Prospects of LNG Markets in the Eastern Partner Countries

Final Report
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Stantec

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LIST OF ACRONYMS

ADR	Accord européen relatif au transport international des marchandises Dangereuses par Route
bcm	Billion Cubic Meters
BELAZ	Belarusian Automobile Plant
CBA	Cost Benefit Analysis
CHP	Combined heat and Power
CNG	Compressed Natural Gas
DG	Directorate-General
EaP	Eastern Partnership
EC	European Commission
EU	European Union
FSRU	Floating Storage Regasification Unit
FWC	Framework Contract
GHG	Green House Gas
GIPL	Gas Interconnection Poland–Lithuania
GOGC	Georgian Oil and Gas Corporation
HFO	Heavy Fuel Oil
IMO	International Maritime Organization
IP	Interconnection Point
JSC	Joint-Stock Company
KE	Key Expert
L-CNG	Liquified-to-Compressed Natural Gas
LLC	Limited Liability Company
LNG	Liquified Natural Gas
LPG	Liquified Petroleum Gas
MAZ	Minsk Automobile Plant
Mcm	Million Cubic Meters
MGO	Marine Gas Oil
PSO	Public Service Obligation
SCP	South Caucasus Pipeline
SCPX	South Caucasus Pipeline Extension
SOCAR	State Oil Company of Azerbaijan Republic
SSO	Storage System Operator

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TL	Team Leader
TSO	Transmission System Operator
TYNDP	Ten Year Network Development Plan
UGS	Underground Gas Storage
UTG	Ukrtransgaz

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1 Introduction and Purpose of the Study

The overall objective of the Study is to further develop the co-operation and integration between the Eastern Partner Countries and the EU in assessing and developing the potential of LNG in the gas markets of the region. Specific objectives of the Study are to:

- Assess current situation in Eastern Partners' gas markets and identify barriers for LNG;
- Formulate recommendations for development of LNG markets country-by-country and for the region as a whole;
- Strengthening awareness of gas stakeholders in Eastern Partner countries on technical, market, and regulatory aspects of LNG, and particularly the use of LNG in the EU;
- Identify specific actions to enhance trading, promote new infrastructure, improve market functioning and competition, fostering cooperation within the Eastern Partnership region;
- Further EU's Energy Dialogue with the Eastern Partner countries in the area of LNG.

The present document is a short version of the Final Report of the Study. The reader should refer to the full version of the Final Report[1] for more details on the analysis carried out by the Consultant, the assumptions and benchmarks used and the findings of the Study.

It is noted that the analysis carried out within the Study is based on high-level cost estimations using assumptions and benchmarks, as well as any available data at the country level. Thus, the analysis is considered preliminary, and the results and conclusions are not meant to be definitive but to highlight the LNG market development options that merit further consideration and detailed analysis by the Eastern Partner countries to assess in full their viability and to formulate their policies accordingly.

It is further noted that the LNG industry is undergoing significant challenges related to methane emissions. Although natural gas is considered to be a 'cleaner' fuel in terms of CO2 emissions compared to oil and coal, methane emissions throughout the gas supply chain caused by leakages, releases of gas and flaring of gas, are considerable. Methane emissions from the LNG supply chain could be higher than natural gas, in case there are inefficiencies of treatment of 'boil-off gas' during the LNG liquefaction, transport and storage processes. Additionally, emissions of unburnt methane (known as the 'methane slip') occur during LNG end-use as fuel (LNG powered ships and trucks). The challenges faced by the LNG industry to reduce methane emissions, and the relevant dilemmas facing policy makers regarding the environmental standing of LNG vis-à-vis other fuels, are outside the scope of this study.

[1] Available at: https://ec.europa.eu/energy/en/topics/international-cooperation/key-partner-countries-and-regions/neighbourhood-east/meetings-eastern-partnership

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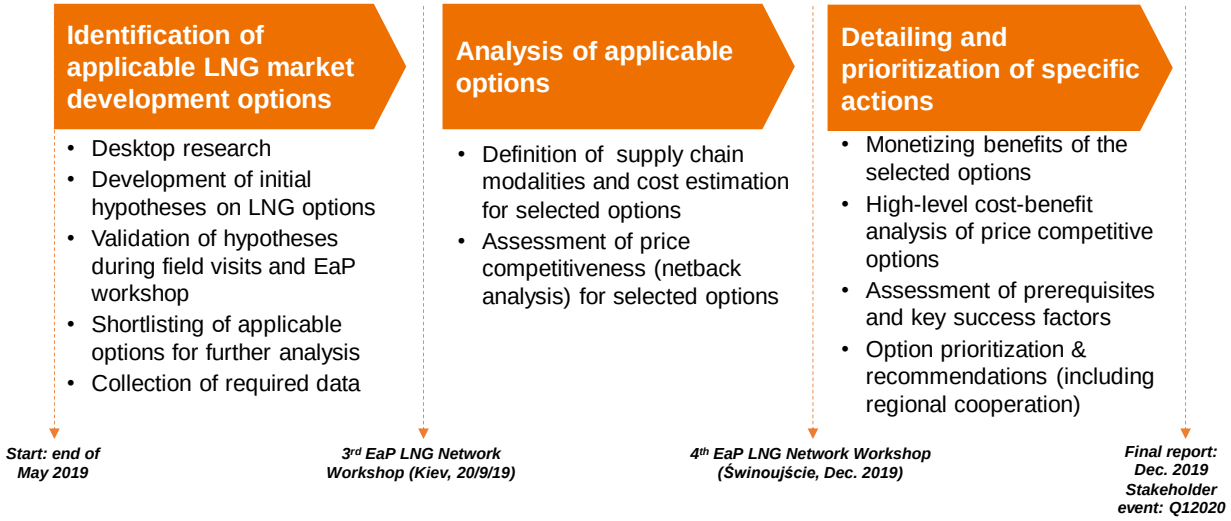
2 Methodological Approach

2.1 Overview of methodological approach

The overview of the approach in implementing the Study is shown in Figure 1 below.

Figure 1 Overview of methodological approach



2.2 Identification of applicable options for LNG market development per country

The first step of the Study involved the identification of potentially applicable options for LNG market development for each Eastern Partner country, based on characteristics and market conditions relevant to each country.

The identification of potentially applicable options required research into Eastern Partner countries, and particularly their gas and energy markets. Field visits were also undertaken to all Eastern Partner countries from June to September 2019, to discuss with key stakeholders in each country the current situation and prospects for developing markets for LNG, their policies and interests, and barriers and prerequisites for LNG market development, and importantly, to reach a consensus with the key stakeholders in each Eastern Partner Country on the LNG options deemed potentially applicable for them that merit further analysis. During the field visits, the Consultants presented information to enhance gas stakeholders' awareness on EU LNG strategy, market development, demand, supply, prices and key infrastructure, operational modalities of LNG terminals and 'virtual' gas pipelines involving LNG.

Applicable LNG options are grouped under two broad categories, those enabling **gas-to-gas competition** and those enabling **gas-to-other fuels competition**. Gas-to-gas competition occurs when (regasified) LNG competes against natural (piped) gas for customers that are connected to the gas transmission system. In gas-to-other fuels competition, LNG competes with other fuels (diesel, MGO, HFO etc.) for customers that do not currently use gas and are not

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connected to the gas network. Depending on the end-use, LNG may be used by customers in liquid form (e.g. as fuel for trucks) or regasified and used in gaseous form (e.g. by off-grid consumers). The Table below summarises the main LNG development options under each of the two cases, and discusses the alternative supply modalities under each option[2].

Table 1: LNG Market Development Options under Gas-to-Gas and Gas-to-Other Fuels Competition

Competition Case	Options for introducing LNG to the market	Main Uses of LNG	LNG Benefits
Gas-to-gas competition	• Pipelines (receiving gas of LNG origin) • LNG receiving Terminal with regasification facility • LNG trucks and trains supplying LNG to existing natural gas grid-connected customers) • Swaps (pipeline gas for LNG)	• LNG is regasified and transported for final consumption	• Gas price reduction • Security of supply benefits (mitigating impact of disruption as a result of supplier/route diversification)
Gas-to-other fuels competition	• LNG receiving Terminal with bunkering and lorry loading facilities • LNG trucks and trains (supplying LNG to new off-grid customers) • Small Scale Liquefaction Facilities (liquification of piped gas and supply to customers via LNG trucks	• Trucks that use LNG as fuel • Ships that use LNG as fuel • Agriculture and Mining customers that use LNG to generate power for processes (lighting, drying, sorting etc.) and for moving equipment (tractors, harvesters, graders etc.) • Off-grid industrial customers, large commercial customers, sizeable gas distribution systems that can use LNG to feed their systems (regasification of LNG is required) • Old distribution systems ('virtual' gas pipeline using LNG instead of investing in replacement gas pipelines) • Remote gas production fields not connected to the gas network • Peak shaving LNG plant (combining liquefaction, storage and regasification)	• Energy cost reduction (substitution of other fuels by less costly LNG) • Environmental benefits (differential in greenhouse gas emissions by using gas as opposed to other fuels)

[2] The list of LNG market development options included in the Table is not exhaustive. Other options, such as the use of LNG as engine fuel for municipal vehicles, were not identified during field visits, and thus were not analysed further in this Study.

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2.3 Analysis of applicable options for LNG market development per country

The second step involved the analysis of price competitiveness of the applicable LNG market development options for each country, using Netback Analysis, with the objective of identifying the options that are deemed economically viable. The Netback Analyses carried out are high-level, using proxies of actual costs and based on international benchmarks and assumptions. In cases where market demand data were not available and netback analysis could not be reasonably performed, the analysis focused on identifying the 'breakeven' demand in the Eastern Partner country that could render the option viable under assumed price and cost conditions throughout the supply chain relevant to the option.

