Cost-benefit analysis for the socialization of the Revithoussa LNG terminal

Strategy & Development Division

10/3/2023

Executive summary

- The CBA guidelines provided by EC and ENTSOG set the general directions and are the starting point of this Cost-Benefit Analysis. However, Revithoussa LNG terminal is already built, thus the default scenarios (i.e., with and without the infrastructure under investigation) are not relevant. Therefore, is a need for a tailor-made approach based on the ENTSOG methodology towards the definition of the scenarios and the quantification of the costs and benefits of the socialisation of Revithoussa LNG terminal
- To that end, the counterfactual scenario of the CBA is considered with 0% socialization level (*without project*) and the alternative scenarios (variants) are considered with 25%, 50%, 75% and 100% socialization level (*with project*). Multiple alternative scenarios (based on different socialization levels) are investigated for assessing the impact of different socialization levels to the welfare of gas consumers
- The cost of socialization is the amount of the required revenue of the Revithoussa LNG terminal that needs be recovered from domestic, and interconnection exit points*
- The study is considered complete in terms of the indicators examined as it incorporates all monetised indicators relevant to socialisation (Supply Cost Savings, Fuel Cost Savings and Emission Cost Savings), while it excludes the non-monetised indicators for the review of the costs and benefits of socialisation
- The Supply Cost Savings indicator quantifies the reduction/increase of the overall cost of gas supply for flexibility in Greece and regionally due to the socialization of the Revithoussa LNG terminal and is equal to the difference of the total amount paid for gas flexibility between the counterfactual scenario and a variant scenario with x% socialization level
- The Fuel Cost and Emission Cost Savings indicators have been considered; however, they do not contribute to the net benefit of the analysis, due to the minor impact of the socialization level to the merit order of the wholesale power market compared to the commodity price of gas
- Under the baseline scenarios and the parametric analyses, for all socialization levels there is a net benefit, with the highest being for 100% socialization level. The higher the socialization, the higher the net benefit becomes
- Following the results of the CBA, Desfa proposes for **the socialisation level of Revithoussa to remain at current levels and specifically at 50%, although higher socialization levels could be justified from the results of the study**

**since the interconnection exit points also benefit from the Revithoussa LNG terminal. This was also suggested by ACER in "Analysis of the Consultation Document for Greece - 28/03/2019" and is also regulated by Par. 4, Art. 20 of the Tariff Regulation (RAE Decision 98/2023)*

A Introduction

B Overview of Cost Benefit Analysis methodology

C Calculation of indicators and benefits

D Summary and key findings

E Appendix

A tailor-made CBA methodology was developed, based on the ENTSOG guidelines to calculate the costs and benefits of the Revithoussa LNG terminal socialization

- ACER in its report "Analysis of the Consultation Document on the Gas Transmission Tariff Structure" (28/03/2019) undertaken in the context of the requirements of Regulation (EU) 2017/460, recommended that the costs and benefits related to socialization of the LNG Required Revenue (from the use and operation of the Revithoussa Terminal) to the domestic Exit Points of the transmission system are further evaluated

- Following ACER's recommendation, Article 8 of the Tariff Regulation provides that "*The Operator submits during the tariff review process a cost benefit analysis on the contribution of the LNG Facility to the balancing of the NNGS, the security of supply and the facilitation of the entry of new Shippers in the Greek gas market including a proposal on percentage of Dispersion of the Required Revenue of LNG Services*"

- In this context, Desfa in Nov. 2019 submitted to RAE a CBA that justified the optimal socialisation level, based on which RAE defined arithmetically in the Tariff Approval Decisions (RAE Decisions 566/2019, 1038/2020, 512/2021) the socialisation level at 50%, for years 2020, 2021 and 2022 respectively

- Art. 20 of the new Tariff Regulation of Desfa, applicable from the Regulatory Period 2024-2027, also includes an obligation for DESFA to perform a CBA to justify the socialisation level. Moreover, Para. 4 of the same article regulates that socialisation can be also recovered through IP exits

- Based on the above, Desfa is requested to submit an updated Cost-Benefit Analysis of the socialisation level of Revithoussa for the period 2024-2027

- The aim of the study is to identify, calculate and compare Costs and Benefits of Revithoussa socialization with the view to justify its level

- To conduct the analysis, a tailor-made CBA methodology was developed, based on the ENTSOG methodology*, appropriately modified where necessary, for the purposes of assessing the socialisation impact of the regasification tariff of Revithoussa LNG terminal

** https://www.entsog.eu/sites/default/files/2019-03/1.%20ADAPTED_2nd%20CBA%20Methodology_Main%20document_EC%20APPROVED.pdf*

The “standard” ENTSOG CBA methodology offers detailed guidance, but it is meant for new projects or expansion of existing ones, so ...

- The CBAs have been used in EU Cohesion Policy since the 1990s and became mandatory since 2000 as they represent a standard technique to weigh anticipated capital and operating costs of future investments against respective benefits over a time period of 20-25 years. They also represent a standard approach for assessments carried out by the European Investment Bank

- Following Regulation (EU) 347/2013, a specific methodology for the assessment of gas infrastructure projects has been developed by ENTSOG, in 2015, prior to which no widely standardized procedure on the evaluation of benefits of natural gas infrastructure existed

- The 2nd ENTSOG CBA methodology (revised Oct 2018), as the EC Guideline, is applicable to new proposals for the creation of new infrastructure or for a proposed expansion of existing infrastructure

- The ENTSOG CBA methodology is tailor-made for the PCI process providing a cross-European common method for the assessment of investment requests to be included in the list of PCI projects and in the EU-Wide Ten-Year Network Development Plan (TYNDP). The methodology is also followed by an increasing number of EU TSOs

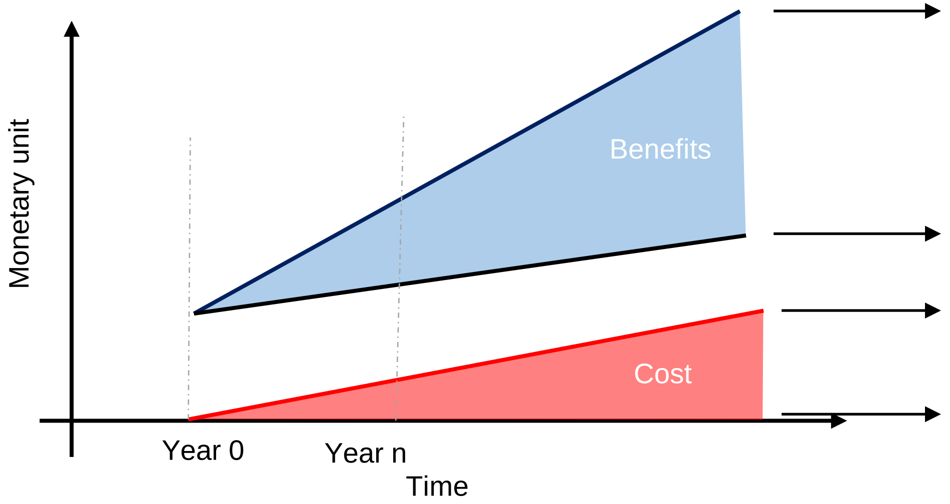
- ENTSOG CBA methodology aims to quantify the benefits and compare them with the respective costs of an investment decision by considering two scenarios (“with” and “without” investment) before the construction of the infrastructure

… there is a need for a tailor-made approach regarding the definition of the scenarios and the quantification of the costs and benefits

- The mandate of ACER is to "*…use a cost-benefit-analysis (CBA) to assess whether and to what extent the terminal has positive externalities…that would justify socialisation*…" of cost of the Revithoussa LNG terminal
- The CBA guidelines provided by EC and ENTSOG can set the general directions and should be the starting point as this is an already accepted methodology (approved by the Commission, accepted by ACER and thus also by RAE), however Revithoussa LNG terminal is already built thus the default scenarios (i.e., with and without the infrastructure) are not relevant to this study
- The ENTSOG methodology needs to be appropriately modified to the scope of the specific study, which is to assess and compare the cost of socialisation with the benefits from socialisation to the end-consumers by an existing infrastructure
- The 2nd ENTSOG CBA methodology requires market modelling and simulation, which, at this stage, is out of the scope of the present study. Therefore, there is a need for the introduction of simplifications and assumptions for the quantification of the benefits of socialisation
- A balance between complexity and accuracy should be achieved

The CBA indictors included in the ENTSOG guidelines - ten in total, are split into two categories, monetized and non-monetized, …

- In the ENTSOG CBA Methodology, the benefits from externalities of a project are assessed through the evaluation of a series of indicators:
  - Four (4) monetized, and
  - Six (6) non-monetized
- This study is considered complete in terms of the indicators examined, as it incorporates all monetised indicators relevant to socialisation, while it excludes the non-monetised indicators since they do not allow for a tangible (monetised) review of the costs vs benefits. The indicators that were taken into consideration in this CBA are the following monetized indicators:
  - **Supply Cost Saving** (SCS): *Monetises benefits stemming from reducing the overall cost of gas supply*
  - **Fuel Cost Saving** (FCS): *Monetises fuel cost savings from the consumption of gas as opposed to an alternative fuel*
  - **Emission Cost Saving** (ECS): *Monetises CO_2 cost savings from the consumption of gas as opposed to an alternative fuel*



Total welfare of the scenario **with** the respective project (i.e., with socialisation)

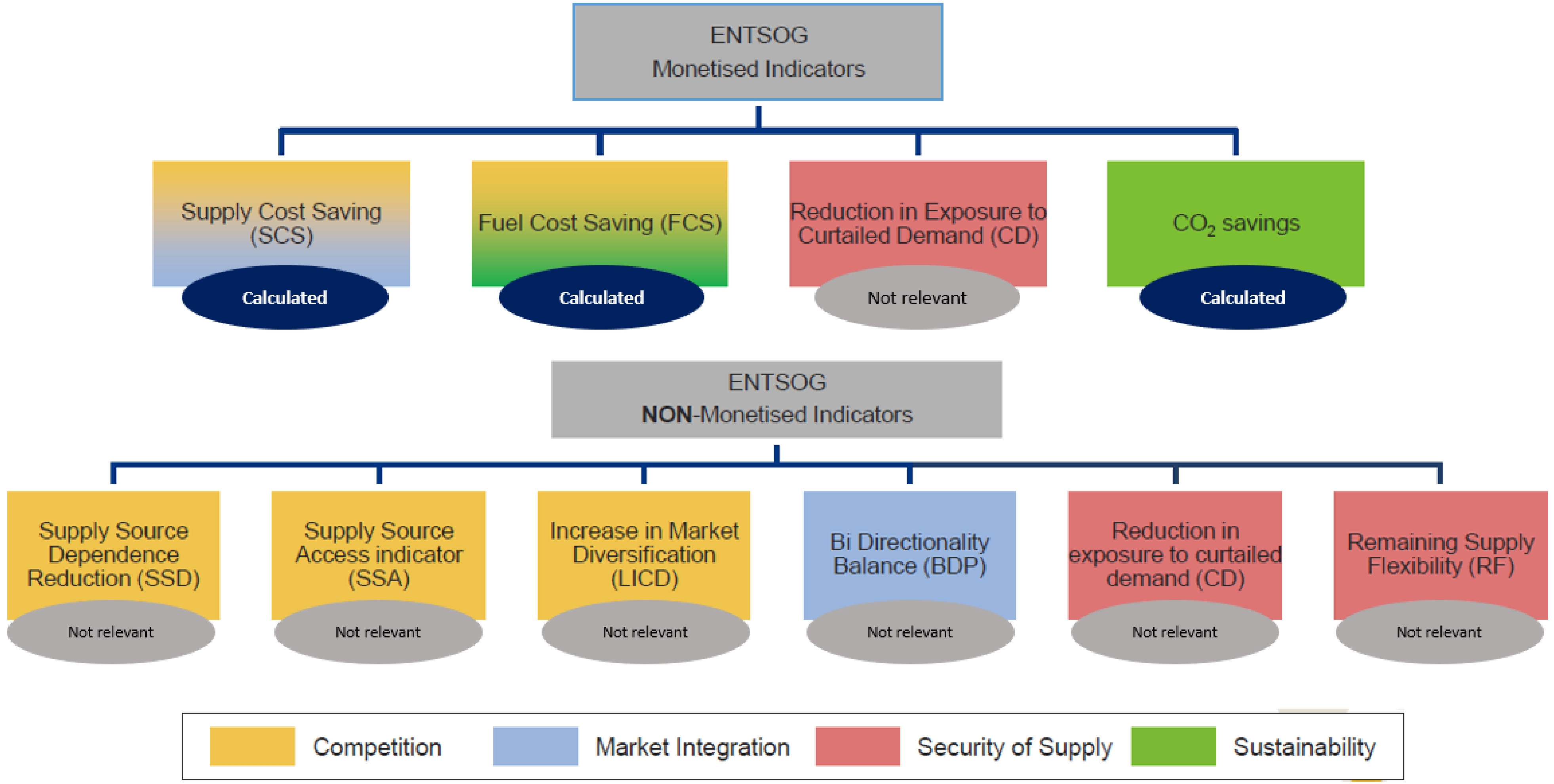
Total welfare of the scenario **without** the respective project (i.e., without socialisation, counterfactual scenario)

Costs of the project (CAPEX and OPEX, i.e., cost of socialisation)

Costs without the project (i.e., zero costs)

Benefits > Costs => <u>CBA grants a positive result</u>

… and cover the criteria of competition, market integration, security of supply and sustainability



The methodology focuses on calculating the cost of socialisation and the benefits of the end-consumers following a six-step approach

1	**Costs**	Define the costs related to the socialisation of Revithoussa
2	**Indicators**	Examine the ENTSOG indicators and define their relevance to the present study along with the possibility of monetization
3	**Modifications**	Modify the relevant indicators when feasible to assess the impact of socialisation
4	**Scenarios**	For each indicator, the counterfactual scenario (0% socialization level) is compared with a variant scenario (x% socialisation level), to assess the benefit of the socialisation of the Revithoussa terminal to the end-consumers
5	**Indicators**	For the monetized indicators, calculate the costs and benefits of socialisation in monetized terms. Conduct a sensitivity analysis on key parameters of the methodology
6	**Result**	Summarize the impact of socialisation and the infrastructure based on the monetary indicators examined

Alternative scenarios (variants) for different socialization levels are considered to assess the impact of socialization levels to the welfare of national gas consumers

