Discussion Paper

Unlocking the Potential of Small-Scale LNG in MENA

A SWOT Analysis to Assess Strategic Positioning in the Region

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June 2026 | DOI: 10.30573/KS--2026-DP22



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Key Points

- A quantified strengths, weaknesses, opportunities, and threats (SWOT) analysis shows operational flexibility as the dominant strength of ssLNG systems, which are adaptable to dispersed, variable, and uncertain demand.
- Limited economies of scale remain the key constraint, with sub-1 Mtpa projects incurring 50%-100% higher unit costs.
- Regional fundamentals are favorable, with gas demand rising from ~285 to ~385 bcm by 2050, led by Saudi Arabia and Iraq, creating strong market potential for flexible supply solutions.
- There are niche opportunities: ssLNG can monetize flared gas and emitted methane (estimated at 35 bcm per year in the Middle East and North Africa (MENA) region), enable renewable integration, and support LNG bunkering growth, with the global LNG-fueled shipping fleet expected to double by 2030.
- Competitive and structural threats are significant, notably from compressed natural gas, which is often less than 50% of the cost of ssLNG at small volumes (below 10 mmscf/d) and short distances, as well as from pipeline expansion and regulatory and geopolitical risks.
- Strategy selection for ssLNG could be guided by a SWOT framework. Strengths-opportunities strategies focus on leveraging existing ssLNG advantages to capture emerging opportunities, while weaknesses-threats strategies emphasize managing constraints to mitigate external risks.
- Saudi Arabia is well-positioned to pursue a strengths-opportunities strategy, leveraging ssLNG's flexibility and multi-sector applicability across off-grid industry and remote power generation (particularly with limited pipeline coverage in the north and southwest), renewable integration, LNG bunkering (with the Red Sea corridor exposed to Mediterranean Sea sulfur limitations), and heavy-duty transport.

Abstract

This study assesses the potential for small-scale liquefied natural gas (ssLNG) in the Middle East and North Africa (MENA) region, using a quantified strengths, weaknesses, opportunities, and threats (SWOT) framework to identify country-specific deployment strategies. Flexibility is ssLNG's strongest advantage, with modular plants installable in <18 months and scalable to manage dispersed, variable, and uncertain demand. This makes ssLNG suitable for off-grid power, industry, and remote locations where pipeline infrastructure is limited. Cost remains the main weakness, as sub-1 Mtpa plants face unit capital and fixed operating costs of $1-$5/MMBtu, or 50%-100% higher than large-scale LNG. Competitiveness is further constrained in countries with low-regulated gas prices (e.g., Iraq at ~$1.7/MMBtu) or narrow gas-to-diesel price ratios (e.g., Egypt), alongside technical issues such as BOG losses and high sulfur/CO_2 content. Opportunities are significant: regional gas demand is projected to rise from 285 bcm in 2023 to 385 bcm by 2050, with Saudi Arabia and Iraq adding ~90 bcm by midcentury. Small-scale LNG can also monetize flared gas and emitted methane (estimated at 35 bcm/year) and support LNG bunkering growth, with the LNG-fueled fleet expected to double by 2030. Threats include competition from CNG, pipelines, and renewables, as well as regulatory and geopolitical risks and potential gas price increases. The SWOT framework allows the identification of strategies that can be prioritized. It suggests that, for the case of KSA and the UAE, strengths-opportunities strategies should be pursued by leveraging ssLNG's versatility and flexibility to capture multi-sector demand growth and opportunities in LNG bunkering, decentralized power, LNG storage for renewable integration, heavy-duty transport, and flared or vented gas monetization. In contrast, Iraq requires a weaknesses-threats strategy, favoring a phased, modular ssLNG rollout to limit exposure to regulatory, geopolitical, and price uncertainty.

Keywords: Flexible Supply, Natural Gas Demand, Liquefaction, Regasification, SWOT, Strategic Deployment, ssLNG

Introduction

01

Small-scale liquefied natural gas (ssLNG) has emerged as a practical solution to meet rising gas demand and extend access in areas without pipeline infrastructure. Its supply chain covers the production, transport, storage, and use of LNG at volumes well below those of conventional large-scale supply chains.

The ssLNG market has expanded rapidly in recent years, with growing deployment of liquefaction and regasification projects below 1 million tons per annum (Mtpa), compared with typical large-scale plants exceeding 3 Mtpa for liquefaction and 1.5 Mtpa for regasification. Consistent with IGU (2015) standards, this paper defines ssLNG as projects with liquefaction or regasification capacities of 0.05-1 Mtpa and transport systems below 60,000 m^3.

Small-scale LNG serves a wide range of applications, including LNG bunkering and heavy-duty transport fuels in liquid form, as well as power generation and industrial supply after regasification. Growth in bunkering, trucking fuels, and off-grid power has been a key market driver. Global ssLNG capacity reached about 38 Mtpa in 2024 (Research and Markets 2024), nearly double 2014 levels (IGU 2015), yet remains small relative to large-scale seaborne LNG, which exceeded 470 Mtpa (IGU 2025). Adoption is strongest in Asia-Pacific, the United States, and Europe, while remaining limited in the Middle East and North Africa (MENA).

Despite substantial gas reserves, MENA countries face heterogeneous subsurface conditions and surface constraints, including limited pipeline reach, remote demand centers, and investment challenges, creating supply chain gaps that ssLNG could help bridge.

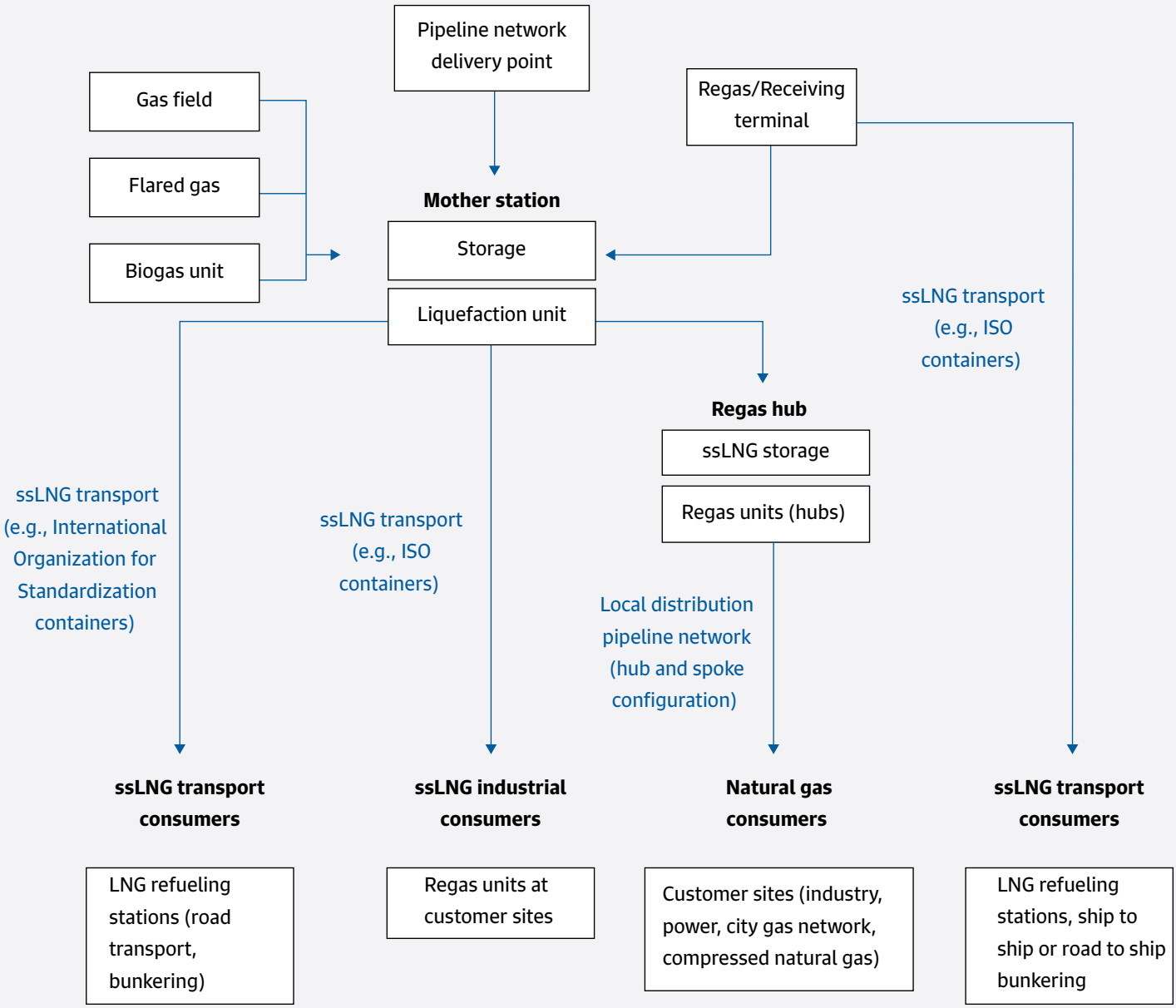
The study applies a strengths, weaknesses, opportunites, and threats (SWOT) analysis to position selected MENA countries within the ssLNG value chain and then discusses implementation strategies. The paper explores ssLNG's potential in MENA, drawing on global experience, and asks:

- What are ssLNG's internal strengths and weaknesses, and how do they fit different contexts in MENA countries?
- What opportunities and risks arise in implementing ssLNG across MENA?
- What strategies can support effective deployment in MENA?

1.1 What is a ssLNG Supply Chain?

In general, ssLNG is associated with capacities below 1 Mtpa (IGU 2015; APEC 2019). It serves niche but growing markets, such as marine bunkering, heavy-duty road transport, off-grid or backup power, remote industrial sites, and city gas networks. Figure 1 illustrates the ssLNG supply chain from the gas source to end users.

Figure 1. Small-scale LNG value chain.



Source: Authors.

The ssLNG value chain can be described through the following components:

- Gas sourcing: Feed gas can come from small or stranded fields (including flared or vented gas), biogas plants, network offtakes, or LNG reloads at receiving terminals, with delivery to end users via small-scale transport such as trucks, International Organization for Standardization (ISO)[1] tanks, barges, or coasters.
- Small-scale liquefaction: Mother stations are typically modular, skid-mounted plants designed for rapid deployment and incremental expansion, relying mainly on expander or mixed-refrigerant cycles.
- Small-scale transport: LNG is moved in vacuum-insulated trailers or ISO tanks by road, rail, or coastal shipping, enabling multimodal connections between liquefaction or import terminals, satellite regasification sites, and refueling facilities.

1 An ISO tank is a standardized container that complies with ISO standards. It typically refers to tank containers used to transport hazardous and non-hazardous products under stringent safety requirements.

- Small-scale storage: Storage options range from flat-bottom tanks at mother stations to shop-fabricated tanks or ISO containers used for permanent or temporary storage (World Bank 2015a; Wärtsilä 2016).
- Regasification: Daughter stations either operate as hubs supplying short distribution networks or as on-site units delivering gas directly to end users.

Literature Review and Methodology

02

The emergence of ssLNG as a flexible solution to unlock latent gas demand has attracted increasing academic and industry attention over the past decade.

2.1 Literature Review

A strand of the literature examines ssLNG's advantages in terms of flexibility and its ability to overcome supply-chain bottlenecks (Rahmanta et al. 2025; APEC 2019; World Bank 2015a; Steyn 2021; Budiyanto et al. 2020; IGU 2015). These studies emphasize ssLNG's modular and scalable nature, shorter development timelines, and capacity to serve off-grid or geographically dispersed consumers not connected to conventional gas infrastructure.

Beyond technical adaptability, several studies explore ssLNG market opportunities across multiple demand segments, including road transport, off-grid power generation, and industrial fuel use (PwC 2017; Singh 2022; Budiyanto et al. 2020; MAN Energy Solutions 2019; FTI Consulting 2020; Air Products 2019). PwC (2027) estimates a potential market of 75-97 Mtpa by 2030, driven mainly by LNG bunkering, heavy-duty vehicles, and off-grid power. The World Bank (2015a) documents ssLNG deployment in China and the United States, supported by virtual pipelines and peak-shaving facilities to address infrastructure gaps and seasonal demand variability.

Other studies highlight ssLNG's role as an alternative to diesel and fuel oil, contributing to emissions reduction and energy diversification, particularly in Europe and Asia (USEA 2020; FTI Consulting 2020; APEC 2019). Zhao et al. (2021) analyze LNG heavy-duty trucks and find lifecycle operating costs 10%-17% lower than diesel equivalents.

The monetization of flared or stranded gas through ssLNG has also gained attention. Putriastuti et al. (2021) show that ssLNG offers a viable pathway for capturing and valorizing flare gas in regions with limited pipeline networks. Le Fevre (2018) assesses the LNG bunkering market, highlighting sulfur regulations and fuel-switching incentives as key growth drivers. Raimondi (2023) further examines ssLNG's expanding role in marine fuel supply across the Euro-Mediterranean region, emphasizing port infrastructure and regulatory harmonization.

Conversely, the lack of economies of scale is widely identified as a core challenge for ssLNG (World Bank 2015a; Steyn 2021; Kim, Seo, and Chang 2016). Kim, Seo, and Chang (2016) assess ssLNG feasibility and highlight cost penalties linked to scale limitations, proposing synergies between LNG and liquid nitrogen production to improve economics.

Cost optimization remains central, with several studies applying optimization models to ssLNG supply chains. Rahmanta et al. (2025) optimize ssLNG routes and investment for off-grid power in Indonesia, while Doymuş et al. (2022) use a MILP framework to optimize marine bunkering supply chains in Turkey.

In the African context, Soro et al. (2024) evaluate a 0.5 Mtpa ssLNG project in Nigeria, concluding that it can be economically viable under favorable pricing and logistics assumptions. Their SWOT analysis also stresses the importance of benchmarking ssLNG against compressed natural gas (CNG) for flare-gas monetization.

Zhang et al. (2020), based on a meta-analysis, report liquefaction CAPEX ranging from $124/tpa to $2,200/tpa, driven more by plant complexity and local conditions than capacity alone. They also show that OPEX, particularly maintenance and energy costs, significantly contribute to higher unit costs in small-scale plants.

Finally, the literature identifies several risks that may constrain ssLNG deployment, including competition from alternative fuels under energy-transition policies and regulatory uncertainty (DNV 2022). Safety risks are also emphasized due to frequent handling and the involvement of multiple small actors (Cambridge Systematics 2019; Planas-Cuchet al. 2004). Cambridge Systematics (2019) highlights the need for specialized routing, handling, and emergency-response frameworks for virtual pipelines. Al Ghazi et al. (2023), in a SWOT analysis of an ssLNG chain combining FSRU (floating storage and regasification units) and truck delivery, identify supply uncertainty, regulatory risk, and seasonal pricing as key threats, while Tsvetkov (2021) underscores weak regulatory capacity to govern markets with multiple actors as a persistent barrier, particularly in countries with less mature regulations.

2.2 Methodology

This paper applies a SWOT analysis to assess ssLNG's potential in the MENA region and the relative positioning of selected countries.[2] SWOT is a strategic analysis tool that links internal strengths and weaknesses with external opportunities and threats in the operating environment (Sammut-Bonnici and Galea 2015; HBSPC 2006a; 2006b).

While commonly used at the firm level, SWOT has also been applied to technologies and energy systems to assess intrinsic advantages and limitations alongside market-specific enablers and risks. For example, Songhurst (2016, 2017) applied SWOT to FSRUs and FLNG, highlighting monetization benefits and infrastructure challenges, while Simões and Santos (2024) evaluated green hydrogen, emphasizing both its potential and policy dependence. Similar approaches exist for CCS technologies.

SWOT is often criticized for subjectivity, unclear weighting, and weak links to actionable strategy. This study addresses these limitations by grounding factors in measurable indicators, applying explicit weights, and translating results into deployment-relevant strategies.

The methodology is as follows:

- Identify strengths and weaknesses intrinsic to ssLNG through a systematic literature review.
- Contextualize internal factors for MENA countries using criteria that capture how national conditions amplify or constrain each strength and weakness.
- Identify external opportunities and threats in each country's operating environment affecting ssLNG deployment.
- Quantify SWOT factors using observable country-level indicators (e.g., pipeline length and density to proxy the value of ssLNG flexibility), normalized to a 1-5 scale and discretized to reduce sensitivity to data uncertainty and outliers (see Appendices A-D).
- Derive factor weights within each SWOT group using the Analytic Hierarchy Process (AHP), based on pairwise comparisons and expert judgment, with consistency checks (Saaty 1980; Pant et al. 2022) (Appendix E).
- Aggregate weighted factors using IFAS (Internal Factor Analysis Summary) and EFAS (External Factor Analysis Summary) to assess the balance between strengths and weaknesses and between opportunities and threats (Saputra et al. 2025; Rachmawati et al. 2019).
- Translate results into strategy through the SWOT quadrant matrix, which identifies country-specific strategic orientations based on their IFAS and EFAS positioning (Sofyan et al. 2020).

2 KSA, UAE, Oman, Egypt, Iraq, and Jordan. The selected countries include both gas producers and import-dependent markets with potential for deploying ssLNG. The sample captures differences across countries in demand, supply, infrastructure, policy, and access to technology and expertise, allowing the analysis to reflect diverse use cases.

