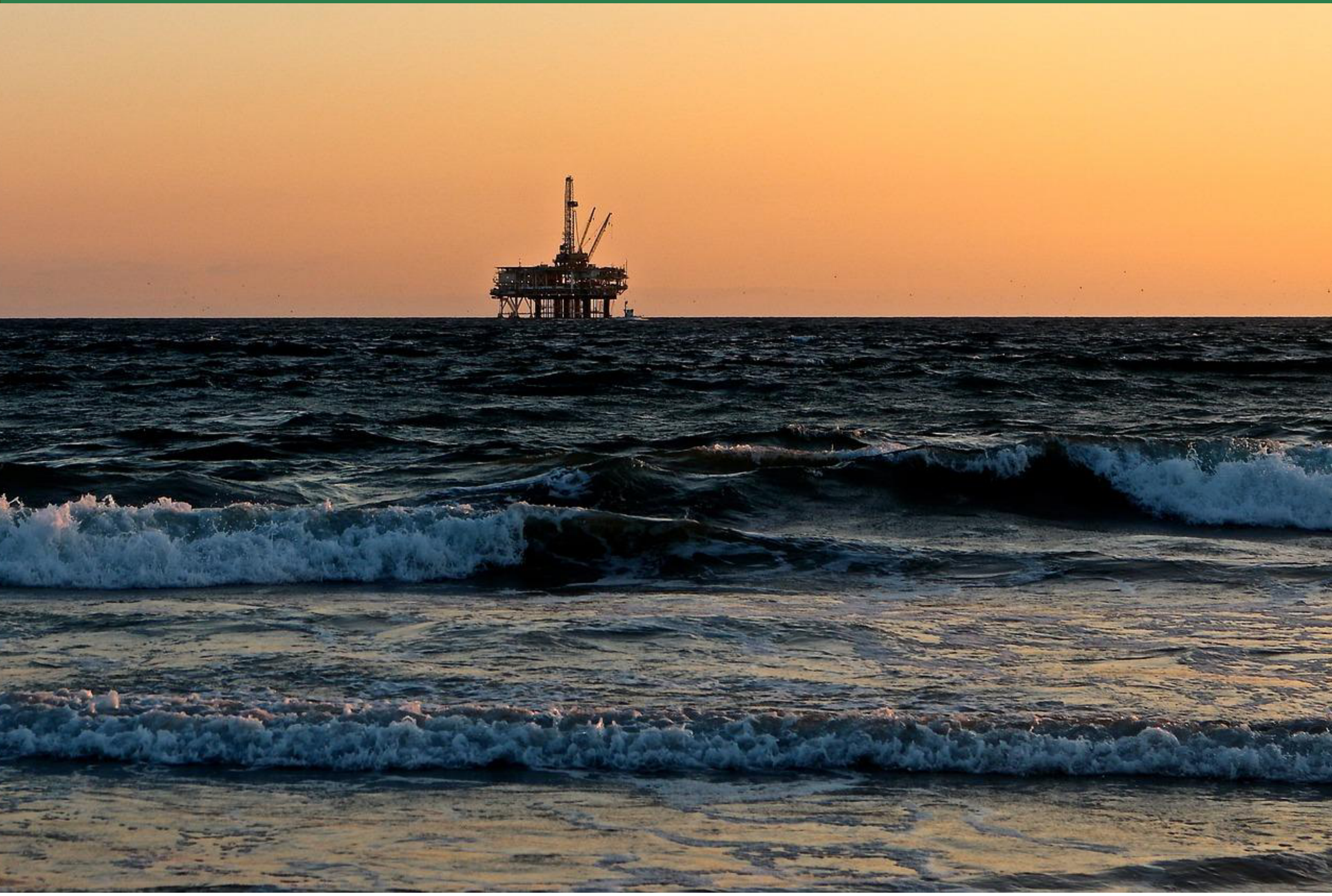
2024

The Carbon Footprint of Neptun Deep

Estimation of the greenhouse gas emissions resulting from the exploitation of the offshore deposit in the Neptun Deep perimeter and the construction of the Tuzla-Podișor gas pipeline segment



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Funder

This report was commissioned by Greenpeace Romania.

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Final report, initially released: 31.01.2024

Last updated: 28.02.2024

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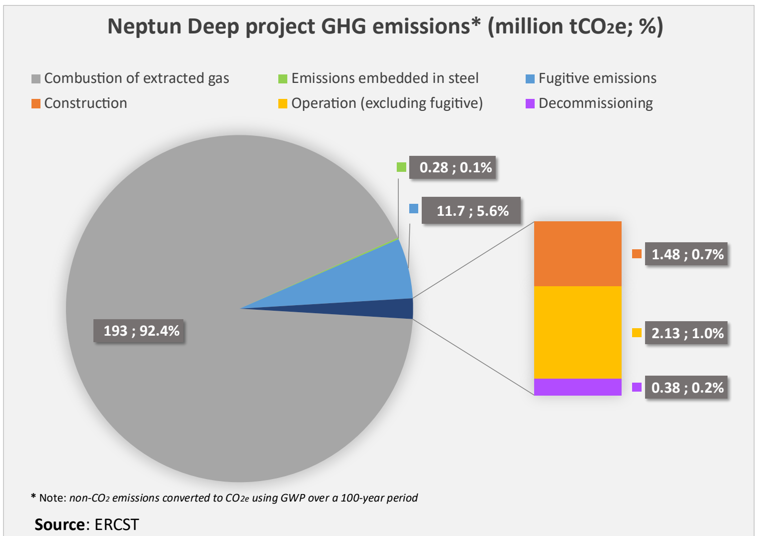
Executive Summary

Total greenhouse gas (GHG) emissions over the lifetime of the Neptun Deep natural gas project in the Black Sea have been estimated at ~209 million tCO_2e when using a Global Warming Potential (GWP) over a 100-year period for methane (CH_4), or ~227 million tCO_2e when using a GWP over a 20-year period. The GHG estimate assumes a total of 100 billion cubic meters (BCM) of natural gas to be extracted over the project's lifetime[1].

The estimate covers the GHG emissions associated with the following set of planned natural gas infrastructures: 1) the infrastructure for the exploitation of the offshore natural gas deposit in the Neptun Deep perimeter; and 2) the Tuzla-Podișor gas transmission pipeline that will connect the gas exploitation infrastructure to the main gas transmission corridor between Bulgaria-Romania-Hungary-Austria (BRUA).



The total estimate includes emissions from the construction, operation and decommissioning of the respective infrastructures, emissions embedded in certain energy intensive materials (i.e. steel) used in the construction of the infrastructure, as well as the combustion of the extracted natural gas.

The predominant contributor to the emissions is combustion, accounting for ~193 million tCO_2e, which is approximately 92% of the total project emissions. Fugitive emissions, from the gas exploitation infrastructure and the Tuzla-Podișor gas transmission pipeline, account for 11.7 million tCO_2e, approximately 6% of the total. Emissions during the construction, operation (excl. fugitive), and decommissioning of both infrastructures sum up to ~4 million tCO_2e, which is equivalent to about 2% of the total. Additionally, emissions embedded in the steel used for constructing the infrastructure (the steel gathering pipe, the transmission pipe and the platform) contribute ~0.3 million tCO_2e, which is approximately 0.1% of the total.

The following table outlines the GHG emissions associated with the natural gas exploitation infrastructure and transmission pipeline, and provides a breakdown across different categories. From it, it can be inferred that the gas exploitation infrastructure (including emissions from combustion of the produced gas) accounts for the lion share (99.6%) of total project emissions, with emissions from the gas transmission pipeline accounting for 0.4% of the total. Even when disregarding emissions from the combustion of the produced natural gas, the pipeline accounts for about 5% of the emissions associated with the construction, operation, decommissioning, construction materials (i.e. steel) and fugitive emissions from the two infrastructures together. When the emissions from the combustion of the natural gas are not taken into account, fugitive emissions account for nearly three quarters of the total (~73%), operational emissions (excluding fugitive)

[1] This corresponds to the lower bound of the total volume estimate of 100-200 BCM according to most recent announcements in December 2023; see https://newsweek.ro/economie/200-de-miliarde-de-metri-cubi-de-gaze

for ~13%, emissions from construction for ~9.3%, followed by decommissioning (2.4%), and steel-embodied emissions (~1.8%).

Estimate of greenhouse gas emissions from the Neptun Deep gas exploitation and transmission infrastructures

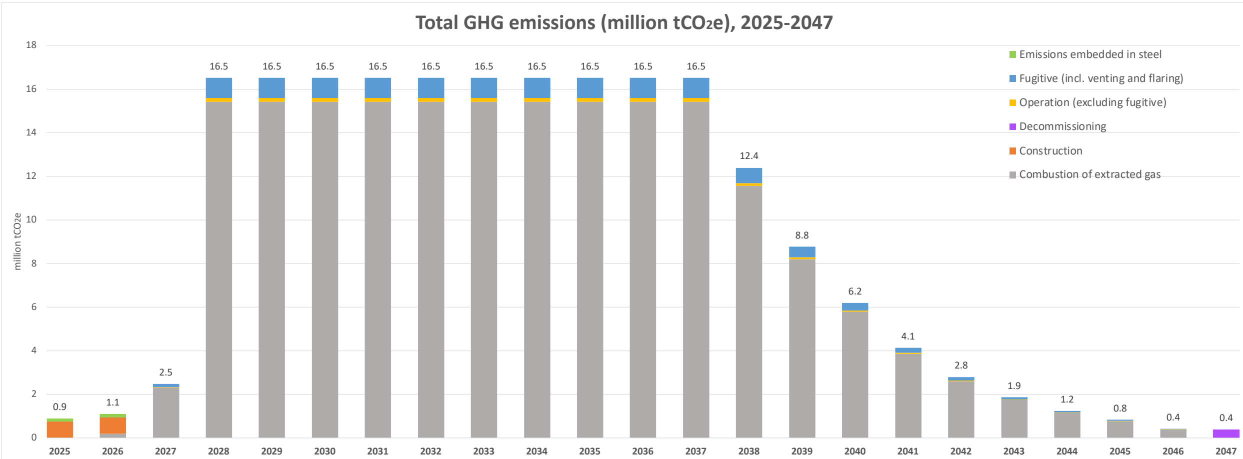
	Gas exploitation infrastructure			**Gas transmission pipeline**			**Grand total**		
	Emissions (m tCO_2e)	**% of total**	**% of total excl. combustion**	**Emissions (m tCO_2e)**	**% of total**	**% of total excl. combustion**	**Emissions (m tCO_2e)**	**% of total**	**% of total excl. combustion**
Combustion of extracted gas	192.68	92.35%		-	-		192.68	92.35%	
Emissions embedded in steel	0.21	0.10%	1.30%	0.075	0.04%	0.47%	0.28	0.14%	1.77%
Fugitive emissions	11.67	5.59%	73.09%	0.019	0.01%	0.12%	11.68	5.60%	73.21%
Construction, operation, decommissioning	3.30	1.58%	20.66%	0.697	0.33%	4.37%	3.99	1.91%	25.02%
- of which construction	*1.48*	*0.71%*	*9.28%*	*0.0008*	*0.00%*	*0.005%*	*1.48*	*0.71%*	*9.28%*
- of which operation (excl. fugitive)	*1.44*	*0.69%*	*9.02%*	*0.693*	*0.33%*	*4.34%*	*2.13*	*1.02%*	*13.36%*
- of which decommissioning	*0.38*	*0.18%*	*2.36%*	*0.0037*	*0.002%*	*0.02%*	*0.38*	*0.18%*	*2.38%*
Total, using GWP (100) for CH_4	**207.85**			**0.79**			**208.64**		
Share of total (%)	99.6%			0.4%					
Share of total, excluding combustion (%)	95.0%			5.0%					
Total average per annum (assuming 20 years)	10.39			0.04			10.43		
Total per annum during plateau stage	16.46			0.06			16.52		
Total per BCM of gas (assuming total of 100 BCM)	2.08			0.008			2.09		
Total using GWP(20) for CH_4	**226.53**			**0.83**			**227.36**		

Source: ERCST

On an annual basis, assuming a twenty-year project lifetime, average GHG emissions amount to about 10.4 million tCO_2e annually, of which 9.6 million tCO_2e from the combustion of the gas, 0.58 million tCO_2e in fugitive emissions, 0.2 million tCO_2e from the construction, operation and decommissioning of the infrastructures, and 0.014 million tCO_2e embedded in the steel.