- The time horizon of the Cost-Benefit Analysis is 25 years starting from 2024 and ending in 2048
- For the socialization of the Revithoussa LNG terminal both the domestic gas consumption in Greece and the gas exports from Greece have been taken into consideration
- Calculation of the Required Revenue of Revithoussa for the period 2024-2042 is based on the latest available information. For the remaining period until 2048, the Required Revenue is assumed to remain constant
- The baseline scenario of the CBA is considered with 0% socialization level ("*without project*") and the alternative scenarios (variants) are considered with 25%, 50%, 75% and 100% socialization level ("*with project*")
- The calculation of the cost and benefits is performed by comparing the counterfactual (“*without socialisation*”) with an alternative scenario (“*with socialisation*”)

Counterfactual

Scenario_0 baseline – Scenario_0 refers to 0% socialization level of Revithoussa cost
(i.e., the total required revenue for the Revithoussa LNG terminal is recovered from regasification tariffs charged upon terminal users)

Variants

Scenario_25 – Scenario_25 refers to 25% socialization level of Revithoussa cost
(i.e., 75% of the required revenue is recovered from regasification tariffs charged upon Revithoussa LNG terminal users)

Scenario_50 – Scenario_50 refers to 50% socialization level of Revithoussa cost
(i.e., 50% of the required revenue is recovered from regasification tariffs charged upon Revithoussa LNG terminal users)

Scenario_75 – Scenario_75 refers to 75% socialization level of Revithoussa cost
(i.e., 25% of the required revenue is recovered from regasification tariffs charged upon Revithoussa LNG terminal users)

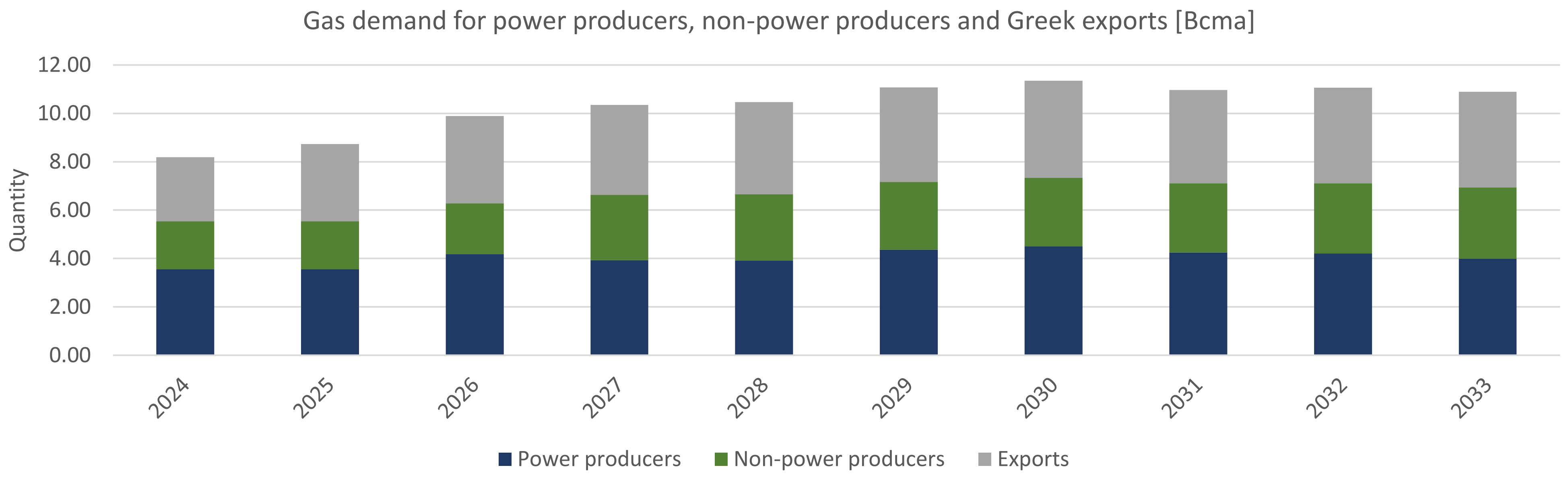
Scenario_100 – Scenario_100 refers to 100% socialization level of Revithoussa cost
(i.e., the total required revenue for the Revithoussa LNG terminal is recovered from tariffs at the exit points of the NNGTS)

Both domestic gas consumption in Greece and gas exports from Greece have been taken into consideration for the CBA of socialisation

- Regarding the demand for gas, an inelastic domestic gas consumption in Greece (both power and non-power producers), and for gas exports from Greece are assumed. All three are considered independent of the socialization level of Revithoussa LNG terminal, so they are constant across the counterfactual and the variant scenarios

- For the period 2024-2033, the domestic gas consumption in Greece and gas exports from Greece are in line with the Tariff 2024 assumptions. From 2034 and until 2048 the domestic gas consumption in Greece and gas exports from Greece are assumed to decrease linearly

- In the present study, production and consumption of renewable gases have not been investigated, thus the potential replacement of natural gas from biomethane or hydrogen towards 2050 is not taken into consideration

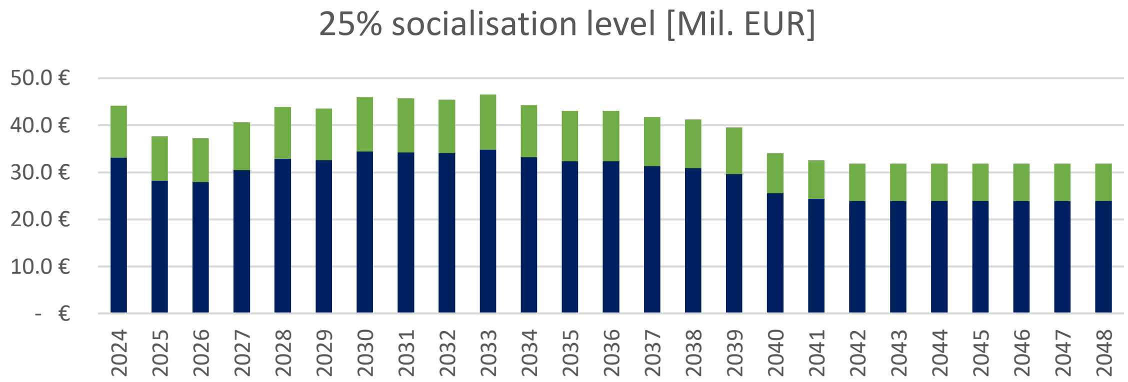


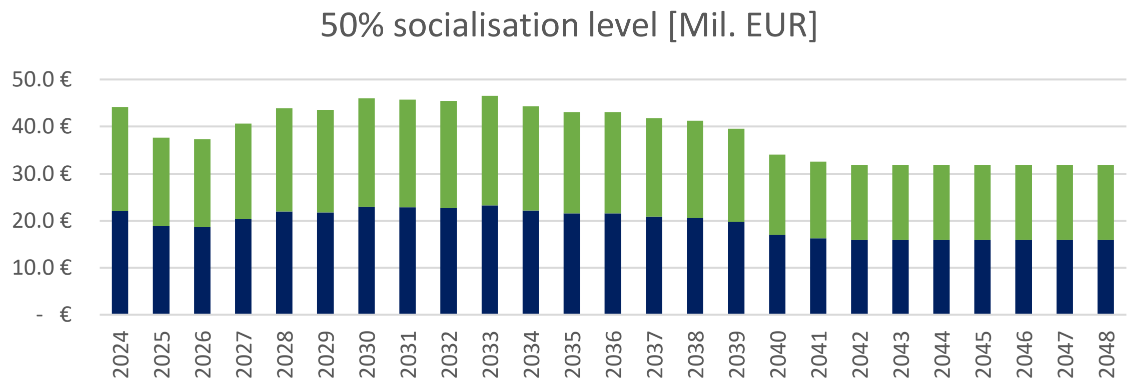
The cost of socialisation is the amount of the Required Revenue of Revithoussa LNG terminal that will be recovered through domestic, and interconnection exit points

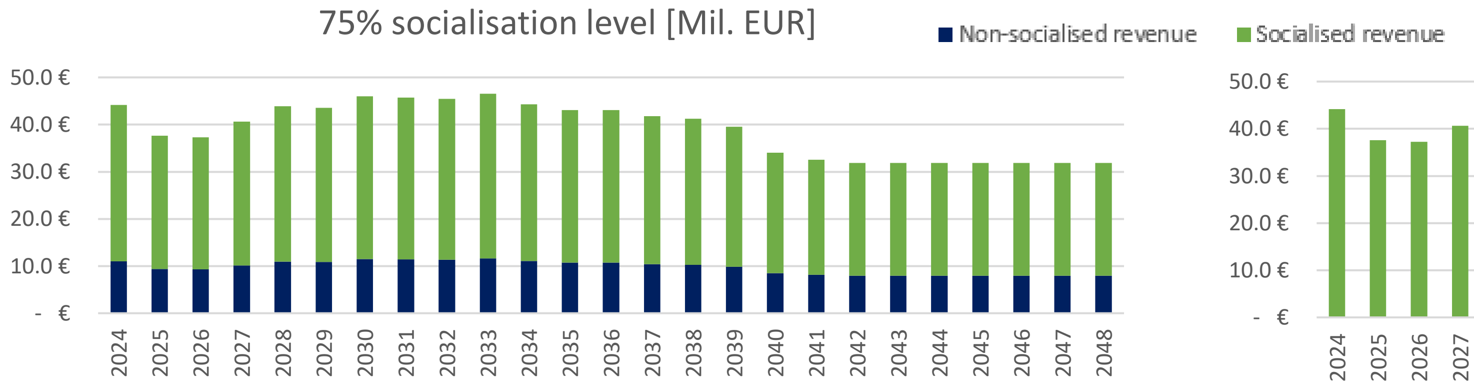
$$\text{Cost}_{\text{Scenario x}}\ (\text{Year n}) = \text{Socialization level} \times \text{Required Revenue}_{\text{Rev}}\ (\text{Year n})$$

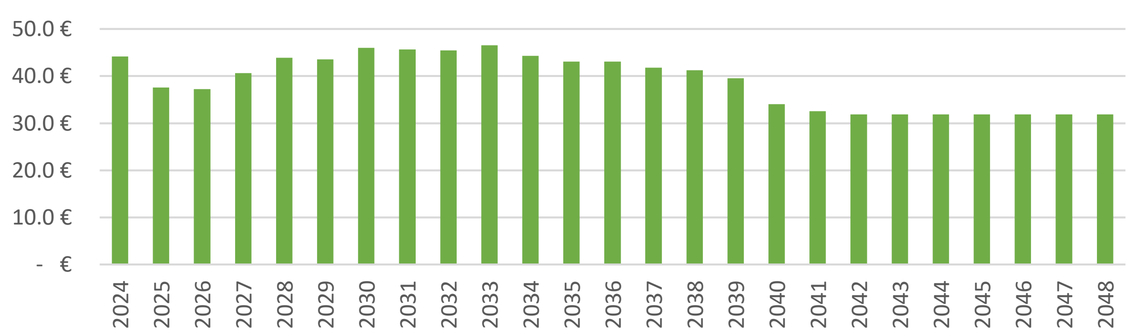
where

Cost $_{\text{Scenario X}}$ (Year n)	The socialisation cost of Revithoussa LNG terminal for Year n and socialisation level x% [EUR]
Socialization level	The socialisation percentage (i.e., 25%, 50%, 75% and 100%) [%]
Required Revenue $_{\text{Rev}}$ (Year n)	The Required Revenue of the Revithoussa LNG terminal for Year n [EUR]









The Supply Cost Savings indicator quantifies the reduction/increase of the overall cost of gas supply for flexibility due to the socialization of Revithoussa LNG terminal …

- For the quantification of the Supply Cost Savings indicator, the following approach is followed:
  - The gas consumption of Greece is split into two categories: Power Producers (PP) and the rest (Non-PP)
  - Gas demand for exports from Greece are considered (Exporters)
  - The Marginal Gas price of Greece is always set by LNG and specifically LNG from the Revithoussa LNG terminal (details on slide 22)
  - When flexibility is required from end-consumers (PP and Non-PP), this will be covered at VTP price (i.e., GMP)
  - In the Baseline scenario, the following assumptions are made for the flexibility needs of each category (details on slide 18-19):
    - Power producers will get 70% of their consumption through bilateral contracts and 30% will be priced at MGP
    - Non-power producers will get 50% of their consumption from bilateral contracts and 50% will be priced at MGP
    - Exporters will get 70% of their demand through bilateral contracts and 30% will be priced at MGP
  - A sensitivity analysis for the above percentages of the Baseline scenario is performed by ranging +/- 10% the flexibility needs of the end-consumers
  - Benefits are calculated on a yearly granularity and then are discounted with a factor of 5.7% [nominal discount rate, calculated as the real social discount rate suggested by ENTSOG guidelines (4%), plus 1.7% inflation rate] to calculate the Net Present Value

Additional assumptions

- The throughput of Revithoussa LNG terminal serves equally the power producers and non-power producers. The split does not contribute towards the level of benefits but towards the split of benefits to power and non-power producers
- In the baseline scenario, Revithoussa is the only LNG terminal considered to be operational in Greece for the reference period
- In the parametric analysis, additional LNG terminals are considered operational in order to assess the impact to the socialization of Revithoussa

… and is equal to the difference of the total amount paid for gas flexibility between the baseline scenario and a variant scenario with socialization level x%

- The Supply Cost Savings indicator, as defined by ENTSOG, compares the total gas supply (annual gas volume x unit cost of gas) with and without the project under investigation
- In this study, a modified approach is used for the calculation of the Supply Cost Savings indicator that compares the total gas supply cost for the end-consumers (power, non-power producers and exporters) required for flexibility without (counterfactual scenario) and with the socialization of Revithoussa LNG terminal
- The SCS indicator is calculated every year for the reference period and then for comparison purposes the NPV is derived

