Igniting Action to Reduce Gas Flaring:
Real Opportunities. Real Projects. Real Results.

Columbia Center on Sustainable Investment
A JOINT CENTER OF COLUMBIA LAW SCHOOL AND COLUMBIA CLIMATE SCHOOL

capterio

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While the authors have direct experience in many of the projects discussed in this report, the discussion in this report is limited to publicly available information, analyses drawn from public information, the authors' own proprietary datasets and interviews with project participants and experts. The authors confirm that the confidential project information to which they have access, but which they cannot present here, does not materially contradict the information in this report or render it misleading in any material respect.

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ABOUT THE COLUMBIA CENTER ON SUSTAINABLE INVESTMENT

The Columbia Center on Sustainable Investment, a joint Center of Columbia Law School and Columbia Climate School, is an applied research center that works to develop critical understanding, practical approaches, and governance tools for governments, investors, communities, and other stakeholders to maximize the benefits and minimize the potential harms of international investment for sustainable development.

ABOUT CAPTERIO

Capterio is a British company founded in 2018 with a mission to drive real-world reductions in gas flaring. Its award-winning analytics platform, FlareIntel, uses proprietary algorithms to track every flare, for every asset, across every company and country, by satellite multiple times per day. Capterio partners with oil and gas producers, governments, regulators, service companies, and the financial sector to improve flaring transparency, enhance operational performance, and identify and prioritize projects that capture and monetize flared gas.

SUGGESTED CITATION

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PRINCIPAL SOURCE OF FLARING DATA

The satellite flaring volume and flaring intensity data in this report are derived from annual data published by the World Bank[1] and daily data derived from Capterio's FlareIntel analytics platform.[2] For simplicity and to avoid duplicate citations, we have not included further references to these datasets in footnotes below.

1 "Global Gas Flaring Data," World Bank Group, June 2024, https://www.worldbank.org/en/programs/gasflaringreduction/global-flaring-data.
2 "Track every gas flare," Capterio, 2025, https://flareintel.com/.

Table of Contents

Executive Summary

Gas flaring is a major global challenge. Despite bold commitments from governments, national oil companies (NOCs), international oil companies (IOCs), and leading independents, global flaring levels have stagnated at around 140–150 BCM per year, emitting up to 1 billion metric tons of CO^2-equivalent greenhouse gases annually, while representing as much as $30 billion per year in potential lost revenue.

Numerous studies have outlined how flared gas can be captured and monetized—through power generation, fertilizers, petrochemicals, liquefied natural gas (LNG) and pipeline exports, among other use cases. Studies have also identified flaring barriers, and challenged the notion that flare-reduction projects are economically unattractive. Yet progress remains insufficient.

We believe substantial reductions in flaring are not only technically achievable but can often create significant commercial value with attractive returns. By reducing flaring, companies and governments can increase revenue, generate valuable assets, enhance energy security, reduce greenhouse gas emissions, and accelerate the energy transition. Compared with other levers, reducing gas flaring is a material decarbonization "quick win."

The proof is that many countries have successfully limited flaring. These are mainly countries with large, diversified economies, liberalized market-based gas sectors, and/or substantial wealth. But the experience in these countries shows how the right levers can be used to overcome challenges elsewhere.

We are convinced that countries with high flaring volumes and intensity can make substantial progress in reducing flaring, to their great benefit. The most challenging obstacles are often commercial, organizational, and political in nature. Successfully delivering flare-capture projects requires an integrated, thoughtful and collaborative approach, underpinned by leadership, appropriate incentives, and an unrelenting focus on delivery over rhetoric.

In this report, we illustrate the potential to reduce flaring with six case studies, going beyond analyzing the "what" and "why" of flaring, and focusing on the "how" to unlock and accelerate delivery. Three project-based case studies present projects that have successfully captured and utilized associated gas in countries and regions that are not among the global leaders in flare reduction (Angola, the Kurdistan Region of Iraq, and Argentina). Three country-based case studies (Federal Iraq, Egypt, and Algeria) highlight not only where modest progress in flare reduction has been observed, but also where opportunities to do more can and should be developed.

Our findings are extensive, and we highlight three main generic learnings. First, governments must foster an investable environment that facilitates energy security through decisive action and planning, leveraging existing policies and infrastructure and supported by incentives/penalties that are applied and enforced. Second, collaboration among governments, NOCs and IOCs is vital, requiring a "country-first" perspective to drive synergies between assets and projects, with a data-driven approach and creativity in fiscal structuring to ensure that the appropriate incentives are in place to make tackling flaring a true priority for operators, without depriving the government of much-needed revenue. Third, government and company leadership must engage, empower, and mobilize resources effectively. Ambitions need not only grand initiatives, but also grit.

A critical component of the drive toward reducing flaring is a holistic analysis of the greenhouse gas (GHG) reductions that can be gained by capturing and utilizing flared gas. Our first set of recommendations takes a novel approach by going beyond the calculation of direct emissions from flaring, developing a framework to analyze the true "net" climate benefit from flare reduction projects. A fulsome analysis must include the GHG benefits from reducing "methane slip" (release of methane from incomplete flaring combustion) as well as substituting captured gas for dirtier legacy fuels, offset by emissions from the combustion of processed gas and NGLs, and especially by the potential impact of increased oil production that can be associated with flare reduction (although it is not easy to determine the cause-and-effect, as oil production often would proceed with or without the flare reduction). We believe our framework can make a valuable contribution to the prioritization of flare-reduction opportunities based on their decarbonization potential, over and above the analysis of economic value and opportunity.

Our second set of recommendations focuses on the commercial, economic and financial aspects of flare reduction. They are multi-faceted and include the formation of dedicated "national task forces," the mapping and prioritization of idle gas infrastructure to prevent carbon lock-in, the development of gas processing hubs or clusters, the creation of innovative "inside/outside the ring-fence" policies, and the enforcement of (sometimes already established) flaring penalties and restrictions. Additionally, we emphasize the critical need to mobilize new and diverse sources of capital for flare-capture projects, particularly to bridge temporary negative cash flow of governments and NOCs during the early phases of projects. Lastly, we underscore the deployment of data-driven strategies and an unwavering commitment to operational excellence. With the industry's reputation and billions of dollars and metric tons of GHG emissions at stake, adopting a bold and actionable framework is essential to achieving meaningful progress and delivering results.

Our report is structured as follows:

- In Section 1 we discuss the context of gas flaring, including the ways in which associated gas can be used to generate value.
- In Section 2 we describe barriers to flare reduction that are often cited as reasons for the lack of global progress.
- In Section 3 we present summaries of our case studies (our full, in-depth studies are presented in an Annex, available here).
- In Section 4 we summarize the main insights from the case studies.
- In Section 5 we discuss our recommendation to adopt a holistic framework to analyze the net greenhouse gas benefits of flare-reduction projects.
- In Section 6 we formulate concrete recommendations on commercial, economic, and financial topics for each major stakeholder group (governments, NOCs, IOCs, consuming countries, and international financial institutions).

