OPPORTUNITIES FOR SMALL-SCALE LNG IN CENTRAL & EASTERN EUROPE

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About the authors

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Gas Technology Institute (GTI) is a leading independent research, development, and training organization addressing energy and environmental challenges to enable a secure, abundant, and affordable energy future. For more than 75 years, GTI has been providing economic value to the natural gas industry and energy markets by developing technology-based solutions for industry, government, and consumers to expand the supply of affordable energy, ensure a safe and reliable energy delivery infrastructure, and promote the efficient use of energy resources. To date, GTI programs have resulted in nearly 500 products, 750 licenses and more than 1,300 associated patents. For more information please visit the organization's web site at www.gti.energy.

ADI Analytics is a boutique-consulting firm serving the oil & gas, energy, and chemical industries. In oil & gas, ADI brings deep expertise in global large- and small-scale LNG markets along with upstream and oilfield services, midstream and natural gas, and fuels and refining. Founded in 2009, ADI Analytics has completed 450+ projects for 150+ clients including Fortune 500 and mid-sized companies, start-ups, investors, and government agencies. The company's offerings include consulting services, subscription research, data analytics, and executive forums. ADI Analytics' consulting services include market research, competitive intelligence, economic analysis, strategic planning, and technology assessments. ADI Analytics conducts its work through the disciplined use of content, data, and analytics, reliance on field-based energy industry expertise, and a relentless focus on creating value for clients. For more information, please visit the company's web site at www.adi-analytics.com.

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List of abbreviations

bcfd	Billion cubic feet per day
Bcm	Billion cubic meters
BOG	Boil-off gas
Btu	British thermal unit
CEF	Connecting Europe Facility
DOE	U.S. Department of Energy
E&P	Exploration and production
EU	European Union
FSRU	Floating storage and regasification unit
FSU	Floating storage unit
GWh	Gigawatt-hours
IMO	International Maritime Organization
ISO	International Organization for Standardization
ktoe	Kilo tons of oil equivalent
kWh	Kilowatt-hours
LNG	Liquefied natural gas
m^3/h	Cubic meters per hour
MGO	Marine gas oil
MMCFD	Million cubic feet per day
MMTPA	Million tons per annum
SSLNG	Small-scale LNG

1.0 Executive summary

Study Rationale

Liquefied natural gas (LNG) global demand is surging with expanding applications and is a far cry from its modest beginnings when it was merely used to transport natural gas over long distances where pipelines would be impractical. There are a few major drivers for LNG demand and demand growth globally.

- Growing societal and, therefore, policy and regulatory pressure towards decarbonization and environmental quality improvements are two primary drivers.
- Regional interest in energy supply security is another critical driver in a few key markets.
- Falling LNG prices and growing supply from expanding natural gas liquefaction capacity is accelerating adoption of LNG in existing markets as well as creating new LNG demand in emerging markets and applications.

Cheap and abundant supply, cost-effective transportation options at various scales, and growing use in numerous emerging applications – coupled with Europe's decarbonization and environmental policies, familiarity with LNG, and energy supply security goals, make small-scale and containerized LNG an increasingly attractive strategic option for this region.

Recognizing this potential, the U.S. Department of Energy has commissioned this study to assess the potential of LNG specifically in Central & Eastern Europe. Furthermore, given that this region's energy needs are likely smaller and more fragmented in comparison to other parts of Europe which have come to rely on LNG use via traditional large-scale volumes delivered after regasification through pipelines, the U.S. Department of Energy has limited the scope of this study to small-scale and containerized LNG.

Introduction to LNG

Global demand for LNG is growing rapidly and reached 363 million tons in 2020, a 48% increase compared to the 2015 level. Asia accounted for nearly 70% of LNG demand with Japan, China, South Korea, and India accounting for 57% of global LNG demand. Almost 25% of global LNG demand is in Europe while a total of 42 countries collectively import LNG.

Since 2016, global LNG trade has seen growth every year with nearly 9% growth in 2019. Since LNG was first introduced in the late 1960s, Asia led by Japan and Korea and, increasingly in recent years, China has accounted for most – as much as 70% in 2019 – of global LNG demand growth. However, in 2019, Asia accounted for less than 15% of LNG demand growth due to the economic downturn and U.S. and China trade tensions. Most of the LNG demand growth in 2019 – as much as 80% – came from Europe in volumes that collectively represented 20% of total regional gas demand.

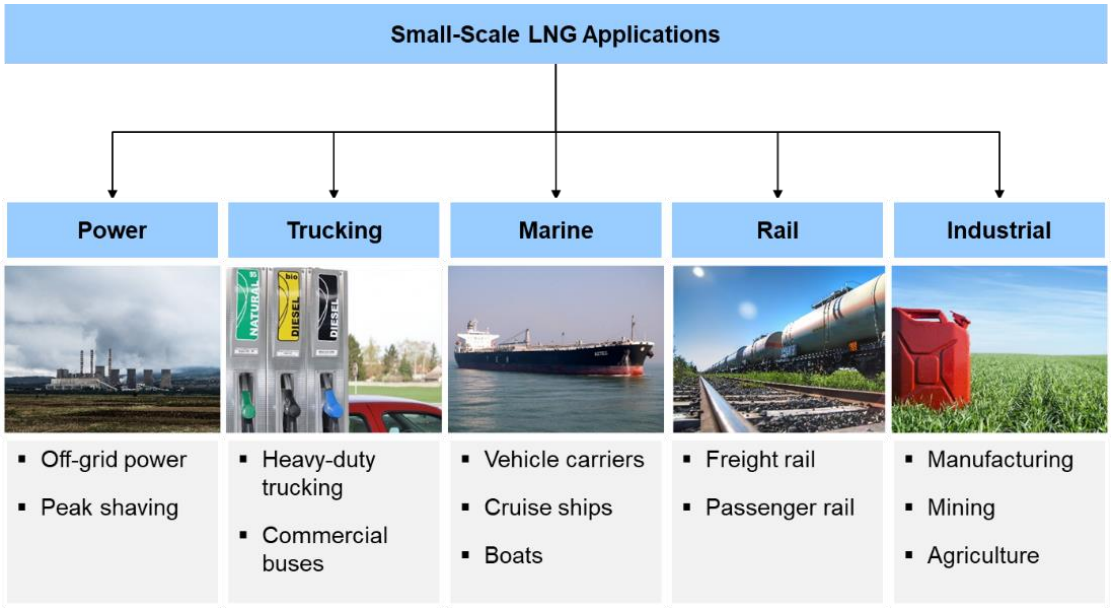
LNG has typically been transported in sizeable volumes by large double-hulled ships to various destinations where it is re-gasified to be used along with other sources of natural gas at power plants, industrial facilities, and commercial and residential communities usually via pipelines. Natural gas can then be used in many applications as a fuel to generate power or heat.

Small-scale LNG

In the past decade, LNG has been used in smaller volumes for various applications (see Exhibit 1) including as a transportation fuel replacing diesel and fuel oil in heavy-duty trucking, marine, and rail transport. In addition, LNG has been long produced at small scales as an emergency fuel for power generation. In the U.S., LNG is a peak shaving fuel used both for power plants to produce electricity during peak utilization seasons and for local distribution companies during periods of peak demand.

Newer applications of LNG at a smaller scale have emerged in recent years, including industry, (e.g., for boilers), agricultural operations, and as a bunkering fuel for large and small vessels. All these are facilitated by the abundance of inexpensive LNG supply resulting in emissions reduction, energy security and diversity, and cost saving benefits.

Exhibit 1. Small-scale LNG applications.



Small-scale LNG, which is broadly defined in this report to also include mini, micro, and containerized LNG segments, is focused on serving specific and niche end-use markets including heavy-duty trucking, rail, marine, peak shaving power, and industrial. Small-scale LNG production plants have capacities lower than 1 million tons per annum (MTPA) or 100 million

cubic feet per day (MMCFD) while mini or micro plants are typically much smaller at less than 0.2 MTPA.

LNG can also be transported by ship, truck, or rail in ISO containers which are typically 10,000 gallons (40 cubic meters) in volume each. Containerized LNG is finding application in small industrial plants, agricultural farms and road paving, as well as power generation in small, remote communities.

Energy Markets in Central & Eastern Europe

Most of the economies in Central & Eastern Europe are heavily dependent on coal or oil products such as diesel and heavy oil as primary sources of energy. Many countries in the region – i.e. Austria, Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania, Slovakia, and Slovenia – are European Union (EU) members, and several others – i.e. Albania, Bosnia & Herzegovina, Kosovo, Montenegro, North Macedonia, and Serbia – are signatories to the Energy Community Treaty and are obligated to adopt and implement EU energy law as they seek eventual EU membership. Although implementation is uneven, EU energy policy is already impacting policymaking and investment decisions in these countries. Decarbonization of the energy sector is a priority EU policy objective.

Natural gas via pipelines or large-scale LNG imports can play an important role towards these decarbonization goals through displacement of coal for power generation. In addition, LNG is now available far more economically given the dramatic growth in new supply led primarily by projects in the U.S. based on shale gas discoveries. LNG also offers the opportunity to decarbonize other sectors by displacing diesel and heavy fuel oil in heavy-duty trucking, rail, and marine transport. Similarly, several other sectors such as agriculture, marine, and industrial applications in remote areas are also dependent on diesel or heavy fuel oil for their energy demand, and some of these applications can switch to LNG for economic and environmental benefits.

If new pipeline investments are not economical in the near to mid- term given the scale of demand in these regions, small-scale LNG could address this market with increasing supply, falling prices, and ease of transportation via tanker vessels, trucks, and even rail. In addition to the various demand drivers, there are a number of regional and local factors – e.g., economic and energy demand growth, taxes, regional infrastructure, etc. – that can impact adoption of small-scale LNG. Each of the end-use sectors will rely on LNG sourcing that will most likely involve a large-scale LNG terminal with small-scale services such as breakbulk, truck and rail loading, ship-to-ship transfers, or via containerized LNG at one of the regional ports.

Opportunity assessment findings indicate there are three categories of countries in the region. Countries with limited barriers to near-term – say, 2-3 years – opportunity for growth in small-scale LNG adoption include Hungary, Poland, Serbia, Albania, Slovakia, and North Macedonia. All these countries have several factors that drive demand for small-scale and containerized LNG. In comparison, Montenegro, Romania, and Kosovo have significant barriers to adoption of

small-scale LNG today, and will likely see growing adoption of small-scale LNG only in the long term (more than 5 years) if these barriers remain unaddressed. The remaining countries – Czech Republic, Slovenia, Croatia, Austria, Bosnia & Herzegovina, and Bulgaria – are likely to see growth in small-scale LNG adoption in the medium term of 3-5 years.

Generally speaking, a few common themes among near-term opportunity countries include strong and growing economies, and therefore rising demand for energy, and, in some cases, for growing use of natural gas in the industrial and transportation sectors and remote applications. In contrast to these countries, some obstacles to small-scale LNG adoption are somewhat country-specific such as low economic growth, falling energy demand particularly in transportation and remote applications, minimal experience with natural gas, existing and well distributed gas infrastructure, and inadequate small-scale services at LNG import terminals.

Small-scale LNG market in Central & Eastern Europe

Six demand drivers have enabled the growth of small-scale and containerized LNG in most regions and market segments around the globe where it is being used. These drivers include environmental regulations, price differentials between LNG and incumbent fuels, energy supply constraints, growing availability of cheap LNG, decarbonization policies, and innovation in technology and business models.

The use of small-scale and containerized LNG could significantly benefit three segments – heavy-duty trucking, marine bunkering, and industrial power – where we expect the fuel to gain traction in Central & Eastern Europe. A few other potential niche markets, e.g., small-scale LNG use in agriculture and road paving, could see varying degree of penetration among different countries in the region.

New infrastructure investments will be necessary across supply, storage, transportation, and utilization segments of the LNG value chain. These include LNG bunkering terminals and/or vessels, truck loading and refueling stations, storage tanks, and end-use logistics facilities. Fortunately, many of these projects are not prohibitively expensive in the regional context.

Successful adoption of small-scale and containerized LNG will require significant investment, policy drivers and support from a wide range of stakeholders. Although each investment project will have a specific set of stakeholders, there are, at a high level, six types of key stakeholders that will play a role in facilitating small-scale LNG investments in Central & Eastern Europe. These include government agencies, gas pipeline and power grid operators, state-owned and private energy companies, multilateral financial institutions, and private investors.

Policy considerations

Most of the existing policies supportive of LNG use in various applications are generic and developed broadly for alternative fuels to coal and diesel, as opposed to specifically for small-scale LNG. These policies will have to become more specific – such as rebates for LNG-fueled

vehicles, tax exemptions for LNG fuel sales, and depreciation benefits for small-scale LNG services at ports to list a few – in supporting small-scale LNG in order to further drive market adoption in the short- to medium-term.

Conclusions

Heavy-duty transportation followed closely by industrial applications are the most promising demand segments for small-scale and containerized LNG. Economic competitiveness and environmental benefits of small-scale LNG in industrial and other (e.g., back-up power, agriculture, and district heating in remote areas) applications are highly customer- and end-use-specific. Taking into consideration current supply and gas infrastructure, several countries in the scope of this study have moderate to strong interest in LNG as a gas source. More than two-thirds of the 15 countries in the region have some LNG refueling infrastructure or plans to invest in them, thus reinforcing the strong potential for small-scale LNG in heavy-duty transportation sector.

There are few opportunities for marine bunkering along the Adriatic coast in Croatia, Montenegro, and Albania. Krk terminal in Croatia does not plan to offer small-scale services such as truck loading and bunkering, while Montenegro has put a hold on development of Port of Bar for small-scale LNG import citing environmental concerns. Moreover, there is considerable interest but lack of private investment and policy support in Albania to develop small-scale LNG import terminal or bunkering facility. Overall, the potential for marine bunkering is muted in the region given that several countries are landlocked. However, given the broad support bunkering has enjoyed in Europe, it is likely that marine bunkering in Central & Eastern Europe may accelerate along the Danube river or in the Black Sea area. Looking at enablers for small-scale and containerized LNG in the region, policy support is limited and often tied to the Energy Community Treaty or EU membership.

Slow demand growth of gas and LNG in the region, insufficient fuel price differential between incumbent fuel and LNG, stricter EU policies against fossil fuels, lower pipeline gas prices, and faster rate of electrification of trucks and passenger vehicles are among the top risks threatening the growth of small-scale LNG in the region. In addition to the alternative vehicle fuel directive and decarbonization mandates, incentives and funding for higher participation and investment in LNG infrastructure development will accelerate growth of LNG in the region.

In summary, Central & Eastern Europe can realize strong economic and environmental benefits from the use of small-scale and containerized LNG in various applications with emphasis on road and marine transport, as well as industrial and manufacturing sectors.

2.0 Background

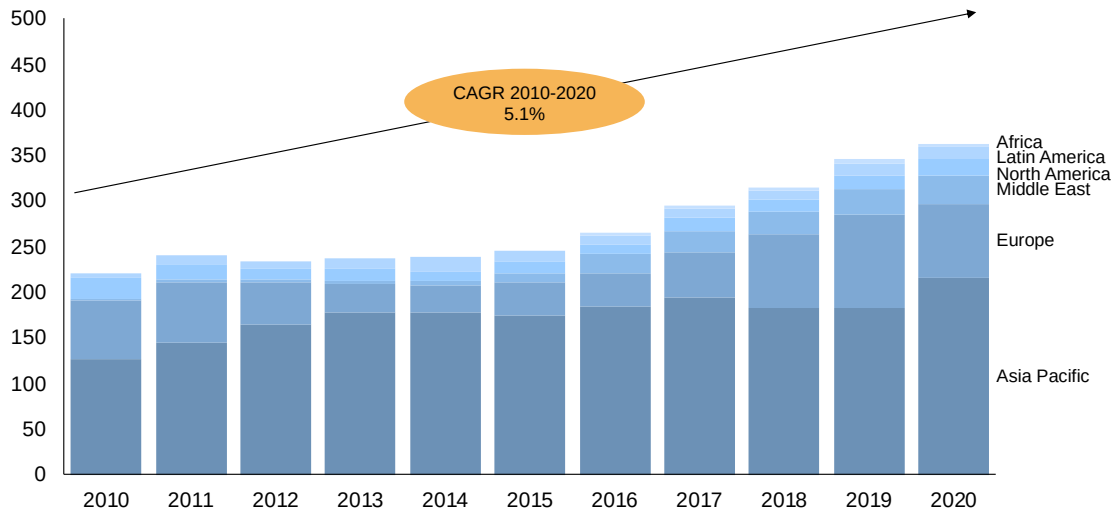
2.1. Introduction

Liquefied natural gas (LNG) global demand is surging with expanding applications and is a far cry from its modest beginnings when it was merely used to transport natural gas over long distances where pipelines would be impractical. Between 2015 and 2017, LNG demand grew at 9% annually[1], while jet fuel, liquefied petroleum gas (LPG), and natural gas grew at 5.3%, 3.8%, and 3.2%, respectively.[2] LNG – natural gas cooled to -260 °F – takes up one six hundredth the volume of its gaseous form and has properties that allow its transportation at ambient pressures.

Global demand for LNG is growing rapidly and reached 363 million tons in 2020, a 48% increase compared to the 2015 level.[1] Asia accounted for nearly 70% of LNG demand with Japan, China, South Korea, and India accounting for 57% of global LNG demand.[1] Almost 25% of global LNG demand is in Europe while a total of 42 countries collectively import LNG.[1]

Since 2016, global LNG trade has seen high digit growth every year with nearly 9% growth in 2019 (see Exhibit 2).[1] Since LNG was first introduced in the late 1960s, Asia led by Japan and Korea and, increasingly in recent years, China has accounted for most – as much as 70% in 2019 – of global LNG demand growth. However, in 2019, Asia only accounted for less than 15% of LNG demand growth due to the economic downturn and U.S. and China trade tensions.[1],[3] Most of the LNG demand growth in 2019 – as much as 80% – came from Europe in volumes that collectively represented 20% of total regional gas demand.[1]

Exhibit 2. Global LNG trade over 2010-2020 in million tons per annum.[1]



There are a few major drivers for LNG demand and demand growth globally:

- Growing societal and, therefore, policy and regulatory pressure towards decarbonization and environmental quality improvements are two primary drivers.
- Regional interest in energy supply security is another critical driver in a few key markets.
- Falling LNG prices and growing supply from expanding natural gas liquefaction capacity is accelerating adoption of LNG in existing markets as well as creating new LNG demand in emerging markets and applications that have traditionally relied on refined products.

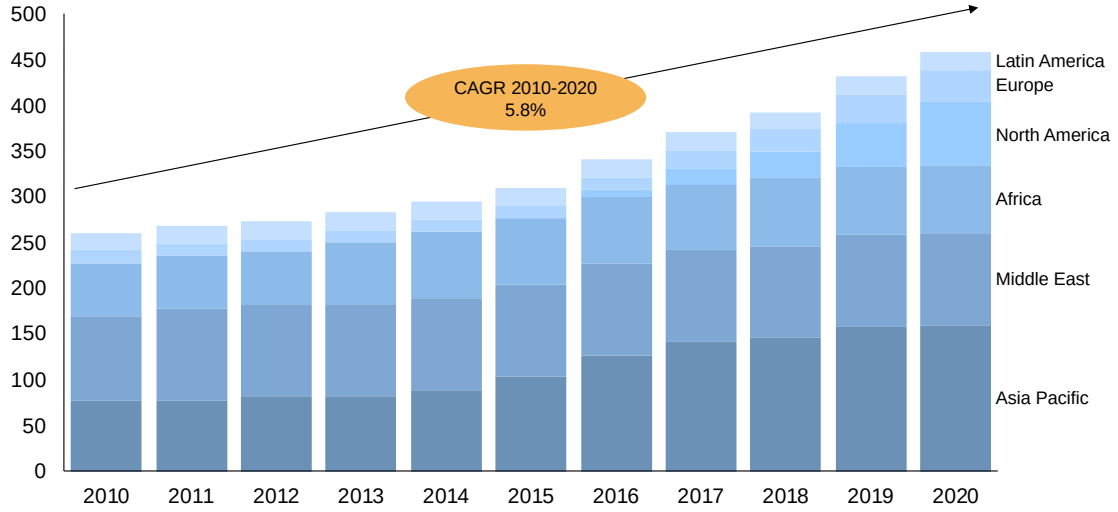
Japan, Korea, and India along with some of the newer importers continue to pursue decarbonization goals by switching power plants away from coal to gas from LNG. Coal-to-gas switching continues to be a strong driver for LNG demand but going forward will have to compete with renewable power whose costs are falling rapidly. It is likely that, in the future, LNG may be used in gas-fired power as a balancing resource for a predominant but variable renewables-based power generation system. Further, LNG-fired power generation could accelerate deployment of renewables in countries with limited supply of hydro-based power. Such applications would be similar to the use of LNG for peak shaving in natural gas-fired electric utilities in the United States, which is an application that is expected to rise significantly as the share of natural gas rises in the country's power generation mix.

Beyond decarbonization policies, air quality concerns are also driving LNG demand in China and, to a lesser extent, in India and other emerging economies. China's coal-to-gas conversion program, officially launched in 2017, drove up the country's LNG imports as industrial and residential segments intensified fuel switching in favor of natural gas. Switching to natural gas offers several environmental benefits including lower particulate matter and greenhouse gas emissions and higher efficiencies. For example, replacing coal with natural gas for power generation cuts particulate matter and greenhouse gas emissions by 90% and 50%, respectively. Similarly, replacing fuel oil in marine transportation with LNG reduces greenhouse gas emissions by as much as 21%. Further, home heating can have efficiencies higher than 95% when natural gas is used as a fuel.

Ensuring a secure supply of energy has been a second major driver for LNG demand growth. This is particularly true in Europe where LNG is widely seen and supported politically as an option that mitigates supply risk and enhances energy supply security. As a result, LNG accounted for over 23% of EU's total gas imports in 2019, and that share is expected to increase as many as 18 operators are planning 12 new LNG import terminals[4]over the next few years, adding to the existing slate of 24 terminals.[5]

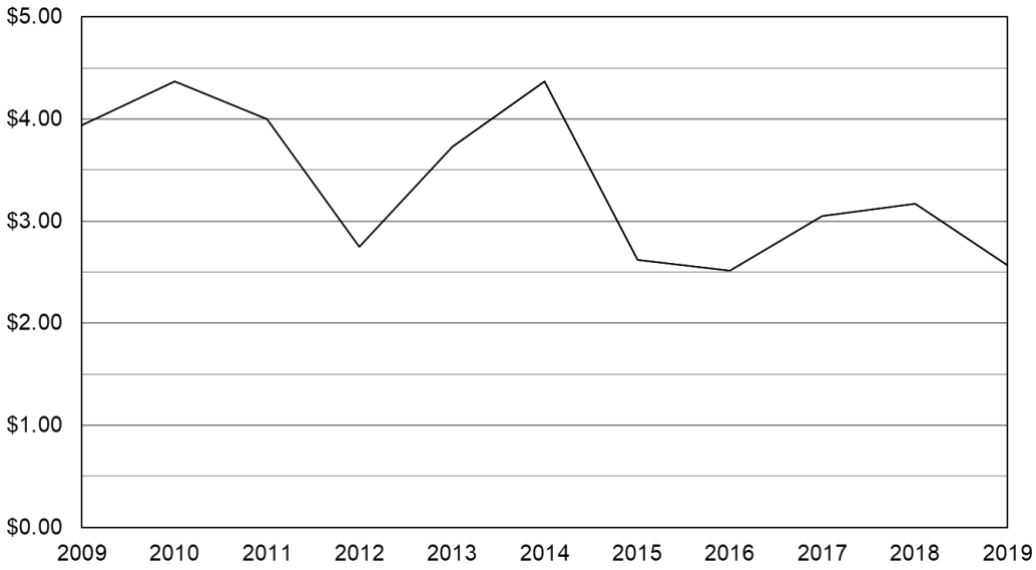
A third critical driver for LNG demand has been supply capacity growth and, consequently, its downward pressure on pricing. Exhibit 3 shows that global LNG capacity grew from 261 million tons per annum (MTPA) in 2010 to 458 MTPA in 2020, growing by almost 6% each year.[1] LNG supply capacity is expected to grow further as capital investments in new LNG projects totaling another U.S. $65 billion were approved in 2019.[1] This will increase global LNG capacity by another 16% - equivalent to total EU LNG imports in 2019.

Exhibit 3. Global LNG supply capacity growth over 2010-2020 in million tons per annum.[1]



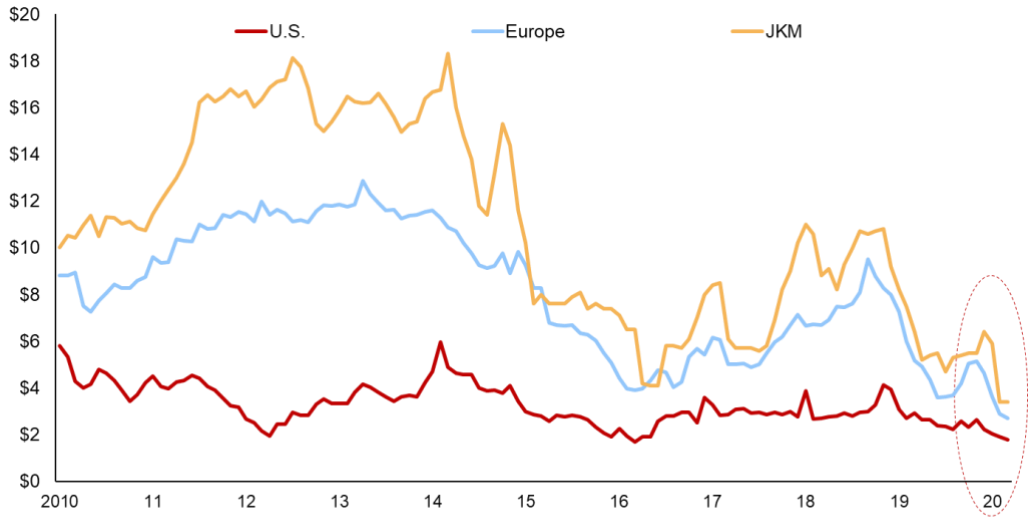
Some of the major LNG producers and exporters are Qatar, Australia, and the United States. The United States has emerged as a major LNG supplier in recent years, enabled by the discovery and development of shale gas resources in the past decade. Given the current abundance of supply, natural gas is now very competitively priced in the U.S. and the Henry Hub benchmark price has fallen to historic lows as shown in Exhibit 4. These low feedstock prices have allowed new U.S. LNG exporters to disrupt the traditional pricing formulas where LNG price was indexed to oil prices. Instead, U.S. exporters now offer LNG that is linked to the Henry Hub benchmark price of natural gas, which is expected to remain low for many more decades.

