

Levers for capturing methane emissions to improve gas availability

Executive Summary

Agenda

Project background and methane / natural gas landscape

Regional barriers to monetizing vented, fugitive, and flared natural gas

Regional abatement pathways

Project background, key objectives and results of the effort

Background

- With natural gas prices at historic levels and energy security returning as a global priority, accelerating effort to capture and commercialize vented, fugitive and flared methane is a no-regret approach that supports climate imperatives and energy security
- Environmental Defense Fund (EDF) engaged S&P Global to assess target regions¹ where efforts to capture methane could quickly increase the supply of natural gas in global markets while reducing methane emissions.² The following regions were selected as part of the study:
 - > North America
 - > North Africa
 - > Central Asia-China
 - > Nigeria
 - > Aussie-ASEAN
 - > Eastern Mediterranean

Objectives

- S&P Global identified key barriers to capturing and commercializing methane across the six target regions. Next, S&P Global developed abatement pathways to address these barriers and unlock methane emission reduction opportunities. This work consisted of:
 - > **Developing rough estimates of country-level methane emissions** from venting, fugitives and flaring, and associated **abatement costs**. This analysis utilized IEA's methane tracker, SkyTruth flaring data, and S&P Global's infrastructure and field-level data
 - > **Identifying key barriers** to capture and monetize methane based on export capacities, capital availability of major players, commercial and financing environment and security risks
 - > **Developing abatement pathways** to address key barriers and facilitate gas capture and commercialization projects

¹ Regions were based on two criteria: size of the opportunity and connectedness/likelihood to impact global markets. Because of the latter criteria, several countries with high methane emissions were excluded due to sanctions (e.g., Russia, Iran, Venezuela) or lack of gas infrastructure/connectiveness (e.g., Iraq) to influence global markets

² Study assessed potential to increase global supply of natural gas through the capture of vented, fugitive and flared methane. When assessing flaring, analysis included both the successfully combusted portion and the uncombusted methane, given the potential to add to global supply of natural gas

Summary of findings

Elevated natural gas prices are making most gas capture and commercialization projects economic

Regional abatement pathways described in this report can unlock 40 bcm (of the more than 80 bcm identified as economic¹) of new natural gas supply in the next 2-3 years

Abatement pathways are designed to drive project implementation by clarifying roles, increasing capital availability and improving market design

- There are well established technologies to capture and commercialize vented, fugitive and flared gas. These technologies are widely economic under the current gas price environment
- Forecasted revenues for a gas capture project deployed (in 2023) for 10 years are estimated to be ~140-240% higher than under pre-war natural gas price forecasts
 - > Delaying the project from 2023 to 2026 reduces forecasted revenue by ~50% as prices begin to stabilize. Still, revenues remain significantly higher than under pre-war price forecasts
- Using S&P planning case gas price forecast, more than 70%² of 112 bcm of potential natural gas supply due to lost methane and flared natural gas, representing a volume of ~80 bcm, could be captured with a positive NPV
- S&P Global developed abatement pathways for each of the six target regions to drive near-term efforts to simultaneously reduce GHG emissions by approximately 750 Mt CO₂e³ and deliver ~40 bcm of incremental natural gas to global markets
- Dedicated (third-party) project developers can provide a holistic methane management solution when gas is not a core-product of the operator
- Fast and low-cost financing will ensure capital constraints are not preventing otherwise viable projects
- Access to international prices will align incentives for commercialization projects with international needs

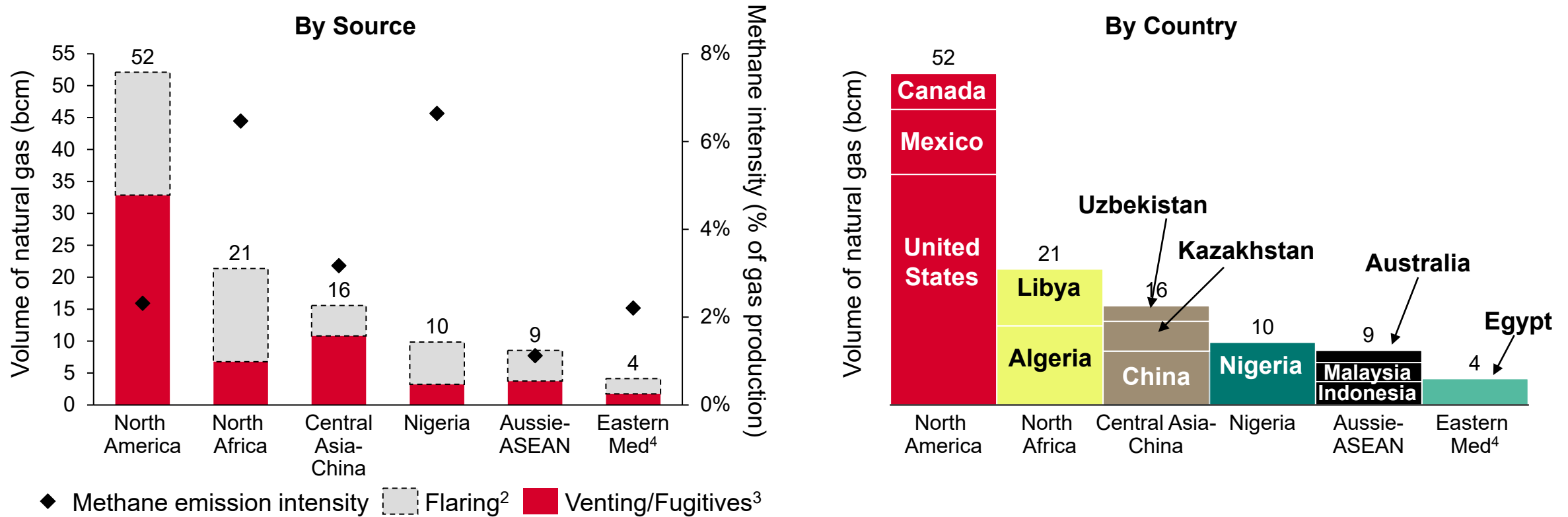
¹ Throughout this report, "economic projects" refers to projects that are NPV positive. Project economics are estimated at a high level by adjusting IEA's 2022 abatement cost curve with S&P Global's gas price forecast assuming the project is launched by 2026

