	0,00	0,00	0,00	0,00	0,00	669.658,28	661.958,54	681.520,05
Hydros [MWhe]	**4.346.367,27**	**4.347.472,52**	**4.614.622,11**	**4.607.899,62**	**4.610.282,47**	**4.611.735,02**	**4.615.891,42**	**4.613.768,00**	**4.613.304,90**	**4.613.494,11**
Imports [MWhe]	11.291.645,71	11.325.959,22	11.401.458,43	11.387.925,44	11.427.770,13	11.415.179,00	11.443.426,39	11.325.423,14	11.428.066,90	11.472.576,22
Exports [MWhe]	3.224.708,99	2.925.478,61	2.878.496,83	2.877.038,29	2.838.255,70	2.839.403,07	2.859.186,34	2.891.773,04	2.840.673,79	2.864.484,08
Net imports [MWhe]	**8.066.936,71**	**8.400.480,61**	**8.522.961,60**	**8.510.887,16**	**8.589.514,43**	**8.575.775,92**	**8.584.240,05**	**8.433.650,10**	**8.587.393,11**	**8.608.092,15**
Wind plants [MWhe]	5.277.677,01	5.742.060,86	6.149.751,50	6.527.986,19	6.761.501,63	6.873.138,68	7.001.783,89	7.096.413,08	7.208.049,88	7.319.686,54
PVs [MWhe]	3.794.022,82	3.887.689,55	3.940.819,39	3.987.489,37	4.037.038,57	4.086.356,05	4.138.715,44	4.184.291,59	4.232.909,78	4.281.294,83
Biomass/Biogas [MWhe]	346.455,70	404.975,98	466.645,86	525.840,71	586.274,01	646.705,68	709.050,92	767.570,58	828.003,12	888.436,30
Small hydros [MWhe]	756.672,64	780.220,51	801.967,23	819.290,90	838.826,99	858.362,36	880.326,90	897.433,12	916.969,16	936.504,69
Small co-generation [MWhe]	160.183,51	163.213,18	163.868,26	163.213,18	163.213,18	163.213,18	163.868,26	163.213,18	163.213,18	163.213,18
Total RES/Co-generation units [MWhe]	**10.335.011,68**	**10.978.160,08**	**11.523.052,24**	**12.023.820,35**	**12.386.854,38**	**12.627.775,95**	**12.893.745,41**	**13.108.921,55**	**13.349.145,12**	**13.589.135,54**
Total production [MWhe]	**52.523.131,48**	**53.181.377,62**	**53.438.191,21**	**53.810.873,86**	**55.373.515,50**	**55.742.703,46**	**56.123.497,60**	**57.989.337,46**	**58.407.747,03**	**58.811.029,91**
Gas units' percentage [%]	27,52%	25,98%	26,80%	27,27%	26,02%	25,95%	25,73%	24,08%	25,78%	25,87%
Pumping [MWhe]	**25.146,33**	**24.853,95**	**28.390,44**	**24.520,43**	**25.347,57**	**27.407,64**	**29.277,40**	**30.531,41**	**29.620,21**	**29.540,66**
System load [MWhe]	**52.497.985,28**	**53.156.523,56**	**53.409.800,66**	**53.786.353,28**	**55.348.167,90**	**55.715.295,81**	**56.094.220,13**	**57.958.805,72**	**58.378.126,90**	**58.781.489,12**
System losses [MWhe]	**1.055.825,24**	**1.095.003,60**	**1.081.720,60**	**1.107.433,32**	**1.179.451,82**	**1.190.839,86**	**1.207.791,28**	**1.309.905,94**	**1.338.206,85**	**1.347.609,11**
Total demand of consumers (with distribution network losses) [MWhe]	**51.442.159,97**	**52.061.519,95**	**52.328.079,95**	**52.678.919,91**	**54.168.716,06**	**54.524.455,98**	**54.886.428,80**	**56.648.899,89**	**57.039.919,95**	**57.433.880,00**
PP n.g. demand [kNm3]	**2.813.673,10**	**2.709.708,98**	**2.795.387,93**	**2.812.038,56**	**2.743.136,71**	**2.756.539,25**	**2.750.226,34**	**2.558.091,22**	**2.749.426,21**	**2.772.913,83**
Other Consumers demand [kNm3]	**1.460.528,08**	**1.504.130,21**	**1.561.262,14**	**1.611.770,05**	**1.657.821,22**	**1.695.036,18**	**1.737.103,75**	**1.766.500,73**	**1.799.364,14**	**1.829.399,86**
Transit of n.g. [kNm3]	**10.000,00**	**50.000,00**	**100.000,00**	**500.000,00**	**550.000,00**	**600.000,00**	**620.000,00**	**650.000,00**	**650.000,00**	**650.000,00**
Small Scale LNG [kNm3]		**1.183,20**	**2.366,40**	**17.516,00**	**29.232,00**	**52.664,00**	**81.896,00**	**93.496,00**	**122.496,00**	**151.496,00**
Total transmission of n.g. [kNm3]	**4.284.201,18**	**4.265.022,39**	**4.459.016,48**	**4.941.324,61**	**4.980.189,94**	**5.104.239,43**	**5.189.226,10**	**5.068.087,95**	**5.321.286,35**	**5.403.809,70**

the use of natural gas from the AdG unit for thermal use is included

In Chapter 3.4. of the present study, both scenarios results are presented.

AMENDMEND OF CHAPTER 3: DEVELOPMENT OF NATURAL GAS MARKET 2018-2027

3.1 DEMAND FORECAST FOR THE PERIOD 2018-2027

The term “demand scenario” refers to the forecast of annual total consumption of n.g. as well as to the natural gas daily peak demand per year, where both are based on certain estimations/assumptions.

For the preparation of the Development Study 2018-2027, all latest data currently in force, concerning the Greek natural gas market, have been taken into account.

Demand forecast is one of the most important responsibilities of the Operator of the NNGS, as it forms the basis for its design, development and operation. The forecasted demand is also a key parameter for the calculation of the NNGS charges and the hydraulic simulation of the system in order to evaluate new investments related to connection or development projects.