Exhibit 4. Historical Henry Hub prices over 2009-2019 in U.S. dollars per million Btu.[6]



In addition to abundant and economic feedstock gas, U.S. LNG projects have exploited technology advancements and the country's brownfield sites and extensive and well-established oil and gas infrastructure to cut capital costs and improve their economic competitiveness. Collectively, low shale gas prices and cost-competitive projects in the U.S. have contributed to LNG price declines and growing price convergence globally. Although LNG prices hit historical lows in 2020 (see Exhibit 5) driven by the COVID-19 pandemic and related demand reductions, LNG prices have, in general, been falling in recent years driven by oversupply as a result of significant growth and ongoing investment in new natural gas liquefaction capacity.

Exhibit 5. Regional LNG prices over 2010 to 2020 in U.S. dollars per million Btu.[7]



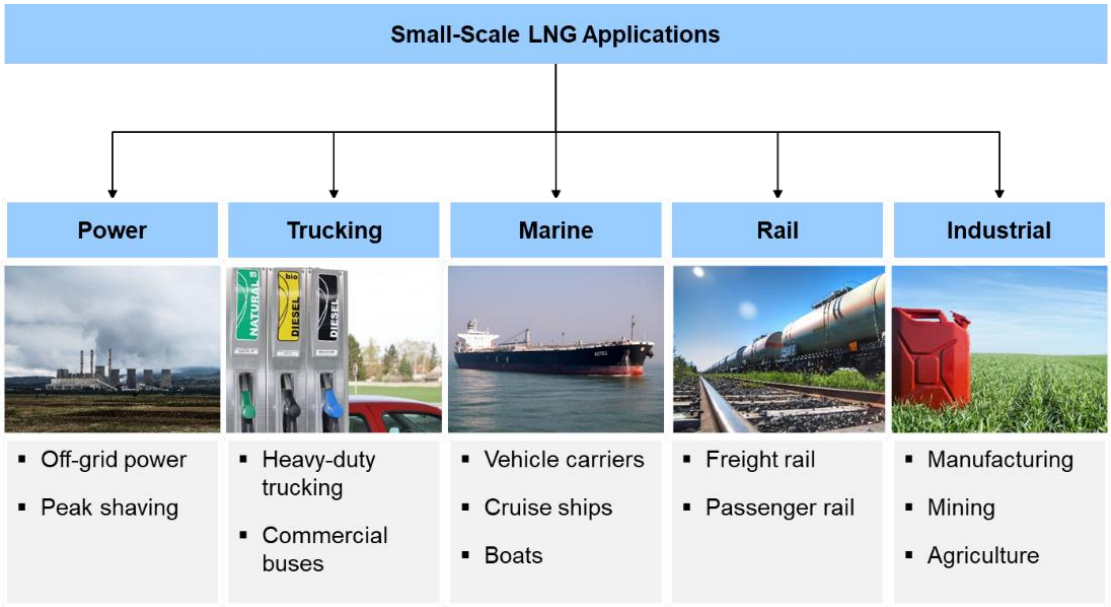
As LNG prices have fallen, demand elasticity has driven some demand growth. For example, the EU's imports of LNG doubled in the past two years primarily because the commodity has become less expensive. Further, abundant supply and lower prices have allowed new regions and sectors to consider adoption and development of applications of LNG (see Exhibit 6).

For example, LNG is finding use as a fuel to replace diesel in heavy-duty trucking, freight, and rail markets. Similarly, LNG is being adopted by ships and vessels with additional impetus for this application from the International Maritime Organization (IMO)'s rule limiting sulfur content in marine fuels.

Further, as LNG price drops, it is being used to fuel equipment in new market segments, including road paving; oilfield service; mining applications; power generation for agricultural, industrial, and remote residential activities. In addition, because LNG is competitively priced, its transportation in smaller volumes via ISO containers and small ships over shorter distances is becoming economically viable. As a result, LNG is being used to displace diesel for industrial or

back-up power generation in regions such as the Caribbean, where the markets are too small to be served by the traditional, large-scale LNG supply vessels and commercial models.

Exhibit 6. Small-scale LNG applications.



These factors – cheap and abundant supply especially from the U.S., cost-effective transportation options at various scales, and growing use in various emerging applications – coupled with Europe's decarbonization and environmental policies, familiarity with LNG, and energy supply security goals make LNG supplied at small scales and in containerized volumes an attractive fuel for various applications. Recognizing this potential, the U.S. Department of Energy has commissioned this study to assess the potential of LNG specifically in Central & Eastern Europe. Furthermore, given that this region's energy needs are likely smaller and more fragmented in comparison to other parts of Europe which have come to rely on LNG use via traditional, large-scale volumes, the U.S. Department of Energy has deliberately limited the scope of this study to small-scale and containerized LNG.

2.2. Objectives and scope

The U.S. Department of Energy commissioned the U.S. Energy Association (USEA) to assess market potential for small-scale and containerized LNG in Central & Eastern Europe. USEA has, in turn, partnered with the Gas Technology Institute (GTI) and ADI Analytics. This project has four main objectives:

1. Developing a concrete and thorough understanding of the market potential for small-scale LNG in Central and Eastern Europe

2. Identifying key infrastructure needs to enable the rapid deployment of small-scale LNG to the region
3. Identifying near- and medium-term opportunities to jump-start and accelerate deployment of small-scale LNG
4. Based on these opportunities, providing actionable recommendations to outside and local stakeholders in the public and private sectors

The fifteen countries that were specifically included in the geographical scope of this project include Albania, Austria, Bosnia & Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, Kosovo, Montenegro, North Macedonia, Poland, Romania, Serbia, Slovakia, and Slovenia. Exhibit 7 highlights these countries in the Central & Eastern Europe region.

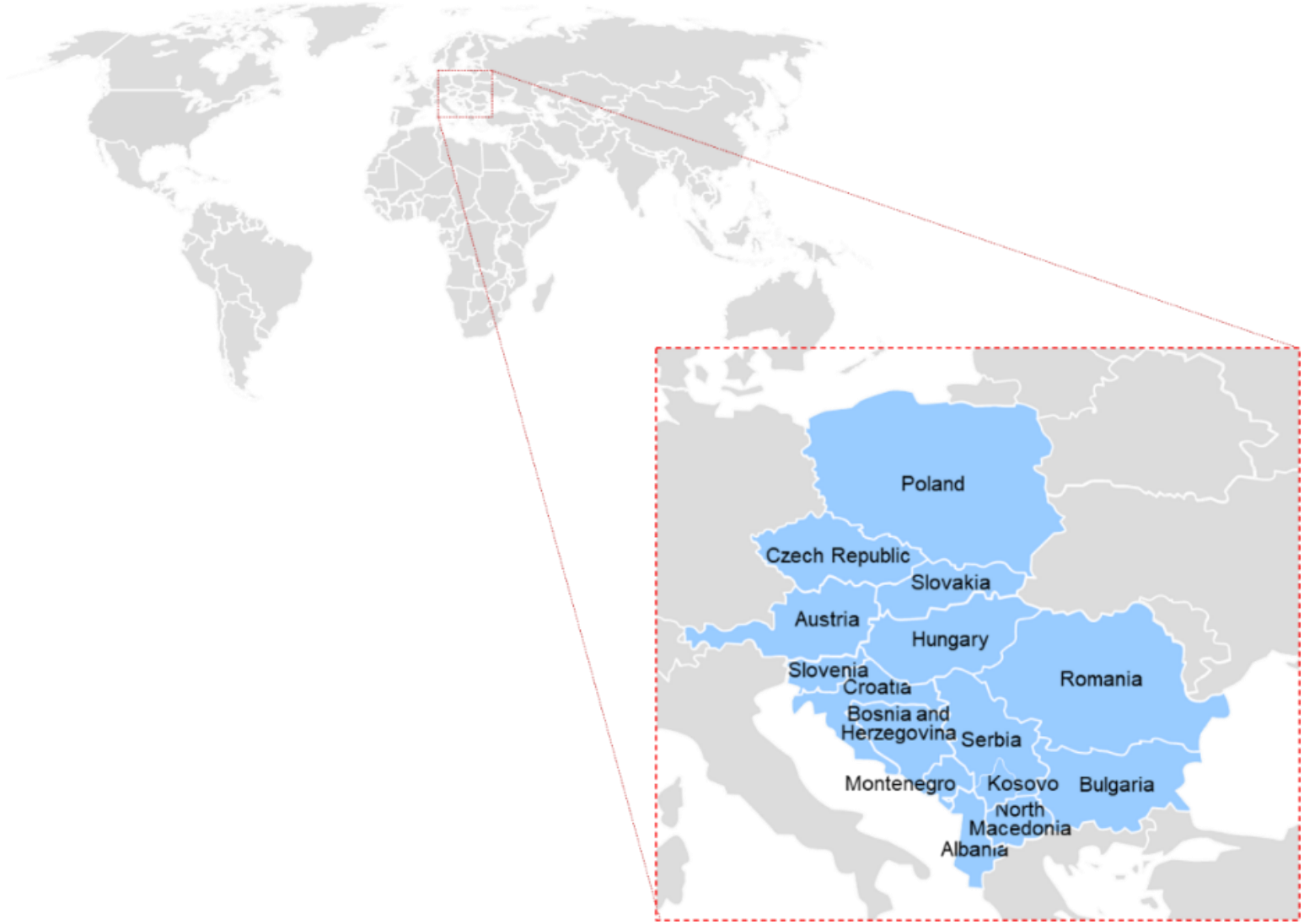
Further, the primary deliverable of this project – this study report assessing the potential for small-scale and containerized LNG in Central & Eastern Europe – has a scope with the following eight specific elements:

1. Review regional energy demand, mix, and outlook for potential LNG market drivers
2. Assess the historical and forecasted share of natural gas and LNG in the regional energy mix
3. Evaluate potential for small-scale LNG in various applications in the region
4. Evaluate existing and required infrastructure needs in likely demand scenarios
5. Estimate costs and summarize economics of small-scale LNG in representative applications
6. Review investment needs to facilitate the growth of small-scale LNG in the region
7. Analyze outcomes and findings to define strategic implications for the sector and region
8. Assess risks and develop recommendations including high-level policy guidance

2.3. Methodology

The team, including USEA, GTI, and ADI Analytics, completed this project in three key phases with frequent interactions and consultations with the U.S. Department of Energy. The first phase included a series of kick-off workshops with key regional stakeholders from a representative set of countries in the target region, to identify relevant issues and validate the proposed study scope and plans. The second phase was focused on developing this report using a mix of data collection and research tools and methods. The final phase of this project will include a series of virtual workshops to disseminate our findings and facilitate conversations around specific initiatives and projects.

Exhibit 7. Countries under study in Central & Eastern Europe.



The first phase of the project began with a series of kick-off workshops in February 2020 in Tirana, Albania and Podgorica, Montenegro. Both workshops were well-attended, attracting a wide range of stakeholders including U.S. and local government officials, policymakers, industry leaders, project developers and entrepreneurs, technical experts, and multilateral organizations. At each workshop, the project team introduced the technical and market fundamentals of small-scale and containerized LNG, its applications, advantages, and its costs and benefits. In addition, GTI and ADI Analytics introduced the goals, methodology, and timeline of this study, while also gathering inputs from other presentations at the workshops made by relevant stakeholders. The appendix includes agendas for both workshops.

In the second phase of this project, work on conducting the research and report writing was completed. ADI Analytics conducted the research and analytics and drafted this report in close collaboration with GTI and USEA. The effort to write this report began with extensive primary research with emphasis on phone interviews and conference calls with a broad range of relevant stakeholders in each of the 15 countries of interest. We interviewed approximately 75 U.S. and local stakeholders from government agencies, U.S. embassy offices, gas and LNG equipment vendors, and regional oil and gas companies including refiners, fuel retailers, and pipeline and electricity grid operators. A full list of stakeholders interviewed for this project is provided in the appendix.

These primary research efforts were supplemented by extensive secondary research covering a comprehensive range of materials in the public domain from government, industry, and policy groups. ADI Analytics gathered data from public sources on the energy supply and demand mix in the region, overall economic and industrial growth in each country, and policy and regulations supporting or hindering the prospects of small-scale and containerized LNG in the region.

Further, extensive spreadsheet modeling was conducted in the second phase of this project. The goals of the spreadsheet modeling were to quantify the price and cost competitiveness of small-scale and containerized LNG across key applications in Central & Eastern Europe. In addition, the opportunity for small-scale and containerized LNG in all fifteen countries was also evaluated based on a wide range of regional energy, economic, policy, and industrial metrics.

The third phase will be completed with publication of the report and a series of virtual workshops with interested regional stakeholders. Workshop agendas will focus on sharing the findings, strategic implications, and policy recommendations developed in this report along with facilitation of conversations to identify specific initiatives and actions to support the development of small-scale or containerized LNG projects in the region.

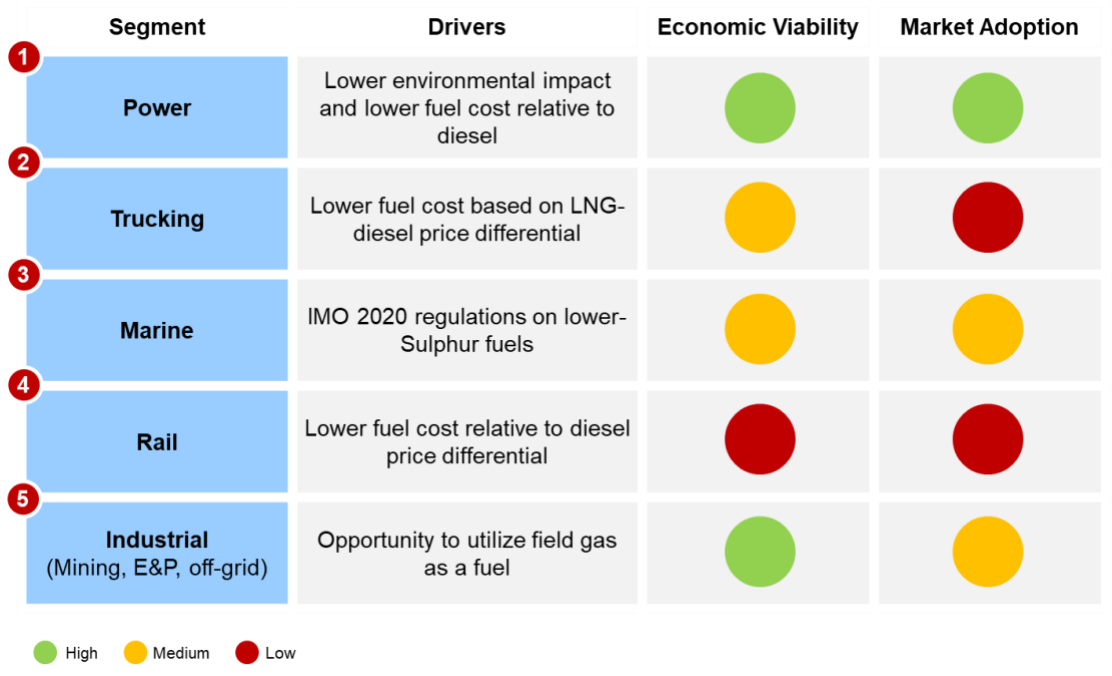
3.0 Introduction to small-scale LNG

3.1. LNG market segments and drivers

LNG is natural gas composed mainly of methane that has been cooled to about -260 °F to a liquid state. It is a clear, colorless, and non-toxic liquid and occupies almost 600 times less volume than natural gas. These features have enabled the use of LNG as a way to transport natural gas over long distances to end-users, markets and locations with growing energy needs, limited pipeline infrastructure, or where new pipelines are uneconomical or infeasible. LNG's ease of transportation also offers an opportunity to explore for and develop natural gas resources that are offshore or in remote locations.

LNG has typically been transported by large ships to various destinations where it is re-gasified to be used along with other sources of natural gas and sent to power plants, industrial facilities, and commercial and residential communities usually via pipelines. Natural gas can then be used in numerous applications as a fuel to generate power or heat. When compared to other forms of thermal power generation, LNG is a cleaner fuel that produces less greenhouse gas emissions and other pollutants such as the oxides of sulfur and nitrogen. Although power generation currently is the primary application of LNG, there are several other end-uses for the fuel which are shown in Exhibit 8.

Exhibit 8. Primary market segments and drivers for small-scale LNG.



In the past decade, LNG has also been used as a fuel replacing diesel and fuel oil in heavy-duty trucking, marine, and rail transport. Reduced emissions, regulatory incentives such as subsidies and tax rebates on cleaner vehicles, and potential fuel cost savings have all been drivers for the use of LNG as a transportation fuel. For example, the International Maritime Organization's IMO 2020 rule has cut allowable sulfur content of marine fuel oil from 3.5 weight percent (wt%) to 0.5 wt% starting January 1, 2020. Against this backdrop, LNG has become a more viable option as a marine fuel since it emits almost 90% fewer NOx and virtually no SOx and particulate matter in comparison to existing petroleum-based marine fuel oils.

Finally, LNG has also been long used as an emergency fuel for power generation. In the U.S., LNG is a peak shaving fuel used for power plants to produce electricity during peak utilization seasons. Newer applications of LNG at smaller scale have emerged in recent years, including industry, (e.g., for boilers), agricultural operations, and as a fuel for large and small vessels in the fishing and cruise industries. These applications are facilitated by the abundance of cheap LNG supply along with emissions reduction, energy security and diversity, and cost saving benefits.

3.2. Definition of small-scale LNG

The LNG industry has traditionally required scale to make its economics work. As a result, the conventional LNG industry has comprised of large liquefaction plants, storage tanks, shipping vessels, and regasification units. It has also typically served large consumers of natural gas such as utilities and natural gas-fired power plants. In comparison, several new applications that consume smaller volumes of LNG have emerged in recent years with a unique set of needs and business models that have spawned the small-scale LNG industry.

A modern natural gas liquefaction operation includes a suite of trains, each of which takes a certain volume of natural gas and converts it into LNG. A typical liquefaction train has capacities that range from 3 to 8 MTPA, which amounts to 4 to 10 Bcm per year. Exhibit 9 describes the various scales of liquefaction operations. Even so, most of these trains and plants are focused on LNG exports and their operating, investment, and commercial models do not allow them to serve smaller customers.

Until the recent past, most trains were at the higher end of large-scale LNG train capacity range but growing technology and capital project innovation has led to the emergence of mid-scale LNG trains. Mid-scale LNG trains are far fewer than large-scale or, even smaller-scale LNG plants but are receiving growing interest. Mid-scale LNG plants typically have trains of 1 to 2 MTPA in capacity, which translates to 100 to 300 Million standard cubic feet per day (MMCFD).

Small-scale LNG, which is defined is this report broadly to also include mini, micro, and containerized LNG segments is focused on serving specific end-use markets including heavy-duty trucking, rail, marine, peak shaving power, and industrial activities. In volume terms, small-scale LNG includes all plants with capacities lower than 1 MTPA or 100 MMCFD[8] while mini- or micro-plants are typically much smaller at less than 0.2 MTPA. Finally, LNG can also be shipped

around in ISO containers which are typically 10,000 gallons in volume each. Containerized LNG is finding application in small industrial plants, farming activities, and road paving, as well as power generation in small, remote communities.

Exhibit 9. LNG supply scales and capacities.

Focus of this study

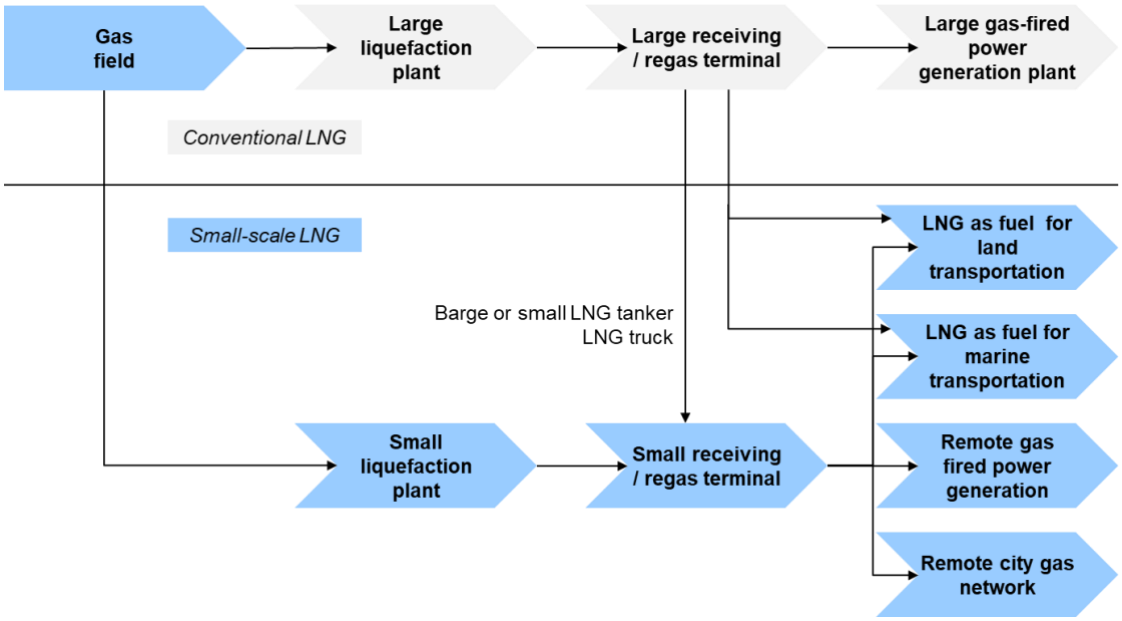
	Large-scale	Mid-scale	Small-scale	Mini / Micro	Containerized
					
million tons per year	3 - 8	1 - 2	<1	<0.2	16 tons or 10,000 gallons per container
million tons per day	0.008-0.022	0.002-0.005	<0.002	<0.001	
million cu. ft. per day	300 - 1,000	100 - 300	<100	<26	
billion cu. m. per year	4 - 10	1.4 - 2.7	<1.4	<0.27	
million gallons per year	1,875-5,000	625-1,250	<625	<125	
million gallons per day	5.15-13.70	1.71-342	<1.71	<0.34	

3.3. Small-scale LNG value chain

At a high level, the conventional LNG value chain comprises a few key steps. Natural gas is liquefied and shipped from export terminals in special ocean-going tankers that offload the LNG at import terminals. Regasification units then convert LNG back into natural gas for transportation usually via pipelines to gas-fired power plants, industrial facilities, and residential and commercial customers. Small-scale LNG value chains are similar to that of conventional, large-scale LNG although there are key differences. For example, a number of small-scale LNG applications, such as refueling service for land and marine transportation, industrial boilers, remote power generation, and farm equipment do not require regasification or pipeline construction and can be transported via trucks stored in tanks as LNG.

Exhibit 10 shows a representative view of a small-scale LNG value chain. Its five segments begin with LNG production and supply followed by supplier storage and transfer logistics, LNG transportation, customer storage and transfer logistics, and ending with utilization. Each of these segments is described in further detail later in this report.

Exhibit 10. A representative view of the small-scale LNG value chain.



4.0 Energy market review for Central & Eastern Europe

Most of the economies in Central & Eastern Europe are heavily dependent on coal or oil products such as diesel and heavy oil as primary sources of energy. Many countries in the region – i.e. Austria, Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania, Slovakia, and Slovenia – are European Union (EU) members, and several others – i.e. Albania, Bosnia & Herzegovina, Kosovo, Montenegro, North Macedonia, and Serbia – are signatories to the Energy Community Treaty and are obligated to adopt and implement EU energy law as they seek eventual EU membership. Although implementation is uneven, EU energy policy is already impacting policymaking and investment decisions in these countries. Decarbonization of the energy sector is a priority EU policy objective.

Natural gas via pipelines or large-scale LNG imports can play an important role towards these decarbonization goals through displacement of coal for power generation. LNG also offers the opportunity to decarbonize other sectors by displacing diesel and heavy fuel oil in heavy-duty trucking, rail, and marine transport. Similarly, several other sectors such as agriculture, fishing, and industrial applications in remote areas are also dependent on diesel or heavy fuel oil for their energy demand, and some of these applications could switch to LNG for decarbonization as well as energy supply security goals.

These decarbonization pathways will require additional natural gas supply which cannot be met by existing pipeline infrastructure. Further, new pipeline investments will likely be too expensive and unjustified in the near to mid-term given the scale of demand in these regions. As discussed earlier, small-scale LNG, however, could address this market with increasing supply, falling prices, and ease of transportation via tanker vessels, trucks, and even rail. Even so, the potential and viability of small-scale LNG varies widely within the region.

4.1. Regional small-scale LNG opportunity assessment

Given this background, we conducted a high-level opportunity assessment for small-scale LNG in Central & Eastern Europe. This is based on analyses of several key economic and energy indicators for the fifteen countries covered in this study. Specifically, we looked at energy demand and supply mix, prices, and policy and regulatory frameworks. In terms of economic activity, the analysis considered GDP growth rates, EU membership status, and current energy infrastructure investments.