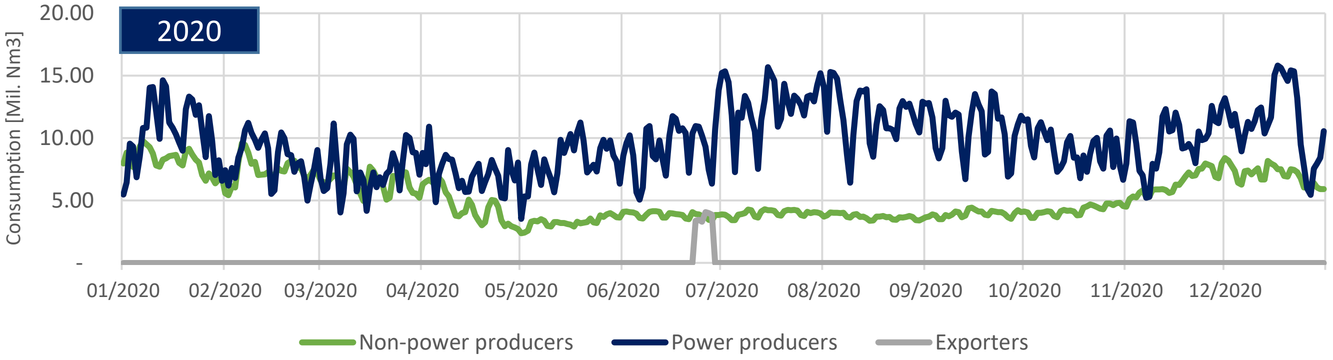
$$SCS\ (\text{Year } n) = [\ \text{Supply}\ (\text{Year } n) \times GMP\ (\text{Year } n)\ ]_{\text{Scenario } 0\%} - [\ \text{Supply}\ (\text{Year } n) \times GMP\ (\text{Year } n)\ ]_{\text{Scenario } x\%}$$

where

SCS (Year n)	The Supply Cost Savings indicator for Year n [EUR]
Supply (Year n)	Annual quantity of gas that is purchased (flexibility needs) at Gas Marginal Price [MWh] – see slide 20
GMP (Year n)	The Gas Marginal Price (GMP) of Greece in Year n [EUR/MWh] – see slide 22
Scenario 0%	Counterfactual scenario with no socialisation [%]
Scenario x%	Any scenario of the following with 25%, 50%, 75% and 100% socialisation level [%]

The variability of gas consumption and the need for supply flexibility …

Daily gas demand of power and non-power producers and exporters of Greece for 2020



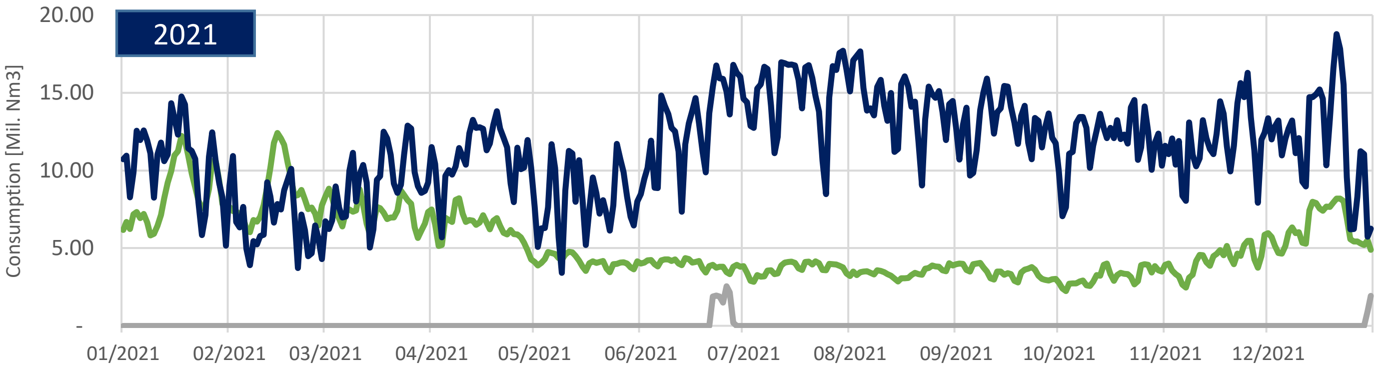
	Non-power producers	Power producers	Exporters
Max [Mil. Nm3]	9.77	15.80	4.07
Min [Mil. Nm3]	2.39	3.54	-
Average [Mil. Nm3]	5.25	9.73	0.06

	Non-power producers	Power producers	Exporters
(Max-Min)/Max	76%	78%	100%
(Max-Avg)/Max	46%	38%	99%

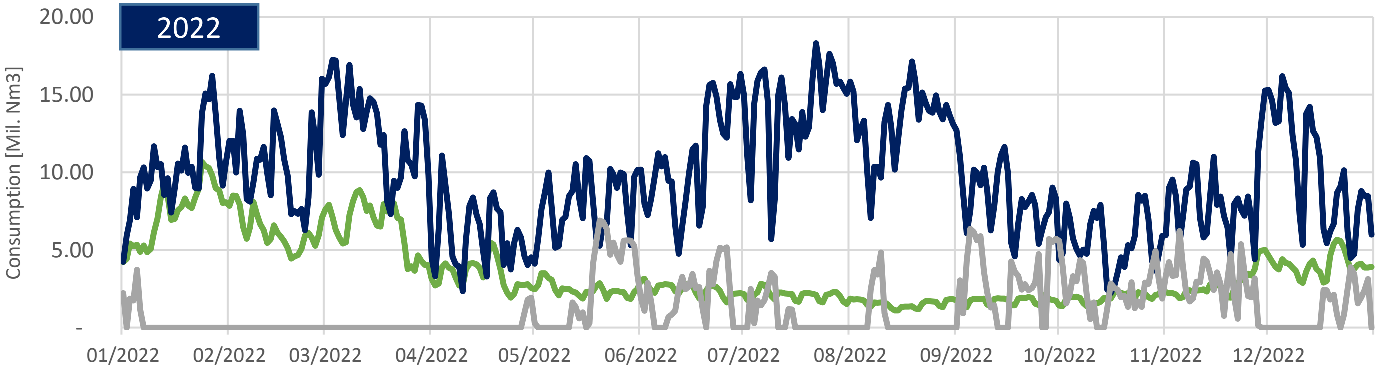
Daily gas demand of power and non-power producers and exporters of Greece for 2021

	Non-power producers	Power producers	Exporters
Max [Mil. Nm3]	12.41	18.78	2.55
Min [Mil. Nm3]	2.23	3.41	-
Average [Mil. Nm3]	5.23	11.43	0.04

	Non-power producers	Power producers	Exporters
(Max-Min)/Max	82%	82%	100%
(Max-Avg)/Max	58%	39%	98%



Daily gas demand of power and non-power producers and exporters of Greece for 2022

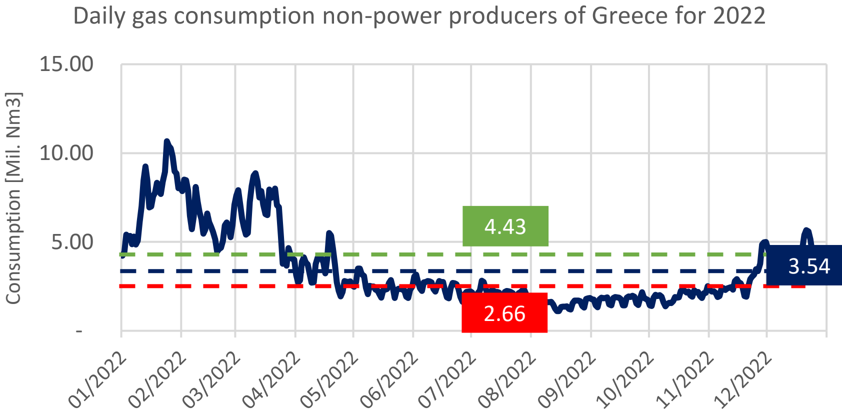


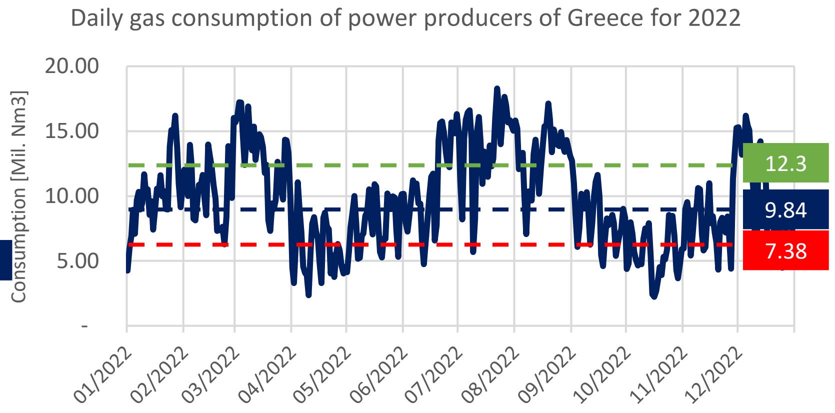
	Non-power producers	Power producers	Exporters
Max [Mil. Nm3]	10.67	18.30	6.90
Min [Mil. Nm3]	1.12	2.23	-
Average [Mil. Nm3]	3.54	9.84	1.27

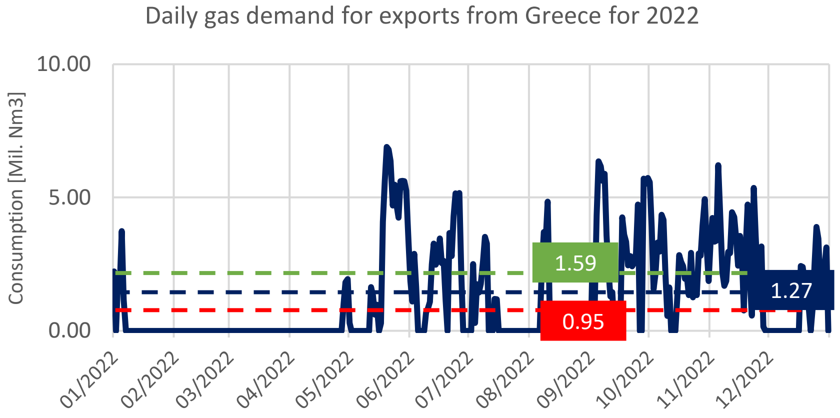
	Non-power producers	Power producers	Exporters
(Max-Min)/Max	90%	88%	100%
(Max-Avg)/Max	67%	46%	82%

… in gas consumption for both power and non-power producers is of increasing importance in the domestic and regional landscape (exports)

Average | 1.25*Average | 0.75*Average







Gas consumption and flexibility for 2022

	Non-power producers	Power producers	Exporters
Max [Mil. Nm3]	10.67	18.30	6.90
Min [Mil. Nm3]	1.12	2.23	-
Average [Mil. Nm3]	3.54	9.84	1.27

	Non-power producers	Power producers	Exporters
Average+25% [Mil. Nm3]	4.43	12.30	1.59
Average-25% [Mil. Nm3]	2.66	7.38	0.95
Consumption > 1.25*Average [Mil. Nm3]	639	1 507	432
Consumption < 0.75*Average [Mil. Nm3]	358	578	9
Total consumption [Mil. Nm3]	1 292	3 591	463
Flexibility	**77%**	**58%**	**95%**

Flexibility$_i$ = (+/-25% Average Consumption / Total Consumption)$_i$

, where i = power producers, non-power producers and exporters

- A +/-25% deviation from the average gas consumption of each of the three categories (power producers, non-power producers and exporters) is assumed as a need for flexibility
- For 2022, the total gas volumes required for flexibility (as defined below) are 997, 2085 and 441 Mil. Nm^3 for non-power producers, power producers and exporters respectively
- The flexibility as a percentage of the total consumption of each category is 77%, 58% and 95% for non-power producers, power producers and exporters respectively
- **For this CBA, a conservative approach is followed, and the flexibility percentages assumed in the baseline scenario are 50%, 30% and 30% for non-power producers, power producers and exporters respectively**
- Similar analysis for the years 2020 and 2021 can be found in the Appendix (slide 39)

The amount of gas injected to the system at the GMP is based on projected sectorial consumption and the respective flexibility assumption

- As previously explained, there is a considerable need for flexibility related to gas consumption for the electricity sector (power generation), for other sectors (non-power generation) and for exports
- The ambitious RES penetration targets, the security of supply obligations for protected consumers and the RePowerEU plans will make in the future the need for flexibility in power generation even more pronounced than it is today
- Additionally, the gasification of remote domestic areas, currently not consuming gas, in combination with a projected decrease in the load factor in the forthcoming years will also increase the need for flexible gas consumption for the non-power producers as well
- The quantitates of gas to be supplied for flexibility purposes to the power producers, non-power producers and exporters are assumed to be acquired from the VTP and thus priced at the Gas Marginal Price of Greece

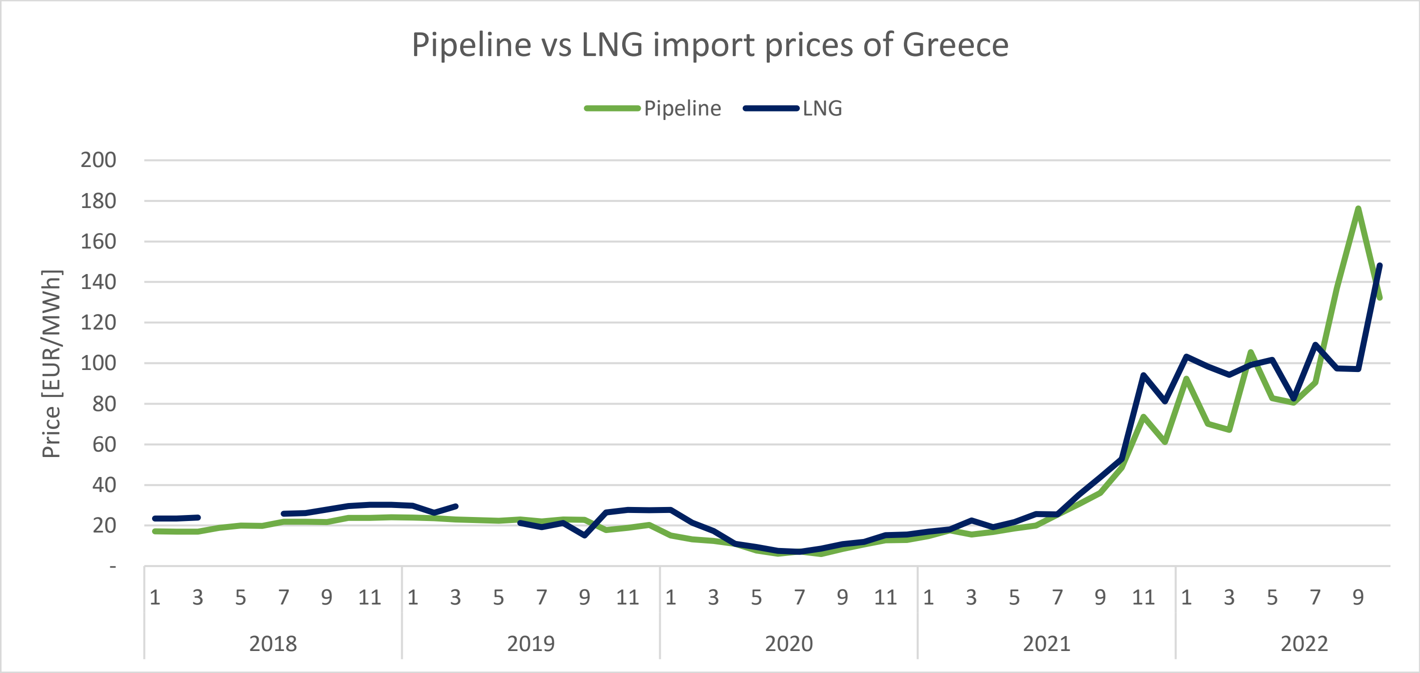
$$\text{Supply}\,(\text{Year } n) = \text{Flexibility}_{PP} \times \text{Consumption}_{PP}\,(\text{Year } n) + \text{Flexibility}_{Non\text{-}PP} \times \text{Consumption}_{Non\text{-}PP}\,(\text{Year } n) + \text{Flexibility}_{Exporter} \times \text{Consumption}_{Exporter}\,(\text{Year } n)$$

where

Supply (Year n)	Amount of gas to be supplied for flexibility purposes to the power, non-power producers and exporters for Year n [MWh]
Flexibility_{PP}	Flexibility needs of power producers - assumed 30% of respective consumption (see slide 19)
$\text{Flexibility}_{Non\text{-}PP}$	Flexibility needs of non-power producers - assumed 50% of respective consumption (see slide 19)
$\text{Flexibility}_{Exporter}$	Flexibility needs of non-power producers – assumed 30% of respective consumption (see slide 19)
Consumption_{I} (Year n)	Gas demand of Power Producers, Non- Power producers and Exporters in Year n [MWh]