Internal Factors of the SWOT Analysis: Strengths and Weaknesses

03

3.1 Strengths

This section highlights the core strengths of ssLNG, emphasizing the intrinsic characteristics that make it a viable solution for achieving targeted policy or commercial objectives.

3.1.1 Diversity of Applications

A key advantage of ssLNG lies in its wide range of applications. It can supply fuel for heavy-duty vehicles and ships (bunkering), serve remote industrial sites and communities, and support power generation, including off-grid plants. From a supply chain perspective, ssLNG can also be used for storage and peak shaving, deployed as a virtual pipeline to bypass infrastructure bottlenecks, monetize stranded gas, and capture gas that would otherwise be flared (World Bank 2015a).

Heavy-duty transport and bunkering have been fast-growing drivers of gas demand. Globally, gas demand (largely met by ssLNG) for heavy-duty vehicles reached about 21 Mtpa in 2022, up from 4 Mtpa a decade earlier (IEA 2023), while LNG bunkering rose to 3.4 Mtpa in 2023, a 60% increase year over year (Rystad Energy 2024). The expansion of small-scale offshore regasification, particularly in emerging and island economies, has further supported ssLNG delivery to dedicated power and industrial users, with capacity reaching about 13.2 Mtpa in 2023, or 1.3% of global regasification capacity (IGU 2025).

China has pioneered ssLNG virtual pipelines to extend gas access to regions without pipeline infrastructure, supporting air quality objectives through mother stations near production areas (APEC 2019). China and the United States have also deployed ssLNG for peak shaving to manage short-term demand spikes, with the United States operating 68 such facilities in 2015, many of which now also supply LNG for transport fuels.

3.1.2 Operational Flexibility

Operational flexibility is the ability of a system to adapt to changes in demand, policy, and supply conditions (Yusuf et al. 2019). ssLNG solutions offer operational flexibility through:

- Modular and scalable liquefaction: Modular plants enable incremental capacity additions, including through plug-and-play units.
- Flexible storage: Cryogenic LNG tanks help manage demand fluctuations and supply disruptions and can be adapted to local site and regulatory conditions.

- Multimodal transport: LNG can be transported by truck, rail, or barge, using road tankers, bobtails, or ISO tanks for flexible logistics.
- Energy system integration: ssLNG can complement oil bunkering in the same port location and provide backup power to mitigate renewable intermittency.

3.1.3 Geographic Flexibility

Geographic flexibility refers to the ability of ssLNG to be deployed across diverse locations, extending gas access to remote or off-grid areas and offering a clear advantage over fixed-route pipelines. This flexibility is reflected in:

- Modular mobility: The modular design of ssLNG components, such as liquefaction units, cryogenic storage tanks, and skid-mounted or containerized regasification systems, facilitates easy transportation and installation across various sites.
- Adaptability to constrained locations: ssLNG can be deployed where pipelines are impractical due to terrain, islands, landlocked regions, land acquisition constraints, or urban density.
- Simplified maintenance: ssLNG designs (e.g., plug-and-play[3] systems) facilitate maintenance and equipment replacement, even in remote areas, reducing downtime.
- Versatile deployment and sourcing: ssLNG systems can serve multiple locations and draw gas from diverse supply points, enhancing resilience and reach.

3.1.4 Lower Upfront Investment

Small-scale LNG facilities require significantly lower upfront investment than pipelines or large-scale LNG plants, reducing capital financing needs and making them attractive for countries with limited financial resources. Lower initial costs reflect simpler permitting, smaller and standardized equipment, shorter construction timelines, and extensive prefabrication. The modular nature of ssLNG further enables scalable deployment through repeatable liquefaction units, lowering engineering and design costs.

3.1.5 Short Execution Timelines

Large-scale LNG liquefaction projects have historically had long execution timelines, with projects typically taking about three to four years to construct. This is in addition to the time required to complete a bankable feasibility study, finalize the SPA, and conduct the detailed design of the LNG facility. Over the past 10 years, the trend has been toward longer project execution times, often exceeding five years (Zeal 2019). In comparison, a standardized and modularized ssLNG plant can be built in less than 18 months.

3.2 Weaknesses

In addition to the strengths identified above, ssLNG solutions have several weaknesses, outlined in the next section.

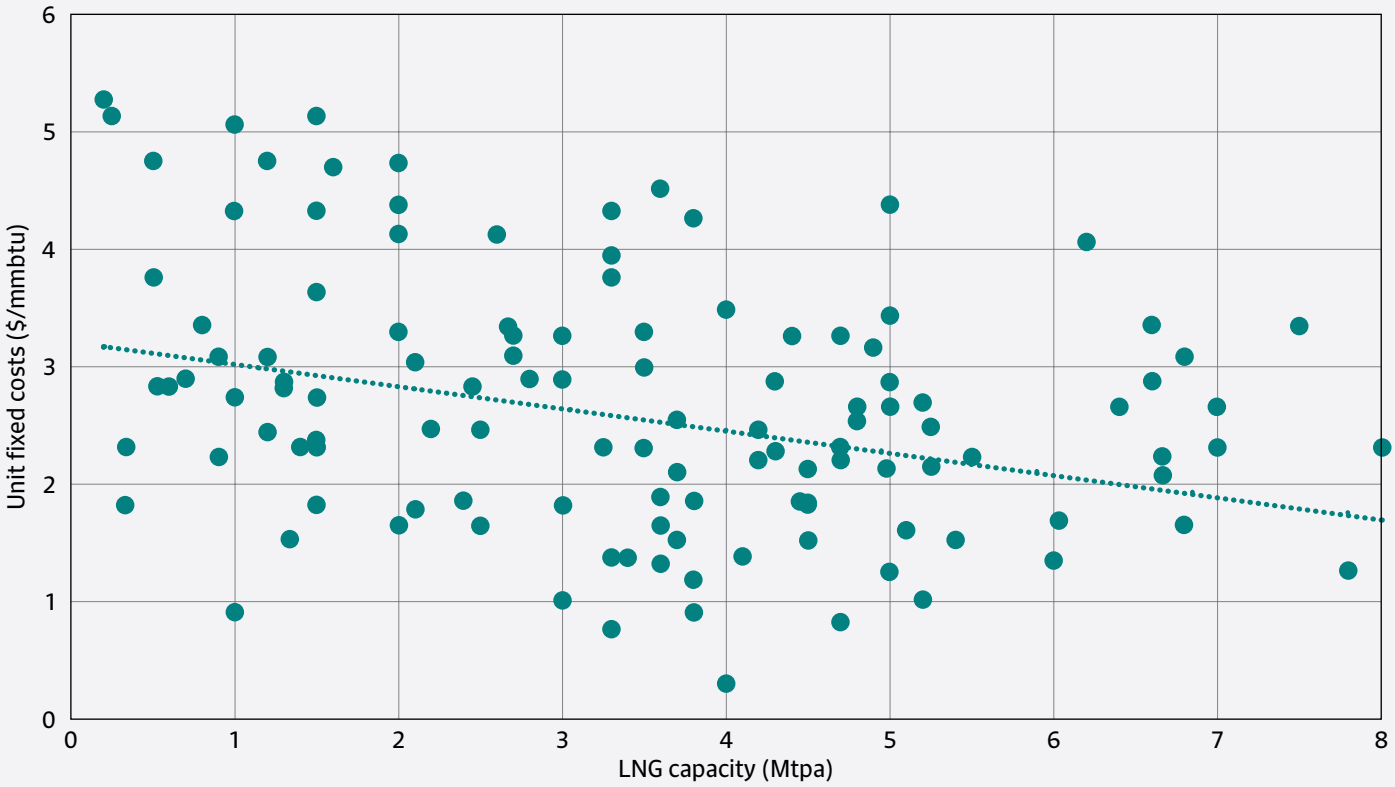
3.2.1 Limited Economies of Scale

Limited economies of scale in the ssLNG supply chain are widely recognized as a key weakness, as they directly affect gas delivery costs and project viability. Economies of scale are achieved by spreading high capital and fixed operating costs over larger output volumes and by reducing design redundancies, optimizing equipment size, and lowering procurement costs through large orders (Songhurst 2018).

Figure 2 illustrates estimated unit fixed costs (CAPEX and Fixed OPEX in $/MMBtu) for small- and large-scale LNG liquefaction projects worldwide using Nexant data (NexantECA 2025). Projects with exceptional technical complexity or major cost overruns (e.g., Australian coal bed methane or Mozambique LNG) are excluded. The results show a clear decline in unit fixed costs as plant capacity increases, reflecting scale effects. Facilities below 1 Mtpa typically exhibit higher unit fixed costs, ranging from $1-$5 MMBtu, with variation driven by location, technology, and local labor costs.

3 Plug-and-play systems are modular, preassembled systems that can be easily connected to existing infrastructure.

Figure 2. Estimated unit fixed costs and LNG capacities.



Source: NexantECA (2025).

3.2.2 Boil-Off Gas

Boil-off gas (BOG) refers to LNG that vaporizes due to heat ingress, raising cryogenic temperatures above the level required to keep gas in liquid form. BOG poses challenges across LNG supply chains by causing energy losses, methane emissions, safety risks, and potential changes in LNG composition that can affect end-user specifications. Managing BOG is particularly important for ssLNG, as it can add capital and operating costs, although these must be weighed against the value of recovered gas. BOG can be reliquefied, used as fuel, injected into gas networks after compression, or flared or vented for pressure control.

BOG rates are generally higher in ssLNG than in large-scale LNG because small tanks have higher surface-area-to-volume ratios, faster pressure buildup, less advanced insulation, and more frequent handling during transport and transfer operations.

3.2.3 Gas Pre-treatment

Gas pretreatment is a critical step in the ssLNG supply chain, removing impurities and freezable or corrosive components before liquefaction. Compared with alternatives such as pipelines or CNG, pretreatment adds complexity and cost to ssLNG systems. If feed gas does not meet specifications, components with freezing points above LNG temperatures (-160 °C) can form solids, causing blockages in pipelines, compressors, and cryogenic heat exchangers.

Pretreatment units must therefore handle variable gas qualities to meet ssLNG specifications (Table 1). Key impurities removed include acidic gases (H_2S and CO_2), other sulfur compounds (e.g., mercaptans), water, and heavy hydrocarbons such as benzene.

3.2.4 Technology Dependence

Dependence on foreign technology and expertise represents a key weakness of ssLNG deployment. Although less complex than large-scale LNG, ssLNG remains a relatively new domain in which many countries, including those in MENA, lack sufficient experience, particularly where there is limited exposure to LNG and cryogenic systems. Small-scale liquefaction and cryogenic technologies are largely supplied by European, American, and Asian firms, especially Chinese companies, creating reliance on external expertise that can entail licensing constraints, supply chain risks, and higher costs.

This dependence is further compounded by shortages of skilled local labor, increasing reliance on foreign personnel and underscoring the need for targeted training and talent development to avoid delays, inefficiencies, and safety or compliance risks.

Table 1. LNG specifications.

Component	Specification for LNG	Main impacts
Hydrogen sulfide (H_2S)	<4 ppmv	Corrosive, high freezing temperature (risk of operational failure due to formation of solids)
Total sulfur (including sulfur dioxide, mercaptan)	<30 ppmv	Corrosive, high freezing temperature, toxicity, and environmental effects
Water (H_2O)	<0.1 ppmv	Expanded corrosive effect, when combined with acidic gases, risk of ice formation at low temperature
Carbon dioxide (CO_2)	<50 ppmv	Corrosive, environmental effects
Heavy hydrocarbons such as C_5+	<0.1 mol%	High freezing temperature, gas quality requirements
Mercury	<0.01 µg/Nm^3	Corrosive, gas quality requirements, toxicity, and environmental effects

Source: Mokhatab et al. (2019).

Small-Scale LNG Strengths and Weaknesses in the Context of Different MENA Countries

04

After identifying the internal strengths and weaknesses of ssLNG, this section examines how country-specific conditions shape their relevance. A set of criteria is used to capture national specificities and enable a comparative assessment across selected MENA countries (Table 2), with resulting scores reported in the Appendices.

For example, the strength of ssLNG's application diversity depends on factors such as gas-supportive energy policies, the availability of competitive gas supplies, pipeline coverage, sectoral demand potential, and demand uncertainty. Similarly, ssLNG's operational flexibility is particularly valuable in countries with volatile gas demand, a high penetration of intermittent renewables, limited pipeline networks, reliable transport infrastructure, and uncertain demand growth.

The following section assesses the key criteria that influence the strengths identified in the SWOT analysis.

4.1. Key Criteria That Influence the Strengths Identified in the SWOT

4.1.1 Policies Promoting Natural Gas

Policies promoting natural gas can significantly enhance its penetration across sectors and reinforce the diversity of applications enabled by ssLNG. Such policies operate through both demand- and supply-side (Table 3), with country scores reported in Appendix A.

4.1.2 Gas Pipeline Coverage and Infrastructure

Extensive gas pipeline coverage and its potential to reach remote areas might weaken the advantages of ssLNG solutions, primarily by reducing the need for these solutions to supply different gas demand segments and provide operational and geographic flexibility.

Transmission and distribution networks can be extended over large areas, provided that the gas volumes justify their economic viability and that routing constraints (e.g., topography and land use) can be effectively managed. The extent of pipeline coverage in a specific country can be assessed by measuring the total pipeline length and its ratio to the country's land area (Appendix A).

4.1.3 Gas Demand Potential Across Sectors

Gas demand potential refers to the maximum feasible gas demand under favorable conditions, such as supportive gas policies. High-demand potential enhances ssLNG advantages by expanding application diversity, enabling scalable and flexible deployment, and extending geographic reach, including to remote areas. Countries with high gas demand potential

typically combine growing energy needs, reliable gas supply access, and strong opportunities to substitute liquid fuels with natural gas (captured through oil and gas shares in the energy mixes). These factors underpin the scoring of gas demand potential across the selected MENA countries (Appendix A).

Table 2. Criteria to assess strengths and weaknesses at a country level.

Strengths	Criteria to assess strengths at a country level	Weakness	Criteria to assess weaknesses at a country level
Diversity of applications	• Policies promoting natural gas • Lack of pipeline coverage • Gas demand potential in various sectors • Gas demand growth uncertainty • Availability of gas supply	Limited economies of scale	• Domestic gas price • Gap between gas and oil products prices (oil products as an option) • Policies promoting natural gas (e.g, subsidies to reduce the high unit cost for delivered gas)
Operational flexibility	• Gas demand variability • Renewables penetration • Transportation infrastructure • Lack of gas pipeline coverage • Gas demand potential in various sectors • Gas demand growth uncertainty	Boil-off gas	• Environmental commitments • Gas demand potential in various sectors • Fragmentation of the supply chain (size of the country, remote areas)
Geographical flexibility	• Size of the country (remote areas) • Lack of gas pipeline coverage • Gas demand potential in various sectors • Gas demand growth uncertainty	Gas pretreatment	• Sulfur content • CO_2 content • Heavy liquids • Gas demand seasonality and variations
Lower upfront investment	• Funding capabilities and budget constraints	Technology dependance	• Share of imports of machinery, equipment, and EPC services in the industry value added
Shorter project execution time	• Need for fast access to energy • Need for immediate cost savings compared to other alternatives		• Involvement in LNG supply chain

Source: Authors.

Table 3. Demand- and supply-side policies promoting natural gas.

Demand-side	Supply-side
• Promote natural gas by displacing liquids (Saudi Arabia: target -1 mb/d oil use by 2030; Iraq: cut oil-fired power, currently ~48% of the power mix, and monetize flared gas). • Position gas to drive industrial growth, lower emissions, and support renewables integration (especially in Saudi Arabia, Egypt, and the UAE). • Transport: expand gas-powered vehicles in Egypt; develop LNG bunkering in the UAE and Oman; and support growing interest in bunkering in Saudi Arabia and Egypt. • Leverage gas to cut emissions (NDC commitments).	• Streamline permitting, offer financial incentives, and form strategic partnerships to expand gas supply chains. • Leverage national energy companies as investment arms to scale gas infrastructure. • Saudi Aramco: Commit >$100 billion to Jafurah unconventional gas and expand the Gas Master System. • UAE: Advance sour and non-associated gas developments. • Oman: expand production via partnerships, including BP's Khazan field. • Egypt: Intensify bidding rounds to accelerate exploration and development. • Egypt, UAE, and Jordan: Use natural gas and LNG imports to bridge domestic supply gaps.

Source: Authors' research; Hamdani (2024).