The results of the Netback Analysis, as well as the underlying assumptions were included in the November 2019 Interim report of the Study that was shared with Easter Partner countries for views and comments. Feedback and additional information provided by the Eastern Partner countries, as well as during the fourth Eastern Partnership LNG Gas Network Workshop in Świnoujście in December 2019 were taken into account in the Final Report.

It is noted that the netback analyses carried out in the study are high-level, using proxies of actual costs and based on international benchmarks and assumptions. All calculations have been made using latest available data concerning market prices, consumption levels and LNG supply costs. Sensitivity analysis has been used to assess the robustness of the results in fluctuations of key parameters. Dynamic supply-demand conditions were not examined, and contextualization of infrastructure costs and other parameters was limited by the available data.

2.4 Detailing and prioritization of specific actions

In the third step of the Study a high-level Cost Benefit analysis was undertaken, for selected LNG options, to assess additional benefits accruing to economy and society. This CBA was carried out for all potentially applicable gas-to-gas competition LNG market development options in each Eastern Partner country, and for those gas-to-other fuels competition options deemed to be economically viable in each Eastern Partner country.

Furthermore, the Consultants analyzed and highlighted all key prerequisites and success factors for the implementation of viable LNG options, and formulated proposals for the prioritization of economically viable options in each country, and actions that could be taken by policy makers in each country to foster development of the selected options.

Regional perspectives for LNG market development are also included in the Final Report, together with regional and sub-regional policy initiatives and joint EU-Eastern Partners countries actions that could be undertaken.

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3 LNG Market Prospects in Armenia

3.1 Identification of applicable LNG market development options

Key findings related to the development of LNG markets in Armenia are as follows:

- Gas-to-gas competition from LNG seems to be a non-applicable, or at best a very weak case, for Armenia. This is due to lack of proximity to LNG sources, from which LNG can be transported to the country at reasonable cost, and the monopoly on gas imports for wholesale and retail supply held by Gazprom Armenia.
- LNG could be considered for security of supply purposes (i.e. import LNG, regasify and store it for emergency use) but this is an expensive option compared to others e.g. storing natural gas in existing UGS facilities at Abovyan.
- On the other hand, Armenia appears to have potential for use of LNG as road transport fuel. Armenia has a sizable fleet of trucks involved in local, regional and international transport (over 65,500 trucks), the majority of which (65%) are fuelled by petrol and secondarily by diesel (34%), and which include a number of long haul trucks that are involved in the transport of goods regionally or internationally over distances exceeding 1,500 kms per journey. Provided a sufficient number of these trucks can be induced to switch to LNG, there could be a potential market.
- Notably, Armenia has one of the largest networks of CNG filling stations in the region. There are 380 CNG filling stations in the country, with 0.6 bcm annual sales of CNG. 85% of passenger vehicles are fuelled by CNG in Armenia, the rest by diesel. Most CNG filling stations are quite old and need of modernization, and could be converted to use LNG as well (L-CNG).
- The familiarity of consumers with using CNG, the existence of filling stations and the availability of technology for their conversion to use LNG, provide advantages to developing a market for LNG for trucks, provided LNG is competitive in price to diesel.
- LNG can be supplied in the country by establishing a small scale liquefaction facility to convert piped gas into LNG; Gazprom Armenia is interested in invest in such a facility, provided there is a potential market for LNG for use in transport, and private investment takes place in required supporting infrastructure (transporting LNG to filling stations, filling stations, storage etc.). Alternatively, LNG can be sourced from Georgia, in case an LNG receiving terminal or a liquefaction terminal with truck loading facility is built there or sourced from Russia by trucks.
- Use of LNG virtual pipelines to supply off-grid consumers or distribution systems is not an applicable option for Armenia, as around 95% of the country is already gasified.

Based on the above, the only applicable LNG market development option for Armenia is the use of LNG as engine fuel for long-haul trucks.

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3.2 Analysis of applicable option for LNG market development

The option of using LNG as engine fuel for trucks can be viable provided the LNG price at the filling station is competitive to that of diesel, taking into consideration the efficiency gains of LNG engines, as well as all costs associated with the LNG supply chain. The available information on Armenia's traffic of long-haul trucks (local and transit) is not sufficiently detailed to allow estimation of the market size of LNG as fuel for trucks. For this reason, instead of performing netback analysis, the 'breakeven' (or minimum) LNG market size (number of LNG-fuelled trucks and annual LNG volumes consumed) required for the option to be economically viable was estimated, under assumed supply chain cost conditions.

The analysis showed that, in case LNG is sourced from a receiving terminal in Georgia, LNG can be competitive to diesel provided at least around 130 LNG trucks operate in the Armenian market. LNG supply from a mini liquefaction terminal in Armenia, would be a more expensive solution, necessitating a 'breakeven' number of around 340 LNG-fuelled trucks for the option to be competitive. Considering that Armenia has a sizable fleet of trucks involved in local, regional and international transport, it appears that the required 'breakeven' market size of truck numbers is feasible to attain, and a market for LNG in road transport could potentially develop.

Economic analysis was also performed for the identified minimum required LNG market, to estimate the extent to which economic benefits for using LNG as engine fuel (energy cost reduction for end consumers, impact on GHG emissions) outweigh the costs for developing the option. The analysis shows that the reduction of GHG emissions has a positive impact.

3.3 Priorities and policy directions

Decision for and implementation of an in-country supply chain for LNG in trucks using a mini liquefaction facility could be done in short-term horizon, as it only involves local actors, however the high investment costs in required infrastructure necessitate a large number of LNG fueled trucks for viability. In contrast, supplies of LNG from a receiving terminal in Georgia could considerably reduce costs, but would involve a longer-term horizon due to the nature of the investment, and the uncertainties surrounding the decisions of the involved external parties.

Given the benefits of reducing energy costs and GHG emissions, this option merits further investigation, to assess in detail its feasibility, and decide on the potential policies to be adopted, favoring the use of LNG. These policies could encompass, at the minimum, having a legal and regulatory framework conducive to the development of an LNG supply chain, and could expand to cover incentives for the use of LNG.

3.4 Proposed preparatory actions

The Table below describes the actions that are deemed important in order to evaluate and prepare the option of using LNG as engine fuel for trucks.

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Table 2: Proposed preparatory actions for the option of LNG-fueled trucks in Armenia

	Proposed Actions	Timing
Initial / Preparatory Actions		
1	Perform a feasibility study for use of LNG as engine fuel in Armenia (covering not only greenfield projects, but also retrofitting of existing CNG stations to L-CNG)	Immediate
2	Develop a national policy framework for the use of LNG in trucks, deciding on the role that the State wishes to undertake	Short-term / After the study is concluded (if it is positive and Armenia decides to pursue)
Implementation Actions		
3	Prepare the regulatory and legal framework (legal amendments, regulations, standards, permits and licenses, etc.) necessary for the development of the LNG supply chain	Short-term (based on national policy framework)
4	If the State undertakes a proactive role in developing infrastructure, prepare the incentive mechanisms to attract investments	Short-term (based on national policy framework)
5	Conduct awareness raising campaigns to attract end-users and investors' interest	Short-term (based on national policy framework)

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4 LNG Market Prospects in Azerbaijan

4.1 Identification of applicable LNG market development options

Key findings related to the development of LNG markets in Azerbaijan are as follows:

- Gas-to-gas competition from LNG is not applicable in Azerbaijan. This is due to the country being a major gas producer and exporter, but also due to lack of proximity to LNG sources from which LNG can be transported to the country at reasonable cost. There are discussions for establishing an LNG terminal in the Azeri part of the Black Sea to receive LNG from Kazahkstan, but this will basically involve Azerbaijan as a transit country as Kazakh LNG will be regasified and exported to other markets.
- Another potential option, that could involve LNG in gas-to-gas competition but in other countries, is the export of Azeri gas to a liquefaction terminal in Georgia, and the resulting LNG shipped to markets such as Ukraine, Moldova and Romania where it competes against piped gas supplies. Currently, all gas production in Azerbaijan available for export has already been contracted. However, new fields under development could potentially supply an export route to a liquefaction terminal in Georgia over the mid-term. The liquefaction terminal in Georgia could also be supplied with gas from Kazakhstan and Turkmenistan, in case an LNG receiving terminal is built at the Azeri Caspian Sea coast.
- Gas-to-other fuels competition from LNG is an applicable option in Azerbaijan for supply of off-grid areas. Although around 95% of the Azeri territory is already gasified, Government roadmap targets 100% gasification. Development of LNG virtual pipelines is one of the options being assessed as a means for supplying off-grid areas that currently consume other fuels.
- Gas-to-other fuels competition from LNG in the transport sector could also be an applicable option in Azerbaijan. Although transport fuels (e.g. diesel) are subsidised and development of a supply chain to supply LNG as fuel for trucks would not be financially attractive, given the environmental benefits of LNG use in transport, the Government is willing to consider supporting use of LNG in this respect. Azerbaijan has also the largest fleet active in the Caspian Sea, a new port in Baku is operational, and a new shipyard has been developed by SOCAR. Development of LNG as fuel for ships is of interest to Government, especially for environmental reasons.
- No prospects seem to exist for the use of LNG in agriculture or mining, as demand is limited, and potential consumers are already connected to the transmission system.

