

Small-Scale and Containerized LNG in Central & Eastern Europe

Key Findings

U.S. Department of Energy
December 2020



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Outline

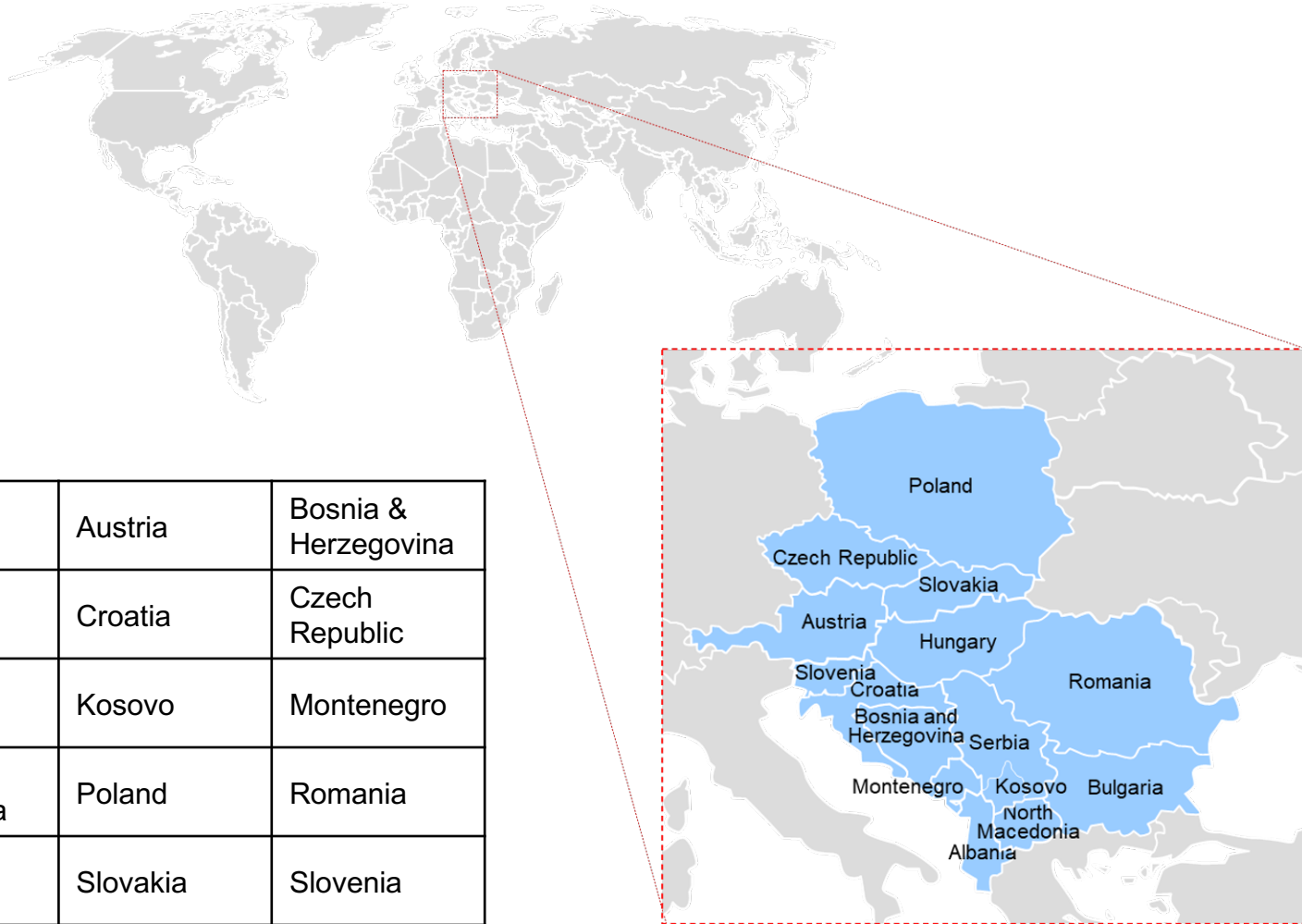
- ▶ **Objectives and scope**
- ▶ Key findings
- ▶ Introduction
- ▶ Regional energy market review
- ▶ Regional demand assessment
- ▶ Regional supply and infrastructure assessment
- ▶ Stakeholders and policy considerations

The study evaluates potential demand for U.S. small-scale LNG in Central & Eastern Europe

- U.S. Department of Energy (DOE) sponsored this study to identify and evaluate opportunities for small-scale and containerized LNG in Central & Eastern Europe
- Key objectives of the study include the following:
 - Develop a concrete and thorough understanding of the market potential for small-scale LNG in Central and Eastern Europe
 - Identify key infrastructure needs to enable the rapid deployment of small-scale LNG to the region
 - Identify near- and medium-term opportunities to jump-start and accelerate deployment of small-scale LNG
 - Based on these opportunities, provide actionable recommendations to outside and local stakeholders in the public and private sectors

Our scope includes 15 countries in Central & Eastern Europe

Countries under study in Central & Eastern Europe



The project was completed in three phases with key findings from the second and third phase summarized in this report

Part I	Part II	Part III
<ul style="list-style-type: none">▪ The first phase of the project began with a series of kick-off workshops in February 2020 in Tirana, Albania and Podgorica, Montenegro.▪ The kick-off workshops were attended by 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 technical and market fundamentals of small-scale and containerized LNG, its applications, advantages, costs and benefits.▪ The project team also introduced goals, methodology, and timeline of the study, while gathering inputs from other presentations at the workshops made by relevant stakeholders.	<ul style="list-style-type: none">▪ The report was developed in the second phase.▪ Primary research included interviews with ~75 U.S. and local stakeholders including U.S. embassy, gas and LNG equipment vendors, and regional oil & gas.▪ Secondary research covered a range of sources in the public domain on energy supply and demand, economic and industrial growth, and policy and regulations supporting small-scale and containerized LNG in the region.▪ Spreadsheet modeling to estimate opportunity for small-scale and containerized LNG in the region.▪ Price and cost competitiveness of small-scale and containerized LNG was quantified across key applications in the region.	<ul style="list-style-type: none">▪ This virtual workshop and the publication of the study report constitute the third and final phase.▪ Workshop agendas will focus on sharing the findings, strategic implications, and policy recommendations developed by the project team.▪ These will eventually lead to further conversations and efforts to identify specific initiatives and actions to support the development of small-scale or containerized LNG projects in the region.

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Key findings

1

A third of the countries in the region – **Hungary, Poland, Serbia, Albania, Slovakia, and North Macedonia** – can immediately benefit from small-scale LNG enabled by several factors including:

- **Economic growth**, e.g., in Hungary, Poland, Serbia, Albania, and Czech Republic
- **High diesel demand growth**, e.g., in Poland, North Macedonia, and Slovakia
- **Remote energy demand growth**, e.g., in Serbia and Albania
- **Rapid natural gas demand growth** seen in Poland, Serbia, and North Macedonia

2

Trucking and industrial followed by marine are promising applications for small-scale LNG.

- **Payback periods for LNG-fueled trucks are most attractive followed by ships and industrial boilers** with robust price differentials to incumbent fuels in most cases.
- **Industrial demand will be in areas inadequately connected to existing gas grids.**

3

The region has **limited LNG infrastructure and particularly at the smaller scale**. Even so, LNG is now so cost-competitive – thanks in part to the U.S. – that it **can compete even if trucked or barged into the region** from nearby terminals. Even so, **new investments are necessary** in small-scale LNG services at existing or upcoming terminals or new sea and river ports to handle ISO containers. Fortunately, **LNG infrastructure costs are falling due to innovation**.

4

Several stakeholders will be key to developing the region's small-scale LNG market including government agencies, regulators, state-owned and private companies, multilateral institutions, and investors. **Transparent and flexible policies, regulatory support and clarity, financial incentives, and public awareness at the country level will drive small-scale LNG adoption.**






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LNG plants with capacity of 1 MTPA or less are categorized as small-scale while containerized LNG is ~10,000 gallons

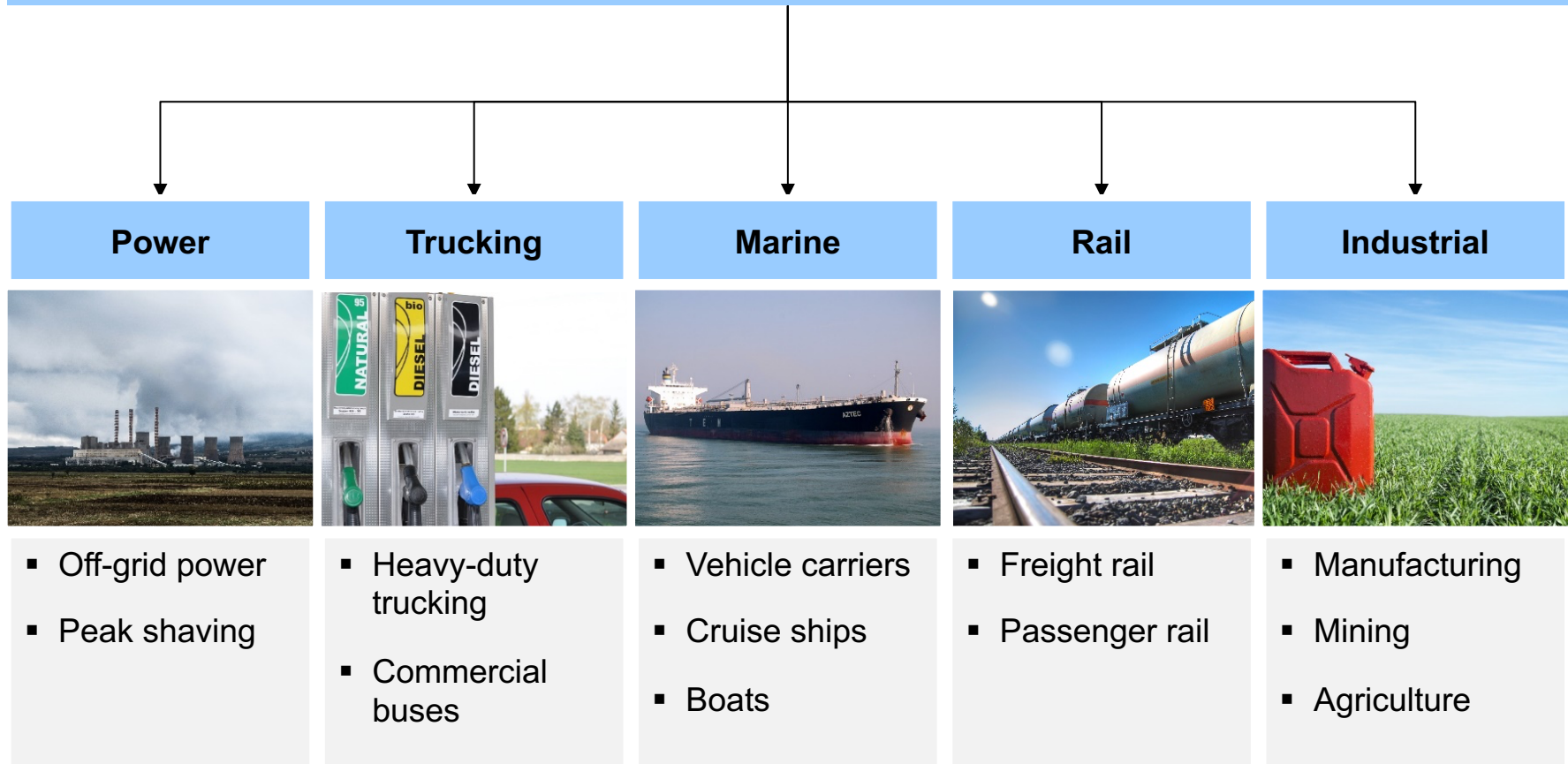
Classification of LNG Projects by Capacity