Assessing the opportunity for small-scale LNG in the region was based on a screening model that included nearly 40 different parameters for each country. Each of these parameters was weighted for relative importance in influencing the country's demand and adoption of small-scale LNG. Exhibit 11 lists the parameters that were used for this screening exercise, grouped into six main sections i.e. total energy demand, natural gas demand, power generation, natural gas supply, diesel demand, and other factors such as economic growth, policy framework, and infrastructure. Exhibit 11 also shows the weighting assigned to each of the parameters.

Energy demand is the first of six parametric categories in our analysis. Sectors analyzed include industrial, transportation, and remote communities. Small-scale LNG can be particularly beneficial to remote areas that are inadequately served by natural gas pipelines or electricity grids. Energy needs of small islands, mines, and communities in forested, mountainous, and other difficult terrains are all examples of remote energy demand. We have assumed that the share of industrial demand that is fulfilled by diesel today is an approximate estimate of remote energy demand in these countries.

Energy demand growth is given a higher weighting than absolute demand which is included in the screening analysis but weighted lower. The underlying assumption is that countries whose energy demand is growing rapidly are more likely to explore emerging options such as small-scale LNG, while countries with high level of existing energy demand have a well-established set of supply options which can be scaled further more easily and economically.

Similarly, natural gas demand, the second set of criteria we use in the screening analysis, constitutes demand from industrial and transportation sectors, as well as remote communities. Natural gas demand growth is also rated highly, while absolute natural gas demand is weighted lower following the same logic as discussed in the preceding paragraph. In this set of criteria, the share of natural gas in the total energy mix of a country as well as in individual end-use segments are also considered, as a country's experience with natural gas is a key factor in its propensity to consider using small-scale and containerized LNG. In comparison to the other parameters, the share of natural gas in the energy mix and various end-uses is weighted at a midrange.

The third and fourth criteria sets in our screening analysis represent two major demand segments for natural gas as well as LNG at smaller scales: power generation and diesel demand. Although power generation often requires natural gas in volumes that are typically best served by large-scale LNG projects, small-scale LNG could potentially fuel power plants with capacities below 100 MW if supported by a number of other enabling factors. As a result, we have considered total power generation and gas-fired power generation growth as well in our analysis, along with other metrics such as the share of gas and coal in the power generation mix, and absolute power generation capacities. We likewise assign higher weights to growth rates over absolute capacities.

Diesel demand is an important criterion to consider in evaluating a country's potential adoption of small-scale LNG as the latter is a particularly effective fuel for heavy-duty trucks. Replacing LNG as fuel for heavy-duty transportation will benefit vehicle operators by lowering emissions, fuel and maintenance costs, and achieving higher fuel efficiency. In light of this, we have also evaluated diesel demand growth, diesel prices, and absolute diesel demand in each country for our screening analysis. Given that a heavy-duty trucking company's interest in switching over from diesel to LNG will depend on the sector's growth outlook and the potential to save on fuel costs relative to diesel, we assign the highest weightings to diesel demand growth and diesel prices.

Exhibit 11. Screening criteria for small-scale LNG opportunities in Central & Eastern Europe.

Metric	Unit	Weight
Energy Demand		
Growth of total energy demand	%	III
Growth of industrial energy demand	%	III
Growth of transport energy demand	%	III
Growth of remote* energy demand	%	III
Total energy demand	ktoe	I
Industrial energy demand	ktoe	I
Transport energy demand	ktoe	I
Remote* energy demand	ktoe	I
Natural Gas Demand		
Growth of gas demand growth	%	III
Growth of industrial gas demand	%	III
Growth of transport gas demand	%	III
Growth of remote* gas demand	%	III
Share of gas in total energy demand	%	II
Share of gas in industrial energy demand	%	II
Share of gas in transport energy demand	%	II
Share of gas in remote* energy demand	%	II
Gas demand	ktoe	I
Industrial gas demand	ktoe	I
Transport gas demand	ktoe	I
Remote* gas demand	ktoe	I

Metric	Unit	Weight
Power Generation		
Growth of total power generation	%	III
Growth of gas-fired power generation	%	III
Share of gas-fired power generation	%	I
Share of coal-fired power generation	%	I
Total power generation	GWh	I
Gas-fired power generation	GWh	I
Coal-fired power generation	GWh	I
Diesel Demand		
Growth of diesel demand	%	III
Diesel prices	€/L	III
Diesel demand	ktoe	II
Natural Gas Supply		
Growth of natural gas supply	%	III
Industrial natural gas prices	€/kWh	III
Natural gas supply	ktoe	I
Others		
GDP growth	%	III
Re-gasification capacity	bcm/yr	III
Coastline		III
Distance from nearest terminal	km	III
Policies and incentives promoting gas utilization		III

III – High importance, II – Moderate importance, and I – Low importance

*Remote demand includes agriculture, forestry, fishing, and other non-specified demand sectors

Natural gas supply is the fifth set of criteria used in the opportunity assessment. Specifically, we consider the pace of natural gas supply growth, industrial natural gas prices, and the absolute volume of natural gas supplied into each country. Of these, we assign the highest weights to the first two criteria followed by a lower weight to natural gas supply. Conceptually, a country's experience with natural gas supply and prices are critical factors in determining their interest and willingness to consider alternative sources of supply, in this context, in the form of small-scale and containerized LNG volumes.

Finally, other parameters such as GDP growth, existing and planned LNG import infrastructure, accessibility to coastlines and port infrastructure, and policies and regulations supporting LNG adoption have also been considered and weighted at the maximum values in this opportunity assessment model. Collectively, each of these factors is an enabler for the use and adoption of LNG in various applications, creating an opportunity for small-scale LNG volumes.

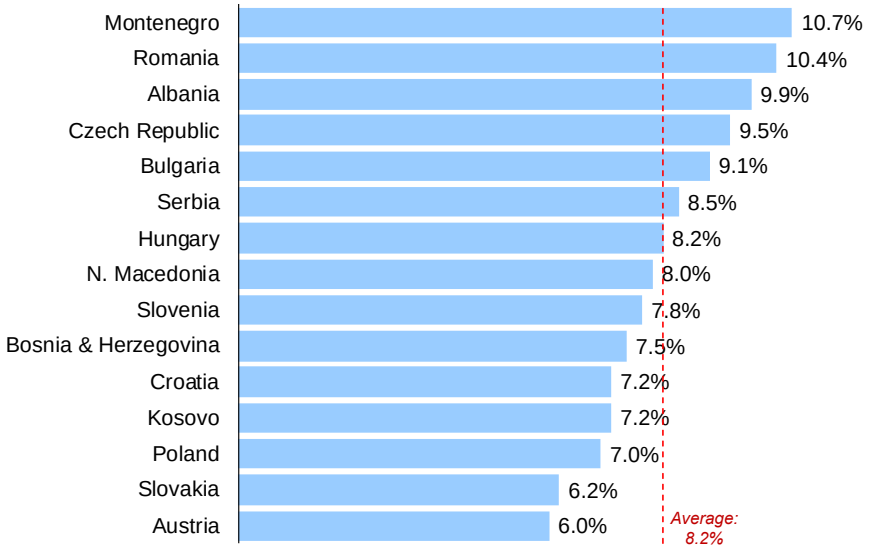
The countries were then grouped in terms of both potential for as well as barriers to adoption of small-scale LNG in the near, medium, and long term. Such an analysis identifies countries where a deeper assessment should be considered, and where efforts should be concentrated to enable and accelerate small-scale LNG adoption. However, such an assessment is not without risks. For example, this assessment uses historical data and may not adequately reflect on-going developments that could enable rapid changes in favor of small-scale LNG volumes. As a result,

it is important that this analysis is used to provide indicative guidance that should be calibrated and adjusted on a regular basis with inputs from additional research.

4.2. Energy demand, drivers, and outlook

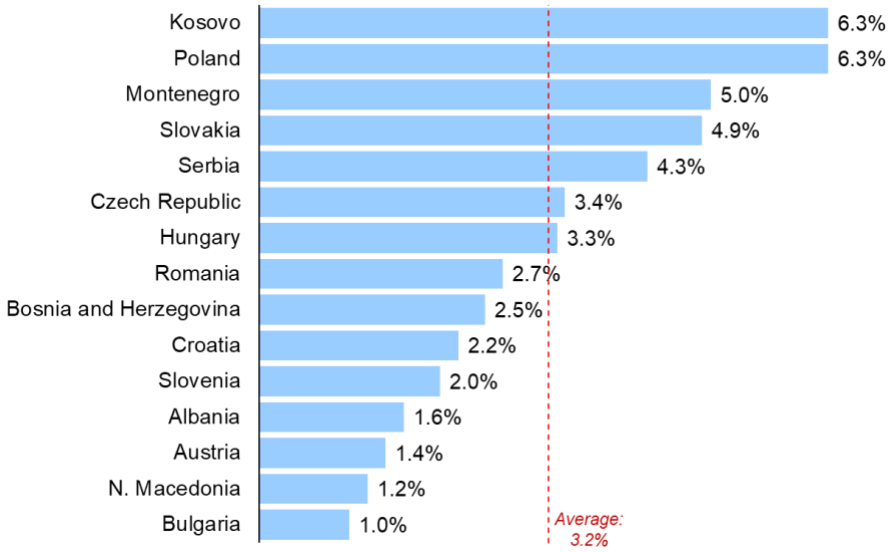
Energy demand, demand drivers, and outlook are a key set of criteria used in our screening model. Specifically, we look at GDP and energy demand growth, share of natural gas in the energy mix, and industrial gas demand growth among other things. Exhibit 12 shows GDP growth in the region, which has averaged 8.2% over the period between 2015-17. Montenegro, Romania, Albania, Czech Republic, and Bulgaria lead the region in GDP growth and all exceeded 9% annually. On that basis, these five countries look promising in their potential to adopt and use small-scale LNG in relevant applications.

Exhibit 12. GDP growth of countries in Central & Eastern Europe during 2015-17.[9]



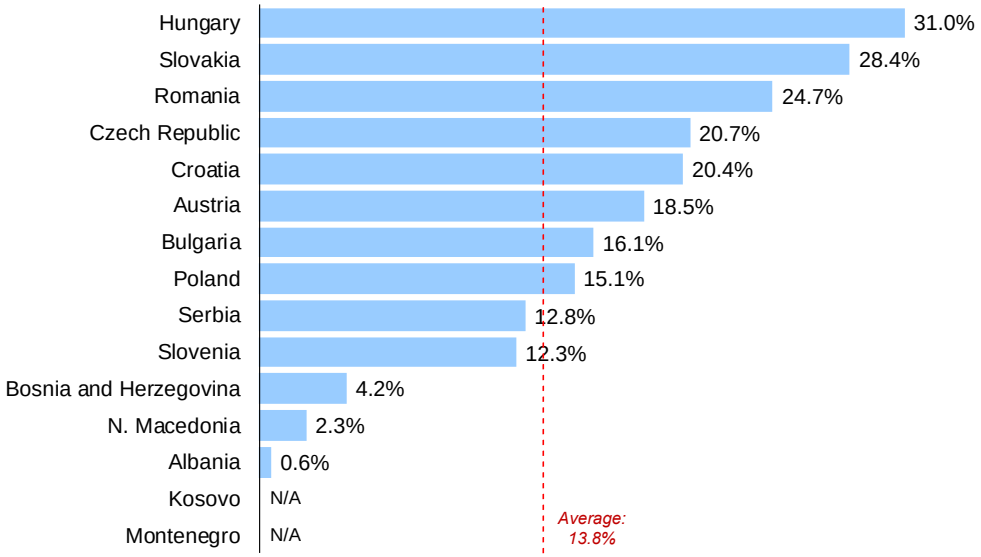
Diving deeper and more specifically into energy demand, Exhibit 13 shows the energy demand growth for the 15 countries covered in this study in Exhibit 11. Kosovo, Poland, Montenegro, Slovakia, and Serbia in that order accounted for the highest level of energy demand growth. Energy demand in all six countries grew at a rate higher than the regional average of 3.7% annually between 2015 and 2017.

Exhibit 13. Energy demand growth of countries in Central & Eastern Europe during 2015-17.[10,9]



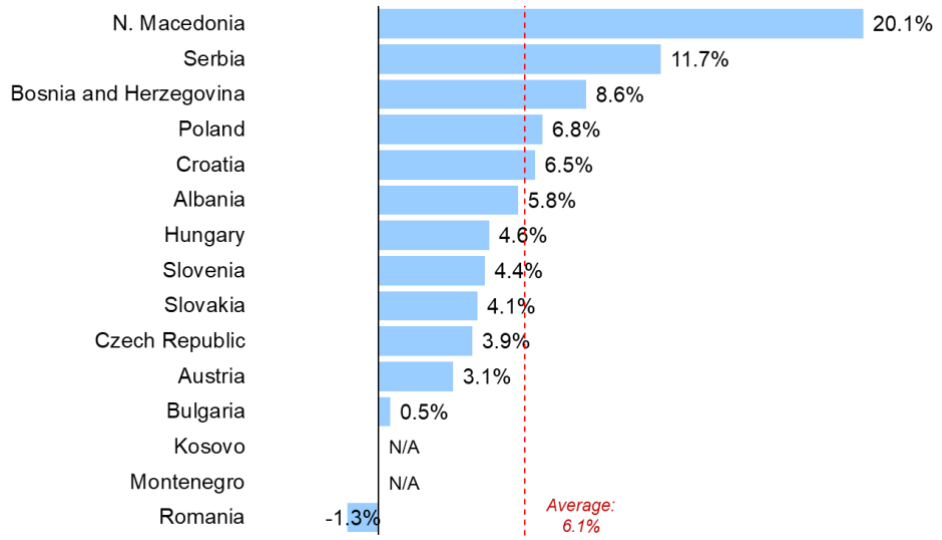
We then evaluated the share of natural gas in the energy mix as well as industrial gas demand growth in each country. As Exhibit 14 shows, Hungary has the highest share of natural gas in its energy mix at 31%, followed by Slovakia at 28%, Romania at 25%, Czech Republic at 21%, and Croatia at 20%. In general, the share of natural gas is higher than the regional average of 14.7% in most countries with four exceptions – Bosnia & Herzegovina, North Macedonia, Albania, Kosovo, and Montenegro. In most cases, the relatively higher share of natural gas in the energy mix correlates positively with a country's willingness to consider adoption of small-scale LNG.

Exhibit 14. Share of natural gas by country in Central & Eastern Europe over 2015-17.[9]



In the first set of assessment criteria, a final important metric that was considered was industrial gas demand growth. In the region, industrial gas demand growth is driven by North Macedonia and Serbia, growing at 20% and 12%, respectively. They are followed by Bosnia & Herzegovina, Poland, Croatia, and Albania, growing at 9%, 7%, 7%, and 6%, respectively. On somewhat expected lines, gas demand growth is highest in countries such as North Macedonia, Bosnia & Herzegovina, and Albania where natural gas has a very small share in the energy mix as shown in Exhibit 15.

Exhibit 15. Industrial gas demand growth in Central & Eastern Europe over 2015-17.[9]



4.3. Current and forecasted energy supply

Following a review of key criteria associated with energy and gas demand, we used a second set of criteria to evaluate energy supply. Specifically, we look at power generation growth by each country in Exhibit 16, growth of natural gas supply and its share in power generation in Exhibits 17 and 18, and, finally, the growth of diesel use in the energy mix of various countries in the region. All these energy supply-related metrics are critical factors in facilitating the use and adoption of small-scale LNG.

In the first criterion, Slovenia, Bosnia & Herzegovina, and Croatia have led the region in power generation growth in the recent past, growing at 2.6%, 2.5%, and 2.5%, respectively. Average growth in the remaining countries in the region was less than 2% annually. In comparison, the region has actually seen power generation decline by an average of 1.3% annually over the period between 2015 and 2017. Far larger declines in Albania, Montenegro, and Bulgaria followed by smaller declines in Slovakia, Serbia, Kosovo, Romania, and North Macedonia have occurred in power generation, driven mainly by irregular rainfall and resulting variations in hydropower generation. Regions where power generation is growing are likely candidates to consider small-scale and containerized LNG to meet their growing power generation needs.

Exhibit 16. Growth in power generation in Central & Eastern Europe over 2015-17.[9]

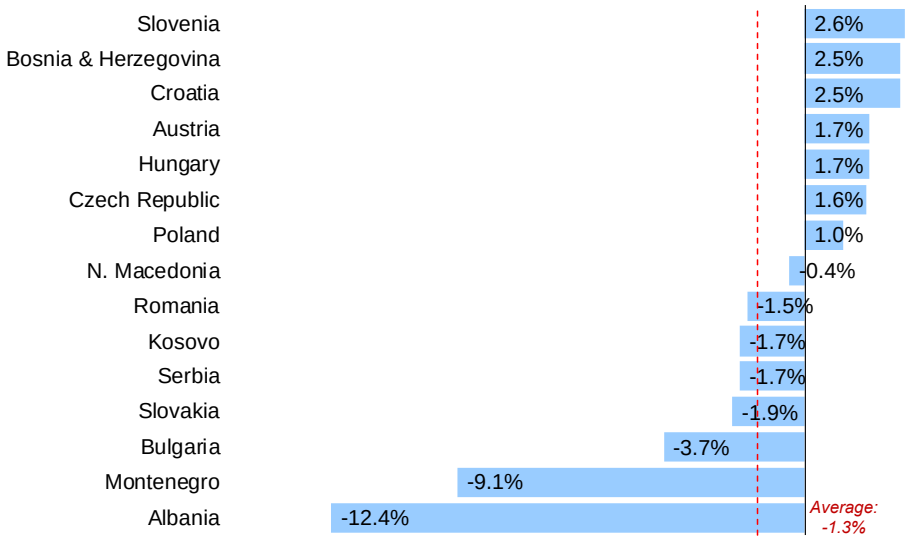


Exhibit 17 shows that North Macedonia is leading the region at 42% gas supply growth in the recent past while gas supply in Albania and Serbia grew at 17% and 10%, respectively. Gas supply growth in Croatia, Bosnia & Herzegovina, and Poland grew at 9%, 6%, and 5%, respectively, over the 2015-17 period while the rest of the region grew at less than 5% annually. Natural gas supply growth reflects potential support for imports and utilization of small-scale plants and containerized LNG.

Exhibit 17. Gas supply growth in Central & Eastern Europe over 2015-17.[9]

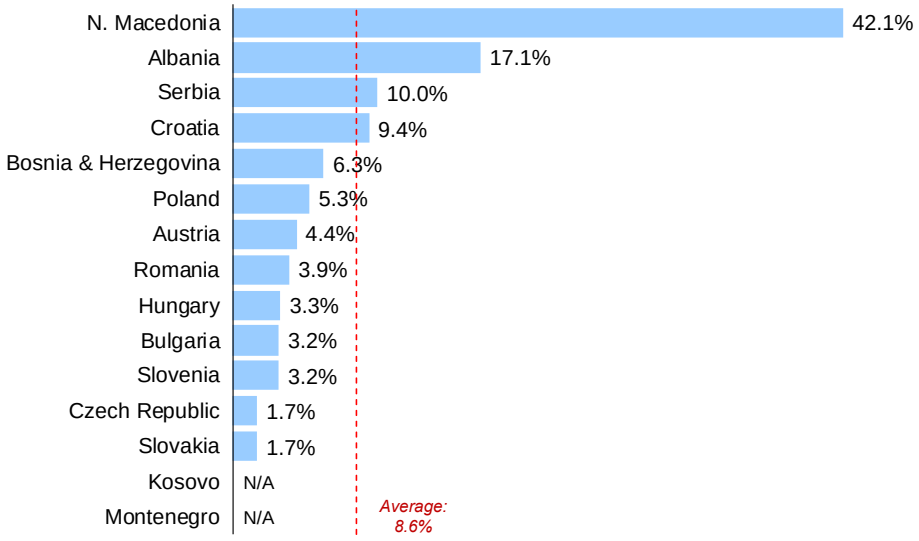
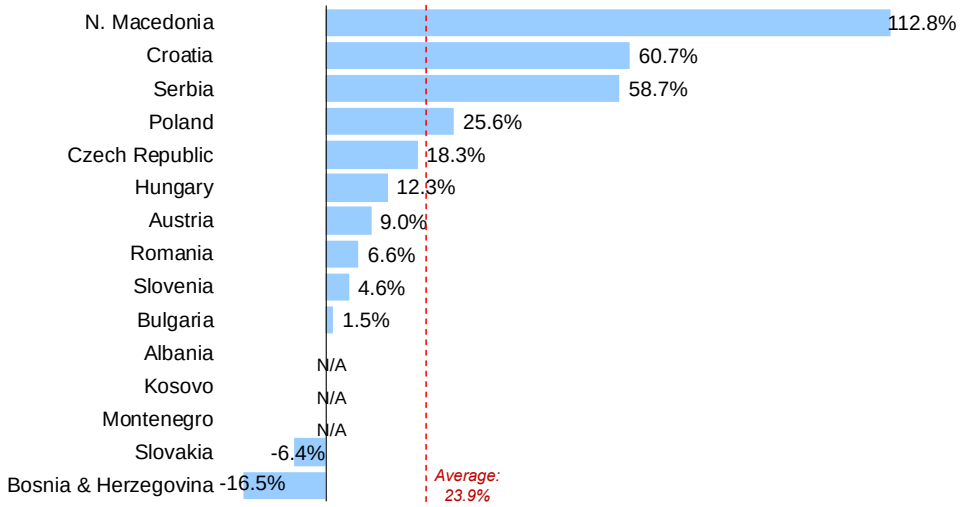


Exhibit 18 shows that the share of natural gas in power generation grew at a robust annual rate of 20.4% over the 2015-17 period. Among all countries, North Macedonia has seen the highest growth rate of 113%. In Croatia, Serbia, Poland, Czech Republic, Hungary, and Bosnia &

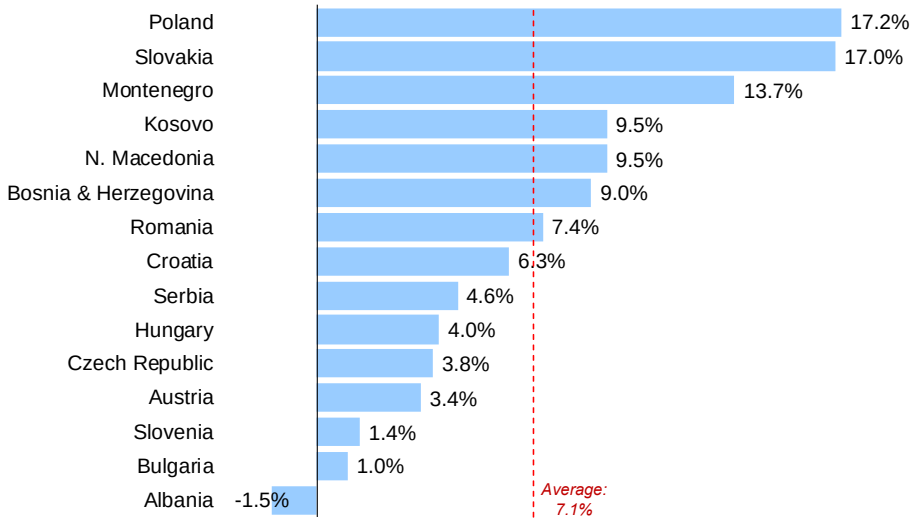
Herzegovina, gas-fired power generation grew at 61%, 59%, 26%, 18%, 12%, and 12%, respectively. The rest of the region grew at less than 10% in the same time period.

Exhibit 18. Natural gas use growth in power generation in Central & Eastern Europe.[9]



A final energy supply metric that was evaluated was supply of diesel. With minimal investments, diesel can be replaced by LNG in various applications such as heavy-duty trucking. As a result, growth in diesel supply can provide interesting insights into countries where this very growth could be supplemented by small-scale and containerized LNG volumes. Considering the growth of diesel demand in the region as illustrated in Exhibit 19, Poland, Slovakia, and Montenegro have seen the highest growth between 2017 and 2019 at 17%, 17%, and 14%, respectively, while North Macedonia, Kosovo, Bosnia & Herzegovina, Romania, and Croatia grew at 10%, 10%, 9%, 7%, and 6%, respectively. The rest of the region grew at less than 5%.

Exhibit 19. Diesel supply growth by country in Central & Eastern Europe over 2015-17.[9]

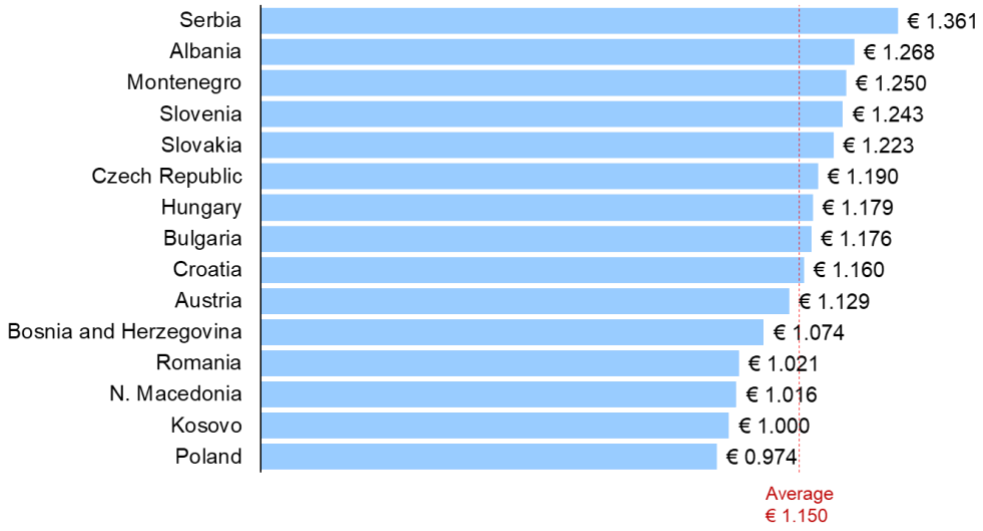


4.4. Energy costs, economics, and pricing

Fuel prices have been a critical driver in establishing the economic competitiveness and, therefore, adoption of small-scale and containerized LNG in the markets where it has been successful. Specifically, delivered LNG cost must be significantly cheaper than the cost of the incumbent fuel before end-users would consider switching, as the fuel price differential is necessary to pay for the incremental capital cost of converting away from diesel or LPG to LNG. As a result, the key fuel prices in each country were reviewed and summarized in Exhibits 20-23.