Historically and under normal market conditions it can be argued that the commodity unit cost of LNG has been higher than the respective of pipeline gas …

- The fact that under normal market conditions, the LNG is the most expensive source of gas is widely acknowledged and supported by the European Commission Reports on Gas Prices (e.g., EC's Quarterly reports on European gas markets, ACER Market Monitoring Report)
- For the evaluation of the Supply Cost Savings indicator and based on ENTSOG's recommendations, apart from the commodity price of LNG, the tariffs of the National Gas Transmission System are also taken into consideration; specifically, the regasification tariff of Revithoussa and the entry tariff to Agia Triada
- For the purpose of this study, the LNG quantities from Revithoussa terminal are considered to set the price at the VTP. Thus, the LNG price is assumed to be the MGP for Greece which is also supported by the following figure illustrating the import prices of LNG and pipeline gas for Greece during the period 2018-2022



Source: Eurostat, δesfa's analysis

... thus, the LNG can be assumed to be the marginal supply source and thus LNG price to be the Marginal Gas Price of Greece

- The Marginal Gas Price of Greece is calculated as the summation of the commodity price of LNG, the tariffs associated with the Revithoussa LNG terminal and the entry/exit tariffs of the NNGTS, shown below

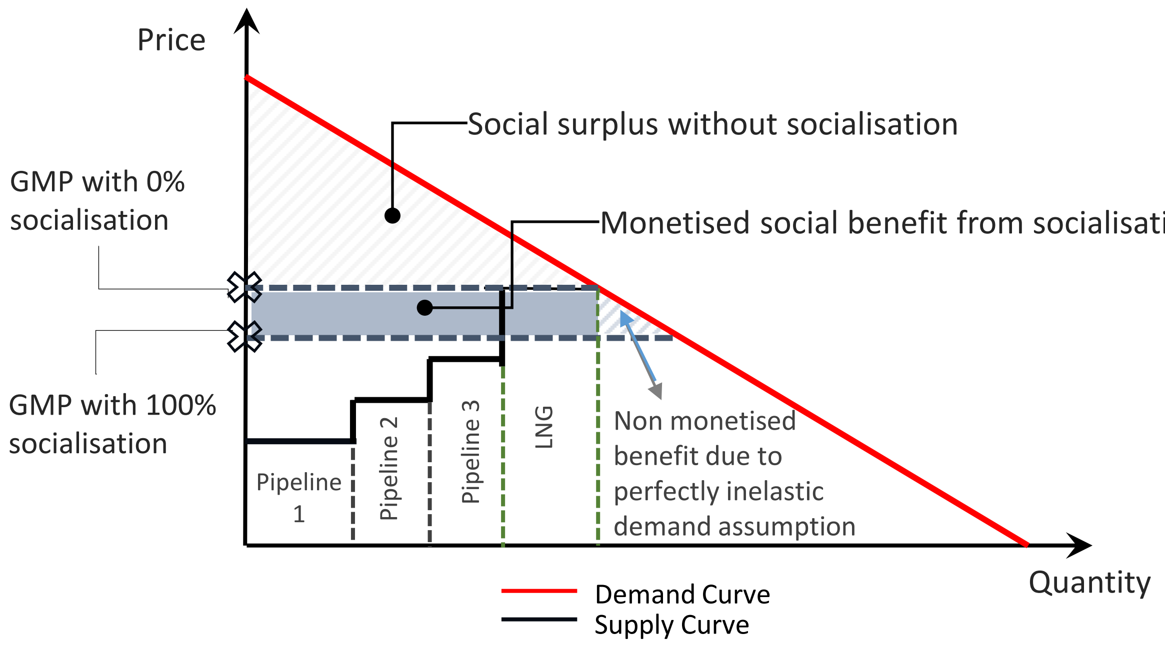
$$GMP\ (\text{Year } n)_{\text{Scenario } x\%} = Price_{LNG}\ (\text{Year } n) + \text{Revithoussa Regassification Tariff}\ (\text{Year } n)_{\text{Scenario } x\%} + \text{Entry Tariff Agia Triada}\ (\text{Year } n)$$

where

GMP (Year n)	Gas Marginal Price of Greece in Year n [EUR/MWh]
Price $_{LNG}$ (Year n)	Average LNG price in Yean n [EUR/MWh]
Rev. Regas. Tariff (Year n) $_{\text{Scenario } x\%}$	Regasification tariff of Revithoussa LNG terminal for Year n and socialization level x% [EUR/MWh]
Entry Tariff Agia Triada (Year n)	Entry tariffs to NNGTS at Agia Triada for Year n [EUR/MWh]
Scenario 0%	Counterfactual scenario with no socialisation
Scenario x%	Any scenario of the following with 25%, 50%, 75% and 100% socialisation level

An increase in socialization of Revithoussa cost decreases regasification tariff and leads to increased welfare of Greek gas consumers

- As already discussed, the price of LNG is assumed marginally higher compared to pipeline gas thus is considered to set the price at the VTP. Hence, the Gas Marginal Price (GMP) of the VTP is equal to the LNG commodity price plus the regasification tariffs at Revithoussa LNG terminal and the Agia triada entry tariff
- The analysis assumes that all traded gas quantities at the VTP are priced at the GMP
- The socialization of costs of the Revithoussa LNG terminal reduces the regasification tariff and as a result the Gas Marginal Price (GMP)
- A decrease in the GMP leads to an increase in the consumer surplus which equals to the socio-economic benefit
- Both domestic (Power producers, non-power producers) and regional (exporters) markets benefit from the socialization based on the gas quantities purchased from the VTP (based on the respective flexibility needs of each category)



The benefit from the socialization is proportional to the difference in Revithoussa regasification tariffs based on socialization level

- Based on the analyses presented in the previous slides regarding the flexibility needs of end-consumers (slide 18-19) and the derivation of the Marginal Gas Price of Greece (slide 22), it is concluded that the benefit of the socialization of Revithoussa equals to the amount of gas purchased at GMP multiplied by the difference of Revithoussa regasification tariffs without and with socialization
- The Benefit from the Supply Cost Savings is directly related to the socialized Revithoussa tariff (all other parameters being constant)

$$\text{Benefit (Year n)} = \text{Supply (Year n)} \times \left[\text{Rev. Regas. Tariff (Year n)}_{\text{Scenario 0\%}} - \text{Rev. Regas. Tariff (Year n)}_{\text{Scenario x\%}} \right]$$

where

Benefit (Year n)	Benefit of socialization for Year n [EUR]
Supply (Year n)	Annual quantity of gas that is purchased (flexibility needs) at Gas Marginal Price [MWh]
Rev. Regas. Tariff (Year n) $_{\text{Scenario\_x\%}}$	Regasification tariff of Revithoussa LNG terminal for Year n and socialization level x% [EUR/MWh]

$$\text{Rev. Regas. Tariff (Year n)}_{\text{Scenario x\%}} = \text{Required Revenue (Year n)}_{\text{Scenario x\%}} \,/\, \text{Regasification Quantities (Year n)}$$

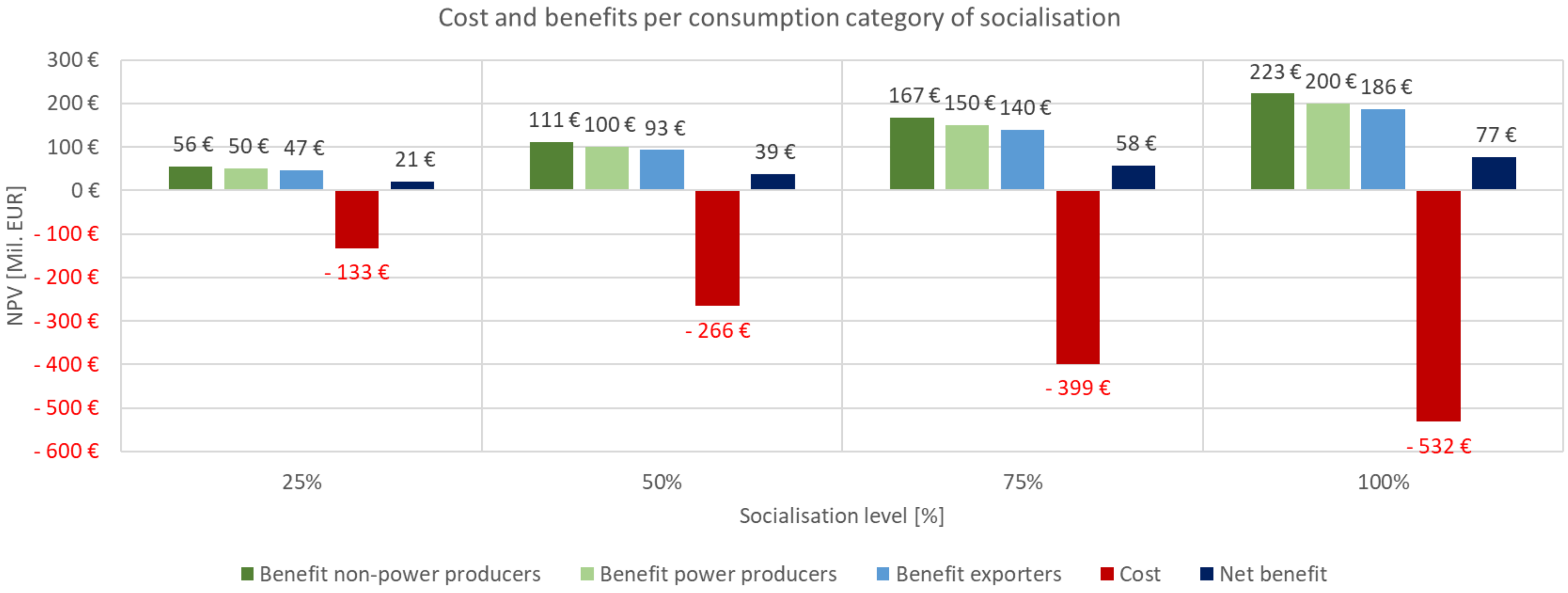
where

Required Revenue (Year n) $_{\text{Scenario\_x\%}}$	Required Revenue of Revithoussa LNG terminal for Year n with socialisation level x% [EUR]
Regasification quantities (Year n)	Regasified gas quantities of Revithoussa LNG terminal for Year n [MWh]

The Baseline scenario shows that increasing socialization levels lead to greater benefits for the end-consumers and that full socialization maximizes welfare

Baseline

Flex $_{PP}$ = 30%,
Flex $_{non\text{-}PP}$ = 50%
Flex $_{Exports}$ = 30%

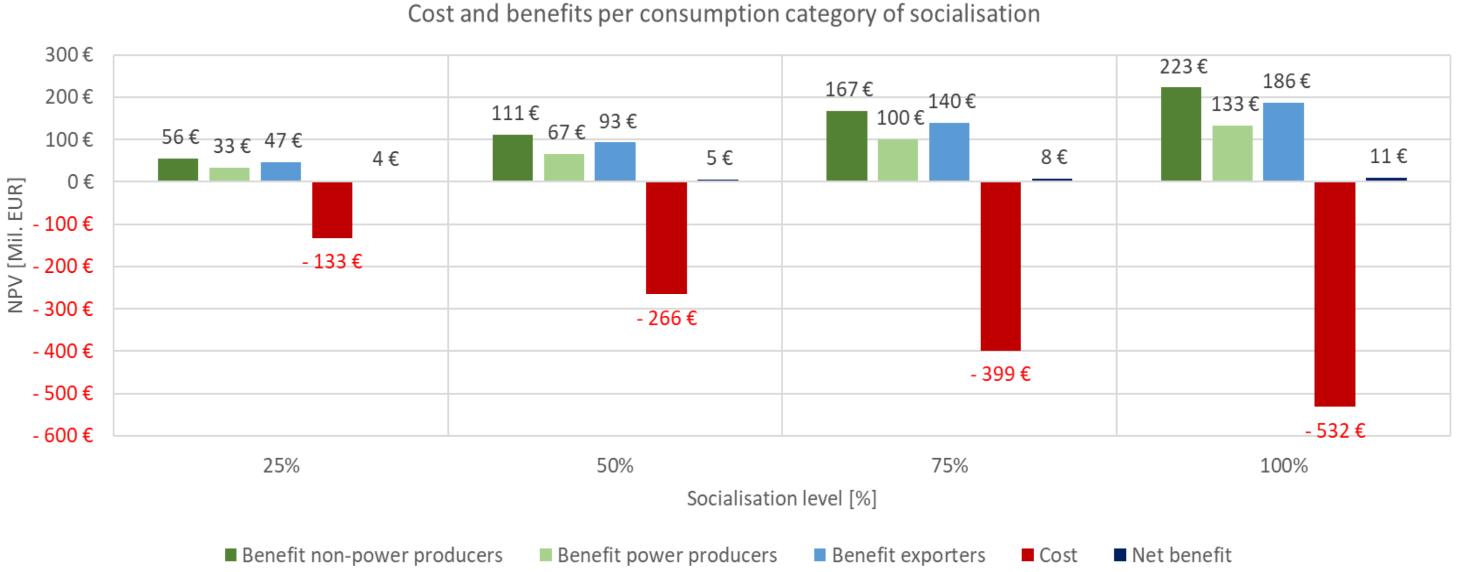


- ❑ In the baseline scenario, the percentage flexibility of the power producers is 30%, of the non-power producers is 50% and of the exporters is 30%
- ❑ As it can be seen from slide 40 (Appendix) when the actual flexibility percentages of each category are assumed, a much higher net benefit occurs
- ❑ The total benefits of each category (due to the decrease of the regasification tariff of Revithoussa LNG terminal) are compared against the cost of socialisation of the terminal
- ❑ The CBA results indicate that for all socialization levels of the Revithoussa LNG terminal, the net-benefit is positive
- ❑ The net benefit of socialization increases with the level of socialization,
- ❑ In particular, the net benefits are 21, 39, 58 and 77 Mil. EUR for 25%, 50%, 75% and 100% socialization level respectively