Focus of
this study

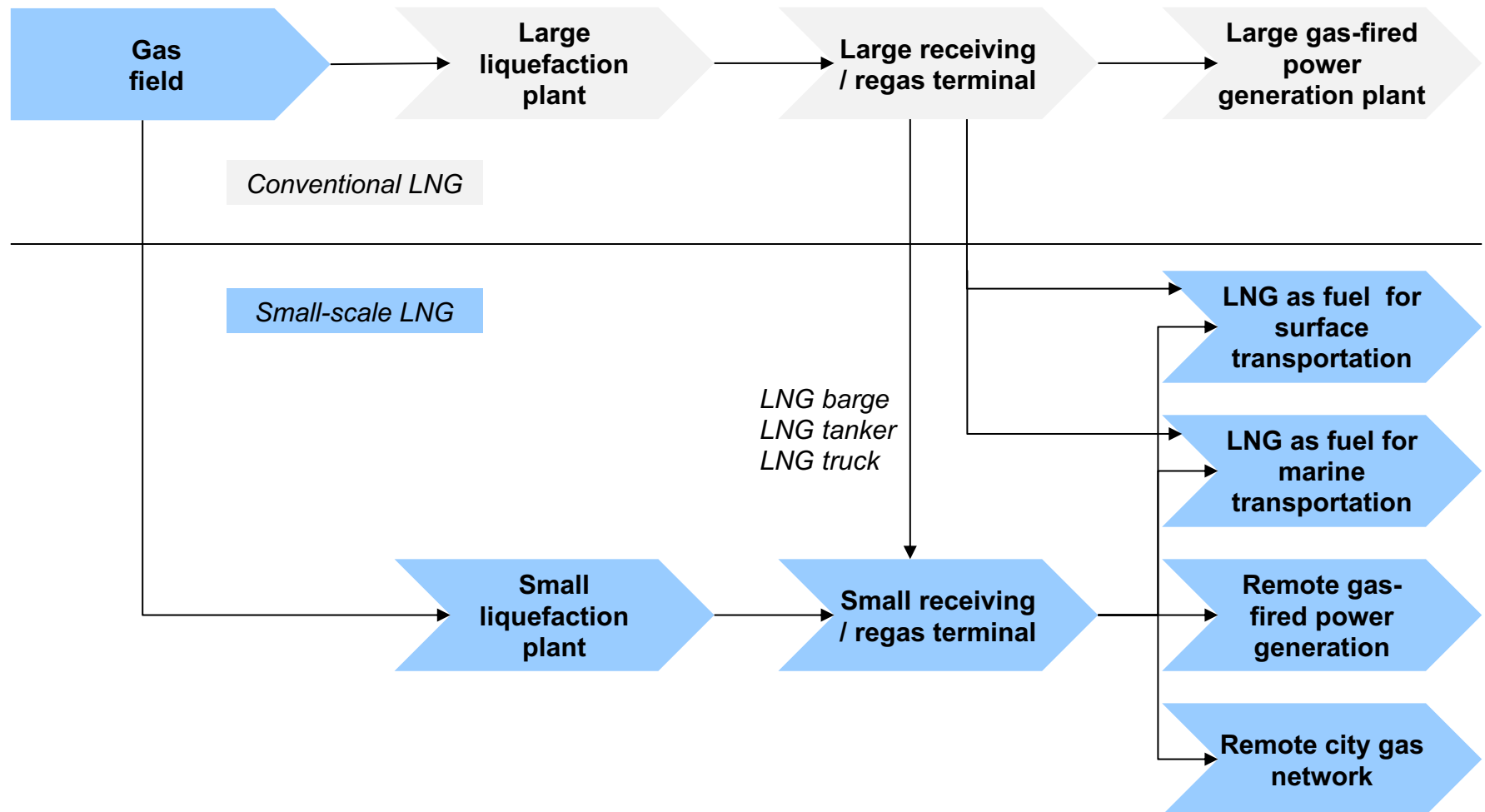
	Large-scale	Mid-scale	Small-scale	Mini / Micro	Containerized
					
million tons per year	3 - 8	1 - 2	<1	<0.2	16 tons or 10,000 gallons per container
million tons per day	0.008-0.022	0.002-0.005	<0.002	<0.001	
million cu. ft. per day	300 - 1,000	100 - 300	<100	<26	
billion cu. m. per year	4 - 10	1.4 - 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	

LNG is mainly used as fuel for back-up power generation, transportation, and industrial operations

Small-Scale LNG Applications



Small-scale LNG supply chains have greater flexibility and more touchpoints relative to conventional, large-scale options



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For small-scale and containerized LNG opportunity screening, ADI short-listed and assigned weighting to 30 metrics

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

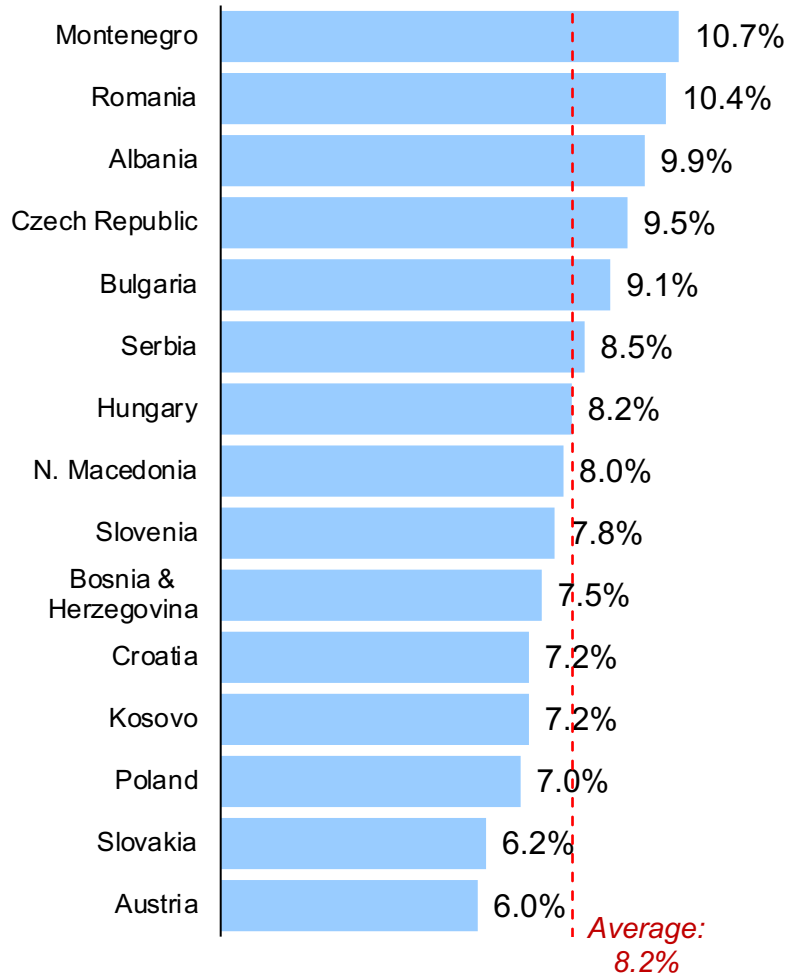
III – High importance, II – Moderate importance, and I – Low importance

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

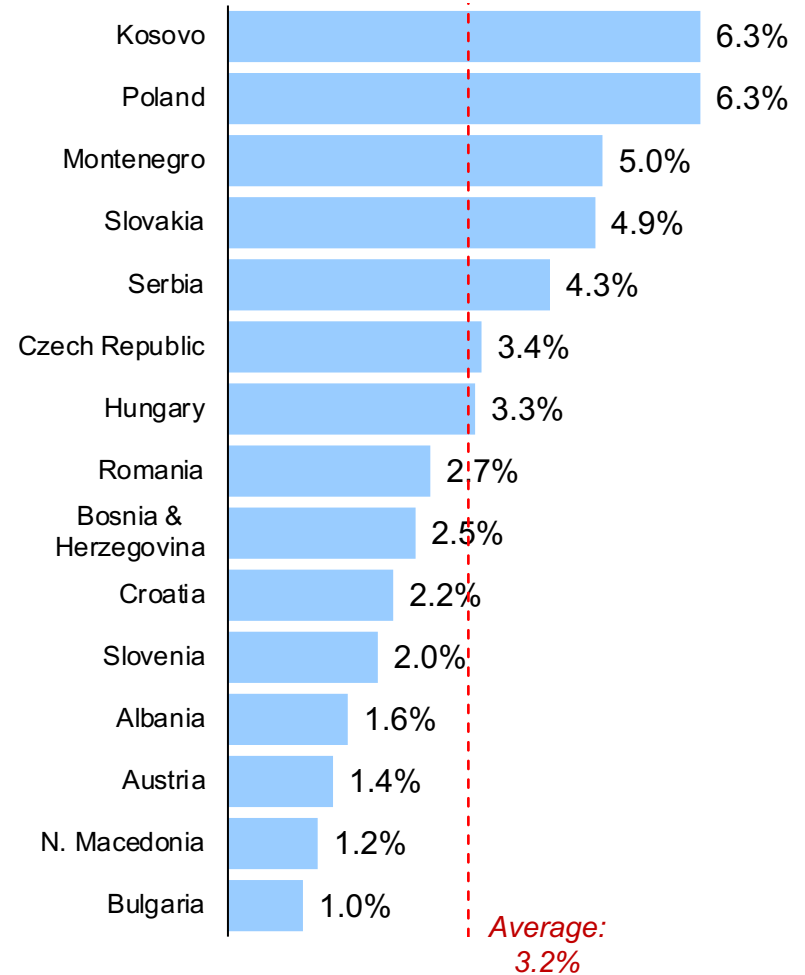
Metric	Unit	Weight
Power Generation		
Growth of total power generation	%	III
Growth of gas-fired power generation	%	III
Share of gas-fired power generation	%	I
Share of coal-fired power generation	%	I
Total power generation	GWh	I
Gas-fired power generation	GWh	I
Coal-fired power generation	GWh	I
Diesel 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

Montenegro and Romania have led economic growth while Kosovo and Poland have led energy demand growth in region

Regional GDP Growth by Country, 2015-17
(Percentage)

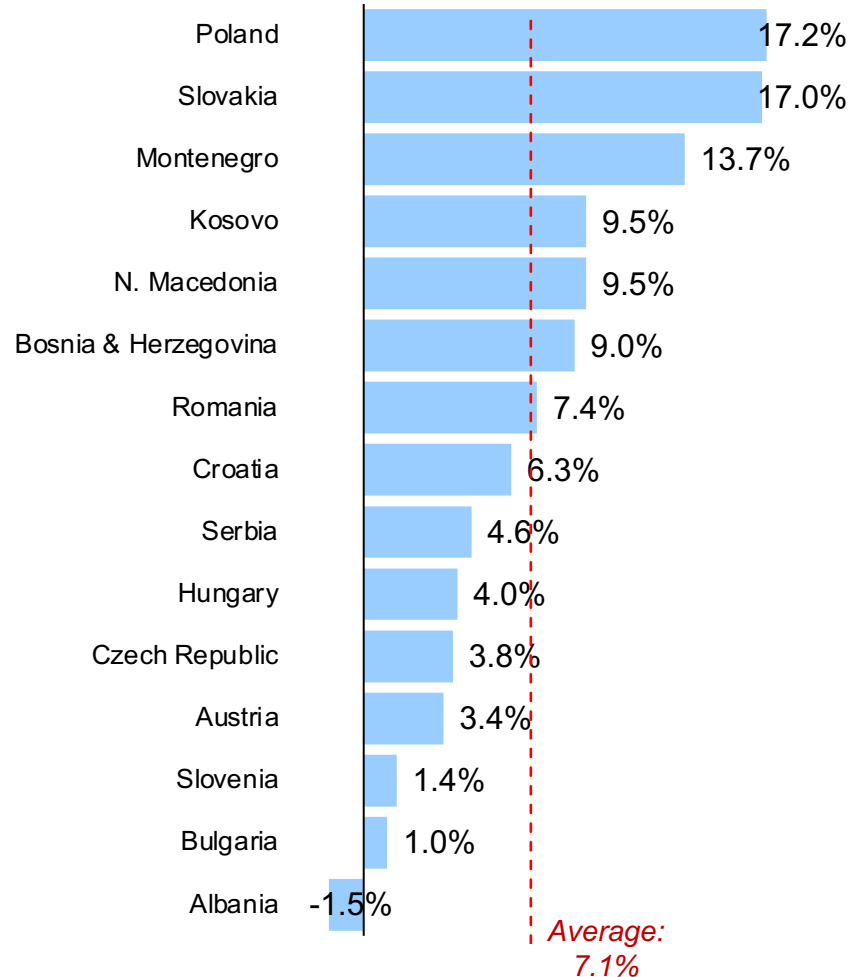


Energy Demand Growth by Country, 2015-17
(Percentage)