Exhibit 20 shows diesel prices (including taxes) in each of the fifteen countries. Average diesel price is €1.15 per liter and most countries have higher prices than that. Serbia, Albania, Montenegro, and Slovenia have the highest diesel prices in the region, while Romania, North Macedonia, Kosovo, and Poland have the lowest diesel prices. Only six countries have diesel prices lower than the regional average. In a later section of this study, regional diesel prices will be compared with the cost of delivered LNG price to estimate the fuel price differential given its importance in driving small-scale and containerized LNG adoption.

Exhibit 20. Regional diesel prices in 2019 with taxes in € per liter.[10]



Industrial use of small-scale LNG will have to compete with pipeline gas as well as LPG, both of which are used widely by that segment in the region. Exhibits 21 and 22 shows natural gas prices paid by industrial customers, and LPG prices by country in Central & Eastern Europe. Average natural gas price for industrial customers – often higher than that paid by the residential customers – is €0.035 per kWh and most countries pay less than that. Similarly, average LPG price is €0.358 per liter without taxes across the region. The countries are almost evenly split across that average with Austria being an outlier with significantly higher prices than the average.

Exhibit 21. Regional industrial natural gas prices in 2019 without taxes in € per kWh.[11]

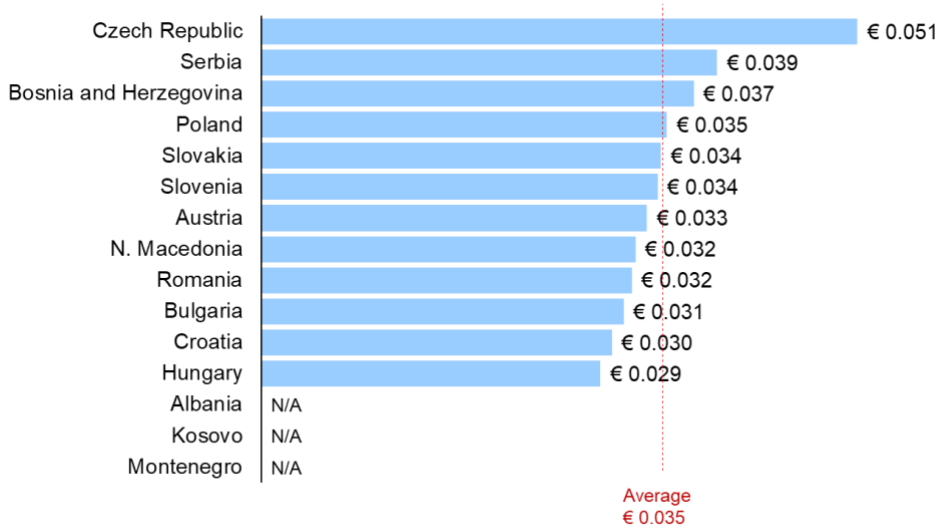
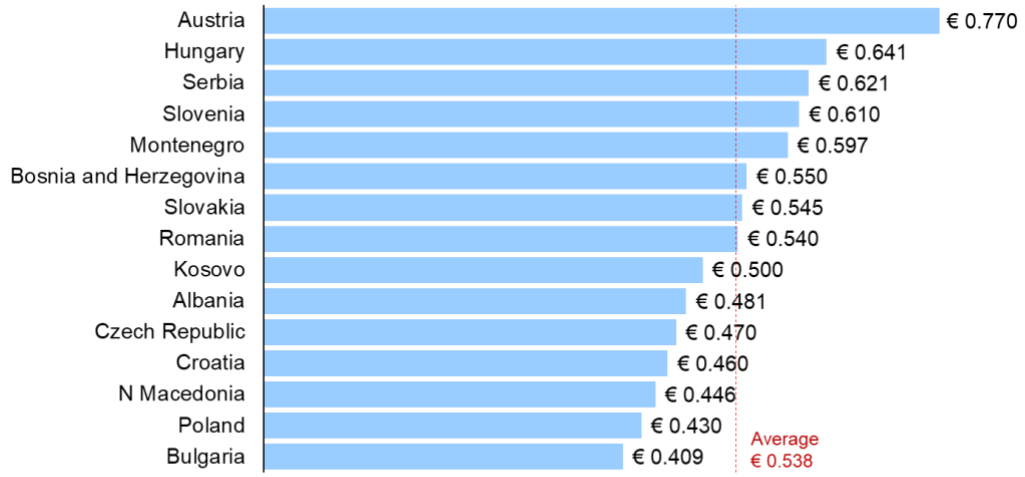
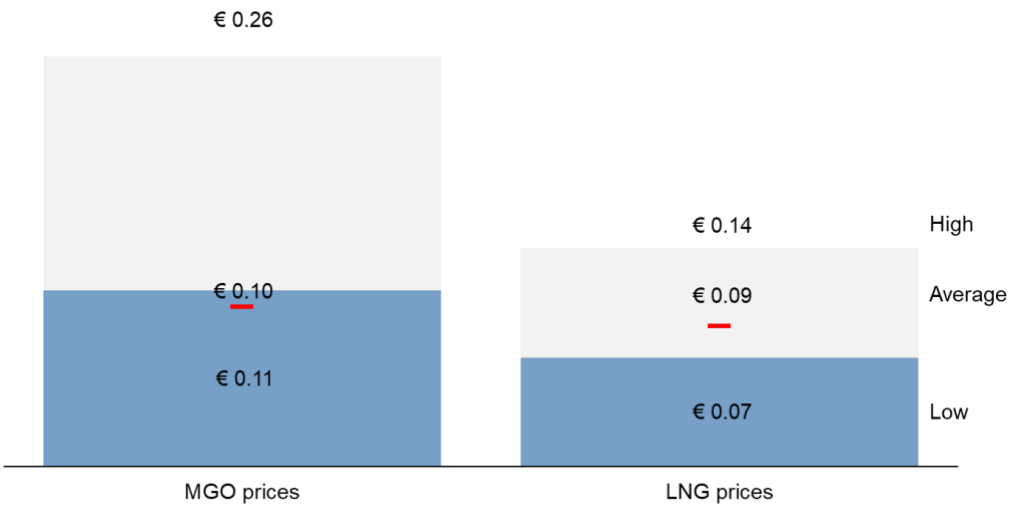


Exhibit 22. Regional LPG prices in 2019 in € per liter with taxes.[12]



Finally, we also summarize recent marine gas oil and LNG prices in the region in Exhibit 23. Marine gas oil is widely used by ships and vessels and is regulated for sulfur content along with other marine emissions by the IMO in a set of rules that took effect in early 2020. As a result, ship fleet operators are switching to LNG and the economics depend on the price differential between marine gas oil and LNG.

Exhibit 23. Regional marine gas oil and LNG prices in 2019 in € per liter without taxes.[13,14]



4.5. Opportunity assessment findings

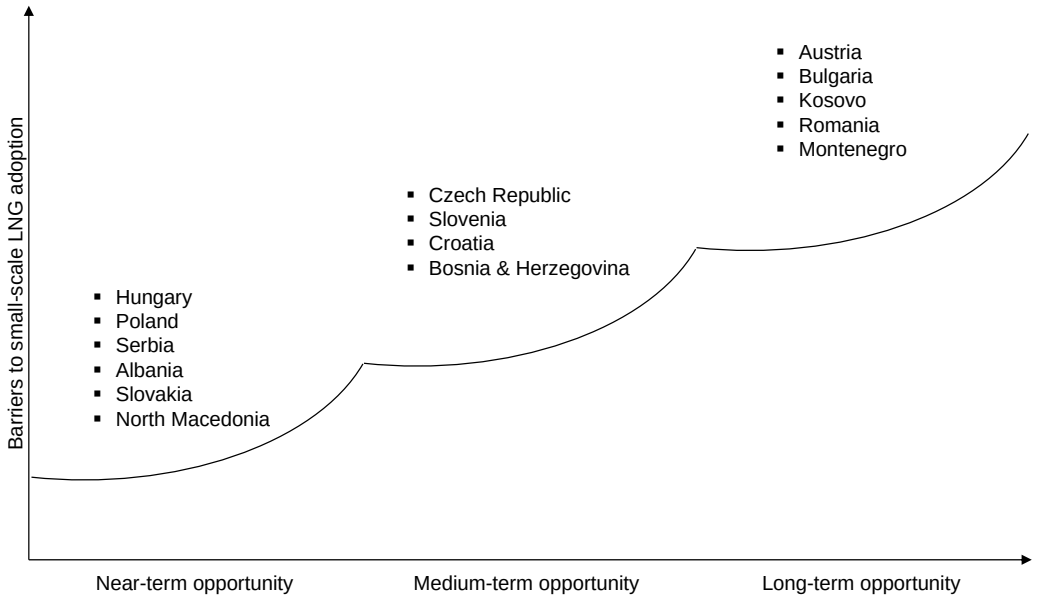
Each of the metrics in these criteria sets, coupled with weights for each criterion, was used in the opportunity scoring model as described in section 4.1 of this report. The total opportunity assessment – an indicator of the potential for small-scale and containerized LNG – for each of the different countries in Central & Eastern Europe is summarized in Exhibit 24. The assessment is representative of prospective growth opportunities and drivers in the individual countries and how soon they will be able to monetize on the small-scale LNG opportunities.

Countries with limited barriers to near-term opportunity for growth in small-scale LNG adoption include Hungary, Poland, Serbia, Albania, Slovakia, and North Macedonia. All these countries have several factors that drive demand for small-scale and containerized LNG. In comparison, the countries including Montenegro, Romania, and Kosovo have significant barriers to adoption of small-scale LNG today, and will likely see growing adoption of small-scale LNG only in the long term. The remaining countries – Czech Republic, Slovenia, Croatia, Austria, Bosnia & Herzegovina, and Bulgaria – are likely to see growth in small-scale LNG adoption in the medium term.

It must be emphasized that this opportunity assessment exercise is representative of the potential for small-scale LNG in these countries. Opportunities concerning gas or large-scale LNG do not fall in the same category as small-scale LNG. It is based on numerous metrics that were used in the screening model. Dramatic changes in these metrics or significant changes to the policy and regulatory landscape could have a major impact on the opportunity assessment of the concerned countries.

As a result, it is important to use this analysis as a purely representative and directional view of the opportunity for small-scale LNG in Central & Eastern Europe. This assessment is in no way a comprehensive and definitive view of the potential for small-scale and containerized LNG. It is also not a forecast for small-scale LNG demand in the region. It describes the ease with which small-scale LNG can be adopted in the region in multiple timeframes.

Exhibit 24. Total opportunity assessment by country in Central & Eastern Europe.



A deeper level of the opportunity analysis is provided in Exhibits 25-28 where we compare the results of the opportunity assessment with a few drivers in the broader context that would be supportive of small-scale LNG adoption. Specifically, we looked at how the opportunity for each region compares to GDP growth, natural gas and diesel demand growth, and remote energy demand growth between 2015 and 2017. These analyses offer greater insight into the underlying factors while the entire data set informing this opportunity assessment is provided in the appendix.

Generally speaking, a few common themes among countries that are opportunistic in the near-term include strong and growing economies, therefore rising demand for energy and, in some cases, for natural gas in the industrial sector. A second common driver is the share of natural gas in the transportation sector, which is especially high in Hungary, Albania, Slovakia, and North Macedonia. Remote applications for natural gas is another driver in Poland and Serbia. Finally, Hungary and Slovakia have the benefit of being closer to LNG terminals in neighboring countries and hence, better connectivity with the spot market.

In contrast to these countries, the obstacles to small-scale LNG adoption in the countries such as Kosovo, Romania, and Montenegro are somewhat country-specific and they can be addressed and overcome in long-term. These obstacles include low economic growth, falling energy demand particularly in transportation and remote applications, minimal experience with natural gas, existing and well distributed gas infrastructure, and longer distances to the nearest LNG terminals.

Exhibit 25. GDP growth versus total opportunity.

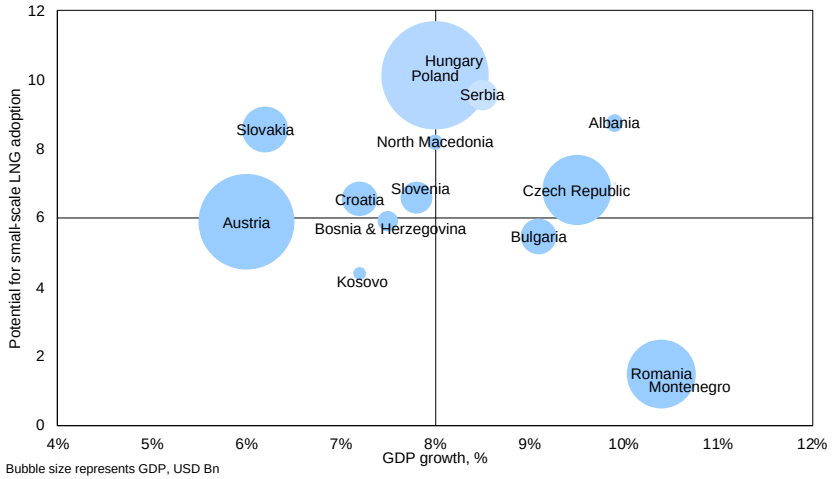


Exhibit 26. Natural gas demand growth versus opportunity.

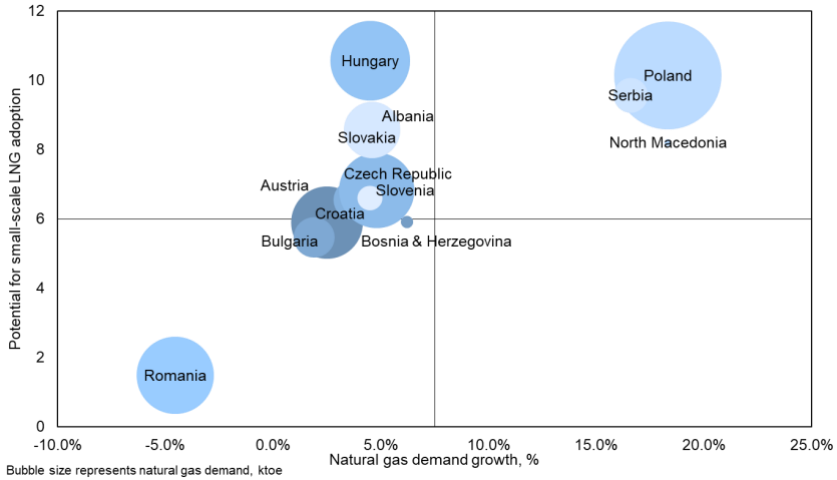


Exhibit 27. Diesel demand growth versus opportunity.

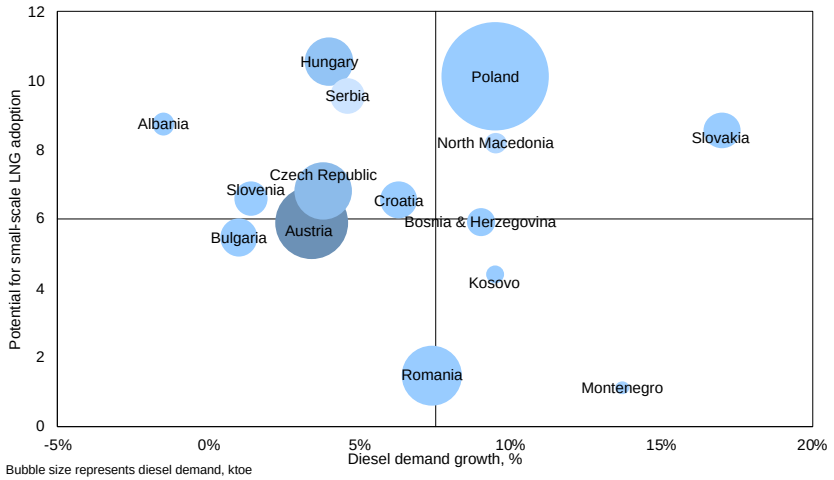
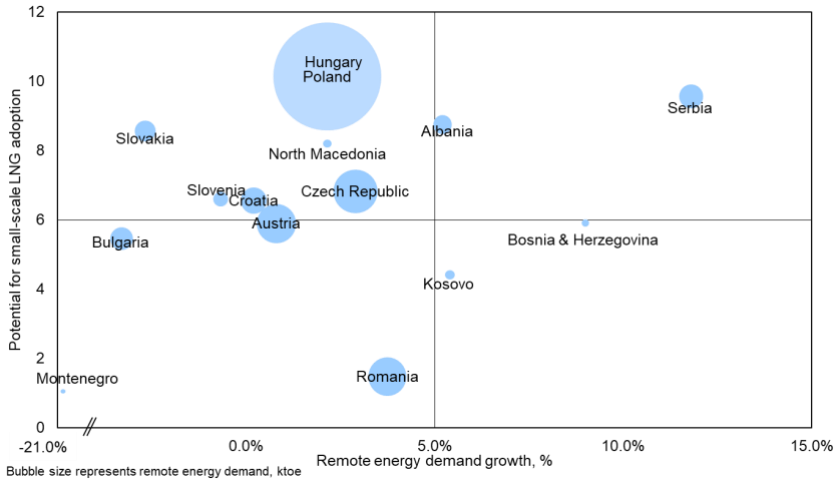


Exhibit 28. Remote energy demand growth versus opportunity.

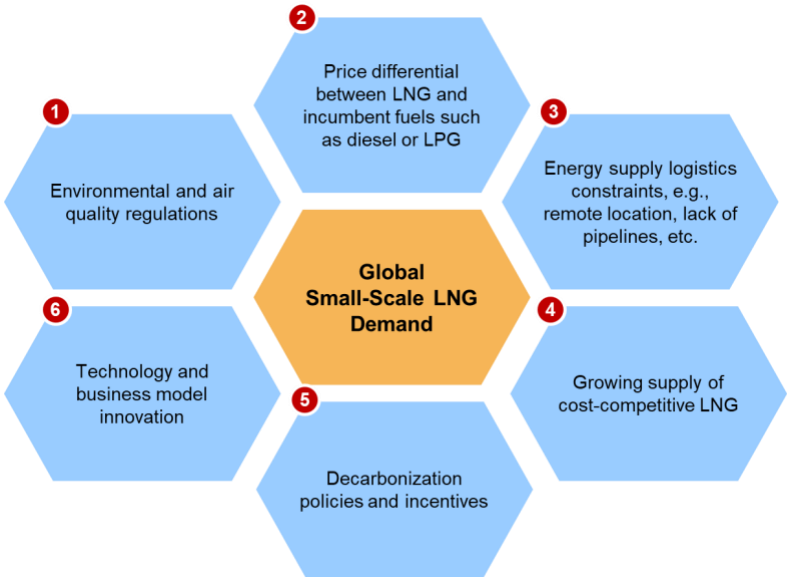


5.0 Small-scale LNG demand assessment for Central & Eastern Europe

5.1. Demand drivers for small-scale LNG

Six demand drivers have enabled the growth of small-scale and containerized LNG in most regions and market segments around the globe where it is being used. Exhibit 29 summarizes these six demand drivers, which include environmental regulations, price differentials between LNG and incumbent fuels, energy supply constraints, growing availability of cheap LNG, decarbonization policies, and innovation in both technology and business models.

Exhibit 29. Demand drivers for small-scale LNG.



Air quality regulations and environmental standards have played an important role in stimulating demand for small-scale and containerized LNG. Replacing diesel with LNG in heavy-duty trucking offers the prospect of substantial emission reductions including greenhouse gases as well as oxides of nitrogen and sulfur – a factor that has led to significant penetration of LNG in heavy-duty trucking in China. Regulations that seek to reduce emissions can particularly drive demand for small-scale LNG. A good example is the IMO 2020 rule limiting sulfur and nitrogen oxide emissions that has led several marine vessel fleets in Europe, U.S., and Asia to switch from fuel oil to LNG.

Each market that has adopted LNG at the smaller scales has been enabled by a mix of drivers. A second important demand driver for small-scale and containerized LNG is the opportunity to reduce energy costs. As natural gas and LNG supply has grown and prices have fallen, end-users in markets with high diesel prices can save money through fuel switching. The opportunity to cut fuel and vehicle operating expenses has been another important driver for small-scale LNG demand in the U.S., Europe, and China where small-scale LNG has emerged as a trucking fuel.

Small-scale LNG has gained traction in demand centers that are in remote locations or in regions with significant energy supply constraints. It offers end-users in these segments the option to switch to a cleaner and cheaper fuel with relatively straightforward storage and logistical requirements. Examples include communities using heavy oil in northeastern U.S. where pipeline connectivity is limited, remote industrial sites such as mining operations, and islands in the Caribbean where tourism demands a switch to cleaner fuels. Additional drivers that typically support small-scale LNG demand and adoption include growing supply of LNG, decarbonization policies, and innovation in both technology as well as commercial models.

Decarbonization targets, like air quality regulations, also have a direct and immediate impact on driving LNG demand. For example, consumer brands and shipping companies have proactively switched away from diesel to LNG as a fuel for their operations to reduce their carbon footprint. Finally, new technologies such as LNG distribution via ISO containers and safer and more efficient LNG storage methods, as well as innovative commercial models including new pricing mechanisms, contractual terms, trading flexibility, and risk management have also made it easier for a wider range of demand segments to consider using small-scale and containerized LNG.

The relevance and impact of these demand drivers can vary by market segment and region. For example, the price differential between diesel and LNG is particularly important for heavy-duty trucking markets but air quality regulations have played a greater role in driving up demand for small-scale LNG in marine applications.

As a result, we expect a high level of variation in drivers for small-scale and containerized LNG's adoption and applications in Central & Eastern Europe. Further, in addition to the various demand drivers, there are a number of regional and local factors – e.g., economic and energy demand growth, fuel taxes, regional energy and transportation infrastructure, etc. – that will play a role in the adoption rate of small-scale LNG. Consequently, it is not possible to predict with high certainty what applications will likely be first or what countries will extensively adopt small-scale and containerized LNG volumes. Even so, a brief review of the most likely applications for the region are discussed in the next section.

5.2. Review of small-scale LNG applications

Our interviews with a broad range of stakeholders in Central & Eastern Europe showed that, at a high level, there is interest and some existing activity in the region around the use of LNG in smaller scales for a number of applications. These include road and marine transportation and power generation for industrial and remote energy needs. Most of these activities, however, are limited in scope and at pilot or demonstration scales except for a few countries in the region such as Poland and Czech Republic. In comparison to Northwest Europe, small-scale LNG activities in Central & Eastern Europe are considerably muted. As a result, even LNG equipment vendors who have manufacturing capacity in the region reported most project activity in northwest Europe and limited opportunities at the present time in Central & Eastern Europe.

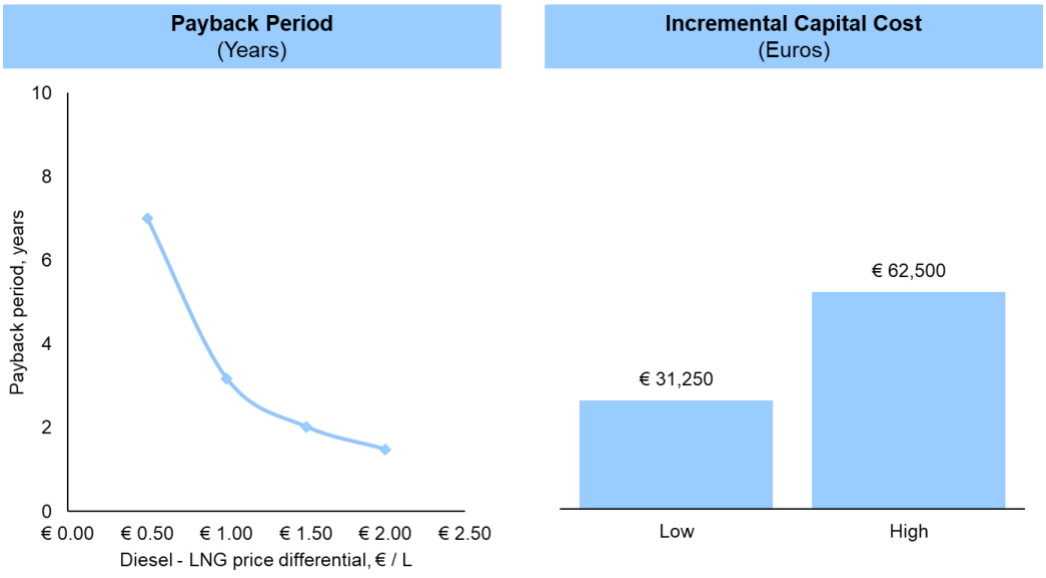
The use of small-scale and containerized LNG could significantly benefit three segments – heavy-duty trucking, marine bunkering, and industrial power – where we expect the fuel to gain traction in Central & Eastern Europe. A few other potential niche markets, e.g., small-scale LNG use in agriculture and road paving, could see varying degree of penetration among different countries in the region. Each of these applications are discussed briefly in this section.

5.2.1 Heavy-duty trucking

LNG is increasingly used in heavy-duty trucking for its potential to offer truck fleet operators significant savings in fuel and maintenance costs and reductions in emissions of greenhouse gases, particulate matter, and oxides of sulfur and nitrogen. China, Europe, and the U.S. lead the world in the use of LNG as a trucking fuel. We estimate that over 10,000 LNG-fueled trucks are currently operating in Europe with more than 4,500 new vehicles registered in 2019.[15]

Truck fleet owners considering switching from diesel to LNG typically incur an incremental cost of €30,000 to €62,500 as LNG-fueled trucks are more expensive than conventional trucks using diesel. However, LNG is typically less expensive than diesel and the price differential between the two fuels can facilitate a rapid payback of the investment. One of the incentives in place that drive cost competitiveness of LNG is toll waivers on German highways, a major destination for many manufacturers in the region. Other incentives include rebates on new LNG trucks and subsidies on retrofit. Exhibit 30 shows the economics of switching away from diesel in favor of LNG for trucks and reflects payback periods of less than three years if the diesel-LNG fuel price differential is at least €1 per liter.