Based on the above analysis, the applicable LNG market development options for Azerbaijan, all of which concern gas-to-other fuels competition, are presented in Table 3. The only potential source of LNG supply is an in-country mini liquefaction facility connected to the Azeri transmission system.

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Table 3: Applicable options for LNG market development in Azerbaijan

Options for LNG market development		Sources of supply
Gas-to-Other Fuels Competition	LNG as engine fuel for long-haul trucks	In-country mini liquefaction facility
	LNG as engine fuel for ships operating in the Caspian Sea	
	LNG supplies to the remaining off-grid areas in Azerbaijan, to increase gasification	

4.2 Analysis of applicable options for LNG market development

4.2.1 Use of LNG as engine fuel for trucks

This option can be considered as potentially viable for Azerbaijan provided the price of LNG at the filling station is competitive to that of diesel, taking into consideration the efficiency gains of LNG engines, as well as all costs associated with the LNG supply chain. However, due to the very low current diesel price levels in Azerbaijan, LNG cannot effectively compete. Consequently, use of LNG as engine fuel for trucks does not seem to be a viable option for Azerbaijan. Nevertheless, the Azeri Government has indicated that it intends to explore this option further for environmental reasons, and potentially provide support.

4.2.2 Use of LNG as engine fuel for ships

LNG would have to compete with other options, such as the use of scrubbers or low sulphur fuel oil, for use in the existing fleet of ships operating in the Caspian Sea, provided Azerbaijan applies emission control rules (such as reduction of sulphur emissions). The retrofitting cost for ships to switch to LNG is higher than alternative solutions, and this has led LNG not to be the preferred option internationally. LNG can be more attractive in the case of new-builds, provided that the price differential between LNG and the existing bunkering fuels is sufficient to cover the additional cost of an LNG-fuelled ship, and that bunkering of LNG is possible at least in the Baku port. The attractiveness of LNG use as ship fuel differs for each individual case of ship, as it depends on a number of factors, including the vessel's size and type, age, service area, fuel used, refuelling pattern, prices of competing fuels, etc. For this reason, a case-by-case analysis would be required, to examine for which ships use of LNG would be competitive. Data on the Azerbaijan shipping sector, required to perform a contextualized analysis of this option, were not available.

4.2.3 Supply of LNG to off-grid distribution systems

In the absence of data on the off-grid areas in Azerbaijan that could be served by LNG, a contextualized analysis of this option was not undertaken.

4.3 Priorities and policy directions

The option of using LNG as truck fuels is not viable, on account of lack of competitiveness of LNG vis-à-vis diesel, but it does have environmental benefits; it is proposed that the Government should assess whether it should place priority on developing this option, on the basis of environmental policy considerations. In doing so, the Government should undertake initiatives to improve LNG relative price competitiveness vis-à-vis competing fuels.

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LNG use for supplying gas to off-grid remote areas, is an option that the Government could potentially apply to implement its national gasification strategy. In this case, the LNG supply chain costs would have to be compared against alternatives (CNG, piped gas) on a case-by-case basis.

The option of LNG use for ships could be explored further on the basis of the Government's environmental policy. In this respect, a case-by-case analysis of LNG application in different ship types operating in the Caspian Sea needs to be undertaken to ascertain feasibility, benefits and the ensuing priorities.

In case the Government decides to move ahead with the development of LNG options for environmental reasons, it should decide on the timing for each option. The option of using LNG for supplying gas to off-grid areas could be considered as a priority, on the basis of the ease and speed of implementation, as the supply chain can be developed by the State, without third parties involved. The development of LNG as engine fuel for trucks is a second priority, as it involves decisions by truck owners to retrofit as well as development of LNG filling stations. The option of introducing LNG in the shipping sector could be developed over a longer-term horizon, as it would require involvement and large investments from ship owners for a diverse number of vessels.

4.4 Proposed actions

The Table below describes the actions that are deemed important in order to evaluate and prepare the identified applicable LNG market development options.

Table 4: Proposed preparatory actions for developing the identified LNG options in Azerbaijan

	Proposed Actions	Timing
Initial / Preparatory Actions		
1	Perform feasibility studies for the use of LNG as engine fuel for trucks and ships, and for supply of off-grid areas. The studies should examine scenarios for either subsidizing LNG use or removal of cross-subsidies of other fuels, and relevant affordability studies.	Immediate
2	Develop a national policy framework for the use of LNG in road and water transport, deciding on the role that the State wishes to undertake	Short-term / After studies for the transport sector are concluded (if Azerbaijan decides to pursue)
3	Develop a programme for gasification of remote areas using LNG supplies	Short-term / After the relevant study is concluded (if Azerbaijan decides to pursue)
Implementation Actions		
4	Prepare the regulatory and legal framework (legal amendments, regulations, standards, permits and licenses, etc.) necessary for the development of the LNG supply chain	Short-term / based on national policy framework and gasification programme
5	If the State undertakes a proactive role in developing infrastructure, prepare the incentive mechanisms to attract investments	Short-term / based on national policy framework and gasification programme
6	Conduct awareness raising campaigns to attract end-users and investors' interest	Short-term / based on national policy framework and gasification programme
7	Undertake initiatives to catalyze interest and seek joint commitments of stakeholders (Socar, Baku port, ship owners) to develop the use of LNG in shipping	Short to medium-term / based on national policy framework

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5 LNG Market Prospects in Belarus

5.1 Identification of applicable LNG market development options

Key findings related to the development of LNG markets in Belarus are as follows:

- Gas-to-gas competition from LNG is not applicable in Belarus. Imports of gasified LNG through pipeline from Klaipeda and/or Świnoujście LNG terminals would require technical reverse flow of existing interconnections (Poland, Lithuania) and/or new interconnections. According to the stakeholders, no new interconnections are currently planned, and it is not feasible to introduce reverse flow from Lithuania and/or Poland. Moreover, several gas interconnections between Belarus and Ukraine are either decommissioned and/or unutilized. Importing LNG from EU, using trucks and/or trains and regasifying it to supply existing gas network customers, is technically feasible but there is no apparent demand. According to Beltopgaz, all major gas consumers are connected to either the distribution or the transmission system and these are not considered as potential customers for LNG, in competition with piped gas.
- Gas-to-other fuels competition from LNG could be applicable in Belarus for road and waterways transport. The country has a sizeable fleet of local and imported international long haulage trucks (over 12,000 in 2013), as well as diesel heavy tractors, that could be potentially converted to use LNG as fuel. Belarus is home to manufacturers of trucks and heavy work vehicles (MAZ, BELAZ), which have already launched pilot projects for LNG fuelled vehicles. The country has a number of waterways where passenger and cargo ships operate, and the Belarus Ministry of Transport and Communications is interested to assess this option. Gazprom Transgas Belarus is considering a small-scale liquefaction facility primarily for supplying LNG to filling stations. Nevertheless, Belarus Government policy is to favour electricity use, given that they expect cheap electricity to be produced from their Nuclear Power Plant planned to be commissioned soon, and concurrently the use of electricity in transport (road, rail and water) is of priority for the country, compared to development of other alternatives, such as LNG. The use of LNG in ships operating in waterways, would compete with other technologies, such as the use of electric propulsion systems and electric powered ships for Belorussian waterways, which is being examined by the Ministry of Transport and Communications (a relevant study was initiated in 2018).
- No significant prospects seem to exist in gas-to-other fuels competition for the supply of remote/off-grid customers. Gasification is high across the country; almost all consumers are gasified apart from households. CNG is extensively used in agricultural sector, where 50% of users are connected to the grid, and the national strategy is to promote biomass and peat for energy use.

Based on the above analysis, the applicable LNG market development options for Belarus concerns the use of LNG as engine fuel in trucks and potentially in waterways (Table 5). Potential sources of LNG supply can either be the EU LNG terminals close to Belarus (Świnoujście,

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Klaipeda) or development of an in-country mini liquefaction facility connected to the Belarusian transmission system.

Table 5: Applicable options for LNG market development in Belarus

Options for LNG market development		Sources of supply
Gas-to-Other Fuels Competition	LNG as engine fuel for long-haul trucks	• Truck loading in Świnoujście and/or Klaipeda terminals • In-country mini liquefaction facility
	LNG as engine fuel for ships operating in Belarusian waterways	

5.2 Analysis of applicable options for LNG market development

5.2.1 Use of LNG as engine fuel for trucks

This LNG market development option can be considered as potentially viable for Belarus provided the LNG price at the filling station is competitive to that of diesel, taking into consideration the efficiency gains of LNG engines, as well as all costs associated with the LNG supply chain. Given the lack of available information on long-haul trucks in Belarus, the market size of LNG as fuel for trucks cannot be estimated. For this reason, instead of performing netback analysis, the 'breakeven' (or minimum) LNG market size (number of LNG-fuelled trucks and annual LNG volumes consumed) required for the option to be economically viable was estimated, under assumed supply chain cost conditions. The analysis showed that, in case LNG is sourced from Klaipeda terminal (the closest one to Belarus), LNG can be competitive to diesel provided at least around 200 LNG trucks operate in the Belarus market. LNG supply from a mini liquefaction terminal in Belarus would be a more expensive solution, necessitating a much higher 'breakeven' number of LNG-fuelled trucks, for the option to be competitive. Considering that Belarus has a sizable fleet of trucks involved in local, regional and international transport, and local manufacturing of LNG-fuelled trucks could lower switching costs, it seems that market for LNG in road transport could potentially develop. Consequently, use of LNG for trucks can be considered as a potentially viable option for Belarus. Economic analysis performed for the identified minimum required LNG market, shows that the reduction of GHG emissions has a positive impact.