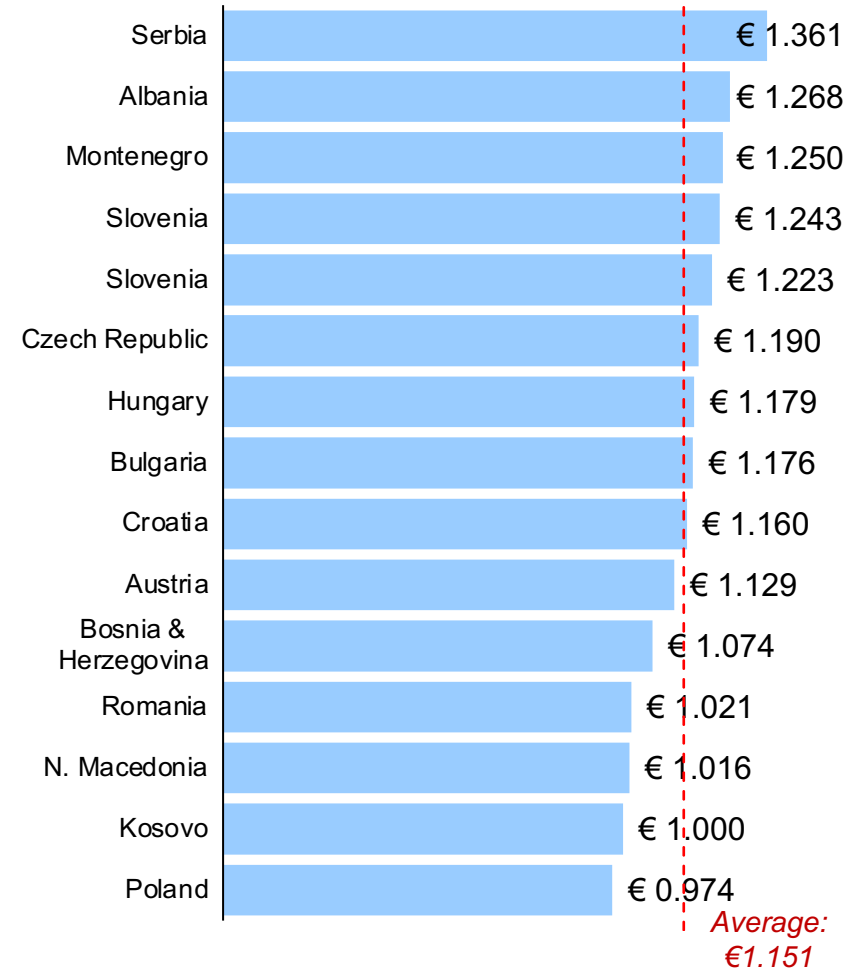


Diesel supply in the region is led by Poland and Slovakia while prices are the highest in Serbia, Albania, and Montenegro

Diesel Supply Growth by Country, 2015-17
(Percentage)

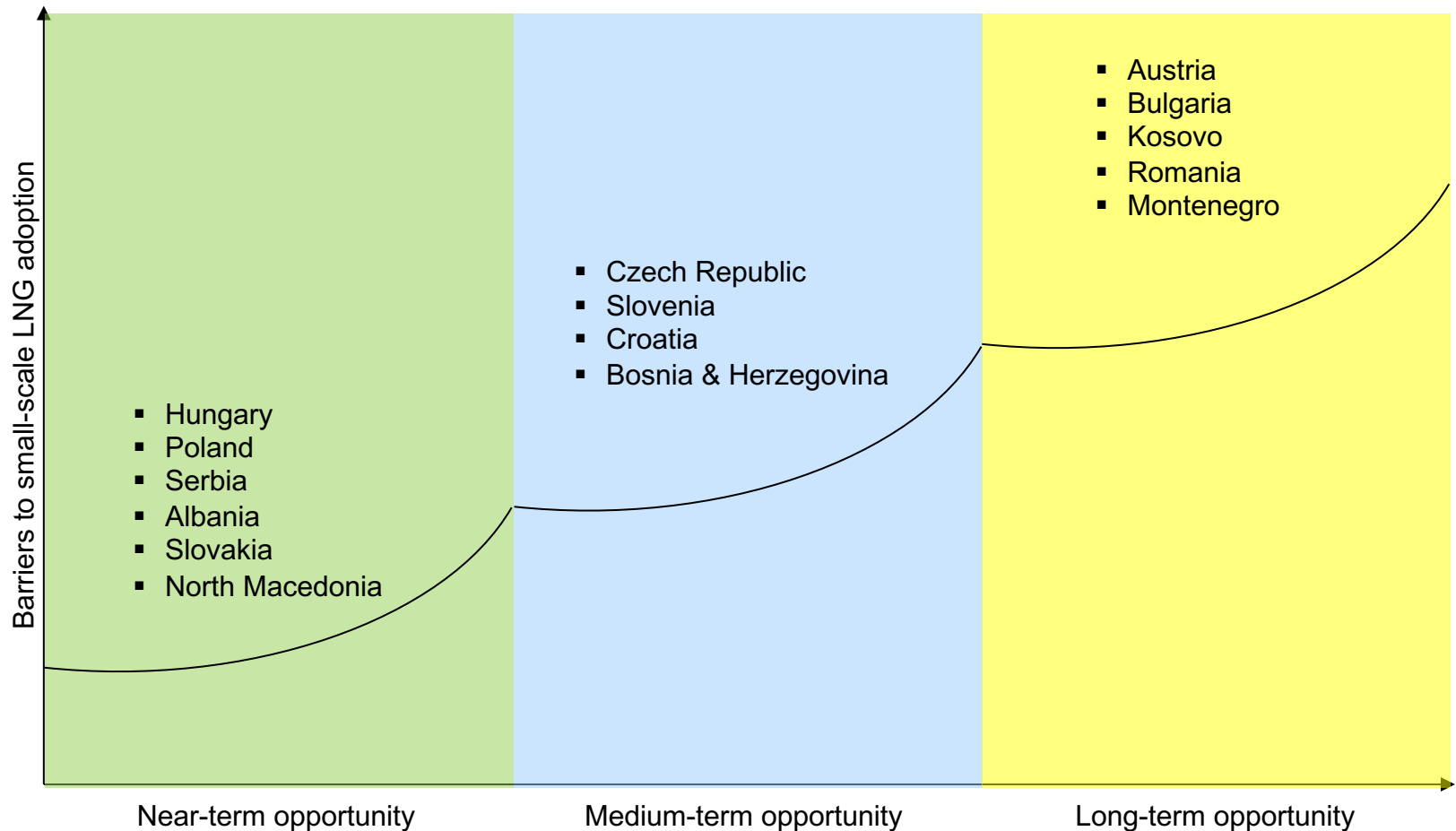


Diesel Prices with Taxes by Country, 2019
(€/L)



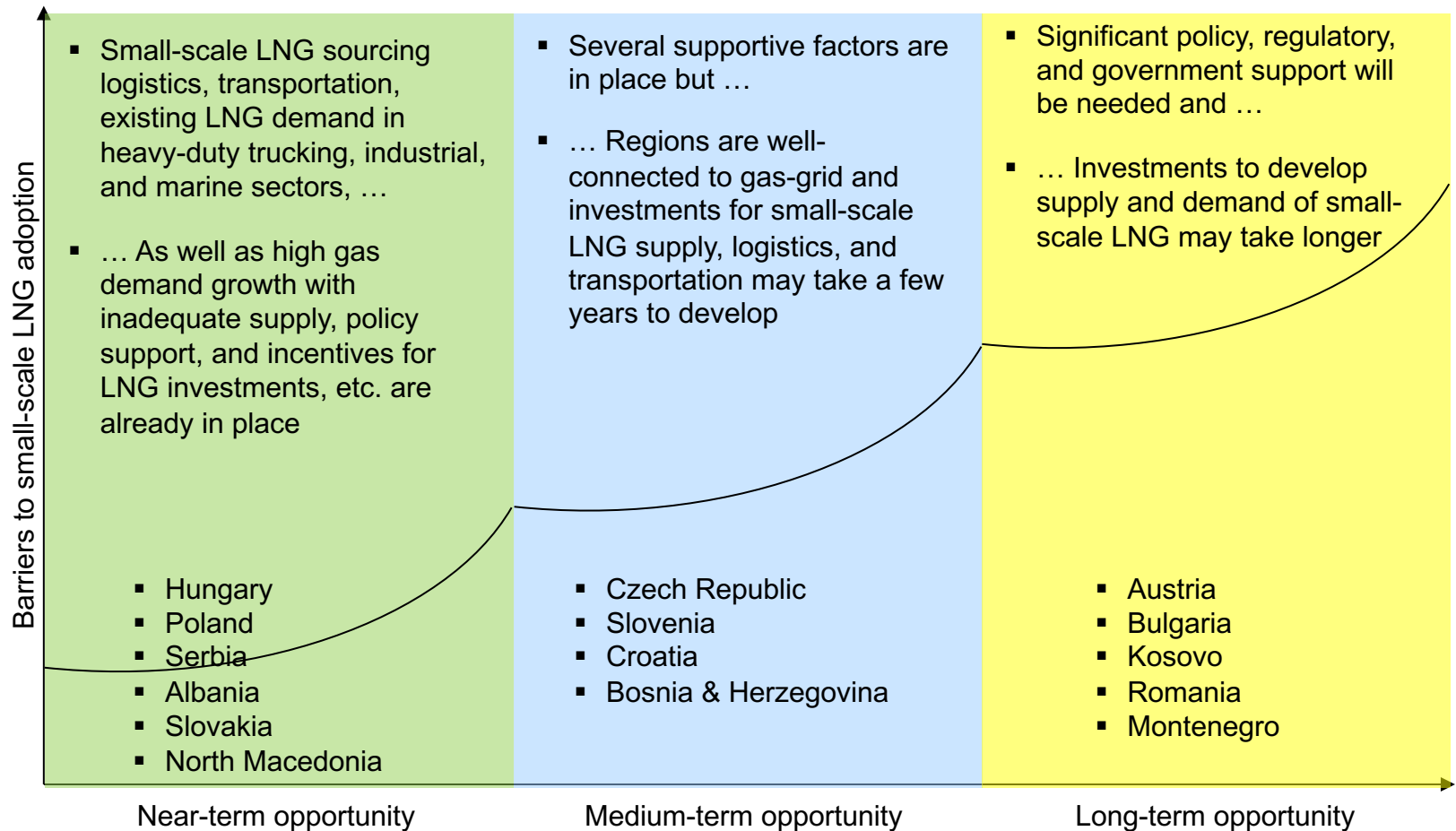
Our work shows that a third of the countries have few adoption barriers and can immediately benefit from small-scale LNG

Opportunity Assessment by Country in Central & Eastern Europe



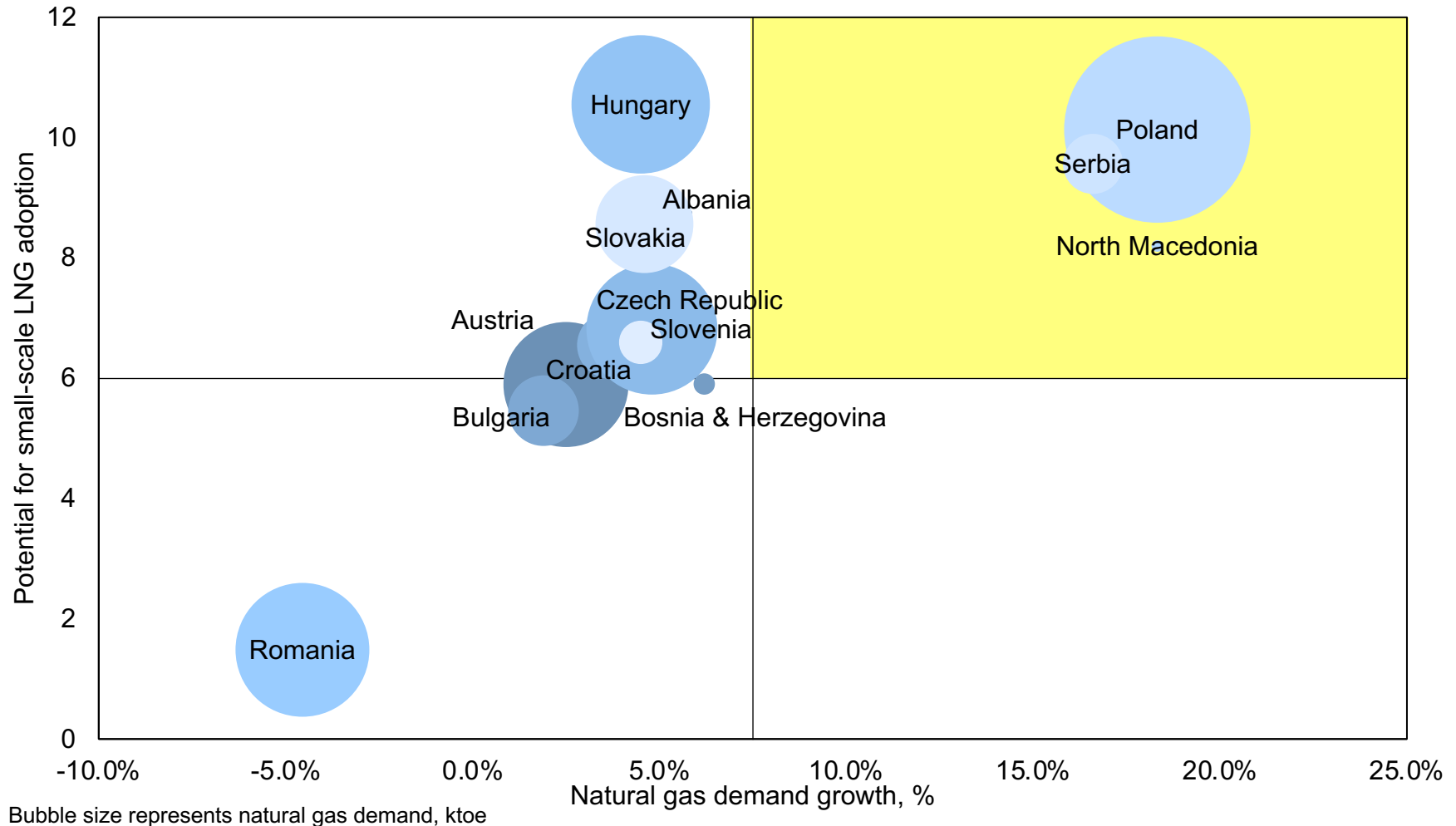
Near-term opportunity for small-scale LNG is based on infrastructure availability and supportive demand drivers