Sensitivity analysis on the flexibility requirements of power producers

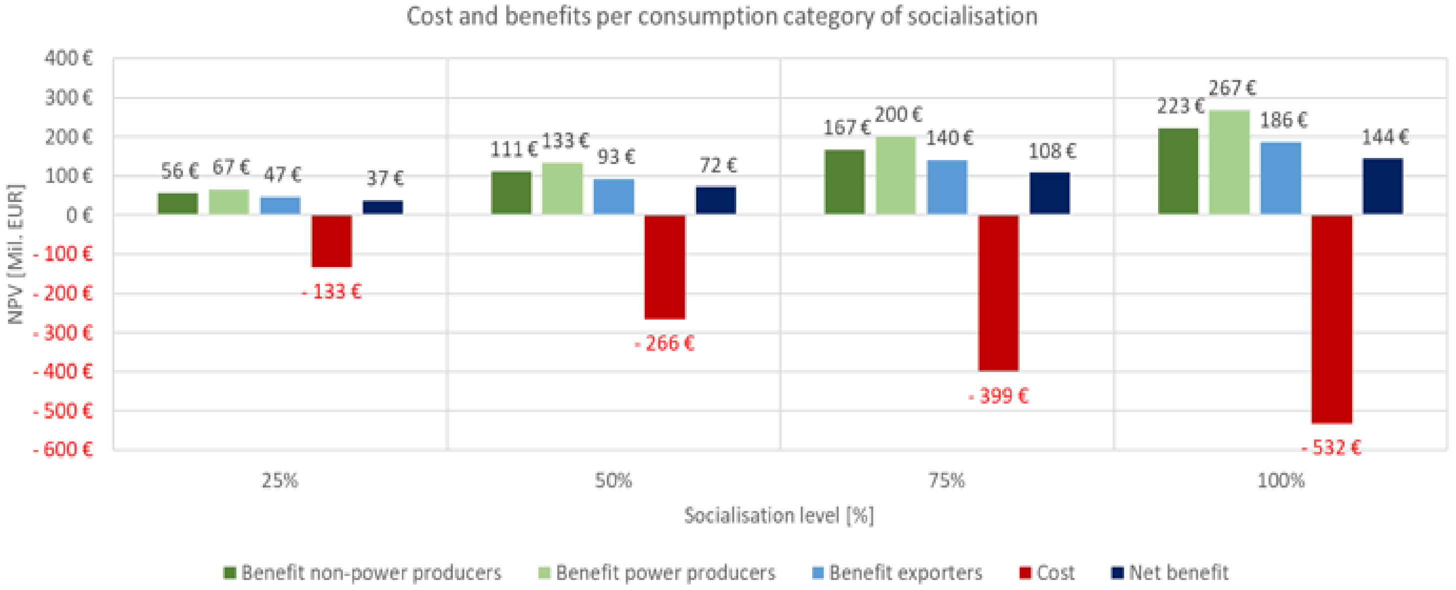
Sensitivity 1

Flex $_{PP}$ = 20%,
Flex $_{non\text{-}PP}$ = 50%
Flex $_{Exports}$ = 30%



Sensitivity 2

Flex $_{PP}$ = 40%,
Flex $_{non\text{-}PP}$ = 50%
Flex $_{Exports}$ = 30%

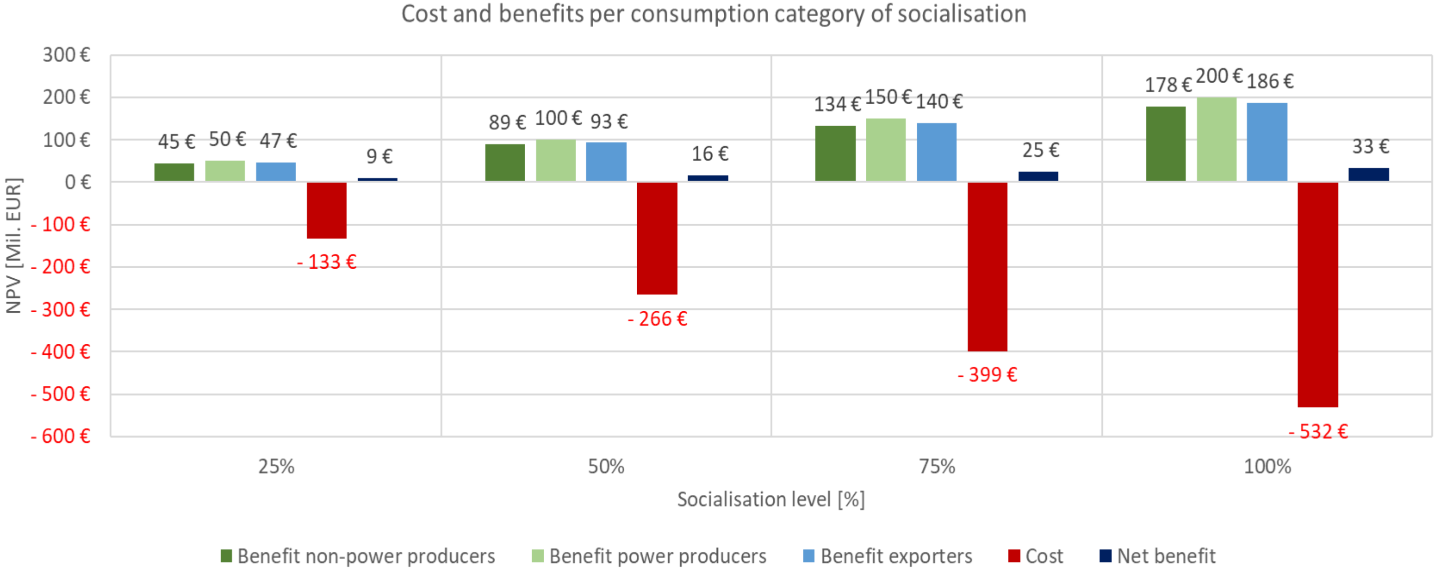


- When the flexibility of the power producers **is decreased to 20%** (assuming flexibility of the non-power producers remains constant), the net benefit of the socialization is still positive equal to 4, 5, 8, and 11 Mil. EUR for 25%, 50%, 75% and 100% socialization level
- When the flexibility of the power producers **is increased to 40%** (assuming flexibility of the non-power producers remains constant), the net benefit of the socialization is higher compared to the baseline scenario and particularly equal to 37, 72, 108, and 144 Mil. EUR for 25%, 50%, 75% and 100% socialization level
- The CBA results indicate that, the higher the flexibility of the power producers, the higher the benefit of the socialization becomes due to the increased gas quantities purchased from the VTP and priced at GMP

Sensitivity analysis on the flexibility requirements of non-power producers

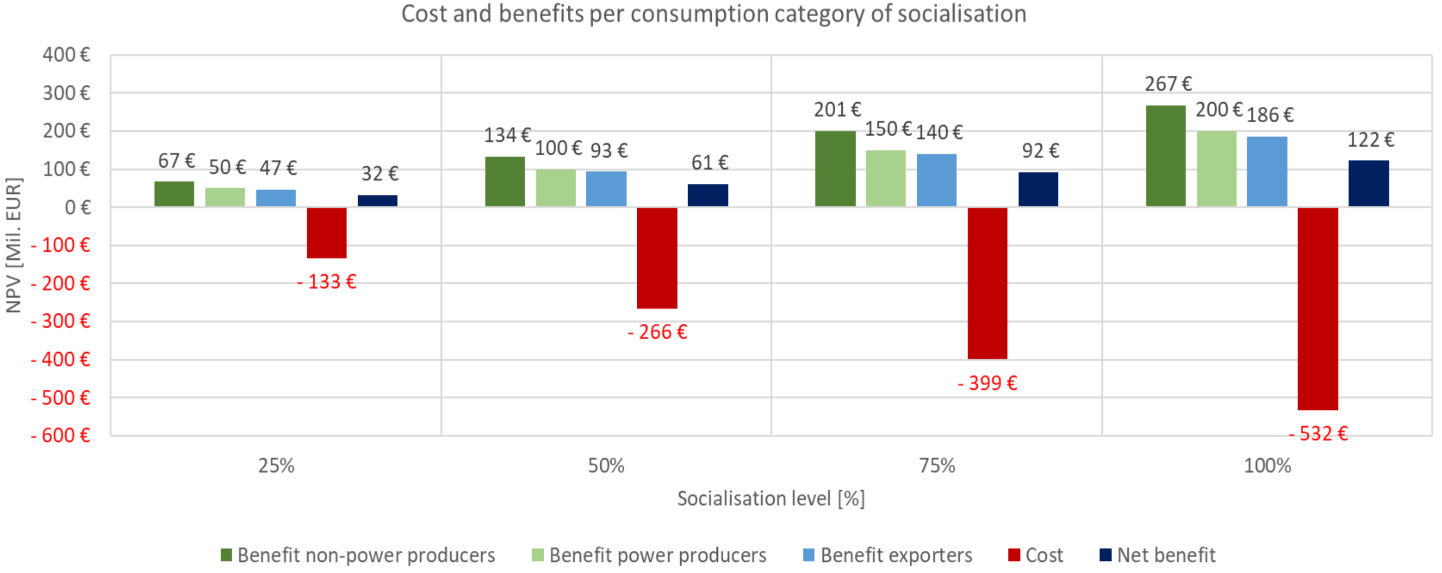
Sensitivity 3

Flex $_{PP}$ = 30%,
Flex $_{non-PP}$ = 40%
Flex $_{Exports}$ = 30%



Sensitivity 4

Flex $_{PP}$ = 30%,
Flex $_{non-PP}$ = 60%
Flex $_{Exports}$ = 30%

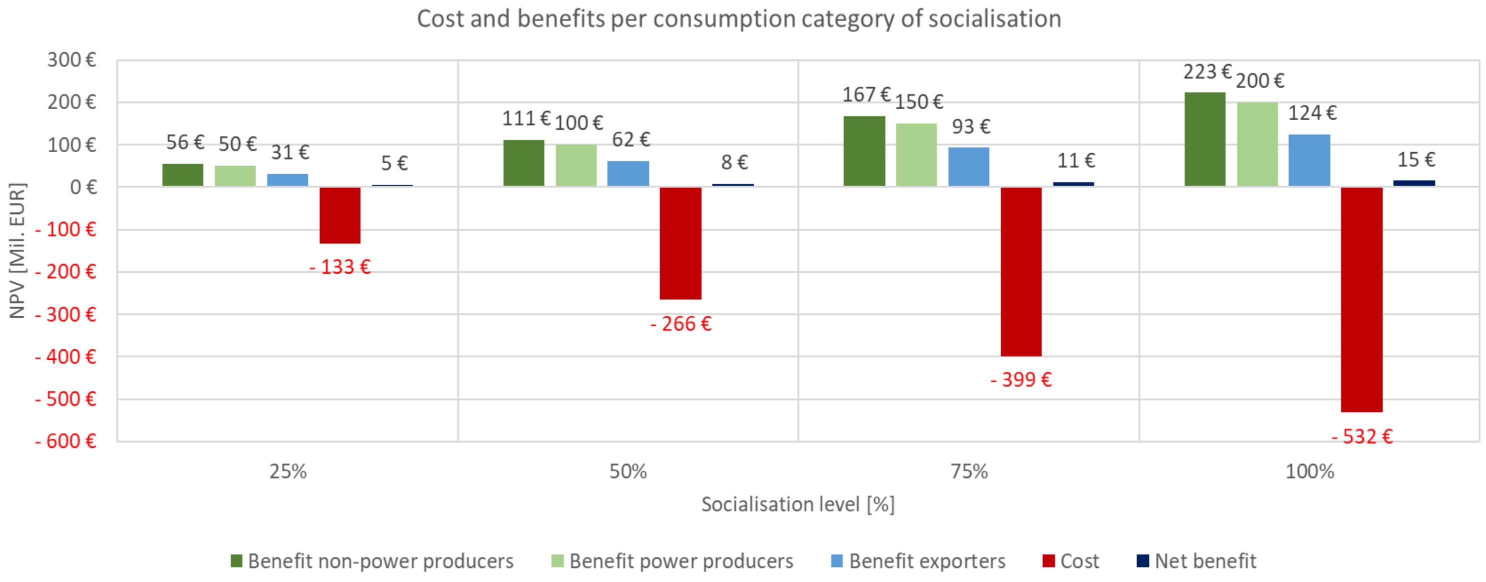


- When the flexibility of the non-power producers **is decreased to 40%** (assuming flexibility of the rest of the categories remain constant), the net benefit of the socialization is still positive equal to 9, 16, 25, and 33 Mil. EUR for 25%, 50%, 75% and 100% socialization level
- When the flexibility of the non-power producers **is increased to 60%** (assuming flexibility of the rest of the categories remain constant), the net benefit of the socialization is higher compared to the baseline scenario and particularly equal to 32, 61, 92, and 122 Mil. EUR for 25%, 50%, 75% and 100% socialization level
- The CBA results indicate that, the higher the flexibility of the non-power producers, the higher the benefits of the socialization becomes due to the increased gas quantities purchased from the VTP and priced at GMP