Abbreviations and Conversion Factors

Basic conversions

FROM	UNIT	TO	UNIT
1	kWh	3.6	MJ
1	m³	35.3	cubic feet
1	Btu	1054	J
1	kWh	3416	Btu (British thermal units)

Volume conversions

FROM	UNIT	TO	UNIT
1	BCM	1.0	Billion cubic meters, a key metric volume measure
1	BCM	35.3	Billion cubic feet, a common imperial volume measure
1	BCM per year	96.7	million standard cubic feet per day
1	million metric tons of LNG	1.47	BCM, assuming pure methane
1	LNG cargo	165000	m³ of LNG (although sizes vary up to 266,000)
1	LNG cargo	0.11	BCM of gas (this varies depending on cargo size)
1	LNG cargo	10.6	million scf/day on a continuous basis

Volume and energy

FROM	UNIT	TO	UNIT
1	m³	10.5	kWh of energy
1	BCM	36.0	TBtu
1	metric tons of LNG	53.1	MMBtu
1	LNG cargo	1.15	TWh of thermal energy
1	barrel of oil	159	liters

Global Warming Potential (GWP)

FROM	UNIT	TO	UNIT
	methane potency	29.8	times CO_2, on a mass basis, over a 100-year time period
	methane potency	10.9	times CO_2, on a volume basis, over a 100-year time period
	methane potency	82.5	times CO_2, on a mass basis, over a 20-year time period
	methane potency	30.1	times CO_2, on a volume basis, over a 100-year time period

Volume and emissions

FROM	UNIT	TO	UNIT
1	m³	1.86	kg of CO_2 (when burnt with 100% combustion efficiency)
1	BCM	2.94	million metric tons of CO_2e (98% combustion efficiency, 20-year GWP)
1	BCM	6.19	million metric tons of CO_2e (92% combustion efficiency, 20-year GWP)
1	BCM	3.33	million metric tons of CO_2e (92% combustion efficiency, 100-year GWP)
1	barrel of oil	430	kg of CO_2 emissions from end-use combustion of oil (this varies a lot)
1	barrel of oil	9	kg of CO_2 emissions from flaring (assuming average flaring intensity and 100% combustion)
1	barrel of oil	121	kg of CO_2e (high flaring intensity, 92% combustion efficiency, 20-year GWP)

Abbreviations and Conversion Factors

Prices and revenues

FROM	UNIT	TO	UNIT
5	$ per MMBtu	3.11	cents per kWh (delivered power, assuming 55% efficiency)
1	BCM	180	$ million per year, at a price of $5 per MMBtu
1	LNG cargo	39.4	$ million per cargo, at $10 per MMBtu

Penalties

FROM	UNIT	TO	UNIT
50	$ per metric ton CO_2	2.58	$ per MMBtu
50	$ per metric ton CO_2	93.1	$ million per BCM of flared gas

Flare-specific view

FROM	UNIT	TO	UNIT
1	moderate flare	5	million scf/day
1	moderate flare	0.1	BCM per year
1	moderate flare	0.5	Moderate-size cargos of LNG per year
1	moderate flare	320	thousand metric tons of CO_2e per year (92% combustion efficiency and 20-year GWP)
1	moderate flare	172	thousand metric tons of CO_2e per year (92% combustion efficiency and 100-year GWP)
1	moderate flare	25.5	$ thousand per day, at a price of $5 per MMBtu
1	moderate flare	9	$ million per year, at $5 per MMBtu
1	moderate flare	62	MW of power (thermal)
1	moderate flare	34	MW of power (electrical, assuming 55% efficiency)
1	moderate flare	111	thousand homes in the UK with electricity for a year
1	moderate flare	4.0	tons of unburnt methane per hour

Table 1: The units used to describe rates, volumes, emissions, and value in the oil and gas industry can be complex and, at times, confusing. This is due not only to the mix of imperial and metric systems, but also to varying standards and inconsistent assumptions across countries, companies, and contexts. This table has a mathematically self-consistent[1] overview of key units and conversions, categorized into “basic” (definitional or formulaic), “volume” (between different volume units), “volume and energy” (mapping the equivalence of these), “volume and emissions” (accounting for the impact of CO_2 and methane, under various “Global Warming Potentials”), “prices and revenues” and “penalties”. We also compute most of these outputs for a moderate-sized flare, of 5 million scf/day. We use standard reference temperature of 15 degrees C, according to ISO 13443.

In this report, references to Scope 1, 2, and 3 greenhouse gas emissions are to those concepts as defined by the GHG Protocol Corporate Standard.[2] In general, Scope 1 includes emissions from operations under a company’s control, Scope 2 includes emissions from purchased energy, and Scope 3 includes emissions produced elsewhere in a company’s value chain (generally, emissions from supplier production of goods and services consumed by the company, and from the use of the company’s products and services by its customers).

1 The figures presented here are internally self-consistent, though readers may be familiar with alternative variants—often reflecting differences in gas composition compared to our simplified assumption of 100% methane. These variations are minor and do not materially affect any of the calculations or conclusions presented.

2 GHG Protocol Corporate Standard, available at https://ghgprotocol.org/corporate-standard.

GAS FLARING IN 2025:

Source: data from Capterio's FlareIntel platform

1. Gas Flaring in Context

Flaring: A World-Class Economic and Environmental Opportunity

Flaring is the controlled burning of natural gas, typically at oil and gas production facilities, refineries and other locations along the hydrocarbon supply chain. Most – but not all – flaring is associated with oil production, which produces gas (so-called "associated gas") as a by-product.

Globally, around 148 billion cubic meters (BCM, or 14.3 bcf/day) of gas were flared in 2023, according to the World Bank,[3] representing some 3.9% of global gas consumption.[4] Capturing flared gas and bringing it to market would mitigate the drive to explore for new gas reserves and generate revenues for host countries and producing companies on the order of $30 billion per year.[5] This is also equivalent to powering 320 million UK homes for a year. When emissions are added from venting (the deliberate and planned release of non-combusted gas) and leaking (the unintended release of gas from faulty infrastructure or partial combustion at flare sites), according to the IEA's 2025 Global Methane Tracker[6], the opportunity rises to 277 BCM (6.8% of all gas consumption) and up to $50 billion in potential annual revenue.[7]

Gas wasted through flaring, venting, and leaking—part of the oil and gas industry's Scope 1 greenhouse gas emissions[8]—also represents a significant loss in energy efficiency that is particularly worrisome during a period combining global energy insecurity and a climate crisis. Based on data from the World Bank and the International Energy Agency (IEA), we estimate that flaring (including leaking from partial combustion) creates somewhere between 560 million and 1060 million metric tons of CO_2-equivalent emissions each year (the wide range reflects the assumption used on the potency of associated methane emissions from incomplete combustion).[9] Flaring can also cause the release of other pollutants, particularly where the gas flared is sour (meaning it contains significant amounts of hydrogen sulfide (H_2S)).

Over many years, many leading companies (supported by leading governments and institutions) have committed to reduce or eliminate gas flaring. The World Bank (which has been working on this topic since at least 2002) established in 2015 the Zero Routine Flaring (by 2030) program,[10] which has been endorsed by 60 oil and gas producers, 36 countries, and 15 development institutions.[11] More recently, zero routine flaring has been committed to by the 56 signatories of the Oil & Gas Decarbonization Charter (OGDC[12]) which includes an impressive list of 33 NOCs.

However, despite many years of pledges and commitments by governments, national and international companies, and international institutions, flaring (measured by volume and intensity) has stubbornly remained broadly flat since 2012 (Figure 1):

3 The World Bank, 2023 Global Gas Flaring Tracker Report (Washington D.C.: World Bank Group, March 2023), https://www.worldbank.org/en/programs/gasflaringreduction/publication/2023-global-gas-flaring-tracker-report.

4 KPMG, Kearney, and The Energy Institute, Statistical Review of World Energy (London: The Energy Institute (EI), 2024), https://www.energyinst.org/statistical-review.