Opportunity Assessment by Country in Central & Eastern Europe



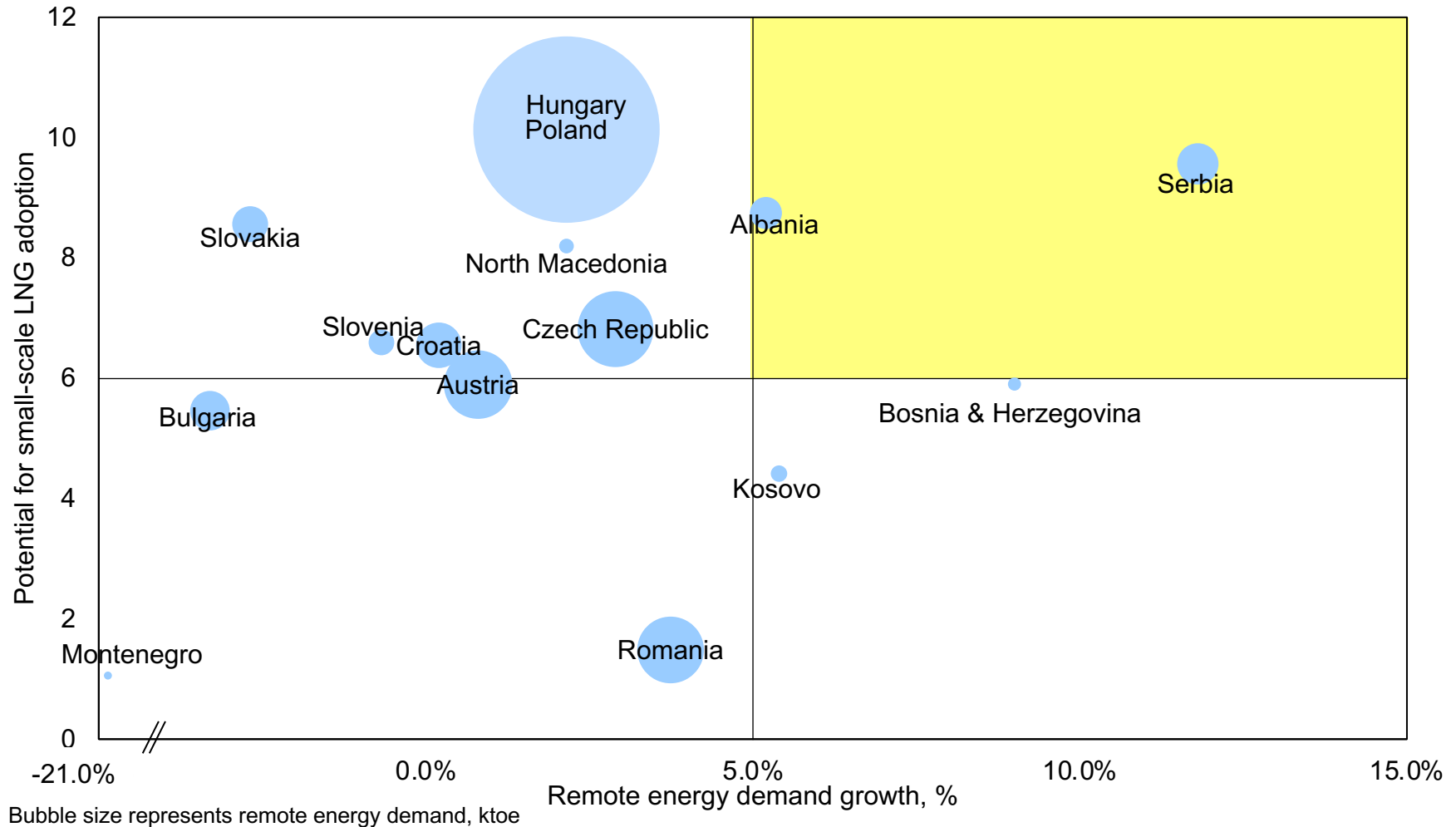
Poland, Serbia, and North Macedonia all have fast growing gas demand potentially creating a need for small-scale LNG

Natural Gas Demand Growth and Small-Scale LNG Adoption



Serbia and Albania have fast growing remote energy demand that can be served by small-scale LNG

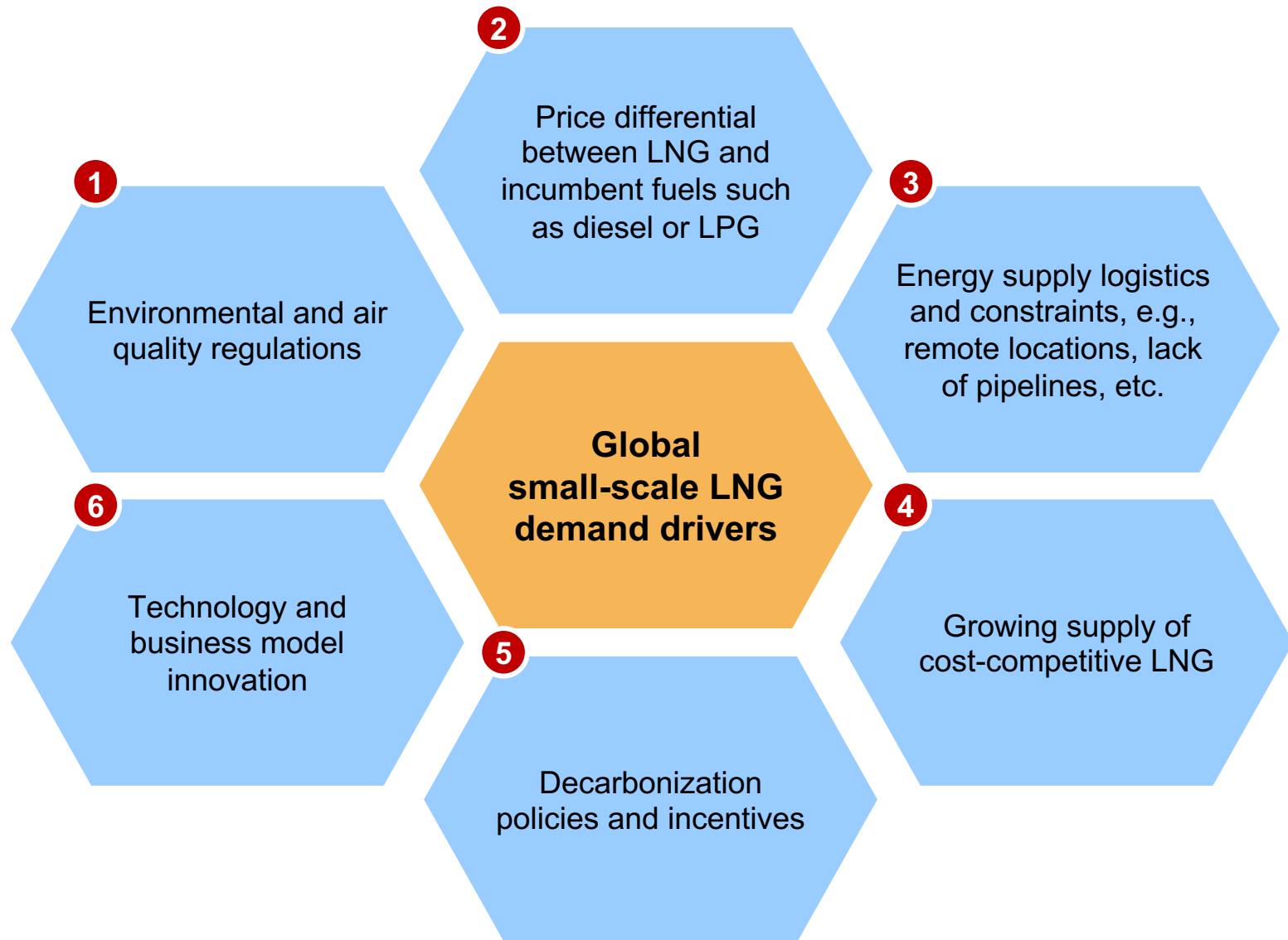
Remote Energy Demand Growth and Small-Scale LNG Adoption



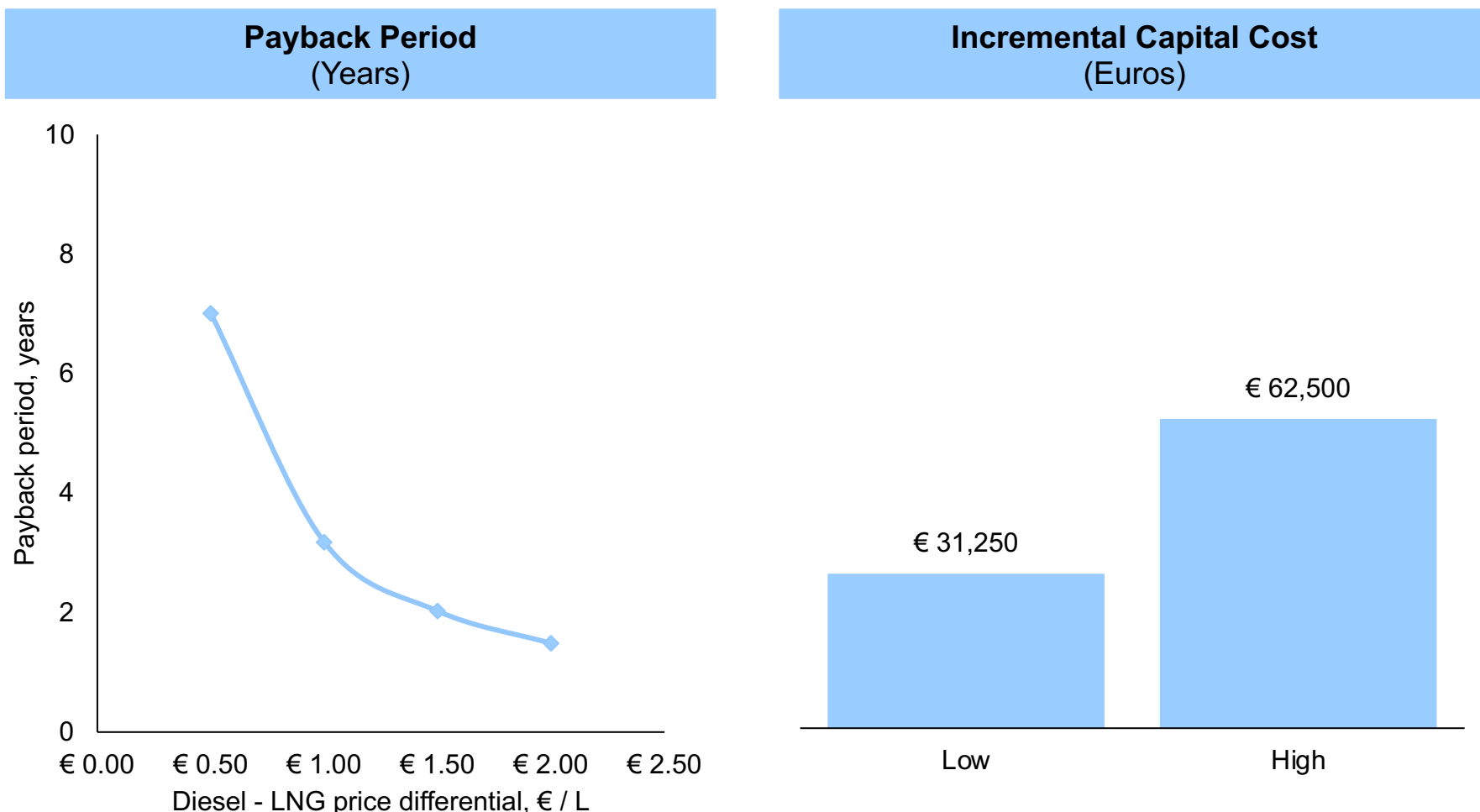
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Several drivers play a role in small-scale LNG demand