Sensitivity analysis on the flexibility of exporters

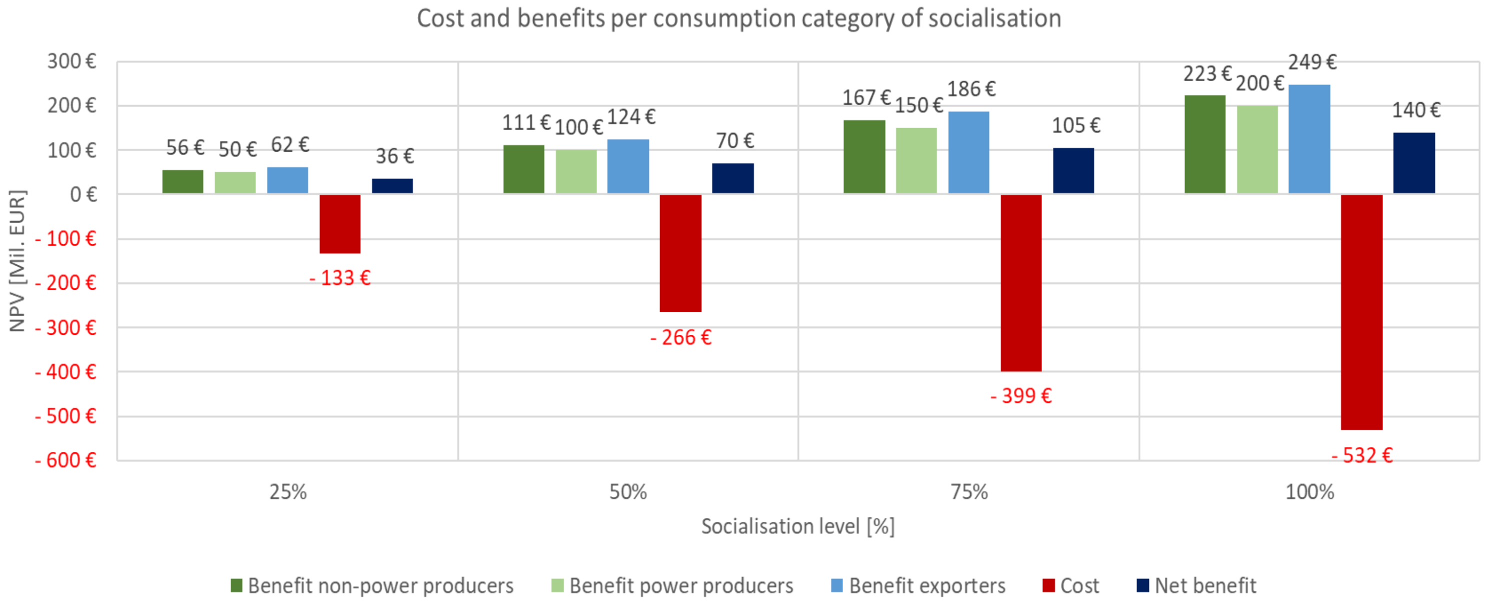
Sensitivity 5

Flex $_{PP}$ = 30%,
Flex $_{non-PP}$ = 50%
Flex $_{Exports}$ = 20%



Sensitivity 6

Flex $_{PP}$ = 30%,
Flex $_{non-PP}$ = 50%
Flex $_{Exports}$ = 40%



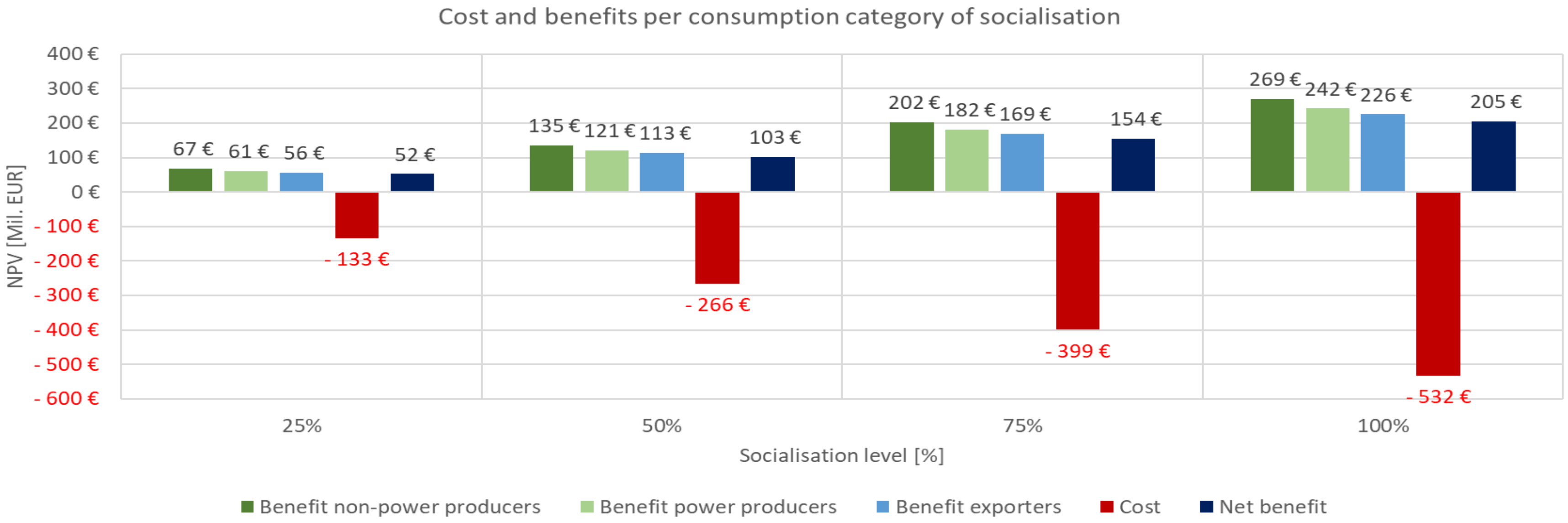
- When the flexibility of exporters is **decreased to 20%** (assuming flexibility of the rest of the categories remain constant), the net benefit of the socialization is still positive equal to 5, 8, 11, and 15 Mil. EUR for 25%, 50%, 75% and 100% socialization level
- When the flexibility of exporters is **increased to 40%** (assuming flexibility of the rest of the categories remain constant), the net benefit of the socialization is higher compared to the baseline scenario and particularly equal to 36, 70, 105, and 140 Mil. EUR for 25%, 50%, 75% and 100% socialization level
- The CBA results indicate that, the higher the flexibility of exporter, the higher the benefits of the socialization becomes due to the increased gas quantities purchased from the VTP and priced at GMP

The net benefit of the socialization of the Revithoussa LNG terminal becomes higher with the utilization of other LNG terminals in Greece

Sensitivity 7

Flex $_{PP}$ = 30%,
Flex $_{non\text{-}PP}$ = 50%
Flex $_{Exports}$ = 30%

Additional operation of LNG terminals



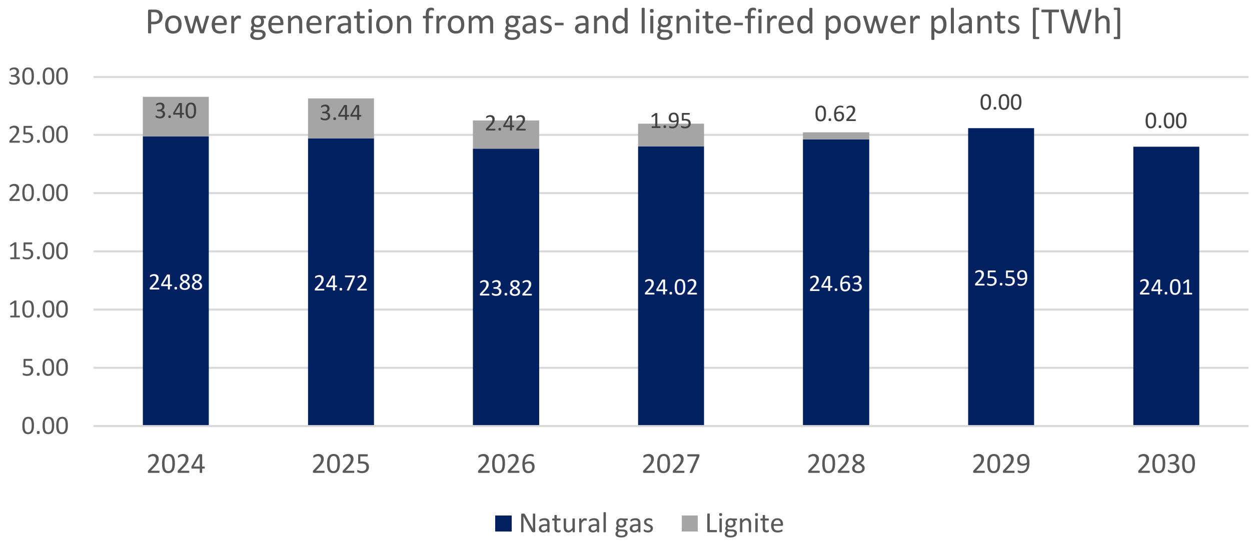
- In this scenario, other LNG terminals are assumed to be operation in Greece. Specifically, **20% of the total LNG consumption in Greece is assumed to be served by other Greek LNG terminals** (i.e., 20% decrease in the regasification volumes of Revithoussa)
- The CBA results indicate that the net benefit of the socialization of the Revithoussa LNG terminal becomes higher when other LNG terminals become operational in Greece under the assumption that LNG from Revithoussa terminal still sets the GMP
- The cost of socialisation is independent from the regasification volumes of Revithoussa (slide 15) but the benefits (for a given socialization level) are inversely proportional to the regasification quantities of Revithoussa LNG terminal (slide 24), thus decreasing regasification volumes – due to the operation of other LNG terminals - result to higher net benefit
- Under this sensitivity, other LNG terminals are assumed to be baseload, so they do not set the price in the VTP. This is justified by the fact that they are served only by long-term contracts since they are exempted infrastructures
- The net benefit of socialization increases compared to the baseline scenario, in particular the net benefit of socialization is equal to 52, 103, 154, and 205 Mil. EUR for 25%, 50%, 75% and 100% socialization level

Benefits from the Fuel and CO2 cost saving indicators occur when there is a switch in the merit order of the wholesale power market

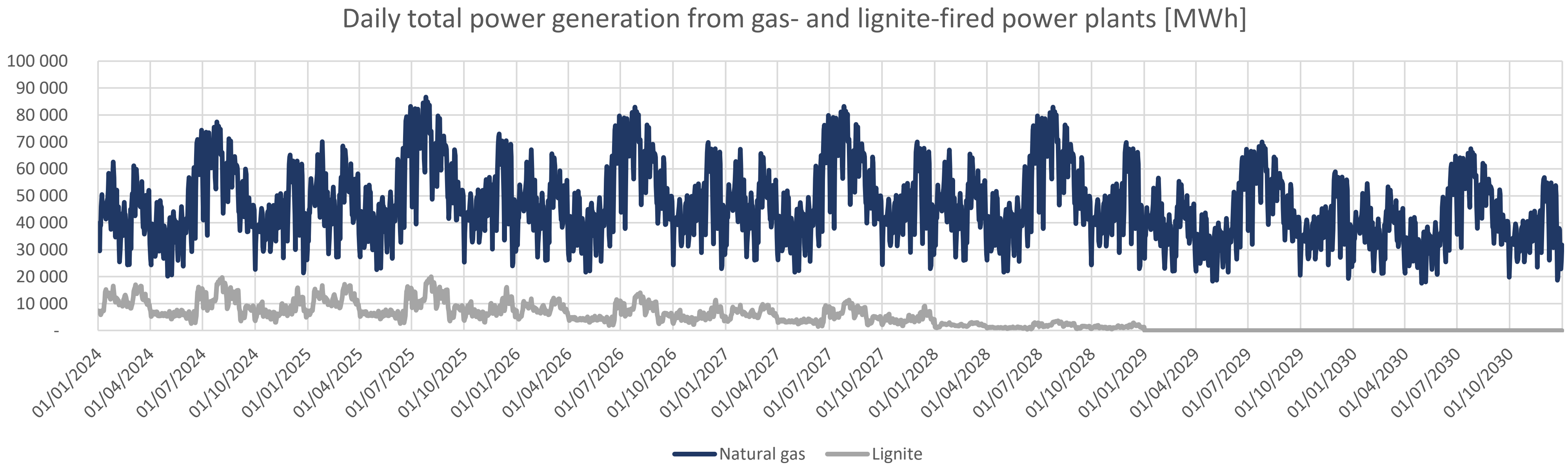
- In particular
  - Fuel Cost Saving (FCS): Monetises fuel cost savings (positive or negative) from the use of gas as opposed to an alternative fuel
  - CO_2 emissions reduction (ECS): Monetises CO_2 savings (positive or negative) emitted from the use of gas as opposed to an alternative fuel
- The following simplified approach was followed to approximate the indicators:
  - Given the gas demand, which is in line with the Tariff 2024 assumptions, and the daily generation profiles of gas-fired and lignite-fired power plants (2021, 2022) the daily generation of the two technologies is derived
  - Based on the latest forecasts of S&P regarding the TTF and Brent prices in combination with Desfa's analysis, the pipe gas and LNG prices for Greece are calculated
  - Using a specific methodology*, the marginal prices for lignite-fired and gas-fired plants are derived
  - The above steps are performed for the counterfactual scenario (0% socialisation level) and the alternative socialisation scenarios (25%, 50%, 75% and 100%)
  - In daily granularity, the occasions that the (cost based) merit order changes are identified (essentially the competitiveness of gas-fired and lignite-fired power plants) in order to capture if there will be any fuel or emission costs savings (positive or negative) due to this change
  - Based on the changes in the merit order (from a lignite-fired to a gas-fired marginal unit and vice versa), difference in the fuel consumed and the CO2 emitted are calculated
- Following the specific methodology and mainly due to the high level of gas prices there is no noticeable switch in the merit order attributed to the change in tariffs due to socialisation. The change in the merit order is caused by the dynamics of gas commodity prices

**The methodology is based on the temporary mechanism that RAE developed for determining the Regulated Producer Revenue Prices , see Appendix (slide 41-42) (PAE_-rithmizomenes_times_July-2022.pdf (rae.gr))*

For the calculation of the Fuel and Emission Cost Saving indicators, the merit order of the power market for different socialization levels needs to be constructed …