Year on year, the level of emissions will fluctuate depending inter alia on the volume of the extracted natural gas. The following figure provides an indication of annual GHG emissions associated with Neptun Deep, assuming that construction takes place in 2025-2026, production starts in 2027 and reaches the plateau stage of 8 BCM per year as of 2028 for a period of ten years, after which production gradually ramps down to zero in 2047 (the year when decommissioning is assumed to take place). Total GHG emissions during the plateau production stage would amount to ~16.5 million tCO_2e/year.

Total project greenhouse gas emissions (million tCO_2e), 2025-2047



Source: ERCST

The project GHG emissions estimate has been compared to Romania's GHG emissions inventory. Emissions from the construction, operation, decommissioning, as well as fugitive emissions from Neptun Deep would purely add to Romania's current emissions. This part of emissions amount on average to an annual ~0.8 million tCO_2e, and would constitute a ~1.2% increase in Romania's 2021 GHG emissions with LULUCF[2] (or a 0.7% increase in Romania's 2021 GHG emissions without LULUCF[3]). When it comes to emissions from the production of the steel used in the project, these would be accounted in the GHG inventory of the country of origin of the steel (based on available information, the steel will be imported and not produced domestically in Romania).

When it comes to emissions associated with the combustion of the produced natural gas, i.e. 193 million tCO_2e in total or on average 9.6 million tCO_2e annually for twenty years (~15.4 million tCO_2e/year during plateau production), the net impact on Romania's GHG emissions is less straightforward and depends on a set of assumptions with respect to the extent to which part of the produced natural gas would be exported or displace natural gas imports, as well as the extent to which it would substitute other more polluting fossil fuels like coal or oil, or crowd-out zero-carbon technologies.

The GHG emissions estimate from the planned infrastructures has also to the extent possible been compared to the emissions of the involved beneficiary companies, OMV Petrom and Romgaz. All else equal, the Neptun Deep project would on average increase OMV Petrom's annual Scope 1 emissions by an estimated ~6%, and their Scope 3 emissions by ~7% compared to 2019 levels, while their target is to reduce their emissions by 20% by 2030. Romgaz lacks targets with respect to their Scope 3 emissions, however their average annual Scope 3 emissions associated with the Neptun Deep infrastructures would be greater than the company's total annual emissions in 2022.

[2] 66.14 million tCO_2e, source: UNFCCC Greenhouse Gas Inventory Data, https://di.unfccc.int/detailed_data_by_party
[3] 115.4 million tCO_2e, source: UNFCCC Greenhouse Gas Inventory Data, https://di.unfccc.int/detailed_data_by_party

1. Background and introduction

1.1. Description of the Neptun Deep natural gas project

The following set of planned natural gas infrastructures is considered in this report: 1) the infrastructure for the exploitation of the offshore natural gas deposit in the Neptun Deep perimeter; and 2) the Tuzla-Podișor gas transmission pipeline that will connect the gas exploitation infrastructure to the main gas transmission corridor between Bulgaria-Romania-Hungary-Austria (BRUA).

1.1.1. Gas exploitation infrastructure

On June 21, 2023, OMV Petrom and Romgaz approved the development plan for the Domino and Pelican Sud commercial natural gas fields in the Neptun Deep perimeter. OMV Petrom is the operator, with each company having a 50% stake in the project. According to official announcements, the project will generate a production of about 100 billion cubic meters of natural gas[4], with first production expected in 2027. Plateau production will be approximately 8 billion cubic meters annually (~140,000 boe/d) for approximately 10 years. A total 20-year project lifetime is expected.

Romania is the second biggest gas producer in the EU (after the Netherlands) with total production of 8.9 BCM in 2021[5]. With an estimated average annual production of 10 BCM, the Neptun Deep project would ceteris paribus double the volume of natural gas production in Romania.

According to the project memorandum[6], the infrastructure required for the development of the Domino and Pelican Sud offshore natural gas fields includes:

- 10 wells, 6 in deep water (~1,000m) and 4 in shallow water (~130m)
- 3 subsea production systems and the associated flow lines
- a shallow water offshore platform (~120 m deep)
- the main gathering pipeline to the shore (~160km)
- the gas metering station at Tuzla

The following schema provides an illustration of the gas exploitation infrastructure components.

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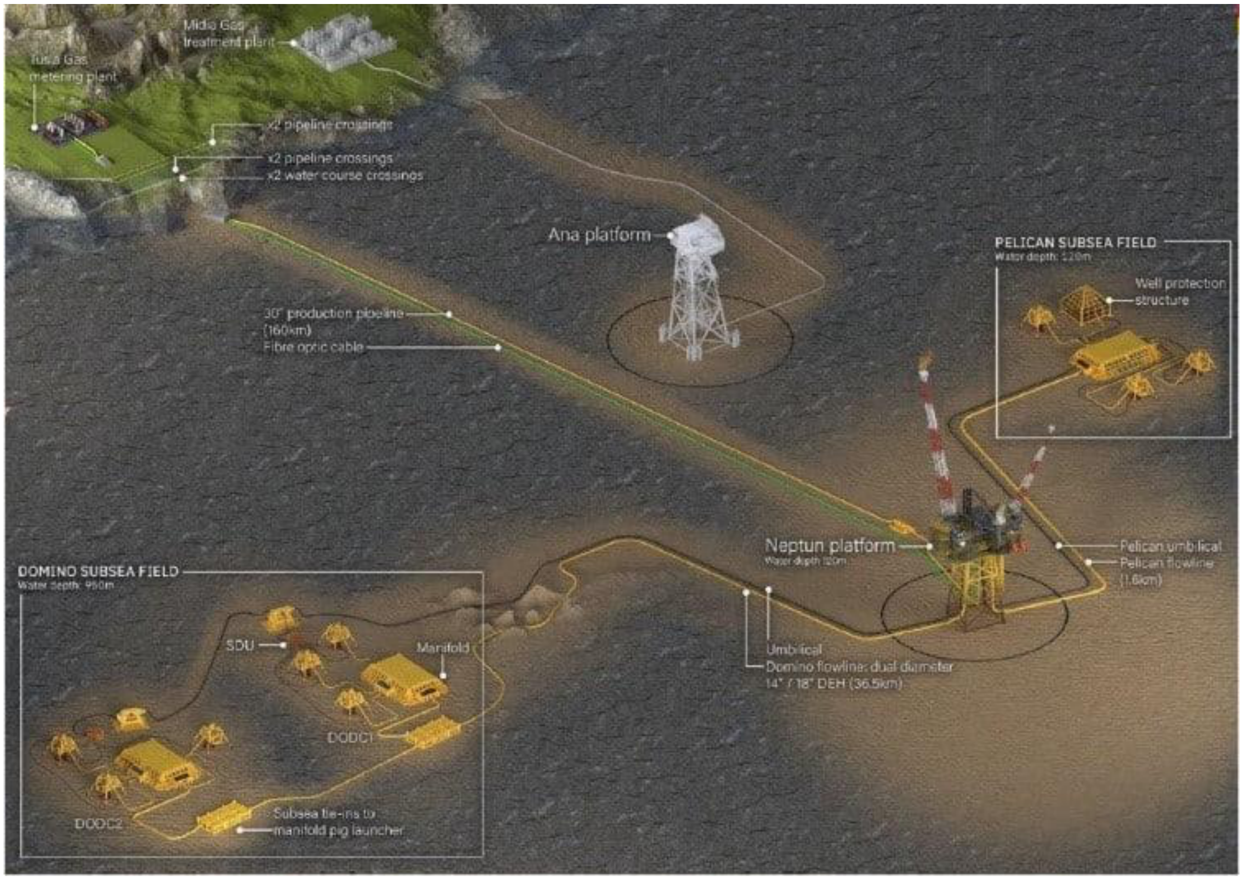
[4] This corresponds to the lower bound of the total volume estimate of 100-200 BCM according to most recent announcements in December 2023; see https://newsweek.ro/economie/200-de-miliarde-de-metri-cubi-de-gaze

[5] p 9. European Commission, 2022. Quarterly report on European gas markets, Volume 14, issue 4, Market Observatory for Energy, DG Energy, https://energy.ec.europa.eu/system/files/2022-04/Quarterly%20report%20on%20European%20gas%20markets_Q4%202021.pdf

[6] Presentation Memorandum of May 2023 in Romanian: apmct.anpm.ro/documents/840114/76184528/05212023_BLUMENFIELD_+MP_RO_rev.E.pdf/5dbfda53-fb1f-4760-ba15-326b7d87bbf4

Figure 1 Schema of the Neptun Deep gas exploitation infrastructure



Source: Cenergy Holdings news release, 13 November 2023, https://cenergyholdings.com/new/corinth-pipeworks-is-awarded-a-contract-to-manufacture-and-supply-the-pipeline-for-omv-petrom-s-neptun-deep-project-in-the-black-sea/

The following table denotes the main project components and technical characteristics.

Table 1 Technical characteristics of the gas exploitation infrastructure components

Variable	Value	Unit	Comment/Source
Main components of the gas exploitation infrastructure	10 wells, 6 in deep water (~1,000m) and 4 in shallow water (~130m)		Project memorandum
	3 subsea production systems and the associated flow lines		Project memorandum
	a shallow water offshore platform (~120 m deep)		Project memorandum
	the main gathering pipeline to the shore (~160km)		Project memorandum
	the gas metering station at Tuzla		Project memorandum

Variable	Value	Unit	Comment/Source
Total natural gas volume	100	BCM (Billion m3)	OMV Petrom webpage about the project
Sour gas proportion	0%	% of gas processed	EN project memorandum, Table 1
Gathering pipe material	Carbon steel		Project memorandum
Gathering pipe length	160	km	Project memorandum
Gathering pipe diameter	762	mm	Project memorandum
Gathering pipe wall thickness	30	mm	Project memorandum
Gathering pipe weight equivalent	86,651	tons of steel	Converted using Steel pipe weight calculator
Gathering pipe – manufacturer/country	Corinth Pipeworks, Greece		Corinth Pipeworks news release, November 2023
Platform jacket structure material	Steel		Project memorandum
Weight estimate of the platform jacket structure	9,000	tons	Project memorandum
Project contractor	SAIPEM to carry out the Engineering, Procurement, Construction and Installation of the offshore components		SAIPEM news release, August 2023

Source: ERCST, based on sources indicated in the table's last column

1.1.2. Tuzla-Podișor gas transmission pipeline

On 16 June 2023, Romgaz signed the order to start the works for the ~308km long Tuzla-Podișor gas pipeline, i.e. the gas transmission infrastructure that will connect the Neptun Deep gas exploitation infrastructure to the main gas transmission corridor between Bulgaria-Romania-Hungary-Austria (BRUA).