Exhibit 30. Economics for use of LNG as fuel in heavy-duty trucking.[16]



Of the various end-use segments, road transportation with emphasis on heavy-duty trucking is an application where small-scale LNG has enjoyed the most interest and attention in Central & Eastern Europe as reflected in our stakeholder interviews. As shown in Exhibit 31, a number of countries in the region – Austria, Croatia, Czech Republic, Hungary, Poland, Slovakia, and Slovenia – have LNG refueling stations for heavy-duty trucks. However, most of these countries do not have more than a few LNG refueling stations and further infrastructure investments are needed to realize the potential of this application. An LNG-fueled heavy-duty truck can travel up to 1,600 km[17] before refueling and hence, not many refueling stations are needed.

In addition to LNG refueling stations for trucks, there are a few other projects such as the conversion of buses from diesel to LNG and CNG in Tirana, Albania. Similarly, since Germany has waived tolls on LNG-fueled trucks, there have been cases of businesses in Slovakia requesting transportation vendors to adopt LNG trucks to save on fuel and transportation costs.

Diesel prices are high in the bulk of the region primarily due to taxes as reported by a number of our interviewees. Against this backdrop, LNG's price competitiveness relative to diesel will be critical to its adoption in the region. However, small-scale LNG will also face stiff competition from other alternative fuels, most notably LPG, CNG, and biofuels which already enjoy higher levels of policy support from the EU.

Exhibit 31. Existing LNG fueling stations in Central & Eastern Europe.[18]

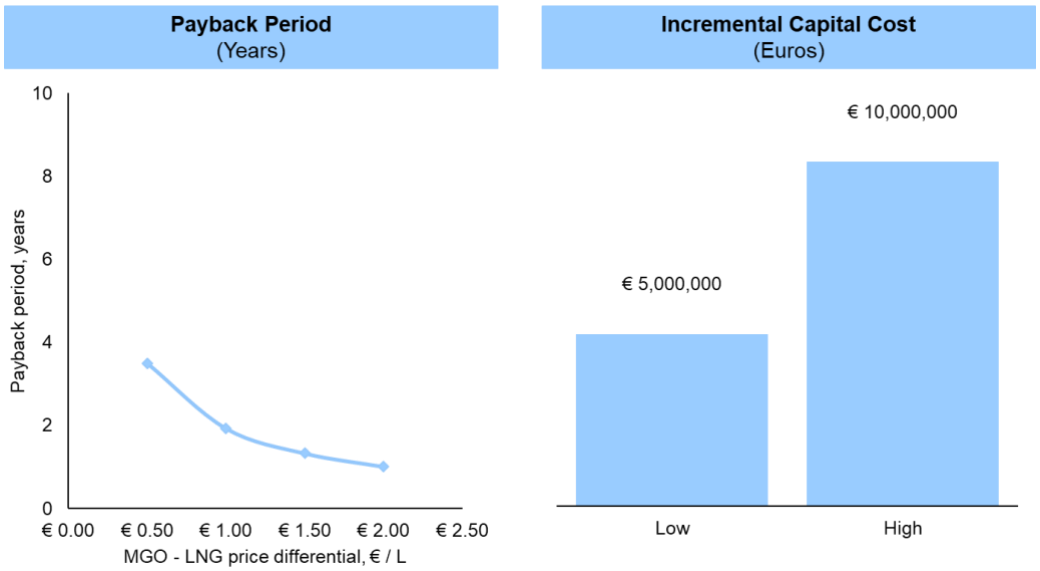
5.2.2 Marine bunkering

Marine transportation is another segment where small-scale LNG has experienced significant market penetration. Europe, U.S., and Asia all have seen greater levels of LNG use in marine transportation replacing fuel oil typically used to power ships and vessels. A lot of this growth for small-scale LNG in the marine transportation segment has been facilitated by regulations, specifically the IMO rule limiting sulfur in fuel oil as well as emissions from engines on ships.

At the beginning of 2020, approximately 175 LNG-fueled cargo ships were in operation globally.[19] Further, more than 220 new ships – 10% to 20% of all new ships on order – are capable of using LNG.[20] In addition, more than 600 LNG carriers are primarily fueled by LNG.[19] Over the past decade, the number of LNG-fueled marine vessels has been growing at a robust pace between 20% and 40% each year.[20] Although there are several types of marine vessels that can use LNG as a fuel, new LNG-capable ships on order tend to be deep-sea vessels such as crude oil and refined product tankers, bulk carriers and containers, and cruise ships.

Similar to the economics of LNG use in heavy-duty trucking, vessel owners will have to invest in either new ships or retrofit their existing engines to use LNG as a fuel and as can be seen from Exhibit 32, it is a competitive option. The incremental capital cost of vessels that can use LNG as a fuel ranges from €5,000,000 to €10,000,000 although this has been declining with growing shipbuilding experience. Fleet owners need LNG to be cheaper by anywhere from €0.50 to €2.0 per liter relative to marine gas oil (MGO) in order to deliver payback within three years.

Exhibit 32. Economics for use of LNG as fuel in marine bunkering.[21]



Small-scale LNG has recently enjoyed strong adoption in marine transportation across Europe supported by clean fuel regulations imposed by the IMO. Several countries in Northwest Europe

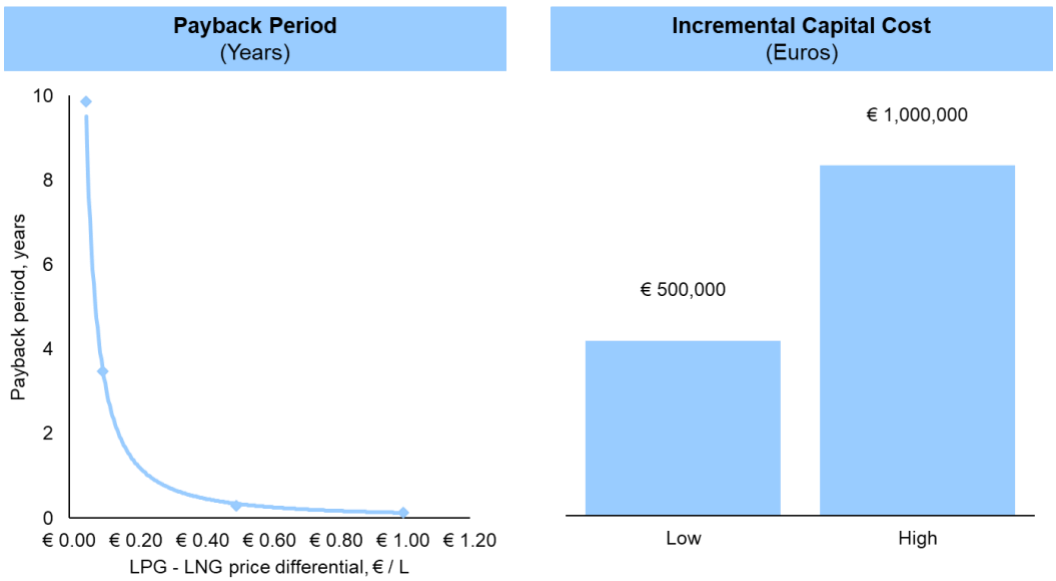
have successfully started using small-scale LNG for marine transportation but its use in Central & Eastern Europe is nascent given limited bunkering infrastructure. For example, the ferry operator, Jadrolinija, in Croatia has been interested in using LNG for its vessels. Similar studies are underway in Slovakia on the use of LNG to fuel marine transportation across the Danube River.

5.2.3 Industrial power

Industrial facilities that have traditionally relied on LPG or diesel as a fuel for their on-site power generation and manufacturing operations could also switch to LNG for various reasons including greenhouse gas and other emission reductions, fuel cost savings, or improved energy supply reliability. In addition to diesel, LPG is also used as a fuel for industrial power needs. We therefore have assessed the economics of switching away from LPG to LNG in Exhibit 33. Since LPG is more competitively priced in comparison to LNG, economics are more favorable when customers switch to LNG in place of diesel, rather than in place of LPG.

Exhibit 33 shows that incremental capital costs to switch from LPG to LNG can vary between €500,000 to €1,000,000. Payback periods, however, have a much broader range in comparison to those for fuel switching in road and marine transportation applications. For example, payback periods can be just a few months at LPG-LNG price differentials exceeding €0.50 a liter but can be as long as multiple years if the price differential is smaller. Further, LNG prices offer the potential for greater stability in comparison to LPG prices that are tied to oil prices, which can be volatile.

Exhibit 33. Economics for use of LNG as fuel in industrial applications.[22]



Our stakeholder interviews suggested that there are interesting industrial opportunities for fuel switching in favor of LNG, e.g., some mining projects in Bulgaria are interested in switching away from diesel to natural gas due to environmental considerations. Natural gas from Russia is unlikely to be a viable solution in such situations due to limited pipeline connectivity, thereby creating opportunities for small-scale LNG.

5.2.4 Other applications

Small-scale and containerized LNG can also support a few other applications although these tend to be niche markets with limited scale. A few examples include the use of LNG for agricultural operations, road paving, and powering rail engines and facilities. The economics and logistics of using LNG in these applications are complex and highly situation specific. Although such opportunities could emerge for small-scale and containerized LNG in Central & Eastern Europe, they are less likely to in comparison with other applications discussed earlier in this section.

Power generation as well as residential and commercial heating were also identified in interviews as a critical application in many countries. But, in most cases, these power and heating needs were too large to be cost competitively served by small-scale LNG. Even so, some countries such as Bosnia & Herzegovina have limited gas pipeline and other energy infrastructure, and in such cases small-scale LNG-based power generation could be a feasible option for some critical, high-value applications. Similar interest in small-scale and containerized LNG was evinced for northwestern parts of Bulgaria which are remote and have limited energy supply infrastructure.

5.3. Small-scale LNG demand case studies

There is strong potential for small-scale and containerized LNG in Central & Eastern Europe as discussed in the prior sections of this report. Although the current use of small-scale LNG in the region is limited, there are a few illustrative examples. We highlight a few such examples in this section.

a. RAG Austria, an oil and gas company, opened its first LNG refueling station in Ennshafen, Upper Austria in 2017, where they have over 12 tons of LNG storage capacity. The LNG fuel is sourced from the company's liquefaction plant in Gampren, Upper Austria that uses domestically produced natural gas. The liquefaction plant's capacity exceeds two tons per day and has storage capacity sufficient to refuel 60 to 90 trucks per day. RAG Austria has another proposed project to make the region an LNG hub with plans for nine additional LNG refueling stations, two small-scale LNG plants, a bio-LNG plant, and a logistics and storage center. The proposed project targets markets in neighboring countries including Germany, Italy, Slovenia, Slovakia, and Hungary and is expected to come online by 2024.

b. State-owned ferry operator in Croatia, Jadrolinija, runs a fleet of 50 ferries including three large RoPax vessels, eight high-speed passenger ferries, and double-ended ferries on

shorter routes. One of the goals for the operator is to renew some of its fleet in the next few years and adopt LNG as a fuel. However, it was discovered that conversion to LNG is not an easy option in the region due to lack of government funds as well as various technical, operational, and supply challenges. The transition to LNG as fuel would either require retrofitting existing propulsion with LNG capability added or converting from mechanical to electric power for the propellers. Also, since the water in the Adriatic Sea is warm, the addition of a cooling mechanism for the electric drive would result in energy losses of 10-15%, nullifying fuel cost reductions of converting to LNG. In addition to these financial and operational challenges, Krk LNG terminal has yet to develop ship-to-ship bunkering to provide cost-effective supply of LNG for bunkering.

c. KAP is a small aluminum smelter in Europe located in Montenegro and operated by Uniprom. The routine operations at the facility utilized almost 10 tons of oil per day. In 2019, KAP transitioned to a small-scale LNG facility to power their factory operations, reducing their fuel-related operating costs by more than 50%. Their aluminum storage facility has a capacity of 55,000 cubic meters with ten LNG transport trailers, and they plan to expand their LNG distribution network as demand develops in the region. Although the LNG is being sourced in containers all the way from France, the switchover to LNG continues to be cost competitive.

d. The Port of Constanta is located in Romania on the western coast of the Black Sea. It has a strategic location as it connects into the Pan-European highway and rail (IV), and the Danube riverway (VII) transport corridors. An LNG import terminal is being planned at the port with 5,000 cubic meters of initial storage capacity along with vessel bunkering and truck refueling facilities. The LNG import terminal is an important component of the Azerbaijan-Georgia-Romania Interconnector (AGRI), which seeks to diversify gas supply in the region.

   AGRI creates an alternative route for Azeri gas to Europe via Black Sea first by pipeline to the Georgian port of Kulevi in Georgia. The gas would then be liquefied there and transported across the Black Sea to the port of Constanta in Romania, where it would be regasified and shipped via the Romanian gas transport system to European markets through Hungary. The proposal plans to use two bullet-type horizontal storage tanks of 2,500 cubic meters capacity each for LNG storage. A regasification facility of 130,000 cubic meters is also being planned to add to the existing gas-grid. Georgian Oil and Gas Corporation, one of the partners of the project, shared in May 2019 that the project has been postponed until the completion of Azerbaijani Shah Deniz Phase 2 and other field development projects between 2024 and 2026. A feasibility study is planned over the next six months driven by LNG bunkering obligations by 2025 per the EU Alternative Fuel Infrastructure Directive.

Exhibit 34. RAG Austria LNG filling station.

Exhibit 35. LNG storage at Uniprom-KAP in Montenegro.

Exhibit 36. LNG filling station in Hungary.

Exhibit 37. Ruse LNG Terminal in Bulgaria.

e. The PAN-LNG project in Hungary is aimed at developing LNG refueling stations and making marine LNG available for vessels along the Danube. With an estimated budget of €1.2 million, the first LNG refueling station in Szigetszentmiklós came online in 2019 and more are expected in the next couple of years. The project is supported by the European Network Facility (CEF) and a significant share of the investment came from EU funds.

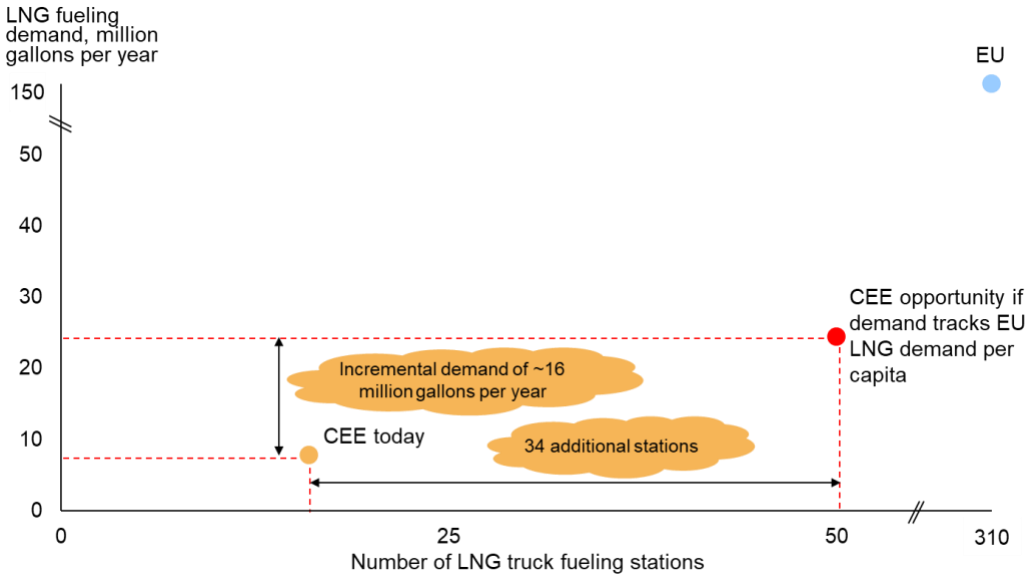
f. The LNGAFT — LNG as alternative fuel for transport — project in Slovakia aims to build one LNG refueling station in Zvolen and deploy 15 LNG buses along the Rhine-Danube Core Network Corridor. It is ongoing and the refueling station became operational in 2019. The estimated investment for the project amounted to about €5 million with 85% support from EU funds.

g. The LNG terminal in Ruse, Bulgaria, operated by Bulmarket DM and located along the Danube, is a river-based LNG terminal with storage capacity of 1,000 cubic meters, comprising four 250 cubic meter LNG tanks. The terminal plans to source LNG from Turkey and Poland via trucks. The terminal includes vessel loading, unloading, truck loading, and truck and vessel refueling/bunkering stations among other facilities. The total investment for the Ruse LNG terminal is estimated to be over €4.5 million. These were developed as part of the LNG Masterplan project along the Danube, and more LNG refueling stations at seaports of Varna and Burgas in Bulgaria are planned to come online by 2026.

5.4. Regional demand opportunity assessment

In summary, there are several opportunities for the use of small-scale and containerized LNG in various applications, collectively suggesting a significant demand opportunity in Central & Eastern Europe. Estimating and forecasting the size of this market is not an objective of this report but an illustrative view of the opportunity is shown in Exhibit 38 where we estimate LNG demand in heavy-duty trucking – one of the more promising applications in the region – assuming a simple forecasted scenario. Exhibit 38 shows the potential demand for LNG as a trucking fuel in Central & Eastern Europe assuming that the number of LNG refueling stations in the region increase from the current level to a new level that corresponds to those across the EU on a per capita basis. In such a forecasted scenario, LNG fueling demand would likely increase by 16 million gallons per year, served by approximately 50 refueling stations – an increase by 34 – across Central & Eastern Europe.

Exhibit 38. Potential LNG demand as a trucking fuel in Central & Eastern Europe.



Similar opportunities for small-scale and containerized LNG exist across the region in marine, industrial, and other applications. While a number of them will require large infrastructure investments, some market segments could potentially advance to using small-scale LNG with small to medium infrastructure investments. A brief qualitative assessment of the most likely applications for small-scale and containerized LNG are summarized in Exhibit 39.

In summary, we see heavy-duty trucking holding the best potential for small scale LNG in most of the fifteen countries, followed by marine transportation and industrial applications. LNG use in industrial applications has some potential in virtually all fifteen countries although only a handful are most promising. Finally, marine transportation can switch to LNG in a limited number of countries where it is quite promising from an economic point of view.

Exhibit 39. Overview of small-scale LNG applications in Central & Eastern Europe.

Country	Trucking	Marine	Industrial	Rail
Albania	Medium	High	Medium	Low
Austria	High	Low	Low	Low
Bosnia & Herzegovina	High	High	High	Low
Bulgaria	High	Medium	High	Low
Croatia	Medium	High	Medium	Low
Czech Republic	High	Low	Medium	Low
Hungary	High	Low	Medium	Low
Kosovo	Medium	Low	High	Low
Montenegro	High	High	Medium	Low
North Macedonia	Medium	Low	Medium	Low
Poland	Medium	High	High	Low
Romania	High	Low	Medium	Low
Serbia	Medium	Low	Medium	Low
Slovakia	High	Low	Medium	Low
Slovenia	Medium	Medium	Medium	Low

High Medium Low

6.0 Small-scale LNG supply assessment for Central & Eastern Europe

6.1. Small-scale LNG supply and infrastructure value chain

Exhibit 40 shows a representative view of a small-scale LNG value chain. Its five segments begin with LNG production and supply, followed by supplier storage and transfer logistics, LNG transportation, customer storage and transfer logistics, and ending with utilization. Each of these segments is described in further detail later in the following sections.

Exhibit 40. A representative view of the small-scale LNG value chain.

In the first step, LNG in small volumes can be produced through liquefying natural gas at small plants or sourced from large-scale LNG import terminals. In the case of liquefaction, natural gas is fed through a receiving station consisting of temperature and pressure control, liquid and solid knock-out and separation, and metering equipment. Natural gas is then treated to remove contaminants such as carbon dioxide, hydrogen sulfide, water, and mercury, and water (dehydration). The on-spec natural gas is then liquefied using a single- or mixed-refrigerant cryogenic process and readied for storage and transportation logistics.

Small-scale LNG plants typically need utilities such as power generation or connectivity to a power grid, feedstock and product handling infrastructure, process steam, instrument and plant air, utility nitrogen, demineralized water, safety equipment, materials (e.g., adsorbents, chemicals, etc.), and personnel accessibility. Further, small-scale LNG facilities need harbor, jetty, access roads, water treatment, workforce accommodation, and administrative buildings.

An alternative to liquefaction is often seen in small-scale LNG value chains. In such cases, LNG is sourced as-is from import terminals that bring LNG in large-scale ships and tankers. Such break-bulk or bunkering – depending on the application – forms of LNG supply are also viable and increasingly feasible as small-scale LNG demand grows. In addition to commercial and contractual arrangements, such supply of small-scale LNG volumes is critically dependent on the quality and capabilities of infrastructure available at an LNG import terminal. Not all LNG import terminals offer such services, and a large-scale LNG import terminal in Germany is the only upcoming terminal that plans to offer small-scale services, while Krk Croatia does not plan to offer such service in the near-term. For example, a steel plant in Montenegro has found it

cost competitive to truck LNG in ISO containers all the way from large regasification facilities in Spain.

Supplier logistics is the second segment in the small-scale LNG value chain. This includes LNG storage and boil-off gas (BOG) solutions. Small-scale LNG has varying storage needs and storage capacity can range from 500 to 5,000 cubic meters with prevailing pressurized storage tanks. Different types of storage tanks are often used for small-scale LNG with varying operational volumes. These include pressurized bullet or spherical tanks with volumes less than 1.2 cubic meters. Spherical pressurized tanks have a higher capacity than bullet tanks but they are less safe and have more limited storage capacities than the atmospheric tanks. Atmospheric tanks have typical storage capacity that ranges between 2 and 4 cubic meters. These can either be flat bottom or bullet tanks. While the flat bottom atmospheric tanks are safer and have higher capacity than bullet atmospheric tanks, they are expensive and take longer to build.

When LNG is stored, heat ingress from the surrounding atmosphere causes nitrogen and methane to boil-off. The boil-off rate is generally 0.1 to 0.5% per day of total stored LNG volumes with additional BOG formed during LNG loading activities. Managing BOG volumes is important to keep LNG cooler and reduce operational pressure requirements. If BOG is not removed, pressure will build up causing either pressure relief valves to open or make LNG heavier due to decreased methane concentrations, and volumes will fail to meet end-user specifications.

LNG transfer and transportation is the third segment of the small-scale LNG value chain. This is more varied for small-scale LNG in comparison to the value chain for traditional LNG where transfer and transportation is restricted primarily via large ships and tankers. In the case of small-scale LNG, there are multiple options for LNG transfer and transportation, including via small to medium marine vessels, truck, rail, and ISO containers. Small-scale LNG carriers typically have capacities less than 30,000 cubic meters. They are regulated by the same specifications for design and safety characteristics as the large-scale carriers. Small-scale carriers can be used for small inland and coastal communities, as well as intercontinental LNG transport and port-based bunkering.

Other unit operations are similar to large-scale LNG practices. LNG loading is generally carried out by creating a pressure build-up from facilities or storage to trucks and vessels via hoses typically smaller than eight inches in diameter. Typical infrastructure needs include a small jetty, safety equipment such as gas and fire detectors, emergency shut-down panels, firefighting equipment, control rooms, flow meters, and LNG spill containment.

Customer-end logistics is the fourth segment, and more important and varied in the small-scale LNG value chain relative to large-scale LNG operations. In conventional, large-scale LNG business, customer-end logistics are fairly simplified and embedded into the regasification operations where some storage is available and natural gas following LNG's regasification is transferred typically via pipelines to customers who are usually large power generation facilities. In the case of small-scale LNG, there is such a wide range of applications, customers,

and end-use configurations, that customer-side logistics becomes a critical path. For example, a large farming operation that has typically relied on the use of LPG may find conversion to LNG difficult without a good assessment of the logistics at its site and how they would fit with LNG.

Regasification or utilization is the final segment in the small-scale LNG value chain. Small-scale LNG regasification plants are highly autonomous with minimum personnel requirements often limited to maintenance or unloading operations. Most small-scale regasification plants have modular designs and are skid-mounted with high safety levels and low maintenance requirements. In some cases, pressure build-up is used instead of a pump for regasification. A flexible hose is frequently used for LNG transfer. BOG generated during storage or due to LNG processing is handled in pressurized tanks.