5.2.2 Use of LNG as engine fuel for ships

Data on the vessels operating in Belarusian waterways were not available, but Belarus fleet reportedly comprises small vessels (barges, push and tow boats etc.). The use of LNG as fuel for such small vessels is challenging, even if LNG price can be lower than the existing bunkering fuels, as the large LNG fuel tanks take up storage capacity, affecting the ship's productivity and freight earnings. Thus, the application potential for smaller newbuilds running on LNG is limited, while retrofit of vessels in operation is not suitable for all types of small vessels. The use of LNG in newbuilds for the Belarusian waterways, or potentially retrofitting of existing vessels, should be examined on a case-by-case basis, as it depends on financial (cost for retrofitting, LNG price) and technical factors (tank space, safety issues). It is also noted that LNG would compete with other potential new options, such as the use of electric propulsion systems and electric powered ships for Belorussian waterways.

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5.3 Priorities and policy directions

The use of LNG as fuel for trucks is the only option analyzed showing, under conditions, to be potentially viable. Availability of LNG in neighboring terminals facilitates the development of the required supply chain over a short-term horizon. The Government could assess feasibility in detail further and take relevant policy actions. These policies could encompass, at the minimum, having a legal and regulatory framework conducive to the development of an LNG supply chain, and could expand to cover incentives for the use of LNG.

The applicability of LNG use as fuel for the ships operating in Belarus' waterways appears to be limited, due to the small size and limited utilization of vessels vis-à-vis investment requirements. Nevertheless, if the Government decides that this option is of interest, it should undertake contextualized analysis, to identify if there are any types of vessels for which switching to LNG may be attractive, assessing also competitiveness against other technologies being examined by the Belarusian State (e.g. electric propulsion).

5.4 Proposed actions

The Table below describes the actions that are deemed important in order to evaluate and prepare the identified applicable LNG market development options.

Table 6: Proposed preparatory actions for developing the identified LNG options in Belarus

	Proposed Actions	Timing
Initial / Preparatory Actions		
1	Perform feasibility study for the use of LNG as engine fuel for trucks	Immediate
2	Develop a national policy framework for the use of LNG in road transport, deciding on the role that the State wishes to undertake	Short-term / After the study for road transport is concluded (if the study is positive and Belarus decides to pursue)
3	Perform feasibility study for the use of LNG as engine fuel for ships	Short-term / If Belarus decides to pursue
4	Inclusion of the use of LNG as engine fuel for ships in the national policy framework	Short-term / After the study for water transport is concluded (if the study is positive)
Implementation Actions		
5	Prepare the regulatory and legal framework (legal amendments, regulations, standards, permits and licenses, etc.) necessary for the development of the LNG supply chain	Short-term / based on national policy framework
6	If the State undertakes a proactive role in developing infrastructure, prepare the incentive mechanisms to attract investments	Short-term / based on national policy framework
7	Conduct awareness raising campaigns to attract end-users and investors' interest	Short-term / based on national policy framework

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6 LNG Market Prospects in Georgia

6.1 Identification of applicable LNG market development options

Key findings related to the development of LNG markets in Georgia are as follows:

- Gas-to-gas competition from LNG could be applicable in Georgia. Currently there is no possibility for Georgia to receive regasified LNG through its gas pipeline interconnections with Russia, Turkey, Armenia and Azerbaijan; only in case Georgia develops its own LNG receiving terminal (smaller size than the one in Ukraine), which the stakeholders consider as interesting to explore. This option is nevertheless heavily dependent upon Turkey agreement to allow LNG vessels' passage through the Bosporus Straits.
- Georgia can facilitate gas-to-gas competition from LNG in other countries. Georgia is interested to establish an LNG liquefaction port terminal for exporting LNG to Ukraine, Moldova (via Ukraine) and further to EU markets (Romania, Hungary). This option is nevertheless subject to availability of gas to be liquefied from Azerbaijan. Azeri supplies could be possible only over the mid-term, given that all current Azeri supplies have been already contracted and new fields would have to be developed for this purpose. Kazakhstan and Turkmenistan could also be a potential supplier for this project over the long term, in case Caspian gas is transited to Azerbaijan (through pipe or through an LNG receiving terminal in the Caspian Sea).
- Swaps of piped gas for LNG landing in Turkish terminals, or terminals in SE Europe (Greece and Italy) is a potential option for gas-to-gas competition, under certain conditions. This option is dependent on Turkish LNG terminals are accessible to such deals, BOTAS agreeing to have such a swap with GOGC, and also that contractual arrangements between SOCAR and BOTAS allow Georgia to off-take gas from the SCP.
- Gas-to-other fuels competition from LNG could be applicable in Georgia for road transport. According to stakeholders, Georgia appears to have a sizable international long-haul traffic (export/imports and transit) that could merit the use of LNG as truck fuel.
- Gas-to-other fuels competition could be also applicable to remote/off-grid customers. Although over 80% of gas customers are connected to the grid, LNG supply could still be an option to supply selected off-grid consumers and areas (mainly mountainous towns and resort areas etc.), within the frame of the Government's aim to increase even further the country's gasification. GOGC may be interested to establish a small-scale liquefaction facility, to supply LNG filling stations and off-grid remote consumers.
- Gas-to-other fuels competition does not seem applicable to sea transport, at least over the short to mid-term. Given that the Black Sea is not an Emission Control Area for the IMO, the requirement to reduce sulphur emissions from the current 3.5% to 0.5% sulphur, as of 1/1/2020, can be addressed with other means (scrubbers, MGO with

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reduced sulphur etc.) instead of using LNG in ships. Additionally, stakeholders informed us that large ships refuel in Turkish ports, as opposed to Georgian ports.

Based on the above analysis, the applicable LNG market development options for Georgia, for gas-to-gas and gas-to-other fuels competition, are presented in Table 7.

It should be noted that gas-to-other fuels options cannot be considered as drivers for the development of an in-country receiving or liquefaction terminal but can benefit in case such infrastructure goes ahead.

Table 7: Applicable options for LNG market development in Georgia

Options for LNG market development		Sources of supply
Gas-to-Gas Competition	Regasified LNG through the development of an in-country LNG receiving terminal in the Black Sea	Potential in-country receiving terminal
	Swap of regasified LNG landing at LNG terminals in Turkey or SE Europe with piped gas supplied to Georgia through the SCP offtake	LNG receiving terminals in Turkey (Marmara Ereglisi), Italy (Panigaglia), Greece (Revythoussa, planned Alexadroupolis FSRU),
Gas-to-Other Fuels Competition	LNG as engine fuel for long-haul trucks	• In-country receiving terminal • In-country liquefaction terminal • In-country mini liquefaction facility
	LNG supplies to the remaining off-grid towns and consumers in Georgia, located in mountainous areas, to increase gasification	

The potential development of a liquefaction terminal in Georgia, for Caspian gas, is considered in the analysis as an additional source of LNG supplies in other Eastern Partners, particularly Ukraine and Moldova (through Ukraine).

6.2 Analysis of applicable options for LNG market development

6.2.1 Supply of regasified LNG from in-country terminal

This LNG market development option can be considered as potentially viable for Georgia if regasified LNG can arrive at a Georgian receiving terminal at a price competitive to that of the existing gas supply sources for the market, taking into consideration all relevant transportation costs. The Georgian terminal is assumed to be located in the Black Sea, near Poti. The development of a terminal with send-out capacity of 1 bcm/yr is assumed, taking into consideration the size of the Georgian gas market.

The results of the netback analysis show that the financial attractiveness for development of a receiving terminal in Georgia depends on the level of gas import prices. Under the examined assumptions and market conditions LNG can be competitive for Azeri supplies at a price over 50% of the current levels (i.e. to have an import price differential of at least 70-80 EUR/1000 m^3 between LNG and piped gas). This is of particular importance after 2025, as the expiry of the existing contracts for supply of optional and additional gas from the SCP can lead to an increase in gas supply prices.

Economic analysis for this LNG option was also conducted, to assess whether the benefits of developing an LNG terminal to the economy and society outweigh its costs. The analysis showed

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the terminal can bring additional security of supply benefits, but these are not sufficient to make the project viable, if prices of LNG are not competitive.

6.2.2 Swaps of piped gas with regasified LNG in Turkish or EU terminals

To enable a swap of regasified LNG delivered to a terminal outside Georgia, with piped gas delivered to Georgia, an agreement would be required between the involved parties. Conditions for effecting such an agreement would require:

- Price of LNG supplied at the selected terminal (including costs for use of terminal and entry at the transmission system) to be lower than the price of gas contracted by BOTAS in SCP (in case the price of LNG is higher, the price differential would have to be covered by GOGC).
- Import prices of Azeri gas in the Georgian market to be higher than the agreed price for the swap (and any price differential to be paid by GOGC, and service fee to be paid to the counterpart supplier).
- SOCAR to have contractual obligation in case of a swap, to deliver gas destined for BOTAS through the SCP to the Georgian gas offtake.

The financial viability of this option cannot be assessed using benchmarks, as it depends on the negotiated price between GOGC and the supplier. The potential for swaps should be further explored, in particular to ensure that there are no contractual constraints for the swap, and that the price differential would create a “win-win” case for all involved parties.

