SAKARYA GAS FIELD DEVELOPMENT PROJECT – ENHANCEMENT OF SUBSEA PRODUCTION CAPACITY AND FLOATING PRODUCTION UNIT

Chapter 4 Alternative Analysis

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4.0 ALTERNATIVE ANALYSIS

IFC PS1 requires full and detailed justification for any proposed alternatives through the environmental and social risks and impacts identification and assessment process. In addition, in the Annex A of the Equator Principles (EP) IV, it is described that the alternatives analysis requires the evaluation of technically and financially feasible and cost-effective options available to reduce Project-related Greenhouse Gas (GHG) emissions during the design, construction and operation of the Project.

With reference to the emissions, the analysis will endeavour to ascertain the best practicable environmental option and will include consideration of alternative fuel or energy sources if applicable. Where an alternatives analysis is required by a regulatory permitting process, the approach has to follow the methodology and time frame required by the relevant process. For projects in high carbon intensity sectors, the alternatives analysis has to include comparisons to other viable technologies, used in the same industry and in the country or region, with the relative energy efficiency, GHG efficiency ratio, as appropriate, of the selected technology.

High carbon intensity sectors indicatively include but are not limited to the following: oil and gas, thermal power, cement and lime manufacturing, integrated steel mills, base metal smelting and refining, and foundries, pulp mills and potentially agriculture. Notably, EP4 describes the oil and gas sector, which the Project falls within, as a 'high carbon intensity' sector. In accordance with EP4s high carbon intensity sector AA guidance, the Project is required to consider alternative fuel or energy sources and viable technology that is used in the same industry or region with energy efficiency and GHG efficiency of the various technologies.

Following completion of an alternatives analysis, the Project Proponent is expected to provide, through appropriate documentation, evidence of technically and financially feasible and cost-effective options and justification on why alternative technologies were not selected. This does not modify or reduce the requirements set out in the applicable standards (e.g., IFC PS 3).

The purpose of this section is to summarize how the Project siting and components represent an optimized design that is technically and financially viable while minimizing overall environmental and social impacts. Chapter 7 of this ESIA Report contains an assessment of the impacts that the Project will have together with the selection of suitable mitigation and monitoring measures.

4.1 Site Alternatives

4.1.1 Export Pipeline

The SGFD Phase 2 Project involves the construction of an offshore export pipeline to transport the processed natural gas from the Floating Production Unit (FPU) to onshore facilities. The Offshore Pipeline Routing Selection Report (SC26-2A-SPM-URF-FL-REP-200247_R03), prepared by SIA and Saipem on June 3, 2024, was shared with WSP Türkiye. In the report, two main route alternatives, Route Alternative 1 (RA-1) and Route Alternative 2 (RA-2), have been assessed for the escarpment and shallower sections of the pipeline, each presenting distinct challenges and advantages in terms of various considerations detailed in the following sections. The locations of the route alternatives, RA-1 and RA-2, are shown in Figure 4-1. As a result of the assessment, RA-2 has been selected, the discussion behind the rationale is elaborated below.

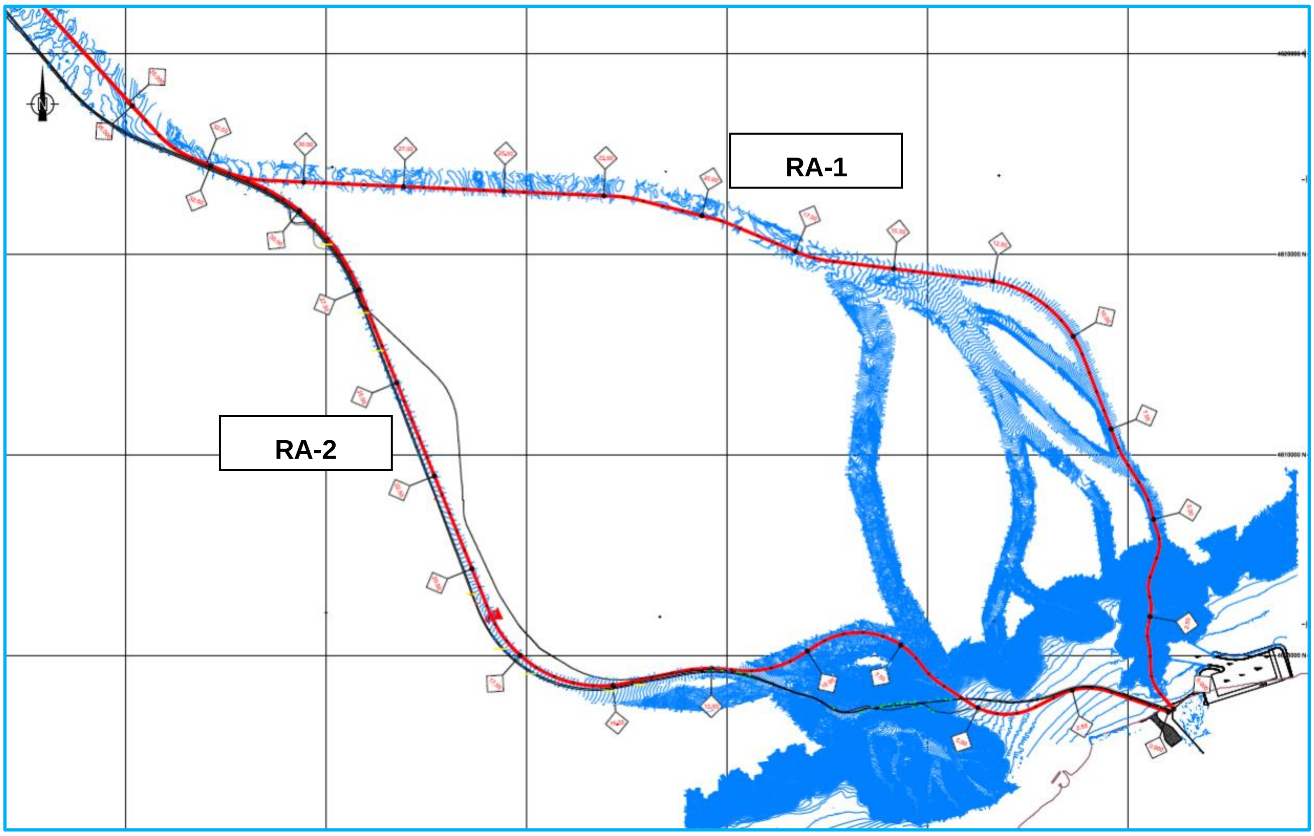


Figure 4-1: Locations of Route Alternatives (RA-1 and RA-2) for the Export Pipeline

4.1.1.1 Route Selection Criteria

The key considerations for selecting the export pipeline route include:

- Geohazard risks
- Interface with Filyos River
- Interface with Filyos Port
- Shore approach and shallow water constructability:
- Concrete and burial requirements
- Curve stability
- Free span correction
- Crossings
- Onshore section

4.1.1.2 Comparative Study of RA-1 and RA-2

4.1.1.2.1 Geohazard

The route alternatives were assessed qualitatively with a potential requirement for protection for geohazard based on the geohazard surveys, engineering judgements, and experience from SGFD Phase 1.