The demand scenario is based on two distinct sections:

A. the gas demand for electricity generation has been particularly analyzed and quantified in a study named “Gas consumption forecast for electricity production provided in the wholesale market during the next decade (2018-2027)”, as performed by the School of Electrical and Computer Engineering of the Aristotle University of Thessaloniki and

B. the gas demand for clients other than electricity producers for the period 2018-2027 has been quantified and analyzed in a study named “Annual Demand Forecast and geographical-daily allocation of other consumers’ demand for the period 2018-2027”, performed by DESFA.

3.1.1 Natural gas demand forecast for power production

To estimate the natural gas consumption from power producers on an annual and daily basis for the 2018-2027 reference period, a simulation of the Greek wholesale electricity market on a daily basis is executed for the relevant period, taking into account the specificities of each mechanism for the solution and clearing of the market (mandatory pool for 2018 or simple power exchange for years 2019-2027) based on the most updated regulatory framework.

According to the provisions of the Power Exchange Code (PEC) and the Market Operation Manual, the Greek wholesale day-ahead electricity market is currently organized as a centralized mandatory pool, in which the market operator solves on a daily basis a short-term unit commitment problem for the following day (also known as “Day-Ahead Scheduling” or DAS), performing a co-optimization of energy and reserves (primary, secondary). These models take also into account several unit technical constraints and

hence the problem is formulated and solved as a Mixed-Integer Linear Program (MILP). Consequently, the production units, provided that they will be committed in the DAS schedule, are dispatched from their technical minimum to their available capacity (or within the corresponding limits when they operate under Automatic Generation Regulation, according to the provisions of Article 44 of PEC).

However, by the beginning of 2019 the Greek wholesale electricity market is expected to be transformed to a decentralized market, based on the operation of a simple voluntary day-ahead Power Exchange (PX), in order to become compliant with the European Target Model. Furthermore, the free signing of bilateral contracts between producers and suppliers, for the sale of electricity, is expected to constitute a basic feature of the new target model, in parallel with the operation of the PX.

The study conducted by the Aristotle University of Thessaloniki (AUTH) carried out a sensitivity analysis in a baseline realistic scenario for the system load forecast from which the following two scenarios stem with a change in the prices of critical parameters:

a) **1st scenario**: High CO_2 emissions prices (high scenario)
b) **2nd scenario**: Low CO_2 emissions prices (medium scenario)

DESFA in collaboration with AUTH and taking into consideration the latest available data of the market considered that the 2nd scenario (medium scenario) is the most possible to be realized. The main assumptions of the scenarios are presented below:

a) Electricity load forecast for the next decade

Based on:
i) the expected consumption and peak load for the period 2018-2027, as these are estimated based on historical data from ADMIE for 2016

ii) the GDP evolution forecast for years 2018-2027[1] and

iii) the correlation between consumption and peak load with Gross Domestic Product (GDP) reduced for the years 2018-2027 based on AUTH's estimates

the expected increase of the system load (consumption) and peak load of the electricity sector for years 2018-2027 is estimated. The total demand of consumers for the reference period on which the AUTH Study is based, will fluctuate from 51,92 TWh (in 2017) to 58,78 TWh (in 2027).

b) Imports/Exports

[1] It is noted that in case that the macroeconomic variables of the Greek economy will change (debt settlement, etc) the forecast will be revised in the next Development Study

Regarding the imports from the Greek northern interconnections (Bulgaria, FYROM and Albania), in addition to the net interconnection capacity combined with the historical data and the maintenance program of the interconnections, it is taken into account the rapid increase in exports to the northern countries (mainly FYROM and Albania) due to the unprecedented and extensive drought that hit the Balkan countries recently.

For the imports/exports on the interconnections with Italy and Turkey and for the exports to the northern interconnections, which fluctuate according to the prices of the Greek wholesale market, a statistical analysis of the imports/exports per interconnection is performed in correlation with the corresponding SMPs for years 2015 and 2016.

c) RES injections

They are calculated based on the forecasted installed capacity per RES technology, and on the studier's forecasts for the hourly injection quantities per year's hour per unit installed capacity. It shall be mentioned that the historical data from ADMIE's site and from the Monthly RES Statistics of LAGIE are used. It is noteworthy that for the time period March-August 2017, RES injections in Greece are decreased when compared to corresponding intervals in years 2013-2016. The level of injections in 2017 is the lowest of the last 5 years. If this trend continues, the total injection of the year will be below 3,8TWh, while in previous estimation was equal to the average hydraulic year of 25 years and the total annual injection for year 2017 was to 4.678TWh.

However, this is considered to have happened due to the relatively dry year in Greece (and Balkans) and is not expected to be repeated every year. For such a reason, no change is made to the assumption already used (average hydraulic year) for the reference period.

d) Pumping

The monthly measured pumping quantity of year 2012 is used as maximum possible pumping quantity that can be executed by pumping stations (on a monthly basis). This pumping quantity is inserted in the yearly market simulation algorithm (1st solution phase of LTS[2] software), and the hourly pumping quantity to be executed is derived.

e) Hydro mandatory injections

The yearly mandatory injection quantities are taken as the mean value of the total annual hydro mandatory injections during the past 25 years, excluding years with high hydro production (considered as outliers). Consequently, the hydro units' usage factor is taken equal to 15,636% for following years. It shall be mentioned that during 2020 the hydro injection will be increased due to commissioning of the hydro units "Metsovitiko" (29 MW) and "Mesochora" (160 MW) proportionally to the increase of installed capacity.

f) Construction/withdrawal of production units

The timeline and the processes regarding the construction of new production units as well as those regarding the withdrawal of old lignite units of PPC are taken into consideration. Specifically:

[2] *LTS : Long Term Scheduling*

1) Units “PTOLEMAIDA 2”, “AG. GEORGIOS 8”, “AG. GEORGIOS 9”, “LAVRIO 1”, “LAVRIO 2”, “LAVRIO 3”, “ALIVERI 3” and “ALIVERI 4” have already withdrawn from the Greek power system.

2) Units “PTOLEMAIDA 3”, “PTOLEMAIDA 4” suffered a complete damage (by a major fire in November 2014) and have been withdrawn.

3) Units KARDIA 1, 2, 3 and 4 will operate up to 17,500 hours from the 1st January 2016 till the 31st December 2023.