² For target regions, IEA's abatement cost curves find ~45% of the opportunities they assessed were economic (based on 2017-2021 natural gas prices). This corresponds to ~one-third of IEA's total O&G methane emissions estimated for these countries (they did not estimate abatement costs for all O&G emissions). Updating costs based on current natural gas forecast results in substantially more economic opportunities

³ This exceeds Germany's annual emissions. Calculation assumes gas captured is replacing other natural gas use. For flare capture projects, 2% of methane is assumed to remain uncombusted. Calculation uses an 86x multiplier to approximate methane's 20-year global warming potential. Using a 25x multiplier to approximate methane's 100-year global warming potential results in over 250 Mt CO₂e

Economic gas capture projects in the target regions could cover almost 60% of the EU/UK¹ natural gas imports from Russia (2021)

Potential natural gas supply from capturing flaring, venting, and fugitives for target regions (2021)



More than 70% of the vented, fugitive and flared gas, representing a volume of ~80 bcm, could be economically captured and commercialized.⁵

¹ In 2021, the EU27 plus UK imported 141 bcm of natural gas from Russia

² Flaring refers to volumes of natural gas sent to the flare tip based on SkyTruth data

³ Total volume of gas lost via venting/fugitives is estimated based on IEA methane emission estimates and assuming average gas composition of 80% methane (figures subject to a high degree of uncertainty as country estimates are extrapolated from US-based data)

⁴ Include Egypt, Cyprus and Israel, but Egypt represents ~98% of estimated methane emissions for the region

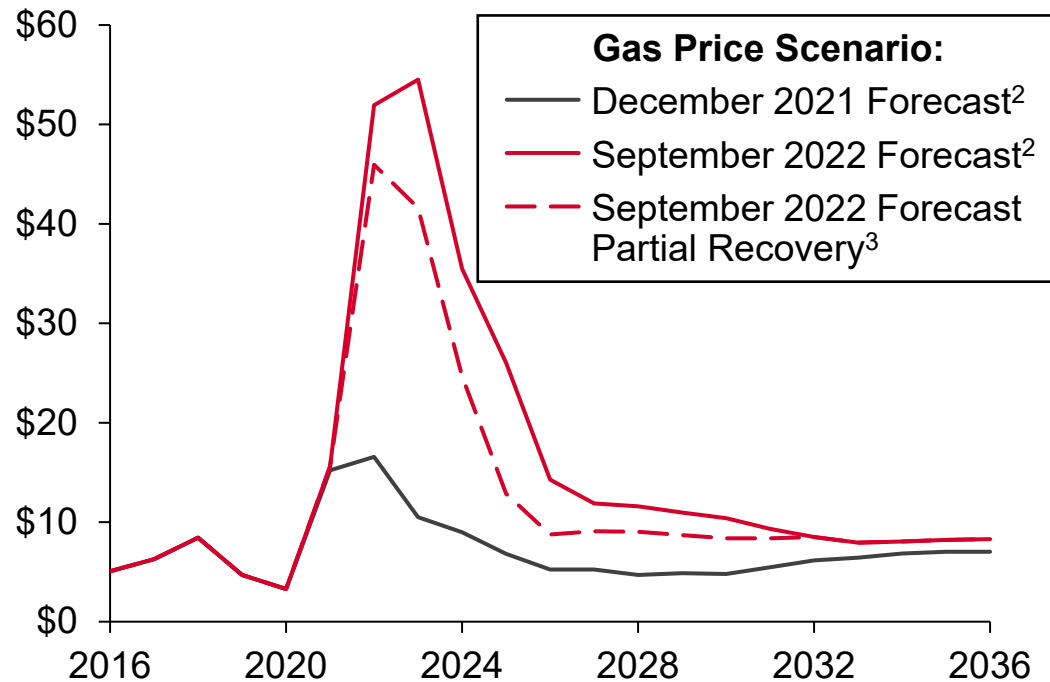
⁵ Based on S&P Global gas price forecast and IEA methane abatement cost estimates (and assuming projects are launched by 2026)

Source: EPA; IEA; SkyTruth; SPGlobal

Current gas price environment has dramatically improved gas capture project economics compared with pre-war price expectations