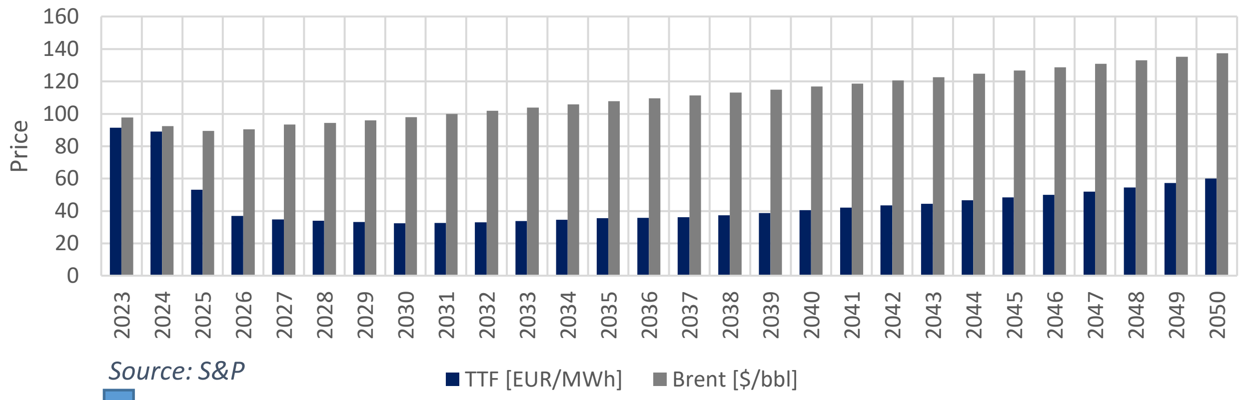


- The yearly total power generation from lignite-fired and gas-fired are in line with the **Tariff 2024 assumptions** of Desfa
- The yearly total power generations of the two technologies were transformed into daily granularity based on the **daily average power generation profiles** of lignite-fired and gas-fired power plants for 2021 and 2022



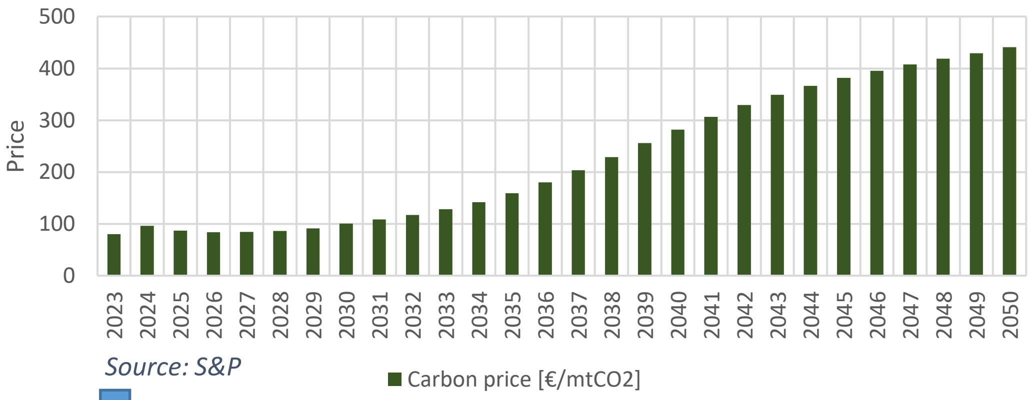
… taking into consideration the latest assumptions on gas demand, gas prices and carbon prices of Desfa

Evolution of TTF and Brent prices



Source: S&P

Evolution of carbon prices



Source: S&P

The transformation from TTF and Brent prices to Greek pipeline and LNG prices is based on:

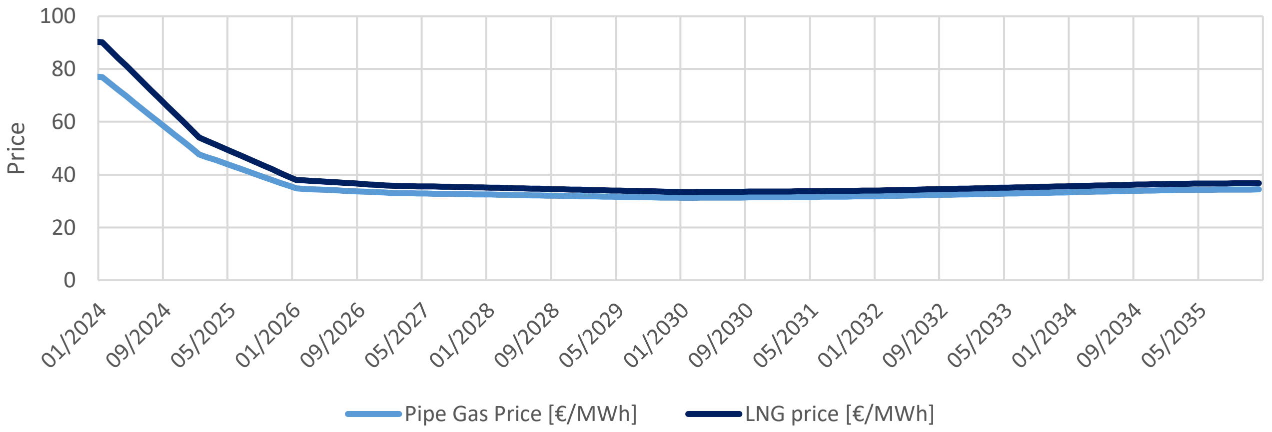
Pipe gas price = A* x TTF price + B* x Brent price

LNG price = TTF price + 1 [EUR/MWh]

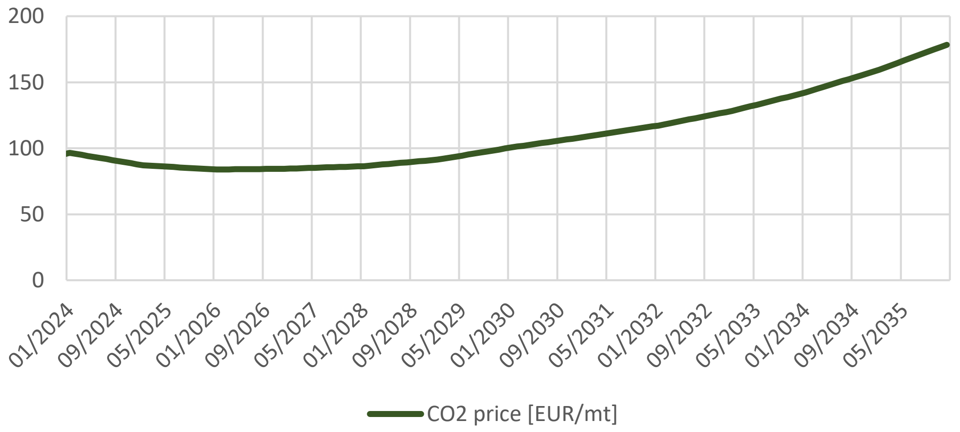
* Regression parameters based on Desfa's analysis

The transformation from yearly to monthly granularity was based on linear interpolation

Monthly average pipe gas and LNG prices [EUR/MWh]



Monthly average carbon prices



The indicators do not contribute to the CBA due to the high marginal prices for power generation …

$$\text{Gas price paid} = \text{PP pipe} \times \text{Pipe gas price} + \text{PP LNG} \times (\text{LNG price} + \text{Rev. Regas. tariff}_{\text{Scenario x\%}}) + \text{Entry tariff} + \text{Exit tariff}_{\text{Scenario x\%}}$$

where

Gas price paid	Final price of gas paid by power producers [EUR/MWhg]
PP pipe	Percentage of pipe gas in the portfolio of power producers [%] – assumed 50%
Pipe gas price	Price of pipe gas based on Brent and TTF prices [EUR/MWhg]
PP LNG	Percentage of LNG in the portfolio of power producers [%] – assumed 50%
LNG price	Price of LNG based on TTF prices [EUR/MWhg]
Rev. Regas. tariff $_{\text{Scenario x\%}}$	Regasification tariff of Revithoussa LNG terminal for socialization level x% [EUR/MWhg]
Entry tariff	Tariff paid by the power producer to enter the NNGTS [EUR/MWhg]
Exit tariff $_{\text{Scenario x\%}}$	Tariff paid by the power producer to exit the NNGTS for socialization level x% [EUR/MWhg]

$$\text{Fuel cost paid} = \text{Gas price paid} / (\text{LCV coefficient} \times \text{CCGT efficiency})$$

where

Fuel cost paid	Final price of fuel paid by a CCGT [EUR/MWhe]
Gas price paid	Final price of gas paid by power producers [EUR/MWhg]
CCGT efficiency	Thermal efficiency of a CCGT – assumed 50%
LCV coefficient	Low calorific value coefficient for natural gas – assumed 90%

$$\text{Fuel cost paid} = \text{Mining cost} / \text{Lignite-fired PP efficiency}$$

where

Fuel cost paid	Final price of fuel paid by a lignite-fired power plant [EUR/MWhe]
Mining cost	Cost of mining lignite – assumed 20 EUR/MWh_{th}
Lignite-fired PP efficiency	Thermal efficiency of a lignite-fired power plant – assumed 28.5%

The indicators do not contribute to the CBA due to the high marginal prices for power generation …

$$\text{CO2 cost paid} = \text{Carbon price} \times \text{Emission rate}_i$$

where

CO2 cost paid	Final emission cost paid by power producers [EUR/MWhe]
Carbon price	Price of CO2 [EUR/tonne] (assumed EUA prices)
Emission rate $_i$	CO2 emission rate of a power producer [tonne CO2/MWhe] – assumed 0.38 for CCGT and 1.38 for lignite-fired

$$\text{Marginal cost of gas-fired power plant} = \text{Fuel cost paid} + \text{CO2 cost paid} + \text{OPEX}$$

where

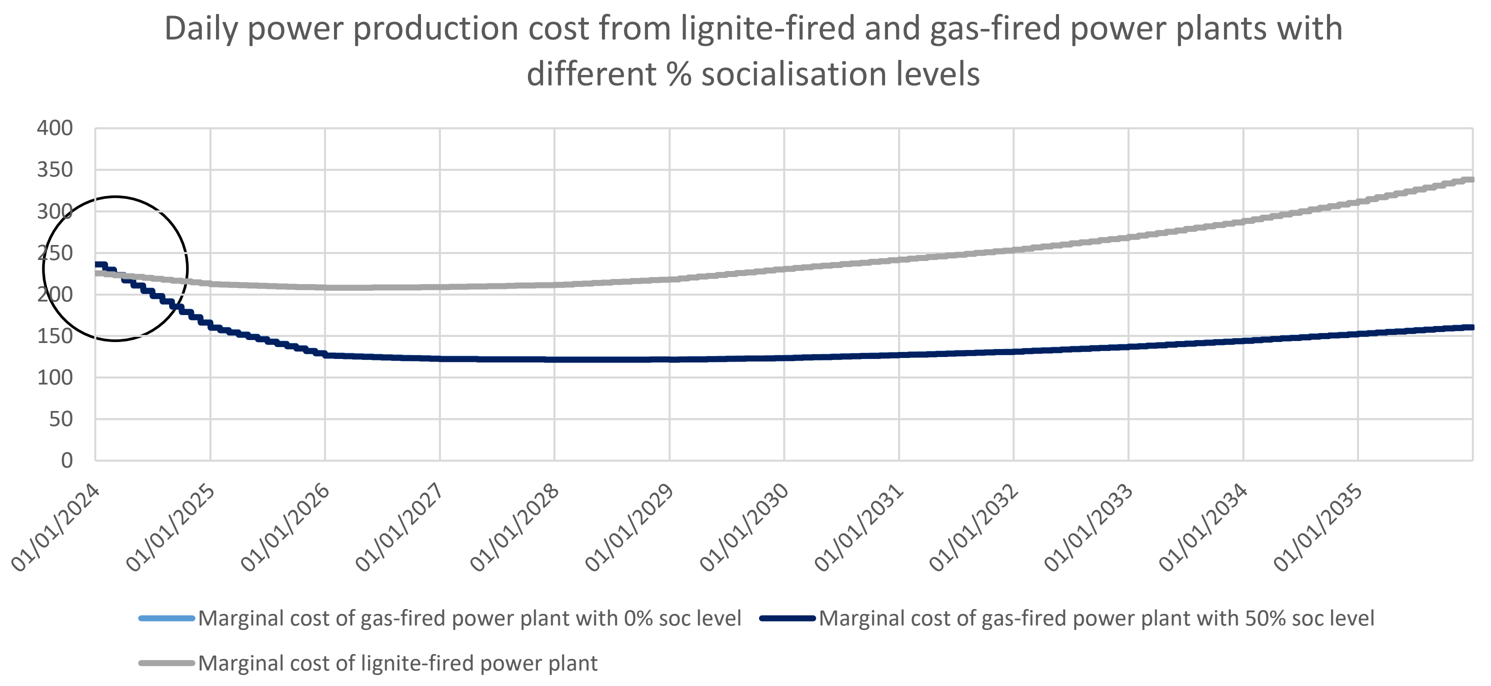
Marginal cost of gas-fired power plant	Marginal cost of gas-fired power plant [EUR/MWhe]
Fuel cost paid	Final price of fuel paid by power producers [EUR/MWhe]
CO2 cost paid	Final emission cost paid by power producers [EUR/MWhe]
OPEX	Operating expenditure of CCGT - assumed 8 EUR/MWhe

$$\text{Marginal cost of lignite-fired power plant} = \text{Fuel cost paid} + \text{CO2 cost paid} + \text{OPEX}$$

where

Marginal cost of lignite-fired power plant	Marginal cost of lignite-fired power plant [EUR/MWhe]
Fuel cost paid	Final price of fuel paid by a lignite-fired power plant [EUR/MWhe]
CO2 cost paid	Final emission cost paid by power producers [EUR/MWhe]
OPEX	Operating expenditure of lignite-fired power plant - assumed 22 EUR/MWhe

… in combination with the small differentiation of the gas prices paid by power producers for different socialization levels



Conclusions

- No change in the merit order has been identified which can be attributed to the socialization level
- There is a change in the merit order (from 1/4/2024 onwards) when the marginal cost of lignite-fired power plants becomes higher than the marginal cost of gas-fired power plants, however this is not attributed to the change of socialization level but due to the decreasing gas price
- The daily marginal technology for power generation remains the same under all socialization levels