Based on the assessment:

- Both routes have similar geohazard issues and based on preliminary estimation of volumes for rock dumping and lengths for post-trenching, they are comparable for both routes.
- RA-1 presents more uncertainties on lateral slopes of rock berms on specific locations, that could have a significant impact in terms of volumes. The slopes on this route are up to 30 degrees with a hard rock surface and feasibility of intervention with seabed excavation equipment is questionable due to risk of equipment instability on the slopes.
- RA-2 presents uncertainties in terms of geohazard on the top of the escarpment, where post-earthquake slides have been found.

4.1.1.2.2 Interface with the Filyos River

The route alternatives were compared in terms of the proximity to the Filyos River (i.e. "Yenice River"). RA-1 is situated on the north-east side of the Phase 1 pipelines, further from the river, whereas RA-2 is positioned south-west side of the Phase 1 pipelines, closer to the Filyos River. The locations of the alternatives are shown in Figure 4-2.

Figure 4-2: Location of Route Alternatives with respect to Filyos River

Based on the comparison, in terms of interface with the Filyos River:

- RA-1 can be considered more advantageous since more distant from the river and so on a more stable area.
- RA-1 can be considered more advantageous since turbidity from the river is crossed on a deeper area.
- RA-1 can be considered more advantageous since route heading is not transversal to the river.

4.1.1.2.3 Interface with Filyos Port

In order to evaluate the potential risks posed by vessel traffic near Filyos Port, A Ship Interaction Frequency Assessment was conducted for both of the route alternatives. The locations of the alternatives with respect to the Filyos Port are shown in Figure 4-3.

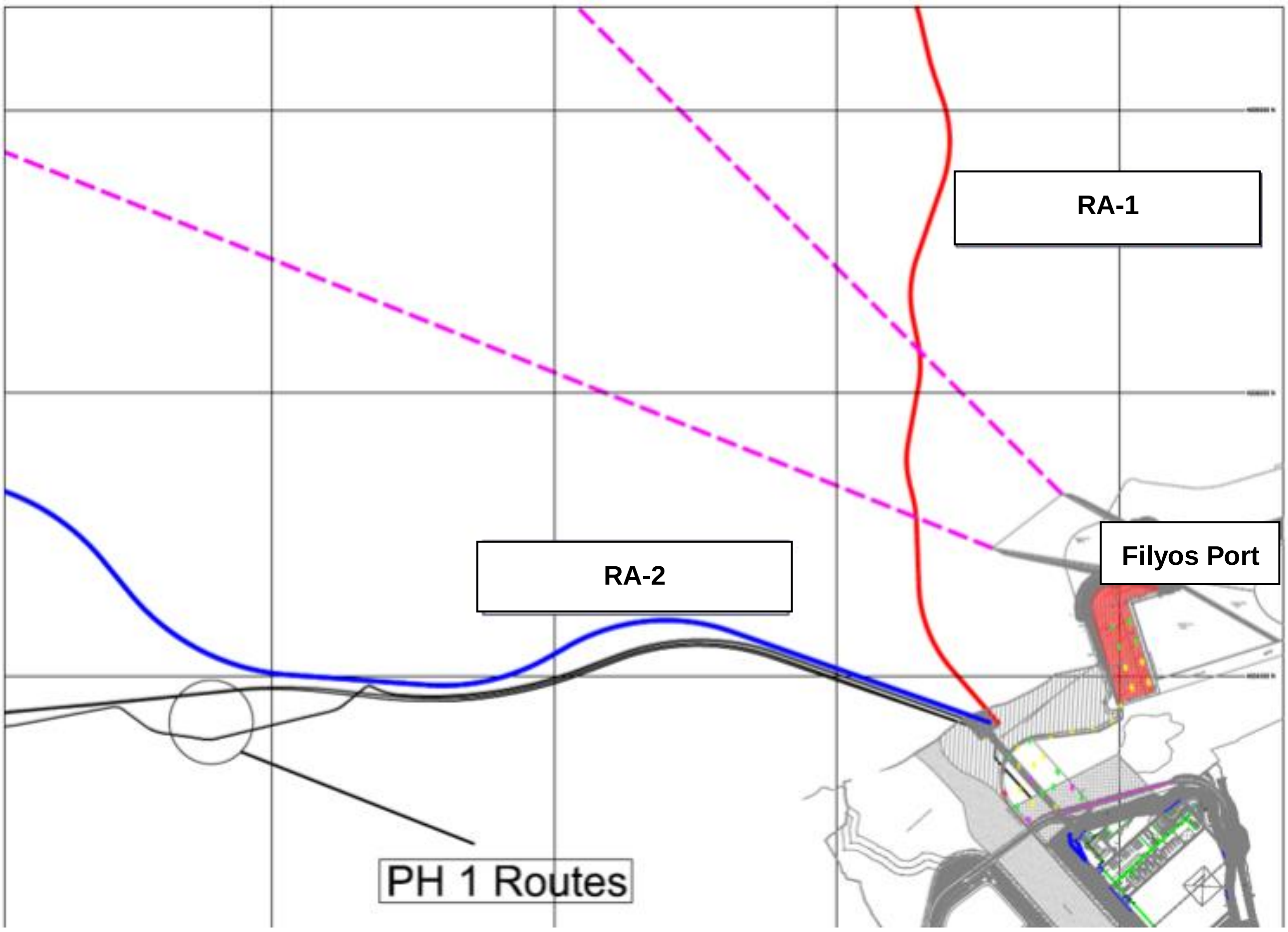


Figure 4-3: Locations of RA-1 and RA-2 with respect to Filyos Port

Based on the assessment:

- RA-2 is considered favourable with respect to interaction with Filyos port and ship traffic, no mitigation is required. Therefore, social impact during the construction of the export pipeline route RA-2 will be lowered compared to the other route option.
- RA-1 requires protection from Filyos port interface, at this location protection is potentially required also for Geohazard.