According to the Transitional National Emissions Reduction Plan (TNERP), conducted pursuant to Article 33 of the Directive 2010/75/EU, the proposed actions concerning the above-mentioned lignite units are the following three:

- Direct (from year 2016) and adequate environmental adjustment
- Gradual environmental adjustment
- Inclusion in regime of limited operation duration and then withdrawal

The regime of limited operation duration deviation is valid from 01/01/2016 to 31/12/2023 and allows the units, which adopt it, 17,500 operation hours per chimney (according to the recent Decision of YPEKA).

Since each unit (KARDIA 1, 2, 3 and 4) bears a separate chimney, there will be no time-binding constraints in its operation distribution and obviously during periods when its production is necessary for the system.

Units KARDIA 3 and 4 provide district heating services at the area of Kozani, which is close to the units. Therefore, they should operate during the winter months, in order to satisfy their contractual obligations for such district heating services. Therefore, these units are expected to operate for about 5 months per year for the following 2 years, namely November, December, February, March and July, to cover the peak summer loads, and withdraw in mid-2020 (unit KARDIA 3) and mid-2021 (unit KARDIA 4), when the new lignite unit “PTOLEMAIDA 5” is expected to operate commercially and undertake the district heating services at the area of Kozani (because from a construction point of view it will have such capability).

However, units KARDIA 1 and 2 do not provide heating services at the area of Kozani. Therefore, it is not necessary to operate during the winter months. Provided that units KARDIA 3 and 4 will operate during the winter months (during the winter system peak), units KARDIA 1 and 2 will minimize the annual overall system cost if they operate during the summer peak load months (June to August for years 2018-2020) and during January in order to cover the winter peak loads. In that way, they shall complete exactly the remaining 17,500 hours of their operation (about 24 months in total).

Unit	Operating hours from 01/01/2016 to 30/06/2017	Remaining operating hours	Estimated operating hours from 01/07/2017 to 31/12/2017	Rest of operating months (from 2018 and onwards)
KARDIA 1	9,042	8,458	1,848	9.18
KARDIA 2	8,240	9,260	1,848	10.29
KARDIA 3	7,948	9,552	2,208	10.20
KARDIA 4	5,541	11,959	1,464	14.58
AMYNTAIO 1	8,133	9,367	2,164	10.00
AMYNTAIO 2	7,825	9,675	2,164	10.43

4) Units “AG. DIMITRIOS 1-4” do not have environmental restrictions in their operation, so they are expected to operate for the whole scheduling time horizon (until the end of year 2027).

5) Unit “MEGALOPOLI 3” is expected to be available until year 2025 (due to gradual reduction of the lignite reserves in the area), while unit “MEGALOPOLI 4” is expected to be available for the whole scheduling time horizon (until the end of year 2027).

6) The recent units “MELITI” and “AG. DIMITRIOS 5” have no environmental issues in their operation, and thus will be in normal operation until year 2027.

7) Unit “MEGALOPOLI 5” has already started commissioning operation in April 2015, and is expected to start commercial operation with decreased capacity (up to about 620 MW) within year 2017. The reason for this delay lies on the fact that the current transmission system in Peloponnese (150 kV) is not capable to transfer the full capacity of the unit. The expansion of the transmission system (400 kV) in the Peloponnese is expected to complete until December 2020. Consequently, in this study, the commercial operation of the unit at full capacity (811 MW) is considered to be achieved from January 2021.

8) Units AMYNTAIO 1 and 2 have the same environmental SOx emission problem as units of KARDIA station. It is noted that the units AMYNTAIO 1 and 2 have one common chimney; therefore, since the constraint of the remaining hours is applied per chimney (not per generating unit), it is necessary to operate at the same hours in order to optimize their use. It is also noted that these units provide heating services to the city of AMYNTAIO (located very close to the units). Therefore, it is necessary to operate during the winter months November-February (for the next three years, until February of year 2020) and also in July or August (for years 2018-2019) in order to cover the summer peak load conditions.

9) As mentioned above, unit “PTOLEMAIDA 5” is expected to enter in commissioning operation within year 2020 and in commercial operation in June 2021.

10) In this study, it is assumed that unit MELITI 2 will start commercial operation in January 2025.

11) Two new hydro units are expected to start commercial operation, “Metsovitiko” (29 MW) and “Mesochora” (160 MW). It is expected that these two units will increase the water potential of hydros on an annual basis.

g) Unit techno-economic data of power production units

All parameters affecting the unit variable cost as indicatively the efficiency level and the cost of emissions allowances CO_2 of thermal units are taken into consideration.

In Scenario 2 it is assumed that the market of CO_2 emission allowances will be kept at reasonable levels. AUTH’s estimate is that the prices will fluctuate between 6,5 €/tn CO_2 (in 2018) – 11 €/tn CO_2 (in 2027). In Scenario 1 the CO_2 price is expected to be higher, namely between 7,5 €/tn CO_2 (in 2018) – 19 €/tn CO_2 (in 2027).

h) The Equivalent Forced Outage Rate (EFOR) and the scheduled periods for maintenance purposes.

i) The units’ injection offers

The units’ injection offers are based on the minimum variable cost of each generating unit, which stems from both form the CO_2 emission allowances cost and the fuel cost.

The procurement price of natural gas is the main parameter for the determination of the variable cost of n.g. thermal units. Within the framework of the present study the Brent prices are equal to 51 $/barrel for year 2017, 55 $/barrel for year 2018, and of 60 $/barrel for years 2019 and onwards.

j) Interconnection of islands with the mainland transmission system

In the relevant study of University of Thessaloniki, Cyclades islands are expected to be interconnected with the mainland in year 2019. Crete is expected to be interconnected with the mainland system in year 2022 through an AC transmission line (underwater cable) at 150 kV with a maximum transmission capacity equal to 2x140 = 280 MW. In 2025, it is expected that a second underwater cable (DC) of Crete (2x350 MW) will be operational, and hence there will be no congestion anymore between the mainland transmission system and Crete.
The results of the study include:

a) the estimation of the total electricity demand in Greece for the period 2018-2027, based on the estimation of International Organizations for the evolution of the growth rate as well as on historical demand data of previous years,
b) the estimation of the electricity production percentage of thermal natural gas units (in MWhe) taking into consideration all the significant parameters that may affect it (penetration of PVs, wind, inclusion/extraction of conventional units), and
c) the estimation of Natural Gas Consumption from gas units, based on each unit’s specific function of heat rate.