Made of steel, the pipeline will be telescopic, designed to transmit gas at a pressure of 63 bar. It will be made up of two sections:

- Section I, Black Sea shore – Amzacea, 32.4 km long, will have a diameter of Ø 48" (Dn1200);
- Section II, Amzacea – Podișor, 275.9 km long, will have a diameter of Ø 40" (Dn1000).

The following table denotes the main components and technical characteristics of the Tuzla-Podișor gas transmission pipeline.

Table 2 Technical characteristics of the gas transmission infrastructure

Variable	Value	Unit	Source
Total Length	308.3	km	Transgaz Scoping report
Length of Section I, Black Sea shore – Amzacea	32.4	km	Transgaz Scoping report
Diameter of Section I, Black Sea shore – Amzacea	1,200	mm	Transgaz Scoping report
Length of Section II, Amzacea – Podișor	275.9	km	Transgaz Scoping report
Diameter of Section II, Amzacea – Podișor	1,000	mm	Transgaz Scoping report
Material of pipes	Steel		Transgaz Scoping report
Pipe suppliers (name, country)	Tosçelik, Turkey; Noksel, Turkey		Toscelik press release, September 2023
Weight of steel pipe	102,000	tons	Toscelik press release, September 2023

Source: ERCST, based on sources indicated in the table's last column

1.2. Scope of the report

This report aims to provide a high-level estimate of the amount of greenhouse gas (GHG) emissions resulting from:

1) the gas exploitation infrastructure in the Neptun Deep perimeter;
2) the Tuzla-Podișor gas pipeline, i.e. the gas transmission infrastructure connecting the gas exploitation infrastructure with the BRUA gas pipeline.

The estimate includes emissions from the construction, the operation and the decommissioning of the respective infrastructures, emissions embedded in certain energy intensive materials (i.e. steel) used in the construction of the infrastructure, as well as the combustion of the extracted natural gas.

The resulting estimate is then compared to Romania's inventory of GHG emissions and the emission reduction plans of OMV Petrom and Romgaz, in order to provide an understanding of the order of magnitude of the impact and its consistency with the climate commitments of Romania, as well as those of the project beneficiaries.

2. Overview of the methodology, key sources and assumptions

The following key data sources and methodologies have been used:

1. Natural gas combustion and fugitive emissions: the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories[7] and Tier 1 emissions factors have been used for the estimation of emissions from the combustion of the natural gas, as well as of the fugitive emissions from the natural gas production, gathering, processing, and transmission.
2. Energy-related emissions from the construction, operation (other than fugitive emissions) and decommissioning of the infrastructures are estimated:
   - based on the Environmental and Social Impact Assessment (ESIA) study of Neptun Deep[8];
   - based on ESIA studies for other gas projects in the Black Sea (e.g. Sakarya Gas Field Development Project[9], the Romanian section of the BRUA natural gas transmission corridor project[10]), while taking into account the specificities and scale of the Neptun Deep project, as these are described in the project presentation memorandum[11].
3. Emissions embedded in certain energy intensive and thereby emissions intensive materials (i.e. steel) used in the construction of the infrastructures are estimated based on estimates of the volume of such materials in key project components (the gathering and transmission pipelines, the platform), as well as emissions intensities of the materials (expressed in tons of CO_2e/ton of product) based on information provided by the involved companies, as well as a recent study by the European Commission's Joint Research Centre (JRC)[12].
4. Non-CO_2 emissions have been converted to CO_2 equivalent (CO_2e) based on Global Warming Potential (GWP) values in the 2021 IPCC 6th Assessment Report[13]. GWP over a 100-year time period – *GWP(100)* - has been used for the central estimate, while we discuss how results vary when a GWP over a 20-year time period - *GWP(20)* - is used for converting methane (CH_4) to CO_2e. The GWP(100) and GWP(20) values shown in the following table have been used.

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[7] 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy, Chapter 2 Stationary Combustion, https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf; and 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 Energy, Chapter 4 Fugitive Emissions https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol2.html

[8] ESIA of Neptun Deep, English version: https://www.moew.government.bg/bg/proekt-neptun-dijp-za-dobiv-na-priroden-gaz-na-teritoriyata-na-rumuniya/

[9] ESIA of the Sakarya Gas Field Development Project: https://tp-otc.com/en/sustainability/environmental-and-social-impact-assessment-en/

[10] Arcadis, 2017. ROMANIAN SECTION OF THE BRUA NATURAL GAS TRANSMISSION CORRIDOR PROJECT, Supplementary Environmental Impact Assessment Report, JUNE 2017, https://www.eib.org/attachments/registers/79726902.pdf

[11] Presentation Memorandum of May 2023 in Romanian, provided by Greenpeace; Presentation Memorandum of December 2021 in English available at https://www.moew.government.bg/bg/proekt-neptun-dijp-za-dobiv-na-priroden-gaz-na-teritoriyata-na-rumuniya/

[12] Vidovic, D., Marmier, A., Zore, L. and Moya, J., Greenhouse gas emission intensities of the steel, fertilisers, aluminium and cement industries in the EU and its main trading partners, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/359533, JRC1346, https://publications.jrc.ec.europa.eu/repository/handle/JRC134682

[13] Table 7.15, IPCC Sixth Assessment Report Working Group I chapter 7, https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-7/

Table 3 Global Warming Potential values over a 100-year and a 20-year period

GHG	**GWP (100-year time period)**	**GWP (20-year time period)**
CO_2	1	1
CH_4 (fossil)	29.8	82.5
N_2O	273	273

Source: Table 7.15, IPCC Sixth Assessment Report Working Group I chapter 7, https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-7/

More details with respect to the used methodologies, including sources, equations and assumptions for each segment of the estimation are discussed in chapter 3, alongside the presentation of results for each respective emissions segment.

3. Results

3.1. Emissions from the combustion of the natural gas

The IPCC Guidelines include the following equation for estimating emissions from stationary combustion.

Text box 1 Equation for estimating greenhouse gas emissions from combustion

EQUATION 2.1 GREENHOUSE GAS EMISSIONS FROM STATIONARY COMBUSTION
EmissionsGHG, fuel = Fuel Consumption fuel • Emission FactorGHG, fuel Where: EmissionsGHG , fuel = emissions of a given GHG by type of fuel (kg GHG) Fuel Consumption fuel = amount of fuel combusted (TJ) Emission FactorGHG, fuel = default emission factor of a given GHG by type of fuel (kg gas/TJ). For CO_2, it includes the carbon oxidation factor, assumed to be 1.

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy, Chapter 2 Stationary Combustion

The following Tier 1 emissions factors from the IPCC Guidelines are used.

Table 4 Emissions factors for natural gas combustion

	Default emissions factors (kg of GHG per TJ of a net calorific basis)		
	CO_2	**CH_4**	**N_2O**
Natural Gas	56,100	1	0.1

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy, Chapter 2 Stationary Combustion

Using the above emissions factors, total emissions from the combustion of the expected natural gas volume from the Neptun Deep perimeter (100 BCM) have been estimated at about 193 million tCO_2e.

Table 5 Estimate of emissions from combustion

	million tons emissions	**million tCO_2e**
CO_2 emissions	192.49	192.49
CH_4 emissions	0.0034	0.10
N_2O emissions	0.0003	0.09
Total emissions from combustion		**192.68**

Source: ERCST
Notes: Makes use of the average gross calorific value (GCV) of natural gas in Romania of 38.12 MJ/m^3 (p.66, IEA, Natural gas information: database documentation (2023 edition), https://wds.iea.org/wds/pdf/Gas_documentation.pdf); Average net calorific value (NCF) = 0.9*GCV

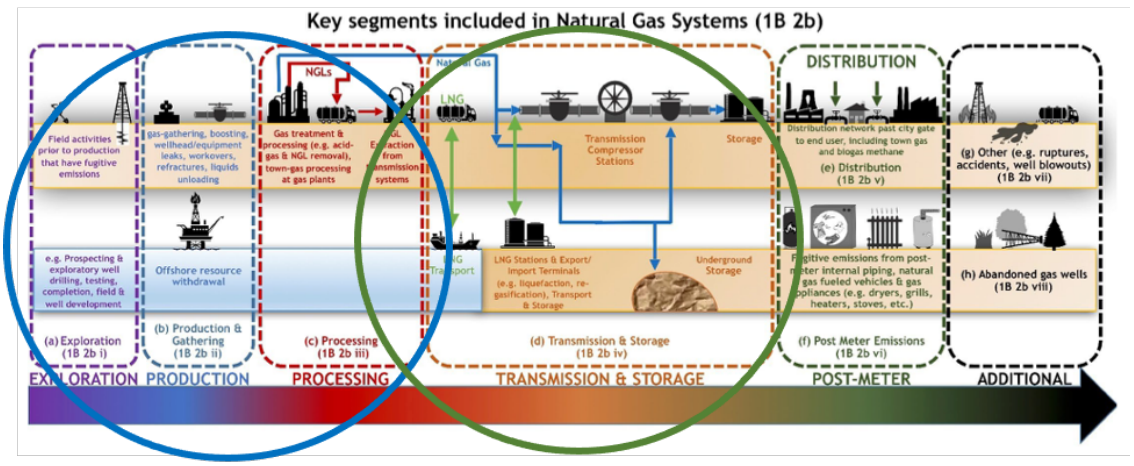
3.2. Fugitive emissions

For the estimation of fugitive emissions, the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 4: Fugitive Emissions has been used.

According to these Guidelines, fugitive emissions include emissions from venting, flaring, and leaks. Fugitive emissions are a direct source of greenhouse gases due to the release of CH_4 and formation CO_2 (i.e., CO_2 present in the produced gas when it leaves the reservoir), plus some CO_2 and nitrous oxide (N2O) from non-productive combustion activities (primarily waste gas flaring).

Different equations and associated Tier 1 emission factors are included in the IPCC Guidelines for the different segments of natural gas systems (see schema below). For the fugitive emissions from the Neptun Deep gas exploitation infrastructure, we take into account the first three segments of "*exploration*", "*production*" and "*processing*", while for the fugitive emissions from the transmission pipeline (section 3.2.2), we take into account the segment of "*transmission & storage*".

Figure 2 Key segments of natural gas systems



Source: Figure 4.2.0 (New) (Continued) Key segments included in oil and natural gas systems, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 4: Fugitive Emissions

3.2.1. Gas exploitation infrastructure

For estimating fugitive emissions from the gas exploitation infrastructure, the three segments of "*exploration*", "*production*" and "*processing*" are taken into account.

Exploration

According to the IPCC Guidelines, the "*exploration*" segment includes fugitive emissions (including equipment leaks, venting and flaring) from gas field activities prior to production (e.g., prospecting and exploratory well drilling, well/drill stem testing, and well completions).

According to the same guidelines, fugitive emissions are thought to be negligible for the case of offshore exploration, and therefore this segment is void for the case of the Neptun Deep gas exploitation infrastructure.