6.2.3 Use of LNG as engine fuel for trucks

This LNG market development option can be considered as potentially viable for Georgia in case the LNG price at the filling station is competitive to that of diesel, taking into consideration the efficiency gains of LNG engines, as well as all costs associated with the LNG supply chain. The available information on the traffic of long-haul trucks (local and transit) in Georgia is not sufficiently detailed to allow reasonable assumptions to estimate the market size of LNG as fuel for trucks. For this reason, instead of performing netback analysis to estimate the maximum price of LNG to be competitive to diesel, the ‘breakeven’ LNG market size (number of LNG-fuelled trucks and annual LNG volumes consumed) is estimated, under different scenarios of LNG/natural gas prices at the beginning of the supply chain.

The results of the analysis show that use of LNG in road transport can be competitive to diesel with a market of 60 LNG-fired trucks for LNG supplies from an in-country receiving terminal (or 100 LNG-fired trucks supplied from a liquefaction terminal), in case the preconditions for the establishment of such terminals are secured. Supplies from a mini liquefaction facility would require a considerably larger market, at least around 280 trucks. Considering that Georgia is a transit country for trade in the region, though its ports, the required breakeven market size appears to be feasible and accordingly the option of LNG as engine fuel for trucks can be considered as potentially viable. Further detailed analysis would be required on the operation of long-haul trucks (such as number of local and transit trucks, destinations and distances covered) to better size the market and its attractiveness.

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Economic analysis was also performed for the identified breakeven LNG market, to estimate the extent to which economic benefits for using LNG as engine fuel (energy cost reduction for end consumers, impact on GHG emissions) outweigh the costs for developing the option. The analysis shows that the reduction of GHG emissions has a positive impact.

6.2.4 Supply of LNG to off-grid distribution systems

This LNG market development option can be considered as potentially viable for Georgia provided the natural gas price at the end customers at the areas targeted for gasification is competitive to that of firewood (the dominant fuel in urban areas outside big cities in Georgia), taking into consideration the efficiency gains of natural gas, and all costs associated with the LNG/natural gas supply chain. A case study was conducted to assess the costs and benefits of displacing firewood with LNG in the largest off-grid town targeted for gasification. The costs of switching from firewood to LNG (including gas installation costs and a 20% price differential incentive) are higher (329 EUR/1000m^3) than the price of LNG that makes it competitive to firewood (280 EUR/1000m^3), considering fuel efficiency gains. Under these conditions, the option to supply off-grid towns in Georgia with LNG is not considered viable.

6.3 Priorities and policy directions

LNG for gas swaps could be a priority option, as it does not require development of new infrastructures and can be implemented in a short time provided the underlying economics of the swap of LNG for gas appeal to the concerned parties.

The LNG receiving terminal is a long-term option, on account of having to fulfil several prerequisites, some of which are critical/on-off, that affect the readiness to implement this option, notably the uninterrupted passage of LNG vessels through the Bosporus Straits and securing of a sufficient market for regasified LNG. A final decision on implementing the terminal should be made only in case of potential price hikes when existing Georgian contracts with Azerbaijan are renewed, post 2026, to ensure the viability of the terminal.

The establishment of a large liquefaction plant and export terminal is also a long-term option, subject to securing adequate gas supplies from Azerbaijan and/or Central Asia for LNG conversion, and long-term sales to LNG buyers in target markets.

The option of LNG as fuel for trucks could be viable using an in-country mini liquefaction facility, and could be done in a short-term horizon, as it involves decisions only of local actors, but the high investment costs in required infrastructure necessitate a large number of LNG fueled trucks for viability. On the other hand, LNG as fuel for trucks with LNG supplied from an in-country receiving terminal, in case such terminal was established, would require a smaller number of trucks, to be viable, but is a longer term option, as the relevant infrastructure is dependent on a number of factors controlled by third, external, parties. The Government could assess feasibility of this option in detail further and take relevant policy actions. These policies could encompass, at the minimum, having a legal and regulatory framework conducive to the development of an LNG supply chain, and could expand to cover incentives for the use of LNG.

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6.4 Proposed actions

The Table below describes the actions that are deemed important in order to evaluate and prepare the identified applicable LNG market development options.

Table 8: Proposed preparatory actions for developing the identified LNG options in Georgia

	Proposed Actions	Timing
Initial / Preparatory Actions		
1	Assess existence of any contractual barriers for implementing swaps through SCP	Immediate
2	Initiate dialogue with Turkish authorities regarding passage of LNG vessels through the Bosporus Straits	Immediate
3	Perform feasibility study for the development of LNG receiving terminal	Short-term / dependent on the progress of negotiations with Turkey
4	Perform feasibility study for the development of liquefaction and export terminal, including assessment of when (and if) sufficient gas supplies from the Caspian Region will become available to allow consideration of the liquefaction terminal	Medium-term / dependent on the availability of Caspian gas supplies
5	Perform feasibility study for the use of LNG as fuel for trucks	Immediate
6	Develop a national policy framework for the use of LNG in road transport, deciding on the role that the State wishes to undertake	Short-term / After the study is concluded (if it is positive and Georgia decides to pursue)
Implementation Actions concerning swaps		
7	Initiate negotiations and establish MoU with relevant stakeholders for swap framework	Short-term / based on possibility to perform swaps
8	Enhance awareness on global LNG market, trading and trends, so as to be ready to secure LNG volumes for the swap when the opportunity arises	Short-term / based on possibility to perform swaps
Implementation Actions concerning large LNG infrastructures (receiving terminal, liquefaction and export terminal)		
9	Gauge and secure the market's interest to use the LNG receiving terminal (e.g. binding market test)	Medium-term
10	Explore investors' interests in the LNG receiving terminal	Medium to long-term
11	Gauge and secure the interest of gas producers to use the liquefaction terminal and suppliers in the region to procure LNG	Medium to long-term
12	Explore investors' interests in the liquefaction and export terminal	Long-term
Implementation Actions aiming at developing use of LNG in road transport		
13	Prepare the regulatory and legal framework (legal amendments, regulations, standards, permits and licenses, etc.) necessary for the development of the LNG supply chain	Short-term / based on national policy framework
14	If the State undertakes a proactive role in developing infrastructure, prepare the incentive mechanisms to attract investments	Short-term / based on national policy framework
15	Conduct awareness raising campaigns to attract end-users and investors' interest	Short-term / based on national policy framework

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7 LNG Market Prospects in Moldova

7.1 Identification of applicable LNG market development options

Key findings related to the development of LNG markets in Moldova are as follows:

- Gas-to-gas competition from LNG could be applicable in Moldova. Currently import prices of Russian gas (only supplier of the market) are lower than LNG. However, regasified LNG supplies could be sourced for diversification of supply purposes. There are multiple potential import routes: from Polish Świnoujście LNG terminal and Lithuanian Klaipeda LNG terminal (once GIPL is completed) through Poland and Ukraine; from the Greek Revythoussa LNG terminal, through Bulgaria – Romania, after completion of the reverse flow of Trans-Balkan pipeline and of the Iasi – Ungheni – Chisinau pipeline; from Croatian Krk LNG terminal, through Hungary and Ukraine, provided that bottlenecks in the Hungarian system are resolved. In case an LNG receiving terminal in Ukraine is built, in the Odessa area, this could also be a source for regasified LNG supplies to Moldova, due to existing interconnections and proximity of the Moldovan system to Odessa. In case a liquefaction terminal is developed in Georgia, in combination with a Ukrainian receiving terminal, regasified LNG of Caspian origin could be supplied to the Moldovan market through Ukraine.
- Gas-to-other fuels competition could be applicable in Moldova through LNG use for peak shaving. Moldova has no gas storage and gas flows fluctuate significantly. Use of small-scale LNG storage for peak shaving at the Chisinau and Belts District CHP stations, can reduce dependence on other fuels (e.g. oil during winter) and enhance security of energy supply
- Gas-to-other fuels competition is not applicable to remote/off-grid customers. All towns are gasified and reportedly off-grid consumers are not interested to use gas
- Gas-to-other fuels competition does not seem applicable to road and water transport. International long-haul traffic through Moldova is very small. There is also very limited vessel traffic in Moldovan waterways. Therefore, it seems that there is no potential for LNG to be used in transport sector

Based on the above analysis, the applicable LNG market development options for Moldova, for gas-to-gas and gas-to-other fuels competition, are presented in the Table below. Regasified LNG can be sourced from neighbouring EU terminals (Świnoujście, Klaipeda, Revythoussa, Krk), or a potential LNG receiving terminal in Ukraine. Development of the later is subject to either Ukraine agreeing with Turkey for the passage of LNG through the Bosporus Straits, or, in the long-term, LNG of Caspian origin being available to be produced and exported from a liquefaction terminal in Georgia (as currently there are no available supplies of Caspian gas to feed such a potential infrastructure).

LNG for gas-to-other fuels competition can be sourced either from the Ukrainian LNG terminal or an in-country mini liquefaction facility connected to the Moldovan transmission system.

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Table 9: Applicable options for LNG market development in Moldova

Options for LNG market development		Sources of supply
Gas-to-Gas Competition	Regasified LNG sourced from neighbouring EU terminals	Świnoujście, Klaipeda, Revythoussa, Krk receiving terminals[3]
	Regasified LNG sourced from a potential LNG terminal in Ukraine	Potential receiving terminal in Ukraine
	Regasified LNG sourced from a potential liquefaction terminal in Georgia, through a receiving terminal in Ukraine	Potential liquefaction terminal in Georgia
Gas-to-Other Fuels Competition	LNG storage for peak shaving at the Moldovan CHP stations	• LNG truck loading in Świnoujście and/or Klaipeda terminals • Potential receiving terminal in Ukraine • In-country mini liquefaction facility

7.2 Analysis of applicable options for LNG market development

7.2.1 Supply of regasified LNG from neighbouring EU terminals

This LNG market development option can be considered as potentially viable for Moldova provided regasified LNG can arrive to the Moldovan market from the neighbouring EU LNG terminals at a price competitive to that of the existing gas supply sources, taking into consideration all relevant transportation costs. The results of netback analysis show that, due to the low gas prices in Moldova, regasified LNG cannot be competitive under the examined assumptions and market conditions. Nevertheless, LNG could be considered as a way to enhance Moldova's security of supply. Economic analysis showed that supply of LNG for security of supply purposes appears to be beneficial for the Moldovan market, as it would eliminate potential demand curtailment, in case of a disruption in Russian gas supplies. Accordingly, regasified LNG supplied from neighbouring terminals to Moldova can be considered as a potentially viable LNG option.