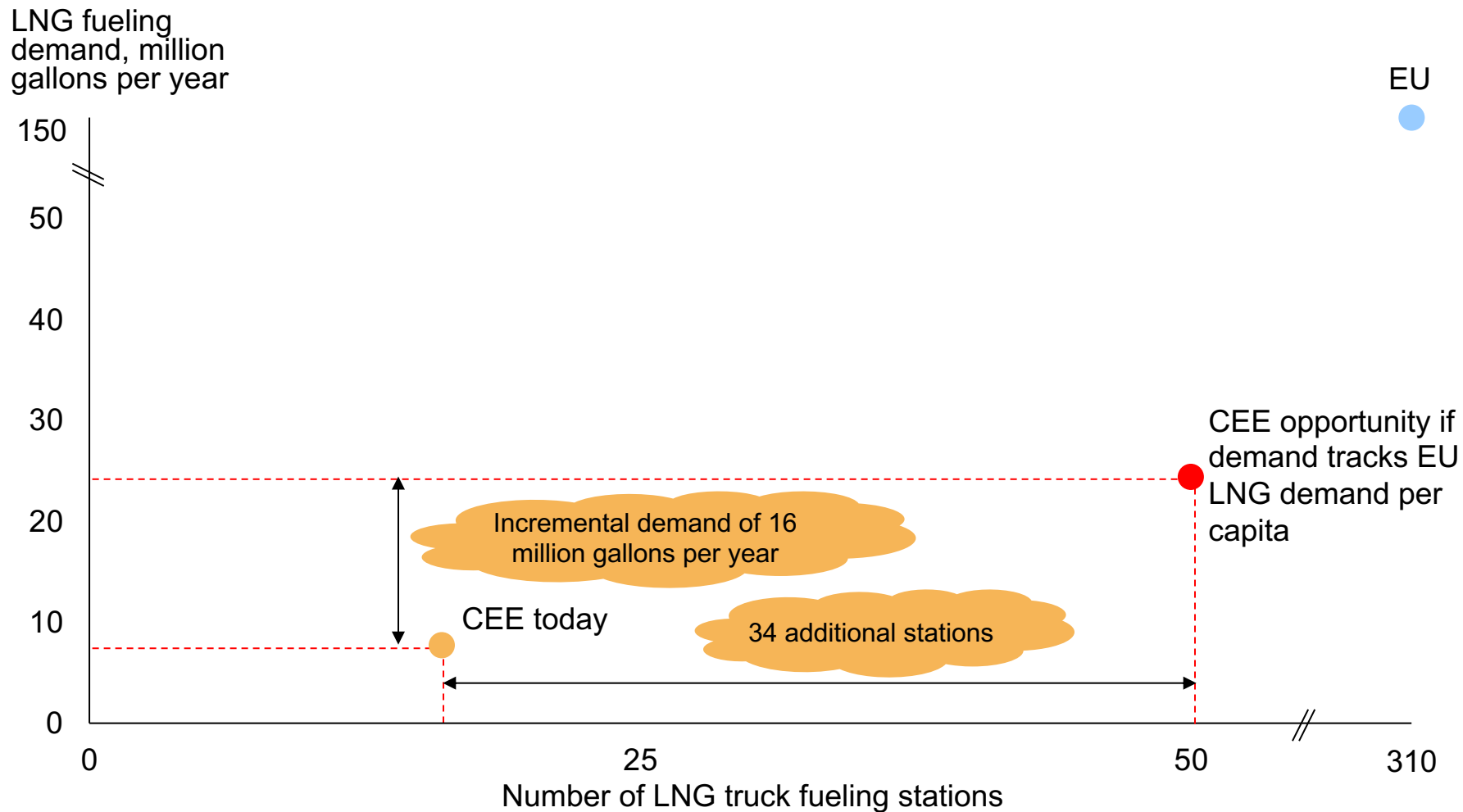
The payback period for investing in an LNG-fueled heavy-duty truck is 2-8 years based on the price differential with diesel



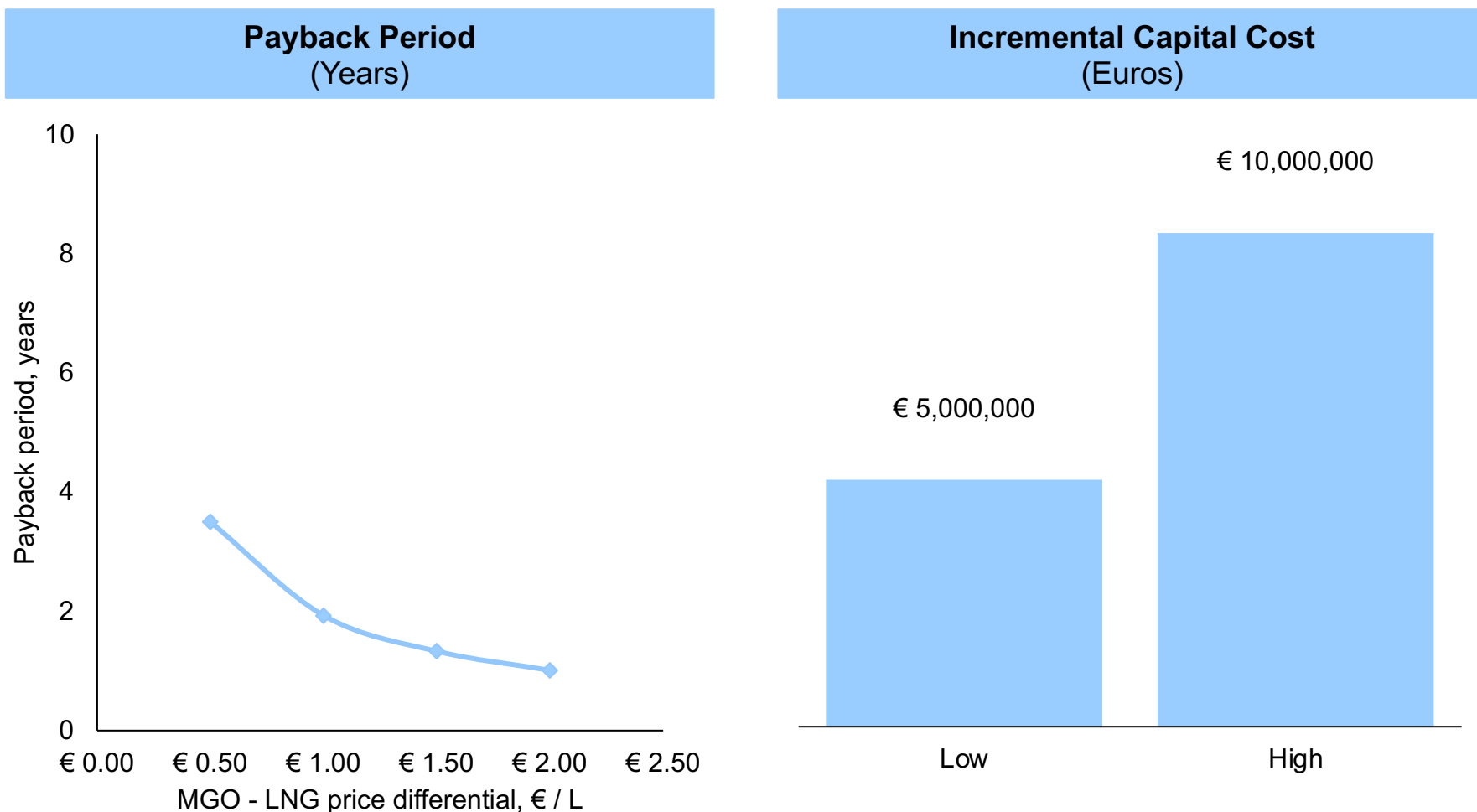
Assumptions: Annual diesel cost increase: 2.0%; Annual LNG cost increase: 0.5%; Annual diesel mileage: 3.05 kilometers per liter; Annual LNG mileage: 2.84 kilometers per liter; Average truck lifetime: 8 years; Discount rate: 20%

LNG demand in trucking could triple in the region if its adoption tracks the per capita demand across Europe

Opportunistic LNG Demand as Heavy-Duty Trucking Fuel (Million Gallons per Year)



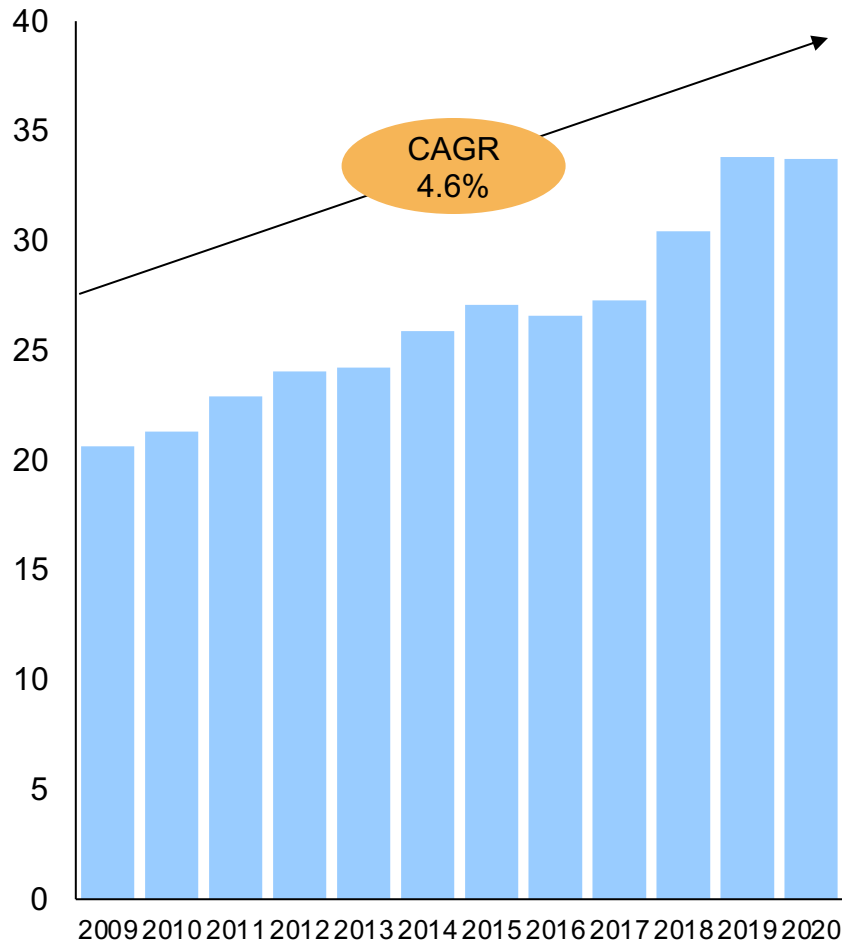
The payback period for incremental investment in an LNG-fueled ship is quite attractive at one to four years



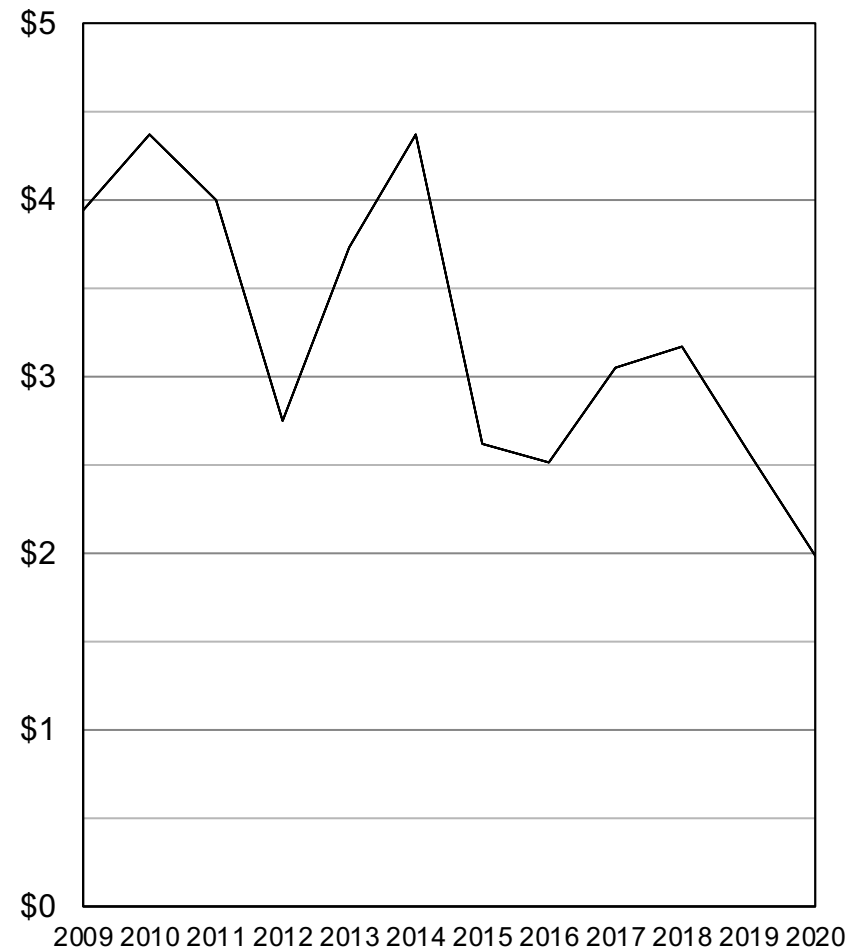
Assumptions: Annual marine gas oil (MGO) cost increase: 1.5%; Annual LNG cost increase: 0.5%; Annual MGO usage: 3.54 million liters; Annual LNG mileage: 2.91 million liters; Average ship lifetime: 30 years; Discount rate: 20%