Forecasted natural gas at TTF: 2016-2036¹

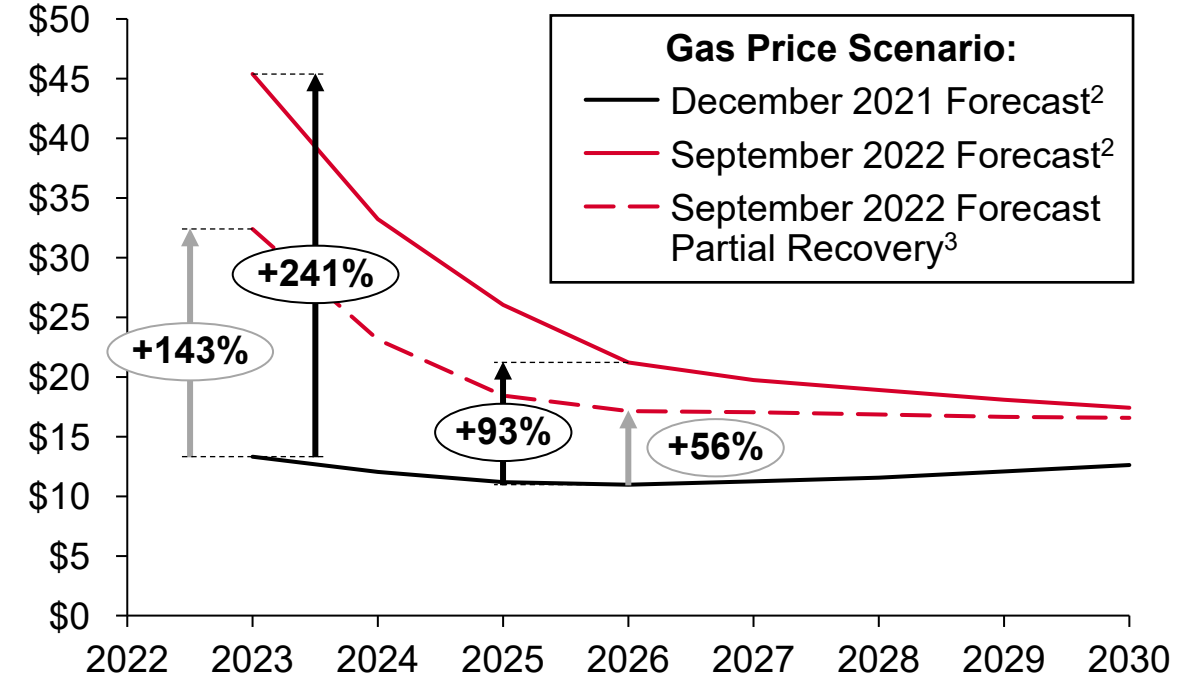
Real 2021 US\$/MMbtu



Gas prices across the globe are at historic levels and are expected to stay elevated above pre-war estimates through 2030

Revenue PV for example project by launch year and price scenario⁴

Real 2021 US\$M



Delaying a project from 2023 to 2026⁵ would reduce revenue by ~50%, but is still much more valuable than a project under pre-war price expectations

¹ TTF (Title Transfer Facility) is a trading hub for gas in the Netherlands. Note that market prices across Europe and Asia LNG spot prices follow a similar trend and price levels

² Based on S&P Global planning case scenario. September 2022 forecast assumes minimal flow of Russia natural gas to Europe going forward

³ Scenario assumes a partial recovery of Russia natural gas supply to Europe, however flows do not return to pre-war levels

⁴ Sample project based on the revenue of annually capturing 0.01 bcm of flared gas. Assumes 10 years of revenues based on relevant TTF price forecast. Discounted at 10%

⁵ With the exception of infrastructure projects to build out new gas trunklines, most gas capture projects could be implemented within one year

Source: SPGlobal

Agenda

Project background and methane / natural gas landscape

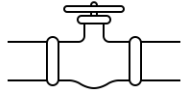
Regional barriers to monetizing vented, fugitive, and flared natural gas

Regional abatement pathways

We have classified barriers for methane and flare reduction projects into four categories

Framework for barriers to emission reduction

Commercialization



Export capacity: Barriers for captured gas to reach global markets due to limited export capacity. This also assesses new export capacity under construction as well as new production that may utilize export capacity



Financial and commercial: Barriers to commercializing methane due to lease contract types used, terms around and ownership of associated gas and price controls/market access