4.1.4 Gas Demand Growth Uncertainty

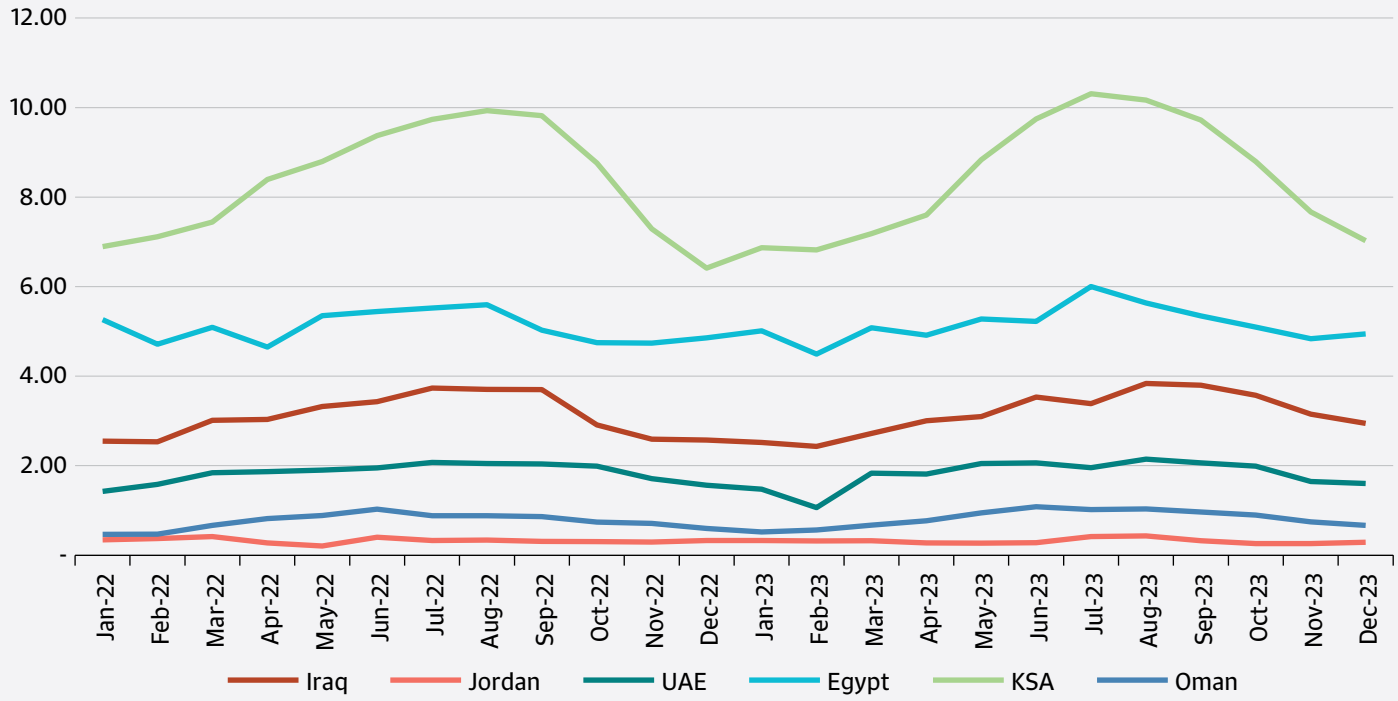
Demand growth uncertainty is another criterion for evaluating ssLNG strengths at the country level. Higher uncertainty strengthens the case for ssLNG due to its modular scalability, relocatability, and ability to serve multiple applications, offering greater optionality than pipelines or fixed large-scale LNG assets. Gas demand uncertainty is measured using an indicator that captures how 2030 demand forecasts change year to year over the previous five years. The indicator is defined as the standard deviation of successive forecast revisions, normalized by the mean forecast level. This approach builds on standard volatility measures (Andersen et al. 2003) and the forecast-revision literature linking revisions to new information (Holden and Stuerke 2008) (Appendix A).

4.1.5 Gas Demand Variability

The operational and geographic flexibility of ssLNG provides clear advantages in countries with highly variable gas demand. Its modular design allows capacity to be adjusted to manage seasonal and daily fluctuations, meet peak loads, and provide backup during infrastructure disruptions.

Monthly gas demand profiles in selected MENA countries illustrate these differences. Saudi Arabia shows pronounced seasonality, driven by summer power generation demand, where ssLNG can help meet peaks and ease temporary pipeline constraints. By contrast, Egypt's flatter demand profile reflects diversified gas use across sectors, reducing seasonal swings and lowering the relative flexibility value of ssLNG. Gas demand variability is measured using the standard deviation across months (Appendix A).

Figure 3. Monthly gas demand in selected MENA countries (bcm).



Source: FGE (2025).

4.1.6 Financing Constraints

Financing constraints and limited access to capital can further enhance the advantage of lower upfront investment requirements for ssLNG systems and their short execution timelines. These financing constraints can be assessed through various indicators, such as the cost of capital (e.g., interest rates, cost of equity), the development of the banking system, the level of FDI, the amount of fiscal or currency reserves (budget deficit), and business and country risks. Country risk can be assessed through sovereign credit ratings, considering various economic and political factors affecting the financing risks.

4.2 Key Criteria That Influence the Weaknesses Identified in the SWOT

The following section assesses the key criteria that influence the weaknesses identified in the SWOT analysis.

4.2.1 Domestic Gas Prices

Low-regulated domestic gas prices can amplify ssLNG's weakness related to limited economies of scale. Higher unit costs associated with small-scale projects require developers to secure higher revenues or rely on government support, such as subsidized feed gas.

Domestic gas prices vary widely across countries and consumption segments, largely reflecting different subsidy regimes that keep prices below international benchmarks. In Egypt, gas prices in 2022 ranged from $3/MMBtu for power generation to $12/MMBtu for cement, with an average of about $5.4/MMBtu, up from $2.6/MMBtu in 2012, and further increases in 2024, particularly for power generation. In Saudi Arabia, the delivery-point gas price rose from $1.25/MMBtu in 2022 to $2.15/MMBtu in January 2025, driven by ongoing price reforms. Industrial customers that might be supplied through ssLNG solutions may face additional costs on top of the price at the delivery point (Appendix B).

4.2.2 Difference Between Gas and Oil Product Prices

The gap between domestic natural gas and oil product prices is another factor that can amplify ssLNG's scale-related cost disadvantage. A narrow price gap weakens incentives to switch from oil products to ssLNG and reduces pricing flexibility to recover delivery costs. This is particularly relevant in MENA, where diesel is widely used in transport, off-grid power, and industrial applications targeted by ssLNG.

To assess this gap, we use the ratio of natural gas to diesel prices, adjusted for calorific value.[4] A lower ratio indicates a stronger cost advantage for gas. This ratio ranges from about 10% in the UAE to 66% in Egypt, while all other countries remain below 25%, suggesting a generally favorable competitive position for natural gas.

Table 4. Gas compositions in selected MENA countries.

Country	H_2-S (mol%)	CO_2 (mol%)	Water content	Heavy hydrocarbons (C_4+, mol%)
Egypt	0.10-0.50 (1,000-5,000 ppmv)	0.65-1.80	112-400 ppmv (feed gas)	~0.15
Oman	Up to 8.0 (Khuff reservoirs); ~4.0 (Rabab Harweel)	5-8	~85 ppmv (pipeline, post-treatment)	0.69-1.56
UAE	5 (conventional); 22-25 (ultra-sour gas)	Up to 10 (e.g., Shah field)	Not reported (typically 20-140 ppmv in pipelines)	0.9-1.5
Iraq	5.3-5.4 (Khurmala)	4.4-4.5 (Khurmala)	1,300 ppmv (Kurmala pre-dehydration) Pipeline spec: ≤150-170 ppmv (≈ -10°C dew point at 75 bar)	~6.7 (Khurmala raw) ~1.5 (after treatment/export)
Saudi Arabia	2.8-5.0 (associated and Khuff gas)	3.5-9.2 (associated/Khuff); ~8-8.5 (Karan field)	Not reported (assumed pipeline range: 20-140 ppmv)	2.1-3.5

Sources: Abbas et al. (2020); Shelbi et al. (2020); Suut et al. (2024); Aijaz, Hameed, and Ahsan (2018); Mohsenzadeh et al. (2024); Alkatheri, Betancourt-Torcat, and Almansoori (2018); Qamar Energy (2021); Al-Saleh et al. (1991); Sen (2015).

4 The gas-to-fuel oil price gap is another relevant comparison, but it is not assessed here due to a lack of data on domestic fuel oil prices.

4.2.3 Need for Gas Treatment

The extent of gas pretreatment required depends largely on feed-gas quality, whether sourced directly from gas fields (e.g., captured associated gas) or from pipeline networks. While pipeline gas is already processed, it may still fall short of liquefaction specifications, particularly for CO_2, water, and heavy hydrocarbons.

Pretreatment needs are assessed based on original gas composition, with an additional criterion reflecting processing severity, which is higher in LNG-exporting countries (see Appendix B). Reported gas composition data for the selected countries (Table 4) underpin the scoring and assessment (Appendix B).

4.2.4 Technology Dependence

Measuring technology dependence in ssLNG is challenging due to limited data on ssLNG-specific equipment and services. As a proxy, imports of machinery, mechanical appliances, and construction and engineering services from United Nations (2024) (Appendix) used to approximate technical inputs required for ssLNG and similar industrial projects (Appendix B).

To account for differences in industrial scale, import values are normalized by industrial value added. This ratio serves as an indicator of each country's reliance on foreign technology and services in industrial applications, including ssLNG.

External Factors of the SWOT: Opportunities and Threats

05

5.1 Opportunities

Opportunities refer to external factors supporting ssLNG solutions' future growth and success in markets. They may relate to market trends, policy developments, or technical innovations.

5.1.1 Growing Gas Demand Trends in MENA Countries

Natural gas remains attractive globally and regionally due to its economic, technical, and environmental advantages. The IEA projects global gas demand to reach nearly 4,380 bcm by 2050, about 200 bcm above 2023 levels, driven mainly by Asia and the Middle East and offsetting declines in OECD countries (IEA 2024b).

In the six assessed MENA countries, gas demand is projected to rise from 285 bcm in 2023 to over 335 bcm in 2030 and around 385 bcm in 2050 (FGE 2025), supported by economic growth, population expansion, and fuel switching from liquids.

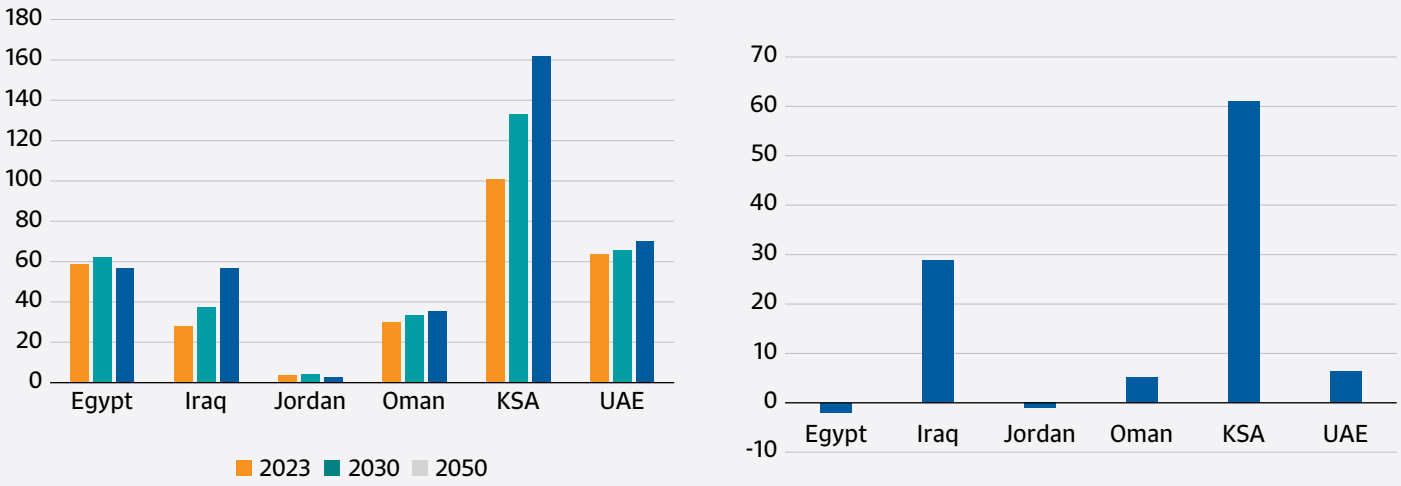
However, growth is uneven: Iraq and Saudi Arabia account for most of the increase, adding about 30 bcm and 60 bcm, respectively, by 2050, while the UAE and Oman see more moderate growth. In contrast, Egypt and Jordan are expected to experience slight declines due to increased penetration of alternative fuels, although Egypt remains a major consumer with demand near 56 bcm in 2050.

5.1.2 Growing Demand for Decentralized Solutions in Power Generation and Industry

Interest in decentralized energy solutions is increasing, driven by the need to improve energy access in remote areas, enhance energy autonomy, ensure uninterrupted supply, reduce environmental impacts, and avoid costly network extensions. In this context, ssLNG is increasingly used to supply off-grid power plants and remote industrial sites and to provide backup for decentralized renewable systems. China has developed a large portfolio of off-grid ssLNG facilities for mining and industrial hubs, while ssLNG-to-power projects have also been implemented in the United States, Brazil, India, Nigeria, Vietnam, and several island nations.

MENA countries may similarly benefit from decentralized ssLNG solutions for power and industry, depending on factors such as electricity access levels, reliance on diesel and fuel oil, pipeline coverage, and grid reliability. When these factors are incorporated into assessment (Appendix C), Iraq and Jordan emerge as strong candidates, particularly for power generation, due to low electricity consumption per capita, continued use of oil products, limited gas infrastructure, and unreliable grids.

Figure 4. Gas demand prospects (left, bcm), incremental change between 2023 and 2050 (right, bcm).



Source: FGE (2025).

Grid reliability indicators highlight these challenges: outage rates reach about 14% in Jordan and 41% in Iraq, compared with 2.7% in Saudi Arabia (World Bank 2024), while transmission and distribution losses rise from 9.5% in Saudi Arabia to 64% in Iraq (Arab Electricity Union 2018).

5.1.3 Gas Demand for Heavy Trucks

LNG-fueled heavy-duty trucks are gaining momentum. In Europe, Volvo reported a 25% increase in gas-powered truck sales in 2024 under EU decarbonization policies, while in China LNG models accounted for nearly 30% of HDV purchases (Volvo 2025; Doleman 2025).

In MENA, NGV programs in the UAE, Egypt, and Algeria, mainly focused on CNG for light-duty vehicles, provide a foundation for LNG adoption in heavy-duty and niche segments. The UAE's uptake is driven by air-quality and emissions objectives and fixed CNG prices, while Egypt's expansion reflects favorable gas–oil price differentials and policies to reduce fuel imports and subsidies (ESCWA 2017).

The opportunity for LNG use in HDVs is assessed qualitatively using three main criteria, covering HDV fleet development, gas pricing incentives, and LNG refueling infrastructure (Appendix C).

5.1.4 LNG Bunkering

LNG's role as a bunkering fuel has expanded in response to stricter environmental regulations in shipping, particularly those imposed by the IMO. By the end of 2024, 641 LNG-powered vessels were in operation, about 2% of the global fleet, but strong ordering activity is expected to double this number by 2030 (DNV 2025)

In MENA, the UAE and Oman have begun developing LNG bunkering infrastructure, reflecting the region's strategic position on major shipping routes. Oman's Port of Sohar is set to host the Middle East's first LNG bunkering facility through the Marsa LNG project (0.8 Mtpa). In the UAE, the first ship-to-ship LNG bunkering operations took place in early 2025 at Dubai Harbour and Khalifa Port, while Fujairah is considering a permanent LNG bunkering facility.

Egypt has signaled a strong interest in establishing an LNG bunkering hub along the Suez Canal through partnerships involving EGAS and Shell, including a joint venture with Kanfer Shipping and Leth Suez Transit. Saudi Arabia is currently prioritizing conventional marine fuels, but evolving IMO standards could support a future shift toward LNG bunkering, particularly in Red Sea ports.

5.1.5 Monetizing Flared Gas and Emitted Methane

Gas flaring and emitted methane represent a loss of valuable resources and generate significant environmental impacts. In 2024, flared volumes in the selected countries are estimated at about 25.1 bcm (World Bank, 2024). More than 10 bcm (7.1 million tons) are emitted as methane from oil and gas and urban waste (Gasim et al. 2026; IEA 2024a).

These practices largely result from insufficient infrastructure, such as limited pipeline access, economic barriers to associated gas monetization, and operational or safety requirements. Small-scale LNG offers a viable option to monetize flared gas and emitted methane as it can economically process small, dispersed volumes in locations lacking large-scale facilities or pipeline networks. Small-scale LNG can also monetize methane from urban landfills and waste streams through bio-LNG production (e.g., Altamont Landfill, California). The opportunity for ssLNG deployment is therefore assessed based on country-level flaring and emitted methane originating from oil and gas and waste (see Appendix C).

5.1.6 Environmental Policies and Actions

Environmental policies create opportunities for natural gas in MENA as a cleaner, less carbon-intensive fuel. Air quality concerns are significant, with particulate matter (PM) and nitrogen oxides (NO_x) levels in several cities exceeding WHO guidelines (WHO 2021, 2022), prompting stricter pollution standards and cleaner fuel regulations. Natural gas aligns well with these measures due to its low PM and relatively lower NO_x emissions.

On climate policy, all sampled countries identify natural gas in their latest NDCs as a means to reduce emissions by substituting oil in power and industry (Saudi Arabia, Iraq), improving efficiency (Oman), or supporting transport use (Egypt, UAE, Jordan). ssLNG storage and peak-shaving solutions can also facilitate renewable integration. Table 5 summarizes the stringency and drivers of environmental policies supporting gas penetration.