5 At a notional gas price of $5 per MMBtu (with BCM converted to MMBtu based on the conversion factors presented under "Abbreviations and Conversion Factors" at the outset of this report).

6 International Energy Agency (IEA), Global Methane Tracker 2025, May 2025 https://www.iea.org/reports/global-methane-tracker-2025.

7 Assuming a notional gas price of $5 per MMBtu, and using the conversion factors presented above under "Abbreviations and Conversion Factors." Total gas market size taken from the Energy Institute, Statistical Review of World Energy.

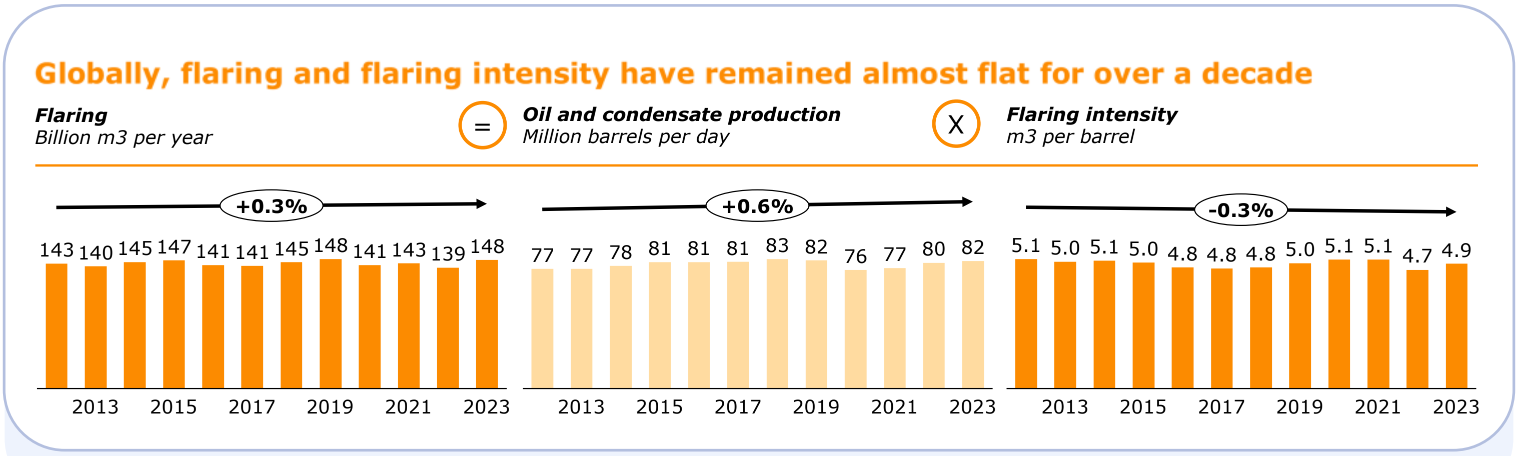
8 Oil and Gas Decarbonization Charter, 2024 Baseline of Action (November 2024), https://www.ogdc.org/2024-a-baseline-for-action/. Scope 1 emissions are defined under "Abbreviations and Conversion Factors" above.

9 The broad range is due to differing assumptions regarding the time period over which the differential in global warming potential between methane and CO2 is measured. See "Gas flaring is heading in the wrong direction, but it's not too late to act differently," Capterio, (July 2024), https://flareintel.com/insights/gas-flaring-is-heading-in-the-wrong-direction-but-its-not-too-late-to-act-differently. See also, "Understanding Methane Emissions," International Energy Agency, (2024), https://www.iea.org/reports/global-methane-tracker-2024/understanding-methane-emissions.

10 "ZBF Initiative Endorsers," World Bank Group, https://www.worldbank.org/en/programs/zero-routine-flaring-by-2030/endorsers.

11 While fixing routine flaring is a clear industry commitment, it is not unconditional, as the commitment text "seek[s] to implement economically viable solutions to eliminate this legacy flaring as soon as possible, and no later than 2030". The use of the word "seek" and "economically viable" in this sentence implied that endorsers have some flexibility which may dilute the potential impact of the program.

12 Oil and Gas Decarbonization Charter, Oil and Gas Decarbonization Charter, (2024), https://www.ogdc.org/signatories/.



Source: World Bank; Capterio analysis.

Figure 1: Profiles of global gas flaring, oil and condensate production, and derived flaring intensity (flaring per barrel), based on from the World Bank.

This report focuses on gas flaring more than venting and leaking since flaring is highly visible, easy to quantify by satellite, and concentrated in discrete locations—the flare stacks. Yet venting and leaking have a significantly higher greenhouse gas footprint than flaring because the release of methane (CH_4) is 82.5 times more potent as a climate-forcing agent on a mass basis over a 20-year period (or alternatively 29.8 times more potent over a 100-year period).[13] Flaring, venting, and leaking are also linked, as some of the methane releases result from incomplete combustion during flaring – so-called “methane slip.” This amounts to around 14.2 BCM per year, according to the IEA (although the IEA appears not to count a small but important minority of flaring which is from the gas supply chain.)[14] A key priority for all flares, for as long as they exist, is that their combustion efficiency should be as close to 100% as possible.

While this report focuses on flaring reduction, we strongly support all efforts to cut methane emissions across the oil and gas sector. In fact, many of the barriers to flare reduction also apply to tackling methane leaks and venting—finding ways to capture and commercialize gas is essential. One important consideration, however, is the unintended (yet often positive) consequence of methane mitigation: it may lead to an increase in gas flaring until viable markets are formed. If previously vented methane is routed to flare, this should be encouraged, even if it results in higher flaring until flare-capture projects are conceived and implemented. Recovering methane from storage tanks or other sources should be promoted even if the immediate solution is flaring rather than utilization. Similarly, we should be encouraging all flares to be properly lit and operating with high combustion efficiency to minimize the methane slip—despite the fact that this will increase gas flaring.

We also focus mainly on flaring that occurs at upstream oil production facilities, even though flaring is also an issue at downstream facilities, such as refineries, and along pipelines. Perhaps counterintuitively, there is also significant flaring from within the gas supply chain (for which gas is the primary product). We see significant flaring in the upstream (even at some non-associated gas fields) and also at processing, transportation, liquefaction, and regasification facilities. In this report, we focus mainly on oil production. This is where the greatest materiality lies and where the largest opportunities for flare reduction exist. Naturally, we fully support initiatives to reduce flaring elsewhere in the oil and gas supply chain.

13 Table 7.15 from IPCC AR6, as found at, “IPCC AR6 methane GWP Tables,” GHG Management Institute, https://ghginstitute.org/ipcc-ar6-methane-gwp-tables/.

14 International Energy Agency (IEA), Global Methane Tracker 2024, (2024), https://www.iea.org/reports/global-methane-tracker-2024.; Genevieve Plant, et al., “Inefficient and Unlit Natural Gas Flares Both Emit Large Quantities of Methane,” (September 2022), Science, Vol. 377, Issue 6614,1566–1571, https://www.science.org/doi/10.1126/science.abq0385.

Measuring and Analyzing Flaring

Flaring is typically assessed using two key metrics: flaring volume and flaring intensity. A third metric, flaring combustion efficiency, is of tremendous importance, although there is less data available.