Production and Gathering

According to the IPCC Guidelines, the "*production and gathering*" segment includes fugitive emissions (including leaks, venting and flaring) from the gas wellhead through to the inlet of gas processing plants, or, where processing is not required, to the tie-in points on gas transmission systems. In the production stage, wells are used to withdraw raw gas from underground formations. Emissions arise from the wells themselves (e.g., as wellhead leaks and from well workovers and refractures), and well-site equipment such as pneumatic controllers, dehydrators and separators. Gathering and boosting emission sources are included within the production sector. The gathering and boosting sources include gathering and boosting stations (with multiple emission sources on site, such as compressors, pneumatic controllers and tanks) and gathering pipelines. The gathering and boosting stations receive natural gas from production sites and transfer it, via gathering pipelines, to processing facilities or transmission pipelines.

The IPCC Guidelines include the following equation for the estimation of emissions from production.

Text box 2 Equation for estimating fugitive emission from gas production and gathering

EQUATION 4.2.14 (NEW)
GENERAL EQUATION FOR ESTIMATING FUGITIVE EMISSIONS FROM GAS PRODUCTION AND GATHERING

$$
\begin{aligned}
E_{production} = {} & A_{onshore\ gas\ production} \bullet EF_{onshore\ gas\ production} \\
& + A_{onshore\ coal\ bed\ production} \bullet EF_{onshore\ coal\ bed\ production} \\
& + A_{gathering} \bullet EF_{gathering} \\
& + A_{offshore\ gas\ production} \bullet EF_{offshore\ gas\ production}
\end{aligned}
$$

Where:

$E_{production}$	= Total amount of GHG gas emitted due to all relevant natural gas production activities
$A_{onshore\ gas\ production}$	= Volume of onshore gas produced/active gas well
$EF_{onshore\ gas\ production}$	= Emission factor for onshore gas produced
$A_{onshore\ coal\ bed\ production}$	= Volume of onshore coal bed methane produced
$EF_{onshore\ coal\ bed\ production}$	= Emission factor for onshore coal bed methane production
$A_{gathering}$	= Volume of onshore gas produced
$EF_{gathering}$	= Emission factor for gathering of natural gas produced
$A_{offshore\ gas\ production}$	= Volume of offshore gas produced
$EF_{offshore\ gas\ production}$	= Emission factor for offshore gas produced

Source: IPCC EQUATION 4.2.14 (NEW) GENERAL EQUATION FOR ESTIMATING FUGITIVE EMISSIONS FROM GAS PRODUCTION AND GATHERING, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 4: Fugitive Emissions

The following Tier 1 emissions factors from the IPCC Guidelines are used.

Table 6 Emissions factors for fugitive emissions from gas production

	Emissions factors for gas production (tonnes/million cubic meters)			
	CH_4	**CO_2**	**NMVOC**	**N_2O**
Offshore natural gas	2.94	4.8	0.7	0.000082

Source: Table 4.2.4G (NEW), IPCC 2019 refinement of guidelines volume 4 fugitive emissions

Based on the above emissions factors, the IPCC equation and the project specifications, fugitive emissions from gas production have been estimated to amount to about 9.24 million tCO_2e (see table below).

Table 7 Estimate of fugitive emissions from natural gas production

	tons of emissions	**million tons of emissions**	**million tCO_2e**
CH_4 emissions	294,000	0.29	8.76
CO_2 emissions	480,000	0.48	0.48
NMVOC	70,000	0.07	
N_2O emissions	8.2	0.00001	0.00
Total fugitive emissions from production (excl. NMVOC)			**9.24**

Source: ERCST

Processing

According to the IPCC Guidelines, the "*processing*" segment includes fugitive emissions (including leaks, venting and flaring) from gas processing facilities. In this stage, natural gas liquids (NGLs) and various other constituents (e.g. sulphur) from the raw gas are removed, resulting in "pipeline quality" gas, which is injected into the transmission system. Emission sources include compressors, equipment leaks, pneumatic controllers, uncombusted gas from engines and flaring, and CO_2 from flaring and sour gas removal.

The IPCC Guidelines include the following equation for the estimation of emissions from processing.

Text box 3 Equation for estimating fugitive emission from natural gas processing

EQUATION 4.2.15 (NEW)
GENERAL EQUATION FOR ESTIMATING FUGITIVE EMISSIONS FROM GAS PROCESSING

$$E_{processing} = A_{gas\ processed} \bullet EF_{LDAR\ or\ no\ LDAR} + A_{sour\ gas\ processed} \bullet EF_{sour\ gas\ removal}$$

Where:

$E_{processing}$ = Total amount of GHG gas emitted due to all relevant natural gas processing activities

$A_{gas\ processed}$ = Volume of natural gas processed or produced

$EF_{LDAR\ or\ no\ LDAR}$ = Emission factor for gas processed with or without LDAR programs

$A_{sour\ gas\ processed}$ = Volume of sour gas processed

$EF_{sour\ gas\ removal}$ = Emission factor for sour gas processing

Source: IPCC EQUATION 4.2.15 (NEW) GENERAL EQUATION FOR ESTIMATING FUGITIVE EMISSIONS FROM GAS PROCESSING, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 4: Fugitive Emissions

Different emissions factors are provided in the IPCC Guidelines depending on the extent of leak detection and the use of dry seals for compressors (see table below).

Table 8 Emissions factors for fugitive emissions from natural gas processing

	Emissions factors for gas processing				
	CH_4	**CO_2**	**NMVOC**	**N_2O**	**unit**
Processing without Leak Detection and Repair (LDAR) or with limited LDAR or less than 50% of centrifugal compressors have dry seals	1.65	0.11	0.13	0.0000012	tonnes/million cubic meters of gas produced
Processing with extensive LDAR and around 50% or more of centrifugal compressors have dry seals	0.57	7.21	0.05	0.000079	tonnes/million cubic meters of gas produced
Processing sour gas (acid gas removal)	0.1	66.6	0.1	0.000054	tonnes/million cubic meters of sour gas processed

Source: Table 4.2.4H (NEW), IPCC 2019 refinement of guidelines volume 4 fugitive emissions

Given that the Neptun Deep project is a new project, the emissions factors assuming better leak detection are taken into account for the estimation (see grey-shaded row in the table above). Moreover, according to the project memorandum, there is not expected to be any H_2S (hydrogen sulfide) present in the gas produced as part of the project development[14], and therefore the proportion of sour gas is assumed to be 0%.

Based on the above emissions factors, the IPCC equation and the project specifications, fugitive emissions from gas processing have been estimated to amount to about 2.42 million tCO_2e.

[14] EN project memorandum, Table 1 – Initial Estimated Gas Composition

Table 9 Estimate of fugitive emissions from natural gas processing

	tons of emissions	**million tons of emissions**	**million tCO_2e**
CH_4 emissions	57,000	0.06	1.70
CO_2 emissions	721,000	0.72	0.72
NMVOC	5,000	0.01	
N_2O emissions	7.9	0.00001	0.00
Total fugitive emissions from processing (excl. NMVOC)			**2.42**

Source: ERCST

Total fugitive emissions from the gas exploitation infrastructure

In total, fugitive emissions from the exploration, production and processing (excl. NMVOC) have been estimated to amount to 11.67 million tCO_2e, including 9.24 from production and 2.42 from the processing. This emissions segment would amount to ~30.16 million tCO_2e when using a GWP over a 20-year period to convert CH_4 emissions to CO_2e.

3.2.2. Tuzla-Podișor gas transmission pipeline

The IPCC Guidelines include the following equation for the estimation of fugitive emissions from natural gas transmission.

Text box 4 Equation for estimating fugitive emission from gas transmission (and storage)

EQUATION 4.2.16 (NEW)
GENERAL EQUATION FOR ESTIMATING FUGITIVE EMISSIONS FROM GAS TRANSMISSION AND STORAGE

$$E_{transmission\ and\ storage} = A_{transmission} \bullet EF_{transmission} + A_{storage} \bullet EF_{storage} + A_{LNG\ import/export} \bullet EF_{LNG\ import/export} + A_{LNG\ storage} \bullet EF_{LNG\ storage}$$

Where:

$E_{transmissin\ and\ storage}$ = Total amount of GHG gas emitted due to all relevant natural gas transmission and storage activities

$A_{transmission}$ = Volume of natural gas consumed/Length of transmission pipeline

$EF_{transmission}$ = Emission factor for gas transmitted

$A_{storage}$ = Volume of natural gas consumed

$EF_{storage}$ = Emission factor for gas consumed

$A_{LNG\ import/export}$ = Number of export/import LNG stations

$EF_{LNG\ import/export}$ = Emission factor for LNG imports and exports

$A_{LNG\ storage}$ = Number of storage LNG stations

$EF_{LNG\ storage}$ = Emission factor for LNG storage

Source: IPCC EQUATION 4.2.16 (NEW) GENERAL EQUATION FOR ESTIMATING FUGITIVE EMISSIONS FROM GAS TRANSMISSION AND STORAGE, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 4: Fugitive Emissions

For transmission, the IPCC Guidelines include different emissions factors depending on the extent of leak detection and use of dry seals for compressors (see table below).

Table 10 Emissions factors for fugitive emissions from natural gas transmission

	Emissions factors for gas transmission				
	CH_4	CO_2	NMVOC	N_2O	unit
Transmission: Limited LDAR or less than 50% of centrifugal compressors have dry seals	4.10	0.28	0.06	NA	Tons/ kilometre pipeline
Transmission: Extensive LDAR, and around 50% or more of centrifugal compressors have dry seals	2.08	0.25	0.03	NA	Tons/ kilometre pipeline

Source: Table 4.2.4I (NEW), IPCC 2019 refinement of guidelines volume 4 fugitive emissions

Because the project is new, it is assumed to have good leak detection technology installed. Consequently, the estimation incorporates emissions factors based on extensive leak detection (see grey-shaded row in the table above).

Based on the above emissions factors, the IPCC equation and the project specifications, fugitive emissions from natural gas transmission have been estimated to amount to ~0.019 million tCO_2e.

Table 11 Estimate of fugitive emissions from natural gas transmission

	tons of emissions	million tons of emissions	million tCO_2e
CH_4 emissions	640.64	0.00064	0.019
CO_2 emissions	77	0.000077	0.000077
Total fugitive emissions from transmission (excl. NMVOC)			**0.019**

Source: ERCST

3.2.3. Total fugitive emissions

In total, fugitive emissions from both the gas exploitation and the transmission infrastructures amount to 11.68 million tCO_2e, including 11.67 million tCO_2e from the gas exploitation infrastructures and 0.019 million tCO_2e from the transmission pipeline. This emissions segment would amount to ~30.2 million tCO_2e when using a GWP over a 20-year period to convert CH_4 emissions to CO_2e.

3.3. Emissions from construction, operation and decommissioning

This section considers the emissions from the construction, operation and decommissioning of the planned set of infrastructures. Fugitive emissions from operation are not taken into account here, as they have been part of the calculations in section 3.2.

3.3.1. Gas exploitation infrastructure

The main emissions sources during the construction/installation phase include GHG emissions from internal combustion engines of the ships, vehicles and equipment needed to perform the construction/installation works.

Similarly, the main emissions sources during operation of the infrastructure (other than fugitive emissions) include GHG emissions associated with: onshore (one back-up diesel generator) and offshore (three gas turbine generators and a diesel driven Essential Service Generator) power generation; and internal combustion engines of the helicopters, ships and vehicles used during operation.

Decommissioning is an engineering challenge that requires a substantial input of energy. GHG emission sources include: offshore and onshore operations; Transport and shipping of materials to disposal/recycling centers.