5.1.7 Technology Advancement

Significant opportunities exist for technological advancement in ssLNG, with potential to improve efficiency, reduce costs, and mitigate environmental impacts from boil-off gas. Key areas include greater standardization and modularization of liquefaction and storage systems, advanced refrigerant expansion processes such as dual mixed refrigerant cycles (Mun et al. 2024), digitalization and automation using data analytics and AI, and improved materials and insulation.

Realizing these gains in MENA depends on countries' innovation capacity and access to international partnerships. Performance under this criterion is assessed using the Global Innovation Index and net foreign direct investment as proxies. Within the sample, the UAE and Saudi Arabia rank highest on the Global Innovation Index, with the UAE also attracting strong FDI, while Iraq's low GII and FDI scores limit its ability to benefit from technological progress (WIPO 2024).

Table 5. Key environmental policy drivers that affect gas penetration.

Country	Environmental policy drivers that affect gas penetration	Environmental policies' strength
Saudi Arabia	• Strong commitment to emissions reduction via oil-to-gas switching • High renewables penetration requiring balancing solutions • Air pollutant limits under Executive Regulations for Air Quality (2021) • Active enforcement (permits, inspections, and penalties), including via the National Center for Environmental Compliance	High
UAE	• Binding air quality standards (Cabinet Decree 12/2006) used in permitting • 2024 climate law mandates monitoring, reporting, and verification • Strict sulfur controls with strong compliance • High renewables penetration requiring balancing solutions	High
Oman	• Emission limits for stationary sources defined in regulations • Permitting and inspections for industrial sources, with progress on flaring reduction	Moderate to high
Egypt	• Strong focus on reducing emissions, especially from urban transport • High diesel sulfur caps (up to 10,000 ppm), limiting alignment with best practices	Moderate
Jordan	• Environmental Protection Law (2017) with air and fuel standards • Enforcement and monitoring constrained by market and capacity limitations	Low to moderate
Iraq	• Environmental Framework Law (2009) and standards in place • Weak enforcement, monitoring, and data transparency across sectors	Low

Source: Authors.

5.2 Threats

Several threats may hinder the success of ssLNG solutions in MENA countries and affect their economic viability. These threats relate to market competition from alternative energy sources, particularly renewables; competition with other gas supply alternatives, including pipelines and CNG; the evolution of gas prices and supply; regulatory uncertainty; geopolitical instability; and safety concerns.

5.2.1 Renewable Competition

Although ssLNG can complement renewables by balancing intermittency and supporting grid stability, rapid renewable deployment, especially when combined with batteries, could constrain ssLNG growth and natural gas demand more broadly, particularly for decentralized and off-grid applications.

In MENA, renewable deployment is driven mainly by cost competitiveness and government commitments. Solar costs have fallen sharply, from about $60/MWh in Jordan's 2015 tender to around $14/MWh in Abu Dhabi's 2024 tender, with a low of $10.4/MWh for Saudi Arabia's 600 MW Al-Faisaliah (Shuaibah) project in 2021. An additional threat comes from the expansion of decentralized off-grid renewables, with Iraq leading the region at around 80 GW in 2023, up from 60 GW in 2013 (Figure 5).

5.2.2 Competition for Gas Supply Alternatives

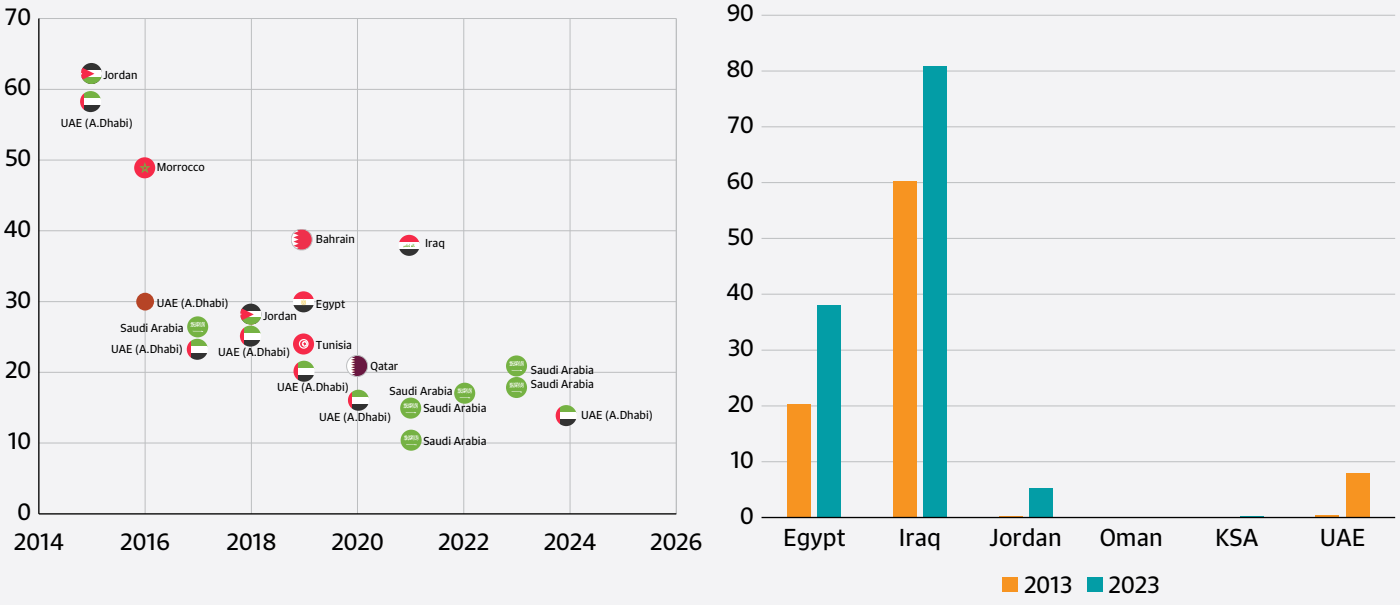
The availability of alternative gas-delivery options to ssLNG can be a major constraint on stakeholders' decisions to adopt this solution. Two principal alternatives are considered in the following section: gas pipeline infrastructure and CNG.

The availability of alternative gas delivery options can constrain the adoption of ssLNG, notably gas pipelines and CNG.

Gas Pipeline Infrastructure

Extensive gas pipeline networks provide a strong alternative to ssLNG where demand volumes justify network extensions. Countries such as Oman and the UAE, with wide pipeline coverage, are well-positioned to connect industrial hubs and power plants located away from existing lines. Planned network expansions can further weaken ssLNG's attractiveness; for example, Saudi Arabia's Master Gas System Phase III will add around 4,000 km of pipelines. However, pipelines pose a weaker threat where demand volumes are insufficient or where technical, regulatory, or land acquisition constraints significantly raise development costs.

Figure 5. Solar-related bidding costs (left, $/MWh) and decentralized off-grid renewable systems (right, MW).



Sources: IEA (2024b); IRENA (2024).

CNG

CNG represents another competing option, particularly for supplying small volumes over short distances. As shown in Table 10, CNG has a strong cost advantage at volumes under 10 mmcf/d and distances below about 400 km, with unit costs less than half those of ssLNG. This advantage diminishes rapidly at longer distances and higher volumes, where ssLNG becomes more competitive.

The relevance of CNG as a substitute is assessed using four criteria: gas demand growth prospects, country size, population density, and the role of CNG in national energy policy.

Egypt stands out due to its extensive CNG adoption in transport and a dense refueling network, followed by Jordan and the UAE, where CNG is promoted to replace oil products and improve urban air (Appendix D).

5.2.3 Gas Price Evolutions

While higher gas prices can improve ssLNG project viability, they may also reduce gas competitiveness against alternative energy sources and suppress demand, posing a risk to future gas adoption. In MENA, gas price trajectories are shaped by pricing reforms and domestic supply-demand balances, with tighter gas

Table 6. Cost of ssLNG vs. CNG depending on distance and volume ($/MMbtu).

Long distance (750-1,000 Miles)				Short distance (0-250 Miles)			
3 mmcf/d		10 mmcf/d		3 mmcf/d		10 mmcf/d	
ssLNG	CNG	ssLNG	CNG	ssLNG	CNG	ssLNG	CNG
11.62	10.46	9.65	10.2	8.12	3.85	6.16	3.61

Source: World Bank (2015b).

supply and higher procurement costs potentially accelerating reforms (Table 7). The possible introduction of CO_2 pricing would further weaken natural gas competitiveness relative to carbon-free alternatives.

5.2.4 Availability of Domestic Gas Supply

Many MENA countries face challenges in expanding gas production to meet rising domestic demand, with future supply depending on the scale of investment and success in developing nonassociated and unconventional resources. Production outlooks provide an indicator of supply availability: Saudi Arabia is expected to nearly double gas output between 2023 and 2040, while the UAE could increase production by about 30% (NexantECA 2025). Saudi Arabia remains the region's largest upstream gas investor, spending nearly US$5 billion annually over 2020-2024, with more than US$100 billion committed to nonassociated and unconventional resources, notably the Jafurah project. The UAE is similarly increasing investment, particularly in sour gas, to supply the planned Ruwais LNG plant.

Iraq is also expected to significantly boost gas availability by monetizing associated gas and reducing flaring, with production projected to exceed 60 bcm by 2040, up from around 10 bcm in 2023. In contrast, Egypt and Jordan face declining production risks due to field maturity.

Alongside production forecasts, average upstream investment over the past five years (Rystad Energy 2025) is used as a complementary indicator to score future supply availability.

5.2.5 Regulatory Uncertainty

As a relatively nascent industry, ssLNG often lacks dedicated regulatory frameworks in MENA, although some countries have regulations for large-scale LNG. ssLNG regulation typically spans licensing, cryogenic and ISO container safety, environmental requirements, end-use eligibility, and fiscal or policy incentives such as power purchase agreements (PPAs), tax relief, and funding support (MAN Energy Solutions 2019). Regulatory uncertainty is higher in countries with weaker regulatory quality.

This threat is assessed using the World Bank Regulatory Quality Index, which measures governments' ability to design and implement sound policies. Scores range from −1.4 in Iraq to about 1 in the UAE, with Iraq and Egypt below the global average (zero) and Oman and Saudi Arabia above it (see Appendix D).

Table 7. Risks and drivers of gas price increase in MENA countries.

Country	Gas pricing drivers	Risk of a substantial gas price increase
Egypt	• IMF-driven price reform toward international benchmarks • Supply shortages • Imports reintroduced, increasing exposure to global price volatility	High
Iraq	• Very low current prices (large upside potential) • Subsidy reform and flaring reduction underway • Increasing exposure to international prices (through imports) • Social and economic constraints may slow reforms	High
Saudi Arabia	• Ongoing energy price reform (prices already increased) • Gradual alignment with international benchmarks • Competitiveness constraints from low oil product prices • Mitigating factor: oil product prices rising faster, maintaining gas competitiveness	Moderate
UAE	• Ambition for full deregulation of energy prices • Strong progress on oil product pricing; gas reforms advancing, but still unclear	Moderate
Oman	• Structured gas price increases (~3% annually) • Already aligned with international levels (limited upside)	Low to moderate
Jordan	• Prices already high and linked to international markets • Policy to cap price increases to mitigate social impact	Low

Source: Authors.

5.2.6 Geopolitical Uncertainty

Geopolitical risk can strongly affect ssLNG development by discouraging investment, constraining financing, and raising concerns over supply chain disruptions, particularly in countries exposed to regional tensions. Such risks may also delay upstream gas projects that supply ssLNG.

This threat is assessed using the Global Peace Index (GPI) from the Institute for Economics and Peace (IEP 2024), which measures stability across conflict, societal safety, and militarization. In 2024, GPI scores for the selected countries range from 1.76 in Oman to 3.045 in Iraq, with higher scores indicating greater geopolitical risk.

5.2.7 Safety and Hazard Risks

ssLNG facilities face multiple safety risks, mainly related to LNG vapor flammability, formation of explosive gas air mixtures, asphyxiation from oxygen displacement, cryogenic exposure, and material embrittlement. Leaks or cryogenic spills often trigger these risks and may be more frequent in ssLNG than in large-scale LNG due to more connections, frequent loading and unloading, boil-off gas releases, and the involvement of smaller operators with varying safety standards. Road transport of LNG also adds safety risks, particularly in densely populated or infrastructure-constrained areas.

Due to limited accident data, country-level safety conditions are assessed using the FM Global Resilience Index (FM Global 2024), which captures both hazard exposure and response capacity.[5] Resilience scores across the sample range from 41.9 in Jordan to 81.9 in the UAE, indicating wide variation in safety environments. Transport-related risks are further proxied using WHO road-traffic fatalities per 100,000 people (WH0 2023) (Appendix D).

5 For our analysis, we selected the indicators most relevant to ssLNG operations.

Assessment of the Strategic Positioning in the MENA Countries

06

After scoring the SWOT factors, strategies are derived using the IFAS and EFAS frameworks, which aggregate weighted ratings across internal strengths and weaknesses and external opportunities and threats.

Differences are then calculated: strengths minus weaknesses for the internal dimension, and opportunities minus threats for the external dimension, capturing how weaknesses and threats offset strengths and opportunities, respectively. Weaknesses and threats are treated as severity-based deficits (higher score = more severe), while strengths and opportunities remain performance-based measures (higher score = more performant) (Saputra et al. 2025).

These results are plotted on a Quadrant strategy matrix to identify the appropriate strategic orientations.

6.1 Internal Factors Analysis

Table 8 presents aggregated strength and weakness indices, with Saudi Arabia, Jordan, and Iraq emerging as well-positioned to leverage ssLNG advantages based on their internal characteristics (Table 8). In KSA, operational flexibility and diversity of applications are the most prominent strengths (see Figure 6, left), driven by high cross-sector gas-demand potential, pronounced seasonal demand variability, and limited pipeline coverage in the north and northwest (Appendix A).

Jordan records its highest score in operational flexibility, reflecting high penetration of intermittent renewables, high uncertainty on gas demand growth, and limited pipeline infrastructure. Overall, operational flexibility ranks as the strongest ssLNG attribute across all countries, underscoring its role in managing demand uncertainty and intra-annual variability through scalable and flexible deployment.

Geographical flexibility further explains the strong positioning of Iraq and Saudi Arabia, where large territories and extensive areas without pipeline access increase the value of modular and relocatable ssLNG. This advantage is less pronounced in the UAE and Oman, where extensive pipeline networks, lower incremental gas-demand potential, and reduced demand variability limit the role of ssLNG, particularly in peak demand management.

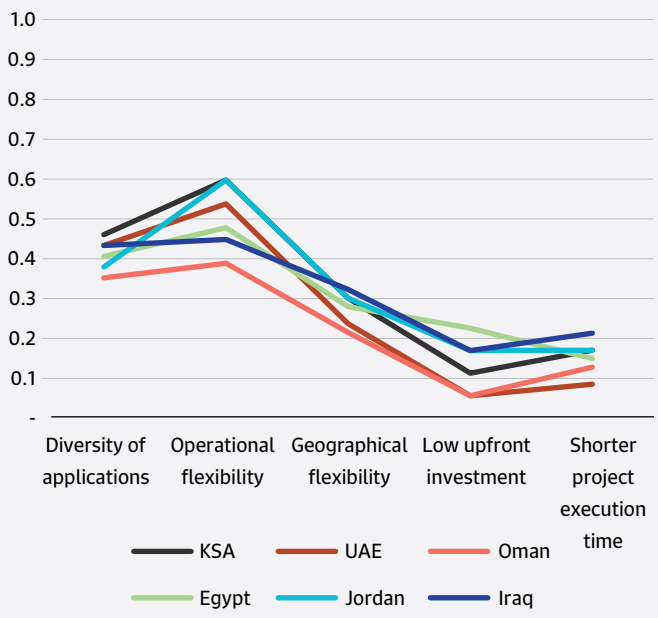
Low upfront investment and short execution times receive lower aggregate scores because they carry smaller weights in the assessment. Even so, Egypt and Iraq rank highest on these factors, consistent with Egypt's tighter fiscal and energy-sector financing constraints and Iraq's urgent need for cost-saving, quickly deployable solutions to improve energy access and reliability.

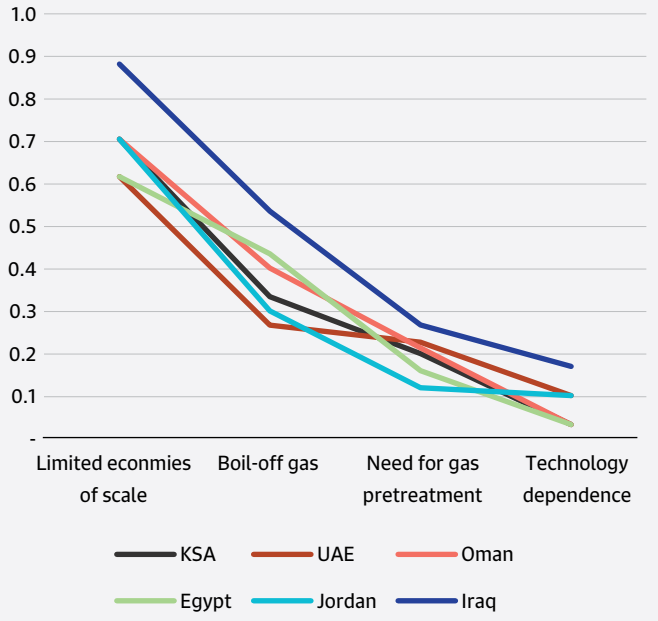
On the weakness side, Iraq and Oman record the highest aggregated indices, indicating where ssLNG drawbacks are most acute. Iraq shows elevated weaknesses across all dimensions, while Oman's weaknesses stem mainly from limited economies of scale and higher gas pretreatment needs, reflecting lower policy support and the sulfur and liquids content of its gas. Similarly, the UAE's sour gas resources accentuate pretreatment requirements.