- Flaring volume refers to the volume of flared gas, usually expressed in millions or billions of cubic meters per year (MCM/a, or BCM/a) or millions of standard cubic feet per day (million scf/d). For context, the United States flared 9.6 BCM in 2023, ranking it fourth globally behind the Russian Federation, the Islamic Republic of Iran, and the Republic of Iraq.
- Flaring intensity is a measure of the volume of gas flared per unit of oil or condensate produced, enabling meaningful comparisons across fields, regions, and countries regardless of their production scale. Returning to the US example: although it ranks fourth in absolute flaring, its intensity is relatively low—just 2.0 m^3/bbl, well below the global average of 4.9 m^3/bbl. This reflects the sector's large size and relatively strong operational performance, as well as the "gassiness" of the country's oil production.
- Flaring combustion efficiency is a measure of the percentage of hydrocarbon gas that is successfully burned at the flare tip.[15] This metric is critical because uncombusted gas—primarily methane—is far more harmful to the climate than CO_2 released through flaring, due to its significantly higher global warming potential. Widespread data on this metric is somewhat limited, but this is a key area for ongoing research and focus. While top-tier flare systems can achieve combustion efficiencies above 99%, many flares around the world perform well below this threshold, highlighting an area for improvement and innovation. Maximizing combustion efficiency is a vital industry objective, as flaring—while not ideal—is far less damaging than venting, as discussed above.

Typically, flaring is classified into three types: safety-related, upset and routine (the dividing line among these categories is somewhat unclear and inconsistently interpreted).[16] According to the World Bank's definition, "routine" flaring of gas is flaring during normal oil production operations in the absence of sufficient facilities or amenable geology to re-inject the produced gas, utilize it on-site, or dispatch it to a market.[17] Put differently, routine flaring is that which occurs consistently at similar rates almost every day, and is driven by a lack of offtake infrastructure or insufficient infrastructure capacity. "Upset" flaring is (or should be) temporary in nature and is at least initially driven by operational problems, such as compressor failures. "Safety" flaring occurs when gas is flared to avoid a danger resulting from a condition such as pressure buildup, although this can often result from an operational failure and therefore can also be classified as upset flaring. Most sites maintain a pilot flare at all times in order to have the ability to ignite otherwise-dangerous gas, and this is also generally thought of as safety flaring.

An important consideration is the distinction of these categories – not only because the solutions differ – but also because of the scale. According to data reported to the World Bank by the endorsers of its Zero Routine Flaring by 2030 initiative, some 70% of all flaring is upset in nature (Figure 2), suggesting that fixing operational problems should be a core priority for industry, in additional to fixing "routine flaring".[18] Yet it is important to take care in drawing deep conclusions here, firstly since the companies that report account for only

15 Combustion efficiency refers to how completely flared gas is converted to CO_2 and water, whereas destruction efficiency measures how much of the original hydrocarbons are broken down—regardless of whether they are fully combusted or turned into by-products like CO or soot. This distinction matters because poor combustion can result in significant methane slip, which has a far greater climate impact than CO_2, even if destruction efficiency appears high.

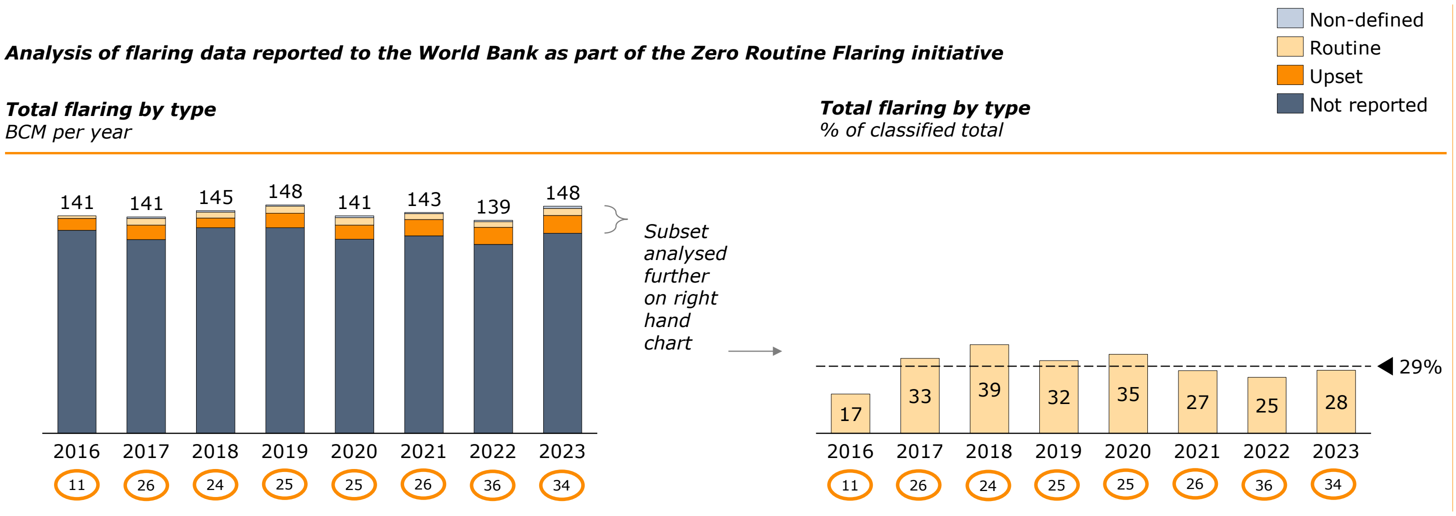
16 See Lesley Feldman, Heny Patel, and James Turitto, Flaring Accountability: Global gas flaring by major oil and gas companies and their partners (Clean Air Task Force, November 2024), p. 14 (Box 2), https://www.catf.us/resource/flaring-accountability/.

17 "ZBF Initiative Endorsers," World Bank Group, https://www.worldbank.org/en/programs/zero-routine-flaring-by-2030/endorsers.

18 See Lesley Feldman, Heny Patel, and James Turitto, Flaring Accountability: Global gas flaring by major oil and gas companies and their partners (Clean Air Task Force, November 2024), p. 14 (Box 2), https://www.catf.us/resource/flaring-accountability/.

around 10-12% of all flared volumes, and secondly because independent data from Capterio strongly suggest that routine flaring is much more significant than these data imply, as much of the flaring reported as upset seems to occur on a long-term, continuous (or routine) basis.

Around 10% of all global flaring is reported to the World Bank, and these self-reported data (if correct) suggest that "routine" flaring is in the minority



Source: World Bank; Capterio analysis.

Figure 2: Left: Chart showing the classification of flaring into routine, upset, and undefined (according to the self-reported data submitted to the World Bank by the 35 companies that endorse the Zero Routine Flaring by 2030 initiative), plus the total of all the non-reported flaring. Only c 10% of global flaring is reported to the World Bank initiative. Right: Of the reported data, companies report that an average of 29% of flaring is routine, suggesting that the majority of flaring is upset in nature (at least for this subset of companies, and assuming the data is properly classified).