Operation

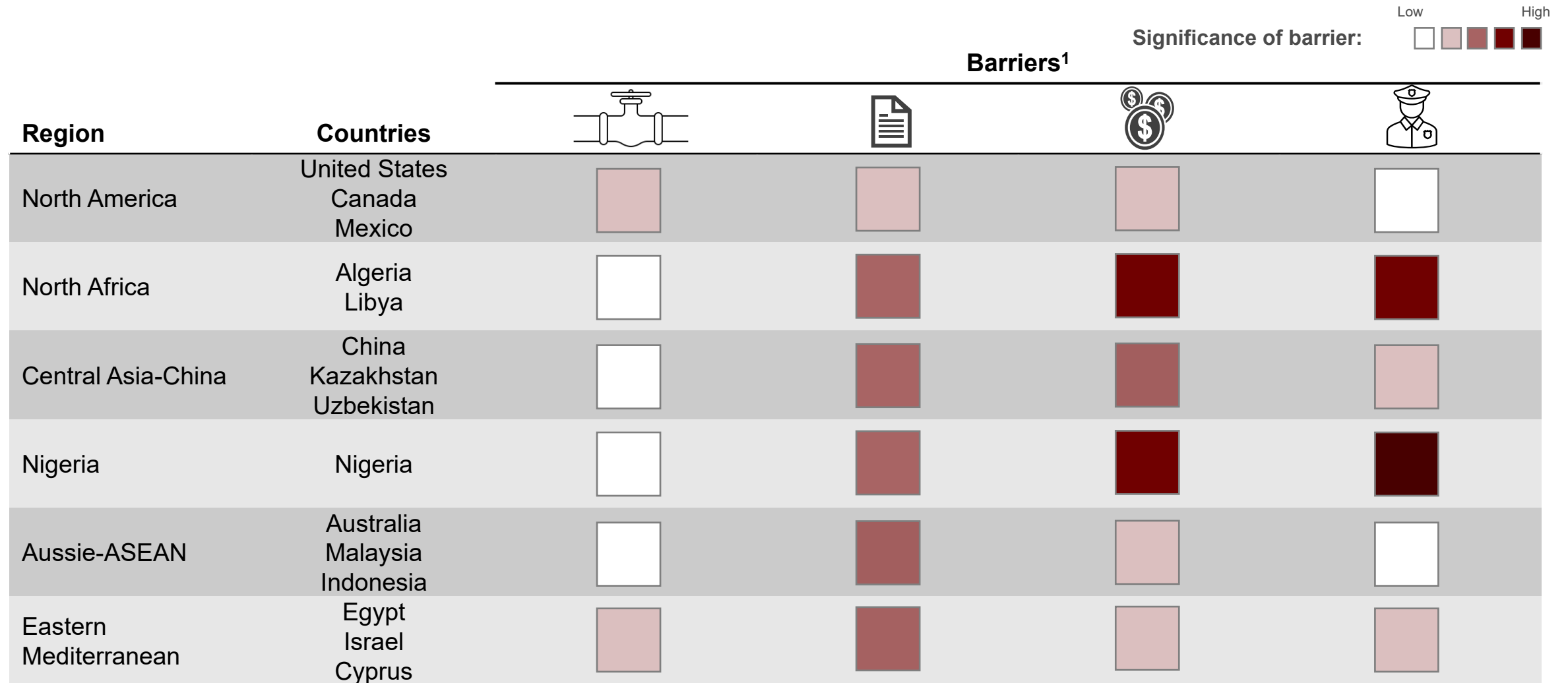


Capital availability: Inability for O&G operators in the country and the to raise capital as needed. For example, due to low credit ratings or a small balance sheet



Security : Barriers to operate in the country due to security and geopolitical risks

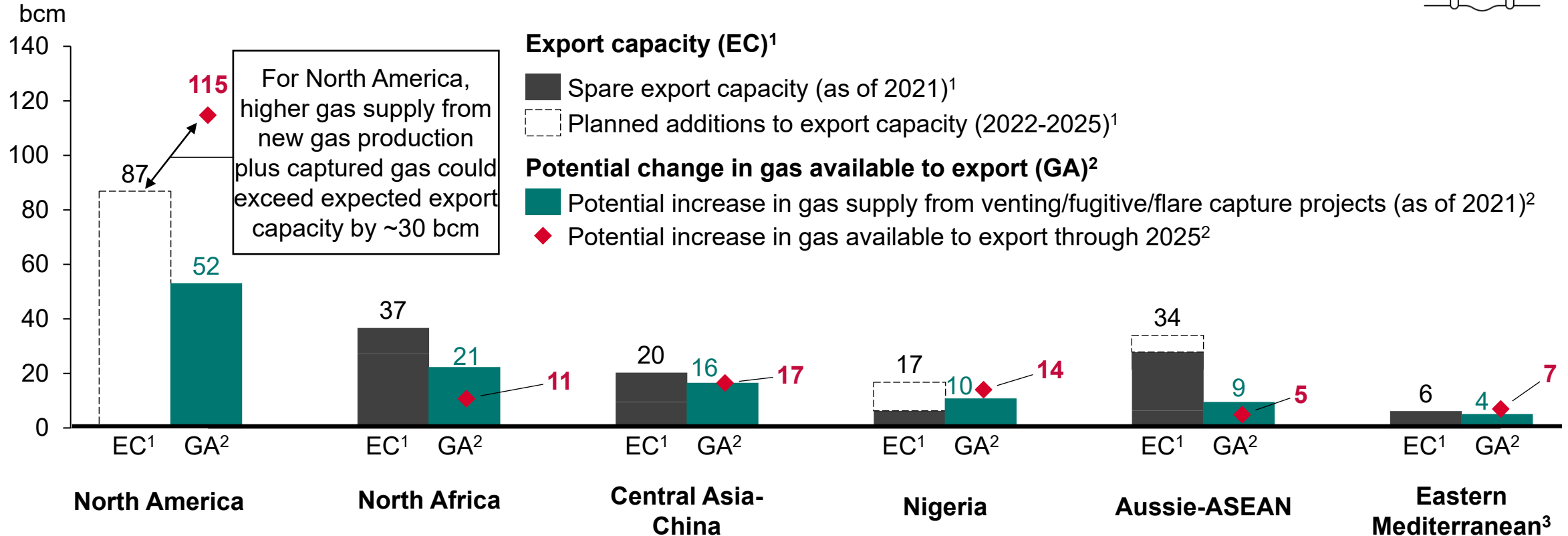
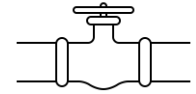
North Africa and Nigeria face the most significant barriers, but spare export capacity provides a lucrative opportunity to monetize captured gas