Table 8. IFAS: Internal factors normalized weighted scores.

Strengths	IFAS weights	KSA	UAE	Oman	Egypt	Jordan	Iraq
Diversity of applications	14%	0.46	0.43	0.35	0.41	0.38	0.43
Operational flexibility	18%	0.60	0.54	0.39	0.48	0.60	0.45
Geographical flexibility	9%	0.30	0.24	0.22	0.28	0.30	0.32
Low upfront investment	6%	0.11	0.06	0.06	0.23	0.17	0.17
Shorter project execution time	4%	0.17	0.09	0.13	0.15	0.17	0.21
Total strength score		**1.64**	**1.35**	**1.14**	**1.54**	**1.62**	**1.59**
Weaknesses	**IFAS weights**	**KSA**	**UAE**	**Oman**	**Egypt**	**Jordan**	**Iraq**
Limited economies of scale	26%	0.71	0.62	0.71	0.62	0.71	0.88
Boil-off gas	13%	0.34	0.27	0.40	0.44	0.30	0.54
Need for gas pretreatment	7%	0.20	0.23	0.21	0.16	0.12	0.27
Technology dependence	3%	0.03	0.10	0.03	0.03	0.10	0.17
Total weakness score		**1.28**	**1.22**	**1.36**	**1.25**	**1.23**	**1.86**

Figure 6. Normalized weighted scores for various strengths (left); normalized weighted scores for various weaknesses (right).





Sources: Authors.

Egypt's profile is strongly affected by boil-off gas, consistent with its relatively high methane intensity (IEA 2024a). In Saudi Arabia, weaknesses are driven largely by limited economies of scale linked to low-end-user gas prices, underscoring the need for targeted policy support. The UAE and Jordan also exhibit higher technology-dependence scores, reflected in elevated imports of machinery relative to industrial value added.

6.2 External Factors Analysis

As shown in Table 9, Saudi Arabia and Iraq record the highest opportunity scores, driven mainly by strong gas-demand growth supported by economic and demographic fundamentals and gas's role in the energy mix.

Opportunities for decentralized solutions also raise scores in Iraq, Egypt, Saudi Arabia, and Jordan, reflecting either grid reliability gaps, low per capital electricity use, or limited pipeline coverage. In these contexts, ssLNG can replace diesel-based generation, particularly in Iraq, while Saudi Arabia also offers scope for decentralized ssLNG in non-pipelined areas.

Bunkering represents another opportunity, with Oman and the UAE already advancing projects and Saudi Arabia holding strong potential, with dual coast locations including the Red Sea, a major maritime corridor, exposed to Mediterranean Sea sulfur limitations. For road transport, heavy-duty truck demand scores highest in Egypt and Saudi Arabia, supported by fleet growth, competitive gas pricing in Saudi Arabia, and Egypt's established gas refueling network. Environmental policies score strongly in Saudi Arabia and the UAE, although their weight for ssLNG is lower, underpinned by the policy emphasis on zero-emission options.

Despite its lower weight, the technological progress opportunity scores highest in the UAE, Oman, and Egypt, reflecting stronger innovation capacity, LNG experience, and access to international partnerships.

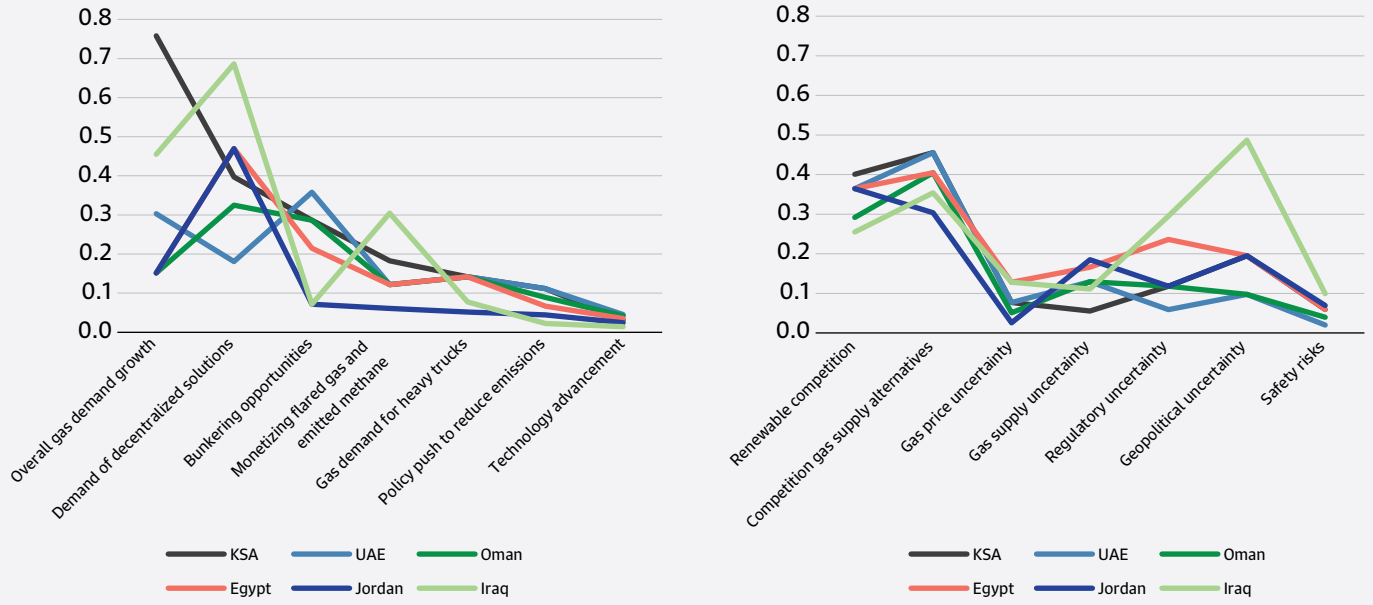
On the threat side, Iraq and Egypt record the highest scores. Iraq's profile is dominated by regulatory and geopolitical uncertainty, while Egypt faces risks from domestic supply uncertainty, competition from alternative gas delivery options, regulatory constraints, and rapid renewable deployment. Egypt's extensive pipeline and CNG infrastructure, together with supportive policies, may favor these options over ssLNG, while aggressive off-grid solar expansion further increases renewable-related threats.

Renewables also pose a significant competitive threat in Saudi Arabia and Jordan, driven by strong cost competitiveness and ambitious deployment targets. Rising gas prices relative to current levels further elevate threat scores in Iraq and Egypt. By contrast, Oman records the lowest overall threat score, reflecting lower renewable and regulatory pressures and reduced exposure to gas price increases following recent price reforms.

Table 9. EFAS: External factors normalized weighted scores.

Opportunities	EFAS weights	KSA	UAE	Oman	Egypt	Jordan	Iraq
Overall gas demand growth	15%	0.76	0.30	0.15	0.15	0.15	0.45
Demand for decentralized solutions	14%	0.40	0.18	0.33	0.47	0.47	0.69
Bunkering opportunities	7%	0.29	0.36	0.29	0.21	0.07	0.07
Monetizing flared gas and emitted methane	6%	0.18	0.12	0.12	0.12	0.06	0.30
Gas demand for heavy trucks	4%	0.14	0.14	0.14	0.14	0.05	0.08
Policy push to reduce emissions	2%	0.11	0.11	0.09	0.07	0.04	0.02
Technology advancement	1%	0.03	0.05	0.04	0.03	0.02	0.01
Total opportunity score		**1.91**	**1.26**	**1.16**	**1.20**	**0.87**	1.63
Treats	**EFAS weights**	**KSA**	**UAE**	**Oman**	**Egypt**	**Jordan**	**Iraq**
Renewable competition	11%	0.40	0.36	0.29	0.36	0.36	0.26
Competition from gas supply alternatives	15%	0.46	0.46	0.40	0.40	0.30	0.35
Gas price uncertainty	3%	0.08	0.08	0.05	0.13	0.03	0.13
Gas supply uncertainty	4%	0.06	0.13	0.13	0.17	0.18	0.11
Regulatory uncertainty	6%	0.12	0.06	0.12	0.24	0.12	0.30
Geopolitical uncertainty	10%	0.19	0.10	0.10	0.19	0.19	0.49
Safety risks	2%	0.06	0.02	0.04	0.06	0.07	0.10
Total threat score		**1.36**	**1.20**	**1.13**	**1.55**	**1.26**	**1.73**

Figure 7. Normalized weighted scores for various opportunities (left); normalized weighted scores for various threats (right).



Sources: Authors.

6.3 SWOT Quadrant Results

The quadrant analysis shows that Saudi Arabia stands out, with strengths and opportunities clearly outweighing weaknesses and threats. The UAE falls in the same quadrant but with a narrower margin, reflecting a smaller addressable market, dense pipeline coverage that reduces ssLNG's flexibility advantage, and higher gas pretreatment requirements.

In Egypt and Jordan, strengths exceed weaknesses, supported by factors that enhance the value of ssLNG flexibility, such as limited coverage, rising renewables, large uncertainty on gas demand prospects, and in Egypt, pro-gas policies. Both benefit from low upfront costs and short lead times, but opportunities are constrained by renewable competition, domestic supply uncertainty, and, in Egypt, pricing and regulatory risks.

In Oman, weaknesses outweigh strengths due to limited economies of scale, higher pretreatment needs, and a weaker flexibility advantage linked to modest demand variability, although opportunities remain in LNG bunkering, decentralized supply, and heavy-duty transport. Iraq falls firmly in the weakness/threat quadrant: limited scale, boil-off losses, and extensive pretreatment needs exacerbate the ssLNG weaknesses and affect its competitiveness, especially under low regulated end-use prices. Threats are amplified by regulatory and geopolitical uncertainties and the risk of rising gas prices dampening demand.

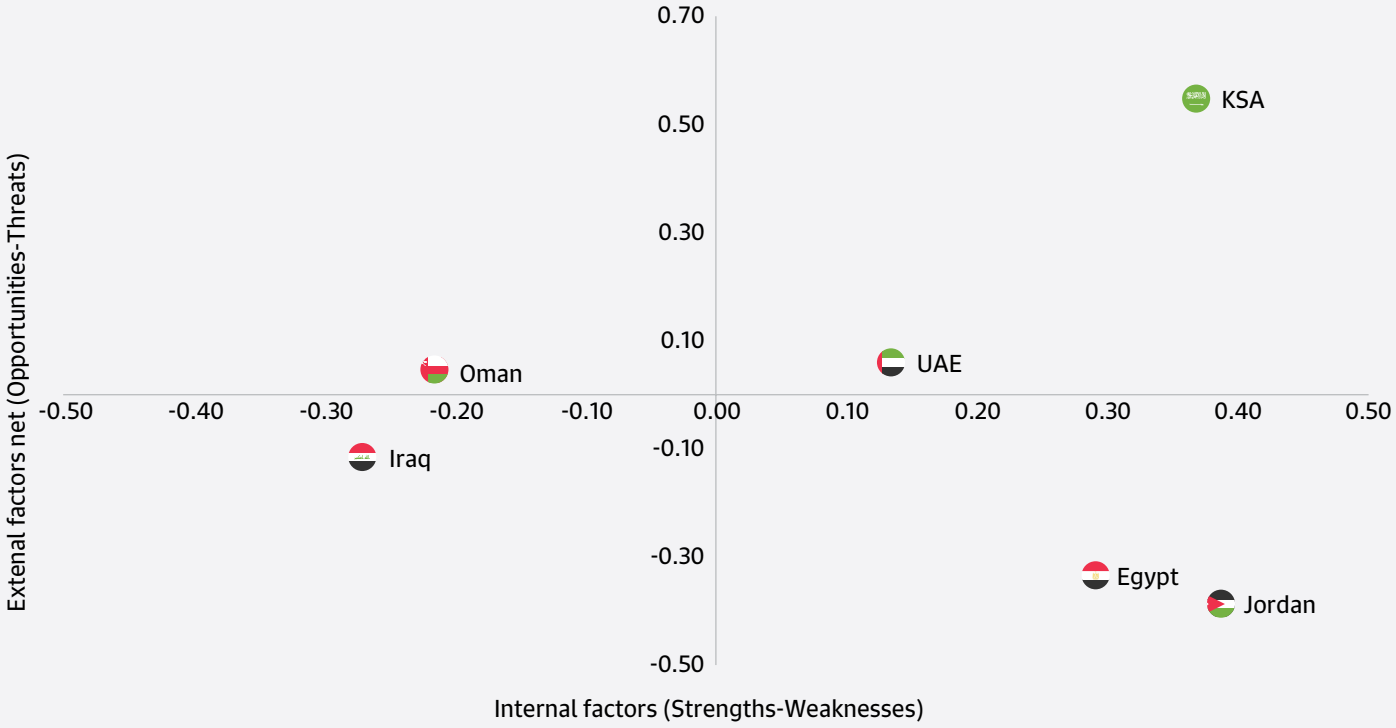
6.4 Targeted Strategies in MENA Countries

Saudi Arabia

Saudi Arabia offers strong opportunities for ssLNG deployment, driven by robust gas-demand prospects, clear use cases for decentralized supply to off-grid industry and remote power, expansion of the heavy-duty fleet, dual-coast access for LNG bunkering, and environmental policies favoring cleaner fuels. These opportunities align with ssLNG's core strengths, including diverse applications and high operational and geographic flexibility, which support modular, scalable deployment. Targeted strategies include:

- Virtual pipelines: Truck ISO-container LNG from MGS-connected mother liquefaction stations to off-grid industrial parks, construction sites, and remote loads.
- Diesel displacement: Convert captive power generators to LNG, potentially hybridized with renewables to cut costs and emissions.

Figure 8. SWOT quadrant matrix.



Sources: Authors.

- LNG storage: Install small LNG storage and regasification near demand centers, high ramping gas-fired power plants, and constrained corridors to reduce summer liquid burning and improve gas system flexibility under renewable variability.
- Stranded gas monetization: Deploy ssLNG at small or stranded fields, or as a bridge solution before gathering systems are built.
- Marine bunkering: Pilot truck-to-ship and ship-to-ship LNG bunkering at Jeddah, Yanbu, Jubail, and Dammam.
- Heavy-duty transport: Develop LNG refueling corridors along Riyadh-Dammam-Jeddah and in major cities to lower fuel costs and air pollution.

UAE

While overall gas-demand growth is modest, the UAE offers clear niches for ssLNG, notably marine bunkering, heavy-duty transport, and flared-gas monetization. Stringent environmental policies strengthen gas's role in reducing air pollutants and emissions, while technology improvements can help lower ssLNG costs and losses. These opportunities align with ssLNG's strengths in the UAE – diverse applications and high operational flexibility. Strategies to focus on include:

- Port-led bunkering: Expand LNG bunkering at major ports (truck-to-ship and ship-to-ship), leveraging existing operations in the UAE.
- Heavy transport corridors: Develop LNG refueling along key highways and in major urban centers.
- Flared-gas monetization: Deploy ssLNG at new or stranded fields as a bridge ahead of full gathering and processing.
- Flexibility optimization: Capitalize on established LNG infrastructure to position ssLNG as a complementary flexibility tool to renewables, enabling efficient peak-shaving and system balancing.

Egypt

Egypt can prioritize strategies that leverage ssLNG's strengths related to application diversity and flexibility to mitigate key threats, including domestic supply and price uncertainty and competition from alternative fuels. These include:

- Supply continuity via satellites and ISO bridges: Deploy satellite regas, mobile ISO tanks, and storage to address shortages and seasonal gaps in under-piped regions, using dual domestic/import supply where needed.
- Hybrid ssLNG-renewables solutions: Pair ssLNG with renewables to exploit flexibility, supported by capacity remuneration mechanisms to strengthen revenues.
- CNG-ssLNG-pipeline complementarity: Use ssLNG to aggregate demand in under-piped areas through hub-and-spoke systems, supplying hubs and large users while CNG serves smaller consumers.
- Price-risk management: Structure delivered-ssLNG contracts indexed to domestic fuel alternatives with floors and caps, and blend imported and domestic gas to hedge price volatility.

Oman

Oman can target ssLNG opportunities in bunkering and decentralized or off-grid energy while addressing key weaknesses, including limited scale, gas pretreatment needs, and boil-off management. Priority strategies include:

- Virtual pipelines: Develop hub-and-spoke systems where large hubs supply satellite regasification for major users.
- Demand aggregation: Use milk-run logistics to serve smaller users, improving scale and load factors.
- Incentive frameworks: Introduce gas-pricing and fiscal incentives to lower unit costs and entry barriers.
- Technology partnerships: Leverage LNG experience to enhance gas pretreatment and liquids recovery.
- BOG management: Apply best practices to reduce methane leakage and ensure clean supply, particularly for bunkering.