The following Tables 1 and 2 summarize the main results of the study for the defined scenarios[3]. It shall be highlighted the difference in demand of power producers between 2018 and 2017. This large fluctuation is due to the increased gas consumption during the first months of 2017 due to extraordinary circumstances, as mentioned in Chapter 2.1 of this study "Historical data on natural gas demand".

At this point, it should be mentioned that on June 10, 2017, huge landslides took place in the AMYNTAIO mine, the PPC's lignite center of Western Macedonia that supplies units AMYNTAIO 1 & 2 with fuel. The landslide did not have a significant impact on the annual schedule of the units, because it took place at a time when the units would be closed in view of the spring and summer.

[3] Tables 1 and 2 do not include the use of natural gas from the AdG unit for thermal use

Table 1. Energy balance in the interconnected power system (per year) – Scenario 1

Unit/load category	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Lignite units [MWhe]	**14.933.936,74**	**15.506.422,78**	**14.123.261,08**	**13.802.700,42**	**14.609.676,45**	**13.065.274,13**	**11.977.335,05**	**13.385.448,02**	**12.986.587,37**	**12.736.700,62**
Gas units (PPC) [MWhe]	6.216.173,53	5.941.069,77	6.105.515,13	7.483.969,09	7.767.458,58	8.376.675,52	8.671.171,21	8.482.805,39	8.781.212,38	9.014.999,69
Gas units (IPPs) [MWhe]	8.612.365,78	7.967.090,80	8.493.608,66	7.364.851,15	7.318.206,75	8.207.967,52	8.693.714,32	8.532.794,63	8.776.952,61	8.842.365,75
Gas units [MWhe]	**14.828.539,31**	**13.908.160,57**	**14.599.123,79**	**14.848.820,24**	**15.085.665,33**	**16.584.643,04**	**17.364.885,53**	**17.685.243,51**	**18.219.155,18**	**18.537.965,05**
Crete CCGT Unit [MWhe]	0,00	0,00	0,00	0,00	0,00	0,00	0,00	669.643,49	660.990,19	680.599,61
Hydros [MWhe]	**4.346.453,26**	**4.347.475,62**	**4.613.938,19**	**4.608.137,74**	**4.610.434,19**	**4.608.806,76**	**4.611.506,06**	**4.609.650,56**	**4.609.692,32**	**4.608.069,21**
Imports [MWhe]	11.298.482,63	11.345.566,73	11.423.575,23	11.394.040,09	11.477.257,42	11.601.476,12	11.939.327,92	11.862.175,37	11.881.107,52	11.980.113,00
Exports [MWhe]	3.220.921,05	2.907.012,22	2.846.967,49	2.871.213,18	2.803.682,43	2.785.588,02	2.726.599,11	2.742.422,41	2.716.274,58	2.722.060,66
Net imports [MWhe]	**8.077.561,57**	**8.438.554,50**	**8.576.607,74**	**8.522.826,91**	**8.673.574,98**	**8.815.888,11**	**9.212.728,81**	**9.119.752,96**	**9.164.832,93**	**9.258.052,34**
Wind plants [MWhe]	5.277.677,01	5.742.060,86	6.149.751,50	6.527.986,19	6.761.501,63	6.873.138,68	7.001.783,89	7.096.413,08	7.208.049,88	7.319.686,54
PVs [MWhe]	3.794.022,82	3.887.689,55	3.940.819,39	3.987.489,37	4.037.038,57	4.086.356,05	4.138.715,44	4.184.291,59	4.232.909,78	4.281.294,83
Biomass/Biogas [MWhe]	346.455,70	404.975,98	466.645,86	525.840,71	586.274,01	646.705,68	709.050,92	767.570,58	828.003,12	888.436,30
Small hydros [MWhe]	756.672,64	780.220,51	801.967,23	819.290,90	838.826,99	858.362,36	880.326,90	897.433,12	916.969,16	936.504,69
Small co-generation [MWhe]	160.183,51	163.213,18	163.868,26	163.213,18	163.213,18	163.213,18	163.868,26	163.213,18	163.213,18	163.213,18
Total RES/Co-generation units [MWhe]	**10.335.011,68**	**10.978.160,08**	**11.523.052,24**	**12.023.820,35**	**12.386.854,38**	**12.627.775,95**	**12.893.745,41**	**13.108.921,55**	**13.349.145,12**	**13.589.135,54**
Total production [MWhe]	**52.521.502,56**	**53.178.773,55**	**53.435.983,04**	**53.806.305,66**	**55.366.205,33**	**55.702.387,99**	**56.060.200,86**	**57.909.016,60**	**58.329.412,92**	**58.729.922,76**
Gas units' percentage [%]	28,23%	26,15%	27,32%	27,60%	27,25%	29,77%	30,98%	30,54%	31,23%	31,56%
Pumping [MWhe]	**25.187,75**	**24.814,00**	**27.946,50**	**24.700,92**	**25.833,43**	**25.321,02**	**27.426,76**	**29.404,16**	**26.634,97**	**24.272,02**
System load [MWhe]	**52.496.314,67**	**53.153.959,28**	**53.408.036,48**	**53.781.604,53**	**55.340.372,02**	**55.677.066,61**	**56.032.774,13**	**57.879.612,22**	**58.302.777,98**	**58.705.650,62**
System losses [MWhe]	**1.054.154,70**	**1.092.439,33**	**1.079.956,53**	**1.102.684,62**	**1.171.655,97**	**1.152.610,62**	**1.146.345,33**	**1.230.712,33**	**1.262.858,03**	**1.271.770,61**
Total demand of consumers (with distribution network losses) [MWhe]	**51.442.159,97**	**52.061.519,95**	**52.328.079,95**	**52.678.919,91**	**54.168.716,06**	**54.524.455,98**	**54.886.428,80**	**56.648.899,89**	**57.039.919,95**	**57.433.880,00**
Gas consumption [kNm3]	**2.742.013,86**	**2.597.487,49**	**2.706.905,86**	**2.709.566,48**	**2.721.671,04**	**2.971.004,67**	**3.101.104,41**	**3.038.339,23**	**3.132.204,84**	**3.187.229,06**
Daily gas peak [Nm3/day]	**11.581,60**	**11.670,08**	**12.093,90**	**13.802,96**	**12.919,51**	**13.997,44**	**13.099,95**	**13.360,66**	**13.541,64**	**13.667,93**
Brent price [$/bbl]	55,00	60,00	60,00	60,00	60,00	60,00	60,00	60,00	60,00	60,00
CO_2 price [€/T]	7,55	8,35	9,18	10,26	12,30	14,78	17,79	18,94	18,99	19,04
GDP increase [%]	1,50%	1,50%	1,50%	1,30%	1,30%	1,30%	1,30%	1,30%	1,30%	1,30%
Consumption increase [%]	0,26%	1,22%	0,51%	0,67%	2,87%	0,66%	0,66%	3,27%	0,69%	0,69%