¹ Barriers are weighted by potential natural gas supply from venting/fugitive/flare capture projects across countries in each region (see slide 5). Note that this weighting can skew a region's barrier score to countries with higher venting/fugitive/flaring emissions. For example, because Mexico accounts for less than 20% of the North America gas supply potential, it has a small impact on the regional weighting. The individual country barrier scores are provided on slide 11

Source: EPA; IEA; SkyTruth; SPGlobal

Each region has (or soon will have) capacity to export more natural gas, but gas capture projects may need to compete with new gas production



North America and Eastern Mediterranean³ could exceed export capacity between forecasted net increases to supply and increases from methane/flaring commercialization efforts

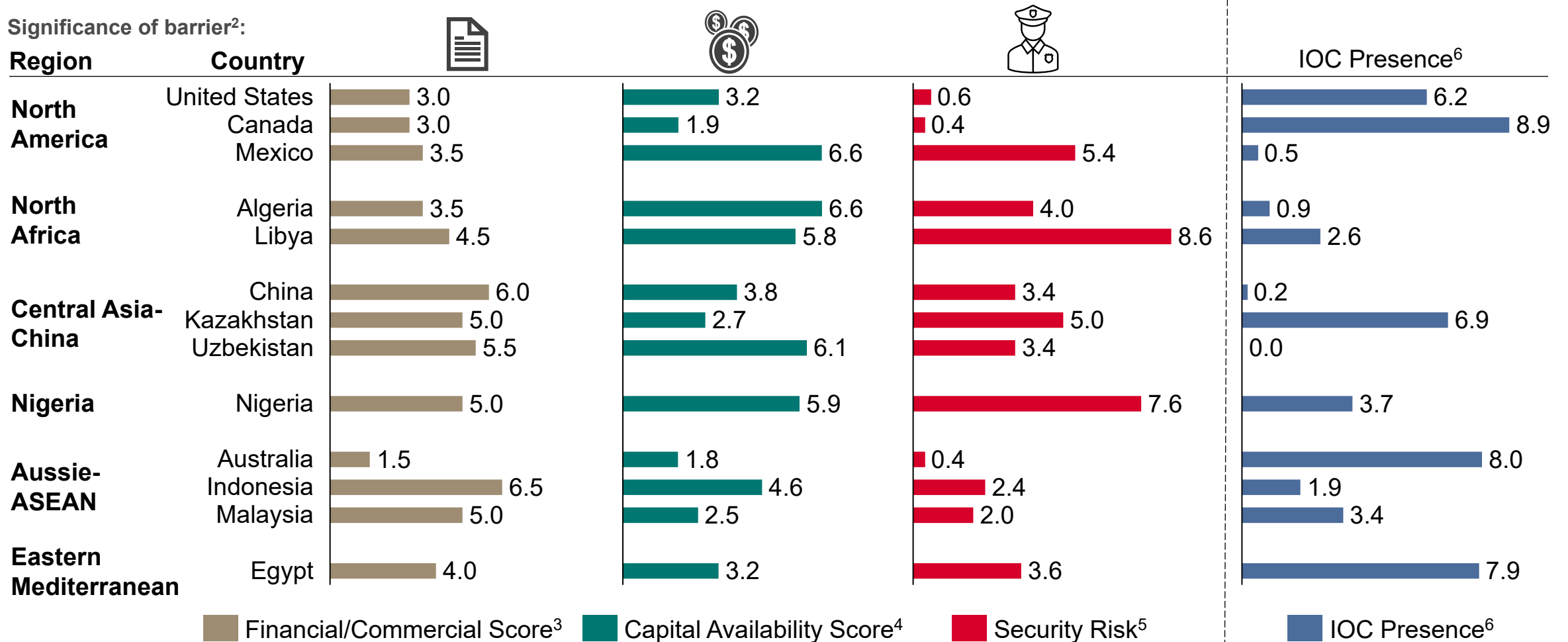
¹ EC = Export capacity. Planned additions includes LNG Liquefaction facilities that began operating in 2022 or are under construction with planned launch by 2025. Spare export capacity is based on excess pipeline and LNG export capacity for each country/region in 2021

² GA = Potential change in gas available to export. Potential increase in gas supply from venting/fugitive/flare capture shows figures presented on Slide 5 (additional emissions associated with new production after 2021 could increase this potential). Potential increase in gas available to export is calculated as potential increase in gas supply from venting/fugitive/flare capture + net increases in gas production – increase in domestic gas consumption in exporting countries/regions in S&P's planning case through 2025

³ Cyprus production is not included through 2025, but its Minister of Energy has indicated goal to export natural gas by 2026