U.S. gas supply growth from shale plays has contributed to abundant and cost-competitive LNG supply in Europe and Asia

U.S. Historical Dry Gas Production
(Annual Trillion Cubic Feet)



Historical Henry Hub Prices
(U.S. Dollars Per Million British Thermal Units)



Trucking and industrial sectors followed by marine are the best applications for small-scale LNG in the region

Country	Trucking	Marine	Industrial	Rail
Albania	Medium	High	Medium	Low
Austria	High	Low	Low	Low
Bosnia and 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

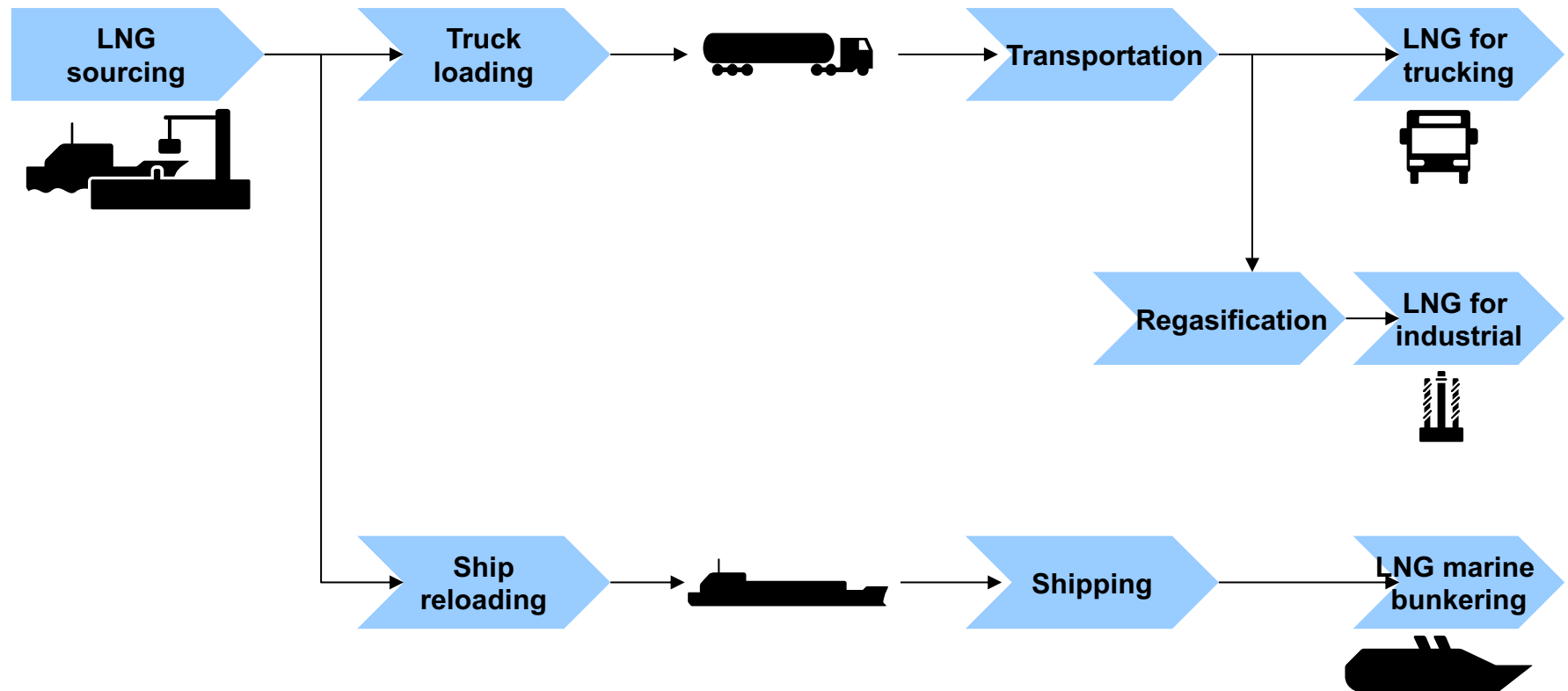
 High
  Medium
  Low

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Typically, LNG can be transported in either trucks or small-scale carriers from a large- or small-scale receiving terminal

Understanding LNG Supply Models



Currently, there are 27 large-scale and 7 small-scale LNG import terminals that supply LNG to Europe

Existing and Planned LNG Terminals in Europe

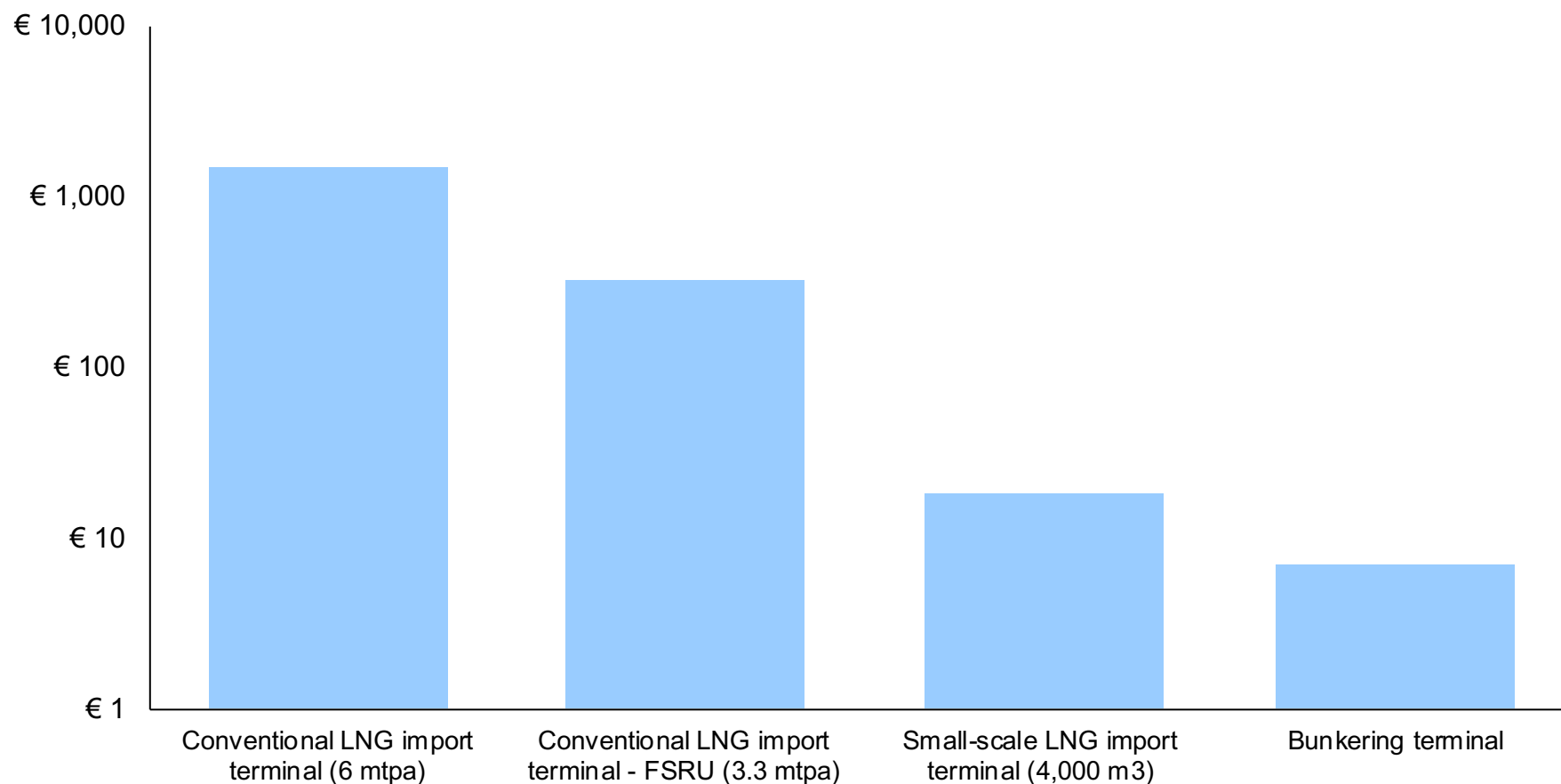


* 6 – Huelva LNG Terminal, Spain only terminal providing rail loading services

Source: GIE, ADI

Large-scale LNG import terminals cost €1+ Bn and small-scale terminal costs are in the millions and falling due to innovation

Typical CAPEX for an LNG Terminal
(Million €)



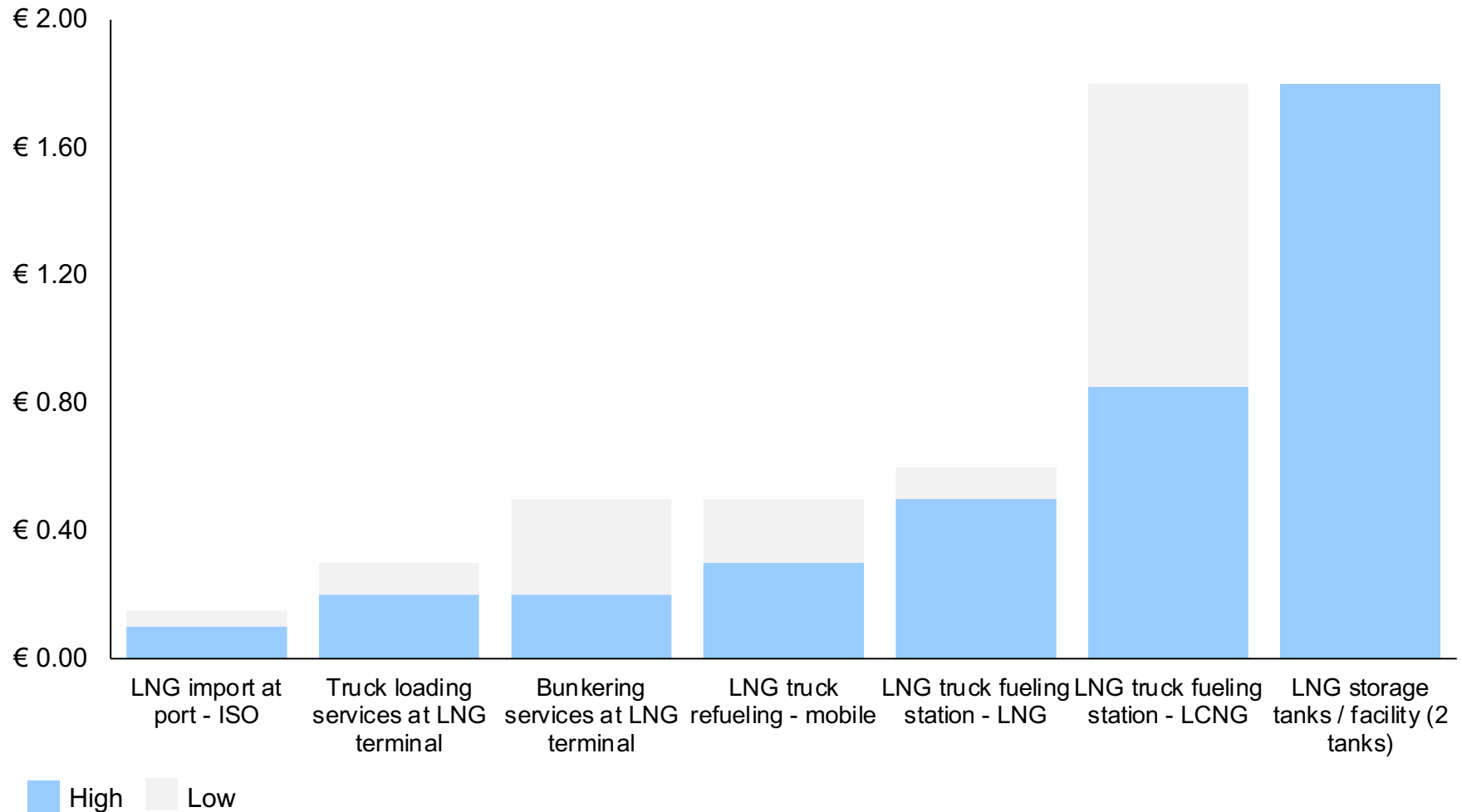
At this time, there are few small-scale LNG plants and terminals in the region or capable of serving it adequately