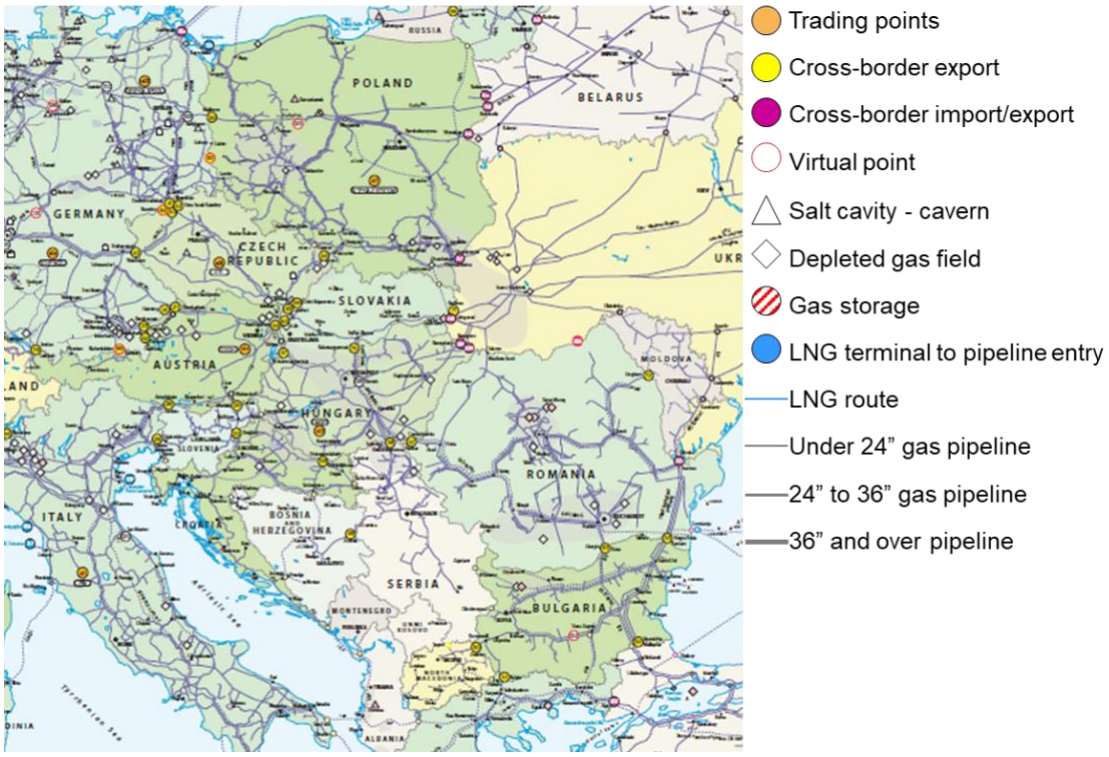
Some of the large- and small-scale receiving terminals are developed to break-bulk or re-load bunker ships and trucks. Further, since small-scale LNG volumes find use in a number of applications, LNG utilization in heavy-duty trucking, rail, and some industrial markets may need infrastructure and systems that go well beyond traditional regasification units. However, there is significant variability in these needs and each of these needs to be assessed on a case-by-case basis.

6.2. Supply assessment of natural gas and LNG

There is extensive literature in the public domain on the supply options for natural gas into Central & Eastern Europe. We therefore provide a brief summary only to give context and not as an exhaustive review of the current supply situation. Natural gas production in the region is limited to a few countries led by Romania which produces almost 80% of all supply followed by Croatia and Serbia. A little less than half of all gas supply into the region is supplied and imported almost entirely by Gazprom. At present, there is neither gas trading on spot prices nor any direct LNG imports into the region.

Natural gas is imported into Central & Eastern Europe via pipelines (see Exhibit 41 for a view of the natural gas infrastructure in the region and its vicinity) under long-term contracts with a wide variation in pricing arrangements that are becoming increasingly competitive as global gas supplies and competition for customers is growing. Even so, there is little material competition that imported pipeline gas from Russia faces due to limited natural gas infrastructure in the region. Further, demand for natural gas is limited in scale and/or not growing fast enough, and is too constrained by the lack of infrastructure to incentivize other traditional natural gas supplies such as large-scale LNG. Although several gas infrastructure projects – new pipelines, mainly – have been proposed over the years driven primarily by energy supply security concerns, they have been stymied as a result of lack of viable economics or financing, uncertain demand outlook, supply challenges, and political instability.

Exhibit 41. Existing gas supply infrastructure in Central & Eastern Europe.[23]



Natural gas demand is, however, rising even if slowly and in fragmented ways, and that coupled with decarbonization, air quality, energy supply security, and cost reduction goals all collectively create opportunities for new sources of natural gas supply into Central & Eastern Europe. LNG could emerge as one important source of new natural gas supply into the region driven by the industry's growing capacity, falling prices, and rapidly evolving commercial and project models that support small-scale LNG adoption. This is reflected in the rapid growth in LNG imports, which have doubled over the past two years across the EU.

However, LNG infrastructure is limited in Central & Eastern Europe. Exhibit 42 shows the existing and planned LNG terminals in Europe. Although there are 24 large-scale LNG terminals in the EU, most are outside Central & Eastern Europe. An additional 12 large-scale LNG terminals are expected to be built over the next five years and most of them are also outside the region.

The Krk LNG terminal in Croatia that is expected to start operations at the beginning of 2021 is the only upcoming terminal within the region. It will be an FSRU with 2.6 Bcm of annual regasification capacity, and that capacity has been fully booked for three years from the date the terminal is expected to commence operations. However, the Krk LNG terminal has no plans to add small-scale services in the near term. Companies that have secured capacity include Hungary's state-owned energy company, MVM, and a mix of private players.

Exhibit 42. Existing and planned LNG import terminals in Europe.[24]

No.	Country	Facility Name	Capacity Classification	Operator Name
1	Spain	Barcelona LNG Terminal	Large-scale	Enagás
2	Italy	Panigaglia LNG terminal	Large-scale	GNL Italia
3	France	Fos-Tonkin LNG Terminal	Large-scale	Elengy
4	France	Montoir-de-Bretagne LNG Terminal	Large-scale	Elengy
5	Belgium	Zeebrugge LNG Terminal	Large-scale	Fluxys LNG
6	Spain	Huelva LNG Terminal	Large-scale	Enagás
7	Spain	Cartagena LNG Terminal	Large-scale	Enagás
8	Turkey	Marmara Ereglisi LNG terminal	Large-scale	BOTAS
9	Spain	Bilbao LNG terminal	Large-scale	BBG
10	Portugal	Sines LNG Terminal	Large-scale	REN Atlantico
11	U.K.	Isle of Grain LNG terminal	Large-scale	Grain LNG
12	Spain	Sagunto LNG terminal	Large-scale	Saggas
13	Turkey	Aliaga Izmir LNG Terminal	Large-scale	EgeGaz
14	Spain	Mugardos LNG Terminal	Large-scale	Reganosa
15	Italy	Porto Levante LNG terminal	Large-scale	Adriatic LNG
16	U.K.	Milford Haven - Dragon LNG terminal	Large-scale	Dragon LNG
17	U.K.	Milford Haven - South Hook LNG terminal	Large-scale	South Hook LNG
18	France	Fos Cavaou LNG Terminal	Large-scale	Fosmax LNG
19	Netherlands	Gate terminal, Rotterdam	Large-scale	Gate terminal
20	Italy	FSRU OLT Offshore LNG Toscana	Large-scale	OLT Offshore LNG Toscana
21	Spain	Gijón (Musel) LNG terminal	Large-scale	Enagás
22	France	Dunkerque LNG Terminal	Large-scale	Dunkerque LNG
23	Poland	Swinoujscie LNG Terminal	Large-scale	Polskie LNG

No.	Country	Facility Name	Capacity Classification	Operator Name
24	Turkey	Aliaga Etki LNG Terminal Neptune	Large-scale	Etki Liman
25	Malta	Malta Delimara LNG terminal	Large-scale	ElectroGas Malta Ltd
26	Greece	Revithoussa LNG Terminal	Large-scale	DESFA
27	Lithuania	FSRU Independence	Large-scale	Klaipedos Nafta
28	Cyprus	Vassiliko LNG terminal	Large-scale	CYGAS
29	Croatia	Krk Island LNG terminal, Omišal	Large-scale	LNG Croatia
30	Greece	Alexandroupolis LNG terminal	Large-scale	Gastrade
31	Spain	Tenerife (Arico-Granadilla) LNG terminal	Large-scale	Gascan
32	Germany	Brunsbüttel LNG terminal	Large-scale	Gasunie, Vopak, Oiltanking
33	Germany	Wilhelmshaven	Large-scale	UNIPER with MOL
34	Italy	Porto Empedocle (Sicilia) LNG terminal	Large-scale	Enel
35	Poland	FSRU Polish Baltic Sea Coast	Large-scale	Polskie LNG/GAZ SYSTEM
36	Spain	Gran Canaria (Arinaga) LNG terminal	Large-scale	Gascan
1	Norway	Mosjoen LNG terminal	Small-scale	Gasnor
2	Norway	Øra LNG, Fredrikstad LNG Terminal	Small-scale	Gasum
3	Sweden	Nynäshamn LNG terminal	Small-scale	AGA
4	Sweden	Lysekil LNG Terminal	Small-scale	Gasum
5	Finland	Tahkoluoto/Pori LNG Terminal	Small-scale	Gasum
6	Finland	Tornio Manga LNG terminal	Small-scale	Manga LNG
7	U.K.	Gibraltar LNG Terminal	Small-scale	Gasnor (100% Shell)
8	Finland	Hamina LNG terminal	Small-scale	Hamina LNG Oy
9	Italy	Oristano - Santa Giusta LNG Terminal	Small-scale	Higas
10	Italy	Ravena LNG terminal	Small-scale	Depositi Otaliani GNL

Another terminal that will support Central & Eastern Europe is in Alexandroupolis in northern Greece. Also an FSRU, the LNG import terminal's annual capacity will be 5.5 Bcm and is expected to be operational by late 2022 or early 2023. In addition to storage and regasification capabilities, the LNG terminal will be connected via a 28 km-long pipeline to the gas transmission system in Greece enabling it to send gas to a wider range of countries in Central & Eastern Europe including Bulgaria, Romania, North Macedonia, Hungary, and Serbia. There are currently no small-scale LNG infrastructure capabilities or services planned at the terminal. The terminal is being developed by Gastrade with equity ownership also held by Gaslog and Bulgartransgaz along with interest for additional investments from Romgaz.

In addition to the import terminals that are aimed at large-scale LNG imports into the region, there are a few existing small-scale natural gas liquefaction plants and one small-scale LNG regasification terminal that can help meet domestic LNG demand in the region as shown in Exhibit 43. Exhibit 43 also shows planned small-scale LNG terminals in the region.

Exhibit 43. Existing and planned small-scale liquefaction plants and LNG terminals.[24]

Polish state-owned oil and gas company, PGNiG, operates nearly 54 oil and gas production facilities in Poland. Some of their gas produced has high nitrogen content and is processed through nitrogen rejection units at the Odolanów and Grodzisk Wielkopolski plants where LNG is also produced. Part of this LNG production is sold to customers or used within PGNiG to power upstream activities.

Similarly, RAG Austria, headquartered in Vienna has oil and gas production operations in Gampern, Upper Austria. At that site, there is a two ton-per-day LNG production plant serving trucking applications. The company has established truck refueling stations in Ennshafen and Feldkirchen bei Graz, both in Austria.

Another small-scale LNG asset is operated by Enos LNG, a Slovenian company that runs a 2.5-tons per year liquefaction plant fed by imported piped gas to serve LNG demand as a trucking fuel, and to occasionally deliver to parts of Slovenia when the existing gas grid is under maintenance or suffering an outage. River LNG terminal at the Port of Ruse along the river Danube in Bulgaria, operated by Bulmarket DM Ltd., also has four 250-cubic meters LNG storage tanks collectively adding up to capacity of 1,000 cubic meters along with truck loading and truck and vessel refueling/bunkering stations.

Finally, two LNG terminals in Galati and Constanta both in Romania have been planned with storage capacities of 4,000 and 5,000 cubic meters, respectively, along with truck refueling and vessel bunkering services. The Galati port project received funding approval from the EU and prefeasibility studies are underway.

Finally, most of the upcoming large-scale LNG terminals (Exhibit 42) do not have truck loading, marine bunkering, and other small-scale LNG services at this time, and therefore are highly unlikely to support small-scale LNG demand and applications until those infrastructure upgrades are made. Additional infrastructure investments will also be necessary to support small-scale and containerized LNG imports into the region.

Some of these additional infrastructure investments could include the systems and permits at various ports to allow the imports of LNG in ISO containers. Exhibit 44 shows a list of large and small sea and river ports in Central & Eastern Europe where facilities to allow containerized LNG imports could significantly improve the supply situation and support regional small-scale LNG demand and applications.

Exhibit 44. Existing sea and river ports in Central & Eastern Europe.[24]

No.	Country	Name of Port	Scale of the Port	Sea or River Port
1	Albania	Port of Vlore	Small	Sea
2	Austria	Port of Vienna	Small	River
3	Bulgaria	Port of Varna	Large	Sea
4	Croatia	Port of Rijeka	Large	Sea
5	Montenegro	Port of Bar	Small	Sea
6	Poland	Port Handlowy Swinojscie	Large	Sea
7	Romania	Port of Mangalia	Large	Sea
8	Romania	Port of Giurgiu	Small	River
9	Serbia	Port of Belgrade	Small	River
10	Slovakia	Port of Bratislava	Small	River
11	Slovenia	Port of Koper	Large	Sea

6.3. Small-scale LNG supply options, costs, economics, and pricing

Small-scale LNG applications in Central & Eastern Europe can secure LNG for their needs through multiple supply pathways. Exhibit 44 lists the various supply pathways for the three major applications – heavy-duty trucking, marine bunkering, and industrial.

At a high level, each of these end-use segments will rely on LNG sourcing that will most likely involve a large-scale LNG terminal with small-scale services or via containerized LNG at one of the regional ports. As discussed in the prior section, at this time there are neither such ports capable of handling LNG ISO containers nor small-scale services at existing or planned large-scale LNG terminals close to the region such as Krk and Alexandroupoulis. Even so, in charting these supply pathways, we assume that such investments will be made thus facilitating LNG sourcing in small volumes into the region.

Following LNG sourcing at a terminal or a port, truck refueling stations and industrial end-users will have to rely on transportation of LNG via truck to their sites. This could involve truck loading at a large-scale LNG terminal with small-scale LNG services or moving ISO containers with LNG on trucks. Truck refueling stations and industrial sites using LNG will then store the fuel on-site for use as required. Truck refueling stations can provide LNG as a liquid fuel or convert it into CNG which can also be used to fuel trucks. Industrial sites will, most likely, need to regasify the fuel prior to use.

Exhibit 45 also illustrates the supply pathway for marine applications. Ships using LNG as a marine fuel will most likely rely on bunkering services at a large-scale terminal. In another variation, smaller bunkering vessels can be loaded with LNG at large-scale terminals and ferried to regional sea and river ports where a wide range of vessels could be refueled with LNG. Finally, some multimodal transportation relying on both trucks and bunkering vessels to serve remote ports is also possible but less likely and, therefore, not illustrated in Exhibit 45.

Exhibit 46 illustrates three typical pathways. First, LNG imported at a terminal with small-scale LNG services is loaded onto trucks which then move LNG to refueling stations. Second, LNG is loaded into ISO tanks at an LNG import terminal and the ISO tanks are transported to various refueling outlets via trucks. Finally, LNG already loaded into ISO tanks is brought to various ports on smaller vessels and the LNG ISO tanks are then transported via trucks to refueling stations.

Exhibit 45. Understanding the LNG pricing model by end-use and supply option.

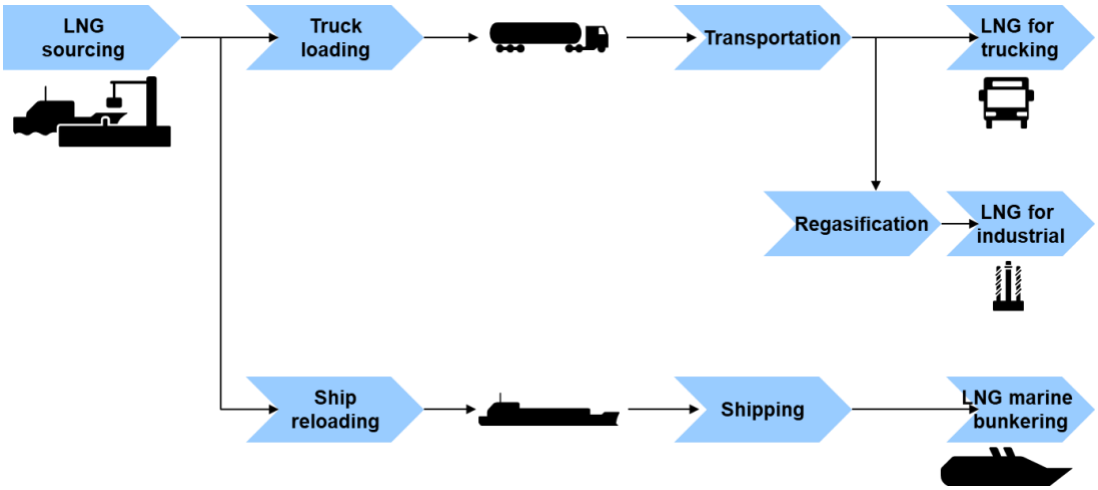
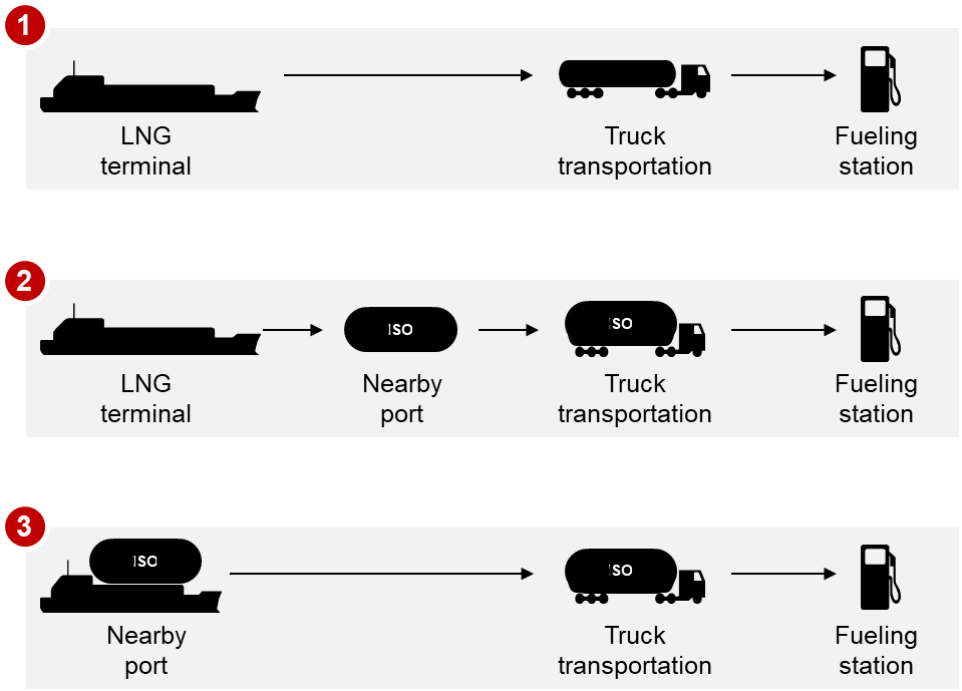


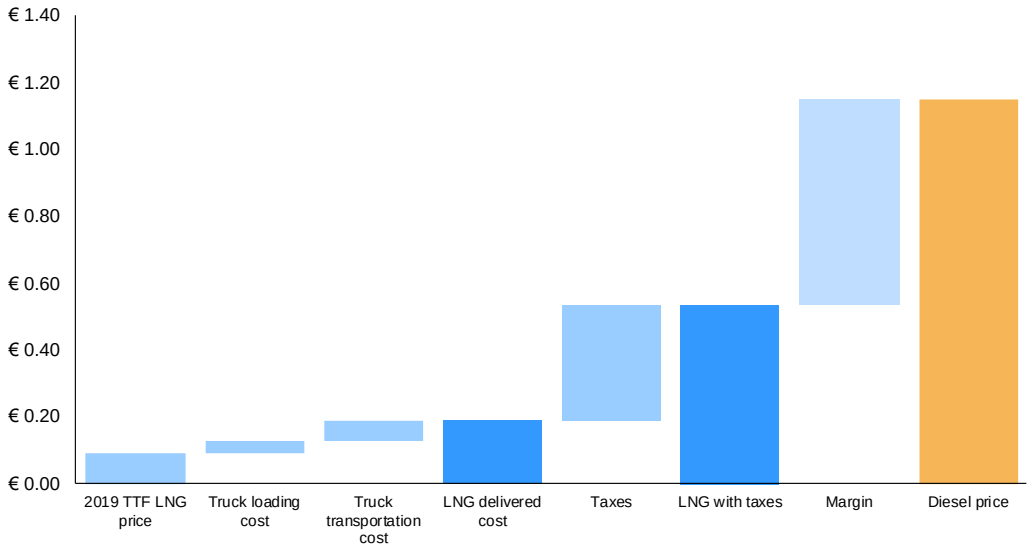
Exhibit 46. Supply options for LNG as trucking fuel in Central & Eastern Europe.



The cost-competitiveness of small-scale LNG for trucking applications is illustrated in Exhibit 47. The Exhibit shows the estimated delivered prices for small-scale LNG in comparison to the incumbent fuel i.e. diesel in the case of heavy-duty trucking. Exhibit 47 shows that the delivered price for small-scale LNG as a trucking fuel is significantly lower in comparison to diesel prices leaving a significant €0.62 per liter in margin to cover the incremental capital cost of purchasing LNG-fueled trucks. The Exhibit provides a detailed build-up of costs beginning with the spot

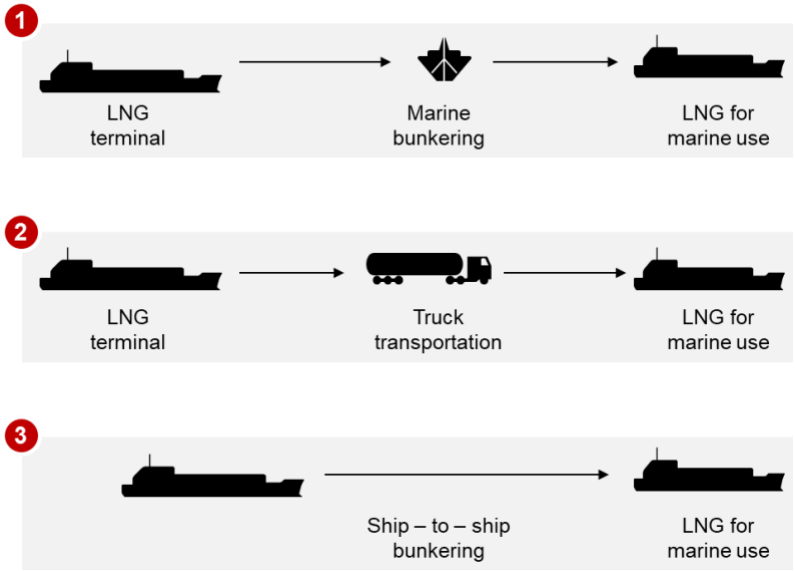
price of LNG in Europe at a reference receiving terminal and accounting for truck loading and transportation costs as well as taxes.

Exhibit 47. Delivered LNG price in heavy-duty trucking applications in € per liter.[25]



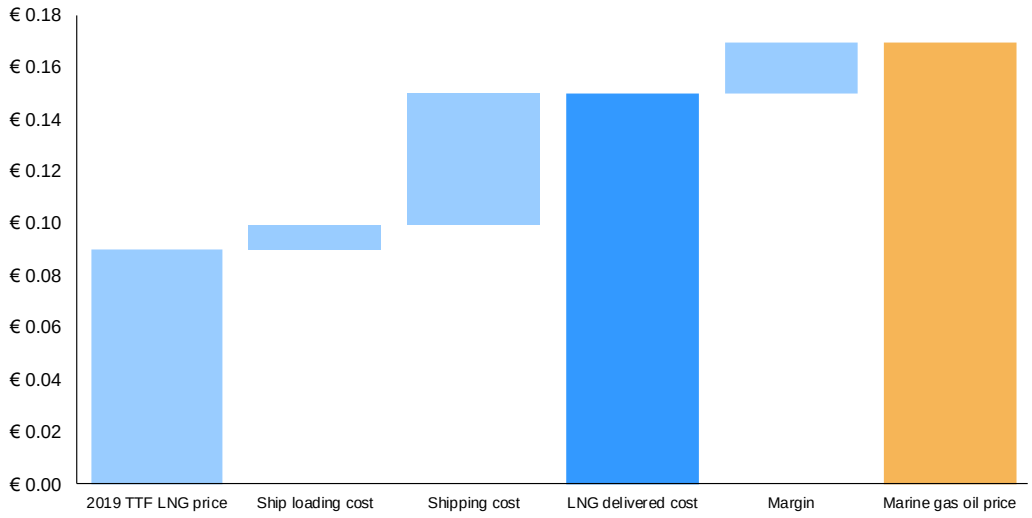
Similar to LNG supply logistics for trucking applications, Exhibit 48 provides various supply pathways to serve marine LNG fuel needs. There are three typical supply pathways with the first being loading a marine bunkering vessel at an LNG terminal with small-scale LNG services. This bunker vessel then serves marine vessels that use LNG as a fuel. The second pathway relies on trucks to transport LNG to a bunkering vessel or LNG-fueled vessels at a nearby port. The final pathway is ship-to-ship bunkering where LNG tankers directly support LNG-fueled vessels.

Exhibit 48. Supply options for LNG as marine fuel demand in Central & Eastern Europe.



Delivered LNG prices for marine fueling applications are estimated in Exhibit 49. In comparison to LNG use in trucking, the margin between the incumbent fuel and delivered LNG cost is small assuming the use of MGO. This margin could be higher if the vessels are relying on low-sulfur diesel. The bulk of the cost after procuring LNG at spot prices at a terminal is attributed to shipping of the fuel to customer sites.