Source: EPA; IEA; SkyTruth; SPGlobal

Barriers around commercial and financial environment, capital availability, and security are often correlated with a lack of IOC presence¹



¹ In particular, this is the case in Mexico, Algeria, Libya, Uzbekistan, Nigeria, and to a lesser extent Indonesia. China and Malaysia perform better comparatively despite significant NOC presence

² Metrics are scored on a scale of 0-10, with higher scores representing a more significant barrier

³ Focuses on commercial/financial barriers such as lease contract type, terms for associated gas, and impacts of domestic price controls/market access

⁴ Measures the ability of the owners of O&G reserves in high emission areas to access capital based on credit ratings (or a company risk score if credit rating is unavailable)

⁵ Security risk is a measure of political/geopolitical instability as well as risk of violence

⁶ Calculated as % of oil and gas reserves owned by IOCs adjust to a 10-point scale

Source: S&P Global

Major barriers to emission reduction in each region

Region	Key barriers to capture and monetize vented, fugitive, and flared methane
North America	<ul style="list-style-type: none">  No mechanism is in place to incentivize the export of captured gas for use in pipelines / LNG  Both Pemex for Mexico and smaller operators in US and Canada face greater challenge to access capital
North Africa	<ul style="list-style-type: none">  The NOCs dominant in each country face challenges with capital availability to implement projects  Instability, particularly in Libya, makes long term projects such as new gas infrastructure difficult to finance and complete
Central Asia-China	<ul style="list-style-type: none">  Strict domestic price controls disincentivize methane emission reduction projects that would be economic at market prices  Lack of capital availability, in part due to limited international presence, limits the ability to implement projects
Nigeria	<ul style="list-style-type: none">  Gas infrastructure is insufficient and unreliable due to security threats and lack of investment  IOCs divesting from onshore and shallow water. Indigenous operators are increasing capabilities, but lack capital  Continued uncertainty around regulatory independence and transparency, despite passing of Petroleum Industry Act
Aussie-ASEAN	<ul style="list-style-type: none">  Higher presence of smaller operators limits overall capital availability  Limited regulations around methane in Malaysia and Indonesia, particularly for legacy projects (carbon pricing is anticipated)
Eastern Med	<ul style="list-style-type: none">  Infrastructure in Western Desert and Suez was primarily built out for oil production, leading to flaring of associated gas  Methane abatement projects will compete for capital and LNG capacity with new gas developments  Lack of direct link between domestic and international prices can limit incentive for abatement projects

Agenda

Project background and methane / natural gas landscape

Regional barriers to monetizing vented, fugitive, and flared natural gas

Regional abatement pathways

Despite diverse barriers, clear project implementation roles and improved capital availability and market design will enable projects across regions

Emission sources

Technical solutions

Gas type

Enablers for implementation



- Strip NGLs
- Power in-situ / to grid
- Small-scale CNG/LNG
- Expand gathering pipelines
- Re-inject*

Mostly by-product (associated gas)

Project implementation

Third-party project developers are well suited to deliver projects when methane is a by-product³
The developer provides a holistic solution as a service, taking the issue off the hands of the operator by managing design, EPC, financing, O&M and even offtake agreements



- Eliminate process upsets
- Capture blowdowns

Typically, main product

Capital Availability

Ability to allocate of own capital; ensure access to sufficient financing to ensure continued project execution without recourse to bank loans for each project

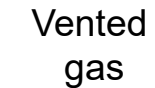


- Use zero-bleed, low-emission devices when appropriate
- Capture and compress (routine and non-routine vents)

Main product and by-product

Market Design

Develop frameworks and initiatives to encourage quantifying methane losses and ensure access to international benchmark prices; address regulatory / contractual issues limiting access to associated gas or limiting cost- recoverable expenditures



- High-frequency LDAR programs
- Repair malfunctioning devices
- Replace devices tending to malfunction
- Improve flare efficiency*