* commercial operation of PTOLEMAIDA 5 in July 2021, MELITI 2 in January in 2025, withdrawal of KARDIA 1-4 and AMYNTAIO 1-2 in 2020, withdrawal of MEGALOPOLI 3 in 2025

Table 2. Energy balance in the interconnected power system (per year) – Scenario 2

Unit/load category	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Lignite units [MWhe]	**15.318.664,04**	**15.639.746,48**	**14.453.760,36**	**13.994.642,12**	**15.381.411,50**	**15.463.923,85**	**15.586.928,90**	**17.866.765,15**	**16.799.543,13**	**16.787.609,99**
Gas units (PPC) [MWhe]	6.086.393,66	5.866.875,91	6.000.928,56	7.309.542,74	7.547.352,87	7.443.287,69	7.562.374,49	6.956.561,58	7.468.176,45	7.552.838,20
Gas units (IPPs) [MWhe]	8.369.758,12	7.948.642,02	8.322.866,34	7.364.081,87	6.858.099,85	7.020.205,03	6.880.317,33	6.340.012,80	6.928.225,78	6.978.339,87
Gas units [MWhe]	**14.456.151,78**	**13.815.517,93**	**14.323.794,90**	**14.673.624,61**	**14.405.452,72**	**14.463.492,72**	**14.442.691,82**	**13.966.232,66**	**15.058.360,77**	**15.212.698,12**
Crete CCGT Unit [MWhe]	0,00	0,00	0,00	0,00	0,00	0,00	0,00	669.658,28	661.958,54	681.520,05
Hydros [MWhe]	**4.346.367,27**	**4.347.472,52**	**4.614.622,11**	**4.607.899,62**	**4.610.282,47**	**4.611.735,02**	**4.615.891,42**	**4.613.768,00**	**4.613.304,90**	**4.613.494,11**
Imports [MWhe]	11.291.645,71	11.325.959,22	11.401.458,43	11.387.925,44	11.427.770,13	11.415.179,00	11.443.426,39	11.325.423,14	11.428.066,90	11.472.576,22
Exports [MWhe]	3.224.708,99	2.925.478,61	2.878.496,83	2.877.038,29	2.838.255,70	2.839.403,07	2.859.186,34	2.891.773,04	2.840.673,79	2.864.484,08
Net imports [MWhe]	**8.066.936,71**	**8.400.480,61**	**8.522.961,60**	**8.510.887,16**	**8.589.514,43**	**8.575.775,92**	**8.584.240,05**	**8.433.650,10**	**8.587.393,11**	**8.608.092,15**
Wind plants [MWhe]	5.277.677,01	5.742.060,86	6.149.751,50	6.527.986,19	6.761.501,63	6.873.138,68	7.001.783,89	7.096.413,08	7.208.049,88	7.319.686,54
PVs [MWhe]	3.794.022,82	3.887.689,55	3.940.819,39	3.987.489,37	4.037.038,57	4.086.356,05	4.138.715,44	4.184.291,59	4.232.909,78	4.281.294,83
Biomass/Biogas [MWhe]	346.455,70	404.975,98	466.645,86	525.840,71	586.274,01	646.705,68	709.050,92	767.570,58	828.003,12	888.436,30
Small hydros [MWhe]	756.672,64	780.220,51	801.967,23	819.290,90	838.826,99	858.362,36	880.326,90	897.433,12	916.969,16	936.504,69
Small co-generation [MWhe]	160.183,51	163.213,18	163.868,26	163.213,18	163.213,18	163.213,18	163.868,26	163.213,18	163.213,18	163.213,18
Total RES/Co-generation units [MWhe]	**10.335.011,68**	**10.978.160,08**	**11.523.052,24**	**12.023.820,35**	**12.386.854,38**	**12.627.775,95**	**12.893.745,41**	**13.108.921,55**	**13.349.145,12**	**13.589.135,54**
Total production [MWhe]	**52.523.131,48**	**53.181.377,62**	**53.438.191,21**	**53.810.873,86**	**55.373.515,50**	**55.742.703,46**	**56.123.497,60**	**57.989.337,46**	**58.407.747,03**	**58.811.029,91**
Gas units' percentage [%]	27,52%	25,98%	26,80%	27,27%	26,02%	25,95%	25,73%	24,08%	25,78%	25,87%
Pumping [MWhe]	**25.146,33**	**24.853,95**	**28.390,44**	**24.520,43**	**25.347,57**	**27.407,64**	**29.277,40**	**30.531,41**	**29.620,21**	**29.540,66**
System load [MWhe]	**52.497.985,28**	**53.156.523,56**	**53.409.800,66**	**53.786.353,28**	**55.348.167,90**	**55.715.295,81**	**56.094.220,13**	**57.958.805,72**	**58.378.126,90**	**58.781.489,12**
System losses [MWhe]	**1.055.825,24**	**1.095.003,60**	**1.081.720,60**	**1.107.433,32**	**1.179.451,82**	**1.190.839,86**	**1.207.791,28**	**1.309.905,94**	**1.338.206,85**	**1.347.609,11**
Total demand of consumers (with distribution network losses) [MWhe]	**51.442.159,97**	**52.061.519,95**	**52.328.079,95**	**52.678.919,91**	**54.168.716,06**	**54.524.455,98**	**54.886.428,80**	**56.648.899,89**	**57.039.919,95**	**57.433.880,00**
Gas consumption [kNm3]	**2.685.460,51**	**2.581.496,39**	**2.666.824,07**	**2.683.825,97**	**2.614.924,12**	**2.628.326,66**	**2.621.662,48**	**2.429.878,63**	**2.621.213,62**	**2.644.701,24**
Daily gas peak [Nm3/day]	**11.434,91**	**11.637,25**	**12.086,13**	**13.735,24**	**12.753,30**	**13.403,75**	**11.956,55**	**12.712,61**	**12.564,57**	**12.852,41**
Brent price [$/bbl]	55,00	60,00	60,00	60,00	60,00	60,00	60,00	60,00	60,00	60,00
CO_2 price [€/T]	6,50	7,00	8,00	10,00	11,00	11,00	11,00	11,00	11,00	11,00
GDP increase [%]	1,50%	1,50%	1,50%	1,30%	1,30%	1,30%	1,30%	1,30%	1,30%	1,30%
Consumption increase [%]	0,26%	1,22%	0,51%	0,67%	2,87%	0,66%	0,66%	3,27%	0,69%	0,69%