4.1.1.2.4 Shore Approach and Shallow Water Constructability

Route alternatives were assessed in terms of shore approach and shallow water constructability. One of the lay vessels named "Castorone" is capable to work with minimum water depth ranging between 25 m/30 m due to interaction between thrusters and seabed. Based on seabed profile, shore pull for Route RA-1 is feasible with "Castorone", so only one vessel is needed for shore pull and normal lay. On the contrary, shore pull for RA-2 needs to be performed within 16 m water depth due to the presence of the first curve to not cross Phase 1 pipelines. So, an additional Shallow Water Vessel is needed for RA-2.

Based on the assessment, in terms of shore approach and shallow water constructability:

- RA-1 can be considered as a more advantageous solution due to the very short shallow water section, with no need of additional shallow water lay vessel.

4.1.1.2.5 Concrete and Burial Requirements

Route alternatives were assessed in terms of concrete and burial requirements based on the on-bottom stability analyses. The analysis indicated that the shallow water section for RA-2 is much more extended on shelf break with respect to RA-1 and the sections to be trenched and the length of the pipe to be coated with Concrete Weight Coating (CWC) are bigger for RA-2.

Based on the assessment, in terms of concrete and burial requirements:

- RA-1 can be considered as a more advantageous solution due to the limited section of the route to be coated with CWC for on bottom stability purpose.
- RA-1 can be considered as a more advantageous solution due to the limited section of the route to trenched for on bottom stability purposes.

4.1.1.2.6 Curve Stability

In order to assess the route alternatives in terms of curve stability, curve stability analyses (Finite Element Analysis) were performed for route curves where the minimum bending radius could not be calculated analytically due to sharp bends and/or the presence of free span sections, typically found in the escarpment area.

Based on the assessment:

- Along RA-1, three (3) curves on the escarpment requires the installation of eleven (11) lateral counteracts due to tight bend radii (<1000m) and the configuration of free spans.
- RA-2 has 2 (two) curves unstable due to lateral slope, potentially re-routing and/or seabed smoothing are expected to be enough and to avoid the installation of lateral counteracts.

4.1.1.2.7 Free span Correction

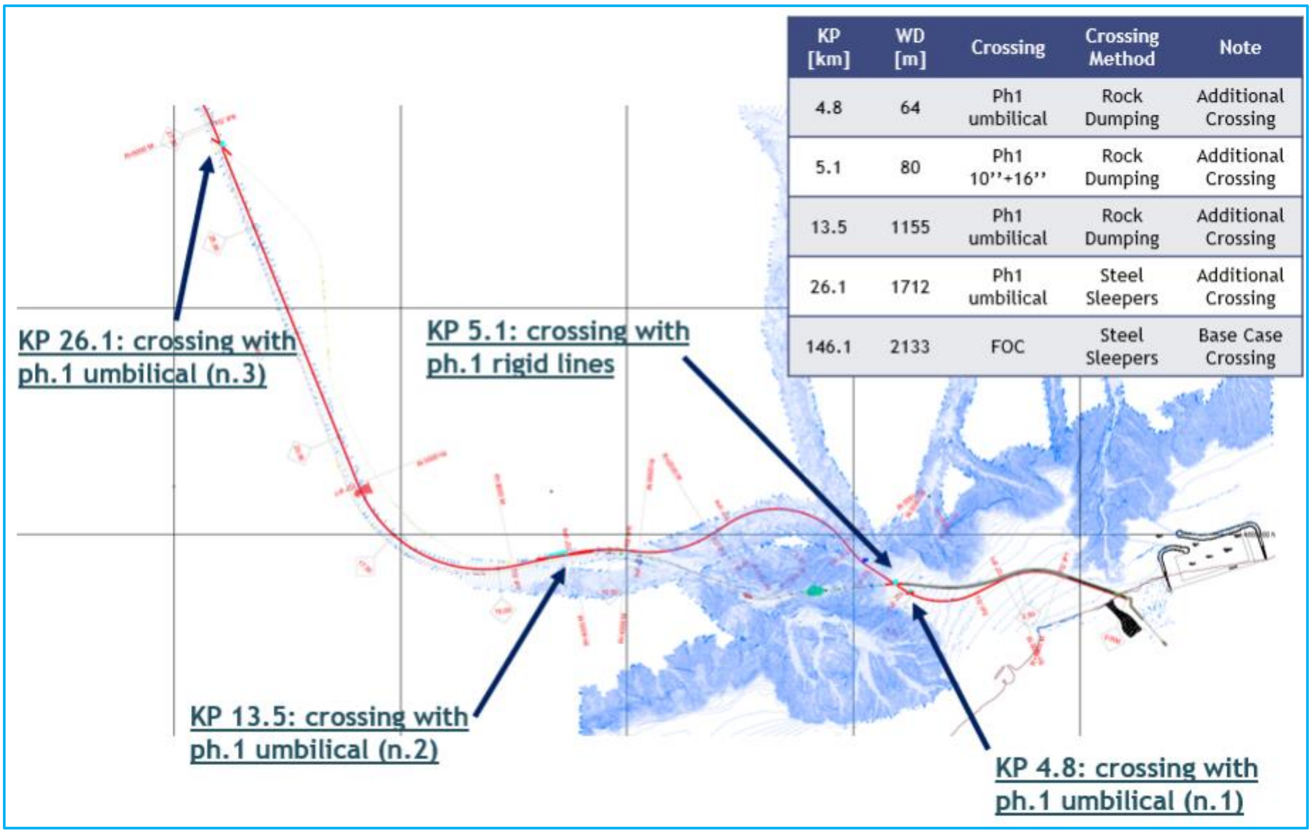
Free span correction was analysed for both of the route alternatives based on the on-bottom roughness methodology. This correction is required where local buckling or dynamic fatigue assessments on the natural seabed are deemed unacceptable. Seabed profile modifications can be implemented through two main methods, depending on local conditions, i.e., Pre/Post artificial supports such as rock dumping and pre/post-trenching interventions.