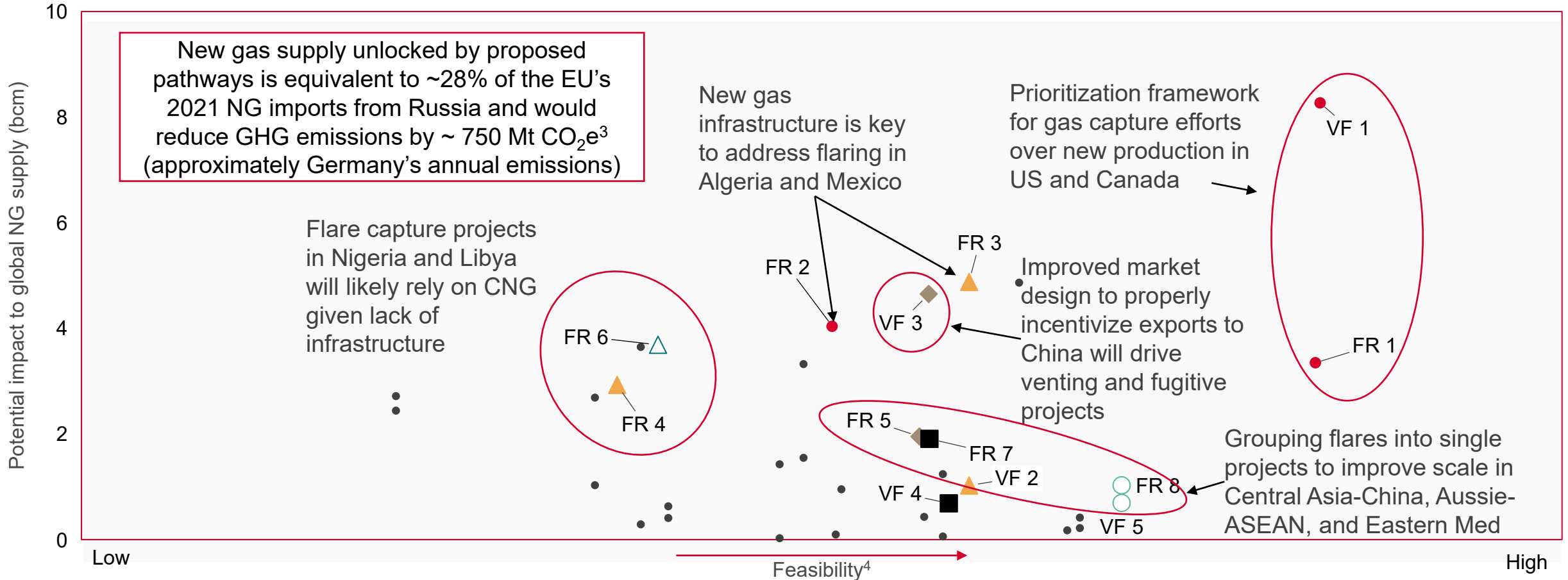
1. Continuous flaring is characterized by a routine, continuous gas stream routed to a flare system because there is no current monetization route for the gas
2. Intermittent flaring is non-continuous flaring that may be planned (e.g.: due to scheduled maintenance, shutdowns, well liquids unloading) or unexpected (e.g., due to equipment failure)
3. In these situations, the RoR (Rate of Return) of abatement projects would typically not compete with the RoR the owner/operator would receive by focuses on their core product
* Indicates solutions will reduce methane emissions, but not support incremental supply of natural gas to global markets
Source: S&P Global

Implementing the prioritized pathways could release ~40 bcm of natural gas to the global market in the next 2-3 years through NPV positive projects¹

Proposed pathways

● North America ▲ North Africa ◆ Central Asia-China ■ Aussie-ASEAN ○ Eastern Med △ Nigeria • Other projects²

FR: Flaring
VF: Venting and fugitives



¹ Project economics are based on IEA abatement cost estimates that have been adjusted for current natural gas forecasts and infrastructure build out needs of sub-regions of each country. Projects are not individually modelled. Proposed pathways focus on the best opportunities with the greatest potential for impact in the next 2-3 years

² Projects that, while economic, are not addressed in action pathways to lower impact, feasibility, or infrastructure requirements likely to delay global supply impact

³ Calculation assumes projects replace natural gas use. For flare capture projects, 2% of methane is assumed to remain uncombusted. An 86x multiplier to calculate a CO₂e for methane to approximate global warming potential over 20 years

⁴ Feasibility scores are estimated as a weighted average of the barrier scores for each region (commercial / financial), capital availability, and security combining for 50% and new gas infrastructure requirements accounting for the remaining 50% (e.g., regions with less gas trunklines and processing capacity will require additional investments than those with robust existing infrastructure)

Source: SPGlobal; ClimateWatch

Select abatement pathways by region

Project Implementation

North America

- **[FR 1]** Third-party project developers (PD) to manage flare capture for smaller operators in Permian/Gulf Coast (US) and Alberta (Canada)
 - Align new gas infrastructure with new oil production to avoid initial flaring activity
- **[VF 1]** Existing operators/service providers to expand methane detection at key infrastructure
- **[FR 2]** PDs to build gathering lines near flaring points in Sureste Basin (Mexico)

North Africa

- **[VF 2]** Develop methane inventory,² launch methane detection and repair initiative for major infrastructure in N Algeria
- **[FR 3]** and **[FR 4]** PDs to dynamically manage shared CNG fleet across Algeria (Hassi Messaoud and Illizi basins) and Libya (Sirte basin) to capture flared gas in advance of new gas infrastructure
 - **[FR 3]** Expand gas infrastructure around Hassi Messaoud in Algeria

Capital Availability¹

- ✓ **[FR1, VF1]** Provide govt loan guarantees to support abatement projects (US, Canada)
- ✓ **[FR 2]** Support project submission for international development financing for flare reduction projects (Mexico)
- ✓ **[All]** Provide local tax exemptions for gas buyers (from abatement projects)

- ✓ **[FR 3, FR 4]** Provide capability assessment of PD and connect PD with strategic partners to facilitate equity investment and line of credits
- ✓ **[FR 3, FR 4]** Pursue shared investments for CNG fleet between Libya and Algeria (with potential investment from EU offtakers)
- ✓ **[All]** Pursue long-term offtake agreements with European stakeholders to support financing of new gas infrastructure

Market Design¹

- ✓ **[All]** Develop frameworks/initiatives to encourage midstream and export operators to prioritize captured gas from abatement projects (e.g., certification for low-carbon gas that certain offtakers would pay a premium for)³
- ✓ **[FR 2]** Support initiatives to demonstrate economic benefits to operator of gas capture projects (Mexico)