* commercial operation of PTOLEMAIDA 5 in July 2021, MELITI 2 in January in 2025, withdrawal of KARDIA 1-4 and AMYNTAIO 1-2 in 2020, withdrawal of MEGALOPOLI 3 in 2025

3.1.2 Estimated consumption of natural gas from Other Consumers

For the estimation of gas consumption from other consumers, the annual demand allocation of natural gas to the Users of the NNGTS, excluding those that are considered to consume natural gas for the power generation and Small Scale LNG infrastructure consumers, is calculated per metering station. The calculation aims to estimate the maximum daily peak of the Year for the transmission system.

The calculation model was based on data processing of the following sources:

i) Daily consumption historic data at each NNGS metering station.
ii) Forecast of the annual gas market demand, as notified by the NNGS Users in accordance with Article 90 of Chapter 12 of the Network Code.
iii) The evolution of the regulatory framework regarding the reform of the Greek gas market through the new regulatory framework that imposed the reconstruction of the retail gas market in the beginning of 2017. Distribution and supply activities that were implemented by Gas Supply Companies (EPAs), are now administrative and operationally independent, and Gas Distribution Companies (EDAs) are now responsible for the distribution.
iv) The estimations and data regarding demand and connections to the distribution networks by consumption category, as published with the approvals on the charges for the basic distribution activity of EDAs.
v) The population data of cities with urban gas consumption, where required
vi) Historical data from previous years from the Athens Observatory
vii) Data regarding the Gross Domestic Product, as estimated by the Aristotle University of Thessaloniki, in the study "Gas Consumption Forecast for Electricity Production Provided in the Wholesale Market during the next decade (2018-2027)".

To begin with, the first stage of the study was the separation of the NNGTS consumers into two main categories: a) Individual Consumers and b) consumers of natural gas that consist entry points in the gas distribution networks. Subsequently, network consumption was geographically distributed to individual, existing or new, consumption points within the network.

Individual Consumers are considered to be points of consumption which do not belong to power generating units and either are points directly connected to the high pressure pipeline of the NNGS or points which, while belonging to an EDA, correspond to an individual consumption point for the supply of a particular installation/ geographic area and therefore a typical daily profile results from historical data available to the Operator.

The breakdown at points of consumption was made for two main categories of natural gas use: a) industrial use (industrial and commercial sector) and b) urban use (residential sector).

The abovementioned sectors were grouped based on the end-user categories[4] as adopted by EDAs.

It should be noted that the Gas Distribution Companies, as established, are the following: EDA Attikis, EDA Thessalonikis, EDA Thessalias and EDA of the rest of Greece, which is composed by distribution networks in the areas of Central Greece, Central Macedonia, Eastern Macedonia and Thrace and Corinth.

In particular, further development of medium and low pressure distribution networks is envisaged in EDA of the rest of Greece, as the networks in the aforementioned areas have not reached yet the desired level of growth in all categories of consumers. Mainly the distribution network related to industrial sector, and not the residential sector, has already been developed. The present study considers that the expected growth of these networks will begin from 2020 onwards.

The total natural gas demand for the period 2018-2027 by each category of use was estimated as follows:

INDIVIDUAL CONSUMERS

Historical data of consumptions until March 2017, data send by Users under Article 90 of the Network Code and data send by distribution network operators were evaluated and processed for the estimation of the consumption from Individual Consumers (including industrial areas).

REGIONS WITH DISTRIBUTION NETWORKS

In order to assess the gas demand, data from the Users, that are available to the Operator, were taken into account as well as the demand per end-user category in accordance with the business plans of the distribution networks operators, as used for the calculation of their usage charges. Thereafter, the abovementioned data were processed and the evolution of the gas consumption in each sector I) residential, ii) commercial and iii) industrial for the four distribution networks is estimated.

Regarding the commercial and industrial consumptions, the published estimates within EDAs approvals of charges were taken into account. Those data were evaluated against data from Users and historical data. For the years that no data are available, a gradual annual increase equal to the estimation of percentage growth of GDP is considered.

The estimate of percentage growth of GDP is shown in Table 3, as adapted by the Aristotle University of Thessaloniki (AUTH) in the study “Gas Consumption Forecast for Electricity Production Provided in the Wholesale Market during the next decade (2018-2027)”, and is

[4] end-user categories: i) residential (central and autonomous domestic and small commercial heating), ii) commercial and iii) industrial

used for the study “Annual demand forecast and geographical - daily allocation of other consumers demand for the period 2018-2027”.

Table 3: Percentage growth of GDP

year	Percentage growth of GDP (AUTH) [%]
2017	1,6
2018	1,5
2019	1,5
2020	1,5
2021	1,3
2022-2027	1,3

The consumption of the residential sector per region with network was approached in two different ways, depending on whether the distribution network is fully developed in the region or not yet.

Specifically, for the consumption of the residential sector of EDAs with a developed distribution network (EDA Attikis, EDA Thessalonikis and EDA Thessalias) the estimation from the network operators is used for the first years of the reference period while a methodology has been developed by the Operator for the estimation of the consumption for the remaining years. The methodology is based on historical data of consumption/ active connections for the region. In particular, the annual change in number of connections between 2022 and 2027 has been assessed as a gradual slowdown in the rate of implementation of new connections and the consumption per connection according to the estimation of percentage growth of GDP has been estimated.

To estimate the average consumption in the residential sector, the actual consumption data of 2016 is used and normalized to the temperature factor. Namely for the effect of temperature, the average consumption for residential sector based on year 2016 is calculated and normalized to the temperature factor, taking into account the days of the latest most representative cold or warm years.