Flaring Solutions

To reduce and ultimately stop flaring (or at least routine flaring), gas needs to be separated from the oil, captured, treated, processed, and fed into an end use: the so-called flare-capture or flare-reduction project. Fortunately, there are many proven technology solutions, which include:

- Capturing the gas for use in field, for example to generate power for oil production operations. A modest-size flare (say 5 million scf/day) could generate up to 35 MW of power.
- Sending the gas to domestic or export markets by pipeline.
- Compressing the gas (CNG) for use mostly as transportation fuels.
- Re-injecting the gas into reservoirs for disposal or storage, or to increase reservoir pressure to increase oil production (enhanced oil recovery or EOR).
- Refining methane-rich gas in gas-to-liquids (GTL) processes.
- Liquefaction to generate LNG for export by ship to international markets, or trucking to domestic markets. A modest flare (5 million scf/day) is equivalent to half of an LNG cargo per year. A recent OEIS report highlighted that, excluding Russia, LNG-exporting countries have reduced flaring by 28% (12 BCM) between 2019 and 2023, reinforcing that LNG development can be an effective pathway for flare reduction.[19]

End markets for gas include power generation, industrial uses (petrochemical production or heavy industries such as cement and steel) and residential and commercial uses

19 Jonathan Stern, Measurement, Reporting and Verification of Methane Emissions from the Gas and Oil Sector and Consequences for LNG Trade: A Three-Year Progress Report, (Oxford Institute for Energy Studies, March 2024), https://www.oxfordenergy.org/publications/measurement-reporting-and-verification-of-methane-emissions-from-the-gas-and-oil-sector-and-consequences-for-lng-trade-a-three-year-progress-report/.

(heating and cooking). Other "exotic" solutions exist, such as generating power for data centers used for cryptocurrency mining, as well as use for vertical farming or the synthesis of alternative proteins.

Associated gas is often rich in liquids that are dissolved in the gas, and can be processed to extract natural gas liquids (NGLs), which include liquefied petroleum gas (LPG) (a mix of butane and propane that can be used for heating and cooking) and condensate (a light natural gas liquid that is often mixed with crude oil). The processed or "dry" gas can then be combusted more cleanly and efficiently by its end user.

Utilizing associated gas will often generate economic value, with the main question being whether the value is sufficient to justify the investment costs. Capturing associated gas rather than flaring it can also reduce GHG emissions, although the analysis can be complicated. Most analyses refer to the gross GHG emissions that directly result from flaring, implying that capturing flared gas would eliminate this volume of emissions.[20]

While this type of analysis is useful, we believe a more fulsome framework is needed. In most cases, the recovered gas and NGLs are ultimately combusted by final consumers in some other form in another location (Scope 3 emissions). On the other hand, using gas may displace a higher carbon-intensity alternative fuel. In addition, many flare-capture projects are implemented alongside new or increased oil production, creating additional GHG emissions when the oil is refined and used. Yet it is often difficult to determine "cause and effect," because in many cases the increased oil production would occur with or without the flare-capture project. At the same time, a flare-reduction project could reduce venting and leaking of methane (both at the flare stack and in connection with production of the fuel displaced by captured associated gas), and as such can have a significant positive impact on GHG emissions, particularly if the project is well conceived and executed to minimize methane slip from incomplete flare combustion. As we analyze in detail in Section 5 of this report, we believe it is important to analyze whether flare-capture projects are *net* positive for the climate—based on their ability to reduce *overall* emissions—after taking into account any related increase in Scope 3 emissions from the use of gas, NGLs, and increased oil production attributable to the flare-reduction projects.

20 See The World Bank, 2024 Global Gas Flaring Tracker Report, (Washington D.C.: World Bank Group, June 2024), p. 14, https://www.worldbank.org/en/programs/gasflaringreduction/publication/2024-global-gas-flaring-tracker-report.; Shayan Banerjee and Perrine Toledano, A Policy Framework to Approach the Use of Associated Petroleum Gas (Columbia Center on Sustainable Investment, Columbia University, 2016), p. 8, https://ccsi.columbia.edu/content/policy-framework-approach-use-associated-petroleum-gas.; Clean Air Task Force, Flaring Accountability: Global gas flaring, p. 8.

2. Challenges and Barriers to Stopping Flaring

For many, the fact that oil and gas producers flare associated gas—one of the industry's primary and valuable products—is somewhere between counterintuitive, inefficient, and absurd. However, the reality is that there are many technical, economic, commercial, organizational, and political barriers that can hinder the intuitively obvious action of capturing and utilizing flared gas. In our view, these so-called "barriers" should more properly be considered complexity factors and not obstacles, as many can be overcome with proper leadership and determination—as borne out by the case studies we present in Section 3 of this report.

Fundamentally, since gas flaring is a direct result of oil production, this wasteful and environmentally damaging practice is a form of "dumping." The global industry has – somewhat unintentionally – established a practice in which waste is placed into the atmosphere and is treated as society's collective problem rather than the industry's problem. As such, gas flaring is a classic example of "free riding" and "tragedy of the commons." Put simply, producers that flare—governments, NOCs, and IOCs—do not bear the consequences or costs (apart from the opportunity cost of revenue loss), and instead pass them to taxpayers, future generations, and countries suffering from climate impacts. A more responsible practice would be that oil producing countries and companies (both national and international) either fix the problem or face financial penalties under the "polluter pays" principle.

A common response is that flare-reduction projects do not provide sufficient economic returns to warrant the investment of time and resources. A 2022 World Bank–sponsored study found that this is not generally correct, and that commercial returns from capturing gas from all but the smallest flares can be satisfactory.[21] Similarly, the IEA's Global Methane Tracker highlights methane capture as having a significant negative marginal abatement cost (meaning capture is intrinsically profitable[22]). Our case studies also show that flare-reduction projects can be attractive, and that some projects are not pursued even though their potential returns are at least on a par with the investment criteria of most major international oil producers. More fundamentally, even when returns from flare reduction are not optimal, fixing flaring should be considered to be part of the inherent cost of an oil project, just like making investments in health, safety and environmental protection.

If a new oil development project cannot support the cost of eliminating or significantly reducing flaring (as well as venting and leaking methane), there are good arguments it should not be approved at all (indeed, this is one of our recommendations presented in Section 6 of this report). The issue is more difficult when flaring is already occurring at existing production sites, where investments in oil production have been approved and realized without taking into account the costs of flare reduction, and producers are awaiting their agreed-upon returns. Even in those cases, however, there are often opportunities to monetize flared gas without unduly impacting overall project economics (and sometimes without adversely impacting economics at all).

21 Gianni Lorenzato, Silvana Tordo, Berend van den Berg, Huw Martyn Howells and Sebastian Sarmiento-Saher, International Development in Focus: Financing Solutions to Reduce Natural Gas Flaring and Methane Emissions (World Bank: Washington, DC, 2022), https://documents.worldbank.org/pt/publication/documents-reports/documentdetail/099754303292216403/idu0998ce4500da6404fef09a4a0e2f195c63880.

22 "Global Methane Tracker Key Findings," International Energy Agency, 2024, https://www.iea.org/reports/global-methane-tracker-2024/key-findings.

Summary of the Main Factors That Can Make Flare Reduction Complex

Valuable work has been done in recent years by multilateral and academic institutions and industry bodies to catalogue the main barriers to flare reduction, and to suggest possible solutions.[23] These studies are useful, and we build upon them in this report, seeking with our case studies to make concrete what is sometimes discussed on a more abstract or theoretical level.

To set the context for our case studies, conclusions and recommendations, we briefly discuss below what are frequently cited as the main barriers said to impact the economic and technical feasibility of flare-reduction projects. At the most basic level, it is important to recognize that gas differs fundamentally from crude oil: it is harder and more expensive to transport, difficult to store, and typically requires customers to be supplied with a steady, non-declining volume from a single source (or limited sources) that cannot easily be supplemented or replaced.

1. Lack of Infrastructure to Process Associated Gas and Send It to a Market

Infrastructure is critical for flare reduction, especially when flares are far from markets. It is a mistake, however, to consider that flares are typically "stranded"—a Capterio analysis cited by the IEA highlights that 54% of all flared gas volume in 2019 was less than 20 km from an existing gas pipeline or gas demand center.[24] Nevertheless, key facilities include systems to gather and treat associated gas at production sites, process it to extract NGLs and meet pipeline or market specifications, compress it for transport, and deliver it to its final destination. Designing and building this infrastructure requires substantial capital investment, while developing infrastructure can be complex and require innovation to coordinate facilities and maximize returns.