Based on the assessment:

- Detail Design for RA-2 is not available, however preliminary estimation show a lower unevenness with respect to RA-1 with potentially no intervention works required for free span mitigation.
- RA-1 presents more uncertainties on lateral slopes of rock berms on specific locations, that could have a significant impact in terms of volumes.

4.1.1.2.8 Crossings

Route alternatives were compared in terms of crossings over existing Phase 1 pipelines and other infrastructure. The only crossing required for RA-1 is the one with fibreoptic cable in deep water area. RA-2 requires four additional crossings with Phase 1 pipelines. The crossings' locations for RA-2 are shown in Figure 4-4.



KP [km]	WD [m]	Crossing	Crossing Method	Note
4.8	64	Ph1 umbilical	Rock Dumping	Additional Crossing
5.1	80	Ph1 10''+16''	Rock Dumping	Additional Crossing
13.5	1155	Ph1 umbilical	Rock Dumping	Additional Crossing
26.1	1712	Ph1 umbilical	Steel Sleepers	Additional Crossing
146.1	2133	FOC	Steel Sleepers	Base Case Crossing

Figure 4-4: Crossings Along RA-2

Based on the assessment:

- RA-2 requires 4 (four) additional crossings with Phase 1 pipelines, those are challenging due to reduced crossing angles.
- No additional crossings are required on RA-1.

4.1.1.2.9 Onshore Section

Route alternatives were also compared in terms of their constraints on the onshore section. The locations of both of the route alternatives are shown in Figure 4-5.

Based on the comparison:

- RA-2 is adding constraints on onshore construction as there is limited available space on the right of way.

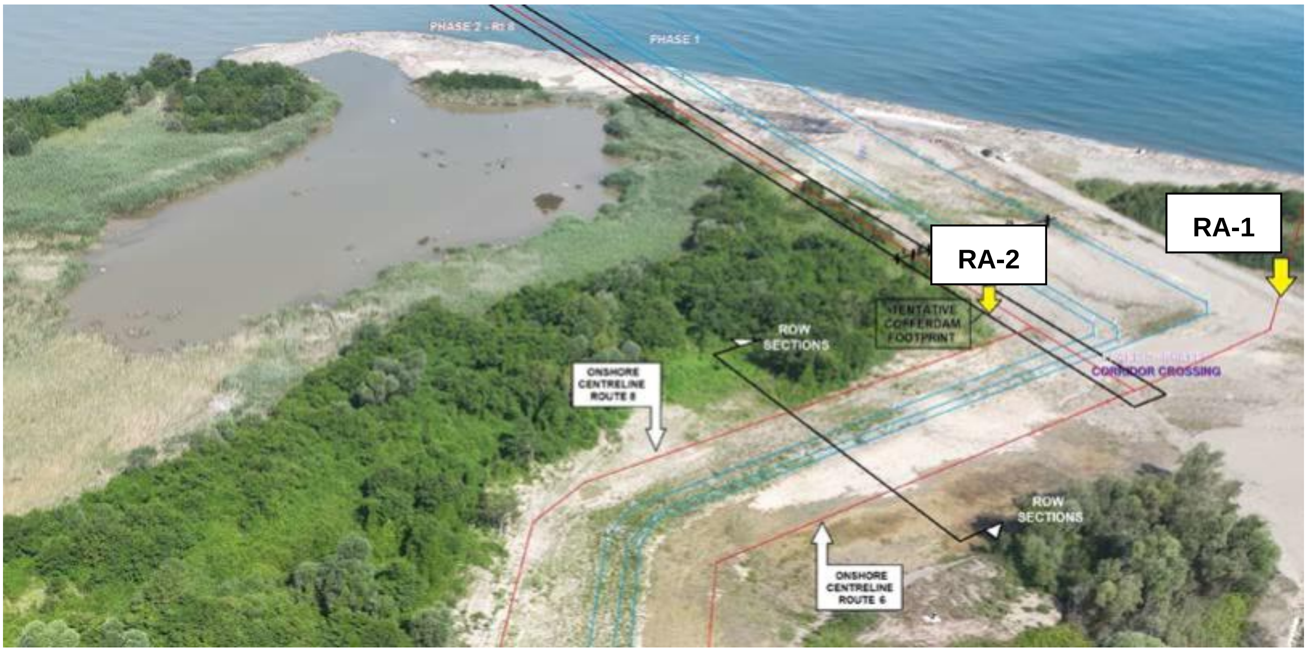


Figure 4-5: Onshore Sections of RA-1 and RA-2

4.1.1.3 Final Selection of Route

The main outcomings from previous sections are the followings:

- Routes have similar issues in terms of geohazards.
- Rock dumping pre and post lay are required on both routes.
- Excavation pre and post lay are required on both routes.
- RA-2 does not require lateral counteract but requires crossing preparation.
- RA-1 has more uncertainties on rock volumes due to stiff seabed and berm lateral slopes.
- The slopes on RA-1 are up to 30 degrees with a hard rock surface and feasibility of intervention with seabed excavation equipment is questionable due to risk of equipment instability on the slopes.
- RA-2 is considered favourable with respect to interaction with Filyos port and ship traffic, with no mitigation required.
- RA-2 has risks for interface with river.
- RA-2 has an additional shallow water scope not required on RA-1.

While RA-2 presents challenges related to river crossings and additional shallow water scope, these issues can be effectively addressed through careful planning, environmental safeguards, and community engagement. RA-2's favourable interaction with Filyos port and ship traffic, combined with its lower uncertainties in rock volumes and geohazard management, offers a more stable foundation for environmental protection and resources management and minimizes social impacts. Therefore, RA-2 is the preferable option for the SGFD Phase 2 export pipeline.

4.1.2 FPU

The position of the Floating Production Unit (FPU) has been selected within the Sakarya Gas Field, as illustrated in Figure 4-6. This location was chosen based on several key considerations:

- **Location Within Sakarya Gas Field:** Positioning the FPU within the Sakarya Gas Field minimizes operational complexity. This choice ensures that the infrastructure aligns with the development phases, reducing logistical and technical challenges associated with connecting to wells at distant or less accessible locations.
- **Proximity to Phase 2 Wells:** The selected position is strategically located to ensure efficient connectivity with the wells to be opened as part of the Project (most of the wells are already opened). This proximity facilitates effective integration of the SPS and SURF, which are essential for transporting the wet gas from the seabed to the FPU.
- **Proximity to Existing Phase 1 Wells:** The Phase 2 development plans include installing infrastructure to control the Phase 1 subsea production system via a new umbilical extending from the FPU to a suitable tie-in location within the Phase 1 subsea controls infrastructure. This new umbilical will enable communication between the FPU and the offshore processing facility (OPF) through an existing Phase 1 umbilical fibre optic cable. In the future, production from Phase 1 wells may be routed to the FPU, and/or the provision of monoethylene glycol (MEG) to the Phase 1 wells may be managed by the Phase 2 FPU. Additionally, the Phase 1 production flowline may be utilized as an export line from the FPU to the OPF. Thus, the proximity to existing Phase 1 wells and seabed infrastructure was a significant factor in selecting the FPU location.
- **Economic Efficiency:** The chosen location for the FPU reduces the length of subsea infrastructure required, leading to cost savings in construction, maintenance, and operations. Shorter pipelines and fewer subsea systems are needed compared to alternative sites that would require more extensive infrastructure.