7.2.2 Supply of regasified LNG from Ukrainian terminal

Netback analysis performed for this option again showed that, due to the low gas prices in Moldova, supply of regasified LNG through a Ukrainian terminal cannot be competitive under the examined assumptions and market conditions. The economic analysis of LNG supplies from a Ukrainian LNG terminal shows that there would be security of supply benefits, as Moldova would have access to an additional supply route through which to address a potential disruption of Russian gas supplies. It should be stressed, however, that Moldova could also enhance its security of supply by considering other options, such as the supply of regasified LNG from existing LNG terminals in the region, as analysed in the previous Section.

[3] Other potential supply options include the Marmara Ereglisi terminal in Turkey and the planned Alexandroupolis FSRU in Greece and Gdansk FSRU in Poland. The netback analysis of these options would wield similar results with the examined terminals

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7.2.3 Supply of regasified LNG from Georgian liquefaction terminal

Netback analysis performed for this option again showed that, due to the low gas price in Moldova, gas liquefied in a Georgian terminal, transported to Ukraine, regasified and delivered to Moldova, cannot be commercially viable for Moldova under the examined assumptions and market conditions. Economic analysis showed that, similarly to the previous option, security of supply would be enhanced.

7.2.4 Use of LNG for peak shaving at CHP stations

This option involves the use of regasified LNG at the Moldovan CHP stations as a back-up supply source, to ensure continuity of electricity generation in case the regular supply of piped gas is distorted (for example due to fluctuations in gas flows through the system, or a disruption in imported gas). Data for the CHP stations, required to analyse this option further, were not available, and consequently netback and economic analysis was not conducted. As the main purpose of this option is to enhance security of supply, and not to provide a competitive supply source to piped gas, it can be expected that the development of the required infrastructure (development of an LNG storage and regasification facility at the CHP sites) would not be viable. Economic analysis should be carried out, to examine if the resulting security of supply benefits can outweigh the costs for developing the LNG supply chain.

7.3 Priorities and policy directions

The supply of regasified LNG from neighbouring LNG terminals to the Moldovan market is not a viable option, on account of lack of price competitiveness of LNG to imported low priced gas. However, in view of the security of supply benefits, which even small LNG volumes could provide, as indicated in the CBA carried out, this option could merit further examination by the relevant stakeholders (Government, Moldovagas). This option can go ahead over a short-term horizon, as it is not impeded by infrastructure constraints.

Additionally, the option of using LNG for peak shaving of CHP plants could also be an important option realized over the short-term to enhance security of energy supply in the country. As such, it needs to be assessed from a cost benefit perspective to determine its priority.

The options of Moldova being supplied with LNG from Ukraine and/or Georgia are highly dependent on the development of LNG receiving terminals in these countries, with significant uncertainties in view of the on/off requirements and prerequisites, that affect the maturity/readiness to implement these options.

7.4 Proposed actions

The Table below describes the actions that are deemed important in order to evaluate and prepare the identified applicable LNG market development options.

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Table 10: Proposed preparatory actions for developing the identified LNG options in Moldova

	Proposed Actions	Timing
Initial / Preparatory Actions		
1	Enhance awareness on global LNG market, trading and trends, so as to be ready to secure LNG volumes for security of supply reasons, when the opportunity arises	Immediate
2	Perform detailed market options' analysis for the supply of regasified LNG to Moldova, and analyze the options for Moldovagas to recover the costs (increase of prices, PSO, grant, etc.)	Immediate
3	Conclude interconnection agreement with the Ukrainian TSO	Immediate
4	Perform feasibility study for the development of peak shaving facility at the CHP stations and analyse the financing options and the recovery of the investment costs increase of prices, PSO, grant, etc.)	Immediate
Implementation Actions		
5	Conclude agreement for procuring LNG for security of supply	Short-term (if Moldova decides to pursue this option)
6	Prepare the regulatory and legal framework (legal amendments, regulations, standards, permits and licenses, etc.) necessary for the development of the peak shaving facility at the CHP stations	Short-term (if Moldova decides to pursue this option)

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8 LNG Market Prospects in Ukraine

8.1 Identification of applicable LNG market development options

Key findings related to the development of LNG markets in Ukraine are as follows:

- Gas-to-gas competition from LNG could be applicable in Ukraine. There are multiple pipeline routes through which regasified LNG can be imported, now or in the future. LNG can come via Poland (from Świnoujście LNG terminal), and from Klaipeda LNG terminal (once GIPL is completed) through the existing interconnection or the planned new Poland – Ukraine interconnection[4]. LNG can also come via Slovakia and Hungary (e.g. Krk or Italian LNG terminals). Moreover, LNG can be sourced via Hungary (e.g. Krk or Italian LNG terminals), provided that bottlenecks in the Hungarian system are resolved, as well as through Romania (Greek and Turkish LNG terminals), after reverse flow of the Trans-Balkan pipeline.
- Ukraine is interested to establish its own LNG import terminal in the Black Sea, near Odessa. An LNG terminal could provide regasified LNG to customers through connection with Ukrainian transmission grid. Additionally, given adequate terminal infrastructure (storage and truck loading facilities), LNG could be supplied directly to off-grid customers and for new gas uses (filling stations for trucks and ships etc.). The option of establishing an LNG receiving terminal is nevertheless contingent upon Turkey's agreement to allow LNG vessels' passage through the Bosporus Straits. Another LNG project being examined is a small-scale LNG receiving terminal in Reni, aiming to be used for bunkering and covering local gas needs.
- Ukraine can also import LNG by trucks and/or trains. Ukraine has road and rail connections to Poland (and on to Lithuania) that could be used to transport LNG with trucks from the Świnoujście and Klaipeda terminals, and via rail once the rail loading facility is developed at the Świnoujście terminal.
- Gas-to-other fuels competition from LNG could be applicable in Ukraine for road transport. According to stakeholders, Ukraine appears to have a sizable international long-haul traffic (export/imports/transit) that could merit the use of LNG as truck fuel.
- Gas-to-other fuels competition could also have some applicability in sea transport in Ukraine. A large number of passenger and cargo ships regularly operate in Ukrainian waterways, especially Dnieper and Black Sea ports. Switching fuel to LNG would nevertheless involve significant costs, and therefore compliance with international treaties regarding emissions, such as IMO regulations, would be important in influencing whether vessels convert to LNG as a cleaner fuel. Given that the Black Sea is not an Emission Control Area for the IMO, the requirement to reduce sulphur emissions from the current 3.5% to 0.5% sulphur, as of 1/1/2020, can be addressed

[4] It is noted that according to UTG the planned Poland – Ukraine pipeline is not included in the 2020 – 2029 TYNDP of Ukraine.

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by shipowners through other means (scrubbers, MGO with reduced sulphur etc.) instead of converting ships to use LNG (or order new ones running on LNG). Potential LNG demand could therefore arise in case of newer vessels that operate international routes and not limited to Black Sea transport, as well as smaller vessels operating in inland waterways, especially the Dnipro and Dunay rivers.

- LNG virtual pipelines could also be an applicable option for supplying gas distribution customers in Ukraine, instead of expensive replacements of old gas distribution pipelines. The Ukrainian gas network is well developed, and most towns are gasified. There are nevertheless cases of very old gas distribution sections that can be replaced by LNG virtual pipelines, instead of heavily investing in rehabilitation.
- LNG virtual pipelines could also have some applicability in supplying remote/off-grid customers in Ukraine. Most consumers in agriculture and mining are already connected to the gas network, but LNG could have some potential as backup fuel or for fuelling heavy work tractors' in mining. Ukraine also has some remote gas fields currently not connected to the network, and whose connection would involve significant difficulties and/or costly investments.
- Liquefaction facilities can be used to develop remote gas fields. Virtual LNG pipelines, with the use of mini liquefaction facilities to transform natural gas into LNG and the transport it to end customers e.g. filling stations etc. can be used to develop such gas fields. According to JSC Ukrgasvydobuvannya (main gas production facilities of Naftogaz Group), studies have been launched to assess such potential.
- Use of LNG as locomotive fuel could also be applicable. The Ukrainian Railway Company (Ukrzaliznytsa) is currently using diesel as main locomotive fuel (327.1 mil. tonnes in 2018), that could potentially be substituted by LNG.

Based on the above analysis, the applicable LNG market development options for Ukraine, for gas-to-gas and gas-to-other fuels competition, are presented in Table 11. Regasified LNG can be sourced from neighbouring EU terminals (Świnoujście, Klaipeda, Revythoussa, Krk) and potentially the development of an in-country LNG receiving terminal, constructed near Odessa. Development of the later is subject to either Ukraine agreeing with Turkey for the passage of LNG through the Bosporus Straits, or, in the long-term, LNG of Caspian origin being available to be produced and exported from a liquefaction terminal in Georgia (as currently there are no available supplies of Caspian gas to feed such a potential infrastructure).