Based on data in the ESIA study for Neptun Deep, an estimate of about 3.3 million tCO_2e from the construction, operation and decommissioning (excluding fugitive emissions) of the Neptun Deep gas exploitation infrastructure has been derived (see table overleaf).

Table 12 Construction, operation and decommissioning emissions - gas exploitation infrastructure

	tCO_{2e}/year (unless stated otherwise)	**Number of years**	**million tCO_2e**	**Comment/assumption**
Construction, onshore	8,862		0.01	ESIA onshore construction emissions provided for the entire construction period.
Construction, offshore	244,757	2	0.49	Assuming a 2-year construction period. According to ESIA "trim 3,2024-quarter 2, 2026"; "The construction and installation of the project infrastructure is estimated to be completed in approximately 2 years"
- of which fugitive	*58,414*	2	*0.12*	idem
Construction - well drilling	549,634	2	1.10	ESIA drilling emissions provided per annum. Assuming a 2-year period. According to ESIA "quarter 1 2025-quarter 4 2026".
Subtotal of construction (incl. well drilling)	**803,253**		**1.60**	
Subtotal of construction (incl. well drilling), excluding fugitive	**744,839**		**1.48**	
Onshore operation emissions	280	20	0.0056	Assuming a 20-year operation period. According the ESIA study "The onshore and offshore facilities will operate for over 20 years."
- of which fugitive	*271*	20	0.0054	idem
Offshore operation emissions	89,822	20	1.80	idem
- of which fugitive	*17,822*	20	0.36	idem
Subtotal of operation emissions	**90,102**	20	**1.80**	idem
Subtotal of operation emissions excluding fugitive	**72,009**	20	**1.44**	idem
Decommissioning onshore	*8,862*		0.01	Assumed equal to total onshore construction emissions. According to ESIA "During the decommissioning stage, dust and pollutant emissions are estimated as during the construction period."
Decommissioning offshore	244,757	1.5	0.37	Assumed equal to total offshore construction emissions per annum and that decommissioning will take 1.5 years. According to ESIA "During the decommissioning stage, dust and pollutant emissions are estimated as during the construction period. The decommissioning period is estimated at […] 18 months in the marine area."
Subtotal of decommissioning emissions	253,619		0.38	
Total construction, operation, decommissioning			**3.78**	
Total construction, operation, decommissioning excl. fugitive			**3.30**	

Source: ERCST, based on Neptun Deep ESIA study, https://www.moew.government.bg/bg/proekt-neptun-dijp-za-dobiv-na-priroden-gaz-na-teritoriyata-na-rumuniya/

This is comparable to the order of magnitude derived when scaling emissions estimates for another natural gas project in the Black Sea, namely the Sakarya Gas Field Development Project[15], to the size and specificities of the planned project in the Neptun Deep perimeter.

Text box 5 Overview of the Sakarya Gas Project

The Sakarya Gas Field is located in the western Black Sea, approximately 165 km offshore Filyos, Turkey. Natural gas is produced with 1 Subsea Production System (SPS) from 10 wells. It will be transported onshore through a 16-inch (40.64 cm) diameter carbon steel pipeline, processed at the Onshore Production Facility (OPF). In Phase 1, the daily production capacity will reach a maximum of 10 million standard m3. In total Sakarya is estimated to hold 540 billion cubic metres (BCM) of gas reserves.

Source: ESIA of the Sakarya Gas Field Development Project[16]

More specifically, the annual Scope 1 emissions estimate from the Sakarya Gas Development project amounts to 39.81 kt CO_2e per BCM produced annually when fugitive emissions are excluded. Scaling this up to the current project in the Neptun Deep perimeter, denotes a total of 3.98 million tCO_2e of Scope 1 emissions (excluding fugitive emissions).

3.3.2. Tuzla-Podișor gas transmission pipeline

The main emissions from the construction, and operation of natural gas pipelines (fugitive emissions aside which have been calculated separately in section 3.2.2) comes from fuel use. For decommissioning, emissions are primarily associated with the venting of natural gas in the pipeline during decommissioning (not part of the fugitive emissions estimate calculated using the IPCC methodology in section 3.2.2).

Construction

The company Transgaz has provided an estimate of the amount of fuel that will be used during the construction period (execution period) of approximately 300,000 liters of fuel[17]. The company has not provided details with respect to the type of fuel but has used a CO_2 emissions rate of 2.68 kg CO_2/liter of fuel, which corresponds to the emissions rate per liter of diesel fuel. Using this emission factor leaves us with 804,000 kg CO_2e which is equivalent to approximately 0.0008 million tCO2e.

Table 13 Estimate of construction of Tuzla-Podișor gas transmission pipeline

Project phase	Fuel consumption (liters)	CO_2 emissions rate (kg CO_2 / liter of fuel)	CO_2 emissions (million tCO_2e)
Construction	300,000	2.68	0.0008

Source: ERCST based on information provided by Transgaz

Operation

For the operation of the 308 km pipeline the company has not provided an estimate of emissions. The main emissions from the operation of a natural gas pipeline come from the fuel used for compressors, maintenance and leakage[18]. Leakage is covered under fugitive emissions in the previous section 3.2.2.

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15 See ESIA of the Sakarya Gas Field Development Project: https://tp-otc.com/en/sustainability/environmental-and-social-impact-assessment-en/

16 https://www.sace.it/en/about-us/our-commitment/our-environmental-and-social-commitment/details/environmental-and-social-impact-assessment-availability-for-the-sakarya-gas-field-development-phase-i-project

17 Transgaz answer with number NR.DSMC 62551/24.08.2023 of Greenpeace request

18 Xu, S., Wang, J., Sun, H., Huang, L., Xu, N., & Liang, Y. (2022). Life cycle assessment of carbon emission from natural gas pipelines. *Chemical Engineering Research and Design*, *185*, 267-280.

To provide a back of an envelope calculation of the order of magnitude of operation emissions, this section draws on available emissions estimate from the greenhouse gas assessment of the Romanian section of the BRUA natural gas transmission pipeline[19].

The annual operational emissions associated with fuel use for Stage 1 of the Romanian section of the BRUA pipeline (excluding fugitive emissions) are 29,794 tCO_2e, which when adjusted proportionally to the natural gas volume of the Tuzla-Podișor pipeline amounts to 34,625 tCO_2e per annum or 0.69 million tCO_2e for the total project duration (of 20 years).

Table 14 Estimate of operation emissions of Tuzla-Podișor gas transmission pipeline based on BRUA Pipeline ESIA

Phase	**BRUA Stage 1 - tons CO_2/per year**	**Tuzla-Podișor pipeline tons CO_2/per year**	**Tuzla-Podișor pipeline for a period of 20 years, in million tons CO_2**	**Comment/Source/Assumption**
Operational emissions from fuel use	29,794	34,625	0.69	Annual operational emissions for the BRUA pipeline have been sources from the EIA of the Romanian section of the BRUA natural gas transmission corridor and proportionally adjusted for the natural gas volume of the Tuzla-Podișor pipeline. The volume of the pipe has been estimated at 253.327 m^3, Neptun Deep, while that of BRUA (Stage 1) has been estimated at 217,979 m^3.

Sources: ERCST, based on the ESIA of the Romanian section of the BRUA corridor, (https://www.eib.org/attachments/registers/79726902.pdf)

Decommissioning

It is assumed that at the end of life of the project, the gas transmission pipeline will remain in situ rather than excavated and removed. The main source of emissions from decommissioning the transmission pipeline would come from venting the natural gas and replacing it with a hydrocarbon-free atmosphere, typically air or a non-flammable stabilising slurry.

Following the approach used to calculate emissions from decommissioning the Katherine to Gove Gas Pipeline in Australia[20], we assume that the entire volume of natural gas in the pipeline would be purged and replaced with dry air or nitrogen (note that this approach provides an upper-bound estimate, as there are techniques that could potentially be employed to minimise the volume of natural gas released during decommissioning).

The volume of the pipeline is approximately 253,327 m^3, which is calculated to contain about 124 tons of natural gas, the composition of which is close to 100% methane. If the entire volume of natural gas is vented during decommissioning, this results in emissions of 0.0037 million tCO_2e when using a GWP(100) to convert methane emission to CO_2e, or 0.0102 million tCO_2e when using a GWP(20).

[19] Arcadis, 2017. ROMANIAN SECTION OF THE BRUA NATURAL GAS TRANSMISSION CORRIDOR PROJECT, Supplementary Environmental Impact Assessment Report, JUNE 2017, https://www.eib.org/attachments/registers/79726902.pdf

[20] Pacific Aluminium (2013) Katherine to Gove Gas Pipeline - Pipeline Greenhouse Gas Assessment. Brisbane Australia.

Table 15 Estimate of emissions from the decommissioning of the natural gas pipeline

Variable	**Value**	**Unit**	**Assumptions/Sources/Comments**
Total gas transmission pipe volume	253,327.42	m^3	Calculated using OMNI Pipe Volume Calculator, for the diameter and length of the pipeline's two sections
Natural gas density	0.49	kg/m^3	Calculated using Unitrove Natural Gas Density Calculator, using Neptun Deep Project natural gas composition, assuming a temperature of 10°C and pressure of 63 bar.
Natural gas in the pipeline	124.13	tons	Assuming natural gas density of 0.49 (see row above)
CH_4 share in the natural gas composition	99.66	%	Average methane % based on natural gas composition table in Project Memorandum
Emissions	123.71	tons of CH_4 emissions	Assuming the entire volume of natural gas in the pipeline would be purged
Emissions	0.0037	million tCO_2e	Based on GWP(100) value of 29.8 from IPCC 2021 6th Assessment Report
Emissions	0.0102	million tCO_2e	Based on GWP(20) value of 82.5 from IPCC 2021 6th Assessment Report

Source: ERCST

Total emissions from construction, operation and decommissioning of the gas transmission pipeline

Total emissions from the construction, operation and decommissioning of the Tuzla-Podișor gas transmission pipeline amount to an estimated 0.697 million tCO_2e.

3.3.3. Total emissions from construction, operation and decommissioning

In total, emissions from construction, operation (excluding fugitive emissions) and decommissioning of both the gas exploitation and the transmission infrastructures amount to about 3.99 million tCO_2e, including 3.3 million tCO_2e from the gas exploitation infrastructure and 0.697 million tCO_2e from the transmission pipeline.

3.4. Emissions embodied in steel

The production of several intermediate goods such as steel or cement that are used in the construction of major infrastructure projects is a highly energy and emissions intensive process.

Embodied carbon emissions, also known as embedded carbon emissions, refer to the upstream greenhouse gas emissions generated during the production and transportation of such materials.

While a detailed accounting of carbon emissions embodied in all materials used in the construction of the Neptun Deep infrastructures would require a detail inventory of such materials and is beyond the scope of this report, this section seeks to provide an estimate of the emissions embodied in the steel used in the following project components:

- Gas exploitation infrastructure:
    - the gathering pipe, i.e. the 160 km carbon steel pipe connecting the offshore platform to the metering station in Tuzla
    - the steel-based jacket structure of the platform
- the 308 km steel gas transmission pipeline

The following emissions intensities (in tons of CO_2e /ton of product) based on a study by the European Commission's Joint Research Centre (JRC), as well as company data have been used for the calculations.