- ✓ **[FR 3]** Where PSCs are utilized in Algeria, incentivize governments to allow detection and abatement initiatives as cost-recoverable expenditures
- ✓ **[All]** Encourage third-party collaboration for projects difficult to capitalize
- ✓ **[FR 3, FR 4]** Prioritize permitting for gas infrastructure expansion in high flaring fields

¹ Capital availability and market design enablers are not specific to single actions

² Using empirical/statistically reliable methodologies and developing better data will enable operators to better target mitigation efforts over time

³ Outside of the US, at liquefaction facilities more directly tied to specific fields, it may also be possible to reserve a portion of LNG capacity for gas capture projects

Source: SPGlobal

Select abatement pathways by region

Project Implementation

Central Asia-China

- **[FR 5]** PDs to expand infrastructure/utilize CNG in areas with clustered flaring (Tarim basin–China, Precaspian basin–Kazakhstan, Amu-Darya basin–Uzbekistan)
- **[VF 3]** Existing operators/service providers to develop methane inventories,² and launch methane detection and repair initiatives on infrastructure with potential to increase NG supply in the domestic and Chinese markets

Nigeria

- **[FR 6]** PDs to expand gas infrastructure where possible or utilize CNG at onshore associated gas fields w/ high flaring (e.g., Utorogu, Obiafu-Obrikom, Nembe Creek)
- **[FR 6]** Existing operators / IOCs to expand gas infrastructure around offshore fields operated by IOCs with high flaring (e.g., Oso, Okan, Erha)

Capital Availability¹

- ✓ **[FR 5]** Provide capability assessment of PD and connect PD with strategic partners to facilitate equity investment and line of credits
- ✓ **[FR 5]** Pursue fee-for-service contracts with service companies and/or technology/EPC companies to implement methane abatement projects and limit upfront capital
- ✓ **[All]** Pursue long term contracts for offtake of gas from gas capture projects by domestic or Chinese stakeholders

- ✓ **[FR 6]** Provide capability assessment of PD to support equity investment or line of credit with strategic partners (onshore)
- ✓ **[FR 6]** Access funding from multilateral banks for selected onshore gas flaring capture projects
- ✓ **[FR 6]** Leverage IOC presence to finance and implement offshore flare reduction projects

Market Design¹

- ✓ **[All]** Promote regional abatement initiatives to secure additional domestic supply at competitive prices for the project implementer
- ✓ **[All]** Support methodology to measure impact of abatement projects and ensure resulting increase NG supply to China (for projects contracted w/ Chinese offtakers)

- ✓ **[FR 6]** Create regulatory or contractual pathway for PD to work for government when it owns the associated gas
- ✓ **[FR 6]** Demonstrate regulatory independence and transparency through implementation and enforcement of Petroleum Industry Act

¹ Capital availability and market design enablers are not specific to single actions

² Using empirical/statistically reliable methodologies and developing better data will enable operators to better target mitigation efforts over time

Source: SPGlobal

Select abatement pathways by region

Project Implementation

Aussie-ASEAN

- **[FR 7]** PDs and existing operators to expand gas infrastructure around clustered flares in Indonesia / Malaysia (Malay, Baram Delta, South Sumatra, West Java basins) and LNG plants in Australia (North Carnarvon)
- **[VR 4]** Existing operators to develop methane inventories² and launch methane reduction efforts to reduce imports in peninsular Malaysia and Sumatra/Java, Indonesia to reduce imports, as well as East Australia

Eastern Mediterranean

- **[FR 8]** PDs to implement CNG/expand gas infrastructure to capture associated gas in Western desert and Suez region
- **[VF 5]** Existing operators/service providers to develop methane inventories² and launch methane detection and repair projects at major infrastructure in Egypt

Capital Availability¹

- ✓ **[All]** Coordinate across producers, LNG operators, and buyers to raise capital for expanded infrastructure that increase supply of LNG
- ✓ **[All]** Fund loan guarantees for abatement projects using collected flaring fees or multi-lateral bank investments

- ✓ **[VF 5]** Build off efforts around methane detection with EBRD to prioritize capital investments
- ✓ **[All]** Pursue transition and sustainability-linked bonds/loans
- ✓ **[All]** Leverage investment efforts to expand gas infrastructure with Cyprus, Israel, Jordan to abate and commercialize methane emissions in Egypt

Market Design¹

- ✓ **[All]** Increase pipeline gas exports and reduce future LNG imports in Indonesia / Malaysia (tied to reduced demand for imports due to captured gas)
- ✓ **[All]** Incentivize govt to reduce cost-recovery approvals needed for abatement projects in Indonesia / Malaysia due to PSC contracts

- ✓ **[All]** Coordinate consistent methane / flaring regulations across the region, with input from EU offtakers
- ✓ **[All]** Promote mechanisms to compensate producers for abatement projects based on international price benchmarks
- ✓ **[All]** Develop mechanisms and/or facilitate partnerships with LNG and midstream operators to reserve export capacity for captured gas from abatement projects

¹ Capital availability and market design enablers are not specific to single actions

² Using empirical/statistically reliable methodologies and developing better data will enable operators to better target mitigation efforts over time

Source: SPGlobal

S&P Global

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