LNG for gas-to-other fuels competition can be sourced from the nearby EU terminals (Świnoujście, Klaipeda), the in-country LNG terminal or a mini liquefaction facility connected to the Ukrainian transmission system. It should be noted that gas-to-other fuels options cannot be considered as drivers for the development of the Ukrainian LNG terminal, but can benefit in case such infrastructure goes ahead.

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Table 11: Applicable options for LNG market development in Ukraine

Options for LNG market development		Sources of supply
Gas-to-Gas Competition	Regasified LNG sourced from neighbouring EU terminals	Świnoujście, Klaipeda, Revythoussa, Krk receiving terminals[5]
	Regasified LNG sourced from an in-country LNG receiving terminal in the Black Sea	Potential in-country receiving terminal
	Regasified LNG sourced from a potential liquefaction terminal in Georgia and an in-country receiving terminal	Potential liquefaction terminal in Georgia
Gas-to-Other Fuels Competition	LNG as engine fuel for long-haul trucks	• LNG truck loading in Świnoujście and/or Klaipeda terminals • In-country receiving terminal • In-country mini liquefaction facility
	LNG as engine fuel for ships operating in the Black Sea and Ukrainian waterways	
	LNG supplies to off-grid customers, especially in agriculture, construction, and mining	
	LNG virtual pipelines in distribution systems instead of large rehabilitation investments in distribution systems	
	LNG virtual pipelines to connect remote gas fields with off-grid customers	
	LNG as engine fuel for locomotives	

8.2 Analysis of applicable options for LNG market development

8.2.1 Supply of regasified LNG from neighbouring EU terminals

This LNG market development option can be considered as potentially viable for Ukraine provided that LNG can arrive to the Ukrainian market from the neighbouring EU LNG terminals at a price competitive to that of the existing gas supply sources, taking into consideration all relevant transportation costs. The results of netback analysis show that, under the examined assumptions and market conditions, regasified LNG sourced from EU terminals seems to be marginally competitive in the Ukrainian market in case the prices of EU imported gas exceed the winter average of the past years. Consequently, this LNG market development option could be considered as potentially viable, provided that the spread between LNG price at the terminals and prices of imported supplies from current sources is at least in the order of 40 – 50 EUR/1000 m^3 (depending on the route chosen). This option does not provide additional benefits of route diversification, as the supply of regasified LNG from the terminals in the region would not open up new supply routes.

8.2.2 Supply of regasified LNG from in-country terminal

Netback analysis performed for this option shows that, under the examined assumptions and market conditions, an LNG receiving terminal in Ukraine can be potentially viable provided in case

[5] Other potential supply options include the Marmara Ereglisi terminal in Turkey and the planned Alexandroupolis FSRU in Greece and Gdansk FSRU in Poland. The netback analysis of these options would wield similar results with the examined terminals.

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there is a price differential of at least 25 – 30 EUR/1000 m^3 between LNG supplies and imports from EU, together with a high (over 50%) utilization of the terminal. Taking into consideration that EU import prices are driven by the prices at the European gas hubs, which in turn are affected by the global LNG price trends, attractive prices of LNG for the terminal could be ensured through long-term contracts that also secure a significant utilization of the infrastructure.

Economic analysis of this option shows that the use of the terminal only for security of supply purposes (in case piped gas prices remain at low levels) does not lead to positive results, as the impact of a potential short-term disruption of Russian transit can be mitigated with indigenous production and storage, and may lead to only a small part of demand to be curtailed.

Based on the above analysis, development of an in-country LNG receiving terminal in Ukraine can be considered as a potentially viable LNG option, in case LNG can be supplied at lower prices than existing sources, and high utilization of the terminal can be ensured, e.g. through long-term terminal use agreements. It is noted that this LNG market development option can only be realized if Ukraine and Turkey conclude an agreement for the passage of LNG vessels through the Bosporus Straits.

8.2.3 Supply of regasified LNG from Georgian liquefaction terminal

Netback analysis is performed for this option shows that the supply of LNG at a Ukrainian receiving terminal from a liquefaction terminal in Georgia can be competitive to existing imports only if the price of Caspian gas supplied to the liquefaction terminal is significantly lower than current import prices of Azeri gas in Georgia.

Economic analysis shows that the main benefit of this option is the reduction in energy costs. The use of the terminal solely for enhancing security of supply in Ukraine and Moldova does not lead to positive results, as the impact of a potential short-term disruption of Russian transit can be mitigated with indigenous production and storage, and may lead to only a small part of demand to be curtailed.

Based on the above analysis, the development of a liquefaction and LNG export terminal in Georgia, supplying an LNG receiving terminal in Ukraine can only be considered as a potentially viable LNG option only in case supply prices of Caspian gas are low, and a high (over 50%) utilization of the Ukrainian receiving terminal can be ensured, e.g. through long-term terminal use agreements. As the results are sensitive on the costs of liquefaction, further analysis of this option requires detailed examination of the investment needs for the liquefaction terminal, taking into consideration current liquefaction technologies and infrastructure.

8.2.4 Supply of LNG via trucks to consumers connected to the transmission system

This LNG market development option can be considered as potentially viable for Ukraine, in case the price of regasified LNG injected to the Ukrainian transmission system through a central LNG receiving terminal, which is supplied with LNG trucks from the Świnoujście and Klaipeda

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terminals, can be competitive to that of the existing gas supply sources, taking into consideration all relevant transportation costs. Netback analysis performed shows that, under the examined assumptions and market conditions, the use of LNG trucks as a means to supply LNG to the Ukrainian market, in competition to piped gas for consumers connected to the transmission system, is not commercially viable.

It is noted that the potential use of block trains as an LNG transportation modality could yield different results, as much larger volumes can be transported per shipment, and therefore transportation costs can be lower. However, this option cannot be analysed in detail, as it has not been widely applied, and unit cost benchmarks are not available. Once the planned train loading facility in the Świnoujście terminal becomes operational, the relevant costs can be assessed.

8.2.5 Use of LNG as engine fuel for trucks

This LNG market development option can be considered as potentially viable for Ukraine if the LNG price at the filling station is competitive to that of diesel, taking into consideration the efficiency gains of LNG engines, as well as all costs associated with the LNG supply chain. The available information on the traffic of long-haul trucks (local and transit) in Ukraine is not sufficiently detailed to allow reasonable assumptions to estimate the market size of LNG as fuel for trucks. For this reason, instead of performing netback analysis, the 'breakeven' LNG market size (number of LNG-fuelled trucks and annual LNG volumes consumed) required for the option to be economically viable was estimated, under assumed supply chain cost conditions.

The analysis showed that, in case LNG is sourced from the neighbouring terminals in Poland and Lithuania, or from an in-country receiving terminal, LNG can be competitive to diesel with a market of less than 100 LNG-fired trucks. Supplies of LNG from a mini liquefaction facility would require a considerably larger market, at least around 250 trucks. As Ukraine appears to have a sizable international long-haul traffic, a market for LNG in road transport of 100 or more trucks could potentially develop. Consequently, use of LNG as engine fuel for trucks can be considered as a potentially viable option for Ukraine. Further detailed analysis of data on the operation of long-haul trucks (such as number of local and transit trucks, destinations and distances covered) in Ukraine would be required, to better size the size of the market, and its attractiveness.

Economic analysis was also performed for the identified minimum required LNG market, to estimate the extent to which economic benefits for using LNG as engine fuel (energy cost reduction for end consumers, impact on GHG emissions) outweigh the costs for developing the option. The analysis shows that the reduction of GHG emissions has a positive impact.

8.2.6 Use of LNG as engine fuel for ships

The attractiveness of this LNG option differs for each individual case of ship, as it depends on a number of factors, including the vessel's size and type, age, service area, fuel used, refuelling pattern, prices of competing fuels, etc. For this reason, a case-by-case analysis would be required, to examine for which ships use of LNG would be competitive. In this Study we provide an indicative example, but the use of LNG for ships is a market development option that would

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merit further investigation, analysing the financial viability and potential LNG penetration specifically with the specific characteristics of the ships operating in Ukrainian ports.

8.2.7 Supply of LNG to off-grid consumers

This LNG market development option can be considered as potentially viable for Ukraine if the natural gas price at the end consumer is competitive to that of the current fuel (e.g. diesel or LPG), any fuel efficiency gains, as well as taking into consideration all costs associated with the LNG supply chain. Although in Ukraine the transmission system is well expanded, and most consumers with significant energy demand are already connected, there are some individual cases of consumers (mainly small to medium agriculture, construction or mining sites) that are off-grid. Details on the number, size and characteristics of these consumers were not made available to the Consultant. For this reason, an indicative case study was analysed concerning an agriculture site in the southern part of Ukraine, that cannot be connected to the transmission system. The findings of the analysis under the case study show that LNG supplied from receiving terminals can be competitive to LPG for the agriculture site examined. Consequently, this LNG market development option is considered as potentially viable, at least for some of the off-grid consumers in Ukraine. Nevertheless, more analysis would be required for each particular off-grid consumer individually, as the parameters affecting the analysis (e.g. distance from the terminal, consumption profile, type of fuel, size of required regasification terminal) differ.

Economic analysis was also performed for the supply of LNG to the examined off-grid agriculture site, to estimate the extent to which economic benefits outweigh the costs for developing this option. The analysis, for the particular case examined, shows that the largest benefit is the reduction of energy costs, while GHG emissions also have had a slight positive impact.