Table 16 Emissions intensity of steel products, EU27 and Turkey

	Emissions intensity (tCO_2e /t product)	
Product	**EU27**	**Turkey**
Steel pipes with external diameter that exceeds 406.4mm (CN 7305)	2.01[a]	2.17[a]
Structures (excluding prefabricated buildings of heading 9406) and parts of structures (for example, bridges and bridge-sections, lock-gates, towers, lattice masts, roofs, roofing frameworks, doors and windows and their frames and thresholds for doors, shutters, balusTrades, pillars and columns), of iron or steel; plates, rods, angles, shapes, sections, tubes and the like, prepared for use in structures, of iron or steel (CN 7308)	3.71[a]	4.41[a]
Toscelik Bare ERW Steel Pipes for Natural Gas to be used for constructing the gas transmission pipeline	0.735[b]	

Sources:

[a] p.135, 136, 144, 145, Vidovic, D., Marmier, A., Zore, L. and Moya, J., Greenhouse gas emission intensities of the steel, fertilisers, aluminium and cement industries in the EU and its main trading partners, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/359533, JRC1346, https://publications.jrc.ec.europa.eu/repository/handle/JRC134682

[b] Toscelik, Environmental Product Declaration for Toscelik Bare ERW Steel Pipes for Natural Gas

3.4.1. Gas exploitation infrastructure

Based on technical specifications, namely the diameter, wall thickness and length, the gas gathering pipeline will involve an estimated 86,651 tons of steel (see table below). Moreover, based on the project memorandum, the steel jacket structure of the offshore platform will weigh about 9,000 tons.

Table 17 Technical characteristics of the gathering pipe

Variable	**Value**	**Unit**	**Comment/Source**
Gathering pipe material	Carbon steel		Project memorandum
Gathering pipe length	160	km	Project memorandum
Gathering pipe diameter	762	mm	Project memorandum
Gathering pipe wall thickness	30	mm	Project memorandum
Gathering pipe weight equivalent	86,651	tons of steel	Converted using Steel pipe weight calculator

Variable	Value	Unit	Comment/Source
Platform jacket structure material	steel		Project memorandum
Weight estimate of the platform jacket structure	9,000	tons	Project memorandum

Source: ERCST based on sources mentioned in the table's last column

The gathering pipe will be manufactured by Corinth Pipeworks, in Greece. We make the assumption that the steel used for the production of the pipe is produced in the EU, and use the EU27 emissions intensity value of 2.01 tCO_2e/ton of steel pipe (CN code 7305) for the calculation. Similarly, we use an EU27 emissions intensity factor for the steel structures used in the platform jacket structure of 3.71 t CO_2e/ton of structure (CN code 7308).

Table 18 Estimate of emissions embodied in steel components of the gas exploitation infrastructure

	Value	Unit
Emissions embedded in the steel gathering pipes	174,169	tCO_2e
	0.17	million tCO_2e
Emissions embedded in the platform steel structure	33,390	tCO_2e
	0.033	million tCO_2e
Grand total of emissions embodied in the gas exploitation steel components	207,559	tCO_2e
	0.21	million tCO_2e

Source: ERCST

3.4.2. Tuzla-Podișor gas transmission pipeline

The gas transmission pipe will be manufactured by companies Tosçelik and Noksel, in Turkey. According to information provided by Transgaz, the steel used for the production of the pipe is also produced in Turkey via the Electric Arc Furnace (EAF) route, and according to the product declaration the pipe encompasses a GHG intensity of 0.735 tCO_2e/ton of product.

Based on estimates by the pipe manufacturer, the gas transmission pipeline will involve an estimated 102,000 tons of steel[21]. The steel transmission pipe will thus encompass an estimated embodied emissions of ~0.075 million tCO_2e (see table below).

[21] See news release of 13 September 2023 'Tosçelik, Supplier for Romania's Black Sea Gas Pipeline Project' https://energyindustryreview.com/oil-gas/toscelik-supplier-for-romanias-black-sea-gas-pipeline-project/

Table 19 Estimate of emissions embodied in the steel gas transmission pipeline

	Value	**Unit**
Steel quantity	102,000	tons
Emissions intensity of steel pipe	0.735	tCO_2e/ton
Emissions embedded in the steel used for the gas transmission pipeline	0.075	million tCO_2e

Sources: ERCST; 'Tosçelik, Supplier for Romania's Black Sea Gas Pipeline Project' news release of 13 September 2023; Toscelik, Environmental Product Declaration for their Bare ERW Steel Pipes for Natural Gas.

3.4.3. Total steel-embodied emissions

In total, the emissions embodied in the steel needed to produce the gathering pipe, the platform and the transmission pipeline have been estimated to amount to ~ 0.28 million tCO_2e.

3.5. Total greenhouse gas emissions estimate

Table 20 outlines the GHG emissions associated with the natural gas exploitation infrastructure and transmission pipeline, and provides a breakdown of emissions across the various categories. Total emissions from both infrastructures have been estimated at ~209 million tCO_2e, when using a GWP over a 100-year period for methane (CH_4), or ~227 million tCO_2e when using a GWP over a 20-year period.

The predominant contributor to the emissions is combustion, responsible for ~193 million tCO_2e, accounting for approximately 92% of total project emissions. Fugitive emissions, from the gas exploitation infrastructure and the Tuzla-Podisor gas transmission pipeline, account for ~11.7 million tCO_2e, approximately 6% of the total. Emissions during construction, operation (excl. fugitive), and decommissioning for both infrastructures sum up to ~4 million tCO_2e which is equivalent to about 2% of the total. Additionally, emissions embedded in the steel used for constructing the infrastructure (the steel gathering pipe, transmission pipe and platform) contribute ~0.3 million tCO_2e which is approximately 0.14% of the total.

The gas exploitation infrastructure accounts for the lion share (99.6%) of total project emissions (including emissions from combustion of the produced gas), with emissions from the gas transmission pipeline accounting for 0.4% of the total.

Even when disregarding emissions from the combustion of the produced natural gas, the pipeline still accounts for an estimated 5% of the emissions associated with the construction, operation, decommissioning, construction materials (i.e. steel) and fugitive emissions from the two infrastructures together. When the emissions from the combustion of the natural gas are not taken into account, fugitive emissions account for close to three quarters of the total (~73%), operational emissions for ~13%, construction and decommissioning for 9.3% and 2.4% respectively, followed by emissions embodied in steel (1.8%).

Table 20 Total estimate of emissions from the gas exploitation and transmission infrastructures

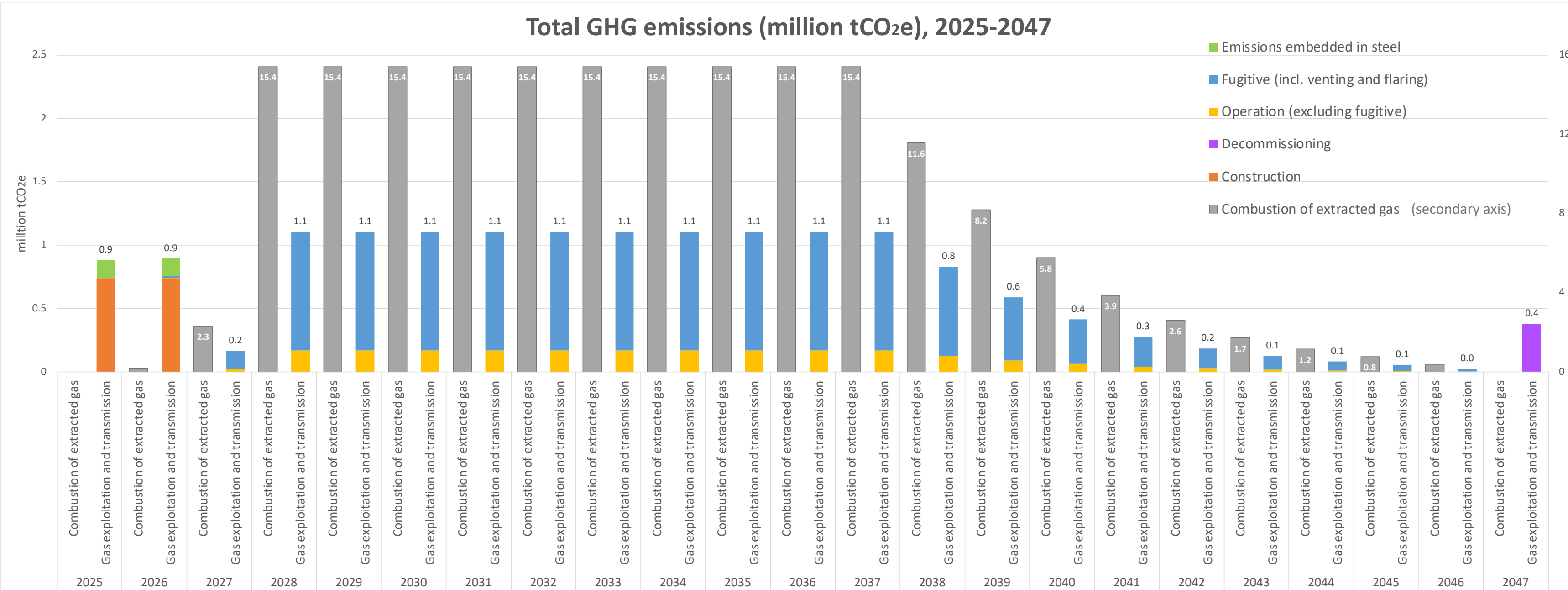
	Gas exploitation infrastructure emissions (million tCO2e)	**% of total emissions**	**% of total emissions excluding combustion**	**Gas transmission pipeline emissions (million tCO2e)**	**% of total emissions**	**% of total emissions excluding combustion**	**Total emissions (million tCO2e)**	**% of total emissions**	**% of total emissions excluding combustion**
Combustion of extracted gas	192.68	92.35%		-	-		192.68	92.35%	
Emissions embedded in steel	0.21	0.10%	1.30%	0.075	0.04%	0.47%	0.28	0.14%	1.77%
Fugitive emissions	11.67	5.59%	73.09%	0.019	0.01%	0.12%	11.68	5.60%	73.21%
Construction, operation, decommissioning	3.30	1.58%	20.66%	0.697	0.33%	4.37%	3.99	1.91%	25.02%
- of which construction	*1.48*	*0.71%*	*9.28%*	*0.0008*	*0.000%*	*0.005%*	*1.48*	*0.71%*	*9.28%*
- of which operation (excluding fugitive)	*1.44*	*0.69%*	*9.02%*	*0.693*	*0.33%*	*4.34%*	*2.13*	*1.02%*	*13.36%*
- of which decommissioning	*0.38*	*0.18%*	*2.36%*	*0.0037*	*0.002%*	*0.02%*	*0.38*	*0.18%*	*2.38%*
Total, using GWP (100) for CH_4	**207.85**			**0.79**			**208.64**		
Share of total (%)	99.6%			0.4%					
Share of total, excluding combustion (%)	95.0%			5.0%					
Total average per annum (assuming 20 years)	10.39			0.04			10.43		
Total per annum during plateau stage	16.46			0.06			16.52		
Total per BCM of gas (assuming total of 100 BCM)	2.08			0.008			2.09		
Total using GWP(20) for CH_4	**226.53**			**0.83**			**227.36**		

Source: ERCST

On an annual basis, assuming a twenty-year period, emissions stand on average at ~10.39 million tCO_2e per year. Expressing emissions per billion cubic meters of gas (BCM), assuming a total of 100 BCM, results in ~2.08 million tCO_2e per BCM.