Jordan

Jordan can focus on strategies that leverage ssLNG's operational flexibility to offset key threats, notably renewable competition and uncertainty over domestic gas supply.

- Hybrid microgrids: Combine ssLNG generators with solar or wind to supply off-grid industry, mining, and tourism, while balancing intermittency.
- Renewables backup: Use ssLNG as a backup to support high renewable penetration and lower integration costs.
- Pipeline-CNG-ssLNG complementarity: Adopt hub-and-spoke systems where ssLNG hubs source gas from pipelines for large users, while CNG serves small businesses.
- Supply security: Deploy ssLNG for stranded gas development or storage near demand centers to mitigate domestic supply risks.
- Virtual pipelines: Use ssLNG to manage pipeline disruptions linked to geopolitical uncertainty.

Iraq

Despite strong ssLNG potential, Iraq should prioritize risk-mitigating strategies that address regulatory and geopolitical uncertainty, gas price and supply risks, and core weaknesses such as limited scale, weak BOG management, pretreatment gaps, and technology dependence. Key actions include:

- Phased deployment: Roll out modular, relocatable ssLNG systems to limit sunk costs until regulations stabilize.
- Virtual pipelines: Use ISO-trucked LNG to sustain deliveries during pipeline disruptions.
- Technology partnerships: Work with experienced operators and embed local-content, training, and knowledge-transfer clauses.
- BOG standards: Enforce robust practices for boil-off gas management.
- Targeted incentives: Support first movers to improve project bankability.
- Supply resilience: Diversify gas sourcing and maintain buffer storage at secure industrial hubs.

Conclusion

07

This paper assesses the potential for deploying ssLNG solutions in the MENA region. ssLNG encompasses the production, transport, storage, and use of LNG volumes smaller than those of conventional large-scale supply chains.

A quantified SWOT framework is applied to evaluate strengths, weaknesses, opportunities, and threats across selected countries and translate the results into a Quadrant strategy matrix to identify priority deployment strategies. The analysis shows the following:

- Operational flexibility is ssLNG's strongest attribute across all countries, enabling modular, scalable deployment to manage demand uncertainty and intra-annual variability. Modular plants can typically be installed within 18 months and expanded incrementally.

- Limited economies of scale remain the main weakness: unit capital and fixed operating costs for plants below 1 Mtpa generally range from $1-$5/MMBtu – around 50%-100% higher than large-scale liquefaction. This challenge is amplified in countries with low-regulated gas prices (e.g., Iraq) or narrow gas-oil price differentials (e.g., Egypt), which weaken fuel-switching incentives. Additional drawbacks, including boil-off gas losses and high sulfur or CO_2 content in some regional gas streams, further increase pretreatment costs.

- On the opportunity side, ssLNG can benefit from rising regional gas demand, projected to increase from about 285 bcm in 2023 to over 335 bcm by 2030 and around 385 bcm by 2050. Saudi Arabia and Iraq alone could add nearly 90 bcm by mid-century. ssLNG can also support decentralized power and industrial supply in weak-grid areas and monetize flared gas and emitted methane (estimated at more than 35 bcm annually). LNG bunkering represents another opportunity, particularly in Oman, the UAE, and Saudi Arabia, as the LNG-powered fleet is expected to double by 2030 under IMO regulations.

- Key threats include competition from alternatives such as renewables, pipeline gas, and CNG. CNG is particularly competitive at small volumes (less than 10 MMscf/d) and distances below 400 km, with costs often less than half those of ssLNG. Regulatory and geopolitical uncertainty, along with the risk of rising gas prices dampening demand, further constrain ssLNG deployment.

- The IFAS and EFAS frameworks aggregate weighted SWOT factors to position countries within the strategy matrix. Saudi Arabia stands out, with strengths and opportunities clearly outweighing weaknesses and threats. The UAE lies in the same quadrant but with a narrower margin due to a smaller addressable market, dense pipeline coverage, and higher pretreatment needs. Both can pursue Strengths-Opportunities strategies by leveraging ssLNG's versatility and flexibility to capture multi-sector demand growth, opportunities in LNG bunkering, decentralized solutions for off-grid industrial sites and remote power plants, heavy-duty vehicles, and flared and emitted methane monetization.

- Egypt and Jordan align with Strengths-Threats strategies, using ssLNG's flexibility – through mobile ISO tanks and storage solutions to ensure supply continuity and support renewables integration, with Egypt benefiting from pricing mechanisms that smooth volatility.
- Oman fits a Weaknesses-Opportunities strategy, targeting bunkering and decentralized energy while addressing scale, pretreatment, and boil-off constraints through gas-incentivizing frameworks.
- Iraq falls within the Weaknesses-Threats strategy, favoring a phased, modular ssLNG rollout to limit exposure to regulatory, geopolitical, and price risks while addressing core technical weaknesses.

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Appendices

Appendix A: Scoring the Strengths

A.1 Scoring Matrix

Table A1. Scores applied to the ssLNG strengths.

ssLNG strengths	Criteria supporting a specific country	KSA	UAE	Oman	Egypt	Jordan	Iraq
1. Diversity of applications	Policies promoting natural gas	5	4	3	5	1	2
	Lack of pipeline coverage	4	2	4	3	5	4
	Gas demand potential in various sectors	4	3	2	2	2	5
	Availability of competitive gas supply	3	4	3	2	1	3
	Gas demand growth uncertainty	1	3	1	3	5	2
	Average index	3.4	3.2	2.6	3.0	2.8	3.2
2. Operational flexibility	Gas demand variations	5	2	1	2	1	2
	Renewables penetration	2	3	2	3	5	1
	Lack of gas pipeline coverage	4	2	4	3	5	4
	Gas demand potential in various sectors	4	3	2	2	2	5
	Logistics and transportation infrastructure	4	5	3	3	2	1
	Gas demand growth uncertainty	1	3	1	3	5	2
	Average index	3.3	3.0	2.2	2.7	3.3	2.5
3. Geographical flexibility	Size of the country (remote areas)	5	3	3	5	2	4
	Lack of gas pipeline coverage	4	2	4	3	5	4
	Gas demand potential in various sectors	4	3	2	2	2	5
	Gas demand growth uncertainty	1	3	1	3	5	2
	Average index	3.5	2.8	2.5	3.3	3.5	3.8
4. Low investment	Funding capabilities and budget constraints	2	1	1	4	3	3
5. Shorter project execution time	Need for urgent access to energy	3	2	3	4	4	5
	Immediate cost savings vs. liquid fuels	5	2	3	3	4	5
	Average index	4.0	2.0	3.0	3.5	4.0	5.0

A.2 Various Indicators Supporting the Scoring

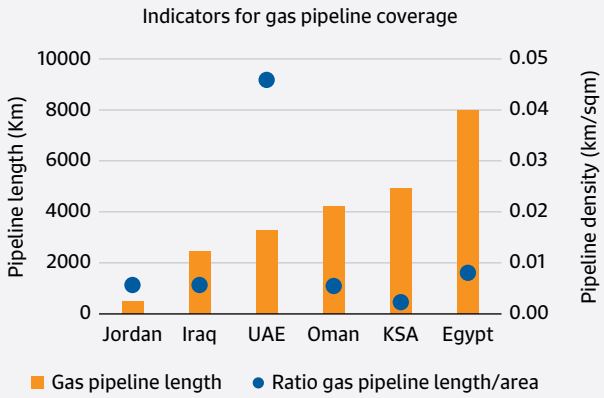
Table A2. Scoring of the gas-promoting policies.

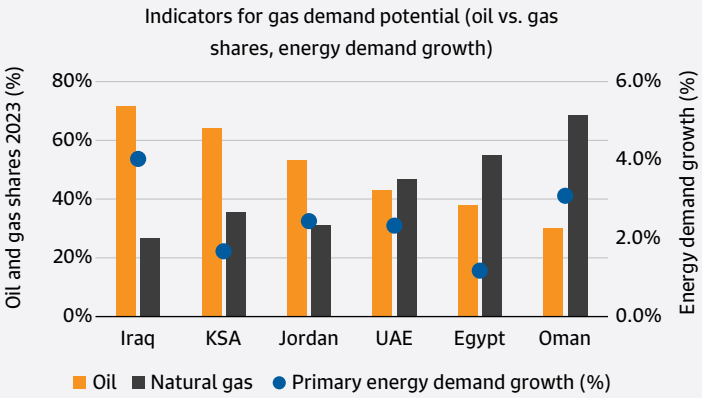
	KSA	UAE	Egypt	Oman	Jordan	Iraq
Upstream gas	++	++	++	+		+
Gas network extension	++	+	+	+		
Gas import infrastructure		++	++		+	+
Power generation	++	+	+	+	+	++
Industrial development	++	+	++	++	+	
Buildings			+			
Transport		+	+	+	`	
Liquid fuel displacement	++		++			++
Emissions mitigation	+	+	+	+		

Scoring of gas-related policies in the SWOT table				
Country	Score*	Normalization (0-1)	Normal (1-5)	Final score
KSA	11	0.889	4.556	**5**
UAE	9	0.667	3.667	**4**
Egypt	12	1.000	5.000	**5**
Oman	7	0.444	2.778	**3**
Jordan	3	-	1.000	**1**
Iraq	6	0.333	2.333	**2**

* The score is calculated by summing the number of "+" signs assigned to each country in the table.

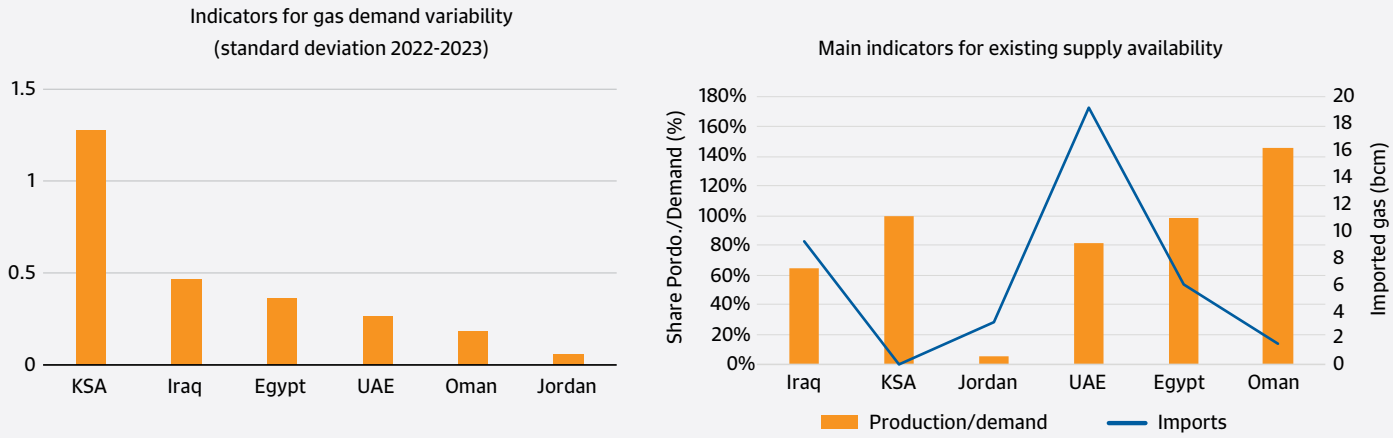
Figure A1. Indicators for gas pipeline coverage and gas demand potential.





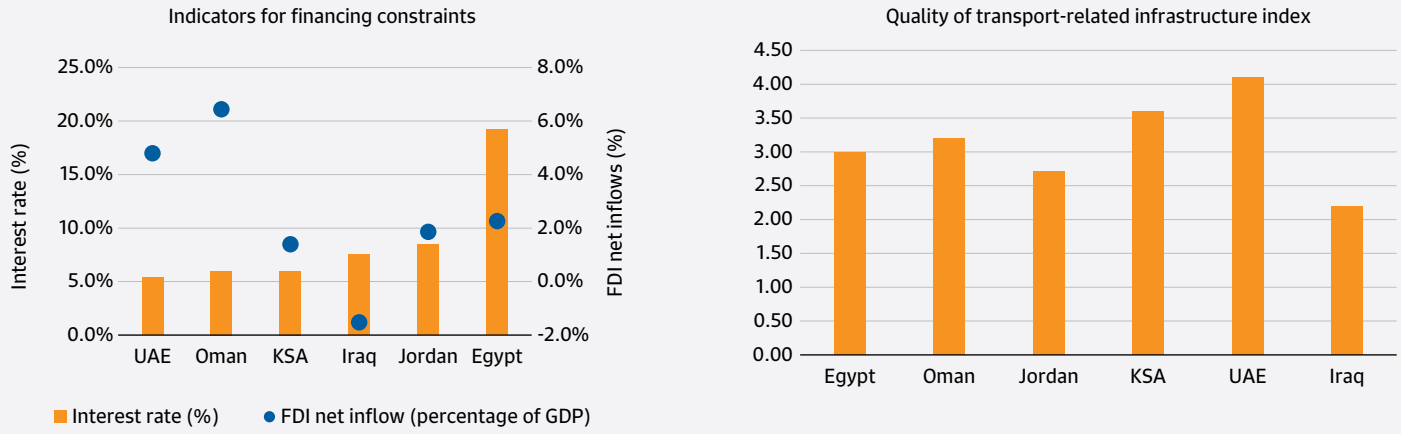
Sources: Aramco (2020); OQGN (2024); GASCO (2024); MEMR (2023) (left chart); Energy Institute (2024) (right chart).

Figure A2. Indicators for gas demand variability and existing supply availability.



Sources: FGE (2025) (left chart); Energy Institute (2024) (right chart).

Figure A3. Indicators for financing constraints and quality of transport-related infrastructure.



Sources: World Bank (2024).

Table A3. Scoring the value of a shorter execution timeline in various countries.

Country	Need for urgent access to energy	Immediate cost savings vs. liquid fuels
Iraq	High (5): Large power deficit and peak shortages; growing energy needs; limited gas infrastructure	High (5): Significant crude and fuel oil use in power; high substitution potential; strong immediate cost savings
Egypt	Moderate to high (4): Power shortages and blackout episodes; gas supply constraints; urgent need for flexible supply	Moderate (3): Use of fuel oil during gas shortages; rising import costs; value of fuel switching, but relatively limited compared to big oil consumers in industry and power
Jordan	Moderate to high (4): High import dependence; exposure to supply disruptions; limited domestic resources	Moderate to high (4): High reliance on imported fuels; diesel use in key sectors; strong cost exposure
Oman	Moderate (3): Localized supply gaps (remote areas); diesel use in isolated systems, but moderate infrastructure constraints	Moderate (3): Diesel use in remote/off-grid areas; moderate substitution potential; localized cost savings
Saudi Arabia	Moderate (3): Rapid growth in energy demand; infrastructure bottlenecks (gas transport and regional imbalances); need to accelerate gas supply to support industrial expansion	High (5): Large oil use in power and industry; high opportunity value from oil to gas substitution; Vision 2030 policy targets to displace liquids in power and industry
UAE	Low to moderate (2): Well-developed energy system; diversified supply (gas, nuclear, renewables); low urgency for rapid deployment	Low to moderate: Limited liquid fuel use in power; gas-dominated system; lower incremental savings

Appendix B: Scoring the Weaknesses

B.1 Scoring Matrix

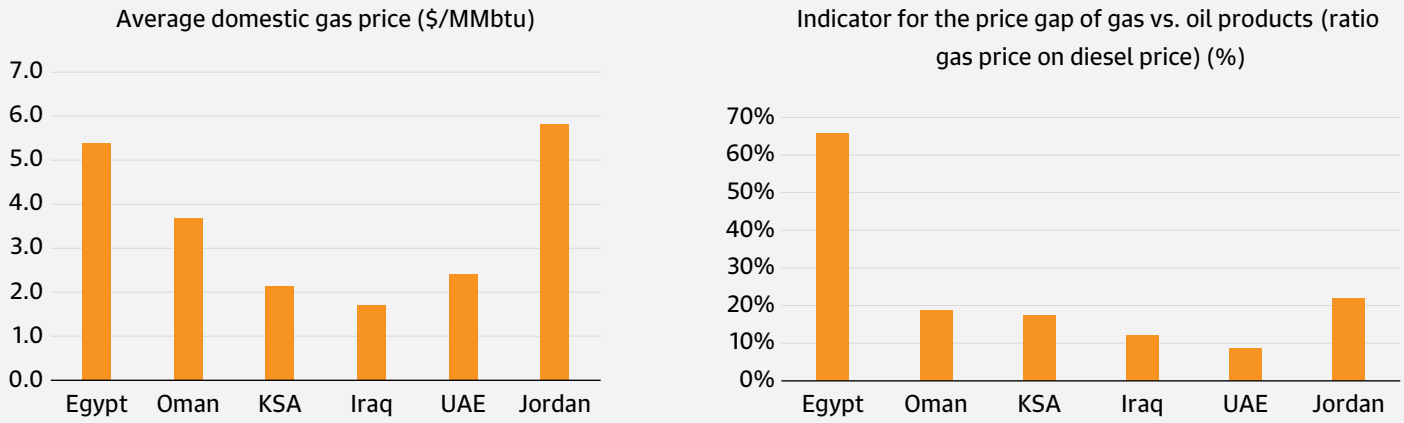
Table B1. Scores applied to the ssLNG weaknesses.