The cost of infrastructure affects flare-reduction projects in two ways. First, it requires project operators and participants to have access to financing, either from their own resources or from third parties (as discussed in more detail below). Second, it directly impacts project returns, as amounts invested in infrastructure must be recovered from project revenues, along with an amount sufficient to generate reasonable returns. The difficult question is what returns can be considered reasonable, as typical upstream returns (often based on an internal rate of return of 15% or more) might not be appropriate benchmarks for flare-reduction projects involving the construction of substantial midstream (processing and transport) and downstream (end-user facilities) infrastructure.

Another infrastructure issue commonly cited is "lock-in", as facilities constructed to process, transport, and utilize associated gas may have to operate for a substantial period of time to allow investments to be recovered. Even in cases where investment recovery is relatively quick, the useful life of infrastructure can be much longer. The consequence may be to extend the time period during which natural gas is used as a fuel (beyond what would be ideal in the context of the global energy transition) or to extend the duration of oil production so that associated gas can continue to be delivered.

23 Some examples include: Gianni Lorenzato, Silvana Tordo, Berend van den Berg, Huw Martyn Howells and Sebastian Sarmiento-Saher, Financing Solutions to Reduce Natural Gas Flaring and Methane Emissions; Shayan Banerjee and Perrine Toledano, A Policy Framework to Approach the Use of Associated Petroleum Gas; International Energy Agency, The Energy Security Case for Tackling Gas Flaring and Methane Leaks (2022), https://www.iea.org/reports/the-energy-security-case-for-tackling-gas-flaring-and-methane-leaks.; International Energy Agency, Driving Down Methane Leaks from the Oil and Gas Industry: A Regulatory Roadmap and Toolkit (2021), https://www.iea.org/reports/driving-down-methane-leaks-from-the-oil-and-gas-industry/regulatory-roadmap.; Mark Thurber, Gas Markets Usually Start with Industrial Applications, (Stanford University Energy for Growth Hub, 2021), https://energyforgrowth.org/article/gas-markets-usually-start-with-industrial-applications/.; IPIECA, International Association of Oil and Gas Producers and World Bank Global Gas Flaring Reduction Partnership, Flaring Management Guidance for the Oil and Gas Industry," IOGP Report 467 (2021), https://www.ipieca.org/resources/flaring-management-guidance.; Mark Davis, Perrine Toledano and Thomas Schorr, North Africa can reduce Europe's dependence on Russian gas by transporting wasted gas through existing infrastructure (Capterio and Columbia Center on Sustainable Investment, 2022), https://scholarship.law.columbia.edu/sustainable_investment_staffpubs/217/.

24 Rebecca Schulz, Christophe McGlade, Peter Zeniewski, "Putting gas flaring in the spotlight," International Energy Agency (IEA), December 2020, https://www.iea.org/commentaries/putting-gas-flaring-in-the-spotlight. We acknowledge that gas pipelines also need to have spare capacity in order to be used for flared or vented gas.

One solution to these problems is to utilize existing infrastructure where possible—indeed, our case studies show there is significant under-utilized infrastructure in many high flaring countries. Where this is the case, the main infrastructure-based obstacles reflect policy choices, fiscal structures, or regulatory/contractual issues, all of which we discuss further below.

Infrastructure costs can sometimes be reduced by clustering developments in hubs, allowing a single processing or transportation facility to handle gas from multiple upstream flares. This approach is especially useful for small, scattered flares across different fields operated under separate contracts. However, shared infrastructure can sometimes introduce fiscal, contractual, and regulatory complexity that requires creative project structuring.

2. Lack of Attractive Market

To recover infrastructure costs and generate a return, an operator must have access to a market in which it can receive reasonable prices for processed associated gas and NGLs. This can mean the ability to sell gas and NGLs directly to end users, to operators of midstream processing facilities or downstream facilities (including LNG facilities), or to intermediaries such as pipeline operators or distribution companies. In some countries, it means having the ability to be paid for production by a state-owned company that has a legal or *de facto* monopoly on the purchase or offtake of natural gas.

A significant barrier to investment in many countries is the lack of credit-worthy off-takers. This can exist in numerous circumstances, such as where downstream operators such as power companies have difficulty paying for gas or where a state-owned monopoly purchaser owes substantial arrears to producers. Structuring a flare-reduction project in these circumstances can require sovereign guarantees or other credit support, such as the allocation of a share of a State's oil revenues to ensure that payment is made for captured gas and NGLs.

Another impediment to flare reduction is the impact of subsidized gas and electricity pricing on project economics. If domestic gas prices are regulated and artificially low, potential revenues from selling captured associated gas shrink. Similarly, regulated electricity prices can make it financially unviable for power producers to buy associated gas at price levels that justify investment. While subsidies—such as government funding of fuel oil purchases for power generation—may sustain artificially low gas and electricity prices, these subsidies might not be available for the purchase of captured associated gas, creating financial barriers to flare reduction.

3. High Technical Complexity

One reason why designing a flare-reduction project is complex is that associated gas supply can be unpredictable. Flared gas volumes depend on oil production levels, which vary due to subsurface factors like reservoir performance, and surface factors such as oil prices, production costs, OPEC+ curtailments and maintenance requirements. Associated gas volumes also change over time—with oil production typically becoming more "gassy" over time—and differ between reservoirs. This uncertainty makes it difficult for upstream operators to guarantee fixed gas volumes. Conversely, if oil production increases without sufficient processing or market capacity for gas, flaring may be the only option.

The most straightforward way to manage unpredictable associated gas supply is to balance it with non-associated gas (see box below for more on the "make-up gas" issue). However, this requires the non-associated gas operator to accept—or be incentivized to accept—the risk of fluctuating demand. Alternatively, offtake facilities can be based solely on expected associated gas delivery volumes, in which case the projects must be designed to remain functional and economic despite absorbing the risk of fluctuating supply. For LNG facilities, access to LNG spot markets can provide a partial solution, as buyers can mitigate shortfalls by purchasing spot cargoes (typically with the LNG facility operator and/or the upstream operators absorbing the risk of price differentials between contract prices and spot prices). However, this solution depends on the willingness of buyers to participate in managing this risk.

Another key technical challenge is optimizing project execution to ensure timely completion and expected returns. This can be difficult, particularly when coordination is required—such as when infrastructure serves multiple upstream fields, projects involve multiple components (processing, transport, liquefaction, etc.), or flare-reduction efforts temporarily disrupt ongoing oil operations.

Once implemented, flare-reduction projects can also suffer from poor operational performance, leading to frequent and prolonged "upset" flaring events. Compressor reliability (for example) is a frequent challenge in many assets, which can be improved through better (predictive) maintenance, better equipment or spare part redundancy, better planning or improved control processes. Underpinning good operational performance is, unsurprisingly, a strong "safety-like" operational focus, a problem-solving mindset and a data-rich decision-making environment.

Box on the Role of "Make-Up" Gas in Flare Gas Capture Projects

The concept of "makeup" gas can be used to enable flare gas capture projects despite the inherent variability of associated gas production, which is fundamentally driven by oil output. Traditionally, makeup gas refers to non-associated gas (i.e., more reliable gas) that can be sent to infrastructure to supplement the unpredictable volumes of flared gas. However, we explore alternative options below.