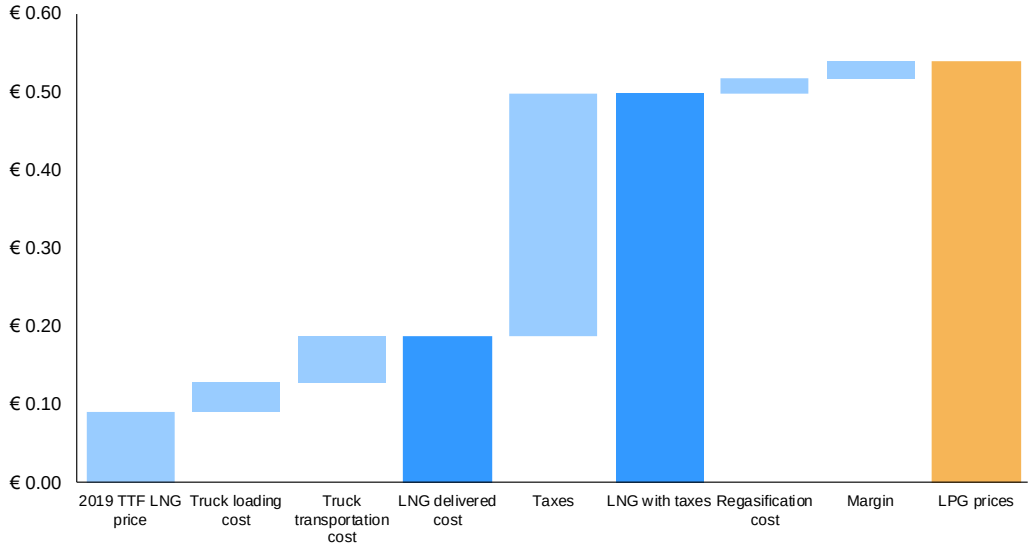
Exhibit 49. Delivered LNG price to replace marine gas oil in bunkering in € per liter.[25]



Industrial uses of LNG are also a promising application at smaller scales. Supply logistics and pathways for industrial applications of small-scale LNG are no different than those for supplying truck refueling stations detailed in Exhibit 46. As a result, only a delivered cost of small-scale LNG (see Exhibit 50) is illustrated for industrial applications.

Similar to marine applications, delivered cost of LNG is marginally cheaper than the incumbent fuel which is predominantly LPG. Of course, this margin could be significantly higher if the incumbent fuel was diesel which is indeed the case in many industrial applications, e.g., for back-up power. As a result, finding the appropriate applications – where incumbent fuel costs are high or where supply is challenged – for using small-scale LNG in the industrial sector will be critical to its economic competitiveness.

Exhibit 50. Delivered LNG price to replace LPG in industrial applications in € per liter.[25]



6.4. Regional supply and infrastructure opportunity assessment

The research and analyses shared in this section reflect the opportunity of delivering LNG competitively in many applications at small scales. Exploiting small-scale and containerized LNG's economic and environmental benefits for Central & Eastern Europe will, however, require investments in infrastructure. Such infrastructure investments should nevertheless be based on a granular, local level understanding of natural gas and other fuel supply infrastructure. To that end, several stakeholder interviews were conducted to assess regional supply and infrastructure, and key findings are discussed here.

First, stakeholder interviews pointed out that natural gas sourced from Russia via pipelines is neither necessarily supply constrained nor expensive and gas from Russia can also be liquefied and transported as LNG in the region. Similar to other markets, gas in regions served by pipelines is inexpensive enough to make LNG less economically competitive. Furthermore, in some countries, e.g., Austria, pipeline gas was so inexpensive that RAG, an oil and gas company, was planning projects to re-liquefy to LNG for sales into road transportation markets through two LNG refueling stations. Slovakia is also considering liquefaction plants to convert Russian gas into LNG for passenger transportation and trucking applications. On the other hand, in some countries, e.g., Bosnia & Herzegovina, although natural gas was not seen as exorbitantly priced, it was reported to be more expensive relative to the country's standard of living.

Stakeholder interviews, however, did reveal that natural gas supply and current price levels were viable only in sub-regions well served by pipelines. In fact, stakeholders indicated that demand for natural gas would have been higher if not for the lack of pipeline connectivity. Improving pipeline connectivity further in the region will be challenging due to environmental and permitting reasons, high costs and financing obstacles, difficult terrain, and small and

fragmented markets. Most stakeholders agreed that in such sub-regions small-scale LNG could be a viable source of natural gas assuming competitive pricing.

Third, LNG supply capacity was, widely viewed as seriously constrained in comparison to natural gas via pipelines. In general, the region has limited access to LNG terminals, and prospects of new investments and facilities are limited. An LNG terminal, with 2.6 billion cubic meters in annual capacity, is coming up in Krk, Croatia. It is anticipated to start operations in December 2020 and has already leased virtually its full capacity to a handful of companies in the region. The success of the Krk LNG terminal in raising investments and leasing out its capacity reflect the region's interest in diversifying its natural gas supply sources as well as latent demand for LNG.

Fourth, if LNG supply was seen as constrained at the larger scales, it is even more absent at the smaller scales today. Upcoming terminals including the one at Krk do not have small-scale LNG services which would be necessary to make LNG available for road and marine transportation and remote industrial and power generation. Historical data shows that LNG terminals in Europe that offer small-scale services such as truck loading and bunkering have seen rapid growth in small-scale LNG demand, as reflected by the number of LNG cargoes distributed via trucks and small vessels. This historical experience coupled with the enabling factors discussed in earlier sections suggest that Central & Eastern Europe would benefit from small-scale and containerized LNG volumes.

A fifth insight from stakeholder interviews on regional supply and infrastructure opportunities was that CNG and LPG are more widely available in Central & Eastern Europe and are already being used in the transportation sector, posing stiff competition for small-scale LNG. In addition, biofuels are also being used aggressively, e.g., in Hungary, to advance decarbonization goals in the transportation sector. EU membership will also drive up the share of biofuels in the energy mix for countries such as Serbia. LNG will have to demonstrate significant cost competitiveness over these alternative fuels. However, some of this competition can also play in favor of LNG adoption in this region. For example, some of the companies currently active in CNG distribution are interested in diversifying into LNG as observed in Bulgaria. Similarly, Butan Plin, an LPG distributor in Slovenia, has established LNG refueling stations for trucks in Slovenia and Croatia.

Sixth, experience with LNG among companies and stakeholders in Central & Eastern Europe is limited but growing as some countries are actively stepping up their involvement and position across the LNG value chain. For example, Bulgartransgaz, Bulgaria's state-owned gas grid operator, has acquired a 20% stake in the Alexandroupolis LNG terminal in Greece in a bid to diversify its gas sourcing. Such experience with the small-scale LNG value chain will be critical to develop the technical and commercial capabilities necessary for wider adoption of LNG in the region.

To that end, various countries and economic blocks are conceptualizing different kinds of energy projects. For example, the Three Seas Initiative (3SI), also known as the Baltic, Adriatic,

Black Sea Initiative, is a regional partnership comprising 12 countries – most of which are within the scope of this study – to promote cross-border cooperation in, among other things, energy. Although no projects have been initiated yet, 3SI has identified LNG terminals as critical projects to develop in the region. The U.S. government has committed up to $1 billion in financing for 3SI projects.

In summary, there is a high level of interest among a wide range of stakeholders in Central & Eastern Europe to pursue infrastructure investments that facilitate adoption and use of small-scale and containerized LNG. To that end, there is a nascent activity in developing infrastructure projects although these efforts will have to be accelerated through various incentives and financing support. Finally, competitive pressures from pipeline gas as well as competing fuels will play an important role in how quickly some of these LNG infrastructure projects will come to fruition.

7.0 Small-scale LNG infrastructure investment landscape

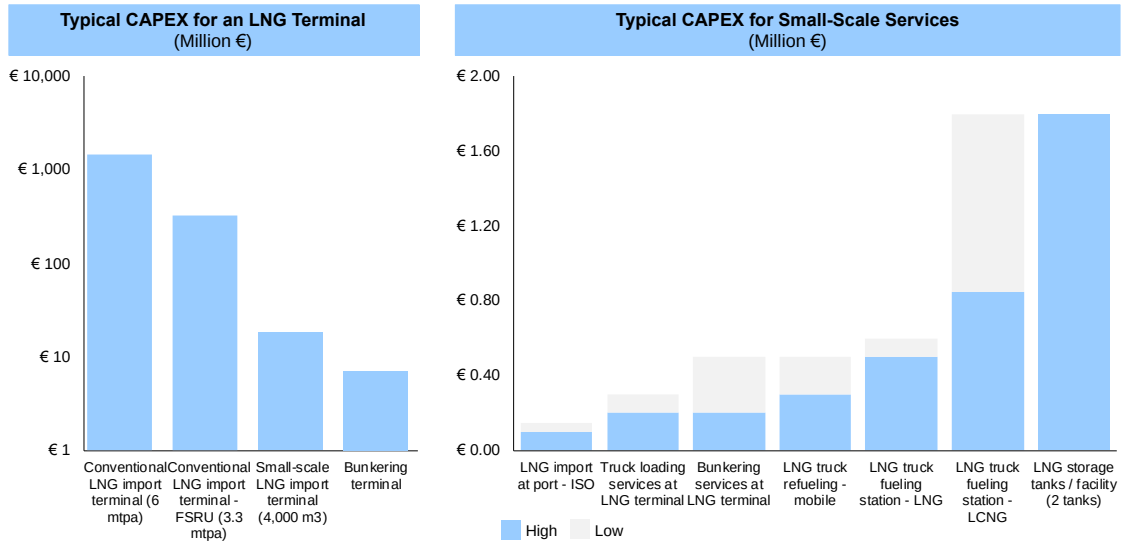
7.1. Capital costs of small-scale LNG infrastructure projects

Central & Eastern Europe will need infrastructure investments to facilitate material adoption of small-scale and containerized LNG. These will include facilities to offer small-scale LNG services such as truck loading and marine bunkering at the upcoming Krk and Alexandroupoulis LNG terminals. A few additional LNG import terminals closer to key countries in the region could meaningfully advance adoption of small-scale LNG. LNG terminal investments are capital intensive and need significant financial investment.

A much higher level of infrastructure investments will be necessary across the broader LNG supply, storage, logistics, and utilization segments of the value chain. These include LNG bunkering, truck loading and refueling, storage tanks, and end-use logistics facilities. Fortunately, a number of these projects are not too expensive, are economically viable, and do not require substantial investments.

Exhibit 51 shows estimated capital costs of various LNG infrastructure projects with emphasis on those relevant to small-scale and containerized LNG. These estimates are, to a large extent, based on public data from actual projects or from other reports on the topic. A conventional LNG import terminal capable of handling 6 MTPA of LNG will likely cost over a billion euros while FSRU-based import terminals are significantly cheaper at approximately €300 million. Smaller-scale LNG and bunkering terminals can be built much less expensively as illustrated in the chart on the left in Exhibit 51 (note the logarithmic scale). Finally, FSRUs as well as small-scale receiving and bunkering terminals can also be built far more quickly than onshore, baseload regasification terminals.

Exhibit 51. Typical capital costs for LNG projects and services.[26]

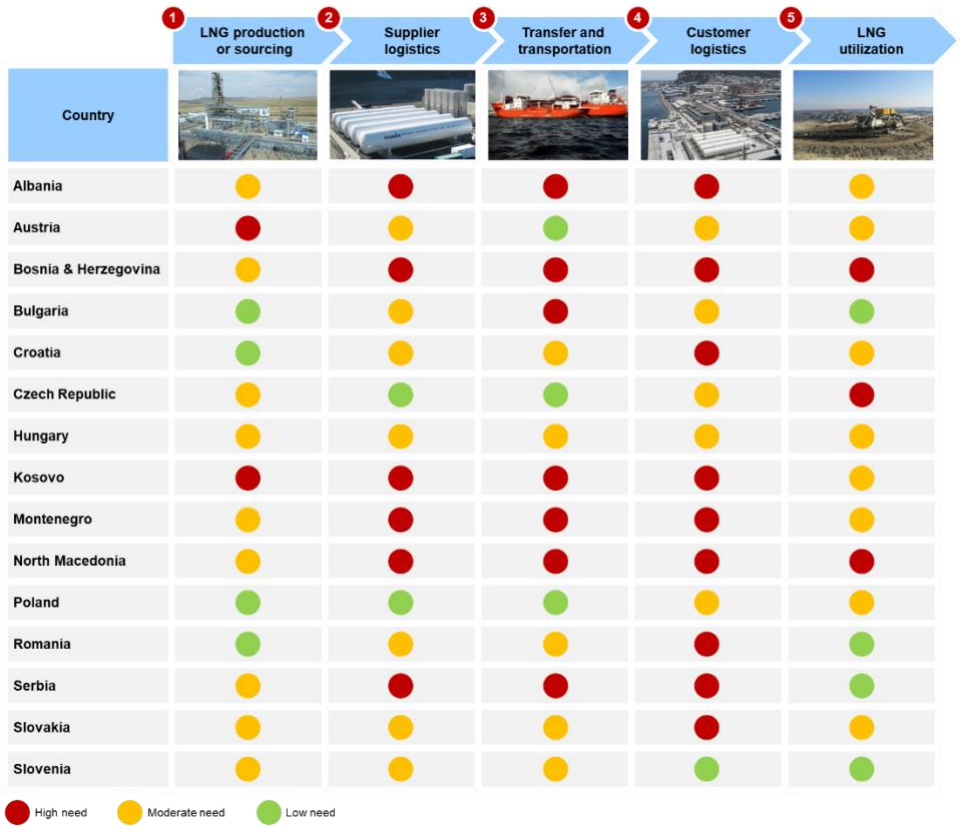


In comparison to capital costs for LNG terminals, those for small-scale services are much lower across the logistics and end-user segments of the small-scale LNG value chain. For example, as shown in the charts on the right side of Exhibit 51, infrastructure investments to facilitate import of ISO containers at regional ports, truck and bunkering service capability additions at existing terminals, and fueling stations all typically cost less than a million euros and often far less. Only storage tank farms are more expensive but still reasonable in comparison to the capital requirements of LNG terminals.

7.2. Regional small-scale LNG investment needs

Exhibit 52 summarizes the investment needs by component of the small-scale value chain by country in the region. Red indicates lack of sufficient infrastructure and hence, high need for investments, green indicates low need due to existing infrastructure, while yellow indicates a moderate need for infrastructure due to existing but insufficient infrastructure or expansion plans.

Exhibit 52. Regional small-scale LNG investment needs in Central & Eastern Europe.



For LNG production or sourcing, Bulgaria, Poland, Croatia, and Romania all have existing or planned LNG terminals where truck loading and vessel bunkering facilities can be installed.

Albania, Czech Republic, Hungary, Kosovo, Montenegro, Serbia, Slovakia, and Slovenia have seaports or river ports where marine bunkering or ISO tanks can be used to bring LNG for domestic use. Bosnia & Herzegovina and North Macedonia on the other hand have an advantage due to their proximity to ports in Croatia and Greece, respectively, and can access small-scale LNG relatively easily in comparison to land-locked Kosovo. Austria has been taking advantage of domestic gas production and LNG capacity.

In the case of supply logistics, Czech Republic and Poland have existing infrastructure for truck transportation and storage of LNG, while most of the region including Austria, Bulgaria, Croatia, Hungary, Romania, Slovakia and Slovenia are on track to develop infrastructure for LNG storage and management. Countries such as Albania, Bosnia & Herzegovina, Kosovo, Montenegro, North Macedonia, and Serbia where natural gas or LNG have not entered the market will need the highest investments in supply logistics.

LNG transfer and transportation in Czech Republic and Poland will need expansion to meet rising demand, while Austria has planned a network of LNG transportation by truck. These countries have low investment needs in these areas relative to other countries. Croatia, Hungary, Romania, Slovakia, and Slovenia, however, will need considerable investments to expand their terminals to distribute LNG and are marked with yellow in Exhibit 52. The countries marked with red such as Albania, Bosnia & Herzegovina, Bulgaria, Kosovo, Montenegro, North Macedonia, and Serbia will need a high level of investment to transport LNG to end users.

In terms of customer logistics, there are some companies and customers that are already using LNG or natural gas in the region, for example in countries such as Slovenia followed by Austria, Bulgaria, Czech Republic, Hungary, and Poland. These range from trucking, mining, and manufacturing companies that have infrastructure in place for receiving and storing LNG. Countries with little to no existing market for gas or LNG including Albania, Bosnia & Herzegovina, Croatia, Kosovo, Montenegro, North Macedonia, Romania, Serbia, and Slovakia will need significant investments to develop infrastructure.

The LNG utilization component is driven by gas and LNG demand in trucking, marine, industrial or district heating applications as discussed in earlier chapters. Countries with existing use of gas will need only investments in storage tanks and vaporizers to replace current fuel sources with LNG, and most of the countries in the region are well placed in this regard. Bulgaria, Romania, Serbia, and Slovenia have remote areas and private players including cruise and ferry operators, ski resort owners, manufacturing facilities, and trucking companies that can benefit by switching to LNG for their operational fuel demand.

7.3. Key investment stakeholders and strategies

Successful adoption and scaling of small-scale and containerized LNG will require significant investments and support from a wide range of stakeholders. Although each investment project will have a specific set of stakeholders, there are, at a high level, six types of key stakeholders

that will play a role in facilitating small-scale LNG investments in Central & Eastern Europe as illustrated in Exhibit 53.

Government agencies will play a critical role in driving small-scale LNG adoption by delivering policies, incentives, and reforms around infrastructure investments and facilitating a level playing field for inter-fuel competition considering taxes and emissions regulation. Regional pipeline and electricity grids are owned or operated by government or quasi-state agencies and will need to offer open access, fair competition, and transparent tariffs for small-scale LNG players.

State-owned energy companies in Central & Eastern Europe will likely initiate pilot and demonstration projects in small-scale LNG. Providing these companies the opportunity to partner and invest flexibly in competitive projects will be critical to small-scale LNG adoption in the region. Private energy companies will likely co-invest before making large, independent investments but will need substantial policy and regulatory clarity to ensure fair competition.

Finally, multilateral financial investors will generally support the first round of investments in the region and will need to recognize small-scale LNG as an effective tool to combat climate change especially in segments where renewables may not be operationally or economically feasible. With the right level of multilateral financing, financial institutional and private investors will support a wide range of projects.

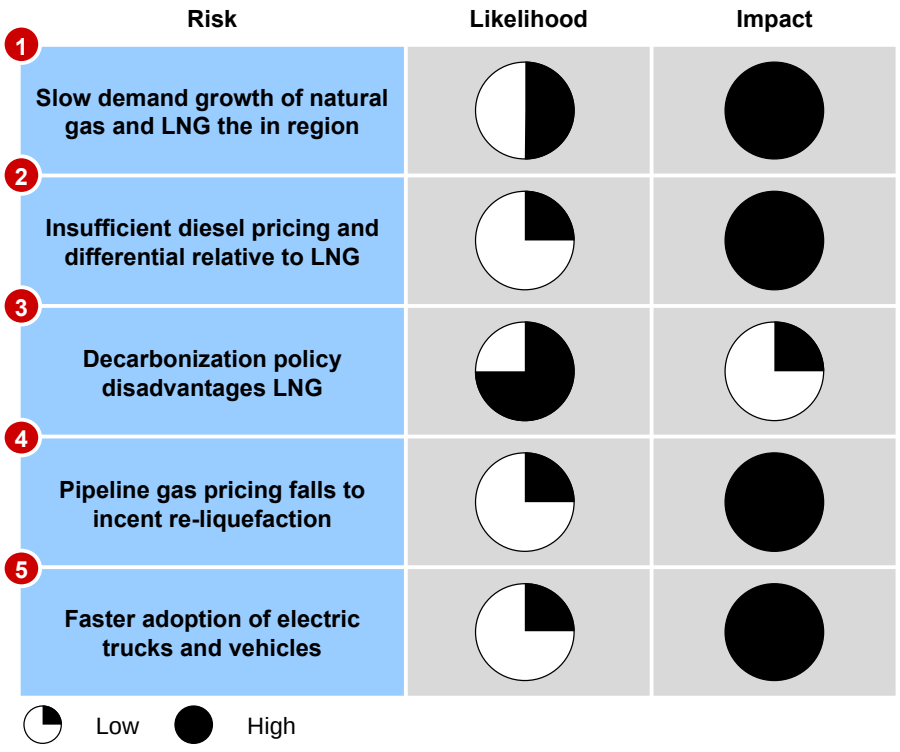
Exhibit 53. Key types of stakeholders for small-scale LNG projects and investments.

7.4. Investment risk assessment

There are five key types of risks to investments in the small-scale and containerized LNG landscape. Exhibit 54 lists these risks and illustrates their relative likelihood and impact on the economics and competitiveness of small-scale LNG projects. Decarbonization policies that are not supportive of LNG and slow demand growth of natural gas and LNG represent the higher risks.

Slow LNG and natural gas demand growth poses significant challenges for projects but decarbonization policies could likely have limited impact. The lack of appropriate infrastructure investments, e.g., LNG terminals, small-scale services at LNG terminals, truck refueling stations, etc. could all play a role in limiting LNG demand growth in Central & Eastern Europe.

Exhibit 54. Risk assessment for small-scale LNG in Central & Eastern Europe.



Stakeholder interviews have indicated diminishing interest among financial investors for natural gas-based projects in many parts of Europe driven mainly by decarbonization policies. Even so, many economic and regional segments, e.g., remote industrial power, marine transportation, and even heavy-duty trucking may not have alternative energy supply options and small-scale LNG could emerge as the most environmentally and economically competitive option. Further, private investors could support some of these projects therefore limiting this risk factor's impact.

An insufficient price differential between LNG and incumbent fuels such as diesel or LPG could reduce the cost saving potential of fuel switching, thereby increase payback periods for the incremental investment required on engines and equipment capable of using LNG. As a result, the impact could be high and could dampen small-scale LNG's adoption considerably. Nonetheless, the likelihood of this risk is limited given the broader dynamics in the global LNG market including currently oversupplied markets and rapidly growing LNG capacity through the medium term, growing supply of cheap LNG with new pricing models, e.g., from shale plays in the U.S.

Two additional risks that are also less likely include rapid innovation and adoption of electric powertrain technologies such as electric trucks and the potential to re-liquefy natural gas brought into Central & Eastern Europe via pipelines. At this time, both of these scenarios are highly unlikely given that significant innovation must occur to reduce costs of electric trucks. In addition, there will be a considerable amount of time before truck fleets progress through turnover and move from conventional fossil fuels. Finally, although pipeline imports of natural gas have become more cost competitive in recent years, the cost is still typically too high for re-liquefaction into LNG at this time although some stakeholders are exploring that option. Needless to say, these additional risks would have a major negative impact on small-scale LNG adoption in the event that either of them progress more quickly.

It must be emphasized, however, that these are risks at the sector level and there may be additional risks for each investment project at a specific and granular level. In addition, at a project level, the relative likelihood and impact of risks will vary. Finally, there are a number of mitigation strategies that can be developed to address these risks. For example, the use of contracts to secure demand and offtake for long periods of time, pursuing investments that are competitive even without government incentives, and exploring opportunities in segments where competing options cannot serve without difficulty are a few relevant mitigation strategies.

8.0 Policy considerations

Successful adoption and exploitation of the economic and environmental benefits of small-scale LNG will require broad and consistent policy support. This includes:

- Level the playing field to facilitate fair inter-fuel competition
- Regulatory and policy certainty for investments
- Regional consistency across policies and regulations
- Clarity around fuel pricing and taxation
- Regulatory incentives to drive small-scale LNG fuel adoption

A few key policy considerations based on research and stakeholder interviews are summarized in this section.

Regulatory clarity and market liberalization for greater private sector involvement

A key enabler for small-scale and containerized LNG is the strong private sector interest noted by several stakeholders during our interviews. For example, a number of stakeholders active in LPG and CNG retailing have indicated strong interest along with initiating pilot projects in small-scale LNG with emphasis on establishing refueling stations. Some U.S. companies have also shown interest in exploring LNG supply opportunities in the region, e.g., Okra Energy in Bulgaria, although they are still at the conceptual stage. Exploiting this nascent interest into specific investments will need policy and regulatory clarity that provide a level playing field for small-scale LNG investments and offerings.

State-owned organizations have a significant impact on how gas is sourced, transported, and sold, and these would need to be liberalized to drive additional penetration for LNG beyond a few projects. Several companies active in the region are state-owned or limited to a small set of private owners. A higher level of competition in the fuel distributor landscape will be necessary to build out LNG infrastructure.

Stronger push toward supply diversification

In addition to the traditional drivers for small-scale LNG – environmental quality, decarbonization, remote locations, and fuel pricing – stakeholder interviews identified strong support around energy supply diversification as an additional driver in Central & Eastern Europe that could favor LNG imports into the region. Countries such as Austria, Poland, Bosnia & Herzegovina are reliant on a single source of gas supply and can be extremely vulnerable to supply shocks. Despite the risks, concrete policies or policy proposals in favor of LNG – e.g., incentives for the use of LNG in heavy-duty trucking like those in Germany – are very limited. Policy and regulatory support to harmonize incentives for LNG or across all fuels on a consistent greenhouse gas emission impact basis help level the playing field for inter-fuel competition and will support LNG as well as other fuels for road and marine transportation applications.

Support for natural gas as a transition fuel

At the same time, the EU's shift away from fossil fuels is weighing strongly on the region's stakeholders and is actively steering investments into renewables, potentially disadvantaging LNG's further market penetration. However, some energy demand segments, e.g., road and marine transportation and remote industrial operations and communities, will require continued reliance on fossil fuels through the medium term where LNG will likely be more feasible operationally and economically, without undermining GHG reduction efforts. Policies that reflect this realism will be necessary to advance small-scale LNG adoption in Central & Eastern Europe. CO_2 emissions from transportation in a few countries covered in the study are subject to additional taxation. Such tax schemes, if managed appropriately, can provide momentum for adoption of small-scale LNG in heavy-duty trucking.

More targeted policy incentives for small-scale LNG

A certain level of policy support in favor of alternative fuels including small-scale LNG is facilitated by the EU for Central & Eastern European countries who are EU members. In general, subsidies and incentives for LNG in the region are limited and should be expanded to facilitate LNG adoption at the smaller scales. Some countries such as Austria offer incentives to electric, fuel cell, or hybrid vehicles, and such support should be extended to LNG-fueled vehicles.

Policy support would be necessary and beneficial across several other areas. These include clarity on how fuel taxes would apply to small-scale LNG if used in the transportation sector as a trucking or marine fuel. Similarly, policy support for financing investments across the small-scale LNG value chain would be critical to spur the infrastructure build-out. Finally, country-specific regulations and policies supportive of small-scale LNG deployment would be necessary. For example, Romania is among the top three providers of commercial trucking service to the European market and incentives for LNG use in trucking there could drive adoption at a significant scale for relatively limited investments. Germany provides a good example with the offer of rebates on new LNG trucks and free passage on highways for new LNG trucks.