Year on year, emissions will fluctuate depending inter alia on the volume of the extracted natural gas. The following figure provides an indication of annual GHG emissions associated with Neptun Deep, assuming that construction takes place in 2025-2026, production starts in 2027 and reaches the plateau stage of 8 BCM per year as of 2028 for a period of ten years, after which production gradually ramps down to zero in 2047, the year when decommissioning is assumed to take place. Total GHG emissions during the plateau production stage (2028-2037) would amount to ~16.5 million tCO_2e/year, of which 15.4 million tCO_2e/year from the combustion of the produced gas, 0.93 million tCO_2e/year in fugitive emissions and 0.17 million tCO_2e/year in operational emissions.

Figure 3 Total project greenhouse gas emissions (million tCO₂e), 2025-2047



Source: ERCST

Note: Based on the following assumptions for annual gas production in billion cubic metres (BCM):

YEAR	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	TOTAL
BCM	0	0.1	1.2	8	8	8	8	8	8	8	8	8	8	6	4.25	3	2	1.35	0.9	0.6	0.4	0.2	0	100

4. GHG estimate in the context of climate commitments

As a Member State of the European Union, Romania has committed to become climate neutral by 2050. In addition, the involved companies, OMV Petrom and Romgaz, have emissions reduction plans for 2030 and 2050. This chapter considers the impact of the emissions from the gas exploitation and transmission infrastructures on Romania's inventory of GHG emissions, as well as how the emissions estimate fits into the emissions reduction plans of OMV Petrom and Romgaz.

4.1. Romania's GHG emissions and climate plan

4.1.1. Romania's inventory of GHG emissions

The following table denotes Romania’s GHG emissions over the years, including total emissions, emissions from fuel combustion and fugitive emissions. Total GHG emissions and removals (net emissions, including the LULUCF sector) amounted to 66.14 million tCO_2e in 2021. If removals from LULUCF are not accounted for, total GHG emissions in 2021 were 115.40 million tCO_2e. The emissions trend since 1989 reflects the economic development of the country. *“During the period from 1989 to 2000, Romania's transition from a centralized economy to a free-market structure, coupled with the reorganization of all economic sectors, the closure of inefficient industries, and the commencement of operations of the first two units at the Cernavoda nuclear power plant, collectively led to a substantial reduction of over 50% in GHG emissions. In the subsequent period between 2000 and 2008, the GHG emissions slightly increased and eventually stabilized due to economic revitalization. Another drop in GHG emissions occurred from 2009 to 2012, attributed to the global financial and economic crisis. From 2013 onward, GHG emission levels have remained relatively constant*”[22].

Table 21 Romania’s inventory of GHG emissions, million tCO_2e

Category	1990	2000	2010	2021
Total GHG emissions without LULUCF	257.14	142.24	126.67	115.40
Total GHG emissions with LULUCF	228.53	109.32	89.43	66.14
1. Energy	185.04	98.36	88.41	76.91
1.AA Fuel Combustion - Sectoral approach	150.85	80.38	75.04	67.47
1.B Fugitive Emissions from Fuels	34.19	17.99	13.36	9.44
1.B.1 Solid Fuels	6.57	12.54	8.91	5.96
1.B.2 Oil and Natural Gas and Other Emissions from Energy Production	27.62	5.44	4.45	3.48
1.B.2.a Oil	6.14	1.17	1.31	0.87
1.B.2.b Natural Gas	18.13	2.12	1.68	1.47
1.B.2.c Venting and Flaring	3.35	2.15	1.46	1.15

Source: ERCST based on UNFCCC Greenhouse Gas Inventory Data - Detailed data by Party, https://di.unfccc.int/detailed_data_by_party

4.1.2. Project emissions in the context of Romania's inventory and climate plan

As noted in section 3.5 of the report, total GHG emissions from the set of the two infrastructures in scope of this report has been estimated at about 209 million tCO_2e, of which 193 million tCO_2e from the

[22] p 147, in Romania’s draft update of its 2021-2030 Integrated National Energy and Climate Plan (NECP), https://commission.europa.eu/publications/romania-draft-updated-necp-2021-2030_en

combustion of the natural gas, about 11.7 million tCO_2e in fugitive emissions, 0.28 million tons CO_2e embedded in steel used in the infrastructures, and 4 million tCO_2e from their construction, operation and decommissioning. Assuming a twenty-year project lifetime, this would on average amount to about 10.4 million tons CO_2e annually, of which 9.6 million tCO_2e from the combustion of the gas, 0.58 million tons CO_2e in fugitive emissions, 0.2 million tCO_2e from the construction, operation and decommissioning of the infrastructures and 0.014 million tCO_2e embedded in the steel.

Construction, operation, decommissioning and fugitive emissions would purely add to Romania's current emissions. This part of emissions amount to an estimated average annual 0.8 million tCO_2e, and would constitute a ~1.2% increase of Romania's 2021 GHG emissions with LULUCF (or a 0.7% increase of Romania's GHG emissions without LULUCF). Fugitive emissions from the project have been estimated at an annual average of ~0.58 million tCO_2e/year or about 0.93 million tCO_2e/year during the period of plateau production of 8 BCM/year (~1.4% of Romania's 2021 GHG emissions with LULUCF). This compares to a total of 1.47 million tCO_2e in fugitive emissions from natural gas in Romania in 2021 (see GHG inventory in table above), when indigenous natural gas production totaled 8.9 BCM[23]. Operational emissions including fugitive emissions during the plateau stage would amount to about ~1.08 million tCO_2e/year (~1.6% of Romania's 2021 GHG emissions with LULUCF).

When it comes to emissions from the production of the steel used in the project, those would be accounted in the GHG inventory of the country of origin of the steel. Based on available information, the steel will be imported and not produced domestically in Romania. Even under a consumption-based approach of accounting for GHG emissions, steel-related emissions from the project would increase Romania's annual emissions by less than 0.1%.

When it comes to emissions associated with the combustion of the produced natural gas, i.e. 193 million tCO_2e in total or on average 9.6 million tCO_2e annually for twenty years (15.4 million tCO_2e/year during plateau production), the net impact on Romania's GHG emissions is less straightforward and depends on a set of assumptions including:

- What share of the produced natural gas would be exported?
- What share of the produced natural gas would displace natural gas imports?
- Will the availability of gas from Neptun Deep have a substitution effect towards more polluting or less polluting fuels? To what extent the produced gas would substitute more polluting fossil fuels like coal or oil, or crowd out zero emission sources?

That said, an assessment of the net impact of the Neptun Deep project on Romania's emissions would require energy modelling, and depending on the assumptions with respect to the above questions as well as the counterfactual scenarios, a wide range of results could be obtained. For illustration purposes, an extreme assumption, where all the gas produced from Neptun Deep would merely displace gas imports to Romania or where all produced gas would be exported, would result to a minimal (near-zero) impact of the project on Romania's emissions; On the other hand, under an extreme assumption of zero natural gas exports from Neptun Deep, zero impact on gas imports as well as a full crowd-out of zero emission energy sources would result to a maximum net impact of the project on Romania's emissions.

[23] Source: 'Eurostat Supply, transformation and consumption of gas' dataset (nrg_cb_gas), https://ec.europa.eu/eurostat/databrowser/view/nrg_cb_gas__custom_9459816/default/table?lang=en

Notwithstanding, based on Romania's draft update of its 2021-2030 Integrated National Energy and Climate Plan (NECP)[24], it appears that the Government of Romania believes in an increased role for natural gas as a transitional fuel on the path to net-zero, as well as a means to enhancing energy security. For example, the draft updated NECP mentions the goal to construct 2.6 GW natural-gas powered CCGT and 947 MW of natural-gas powered CHP by 2030, as well as the vision to advancing the natural gas transmission network with the view to diversifying natural gas supplies and reducing dependence on Russia. Indeed, when replacing other fossil fuels, natural gas can lead to lower GHG emissions and local pollutants. In this respect, the planned Neptun Deep gas exploitation and transmission infrastructures seem consistent with Romania's NECP.

The Neptun Deep project would need, however, to also examine the impact it may have on low-carbon fuels, such as renewables and nuclear.

Fulfilling the NECP hinges upon the assumption that after 2035 the natural gas power plants and natural gas CHP will run on hydrogen, resulting in 95% share of RES in power generation in 2050, with nuclear accounting for the remaining 5%.

Romania needs to ensure that this generation mix, and the attaining of climate change objectives, are not in any way being affected by the availability of natural gas flows from Neptun Deep.

4.2. Beneficiaries' climate commitments & emissions reduction plans

OMV Petrom and Romgaz have endorsed the development plan for the Domino and Pelican Sud commercial natural gas fields within the Neptun Deep perimeter. OMV Petrom serves as the operator, and each company holds a 50% stake in the project[25]. As OMV Petrom is operating the gas infrastructure we have attributed the emissions of operating, constructing, and decommissioning the gas exploitation project to OMV Petrom's Scope 1 emissions. The emissions from the combustion of the produced natural gas, emissions embodied in steel, as well as the emissions associated with the transmission pipeline have been attributed as Scope 3 emissions for both companies. We attribute 50% of Scope 3 emissions to each company, the 50% division reflecting the ownership structure by the two companies.

Transgaz is the owner and operator of the transmission pipeline, and the emission reduction plans of Transgaz is outside the scope of this report. As mentioned above, the emissions associated with the Tuzla-Podișor pipeline are considered as Scope 3 emissions of OMV Petrom and Romgaz.

The following sections compare the emissions from the gas exploitation and transmission pipeline infrastructures to the emissions reduction plans of OMV Petrom and Romgaz.

4.2.1. Emissions reduction plan of OMV Petrom

In its 2030 strategy, OMV Petrom has committed to reducing the carbon emissions of its operations (Scope 1 & 2) by 30% in 2030 compared to 2019 levels and to achieving net zero operations by 2050[26]. The company has also an overall target to reduce total emissions, i.e. Scope 1, 2 and 3 emissions, by 20%

[24] See https://commission.europa.eu/publications/romania-draft-updated-necp-2021-2030_en

[25] OMV announces final investment decision taken by OMV Petrom for natural gas deep-water project Neptun Deep

[26] OMV Petrom. Strategy 2030: Transforming for a lower carbon future (2021) Link: Strategy | OMVPetrom.com

compared to 2019 levels by 2030. In 2022, the company emitted 3.93 million tCO_2e in Scope 1 emissions, 0.088 million tCO_2e in Scope 2 and 23.03 million tCO_2e in Scope 3[27].

In the following table we have attributed the Neptun Deep Project emissions as follows:

- **Scope 1:** OMV Petrom's sustainability report includes emissions from operation that are owned or controlled by the company as Scope 1 emissions. As OMV Petrom is operating the gas exploitation infrastructure we have attributed 100% of the emissions from the operation, construction, and decommissioning of the gas exploitation infrastructure, as well as the related fugitive emissions under OMV Petrom's Scope 1 emissions.
- **Scope 2:** OMV Petrom's sustainability report includes generation of purchased or acquired electricity, heating, cooling, or steam as Scope 2 emissions. Our calculations do not include a disaggregated estimate of Scope 2 emissions from the Neptun Deep project; rather any purchased electricity- or heat-related emissions are included in Scope 1.
- **Scope 3**: OMV Petrom refers to Scope 3 emissions as other indirect emissions that occur outside the organization, including exploration and production, repairs, maintenance, gathering and processing. It also includes the use and processing of the sold products. In this category, we have included the emissions embedded in the steel used in the project, the emissions from the combustion of the sold gas, as well as the total emissions from the transmission pipeline. We attribute 50% of these emissions as OMV Petrom's Scope 3 emissions to reflect its ownership ratio of the infrastructure.