In summary, the selected position of the FPU within the Sakarya Gas Field provides the most efficient, cost-effective, and operationally feasible solution for the SGFD Phase 2 Project. Its proximity to both existing and future wells, combined with its alignment with the project's operational and economic objectives, justifies this location. Consequently, no alternative sites outside the projected area of the gas field were considered for the FPU.

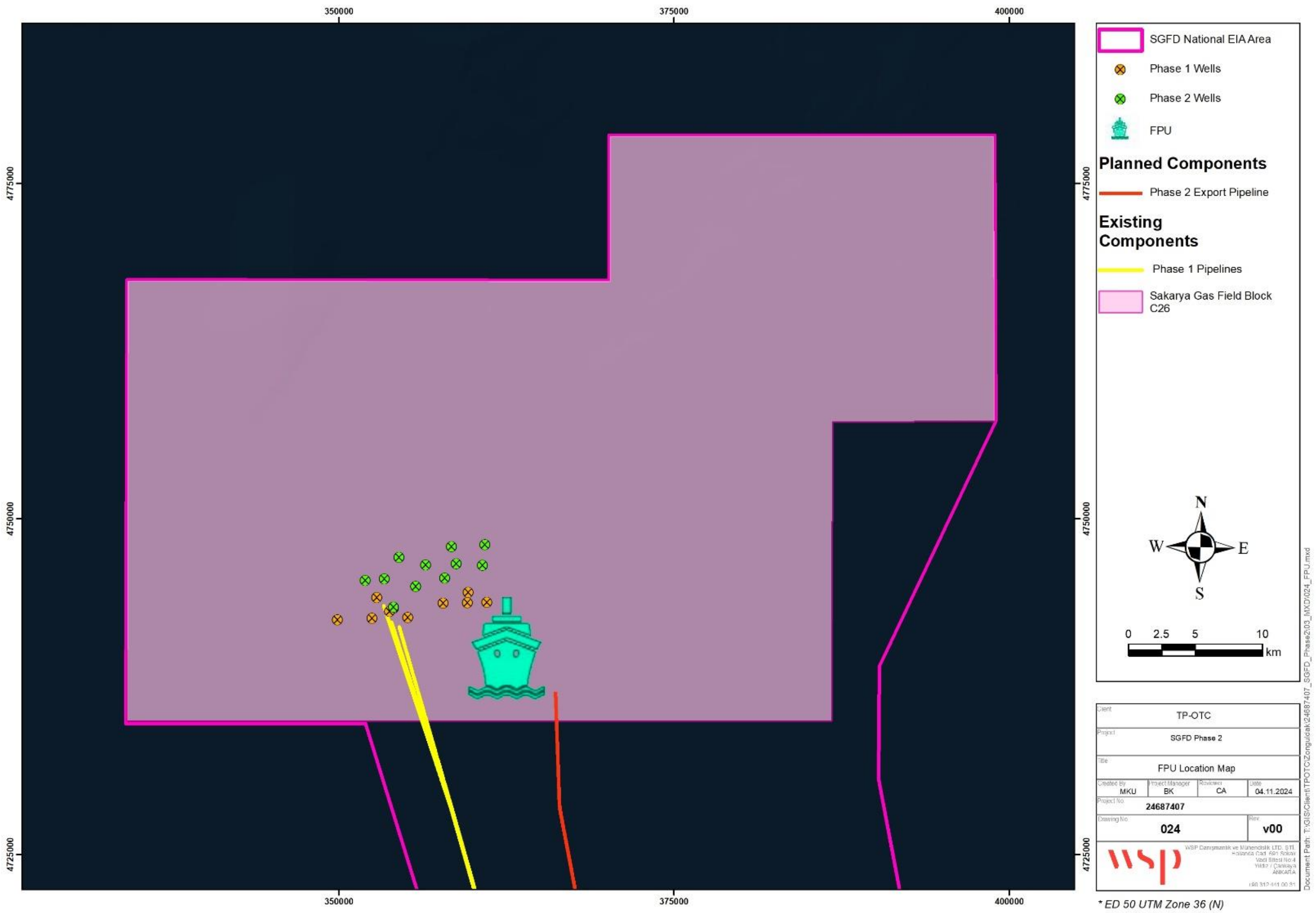


Figure 4-6: Selected Location of FPU

4.1.3 Onshore Facilities

The site alternatives for the onshore facilities were assessed in the SGFD Phase 1 ESIA, which concluded that the Filyos site was optimal due to its proximity to the Sakarya Gas Field, logistical advantages, minimal environmental impact, and reduced construction and operational costs. Since the onshore facilities are already constructed and operational, further assessment of site alternatives for the onshore facilities in this Phase 2 ESIA Report was not deemed necessary.

4.2 Design Alternatives

4.2.1 Technology Selection

This section discusses the various technologies that have been considered for use in the Project that may result in environmental and social impacts.

4.2.1.1 FPU

In evaluating options for gas processing in Phase 2 of the SGFD, the decision was made to utilize a Floating Production Unit (FPU) rather than expanding the capacity of the existing Onshore Processing Facility (OPF) constructed in Phase 1. While the OPF at Filyos base has sufficient space to expand and process the additional gas from the new wells, the FPU offers a more advantageous alternative compared to a tie-back to the Filyos shore. This approach reduces back-pressure and enhances reservoir recovery.

The choice of the FPU is primarily driven by its ability to enhance production efficiency and recovery rates. One of the significant advantages of the FPU is its capability to reduce downhole abandonment pressures to lower levels. FPU contributes to a higher gas recovery factor in the field, maximizing the extraction of hydrocarbons and optimizing overall field production.