Small-scale LNG weaknesses	Criteria supporting the weakness of a specific country	KSA	UAE	Oman	Egypt	Jordan	Iraq
1. Limited economies of scale	Lack of gas policy incentives and subsidies	1	2	3	1	5	4
	Domestic gas price	5	4	3	1	1	5
	Gap between gas and oil product prices	2	1	2	5	2	1
	Average index	2.7	2.3	2.7	2.3	2.7	3.3
2. Boil-off gas	Methane intensity	1	3	4	5	1	5
	Methane commitments	1	1	4	3	4	3
	Gas demand potential	4	3	2	2	2	5
	Fragmentation of the supply chain (size of the country, remote areas)	4	1	2	3	2	3
	Average index	2.5	2.0	3	3.3	2.3	4.0
3. Need for gas pretreatment	Sulfur dioxide	3	5	4	2	1	3
	CO_2 content	4	5	3	2	1	3
	Moisture	2	3	3	4	1	5
	Liquids	3	3	4	2	1	5
	Infrastructure	3	1	2	2	5	4
	Average index	3.0	3.4	3.2	2.4	1.8	4.0
4. Technology dependence	Funding capabilities and budget constraints	1	3	1	1	3	5
	Average index	1	3	1	1	3	5

Note: A higher score reflects a higher weakness.

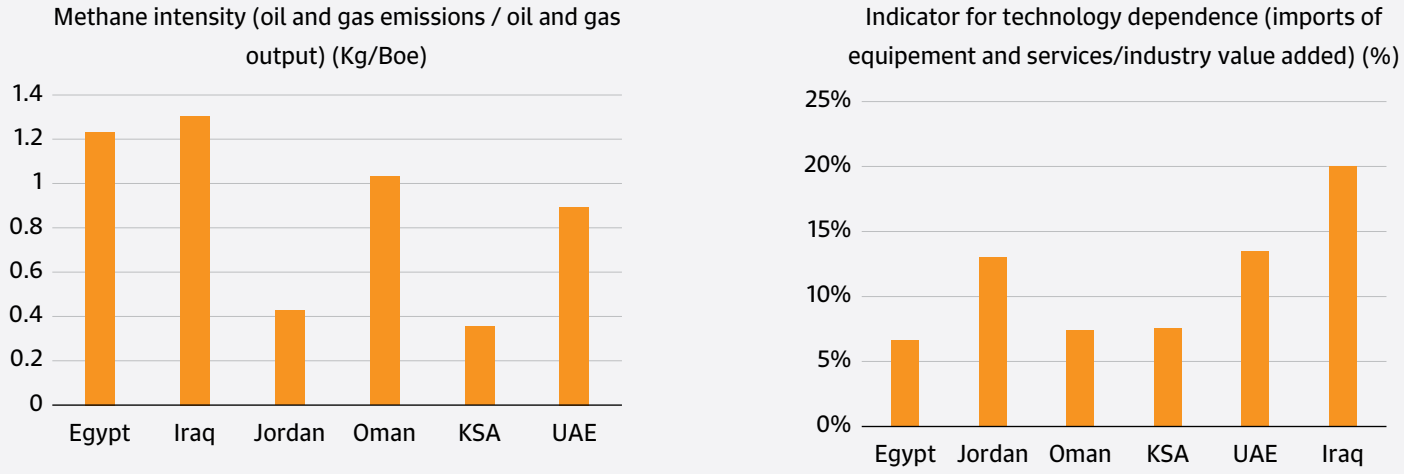
B.2 Various Indicators Supporting the Scoring

Figure B1. Average domestic gas price and price gap of gas vs. oil products.



Sources: Prices are collected from different sources based on the last available information (OAPEC 2023, 2024, 2025; Considine et al. 2024; Hamdani 2024; Carpenter 2025; Amman Chamber of Industry 2022; IGU Wholesale Pricing Survey 2024).

Figure B2. Methane intensity and indicator for technology dependence.



Sources: IEA (2024a); FGE (2025); Energy Institute (2024) (left chart); UN Comtrade Database (2024); World Bank (2024) (right chart).

Table B2. Scoring the value of methane commitments.

	Methane commitments and implementation status	Assessment	Score
UAE	Global Methane Pledge: Methane intensity target (0.15%) by 2025 (ADNOC 2024); active implementation measures (LDAR, venting and flaring reduction, targets for waste, landfill gas recovery)	Strong commitment: Strong corporate leadership, clear targets, active international partnerships, and early implementation	1
KSA	Global Methane Pledge: Aramco aims for near-zero upstream methane by 2030. Active implementation measures (LDAR)	Strong commitment: Robust upstream goals; clear company-level actions; integration into broader climate reforms	1
Egypt	Global Methane Pledge: Developing methane regulations for oil and gas sector	Moderate: Policy direction is clear, but quantitative methane targets and enforcement transparency remain limited	3
Iraq	Global Methane Pledge: Methane inventory and draft regulation under development; technical collaboration with CCAC and World Bank GGFR (CCAC 2024)	Moderate: International technical support, but the regulatory framework is still maturing; implementation challenges remain	3
Oman	Global Methane Pledge: Regional alignment with net-zero 2050 goal; methane mitigation via decarbonization strategy and cooperation	Low to moderate: Lacks published intensity targets or a dedicated methane roadmap	4
Jordan	Global Methane Pledge: Waste sector methane reduction plan (<30%)	Low to moderate: Methane addressed mainly in the waste and energy transition context; limited upstream exposure reduces impact scale	4

Appendix C: Scoring the Opportunities

C.1 Scoring Matrix

Table C1. Scores applied to the ssLNG opportunities.

Small-scale LNG weaknesses	Criteria supporting the opportunity of a specific country	KSA	UAE	Oman	Egypt	Jordan	Iraq
1. Gas demand growth	Forecasted incremental gas demand (2023-2050)	5	2	1	1	1	3
Average index		**5.0**	**2.0**	**1.0**	**1.0**	**1.0**	**3.0**
2. Growing demand for decentralized solutions in power and industry	Lack of energy access (electricity demand/capita)	2	1	3	5	5	5
	Lack of pipeline coverage	4	2	4	3	5	4
	Electricity network reliability (outage indicator)	1	1	1	3	2	5
	Use of oil products in power and industry	4	1	1	2	1	5
Average index		**2.8**	**1.3**	**2.3**	**3.3**	**3.3**	**4.8**
3. Environmental policies	Environmental policies implementation	5	5	4	3	2	1
Average index		**5**	**5**	**4**	**3**	**2**	**1**
4. Bunkering opportunities	Demand potential in bunkering	4	4	4	3	1	1
Average index		**4**	**4**	**4**	**3**	**1**	**1**
5. Monetizing flared gas and emitted methane	Lack of pipeline coverage	4	2	4	3	5	4
	Venting and flaring	3	2	2	2	1	5
Average index		**3.0**	**2.0**	**2.0**	**2.0**	**1.0**	**5.0**
6. Gas demand for heavy trucks	HDV development	5	3	4	4	2	2
	Pricing incentives	4	4	3	3	1	3
	Infrastructure	2	4	4	4	1	1
Average index		**3.7**	**3.7**	**3.7**	**3.7**	**1.3**	**2.0**
7. Virtual pipelines	Lack of gas infrastructure	4	2	4	3	5	4
Average index		**4**	**2**	**4**	**3**	**5**	**4**
8. Technology advancement	Capability to deploy technologies and research	4	5	3	3	3	1
	Access to partnership	2	4	5	3	3	1
	Experience in the LNG industry	3	4	4	4	1	2
Average index		**3.0**	**4.3**	**4.0**	**3.3**	**2.3**	**1.3**

Note: A higher score reflects a higher weakness.

C.2 Various Indicators Supporting the Scoring

Table C2. Normalized scoring for gas demand growth.

Gas demand growth				
	Incremental gas demand (2023-2050) (Bcm)	Normalization (0-1)	Normalization (1-5)	Final score
Egypt	-1.99	0.00	1.00	1
Iraq	28.83	0.49	2.95	3
Jordan	-1.04	0.02	1.06	1
Oman	5.08	0.11	1.45	1
KSA	61.07	1.00	5.00	5
UAE	6.45	0.13	1.54	2

Source: FGE (2025).

Table C3. Scoring LNG deployment for HDVs in MENA countries.

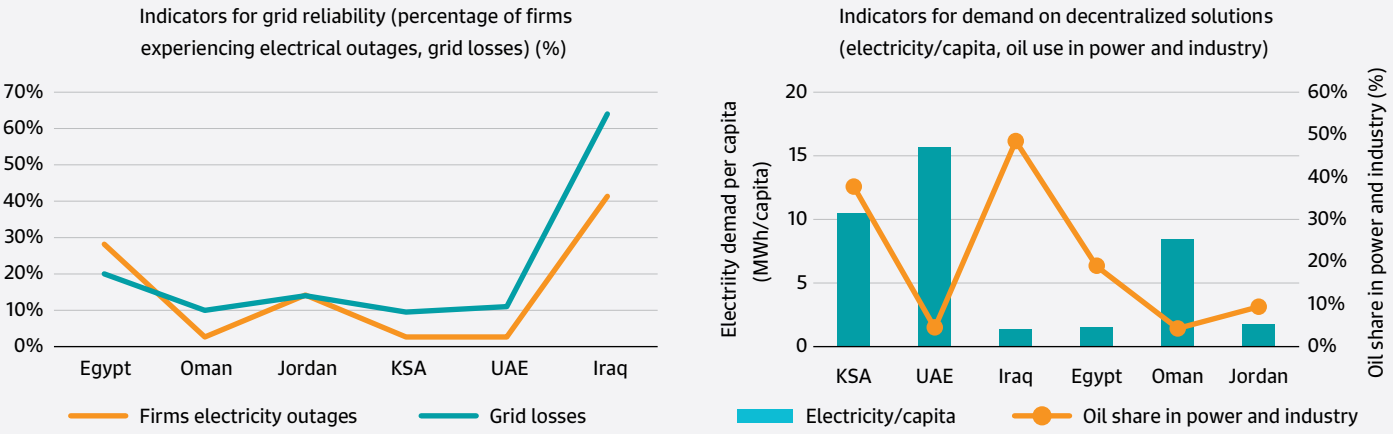
Key criteria supporting LNG deployment for HDVs in MENA countries			
	HDV development	Pricing incentives	Infrastructure
Saudi Arabia	High (5): Large fleet development driven by economic activity	Moderate to high (4): Gas priced lower than diesel	Low to moderate (2): No LNG refueling station, but pilot projects are under consideration for CNG
UAE	Moderate (3): Fleet growth mitigated by lower population increase	Moderate to high (4): Existing pricing policy to support CNG	Moderate to high (4): Existing LNG infrastructure, involvement in CNG, as part of a policy to reduce emissions and air pollution
Egypt	Moderate to high (4): Fleet growth driven by infrastructure projects and economic activity growth)	Moderate (3): Trend to increase price through reform policy)	Moderate to high (4: Policy push for gas in transport
Oman	Moderate to high (4): Economic activity growth and effort to support logistic developments and trade with GCC partners	Moderate (3): Trend to increase price through reform policy	Moderate to high (4): Existing LNG infrastructure and gas pipelines that can support directing LNG for transport
Iraq	Moderate (3): Growing activity for reconstruction, but affected by weak transport infrastructure	Moderate (3): Gas price affected by need to import	Low (1): Lack of gas infrastructure and incentives to build LNG refueling stations
Jordan	Low to moderate: Lower economic growth, and small market	Low: No price incentives	Low: Very limited

Source: Authors' research.

Table C4. Scoring Demand potential in bunkering.

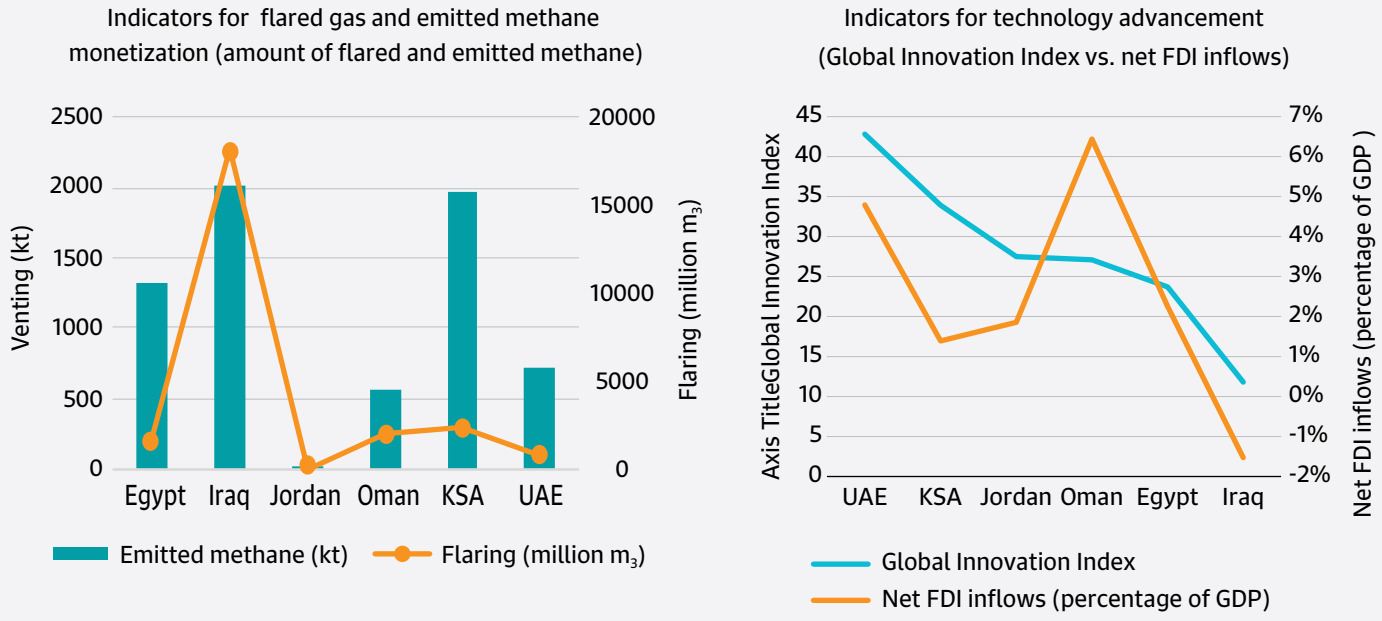
	Demand potential in bunkering	Score
UAE	High: Fujairah as a global bunkering hub; large storage and mature supplier ecosystem; strong position outside the Strait of Hormuz	5
Oman	Moderate to high: Traditional bunkering at Sohar, Duqm, Muscat ports; LNG bunkering project (Marsa LNG) underway (first regional LNG bunkering hub)	4
Saudi Arabia	Moderate to high: Two-coast access (Red Sea and Gulf); refining and trading backing (Yanbu, Jeddah); LNG bunkering is plausible under long-term IMO pressure	4
Egypt	Moderate: LNG bunkering ambition along the Suez Canal; EGAS partnerships (Shell, Kanfer, Leth); transit advantage, but supply constraints mitigate the potential	3
Iraq	Low: Existing bunkering in Basra/Khor Al-Zubair, niche regional demand; limited transit traffic; infrastructure and institutional constraints	1
Jordan	Low: Aqaba serves local/regional bunkering needs; not on major east-west shipping lanes; limited potential scale	1

Figure C1. Indicators for grid reliability and demand for decentralized solutions.



Sources: World Bank (2024); OAPEC (2023) (left chart); IEA (2024c) (right chart).

Figure C2. Indicators for flared gas and emitted methane monetization, and technology advancement.



Sources: Gasim et al. (2026); World Bank Flaring (2025); IEA (2024a) (left chart); – WIPO (2024); World Bank (2024) (right chart).

Appendix D: Scoring the Threats

D.1 Scoring Matrix

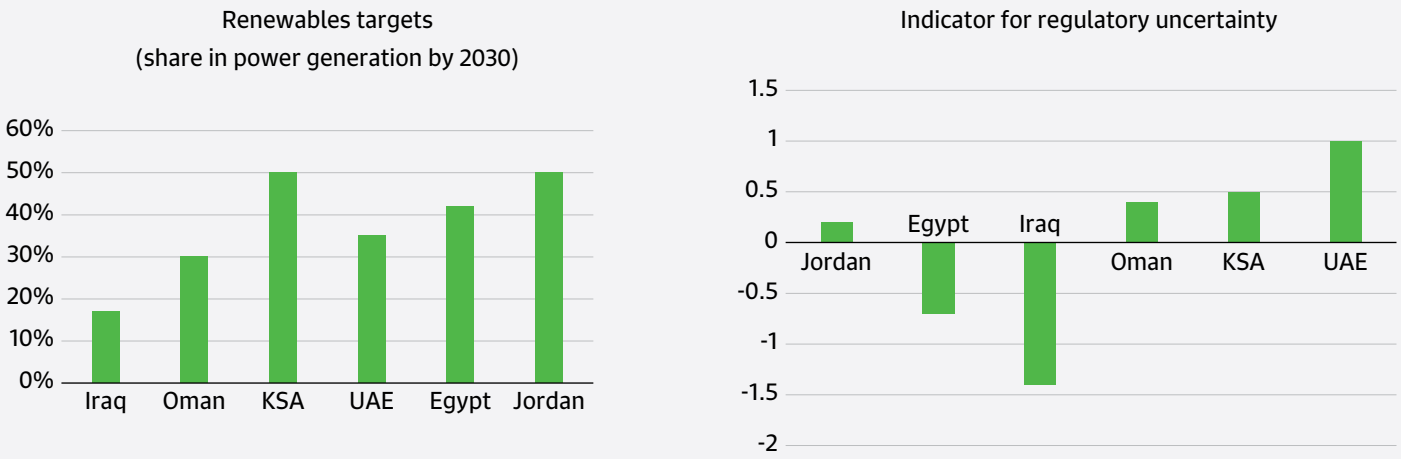
Table D1. Scores applied to the ssLNG threats.