Investing in knowledge growth and public awareness

Finally, stakeholder interviews have pointed out the acute lack of awareness let alone technical understanding and expertise around small-scale LNG. A number of stakeholders demonstrated very limited understanding of the potential applications, benefits, opportunities, challenges, and risks associated with small-scale LNG. Investments would be very useful in educating key stakeholders on LNG ranging from safety to economics for prospective applications and enabling and educating on infrastructure and handling aspects.

9.0 Findings and conclusions

This assessment of the potential and opportunity of small-scale and containerized LNG in Central & Eastern Europe has resulted in several findings and conclusions, with key insights outlined below. A country specific illustrative assessment of the opportunity in the region is provided in Exhibit 55.

1. Central & Eastern Europe can realize strong economic and environmental benefits from the use of small-scale and containerized LNG in various applications with emphasis on road and marine transportation and industrial and manufacturing segments.

2. Trucking followed closely by industrial applications are the most promising demand segments for small-scale and containerized LNG. Investments should focus on driving demand in these sectors. Similarly, companies active in these segments with competing fuels are more likely to be interested in small-scale LNG and should be targeted for market development.

3. Slovenia has promising trucking, industrial, and other application markets for small-scale LNG followed by Poland and Austria, both of whom have at least two promising demand segments. Initial focus on infrastructure upgrades should be focused in these countries.

4. Economic competitiveness and environmental benefits of industrial and other (e.g., back-up power, agricultural farms, and district heating in remote areas) applications for small-scale LNG are highly customer and end-use specific. As a result, systemic approaches to facilitate adoption of small-scale LNG in those segments may have limited effectiveness. Instead, investments in import capabilities, e.g., for ISO tanks at regional ports may be more supportive.

5. Countries with limited natural gas infrastructure are more likely to be interested in small-scale LNG, such is the case for Albania, Bosnia & Herzegovina, Kosovo, and Montenegro.

6. In comparison, more than two-thirds of the 15 countries in the region have some LNG refueling infrastructure or plans to invest in them, supporting the strong potential for small-scale LNG in that sector. Albania, Austria, Czech Republic, Poland, Romania, and Slovakia all have plans for building or expanding the network of LNG refueling stations. The potential for marine bunkering is muted given that several countries are landlocked or without significant river transport. However, given the broad support bunkering has seen in Western Europe, it is likely that marine bunkering in Central & Eastern Europe could accelerate along the Danube River or in the Black Sea area.

7. Albania, Czech Republic, Poland, Romania, and, to a certain extent, Croatia are countries where small-scale and containerized LNG infrastructure is advantageously positioned. Specifically, these countries all have one or more of the following attributes: interest in LNG as a gas source, proximity to an LNG terminal, existing LNG refueling stations, and potential

sites for LNG bunkering. Leveraging this existing footprint to further develop the supply infrastructure or develop demand could help drive small-scale LNG adoption.

8. Looking at enablers for small-scale and containerized LNG in the region, policy support is limited and often tied to their obligations under the Energy Community Treaty. Any policies supportive of LNG use in various applications is generic and designed broadly for alternative fuels as opposed to specifically for small-scale LNG. These policies will have to get more specific in support for small-scale LNG in order to drive market adoption quickly and effectively.

9. Natural gas prices via pipelines are not necessarily high and, therefore, it may be more productive to pursue small-scale LNG projects in regions and segments where the lack of pipelines limits access to natural gas.

10. In general, fuel prices, in particular diesel prices, are a critical driver for small-scale LNG adoption especially in the transportation sector. Diesel prices are currently significantly higher than delivered LNG prices in the region and will be a key driver in small-scale LNG adoption in Central & Eastern Europe. In comparison, prices for natural gas delivered via pipeline are not necessarily high although there is some variation across the region. This is, however, not necessarily an impediment for small-scale LNG's adoption as pipeline gas and small-scale LNG typically serve very different market segments.

11. There are a wide range of stakeholders that will play a role in the development of small-scale LNG in Central & Eastern Europe including government agencies, pipeline and electric grid operators as well as oil & gas companies, private energy companies, multilateral financial investors, and private investors. There is limited operational, technical, and commercial understanding of small-scale LNG in the region but high levels of interest in exploring opportunities. Private sector support is limited in most countries but emerging in some including Bulgaria, Romania, and Slovenia. Significant reforms and stakeholder education will be necessary in these markets in order to accelerate private sector support for the region.

12. Finally, a limited number of projects are underway across the small-scale LNG value chain in Central & Eastern Europe. Two upcoming LNG import terminals -- Krk in Croatia and Alexandroupolis in Greece -- could potentially supply the small-scale segments but neither of them offers direct small-scale LNG services. Investments that allow addition of small-scale LNG services to these upcoming and planned terminals could help accelerate development of the small-scale LNG market in Central & Eastern Europe. In the rest of the small-scale LNG value chain, most of the projects in LNG storage and distribution, refueling stations, and industrial applications are limited to pilot or demonstration scales.

Exhibit 55. Small-scale LNG market assessment for Central & Eastern Europe.

Country	Demand and applications				Supply and infrastructure				Enablers					Projects
	Trucking	*Marine*	*Industrial*	*Other*	*Interest in LNG as gas source*	*LNG terminal proximity*	*LNG fueling*	*LNG bunkering*	*Policy framework*	*EU membership*	*High gas prices*	*High diesel prices*	*Private sector support*	*Plans and outlook*
Albania	Public transport testing shift to LNG as a fuel	Low adoption due to lack of infrastructure	Some industries using gas but slow growth	No other known applications	No plans to access gas from TAP	Very far from existing LNG terminals	LNG use in public transport may drive infra.	Bunkering may develop due to broader EU push	Low incentives for LNG adoption and projects	In talks to enter EU	Not applicable as there is no gas demand	Second-highest diesel prices in the region	Low support in terms of funding or incentives	No supply or infrastructure projects planned
Austria	Active growth in adoption of LNG as trucking fuel	Limited adoption in river vessels along Danube	General push for use of gas in industry	Potential for LNG in remote district heating	Plenty of pipeline gas in Austria	Upcoming Krk terminal would be closest	High growth in LNG fueling infrastructure	Low demand for bunkering fuel along Danube	Policies from EU supportive of alternative fuels	EU member	Low gas prices due to country's Baumgarten hub	Lower than average diesel price in region	Moderate support for private players	Ongoing projects by RAG for LNG as trucking fuel
Bosnia & Herzegovina	Low interest in LNG as trucking fuel	Land-locked	Potential for secure gas supply to industry	Potential for LNG in remote district heating	No gas supply and distribution network	Upcoming Krk terminal would be closest	Limited interest in LNG as trucking fuel	Land-locked	Concerns around pollution may drive policy	In talks to enter EU	Second-highest gas prices in the region	Much below average diesel price in region	Limited support for private investments	No recent projects for LNG use
Bulgaria	Low interest in LNG as trucking fuel	Adoption along Danube and in Black Sea	No infrastructure to support LNG use	No other known applications	Abundant gas supply and river LNG terminal	Existing LNG terminal along river Danube	No existing or planned LNG fueling stations	Potential along Danube or Black Sea	EU grant and subsidies offered to LNG terminals	EU member	Lower than average gas price in region	Slightly below average diesel price in region	Support in terms of tax rebates and financing	Some LNG distribution / storage projects
Croatia	Developing LNG as trucking fuel driven by EU	Growing interest in adopting LNG as marine fuel	Some players are interested to fuel their operations	No other known applications	No supply limitations, Krk aimed at export	Krk will need to develop small-scale services	Will need to plan fueling stations along TEN-T	Potential to add bunkering services at Krk	Moderate policy support to drive LNG demand	EU member	Lower gas prices than most neighbors	Slightly above average diesel price in region	Low support and slow approval process	Some projects expected with LNG imports
Czech Republic	Interest in LNG is growing with push from EU	Low adoption in vessels along Danube	Paper mills and other industries may use LNG	Growing demand for peak-shaving in remote areas	Limited gas supply growth for demand growth	Close to LNG terminals in Poland, Germany	Rising interest in LNG and TEN-T driving planning	Land-locked	Tax benefits for LNG-fueled vehicles	EU member	Highest gas prices in the region	Slightly above average diesel price in region	Limited support for private investments	LNG trucks and fueling stations planned
Hungary	Interest for LNG as trucking fuel is not growing	Land-locked	Manufacturing, chemical, and drug industries	LNG can be stored for energy security	Diversified gas supply including LNG	Has booked capacity on the Krk terminal	Has two existing stations with no expansion plans	Land-locked	No policy support for LNG	EU member	Lower than average gas price in region	Lower than average diesel price in region	Moderate support for private players	Some projects planned for gas utilization
Kosovo	Low transport energy demand and LNG interest	Some adoption growth driven by EU and IMO	Some adoption interest	Potential for LNG in small-scale district heating	No existing supply, in talks to interconnect TAP	Far from nearest existing or planned terminal	No plans or incentives for fueling stations	No planned bunkering capacity	New energy policy may support gas	In talks to enter EU	Not applicable as there is no gas demand	Second-lowest diesel prices in the region	Low support in terms of funding or incentives	Some demand may open at industrial parks
Montenegro	Limited growth in transportation sector and LNG	High potential expected at Port of Bar	Some interest has developed in LNG for industry	No other known applications	No supply, may develop Port of Bar	Close to upcoming Krk terminal	No plans or incentives for fueling stations	Land-locked	No existing or expected policies for LNG	In talks to enter EU	Not applicable as there is no gas demand	One of the highest paying diesel users	Limited support for private investments	Industry may drive Port of Bar development
North Macedonia	Uncertain interest in LNG for trucking	Land-locked	High opportunity but slow growth in LNG adoption	Small-scale thermal application	Growing pipeline gas supply and network	Far from the upcoming Krk terminal	No existing fueling stations, few planned	Land-locked	No existing or expected policies for LNG	In talks to enter EU	Similar to average gas price in region	Lower than average diesel price in region	Limited support for private investments	No upcoming or planned projects for LNG
Poland	High interest and adoption in LNG as trucking fuel	Growing adoption in LNG as bunker fuel	Some industry operations powered by LNG	Potential for LNG in small-scale district heating	Sufficient pipeline gas and LNG terminals	Owns LNG terminal and gas grid	Stations being planned adding to existing six	Has one small-scale bunkering terminal	Some EU push but no national policies for LNG	EU member	Above average gas price in region	Low diesel prices in the region	High policy support for private projects	Expansion of existing gas network planned
Romania	Growing interest in LNG as transport fuel	Some adoption in vessels along Danube	There is some potential in using gas in industry	No other known applications	Existing Black Sea port may receive Turkish gas	Small-scale import terminal being planned	Plans for a couple LNG fueling stations	Growing interest in river terminal for LNG	EU push and funding for LNG projects	EU member	Lower than average gas price in region	Low diesel prices in the region	High support for private investments	Growing investments in LNG projects
Serbia	Low adoption of LNG as fuel in trucking	Land-locked	Interest in LNG for lowering emissions	Potential for LNG in small-scale district heating	Existing supply and may book Alexandroupolis	Close to upcoming Krk terminal	Plans to build fueling stations along TEN-T	Land-locked	EU push but no national policies supporting LNG	EU member	Second highest gas price in the region	Highest diesel prices in the region	Moderate support for private projects	Moderate investments in LNG projects
Slovakia	Rising adoption of LNG in trucking	Land-locked	Some industrial customers may adopt LNG	No other known applications	Gas supply enough to serve 95% consumers	Close to upcoming Krk terminal	New fueling stations planned	Land-locked	Few incentives for private investment	EU member	Slightly above average gas price in the region	One of the highest paying diesel users	Moderate support for private projects	Growing investments in LNG projects
Slovenia	Growing adoption in LNG for trucking	Limited demand in LNG as fuel for small vessels	LNG already used to supply during maintenance	LNG can be used for small-scale back-up power	Some unmet demand in Northern region	Very close to upcoming Krk terminal	Two existing stations, more may be planned	Land-locked	Incentives for alternative fuels to cut emissions	EU member	Slightly above average gas price in the region	One of the highest paying diesel users	High support for private investments	Truck fueling exists but no new projects

Enabler for small-scale LNG · Moderate driver for small-scale LNG · Disabler for small-scale LNG · Non-existent

Notes

[1] International Gas Union, *World LNG Report*, 2020
[2] International Energy Agency/Data and Statistics, *Oil final consumption by product,* 2020
[3] Asia-Pacific Economic Cooperation, *Small-scale LNG in Asia-Pacific*, 2019
[4] Nuffel, L.V., Janzow, N., Rademaekers, K; Kotek, P., Toth, B., Selei, A.; Steck, G., *Study on Gas market upgrading and modernization – Regulatory framework for LNG terminals, Trinomics; Rekk; Enquidity*, 2020
[5] Gas Infrastructure Europe, *LNG Map Database*, 2019
[6] U.S. Energy Information Administration, *Henry Hub Natural Gas Spot Price*, 2020
[7] World Bank, Japan Ministry of Economics, Trade and Industry, and ADI Analytics
[8] In its rules for export authorizations, the U.S. Department of Energy has defined small-scale LNG capacity as less than approximately 142 MMcfd (51.75 Bcf per year). In this report, however, we define small-scale LNG as volumes of less than 100 MMcfd.
[9] International Energy Agency, ADI Analytics
[10]European Commission weekly oil bulletin, https://ec.europa.eu/energy/observatory/reports/List-of-WOB.pdf
[11] Eurostat, https://ec.europa.eu/eurostat/statistics-explained/index.php/Natural_gas_price_statistics#Natural_gas_prices_for_non-household_consumers
[12] Eurostat, https://ec.europa.eu/eurostat/statistics-explained/images/8/80/Consumer_prices_of_petroleum_products%2C_end_of_second_half_2015_%28EUR_per_litre%29_YB16.png
[13] Ship & Bunker, https://shipandbunker.com/prices/emea/nwe/nl-rtm-rotterdam
[14] World Bank, https://www.worldbank.org/en/research/commodity-markets
[15] NGVA Europe, http://www.ngva.eu
[16] Assumptions for the economic analysis of switching to LNG include annual diesel and LNG price inflation of 2.0% and 0.5%, respectively; average fuel economies of 3.05 and 2.84 km per liter of diesel and LNG, respectively; annual distance of 160,000 km traveled by each truck; a truck life of eight years; and a discount rate of 20%.
[17] 2019 Oxford institute for energy studies - A-review-of-prospects-for-natural-gas-as-a-fuel-in-road-transport-Insight-50 - April
[18] Natural & bio Gas Vehicle Association (NGVA Europe), https://www.ngva.eu/stations-map/, ADI Analytics
[19] SEA-LNG, https://sea-lng.org/why-lng/global-fleet/, 2020
[20] Sharples, J., *LNG Supply Chains and the Development of LNG as a Shipping Fuel in Northern Europe*, Oxford Institute of Energy Studies, 2019 and DNV GL.
[21] Assumptions for the economic analysis of switching to LNG include annual MGO and LNG price inflation of 1.5% and 0.5%, respectively; annual MGO and LNG use of 3,539,298 and 2,906,358 liters, respectively; a ship life of 30 years; and a discount rate of 20%.
[22] Assumptions for the economic analysis of switching to LNG include annual LPG and LNG price inflation of 1.5% and 0.5%, respectively; annual LPG and LNG utilization of 10,844,025 and 12,485,730 liters, respectively; equipment life of 15 years; and a discount rate of 20%.

[23] ENTSOG, https://www.entsog.eu/sites/default/files/2020-01/ENTSOG_CAP_2019_A0_1189x841_FULL_401.pdf
[24] Gas Infrastructure Europe, ADI Analytics
[25] European Union, ADI Analytics
[26] ADI Analytics

Appendix

Exhibit 56. List of stakeholders engaged during this study.

Albania U.S. Embassy	ContourGlobal	Ministry of Energy and Infrastructure, Albania
Austria U.S. Embassy	Crimson Capital	MOL Group
Bosnia & Herzegovina U.S. Embassy	Energy Community Secretariat	Monteco doo
Bulgaria U.S. Embassy	Energy Regulation Agency	Montenegrin Foreign Investors Council
Croatia U.S. Embassy	EU Agency for the Cooperation of Energy Regulators	Montenegro Bonus
Czech Republic U.S. Embassy	European Bank for Reconstruction and Development	Montenegro Hydrocarbons Administration
Hungary U.S. Embassy	European External Action Service (EEAS)	Naturgy
Kosovo U.S. Embassy	Ferronikeli	Navita
Poland U.S. Embassy	General Electric	Okra Energy
Romania U.S. Embassy	Government of Montenegro	Petrol
Serbia U.S. Embassy	Hill International	Pivara Trebjesa
Slovakia U.S. Embassy	Interational Finance Corporation	Plinovodi
Slovenia U.S. Embassy	International Finance Corporation	Port of Bar
Abkons	International Vehicles Corporation	Sava Trans doo
Agency for the Cooperation of Energy Regulators	KfW	Sharrcem
Albanian Energy Regulatory Authority	Kinetrex Energy	Slovenský Plynárenský Priemysel, a.s.
Albanian Gas Service Co.	Klikovac doo	Slovnaft
Albgaz	Knežević Transport doo	Srbijagas
AmCham	Korporata Elektroenergjitike Shqiptare (KESH)	StartCo
Autovision sh.a	Kosovo Directorate for Energy	TCRK LNG
Ben-Kov doo	Kosovo Ministry of Economic Development	Tosyali Toscelik
Bolvoil sh.a	KOSTT	Uniprom-KAP
Butan Plin	Lukana doo	United states Agency for International Development
Chamber of Commerce	Millennium Challenge Corporation	United States Department of Energy
Chart Industries	Ministry of Economy, Montengro	World Bank

Exhibit 57. Screening model parameters ... 1 of 3.

		Others					Energy demand							
Country	Score	GDP growth	Policies and incentives	Re-gasification capacity	Distance from nearest terminal	Coastline	Growth of total energy demand	Growth of industrial energy demand	Growth of transport energy demand	Growth of remote energy demand	Total energy demand	Industrial energy demand	Transport energy demand	Remote energy demand
Unit		%		bcm/yr	km		%	%	%	%	ktoe	ktoe	ktoe	ktoe
Weighting		III	III	III	III	III	III	III	III	III	I	I	I	I
Albania	8.7	9.9%	2		831	Yes	1.6%	14.9%	0.1%	5.2%	2,093	396	827	114
Austria	5.9	6.0%	2		537	No	1.4%	2.9%	1.5%	0.8%	27,699	8,046	8,782	521
Bosnia & Herzegovina	5.9	7.5%	1		578	Yes	2.5%	4.8%	10.1%	9.0%	3,554	830	1,243	19
Bulgaria	5.5	9.1%	2		961	Yes	1.0%	0.2%	1.7%	-3.3%	10,151	2,729	3,334	174
Croatia	6.5	7.2%	2	2.60	182	Yes	2.2%	4.1%	4.9%	0.2%	7,323	1,184	2,176	230
Czech Republic	6.8	9.5%	3		724	No	3.4%	1.8%	3.4%	2.9%	27,147	6,703	6,572	640
Hungary	10.6	8.2%	2		524	No	3.3%	4.8%	3.4%	2.3%	20,218	4,374	4,506	610
Kosovo	4.4	7.2%	2		1,092	No	6.3%	1.3%	5.0%	5.4%	1,562	316	412	30
Montenegro	1.1	10.7%	1		677	Yes	5.0%	0.4%	12.2%	-20.9%	758	132	234	5
North Macedonia	8.2	8.0%	1		1,000	No	1.2%	-10.2%	9.1%	2.2%	1,941	384	703	24
Poland	10.1	7.0%	2	7.50	937	Yes	6.3%	6.0%	13.7%	7.9%	75,083	15,839	21,400	3,861
Romania	1.5	10.4%	2	8.00	1,164	Yes	2.7%	0.0%	7.3%	3.7%	23,755	6,158	6,171	494
Serbia	9.6	8.5%	2		572	Yes	4.3%	5.6%	3.2%	11.8%	9,246	2,326	2,092	190
Slovakia	8.6	6.2%	2		546	No	4.9%	1.6%	13.1%	-2.7%	11,048	3,487	2,794	143
Slovenia	6.6	7.8%	3		162	Yes	2.0%	2.7%	2.1%	-0.7%	4,980	1,294	1,850	73

Exhibit 58. Screening model parameters ... 2 of 3.

	Natural gas demand											
Country	Growth of gas demand growth	Growth of industrial gas demand	Growth of transport gas demand	Growth of remote gas demand	Share of gas in total energy demand	Share of gas in industrial energy demand	Share of gas in transport energy demand	Share of gas in remote energy demand	Gas demand	Industrial gas demand	Transport gas demand	Remote gas demand
Unit	%	%	%	%	%	%	%	%	ktoe	ktoe	ktoe	ktoe
Weighting	III	III	III	III	II	II	II	II	I	I	I	I
Albania	5.8%	5.8%	0.0%	0.0%	1%	4%	0%	0%	12	14	-	-
Austria	2.5%	3.1%	4.1%	3.1%	18%	37%	4%	5%	5,115	2,999	323	24
Bosnia & Herzegovina	6.2%	8.6%	0.0%	9.0%	4%	11%	0%	0%	149	95	1	-
Bulgaria	1.9%	0.5%	4.7%	-1.2%	16%	38%	8%	10%	1,631	1,032	273	17
Croatia	3.7%	6.5%	0.0%	6.0%	20%	36%	0%	10%	1,491	429	-	22
Czech Republic	4.8%	3.9%	2.7%	14.9%	21%	35%	1%	11%	5,618	2,378	78	73
Hungary	4.5%	4.6%	41.7%	5.5%	31%	35%	2%	22%	6,269	1,516	73	136
Kosovo	0.0%	0.0%	0.0%	0.0%	0%	0%	0%	0%	-	-	-	-
Montenegro	0.0%	0.0%	0.0%	0.0%	0%	0%	0%	0%	-	-	-	-
North Macedonia	18.3%	20.1%	13.4%	0.0%	2%	11%	0%	0%	44	42	0	-
Poland	3.5%	6.8%	3.2%	15.2%	15%	24%	2%	1%	11,365	3,803	425	40
Romania	-4.6%	-1.3%	-57.4%	25.2%	25%	39%	0%	24%	5,863	2,423	0	117
Serbia	16.6%	11.7%	-12.4%	4.4%	13%	26%	0%	11%	1,182	603	5	20
Slovakia	4.6%	4.1%	27.8%	-0.3%	28%	27%	6%	18%	3,135	950	167	25
Slovenia	4.5%	4.4%	24.5%	3.8%	12%	38%	0%	8%	615	487	4	6

Exhibit 59. Screening model parameters … 3 of 3.

	Power generation							Diesel demand			Natural gas supply		
Country	Growth of total power generation	Growth of gas-fired power generation	Share of gas-fired power generation	Total power generation	Share of coal-fired power generation	Coal-fired power generation	Gas-fired power generation	Growth of diesel demand	Diesel prices	Diesel demand	Growth of natural gas supply	Industrial natural gas prices	Natural gas supply
Unit	%	%	%	GWh	%	GWh	GWh	%	€/L	ktoe	%	€/kWh	ktoe
Weighting	III	III	I	I	I	I	I	III	III	II	III	III	I
Albania	-12.4%	0.0%	0.0%	4,525	0.0%	-	-	-1.5%	1.268	722	17.1%	-	37
Austria	1.7%	9.0%	42.7%	68,591	4.8%	3,294	29,316	3.4%	1.129	7,624	4.4%	0.033	7,776
Bosnia & Herzegovina	2.5%	-16.5%	9.8%	16,432	18.2%	2,996	1,612	9.0%	1.074	1,114	6.3%	0.037	200
Bulgaria	-3.7%	1.5%	4.2%	45,612	45.9%	20,914	1,922	1.0%	1.176	2,022	3.2%	0.031	2,762
Croatia	2.5%	60.7%	25.8%	11,984	11.4%	1,367	3,090	6.3%	1.160	1,923	9.4%	0.030	2,493
Czech Republic	1.6%	18.3%	4.3%	87,997	49.5%	43,583	3,747	3.8%	1.190	4,618	1.7%	0.051	6,819
Hungary	1.7%	12.3%	22.7%	31,905	15.1%	4,802	7,227	4.0%	1.179	3,313	3.3%	0.029	8,261
Kosovo	-1.7%	0.0%	0.0%	5,918	96.8%	5,726	-	9.5%	1.000	459		-	-
Montenegro	-9.1%	0.0%	0.0%	2,483	54.9%	1,362	-	13.7%	1.250	238		-	-
North Macedonia	-0.4%	112.8%	14.8%	5,600	60.5%	3,386	829	9.5%	1.016	627	42.1%	0.032	226
Poland	1.0%	25.6%	7.4%	169,852	78.3%	132,972	12,643	17.2%	0.974	16,278	5.3%	0.035	16,078
Romania	-1.5%	6.6%	8.3%	128,592	13.1%	16,857	10,656	7.4%	1.021	5,023	3.9%	0.032	9,620
Serbia	-1.7%	58.7%	1.5%	37,044	71.7%	26,554	549	4.6%	1.361	1,694	10.0%	0.039	2,117
Slovakia	-1.9%	-6.4%	5.2%	25,308	11.2%	2,826	1,316	17.0%	1.223	1,861	1.7%	0.034	4,077
Slovenia	2.6%	4.6%	2.8%	16,301	28.4%	4,622	462	1.4%	1.243	1,599	3.2%	0.034	730

Exhibit 60. Connecting Europe Facility and EU-funded small-scale LNG projects in the region.

Country	Project	Funding	Description
Hungary	PAN-LNG	CEF and EU funding	Develop LNG refueling stations for trucking and applications marine
Slovakia	LNGAFT	EU funding	LNG refueling station and fleet of 15 LNG buses for public transport
Bulgaria	Ruse LNG terminal	EU funding	Small-scale LNG import terminal for trucking and gas network