8.2.8 Use of LNG Virtual Pipelines in old distribution systems

Development of LNG virtual pipelines, as an alternative to undertaking replacement of old gas distribution pipelines, was examined in the context of a case study. The analysis showed that the cost of establishing and operating an LNG supply pipeline would be much higher than replacing the old pipeline. Therefore, this option is considered as non-viable.

8.2.9 Use of LNG Virtual Pipelines to develop remote gas fields

This LNG market development option can be considered as potentially viable for Ukraine in case the liquefaction of gas produced at remote gas field, and transportation of LNG to off-grid areas can be price competitive to the existing fuels used by the targeted consumers. Data on Ukraine's remote gas fields, required to analyse this option further were not available, consequently netback and economic analysis was not conducted within the frame of this Study. The examination of each remote gas field should be on a case-by-case basis, as the characteristics and location of each field are unique.

8.2.10 Use of LNG as engine fuel for locomotives of Ukrzaliznytsa

The significant consumption of diesel in the Ukrainian rail sector (around 330 mil. tonnes in 2018) provides incentives for assessing the feasibility of switching locomotives to run on LNG. To assess

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the viability of this option requires data and detailed analysis, including identifying the number of locomotives to be retrofitted or replaced, the retrofitting costs, the number of locations for developing LNG refuelling facilities, and the infrastructure requirements (facilities for LNG unloading, storage and locomotive refuelling). In the absence of this data, analysis could not be performed in this study. Benchmark costs were provided to facilitate future analysis.

8.3 Priorities and policy directions

On the basis of the viability assessment analysis performed, the option of LNG as fuel for trucks is viable, and could be implemented in a short-term horizon, as it involves decisions only of local actors and LNG can be sourced from the existing neighboring terminals. The Government could assess feasibility in detail further and take relevant policy actions. These policies could encompass, at the minimum, having a legal and regulatory framework conducive to the development of an LNG supply chain, and expand to cover incentives for the use of LNG.

The option of supplying LNG to off-grid consumers could be viable on a case-by-case basis. Switching to LNG is primarily the consumer's decision, and can be implemented over a short-term horizon, as LNG can be sourced from existing terminals. To enable relevant investments, the Government policy should target the removal of any constraints in the legal and regulatory framework, promote the use of LNG and gauge off-grid consumers' interest.

Concerning the potential for LNG use as fuel for the ships operating in the Black Sea and Ukraine's waterways, this option would require the Government to undertake contextualized analysis, as LNG use is not appropriate for all ships and would depend on technical considerations, utilization and fuel economics and environmental requirements. This option could be developed over a medium-term horizon, as it would require involvement and large investments from ship owners for a diverse number of vessels.

Regasified LNG sourced from neighbouring EU LNG terminals, aiming at gas-to-gas competition, is marginally viable at current market/LNG price conditions, and does not enhance security of supply. Consequently, this option is not a priority from a policy perspective, but it can be implemented in case relative LNG pricing is conducive for market players to take advantage of any potential opportunities.

Development of a Ukrainian LNG terminal is viable only under conditions of LNG prices dropping considerably below current levels and ensuring very high utilisation of the terminal (over 50%). More importantly, there are several prerequisites for the LNG receiving terminal to be realized, that affect the timing of its implementation, notably the uninterrupted passage of LNG vessels through the Bosporus Straits and securing of a sufficient market for regasified LNG. These render this option as medium to long-term.

8.4 Proposed actions

The Table below describes the actions that are deemed important in order to evaluate and prepare the identified applicable LNG market development options.

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Table 12: Proposed preparatory actions for developing the identified LNG options in Ukraine

	Proposed Actions	Timing
Initial / Preparatory Actions		
1	Initiate dialogue with Turkish authorities regarding passage of LNG vessels through the Bosporus Straits	Immediate
2	Perform update of the feasibility study for the development of LNG receiving terminal, including assessment of the prospects for selling LNG in the Ukrainian market	Short-term / dependent on the progress of negotiations with Turkey
3	Perform feasibility studies for the use of LNG as fuel for trucks and ships	Immediate
4	Develop a national policy framework for the use of LNG in road and water transport, deciding on the role that the State wishes to undertake	Short-term / After the study is concluded (if it is positive and Ukraine decides to pursue)
Implementation Actions concerning LNG receiving terminal		
5	Gauge and secure the market's interest to use the LNG receiving terminal (e.g. binding market test)	Medium-term
6	Explore investors' interests in the LNG receiving terminal	Medium to long-term
Implementation Actions aiming at developing use of LNG in transport sector		
7	Prepare the regulatory and legal framework (legal amendments, regulations, standards, permits and licenses, etc.) necessary for the development of the LNG supply chain	Short-term / based on national policy framework
8	If the State undertakes a proactive role in developing infrastructure, prepare the incentive mechanisms to attract investments	Short-term / based on national policy framework
9	Conduct awareness raising campaigns to attract end-users and investors' interest	Short-term / based on national policy framework
10	Undertake initiatives to catalyze interest and seek joint commitments of stakeholders (suppliers, ports, ship owners) to develop the use of LNG in shipping	Short to medium-term / based on national policy framework

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9 Regional Perspectives for LNG Market Development

Some of the identified potentially viable options for LNG market development are of interest to two or more Eastern Partner countries.

The potential development of the LNG receiving terminal in Ukraine (subject to an agreement between Ukraine and Turkey for the crossing of LNG carriers through the Bosporus Straits) can facilitate supplies of LNG to other Eastern Partner countries:

- Regasified gas can be supplied to Moldova through the Ukrainian system. This option seems not to be commercially viable and therefore would not be used by Moldova under normal market conditions, but potentially in case of a supply disruption.
- Opening the Bosporus Straits to LNG vessels could drive the development of a small LNG receiving terminal in Georgia that can be supplied from Ukraine (transhipment) or with dedicated LNG shipments.

Potential development of a liquefaction terminal in Georgia, allowing exports of Caspian gas though the Black Sea (subject to the development of additional export potential in Azerbaijan and/or the commencement of gas supplies gas from Kazakhstan and Turkmenistan through the Caspian Sea), can develop an alternative corridor for LNG supplies to Eastern Partner countries. This corridor, that is not subject to an agreement with Turkey on crossing of LNG carriers through the Bosporus Straits, can allow:

- Supply of LNG shipments to the LNG terminal in Ukraine. This option would provide Ukraine with access to Caspian gas resources, allowing to further diversify its sources and routes.
- Supply of regasified gas to Moldova through the Ukrainian terminal and system. This option seems not to be commercially viable and therefore would not be used by Moldova under normal market conditions, but potentially in case of a supply disruption.

Initiatives for cooperation between Eastern Partners on smaller-scale infrastructure can also be explored. In particular, the interest of most Eastern Partner countries (Armenia, Azerbaijan, Belarus, Georgia, Ukraine) to develop a use of LNG in road transport could lead to the establishment of a regional network of LNG filling stations, that can facilitate accessibility of LNG to long-haul trucks operating in the region, and this provide incentives to truck owners to switch to LNG.

Furthermore, the development of an LNG receiving or liquefaction and export terminal in Georgia would allow Armenia to have access to LNG supplies, facilitating the development of an LNG market.

To foster development of LNG markets in the region, a number of actions could be considered for regional (or sub-regional) coordination and cooperation, presented in the Table below.

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Table 13: Proposed actions for regional coordination and cooperation

	Actions	Involved parties	Timing
1	Creation of sub-committees under the EaP LNG working group, to facilitate dialogue, coordination and initiatives on key LNG issues (technical & standards, regulatory, market, etc.)	Regional level (All interested Eastern Partner countries)	Immediate
2	Joint Georgia – Ukraine initiatives for addressing the Bosporus Straits' constraints	Sub-regional level (Georgia and Ukraine)	Immediate
3	Harmonization of rules, regulations and standards, for LNG-fuelled trucks, and for trucks transporting LNG, for ease of transit through the Eastern Partner and EU countries	Regional level (All interested Eastern Partner countries)	Short-term
4	Assess the potential for joint developing a small-scale liquefaction facility to supply LNG for trucks in the Caucasus region	Sub-regional level (Armenia, Azerbaijan and Georgia)	Short-term
5	Coordination, and potentially preparation of regional development plan for the establishment of LNG filling stations in the Eastern Partner countries	Regional level (All interested Eastern Partner countries)	Short-term

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10 Recommendations for EU and Eastern Partners' joint actions

The analysis carried out in this Study shows that there is interest by the Eastern Partner countries and potential for LNG market development, both for gas-to-gas and gas-to-other fuels competition. However, this potential can only be gradually realised, given the investments requirements and the current market conditions.

In catalysing this development, the Eastern Partner countries would benefit from the experience, practices and lessons learned of EU LNG markets' stakeholders. Joint actions that could be considered with the objective of fostering cooperation and market development include:

- Creation of sub-committees under the Eastern Partnership LNG working group, to facilitate dialogue, coordination and initiatives on key LNG issues (technical & standards, regulatory, market, etc.);
- Knowledge transfer from EU counterparts (from the whole LNG industry) to Eastern Partners, on LNG technologies and benchmark costs, focusing on infrastructure development, especially small-scale applications (regasification, liquefaction, filling stations etc.);
- Sharing of the experience gained through the Blue Corridor initiative, as a model case to develop the use of LNG in the transport sectors of Eastern Partners, by facilitating assessment and planning for the whole LNG supply chain;
- Provision of know-how and technical assistance for the development of the legislative and regulatory framework, technical rules and standards for all LNG related infrastructure and equipment;
- Development of a common IT platform for knowledge sharing of materials relevant to LNG markets;
- Possibility to provide co-financing for selected projects of common interest through the European Network Instrument, or other financing mechanisms.

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