We identify five main options for providing makeup gas:

1) Pooling associated gas projects: Perhaps the best option (perhaps "virtual make-up gas"), this approach aggregates – and contractually sequences – multiple associated gas sources to reduce volatility, allowing them to support one another.
2) Non-associated gas fields: Traditional makeup gas could be sourced from one or more dedicated non-associated gas fields.
3) Gas storage: Makeup gas could be withdrawn from storage facilities to balance fluctuations.
4) Flexible gas reinjection: Varying the amount of gas re-injected into the reservoirs for enhanced oil recovery could provide additional flexibility.
5) Spot LNG purchases: For LNG facilities, buyers could purchase spot cargoes to make up for variability, with the operator of the LNG facility (and ultimately the associated gas suppliers) bearing the risk of price differentials between contract and spot prices.

However, several challenges complicate the makeup gas concept:

1) Geographic and geological constraints: Many basins lack both associated and non-associated gas sources within feasible proximity to flare-capture projects.
2) Incentive misalignment: A makeup gas supplier would need to act as a swing producer, adjusting output dynamically—something many operators would resist, as they typically aim to maximize production and returns.
3) Coordination complexity: Synchronizing the makeup gas supply with flare gas capture projects presents significant operational hurdles.
4) Emissions trade-offs: The use of non-associated gas could introduce additional emissions where the gas comes from new developments, as bringing a new supply source inherently increases life-cycle emissions. The net benefit depends on the scale of non-associated gas emissions versus the emissions reductions from flare capture.

Regardless of the mechanism, flexibility has a cost. Operators of non-associated gas fields would need a financial incentive to provide make-up gas, similar to capacity market payments in electricity markets, where suppliers are compensated for ensuring availability.

4. Insufficient Information and Data on Flared Gas

A significant obstacle to implementing flare-reduction projects at oil production facilities already in operation – brownfield projects – arises when information about flaring volumes is unavailable or inaccurately reported. Put simply, in order to evaluate opportunities and the costs of missing those opportunities, it is important to know the volume of gas being flared. Flare-reduction projects, to be investable, are required to be technically and commercially mature, meaning that considerable subsurface geological and surface engineering studies are required to evaluate gas recovery, processing and transport (or other) options.

While many supermajors have installed top-tier ultrasonic meters on their operated flares, the majority of flares worldwide remain unmetered, including many assets operated by NOCs or independent operators. Without flow meters, flaring is estimated using methods ranging from mass balance and gas-oil ratios to rough approximations, or not quantified at all. Few companies collect high-frequency (e.g., daily) data across all assets, including non-operated ones, in a centralized, impact-driven system.[25] Where direct measurement is lacking, satellite data—capturing flaring at every asset multiple times per day—offers a credible alternative.

Incomplete, aggregated, delayed or inaccurate reporting sometimes leaves senior executives at operating companies, their non-operating partners, NOCs and regulators/ governments underinformed and with a false sense of security. Similarly, lack of transparency can also block leadership from identifying and making progress on some of the largest and most attractive opportunities.

5. Lack of Enforced Flaring Penalties

While the cost of developing infrastructure to capture, process, transport, and utilize associated gas can be high, the cost of not doing so generally is zero (apart from the opportunity cost of revenue loss) unless laws and regulations provide otherwise. When there is no explicit financial cost to flaring, the ultimate cost is borne not by the operator of the upstream facilities, but by society as a whole, which bears the cost of adapting to climate change caused by greenhouse gas emissions.

The most logical way to address this is to impose penalties on associated gas that is flared (or that is vented or leaked in the form of methane). Many countries do this—Norway is one of the most successful examples, with a price for combustion of natural gas the equivalent of US$69 per metric ton of CO_2 as of June 2023[26] (which is equivalent to a hefty US$3.6 per MMBtu, only somewhat lower than the market price of gas under usual conditions). In other countries, such as the United States, methane and flaring penalties are politically controversial, and they can be applied and removed from one administration to the next.[27]

Some countries have legislation providing for substantial flaring penalties, but for the most part the penalties are not collected, either for lack of institutional capacity or for fear of hampering oil production translating into lower government oil revenues. This can be due to a lack of enforcement or to exceptions that apply—for example, where flaring occurs in regions that are said to lack infrastructure to process and transport captured gas. The issue is that where such exceptions are applied too freely, this removes the incentive to build the required infrastructure.

25 Lack of high frequency data also hinders centralized functions to verify the separate reporting (where present) of "routine" vs "non-routine" flaring – coupled with the fact that the definition is anyway somewhat interpretative.

26 "Global Gas Flaring and Methane Reduction Regulations Norway," Case Studies, World Bank Group, December 2023, https://flaringventingregulations.worldbank.org/norway.

27 For example, the US Environmental Protection Agency announced substantial methane emissions penalties in November 2024, as required by the Inflation Reduction Act. See U.S. Environmental Protection Agency (EPA), "EPA Finalizes Rule to Reduce Wasteful Methane Emissions and Drive Innovation in the Oil and Gas Sector," news release, November 2024, https://www.epa.gov/newsreleases/epa-finalizes-rule-reduce-wasteful-methane-emissions-and-drive-innovation-oil-and-gas. Following the US elections, these were repealed by Congressional action in February 2025. See Michael Phillis and Matthew Daly, "Congress votes to kill Biden-era methane fee on oil and gas producers," AP News, February 2025, https://apnews.com/article/methane-fee-repeal-epa-oil-gas-drilling-4844558bece1e683da9246ee226c57b5.

6. Poorly Adapted Fiscal Regimes

Most hydrocarbon-producing countries have upstream fiscal regimes that direct the majority of the pre-tax cash flow to the government. Typical "government take" from upstream projects is often in the 65%–85% range because of the high economic rent to be made in petroleum extraction (and as such is much higher than normal corporate tax rates of around 35%). This means there can be a significant difference in the fiscal regime for revenues and expenditures deemed to occur inside or outside the upstream "ringfence"—meaning the geographical and operational scope covered by an upstream exploration, development and production license, or contract. While gas capture is typically within the ring-fence, power plants (other than those for in-field use) and other end-use offtake facilities are usually outside this ring-fence. Gas processing and transport facilities can fall either inside or outside, depending on legal, regulatory, contractual, and fiscal frameworks.

Few countries have fully thought through how these regimes apply to flare-reduction projects. Many governments fail to recognize that flare-capture projects have fundamentally different economics from oil extraction and can require tailored fiscal policies. Where governments aim to curb flaring—whether to supply domestic markets or boost exports—fiscal incentives can be a powerful tool, particularly when paired with meaningful flaring penalties.

Companies investing in these projects generally prefer to incur and recover costs within the upstream ring-fence (where the government take is highest), while recording revenues outside it (where economic rent, and taxation, is lower). By acceding to such an allocation at least in part, governments can effectively provide a fiscal incentive for flare reduction. Some countries also offer tax incentives like temporary holidays or accelerated cost recovery, but few have fully addressed how these regimes apply to flare-reduction projects.

7. Poorly Adapted Contractual Arrangements

Many upstream exploration and production contracts have clauses devoted to gas, but they typically are inadequate to address issues relating to flared associated gas. Often, these clauses focus primarily on the development of non-associated gas fields, covering associated gas in a paragraph or two at most.[28]

The most common clauses provide either that associated gas must be transferred to the government or NOC free of charge, or that the government can require field development plans to include solutions for the use of associated gas. They sometimes prohibit non-emergency flaring without authorization, although enforcement is often sporadic at best.