An essential operational benefit of the FPU is its ability to separate water on-site. This feature eliminates the need to pump produced water 170 kilometres to shore, significantly reducing logistical challenges and operational costs. Additionally, the FPU reduces the length of the MEG and umbilical lines needed, further minimizing construction and maintenance requirements. This not only reduces logistical and operational costs but also mitigates environmental impacts associated with long-distance water transport. Shorter pipelines also decrease the energy consumption associated with pumping, leading to lower greenhouse gas (GHG) emissions during operations. By processing the gas offshore, the Project avoids the environmental risks linked to extensive pipeline networks and reduces the likelihood of spills or leaks that can occur during transportation. Furthermore, the reduction in infrastructure needs not only minimizes physical disturbances to marine and coastal ecosystems but also aligns with sustainability goals by lowering overall emissions associated with construction and operation.

The FPU's proximity to existing Phase 1 subsea infrastructure is another critical consideration. This close location reduces future complexities related to integrating Phase 1 wells with the Phase 2 infrastructure and the FPU, streamlining operations and minimizing the need for additional installations.

4.2.1.2 FPU Components

4.2.1.2.1 Flare

No continuous production flaring has been adopted as part of the development and flaring will be in place for emergency, safety and operational upsets only. The flare location in FPU is upwind of process units and has been selected considering local meteorological conditions and thermal radiation footprints based on the release rates, composition, tip types, etc. This approach follows the industry good engineering practice for facility siting and layout and reduces the potential risks to As-Low-As-Reasonably-Practicable (ALARP) levels.

Although there are several technology alternatives for the flare system, demountable vertical flare system was selected for the following advantages:

- Space efficiency: The vertical flare system requires minimal deck space, which is crucial in the constrained layout of an FPU.
- Less interaction with process units: By positioning the flare vertically and away from key operations, it minimizes interference with sensitive process equipment.
- Dual low-pressure (LP) and high-pressure (HP) systems: The flare system is equipped to handle both LP and HP flaring needs, providing flexibility in managing various operational scenarios.
- Operational ease and maintenance: The demountable design allows for easier maintenance and inspection without significant disruption to ongoing operations.
- Enhanced safety: The vertical configuration aids in dispersing heat and emissions away from critical areas, improving overall safety.

Flare Gas Recovery (FGR) was not chosen due to the intermittent nature of the flare.

4.2.1.2.2 Power Generation

The primary source of power generation on the FPU will be the natural gas extracted from the field itself. This gas will fuel a high-pressure fuel gas system connected to a steam boiler, which will generate steam to drive a steam turbine generator, producing the necessary power for the FPU's operations. In addition to the main power generation system, emergency diesel generators will be installed as a backup source to ensure continued power supply in case of any operational issues with the main system.

Using natural gas as the primary fuel for power generation offers several advantages compared to alternative fuels such as diesel. First and foremost, the natural gas is already being extracted during the production process, eliminating the need for transporting additional fuel to the offshore facility. If diesel were used, it would require continuous transport and storage, which not only increases operational costs but also presents logistical challenges and environmental accident risk (i.e. leakages and/or spills). Additionally, natural gas combustion produces lower emissions compared to diesel, contributing to a cleaner energy solution with reduced environmental impacts. The lower greenhouse gas emissions and reduced particulate matter from burning natural gas make it a more sustainable choice, aligning with industry best practices and regulatory requirements for minimizing environmental impacts.

The selected power generation system, comprising a steam boiler and steam turbine generator, further enhances efficiency. The steam boiler converts the thermal energy from the combustion of natural gas into steam, which then drives the steam turbine to generate electricity. This system not only optimizes energy use but also improves thermal efficiency, making it a highly effective method for power generation. Steam turbines are well-suited to large-scale, continuous operations like those on an FPU, providing stable power output with fewer mechanical issues compared to alternatives. The system's ability to utilize waste heat recovery also reduces fuel consumption, contributing to lower operational costs and a more environmentally responsible approach especially in terms of emissions and climate effects.

4.2.1.2.3 Disposal of Hydrotest Water

Pre-commissioning activities of the SPS, SURF and export pipeline involves flooding, cleaning, gauging and hydrotesting activities with filtered seawater with the addition of corrosion inhibitors, oxygen scavengers, biocides, dyes and MEG to verify equipment and pipeline integrity. Chemical additives (RX 5255 and RX 5102 D) were selected for their sustainability (no bioaccumulation, high level of dilution) and effectiveness (2-3 years long term preservation). Chemicals are ranked as gold (least hazardous) according to Cefas (The Centre for Environment, Fisheries and Aquaculture Science, UK) ranking based on the physical, chemical and ecotoxicological properties of products. Discharge of the used hydrotest water to deep sea at water depth of 2,200 m was planned since injection into a disposal well option is not available due to the same reasons explained in the above sub-section.

For the pre-commissioning activities of onshore section of the export pipeline potable water will be used and chemical additives will not be included. Therefore, it was decided on discharging resulting wastewater to Filyos river in case discharge standards are complied. If the discharge does not comply with the standards, the option of transporting it to licensed wastewater treatment plants with vacuum trucks is also being considered.

4.2.1.2.4 Heating Medium

For the heating medium system on the FPU, steam has been selected as the preferred heating medium due to its favourable economic, environmental, and safety performance. The system is designed to meet a total heating duty of 62 MW, with a flow rate of 1,609 m³/h, and incorporates a 10% margin to account for any unforeseen fluctuations in demand.

The heating medium system will operate in a closed circuit, providing heat to the topside units, particularly the inlet heater and the MEG package. The primary heat source for the system will come from two sources: Waste Heat Recovery Units (WHRUs) and steam/heating medium exchangers. The WHRUs are installed on each of the gas turbine drivers for the compressors and are capable of extracting up to 15.4 MW of heat from the gas turbine exhaust gas. This innovative approach minimizes the need for additional fuel gas, enhancing the system's energy efficiency while being environmentally friendly by avoiding extra emissions and reducing its climate impact. The steam/heating medium exchangers, rated for 20.6 MW each, will provide supplementary heat as needed, particularly when the WHRUs are not in service or during start-up operations.

The decision to use steam-based heating is based on several advantages. Steam has a high heat release potential per unit, resulting in reduced fuel gas consumption and associated emissions compared to alternative heating mediums such as thermal oils. Steam is also readily available on the FPU and presents a lower environmental and safety risk in the event of an accidental release. Thermal oils, in contrast, would require additional storage, handling, and safety measures, increasing operational complexity.