Existing Supply Options for Small-Scale LNG in Central & Eastern Europe



Typical small-scale infrastructure, e.g., ISO tanks, truck loading, transportation, and storage cost €0.1 to €1.8 million

Typical CAPEX for Small-Scale Service Infrastructure
(Million €)



Ports on seas and rivers can become important supply routes for small-scale and containerized LNG in the region

Existing River and Sea Ports in Central & Eastern Europe



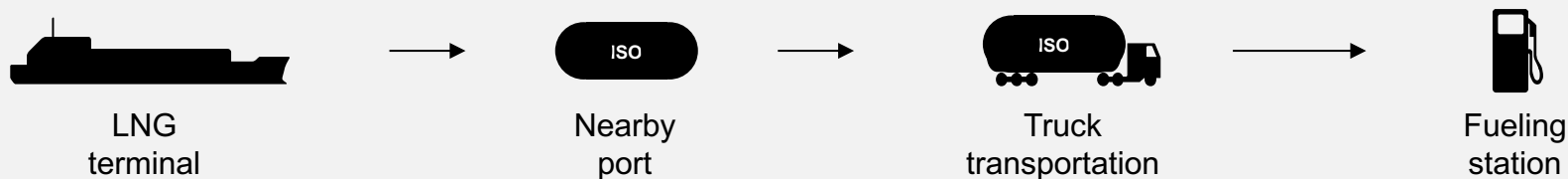
LNG for heavy-duty trucking can be sourced from an LNG terminal in small quantities via trucks or small-scale carriers

Small-Scale LNG Sourcing for Options Heavy-duty Trucking

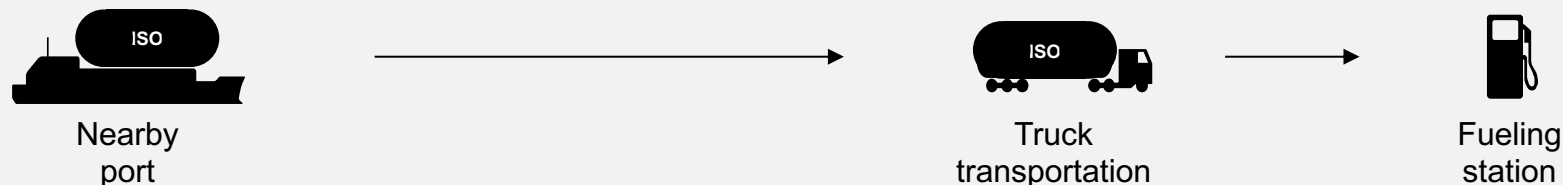
1



2

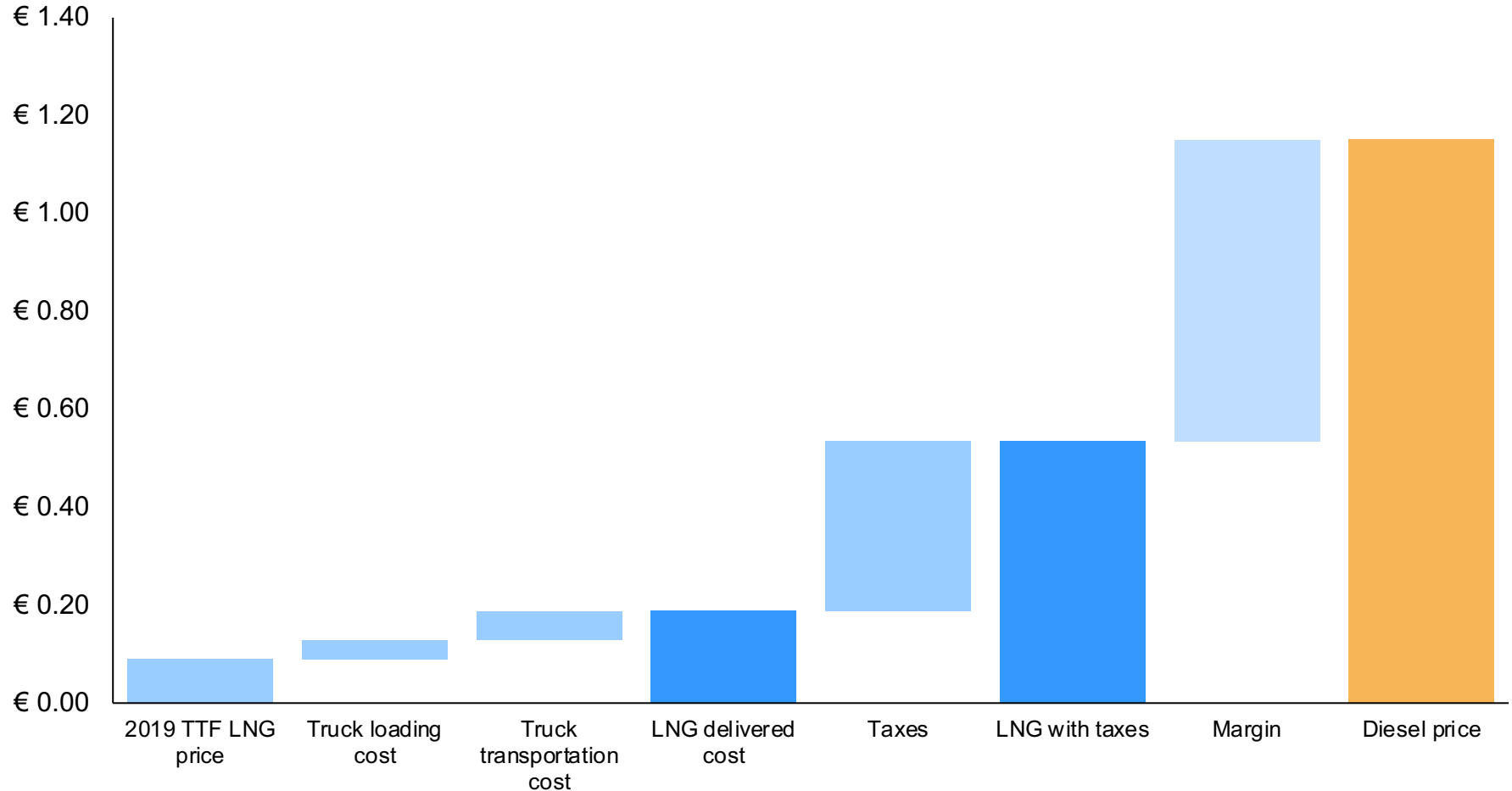


3



Small-scale LNG even when trucked into the region from nearby large-scale terminals can compete with diesel today

Average LNG Delivered Price to Replace Diesel in Heavy-Duty Trucking
(€/L)



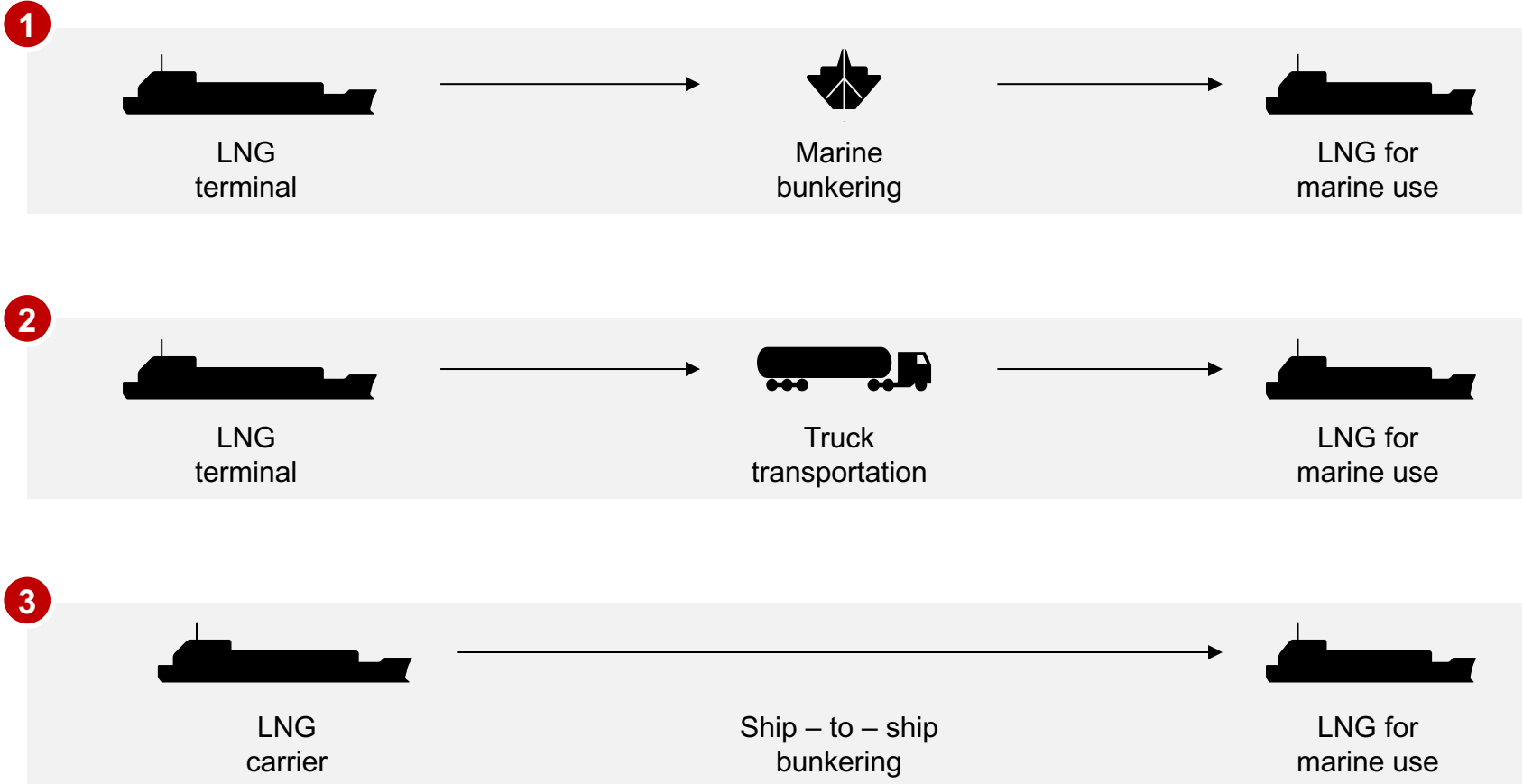
There are 16 LNG fueling stations in the region, mainly in Poland, Czech Republic, Austria, Slovenia, and Hungary

LNG Fueling Stations for Heavy-Duty Trucking



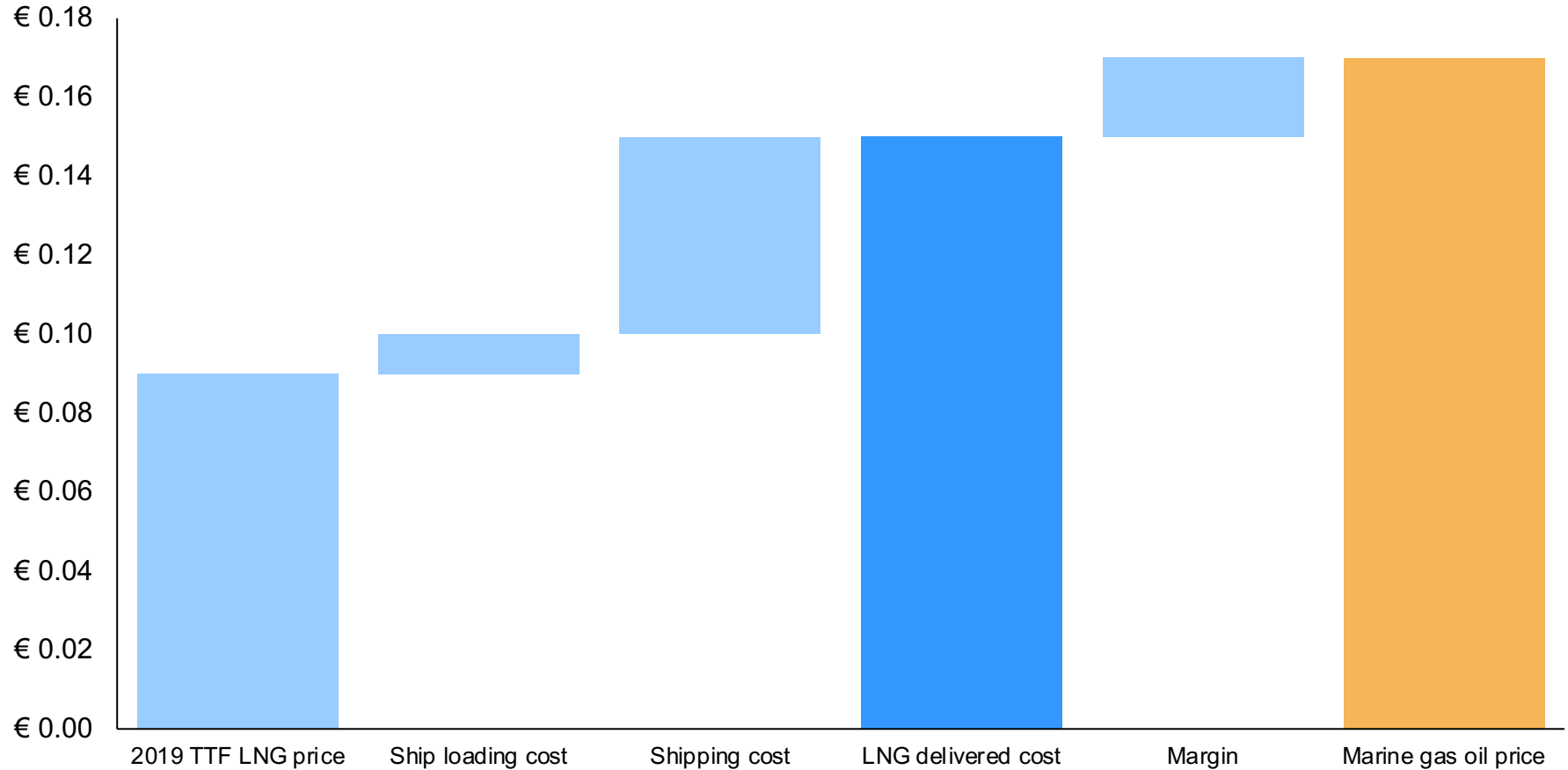
LNG for use as a marine fuel can be sourced via marine bunkering, truck, or ship-to-ship bunkering