		KSA	UAE	Oman	Egypt	Jordan	Iraq
1. Renewable competition	Renewable cost competitiveness	5	5	4	2	3	1
	Off-grid renewable development	1	2	1	4	2	5
	Renewable target	5	3	3	4	5	1
	Average index	3.7	3.3	2.7	3.3	3.3	2.3
2. Competition from gas supply alternatives	Pipeline coverage	2	4	2	3	1	2
	Pipeline new developments	5	1	2	1	1	2
	CNG	2	3	4	4	4	3
	Average index	3.0	2.7	2.7	2.7	2.0	2.3
3. Future gas price trajectory	Risk of high price causing demand destruction	3	3	2	5	1	5
	Average index	3.0	3.0	2.0	5.0	1.0	5.0
4. Gas supply uncertainty	Gas production growth	2	3	4	5	5	1
	Upstream investment	1	4	4	4	5	5
	Average index	1.5	3.5	4.0	4.5	5.0	3.0
5. Regulatory uncertainty	Regulatory quality	2	1	2	4	2	5
	Average index	2.0	1.0	2.0	4.0	2.0	5.0
6. Geopolitical uncertainty	Geopolitical risk assessment	2	1	1	2	2	5
	Average index	2.0	1.0	1.0	2.0	2.0	5.0
7. Safety risks	Resilience	2	1	2	4	4	5
	Number of severe traffic accidents	4	1	2	2	3	5
	Average index	3.0	1.0	2.0	3.0	3.5	5.0

Sources: IEA (2024); World Bank Flaring (2024a) (left chart); WIPO (2024); World Bank (2024) (right chart).

D.2 Various Indicators Supporting the Scoring

Figure D1. Renewables targets and indicator for regulatory uncertainty.



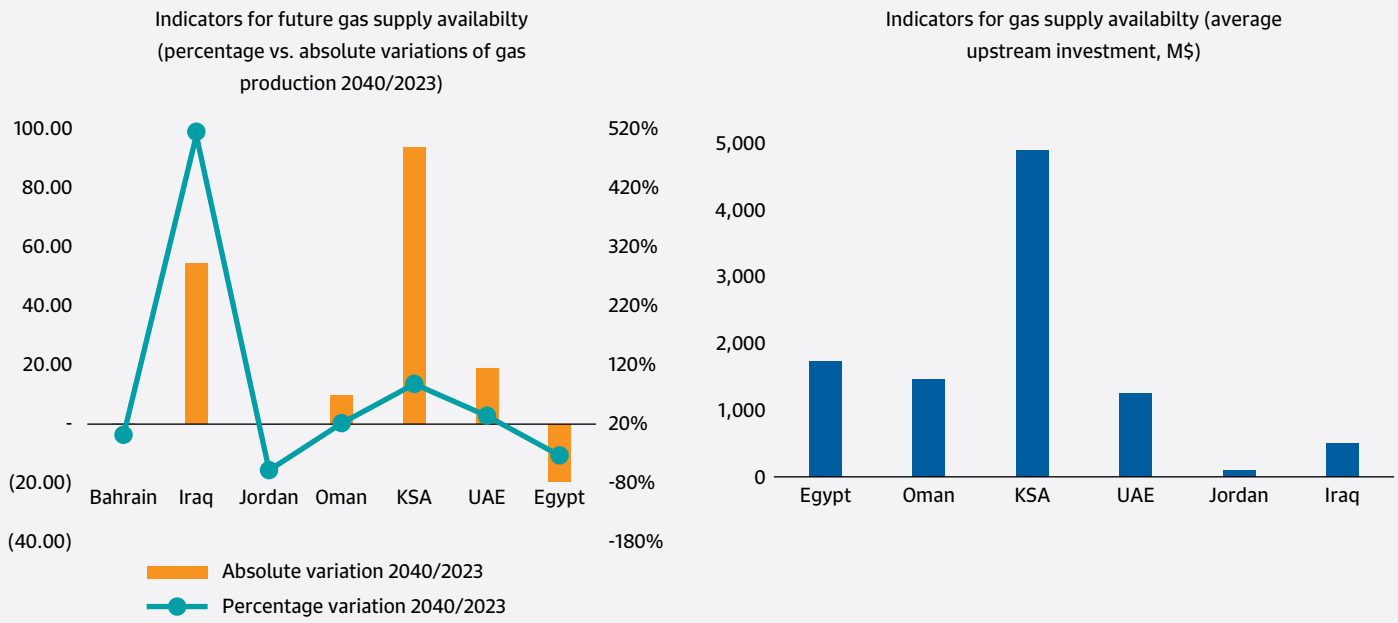
Sources: UNDP (2025); Ministry of Foreign Affairs (Oman) (2025); Egypt NDC (2nd update) (2023); UAE NDC 3.0 (2024); Jordan NDC (2022) (left chart); World Bank (2024) (right chart).

Table D3. Scoring demand potential in bunkering.

CNG	Gas demand growth (bcm)	Size (sqm)	Population (millions)	Density (person/ sqm)	Policy support
Egypt	-2.0	995450	116.5	117.1	Strong (5): National vehicle conversion initiative, large station rollout, and state-backed financing
Iraq	28.8	434128	46.0	106.1	Low: Policy documents mention mini-CNG concepts; no structured national rollout program
Jordan	-1.0	88794	11.6	130.1	Moderate: Government-backed CNG station development; early-stage rollout without a large national conversion mandate
Oman	5.1	770880	5.3	6.9	Low to moderate: Fuel-station regulatory reform noted; no clear documented CNG vehicle conversion program
KSA	61.1	2149690	35.3	16.4	Low to moderate: Technical standards for CNG stations exist; no clear nationwide conversion subsidy/target program identified
UAE	6.4	71020.0	10.9	153.2	Strong: ADNOC-led conversion program, certified conversion centers, expanding NGV station network

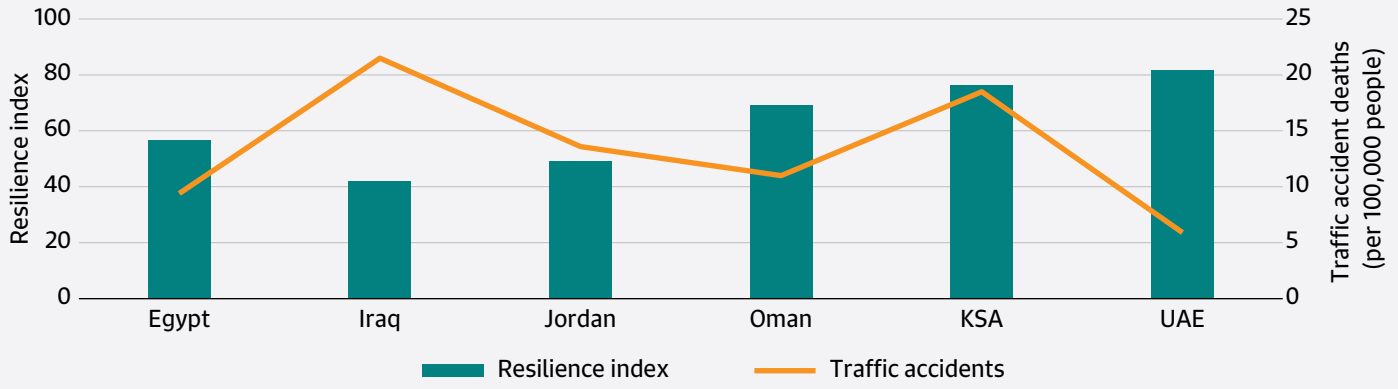
Sources: FGE (2025); World Bank (2024); Authors' research.

Figure D2. Indicators for future gas supply availability (incremental production 2040/2023 and upstream investments).



Sources: NexantECA (2025) (left chart); Rystad Energy (2025) (right chart).

Figure D3. Indicators for safety and hazard risks.



Sources: FM Global (2024); World Health Organization (2023).

Appendix E: Relative Weights Estimates Using the Analytic Hierarchy Process (AHP)

The AHP method is a multi-criteria decision-making method based on pairwise comparisons and consistency checks to derive relative weights (Saaty 2008). The following steps are used to apply the method:

- Construct the pairwise comparison matrix *A* for factors within each SWOT group (Tables 1-4).
- Use Saaty's 1-9 scale, which reflects the intensity of importance of a factor *i* compared to a factor *j* (Table 5). The intensity of importance scores are defined through discussions with researchers and subject matter experts.
- Ensure reciprocity: $\alpha_{ij} = 1/\alpha_{ji}$ in the matrix.
- Estimate weights by solving $Aw = \lambda_{max} w$ (principal eigenvector). The weight of each factor *i* (*wi*) is the component of the principal eigenvector linked to the largest eigenvalue. This provides the most stable and reliable set of weights that best fits all pairwise comparisons. The vector components are normalized, so that $\Sigma w_i = 1$ (Saaty 2008).
- Check consistency using the consistency ratio, which compares the deviation of the maximum eigenvalue from its theoretical value under perfect consistency ($\lambda max = n$), to that of randomly generated matrices. Values below 10% indicate acceptable consistency of the pairwise comparisons (Saaty 1980, 2008).

Table E1. Pairwise comparison matrix for strengths.

	Diversity of applications	Operational flexibility	Geographical flexibility	Lower upfront investment	Shorter project execution time
Diversity of applications	1.00	2.00	2.00	3.00	3.00
Operational flexibility	0.50	1.00	2.00	3.00	3.00
Geographical flexibility	0.50	0.50	1.00	2.00	2.00
Lower upfront investment	0.33	0.33	0.50	1.00	2.00
Shorter project execution time	0.33	0.33	0.50	0.50	1.00

Table E2. Pairwise comparison matrix for weaknesses.

	Limited economies of scale	Boil-off gas	Need for gas pretreatment	Technology dependence
Limited economies of scale	1.00	3.00	4.00	5.00
Boil-off gas	0.33	1.00	3.00	4.00
Need for gas pretreatment	0.25	0.33	1.00	3.00
Technology dependence	0.20	0.25	0.33	1.00

Table E3. Pairwise comparison matrix for opportunities.

	Gas demand growth	Growing demand for decentralized solutions	Bunkering opportunities	Monetizing flared gas and emitted methane	Gas demand for heavy trucks	Environmental policies	Technology advancement
Gas demand growth	1.00	2.00	3.00	3.00	3.00	5.00	7.00
Growing demand for decentralized solutions	0.50	1.00	4.00	4.00	5.00	4.00	5.00
Bunkering opportunities	0.33	0.25	1.00	2.00	3.00	4.00	5.00
Monetizing flared gas and emitted methane	0.33	0.25	0.50	1.00	2.00	6.00	6.00
Gas demand for heavy trucks	0.33	0.20	0.33	0.50	1.00	4.00	7.00
Environmental policies	0.20	0.25	0.25	0.17	0.50	1.00	3.00
Technology advancement	0.11	0.13	0.14	0.17	0.14	0.33	1.00

Table E4. Pairwise comparison matrix for threats.

	Competition from gas supply alternatives	Renewable competition	Geopolitical uncertainty	Regulatory uncertainty	Gas supply uncertainty	Gas price uncertainty	Safety risks
Competition from gas supply alternatives	1.00	3.00	2.00	3.00	3.00	4.00	4.00
Renewable competition	0.33	1.00	2.00	3.00	3.00	4.00	4.00
Geopolitical uncertainty	0.50	0.50	1.00	3.00	4.00	4.00	4.00
Regulatory uncertainty	0.33	0.33	0.33	1.00	3.00	3.00	4.00
Gas supply uncertainty	0.33	0.33	0.25	0.33	1.00	2.00	3.00
Gas price uncertainty	0.25	0.25	0.25	0.33	0.50	1.00	2.00
Safety risks	0.25	0.25	0.25	0.25	0.33	0.50	1.00

Table E5. Saaty pairwise comparison scale.

Intensity of Importance	1	2	3	4	5	6	7	8	9
Definition	Equal importance	Weak or slight	Moderate importance	Moderate plus	Strong importance	Strong plus	Very strong importance	Very, very strong	Extreme importance

Table E6. Estimates of the relative weights (principal eigenvector).

Strengths		Weaknesses		Opportunities		Threats	
Operational flexibility	36%	Limited economies of scale	53%	Gas demand growth	30%	Competition from gas supply alternatives	30%
Diversity of applications	27%	Boil-off gas	27%	Growing demand for decentralized solutions	29%	Renewable competition	22%
Geographical flexibility	17%	Need for gas pretreatment	13%	Bunkering opportunities	14%	Geopolitical uncertainty	19%
Lower upfront investment	11%	Technology dependance	7%	Monetizing flared gas and emitted methane	12%	Regulatory uncertainty	12%
Shorter project execution time	9%			Gas demand for heavy trucks	8%	Gas supply uncertainty	7%
				Environmental policies	4%	Gas price uncertainty	5%
				Technology advancement	2%	Safety risks	4%

Table E7. Consistency ratio and max eigenvalue.

	Strengths	Weaknesses	Opportunities	Threats
Max eigenvalue (λ max)	5.13	4.18	7.51	7.54
Consistency ratio	2.9%	6.7%	6.5%	6.8%

About the Authors



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Sid Ahmed Hamdani is a Principal Fellow in the Oil and Gas program, bringing more than two decades of experience in the oil and gas industry. His expertise spans gas market developments, energy modeling, policy impact assessments, and strategic analyses for oil and gas projects. His current research focuses on the role of natural gas in the energy transition, particularly from the perspective of the MENA region. Before joining KAPSARC, he was an Energy Policy and Environment Expert at the Gas Exporting Countries Forum, where he monitored global energy and environmental policies and assessed their implications for energy and gas markets. Sid holds a Master's in Energy Economics from IFP School in Rueil-Malmaison, France, and a Bachelor's in Industrial Engineering from the National Polytechnic School, Algeria.



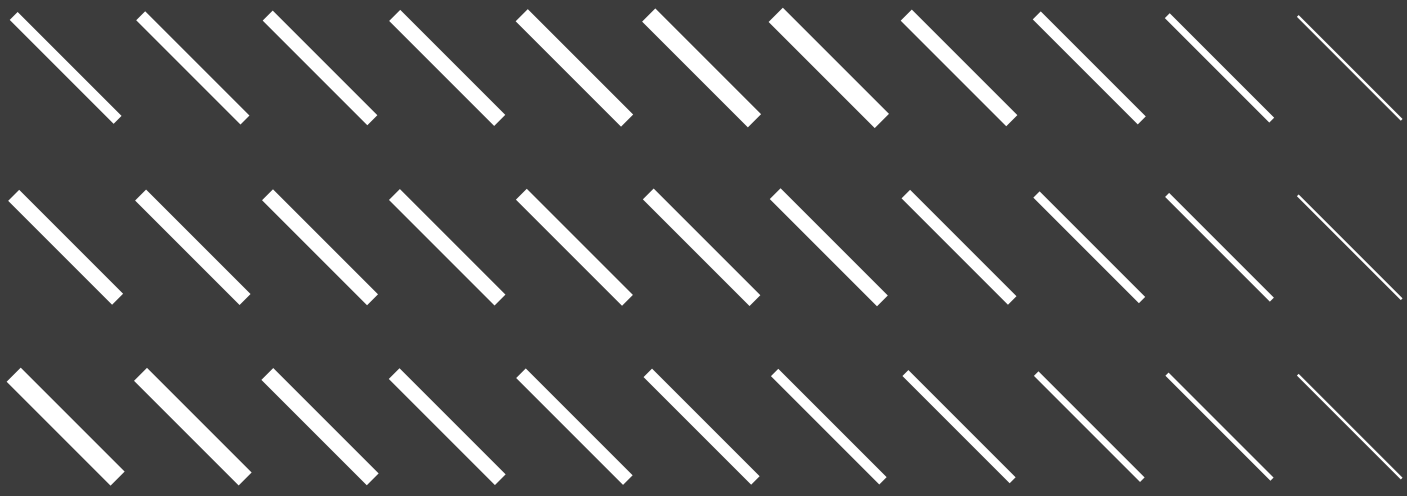
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About the Project

The "Gas and Energy Transitions: A MENA Region Perspective" project aims to investigate the role of natural gas in the context of the global energy transition, which is underpinned by structural change affecting energy supply and demand. The project focuses on assessing this role, especially through the lens of the Middle East and North Africa region and oil- and gas-producing countries. The project outlines the main lessons that can be learned from regional gas developments and countries' approaches to monetizing gas resources by leveraging modeling and forecasting tools. It also assesses the contributions of gas to addressing environmental impacts and the potential developments of low-carbon gases and their synergies with natural gas.





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