The design of the heating medium system also incorporates several efficiency-enhancing features. Waste Heat Recovery Units will ensure that maximum heat is extracted from the gas turbine exhaust, minimizing fuel use. In addition, an air preheater has been incorporated to further improve the system's thermal efficiency, increasing energy efficiency to ≥95%. To further minimize heat losses, the system will be fully insulated, and ball valves will be used for condensate drains to reduce potential leaks.

4.2.1.2.5 Cooling System

The cooling system on the FPU will utilize seawater as the primary source for cooling the cooling medium. Seawater will be drawn from the surrounding environment and used to regulate the temperature of the cooling medium, which will then be circulated throughout the FPU's process units. This closed-circuit system ensures efficient heat exchange while minimizing environmental impact by keeping the seawater and process fluids separate.

The primary function of the cooling medium system is to provide consistent topside cooling for the various critical units on the FPU. The main consumers of the cooling medium include the gas compression coolers, the lean MEG (monoethylene glycol) cooler, and the MEG regeneration condensers. By maintaining optimal operating temperatures for these units, the cooling system ensures stable and efficient operations, reducing the risk of overheating and associated operational disruptions.

The use of seawater as the primary cooling source offers significant advantages over an air-cooling system. Seawater provides a much more consistent and efficient cooling medium due to its higher heat capacity, which enables greater thermal exchange and allows for more effective heat dissipation. In contrast, air cooling systems require larger surface areas and more complex infrastructure, which can increase space requirements on the FPU. Moreover, air cooling is less effective in marine environments where ambient air temperatures can fluctuate, potentially reducing cooling efficiency. Seawater cooling, on the other hand, leverages the vast and stable thermal reservoir of the surrounding sea, minimizing the need for additional energy consumption and lowering operational costs. Additionally, air cooling systems would contribute to higher emissions and require substantial energy input to maintain operational efficiency, whereas seawater cooling is a passive, low-energy solution that aligns with the environmental goals of the project.

4.2.1.3 Technical Options for the Pipeline Construction

For the Phase 2 pipeline construction, the trenching method, which was successfully employed in Phase 1, will again be utilized. This approach involves trenching the pipeline route, including specific sections that require crossings under roads and other infrastructure. As in Phase 1, the pipeline will be routed through conduits and culverts where necessary, ensuring minimal disruption to existing infrastructure such as roads and railways.

As a result, the trenching method was chosen as the most practical and effective solution, with appropriate environmental restoration and offsetting measures planned to mitigate any impacts on sensitive areas such as dunes. The conclusions drawn from Phase 1 remain applicable to Phase 2, and the previously provided analysis in the SGFD Phase 1 ESIA remains relevant for this Project.

4.2.2 GHG Emissions

This AA follows the guidance of the Equator Principle 4 (EP4), which requires an account of the considerations the Project has taken to attain the best practicable environmental options to mitigate its contribution to climate change through reduction on GHG emissions. Notably, EP4 describes the oil and gas sector, which the Project falls within, as a ‘high carbon intensity’ sector. In accordance with EP4s high carbon intensity sector AA guidance, the Project is required to consider alternative fuel or energy sources and viable technology that is used in the same industry or region with energy efficiency and GHG efficiency of the various technologies. The below sections outline the following information:

- main sources of GHG emissions of the Project;
- comparison of the Project GHG Emissions within the context of sector, national and global emissions;
- a summary of the best practicable environmental options for the natural gas processing; and
- alternative options that were considered and justification of the selected processes.

4.2.2.1 Summary of Project's GHG Emissions

EP4 requires projects to calculate Scope 1 and Scope 2 emissions. The scope 1 emissions at the Project site during the operation phase are from stationary combustion, mobile combustion (from offshore transportation), and fugitive emissions. Project emissions from these sources are summarized in Table 4-1.

Table 4-1: Project Emission Sources

Source of Emissions	Calculated GHG (as t CO_2e/y)			Total GHG amount	
	t CO_2/y	t CH_4/y	t N_2O/y	t CO_2e/year	Percentage (%)
Stationary Sources (Boilers and Gas Turbines) - Combustion of Fuel Gas	352,872.6	157.3	187.4	353,217.3	93.8
Stationary Sources (Flare) - Combustion of Fuel Gas	11,347.5	5.1	6.0	11,358.5	3.0
Stationary Sources (Generators and fire water pumps) - Combustion of Diesel Oil	69			69	0.02
Mobile Sources (Helicopter Operations) – Combustion of JET A1	622.3	0.1	5.2	627.6	0.2
Mobile Sources (Marine Vessel) – Combustion of MGO	5,678.0	13.4	45.7	5.737.1	1.5
Fugitive Emissions of VOC	-	6,089.65	-	6,089.65	1.6
TOTAL				376,471.5	100.00

4.2.2.2 Alternative Considered and Best Practicable Options Selected

The information in this section is resultant of a meeting with the design team of TP-OTC and provided information request documents to understand the consideration taken in reducing GHG emissions. This alternatives analysis is discussed in terms of GHG reductions, other environmental benefits, and feasibility of each alternative option. Only alternatives in the highest emitting Project sources are discussed below.