Small-Scale LNG Sourcing Options for Marine Use



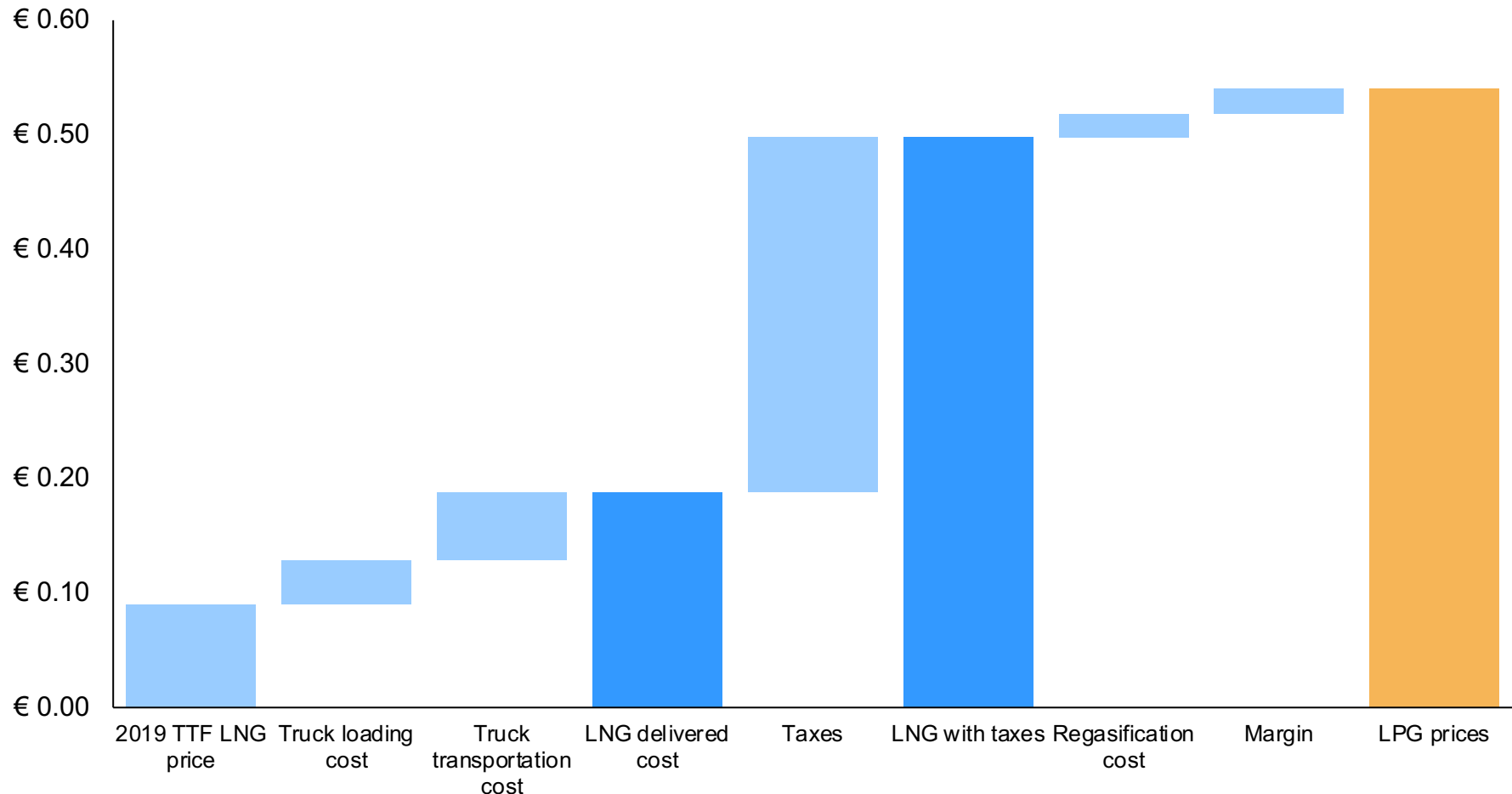
Small-scale LNG is expected to be marginally price competitive with marine gas oil for marine transportation

Average LNG Delivered Price to Replace Marine Gas Oil in Bunkering
(€/L)



Small-scale LNG is at parity with LPG in industrial applications making conservative assumptions around taxes and end-use

Average LNG Delivered Price to Replace LPG in Industrial Applications
(€/L)



Austria, Montenegro, Bulgaria, and Hungary have seen development in trucking, industrial and marine sectors

RAG Austria LNG filling station



LNG storage at Uniprom-KAP in Montenegro



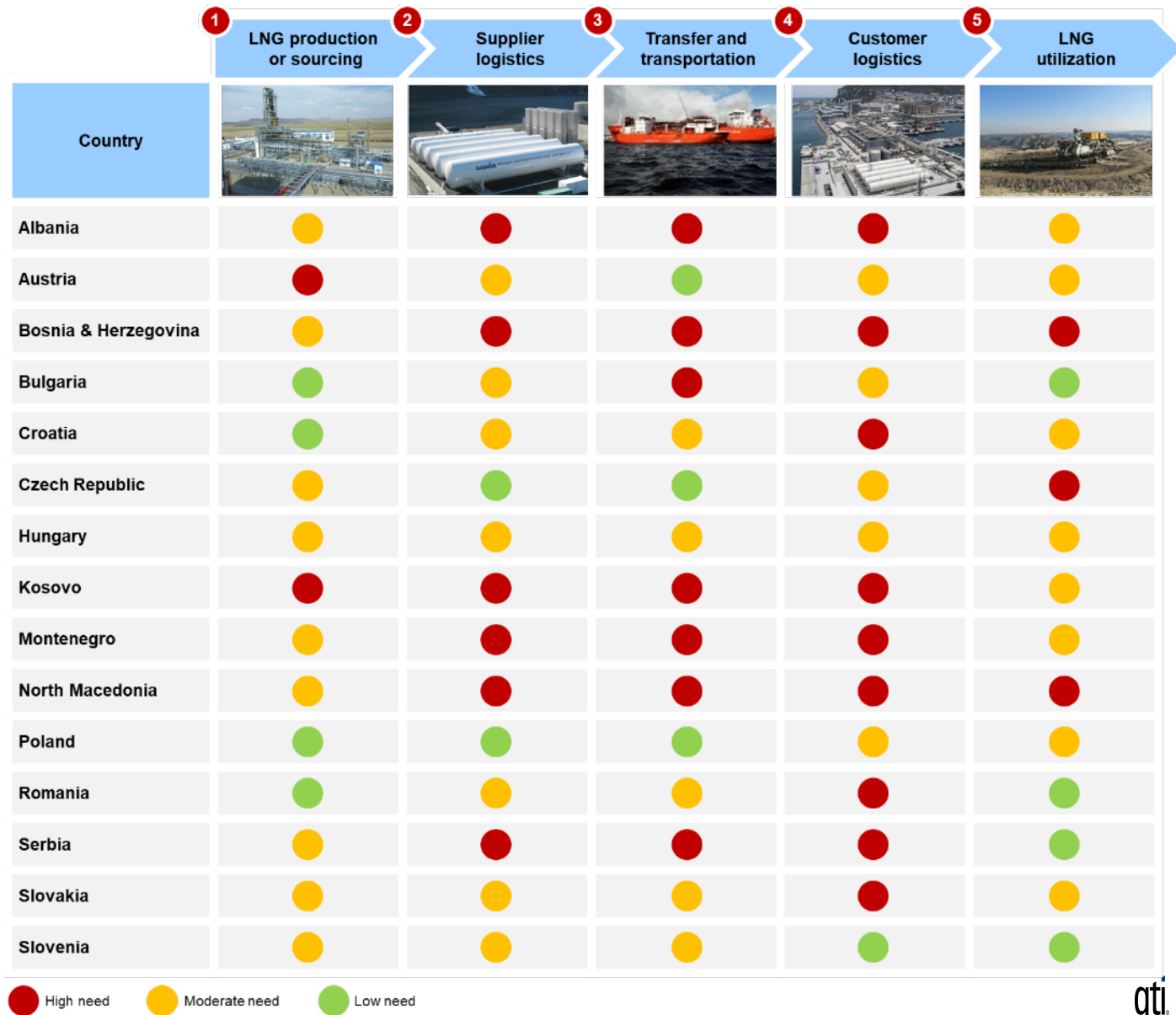
LNG filling station in Hungary



Ruse LNG terminal in Bulgaria



Supply infrastructure needs are high across the region except for Poland, Slovenia, Czech Republic, and Hungary



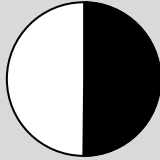
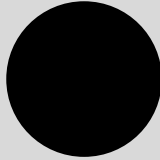
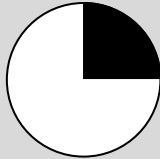
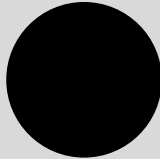

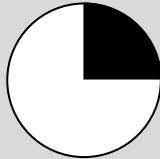
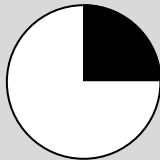
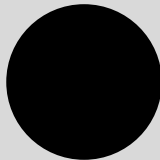
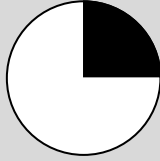
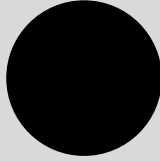
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Small-scale LNG adoption growth depends on broad ranging support and investment strategies from multiple stakeholders



Small-scale LNG adoption risks are low demand growth and price incentive, policies against gas, and energy alternatives

	Risk	Likelihood	Impact
1	Slow demand growth of natural gas and LNG the in region		
2	Insufficient diesel pricing and differential relative to LNG		
3	Decarbonization policy disadvantages LNG		
4	Pipeline gas pricing falls to incent re-liquefaction		
5	Faster adoption of electric trucks and vehicles		

Clarity around regulations and taxes, policy and financial support, and increased awareness will be critical for adoption

1

Regulatory clarity and market liberalization for greater private sector involvement

- Many LPG and CNG retailing stakeholders have indicated interest in initiating pilot projects in small-scale LNG refueling
- They will need policy and regulatory clarity to provide a level playing field to realize this potential

2

Stronger push toward supply diversification

- Countries that are reliant on a single source of gas supply can be extremely vulnerable to supply shocks and ...
- ... A harmonized policy and regulatory support on a consistent emission impact basis will be needed to drive supply diversification

3

State-owned support for natural gas as a transition fuel

- EU regulations are weighing strongly on the region's stakeholders and actively steering investments into renewables
- However, trucking, marine, and industrial sectors will require continued reliance on fossil fuels where LNG can help meet medium term goals

4

More targeted policy incentives for small-scale LNG

- Incentives to electric, fuel cell, or hybrid vehicles as offered by Austria should be extended to LNG-fueled vehicles
- Clarity on taxation on LNG as trucking or marine fuel and financial support for projects including country-specific support will be needed

5

Investing in knowledge growth and public awareness

- Many stakeholders demonstrated limited understanding of potential applications, opportunities, and risks associated with small-scale LNG
- Investments in educating key stakeholders on LNG safety and economics would be very useful to enable market growth and adoption



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