For the estimation of gas consumption of the residential sector of EDA of the rest of Greece, that is considered to be developed in the next years, the Operator’s forecast is based on Users data, EDA’s data and the mileage development expected in the network. The abovementioned data are processed within the demand forecast model.

The total gas demand estimation per category of use for the reference period 2018-2027 is shown in Table 4.

Table 4 : Total Gas Demand estimation of Other Consumers per category of use

	Demand estimation of other consumers (mil.Nm^3)		
	Industrial use	**Urban use**	**Total**
2018	1.060,88	399,64	**1.461**
2019	1.082,77	421,36	**1.504**
2020	1.101,15	460,11	**1.561**
2021	1.114,83	496,94	**1.612**
2022	1.122,11	535,71	**1.658**
2023	1.129,49	565,55	**1.695**
2024	1.138,94	598,17	**1.737**
2025	1.144,55	621,95	**1.767**
2026	1.152,21	647,15	**1.799**
2027	1.159,68	669,72	**1.829**

In the total gas demand estimation, suitable daily profiles are adopted for each category of consumption of every exit point, in order the peak of the system and each point separately to be identified.

In terms of consumption for industrial use, the most representative industrial consumption profile is used for each consumption point based on historical daily consumption data.

Specifically, for the choice of the daily industrial consumption in Athens, a graphic depiction of the daily consumption of year 2002 onwards for the exit point Athens is done, resulting that year 2004 is the most representative for the industrial profile. This assumption is based on the fact that during the first years of operation of the Attiki Gas Supply Company (EPA Attiki was the operator of the distribution network until the end of 2016) the target group of consumers was mainly industrial consumers with larger and more stable consumption.

It should be noted that in the case that the natural gas consumption growth took place simultaneously in the industrial and residential sectors, the best choice is considered to be the daily profile of the exit point Oinofyta or in some cases, mainly in northern Greece, the daily profile of the exit point of the industrial area of Larisa, while both are purely industrial areas. The daily profile of consumption in both points is determined by multiple categories of industries, which on average provides a more representative daily industrial consumption profile.

In terms of consumption for urban use, and taking into account the impact of the use of natural gas consumption for heating, it is necessary to count the impact of temperature in the calculation of the daily profile.

Therefore the daily allocation of urban use consists of:

a) the daily allocation of demand for heating and
b) the daily allocation of demand for other use.

To determine the above daily allocations, the next steps were followed:

1. The "initial" daily profile of consumption for urban use was calculated by the difference of the average consumption of the years 2011-2016 from the industrial consumption based on the consumption allocation of year 2004 for Athens and for the rest of the exit points by the difference of the average consumption of the years 2011-2016 from the industrial profile of year 2016 of Oinofyta or of the industrial area of Larisa. For the calculation of the difference, the weekdays were adjusted to whether a day is a working one or not.

2. Period 1/5 to 15/10 was matched to natural gas consumptions only for other urban use (period 16/7 to 31/8 is treated separately due to holiday season).

3. The average consumption for the period 1/5 to 15/10 gives the daily profile for other urban use, and is considered to be constant for the whole year (daily allocation of demand for other use, point b above).

4. The consumption of natural gas due to heating (daily allocation of demand for heating) is the additional daily quantity resulting from the "initial" profile for the abovementioned intervals. This consumption is reallocated on the basis of the degree days.

Degree day of a given calendar day of the year is an impact indicator of the effect of the temperature. Degree days measure the difference of the mean outdoor temperature from 16,8^{o}C and are taken into account in the sum of degree days of the year only when the aforementioned difference has a positive sign.

The daily profile of gas consumption for heating is calculated considering that the use of natural gas for heating is expected to take place in the period 16/10 to 30/4 and results from the following steps

- Taking into consideration that the gas consumption for heating begins when temperature is below 16,8°C (outdoor temperature), the degree day for each consumption point results from the average temperature of the last most representative years on this point. Temperature historical data of each relative city were derived from the published data from the Observatory of Athens. For cities where temperature data are not available, data of closest points/cities of consumption were used.

- The daily profile for heating is recalculated by using the degree days coefficient, based on the percentage of degree days for each day for which there is consumption due to heating and the estimated quantity for such use (point 4 above)

3.2. ESTIMATION OF CONSUMPTION RELATED TO SMALL SCALE LNG PROJECTS

The need to deploy Small Scale LNG infrastructure projects is now evident in Greece. Based on the increasing demand for the LNG truck loading station both from industries and shipping industry, DESFA has begun all necessary steps for the completion of relative infrastructures that will lead to an increased use of LNG.

As a consequence, the study for the pilot LNG truck loading station has been completed, it is estimated to be commissioned in 2017 and expected to operate by mid-2019.

At the same time, the new jetty is planned to be constructed in the northern eastern part of Revythousa to supply small vessels between 1.000 m^3 and up to 20.000 m^3. The smallest of them will supply vessels, either coastal or seagoing, to the port of Piraeus, while the larger ones will supply satellite LNG storages and distribution stations to other ports of Greece or abroad.

The annual demand from Small Scale LNG projects is expected to begin from 2019 onwards and is presented in a summarized form in the table below.

Table 5: Total volumes from Small Scale LNG projects for the period 2018-2027

Demand in Nm3	LNG	Natural Gas
2017	0	0
2018	0	0
2019	2.040	1.183.200
2020	4.080	2.366.400
2021	30.200	17.516.000
2022	50.400	29.232.000
2023	90.800	52.664.000
2024	141.200	81.896.000
2025	161.200	93.496.000
2026	211.200	122.496.000
2027	261.200	151.496.000

* 1Nm3 LNG=580Nm3 ϕ.α.

3.3. FORECAST OF TRANSIT VOLUMES

The interconnection Greece-FYROM is mainly expected to procure gas to two new power stations (400 MW each) in FYROM, which will come into operation from 2021 onwards. Therefore, taking into account that no final decision has been taken for the transmitted quantities, it is expected that the yearly quantity transmitted through the Greece-FYROM pipeline will be equal to 350 mil. Nm^3, taking into account the (conservative) assumption that only one of these two power stations will be fed with natural gas through Greece (note that FYROM is also supplied with n.g. through Bulgaria).