A Introduction

B Overview of Cost Benefit Analysis methodology

C Calculation of indicators and benefits

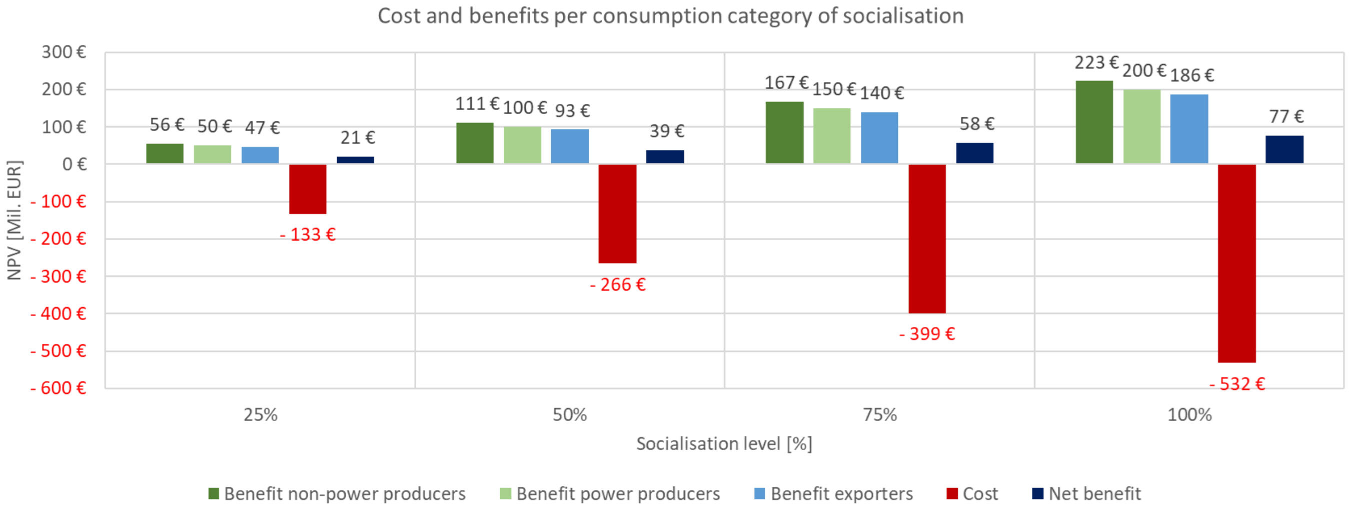
D Summary and key findings

E Appendix

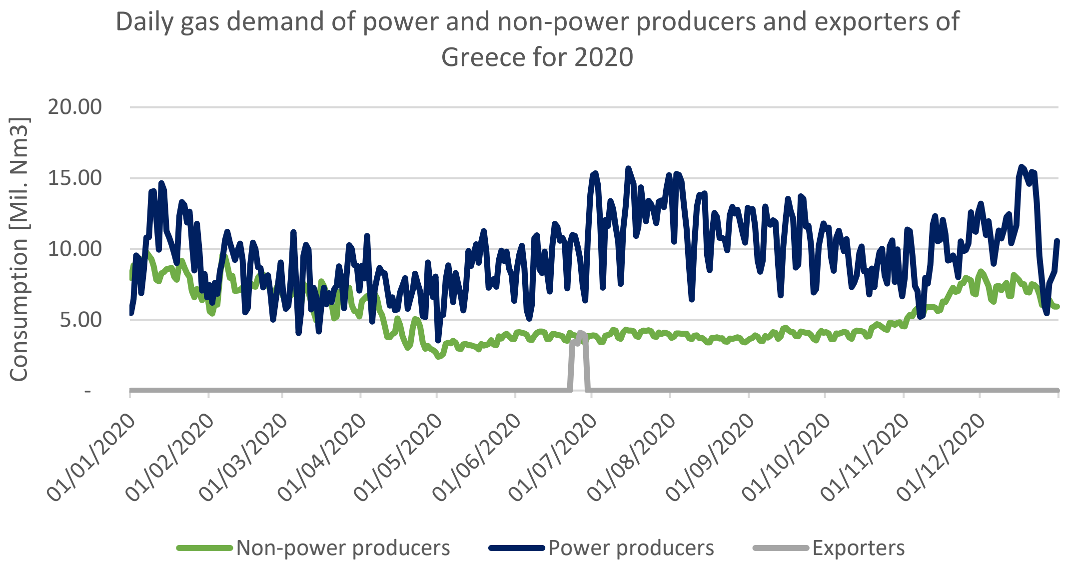
Desfa proposes for the socialisation level of Revithoussa to remain at current levels and specifically at 50%

- The CBA guidelines provided by EC and ENTSOG sets the general directions and is the starting point of this Cost-Benefit Analysis. However, Revithoussa LNG terminal is already built thus the default scenarios with and without the infrastructure are not relevant and there is a need for a tailor-made approach towards the definition of the scenarios and the quantification of the costs and benefits of the socialisation of Revithoussa LNG terminal
- Alternative scenarios based on different socialization levels are considered for assessing the impact of socialization to the welfare of gas consumers. The counterfactual scenario of the CBA is considered with 0% socialization level (*without project*) and the alternative scenarios are with 25%, 50%, 75% and 100% socialization level (*with project*)
- The cost of socialization is the amount of the required revenue of the Revithoussa LNG terminal that needs be recovered from domestic, and interconnection exit points
- The Supply Cost Savings indicator quantifies the reduction/increase of the overall cost of gas supply for flexibility in Greece due to the socialization of the Revithoussa LNG terminal and is equal to the difference of the total amount paid for gas flexibility between the counterfactual scenario and a variant scenario with socialization level x%
- Under the -rather conservative- baseline scenario, for all socialization levels there is a net benefit, with the highest being for 100% socialization level. **The higher the socialization, the higher the net benefit becomes**
- However, Desfa proposes for the socialisation level of Revithoussa to remain at current levels and specifically at 50%

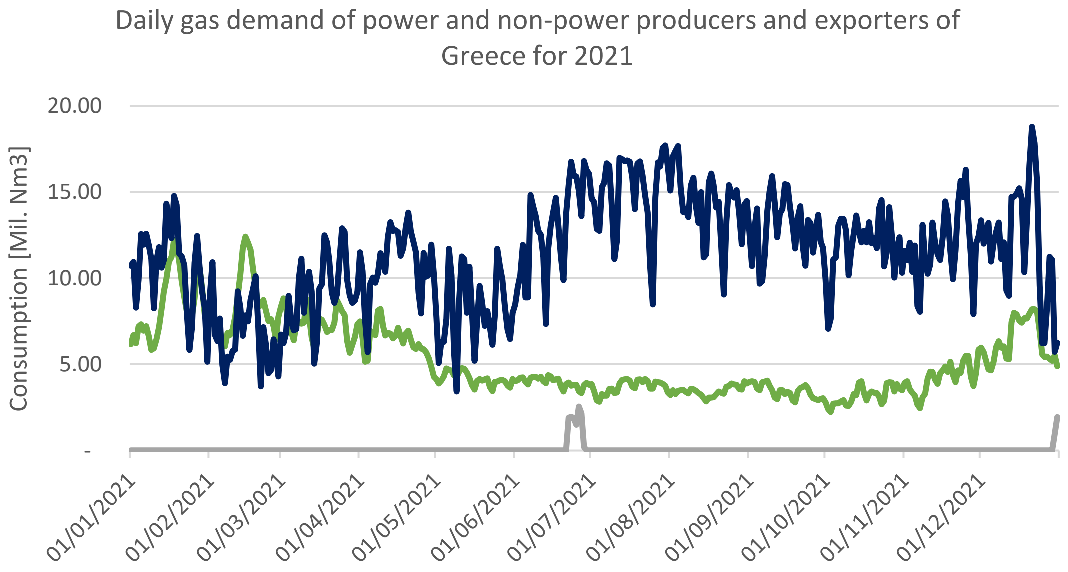
- Under the assumption that LNG from Revithoussa sets the price of gas in the wholesale market, the net benefit of the socialization is proportional to the gas quantities priced at GMP
- When other LNG terminals are considered, the net benefit of the socialization of the Revithoussa LNG terminal becomes higher
- The Fuel Cost and CO2 Cost Savings indicators have been considered; however, they do not contribute to the net benefit due to the minor impact that the socialization level has to the merit order of the wholesale power market



The need for supply flexibility in gas consumption for both power and non-power producers is of increasing importance in the domestic and regional landscape (exports)



	Non-power producers	Power producers	Exporters
Average+25% [Mil. Nm3]	6.56	12.16	0.08
Average-25% [Mil. Nm3]	3.93	7.30	0.05
Consumption > 1.25*Average [Mil. Nm3]	824	902	22
Consumption < 0.75*Average [Mil. Nm3]	429	448	-
Total consumption [Mil. Nm3]	1 920	3 561	22
Flexibility	**65%**	**38%**	**100%**

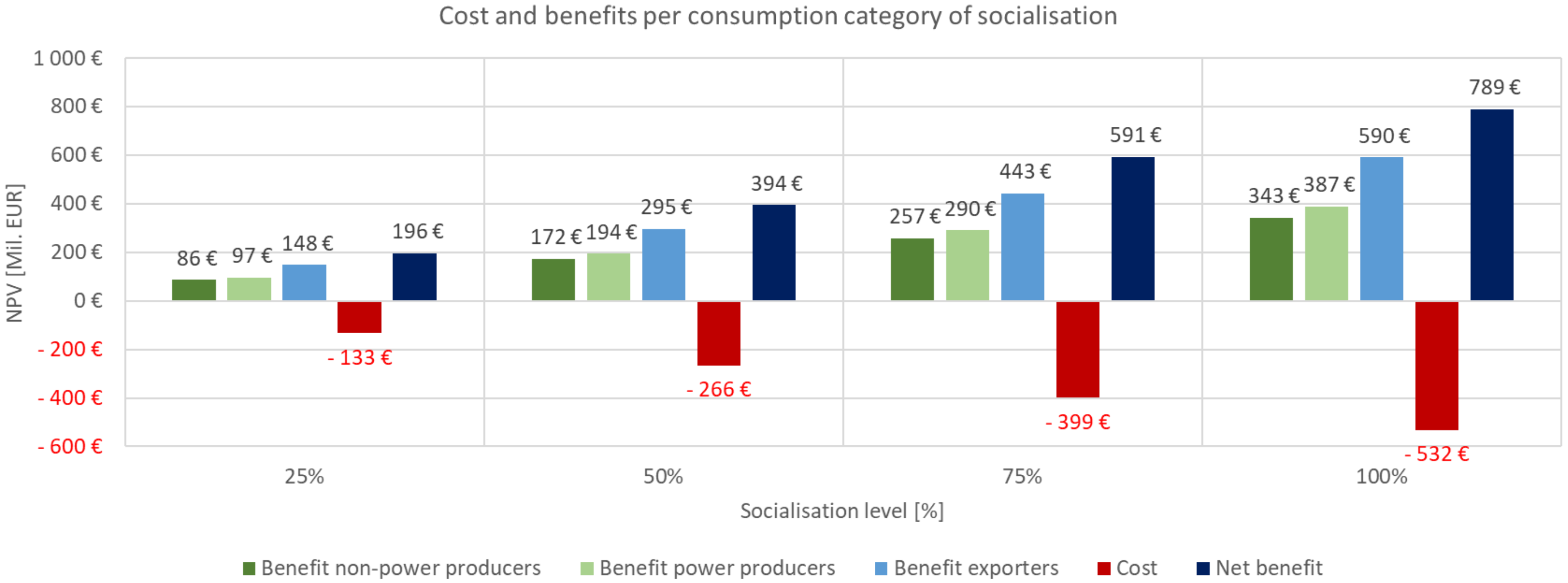


	Non-power producers	Power producers	Exporters
Average+25% [Mil. Nm3]	6.53	14.28	0.05
Average-25% [Mil. Nm3]	3.92	8.57	0.03
Consumption > 1.25*Average [Mil. Nm3]	842	1 117	15
Consumption < 0.75*Average [Mil. Nm3]	434	523	-
Total consumption [Mil. Nm3]	1 908	4 171	15
Flexibility	**67%**	**39%**	**100%**

If the flexibility percentages of 2022 are assumed for each category, the CBA of the socialisation grants much higher net benefit compared to the baseline scenario

Sensitivity 8

Flex $_{PP}$ = 58%,
Flex $_{non-PP}$ = 77%
Flex $_{Exports}$ = 95%



- The flexibility percentages for power and non-power producers are assumed to be equal to the respective ones of 2022 shown in slide 19 (i.e, Flex $_{PP}$ = 58%, Flex $_{non-PP}$ = 77% and Flex $_{Exporters}$ = 95%)
- For all socialisation levels the net benefit of the CBA is positive
- The net benefit of socialization increases with the level of socialization, and it is 196, 394, 591 and 789 Mil. EUR for 25%, 50%, 75% and 100% socialization level respectively

Methodology of temporary Mechanism for Returning Part of Revenues from Day-Ahead and Intraday Market (1/2)

- The administratively determined unit price in the context of the Day-Ahead Market [Regulated Producer Revenue Price (PTEP in €/MWhel)] is calculated on the penultimate working day of each month (hereinafter "calculation day") and concerns the price taken into account for the next day's clearings month (month of application) based on the present table for each category of production units, based on the following figures:
  - Lignite Mining Cost (ΚΕΛ): 20 €/MWh_{fuel}
  - Average Unit Efficiency (MBAM) after self-consumption, defined as follows:
    - Lignite: 0.285
    - NG CCGT: 0.5
    - NG OCGT: 0.35
- **Average Price of CO2 Emission** (ΜΤΔΕ) expressed in €/tn: The arithmetic average of the EUA Futures product for the days of the month preceding the calculation day, as calculated by the DAM Clearing Party, using the daily prices announced by the ICE for the series ending in December of the year of the month of application (ie ending in December 2022 for the months of application July to December 2022, and ending in December 2023 for the months of application January to June 2023) on its website
- **Average Price of Natural Gas** (ΜΤΦΑ) expressed in €/MWh: The arithmetic average of daily TTF prices for the month of delivery (m), coinciding with the month of application, on London UK business days of the immediately preceding month (m-1) from the month of delivery, as they arise each day as an average, of the Bid and Offer prices published in the "ICIS European Spot Gas Markets" magazine in the "TTF Price Assessment €/MWh" table, and refer to the days of the month (m-1) preceding the day of calculation.

Methodology of temporary Mechanism for Returning Part of Revenues from Day-Ahead and Intraday Market (2/2)

- **Average Emission Factor** (ΜΣΕC) expressed in tCO_2/MWh_{el} after self-consumption, defined as follows :
    - Lignite : 1.38
    - NG CCGT : 0.38
    - NG OCGT : 0.54
- **Fixed, Operation & Maintenance cost** (ΣΚΛΣ) expressed in €/ MWh_{el} after self-consumption, defined as follows :
    - Lignite : 22
    - NG CCGT : 8
    - NG OCGT : 3
- **Other NG cost** (ΛΚΦΑ) expressed in €/MWh natural gas : 3.5€/Mwh_{fuel}
- **Coefficient Lower Calorific Value** (ΣΚΘΔ): 0.90

Generation Technology	Regulated Producer Revenue Prices
Lignite	Lignite Mining Cost/Average Unit Efficiency + Average Emission Factor x Average Price of CO2 Emission + Fixed Operation & Maintenance cost
NG CCGT NG OCGT	[(Average Price of Natural Gas + Other NG cost)/Coefficient Lower Calorific Value]/Average Unit Efficiency + Average Emission Factor x Average Price of CO2 Emission + Fixed, Operation & Maintenance cost