Table 22 OMV Petrom's GHG emissions and targets compared to project emissions, million tCO_2e

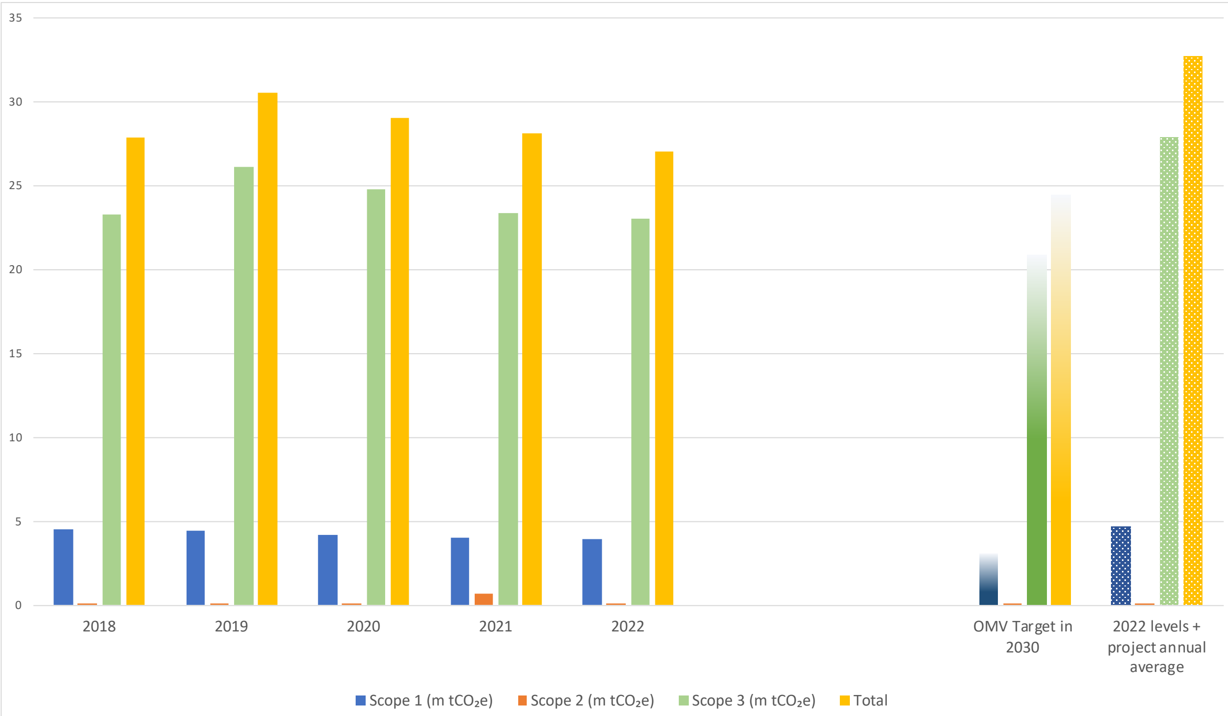
	OMV Petrom 2019	**OMV Petrom 2022**	**OMV Petrom 2030 target**	**Annual average emissions from project**	**Annual emissions from project during plateau stage**
Scope 1 (m tCO_2e)	4.42	3.93	3.09*	0.75	1.05
Scope 2 (m tCO_2e)	0.05	0.09	0.03*	NA	NA
Scope 3 (m tCO_2e)	26.06	23.03	20.85**	4.84***	7.74***
Total (m tCO_2e)	**30.53**	**27.05**	**24.42****	**5.59**	**8.78**

Source: ERCST based on OMV Petrom Sustainability Report, OMV Petrom Strategy, and estimates from chapter 3
Notes: ** Assuming a 30% reduction compared to 2019 levels*
***Assuming a 20% reduction compared to 2019 levels*
****50% of the emissions embedded in the steel, the emissions from the combustion of the sold gas, and the emissions from the transmission pipeline attributed as OMV Petrom's Scope 3 emissions*

The total emissions reduction target of 20% compared to 2019 results in 24.42 million tCO_2e in 2030. The additional emissions from the gas exploitation and transmission infrastructure are estimated on average at 5.59 million tCO_2e per year assuming a 20-year time period. If emissions from the rest of the company's operations remain at 2022 levels, the Neptun Deep Project would result in an ~7% increase in OMV's total emissions compared to 2019 levels. Figure 4 illustrates OMV Petrom's emissions from 2018 to 2022 compared to their target for 2030. The rightmost bar illustrates the level of emissions of OMV Petrom when adding the emissions from Neptun Deep Project to their latest recorded emissions from 2022.

[27] OMV Petrom Sustainability Report (2022) sustainability-report-2022.pdf (omvpetrom.com)

Figure 4 OMV Petrom 2030 emissions strategy compared to emissions from Neptun Deep project



Source: ERCST

Looking at individual emissions scopes, the Neptun Deep project would bring annual Scope 1 emissions of the company to an estimated 4.68 million tCO_2e, which would constitute a ~6% increase compared to 2019 levels. Similarly, the project would bring Scope 3 emissions to an estimated 27.87 million tCO_2e, which would all other things equal constitute an increase of ~7% compared to 2019 levels.

4.2.2. Emissions reduction plan of Romgaz

The emissions reduction plan of Romgaz is to decrease their Scope 1 & 2 emissions by 10% compared to 2020 levels by 2030 and reach net zero CO_2 emissions by 2050[28]. Company emissions in 2022 were 0.88 million tCO_2e in Scope 1 and 0.0004 million tCO_2e in Scope 2[29]. No information on the targets for Scope 3 emissions are provided by Romgaz. Their sustainability report does report emissions from fuels which we regard as the company's Scope 3 emissions.

In the following table we have attributed the Neptun Deep Project emissions as follows:

- **Scope 1:** As Romgaz is not operating any of the infrastructures, we have not attributed any Scope 1 emission from Neptun Deep to Romgaz's Scope 1 emissions.
- **Scope 2:** Similarly, there are no emissions from Neptun Deep attributed as Romgaz's Scope 2 emissions.
- **Scope 3**: Romgaz's sustainability report shows the amount of emissions for natural gas only for 2022 which we have attributed to its Scope 3 emissions. However, there are no available targets with respect to their Scope 3 emissions. For the project, we consider the emissions embedded in

[28] SNGN Romgaz Strategy 2021-2030 (2020) https://www.romgaz.ro/sites/default/files/2021-11/SNGN Romgaz SA Strategy 2021 - 2030.pdf

[29] Romgaz Sustainability Report (2022) https://www.romgaz.ro/sites/default/files/2023-06/Sustainability Report 2022.pdf

the steel, emissions from the combustion of the sold gas, and the emissions from the transmission pipeline, following the same approach as for OMV Petrom in section 4.2.1), and we attribute 50% of these emissions to each company's Scope 3 emissions to reflect the ownership ratio of the infrastructure by them. The emissions from the operation (incl. fugitive), construction, and decommissioning of the gas exploitation infrastructure (i.e. equal to the project emissions attributed as OMV Petrom's Scope 1 emissions) could have but have not been added to the Scope 3 emissions of Romgaz, so as to not double count project emissions.

Table 23 Romgaz's GHG emissions and targets compared to emissions from project, million tons of CO_2e

	Romgaz 2020	**Romgaz 2022**	**2030 Target (10% reduction)**	**Annual average emissions from project**	**Annual emissions from project during plateau stage**
Scope 1 (m tCO_2e)	0.54	0.88	0.48	0	0
Scope 2 (m tCO_2e)	0.0005	0.0004	0.0004	NA	NA
Scope 3 (m tCO_2e)	NA	0.64*	*No target*	4.84**	7.74**
Total (m tCO_2e)	**0.54**	**1.52**	**0.48**	**4.84**	**7.74**

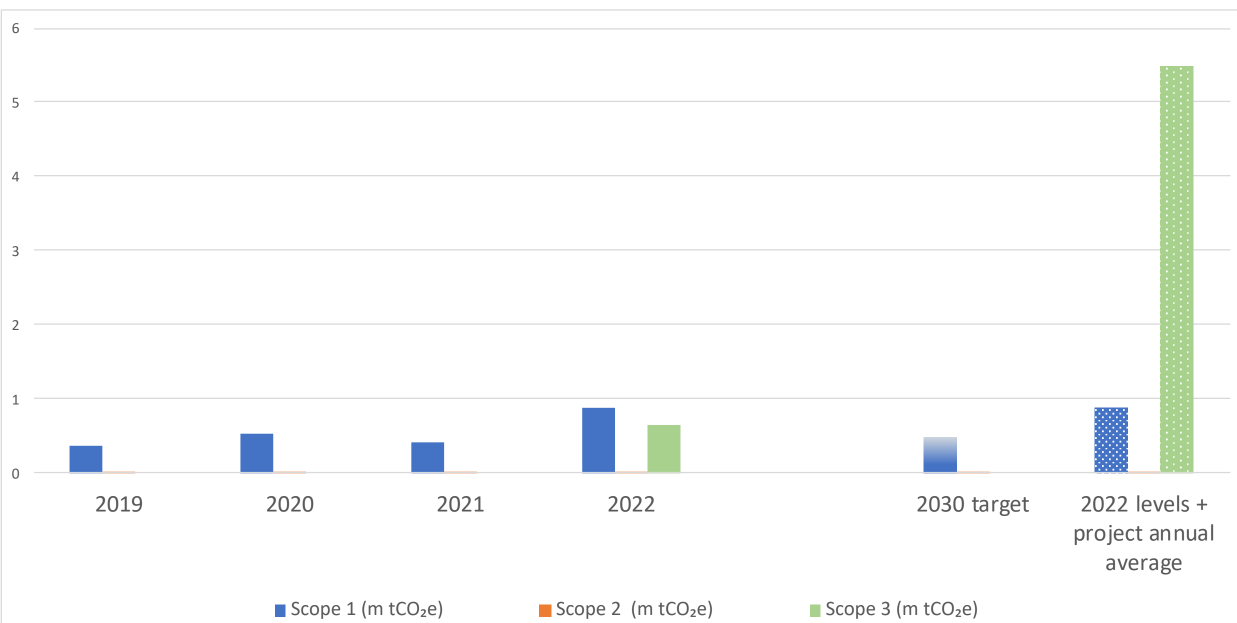
Source: ERCST based on Romgaz Sustainability Report, Romgaz Strategy, and calculations from chapter 3

** Romgaz sustainability report fuel emissions*

*** 50% of the emissions embedded in the steel, emissions from the combustion of the sold gas, and the emissions from the transmission pipeline attributed as Scope 3 emissions of Romgaz.*

It is not possible to compare the Romgaz strategy with the calculated project emissions because Romgaz lacks targets with respect to their Scope 3 emissions, which are the only emissions they contribute to as owners without an operational role in this project. Overall, the Scope 3 emissions estimate from Neptun Deep is significantly greater than the company's total emissions in 2022. This is also illustrated in the figure below where the rightmost bar denotes the level of emissions of Romgaz when adding the average annual emissions from the Neptun Deep Project to their latest recorded emissions in 2022.

Figure 5 Romgaz 2030 emissions strategy compared to emissions from Neptun Deep project



Source: ERCST