Further to that, the national gas transmission system can transmit gas in firm reverse flow from Sidirokastro to Bulgaria. Specifically, up to 2017, the system can transmit on a daily basis the amount of 1mil. Nm3/day, while from 2018 onwards, when the 2nd upgrade of

Revithoussa will be operational, the technical capacity is expected to be increased to 4,1 mil Nm^3/day. A further increase up to the dominant flow capacity (10,8 mil. Nm3/day) can be achieved by operating a compressor station in Ambelia in reverse flow (from South to North) and a compressor station in Kipi.

For the purposes of estimating reverse flow quantities, a conservative scale-up scenario is used while currently there are no available data or contracts related to those quantities. Hence, in 2018 the demand expected to be transmitted to Bulgaria in reverse flow is considered to be equal to 10 mil. Nm^3/year, gradually scaling up to 300 mil. Nm^3/year in 2027.

The annual gas transportation demand for the NNGTS for the reference period is presented in Table 6 below.

Table 6: Total transit volumes of natural gas for the period 2018-2027

	Transit volumes through A) reverse flow and B) Greece-FYROM interconnector [Nm3]
2018	10.000.000
2019	50.000.000
2020	100.000.000
2021	500.000.000
2022	550.000.000
2023	600.000.000
2024	620.000.000
2025	650.000.000
2026	650.000.000
2027	650.000.000

3.4. PRESENTATION OF SCENARIOS

When Chapters 3.1.1., 3.1.2., 3.2. and 3.3 are combined they result in two scenarios. In particular, the total estimated consumption of natural gas from other consumers, the estimated demand for transit n.g. and from Small Scale Infrastructure users in combination with each of the two scenarios of natural gas consumption for power generation is shown in Table 7.

The peak of the system for scenario 2, that is considered to be the main scenario, for each year of the reference period and per customer category, is shown in Table 8.

The forecast of the peak of the system is calculated by the sum of the daily peak of the total of all exit points of other consumers, transit n.g. and Small Scale LNG in the year and the daily peak of all power producers in the winter period of the same year.

Table 7: Total natural gas demand – scenarios

Scenario 1 _ High	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*2027*
Power Producers [mil. Nm3]	2.870	2.726	2.835	2.838	2.850	3.099	3.230	3.167	3.260	3.315
Customers connected to HP Network [mil. Nm3]	569	570	572	573	573	573	574	574	574	574
Distribution Networks [mil. Nm3]	891	934	990	1.039	1.085	1.122	1.163	1.193	1.225	1.255
Transit flows [mil. Nm3]	10	50	100	500	550	600	620	650	650	650
Small Scale LNG [mil. Nm3]		1	2	18	29	53	82	93	122	151
Total Gas Market [mil. Nm3]	**4.341**	**4.281**	**4.499**	**4.967**	**5.087**	**5.447**	**5.669**	**5.677**	**5.832**	**5.946**

Scenario 2_ Basic										
Power Producers [mil. Nm3]	2.814	2.710	2.795	2.812	2.743	2.757	2.750	2.558	2.749	2.773
Customers connected to HP Network [mil. Nm3]	569	570	572	573	573	573	574	574	574	574
Distribution Networks [mil. Nm3]	891	934	990	1.039	1.085	1.122	1.163	1.193	1.225	1.255
Transit flows [mil. Nm3]	10	50	100	500	550	600	620	650	650	650
Small Scale LNG [mil. Nm3]		1	2	18	29	53	82	93	122	151
Total Gas Market [mil. Nm3]	**4.284**	**4.265**	**4.459**	**4.941**	**4.980**	**5.104**	**5.189**	**5.068**	**5.321**	**5.404**

Table 8: Daily peak of the system for the period 2018-2027

	TOTAL NNGS (Nm³/day)					
	Power Production	Other Consumers		Transit flows	Small Scale LNG	Total
		Customers connected to HP Network	Distribution Networks			
2018	11.786.176	2.504.195	5.737.968	34.247	-	20.062.585
2019	11.988.518	2.506.330	6.059.411	171.233	49.300	20.725.492
2020	12.437.398	2.508.465	6.566.117	342.466	49.300	21.854.445
2021	14.086.506	2.512.735	7.119.238	1.579.148	94.701	25.392.327
2022	13.104.566	2.513.392	7.620.051	1.750.381	166.702	25.155.091
2023	13.755.013	2.514.059	7.990.198	1.921.613	261.403	26.442.286
2024	12.307.814	2.514.783	8.351.849	1.990.107	329.505	25.494.058
2025	13.063.880	2.515.470	8.689.004	2.092.846	374.906	26.736.106
2026	12.915.837	2.516.166	9.003.514	2.092.846	488.409	27.016.772
2027	13.203.673	2.516.166	9.281.039	2.092.846	601.912	27.695.636

3.5. FORECAST OF THE HOURLY PEAK DEMAND FOR NATURAL GAS FOR THE REFERENCE PERIOD 2018-2027

The historical data of hourly demand for other consumers, as published on DESFA website, and the hourly demand results from the study that was conducted by the Aristotle University of Thessaloniki regarding power producers, are used to determine the hourly peak demand. The hourly peak demand is calculated for each year of the reference period 2018-2027.

The hourly demand profile of other consumers is calculated by the average of daily consumptions for the months January, February and March for the years 2012 to 2017 for each exit point. For greater accuracy of the results, data related to weekends and holidays are not taken into account.

Based on the above, the maximum hourly peak demand for the years 2018-2027, per customer category, is as follows:

Table 9: Hourly peak demand for NNGS for the period 2018-2027

	Power Production	Customers connected to HP Network	Distribution Networks	Total
2018	606.612	106.306	391.338	1.104.256
2019	591.614	106.707	407.723	1.106.043
2020	607.632	106.472	452.212	1.166.316
2021	657.301	107.046	486.393	1.250.740
2022	658.752	106.663	530.118	1.295.533
2023	675.859	106.689	554.081	1.336.630
2024	658.760	106.718	577.720	1.343.197
2025	644.252	106.744	598.979	1.349.975
2026	565.090	106.771	619.148	1.291.009
2027	632.170	106.771	636.154	1.375.095

**estimates on hourly peak demand regarding the transit n.g. volumes and the volumes related to Small Scale LNG projects are not included*