Table 4-2: Alternatives Considered and Justification of Selected Processes

Source of Emissions	Selected Processes	Alternatives Considered	Associated GHG Emissions for Selected Process	Other Environmental Considerations for Selected Process	Other Factors
Upset and Maintenance Emissions	Non- continuous flaring for upset situations only. HP/LP Vertical flare tower	Ground flare, enclosed type LP/LLP flare Flare Gas Recovery	Flaring is non-continuous and is only in place for operational upsets and emergency situations. The practice of non-continuous flaring causes less GHGs than continuous flaring practices, which contributes to lower overall emissions of the Project.	The vertical flare disperses combustion gases higher into the atmosphere, improving the dispersion of pollutants such as carbon monoxide (CO) and nitrogen oxides (NOx), thus reducing ground-level air quality impacts.	**Ground Flare, Enclosed type LP/LLP Flare** This alternative requires larger spaces and is not suitable for the constrained FPU layout. **Flare Gas Recovery** This practice was not chosen because the flare is not continuous and is only in place for emergency situations. **Vertical Flare Tower** This alternative was chosen as a stand-alone alternative since it requires minimal deck space, crucial for the constrained layout of an FPU.
Power Generation	Gas turbine generators powered by natural gas extracted from the field.	Reciprocating gas engine generators Solar/wind power	Gas turbine emissions were shown to be significantly below the Industrial Air Pollution Control Regulation limits (IAPCR). Gas turbine generators have a continuous combustion process, which ensures more complete combustion, resulting in lower emissions of unburned hydrocarbons (UHCs) and carbon monoxide (CO) compared to reciprocating engines. Additionally, gas turbines can be equipped with advanced NOx control technologies, reducing nitrogen oxide emissions, a major contributor to air pollution. A renewable energy source such as solar and wind would result in less GHG emissions, however these have been deemed unsuitable (see last column).	Gas turbines are also highly suited for combined heat and power (CHP) applications, where waste heat can be captured and used for additional energy generation, increasing overall fuel efficiency and reducing emissions.	**Reciprocating Gas Engine Generators** Although having lower emissions, this alternative was not selected since it is less suitable for FPU design. **Solar/Wind Power** Solar and wind, often require substantial energy storage solutions to ensure a consistent power supply, due to their intermittent nature. These alternatives have been deemed unsuitable due to lack of land availability (for the units itself and the storage solutions) and the climatic parameters of the area that do not support solar or wind power generation. It is important to maintain a stable energy supply to meet demand, and gas engines can provide a more predictable and controllable energy output. **Gas Turbine Generator** This alternative is chosen due to its high efficiency in meeting the FPU design criteria. Gas turbine generators provide reliable and continuous power with shorter start-up times compared to reciprocating engines, ensuring minimal disruption during operational fluctuations. Additionally, gas turbines are well-suited for offshore environments, offering a more compact and lightweight solution, which is crucial for space-constrained platforms like an FPU. Their ability to integrate with waste heat recovery systems further enhances operational efficiency, making them an ideal choice for the FPU's power generation needs.
Process Emissions	Natural Gas fired steam boiler	Diesel-fired steam boilers	Stack gas emissions for natural gas fire steam boiler were found to be below Industrial Air	Natural gas boilers present fewer environmental risks and safety concerns in the event of a leak	**Diesel-Fired steam boilers**

Source of Emissions	Selected Processes	Alternatives Considered	Associated GHG Emissions for Selected Process	Other Environmental Considerations for Selected Process	Other Factors
			Pollution Control Regulation and the EHS General Guidelines limit values. Natural gas combustion produces fewer emissions compared to diesel, contributing to lower overall GHGs and a cleaner process.	and reduce the potential for fuel transport risks associated with diesel. Lower emissions especially PM and SO_2 compared to diesel-fired boiler option.	This alternative is not appropriate due to higher level of emissions, higher storage need, logistical complexity, and environmental risks of fuel transport. **Natural Gas Fired Steam Boiler** This alternative has been chosen as a heating medium due to the availability of natural gas from the field and both power and steam will be generated in the same process on FPU.
Process Emissions	General considerations: valve and flange regulations to reduce potential leakage Fugitive testing on control valves under ISO 15848 Permissible leak limit placed Best Isolation practices selected Best practices applied for piping (i.e. protective coating on pipeline)	N/A	N/A	N/A	N/A Fugitive emissions were assessed and were estimated to be low compared to the stationary combustion emissions. Hence, a detailed alternatives assessment is not required for fugitive emissions.
Emergency Equipment	Emergency diesel generator (EDG) Test Runs Fire water Pumps Test Runs	Due to safety concerns, these processes are required to be in place at the facility.	Periodic testing of the emergency equipment is required.	N/A	Despite relatively high emissions from these emergency measures, there are no suitable alternatives to mitigate these emissions.
Offshore Support Vessel Operations	Use of MGO-powered offshore support vessels for transportation, maintenance, and logistics support.	Electric or hybrid vessels LNG-powered vessels	Diesel-powered vessels contribute to GHG emissions and also NOx, and SOx. However, their emissions are managed within regulatory limits and periodic engine maintenance improves efficiency.	Support vessels follow best practices to minimize emissions, including route optimization, slow steaming, and regular engine maintenance. Oil spill prevention measures are also in place to reduce environmental risks.	Electric or hybrid vessels were not chosen due to high costs, limited availability, and the long operational range required. LNG-powered vessels were not selected due to logistical challenges of refuelling and limited offshore LNG bunkering infrastructure.

N/A = Alternatives not considered based on design considerations

4.2.2.3 Net Zero/GHG Abatement Plan

A net–zero plan/GHG abatement plan typically outlines how the facility (including proposed expansions where appropriate) is designed and operated in a way to reduce emissions, to provide support for emission reductions, and to manage emissions in accordance with corporate/regulatory GHG reduction targets. In Türkiye, recent, unprecedented, climactic events such as the 2021 forest fire season, and Türkiye's high climate vulnerability, make climate change mitigation and adaptation a national priority (World Bank 2022). Türkiye has ambitiously committed to being net-zero by 2053, which was a decision that was resultant of Türkiye ratifying the Paris agreement in October of 2021 (World Bank 2022). New institutional arrangements have been established in Türkiye to assist in achieving the net-zero target including an updated National Climate Change Action Plan and Republic of Türkiye Ministry of Environment, Urbanisation and Climate Change (MoEUCC) (World Bank 2022). Due to Türkiye's national commitments of net-zero operations, the project will comply with these commitments as Türkiye moves towards its net-zero goals though a net-zero/GHG abatement plan.

Türkiye's national plan will require a shift in major sectors towards energy efficiency, electrification, and renewable energy as well as practices that maximize carbon sequestration from forest landscapes (World Bank 2022). Energy efficiency practices in the proposed project aligns with the national plan to achieve net zero by 2053, and as Türkiye moves towards this goal, the project may adapt to create higher GHG emission reductions.

4.3 No Project Alternative

The 'No Project' alternative is the situation where the Project, does not proceed. Under this scenario, there would not be any impacts on the environment, and the beneficial socio-economic outcomes of the Project would not happen.

However, the need for the Project is driven by Türkiye's rapidly increasing natural gas demand and shortages due to political and technical reasons; further details are provided in Chapter 3.3. If the Project does not proceed, the goal of reducing dependency on imports of natural gas and meeting the increasing demand without any shortages accordingly would not be realized. Consequently, the economic benefit to local and national stakeholders, as well as the energy security it would bring, would not be realised. On this basis, the 'No Project' option was rejected.