In some cases, upstream contracts provide operators with little or no economic benefit from capturing associated gas (especially where the gas must be provided to the government or NOC for free). In other cases, contractual provisions impacting economics, such as royalty rates or profit oil-sharing formulas, are well adapted to oil production and non-associated gas production, but not to the specifics of associated gas, such as the need to invest in processing facilities to remove (and sell) NGLs or the complexity of developing infrastructure common to multiple fields. Amending contracts can be politically fraught, particularly where the impact is to ease the economic burden on international companies in order to incentivize investment.

28 Model Petroleum Agreement of Ghana, Arts. 14.4-14.6 (2000); Model Exploration and Production Sharing Contract, Republic of Cyprus, Art. 7.2.1(v) and (vii)(c), and 23.5 (2012); Model Production Sharing Agreement, Kurdistan Region of Iraq , Art. 14.3; Production Sharing Agreement, Republic of Equatorial Guinea, Arts. 13.2.1 – 13.2.5. These and other model and actual agreements can be found in the database of upstream oil and gas exploration and development contracts at the <Resource Contracts, "Online Repository of Petroleum and Mining Contracts," https://www.ResourceContracts.org.> In contrast, the 2012 Production Sharing Agreement in Angola provides for associated gas to be delivered to the NOC free of charge, but specifically allows the Contractor to recover costs relating to associated gas capture, as well as providing for modifications of economic terms if gas capture has a significant negative impact on the Contractor's returns. See Angola Block 20 and Sonangol E.P. Production Sharing Agreement (Luanda: 2012), https://www.resourcecontracts.org/contract/ocds-591adf-0014595575/view#/. Egypt's 2019 model production sharing agreement provides that if associated gas is not utilized, the NOC and the Contractor will "negotiate in good faith on the best way to avoid impairing production," effectively giving priority to oil production. See the Egypt Ministry of Petroleum and Mineral Resources and Ganope, Red See Bid Round Main Commercial Parameters (Cairo; 2019), https://www.ogel.org/legal-and-regulatory-detail.asp?key=22050.

Some contractual clauses present obstacles to techniques that otherwise might prove effective at limiting flaring. Most prominently, many upstream contracts contain legal and fiscal "stabilization" clauses that provide operators with the right to renegotiate terms or to obtain compensation where changes in laws and regulations significantly impact their economic returns. This could affect the ability of governments to adopt effective flaring penalties, as companies might argue they would impose unforeseen costs by requiring them to make new infrastructure investments or to pay penalties.

Difficulties can also arise from the contractual arrangements applicable to the flare-reduction projects themselves. Processing and transport infrastructure can be developed under many different contractual and operational models (concessions, common carrier, purchase-sale, tolling and more), and it is not always easy for regulators or NOC officials to choose among them, particularly where their experience is mainly in upstream projects that follow well-known models that often have been used for decades without substantial modification.

8. Regulatory Obstacles

One major challenge to flare reduction in some countries is determining which regulators oversee flare-reduction projects. Unlike upstream oil and gas operations, which often have a clear regulatory framework, flare-reduction projects can fall under multiple jurisdictions. Different regulators may govern upstream production, midstream transport and processing, and downstream distribution and marketing. Additional authorities may oversee electricity, industry, finance, taxation, labor, and trade. In some cases, it is unclear which competent regulator has authority over specific aspects of a project—or whether any regulator has jurisdiction at all.

Another obstacle is access to gas transportation infrastructure, which is often controlled by state-owned companies with monopolies on pipeline systems. In some countries, upstream operators can sell their gas directly to end-users, allowing them to reach customers, while other countries require gas to be sold to a national gas company or delivered to a transportation system operator for a fixed tariff, allowing them to reach customers. Where no systems at all exist, or where the systems fail to function as intended, operators that capture and process associated gas may have no way to transport or sell it to a gas off-taker, making flare reduction economically infeasible.

9. Lack of Capital Allocation or Financing

Fixing flaring will require significant capital—but not as much as many assume. A 2018 World Bank study estimated that eliminating routine flaring by 2030 would require around $100 billion in investment.[29] While this is a significant sum, we calculate that it represents just 1.6% of the oil and gas industry's capital expenditure over the same 13-year period[30] (and a far smaller percentage of industry's revenue). This is far outweighed by the potential revenue from the recovered gas, which could be as high as $300 billion over this period, at $5 per MMBtu.

Assuming routine flaring accounts for a clear majority of all flaring, and comparing a future with zero routine flaring after 2030 to a counterfactual where the flaring intensity remains constant at 2023 levels (but with its underlying oil production declining naturally, with any new production being flaring-free), this investment could bring up to 1,300 BCM of gas to market by 2050 (or 900 BCM by 2040). That equates to a cost of roughly $2 per MMBtu ($3 per MMBtu if a 2040 reference is taken)—significantly below typical market prices—and an abatement cost of just $40 per metric ton of CO_2, which is lower than many other decarbonization options.

Importantly, because flare-capture projects actually generate revenue, the *net* cost per metric ton of CO_2 abated is likely far lower. In fact, for a significant majority of the recovered

29 What would it cost to eliminate routine flaring by 2030? See "ZBF Initiative Endorsers," World Bank Group, https://www.worldbank.org/en/programs/zero-routine-flaring-by-2030/endorsers.

30 Allyson Cutright, Roger Diwan, and Karim Fawaz, Upstream Oil and Gas Investment Outlook (International Energy Forum and S&P Global Commodity Insight, June 2024), https://www.ief.org/focus/ief-reports/upstream-oil-and-gas-investment-outlook-2024/download.

gas, we believe (and the IEA Methane Tracker concurs[31]) that the net cost (so-called marginal abatement cost) is actually negative.

Associated gas capture projects and the development of related infrastructure can be subject to restrictions on funding applied by international financial institutions to hydrocarbon projects. Financing in the oil and gas sector is becoming increasingly difficult to attract because many commercial and multilateral banks are avoiding the sector, potentially concerned about (a) their own market perception around being seen to invest in "fossil fuels" or to create infrastructure and behavioral "lock-in," (b) too high country or project risk, and/or (c) a lack of finance-ready investable projects. One executive at a multilateral bank captured the sentiment saying, "*Why should we invest in gas flaring when the companies themselves can do so and it's in their own interest to reduce flaring?*" Yet not financing flare-capture projects will not make the problem go away—not least because some of the biggest flaring countries are often also those with the lowest cost of oil production, so those assets are likely to be around the longest and the slowest to be "transitioned."

While supermajors typically have the financial resources to develop flare-reduction projects should they choose to allocate capital to them, the same is not necessarily true for independent international oil companies, NOCs and governments. Since flare-capture projects are often perceived by oil and gas companies as "non-core" activities—coupled with the perception that their commercial returns are lower than other investment opportunities—companies frequently are not motivated to allocate scarce capital to such projects. Where infrastructure is to be developed to serve multiple upstream fields, even supermajors might seek to raise project financing rather than funding the infrastructure from their own resources.

Moreover, when governments approve flare-reduction projects, they may suffer reduced cash flows for a period of a few years, while companies recover their costs from oil revenues that otherwise would have been part of the government "take." Where the NOC is a project investor, the government might need to inject capital or to forego dividends for a period of time, which could negatively impact State budget revenues and compete with national spending priorities. Thus, even where a project is economically attractive to a government in the medium and long-term, the government might require short-term financing to cover the budgetary hole arising during the cost recovery period.

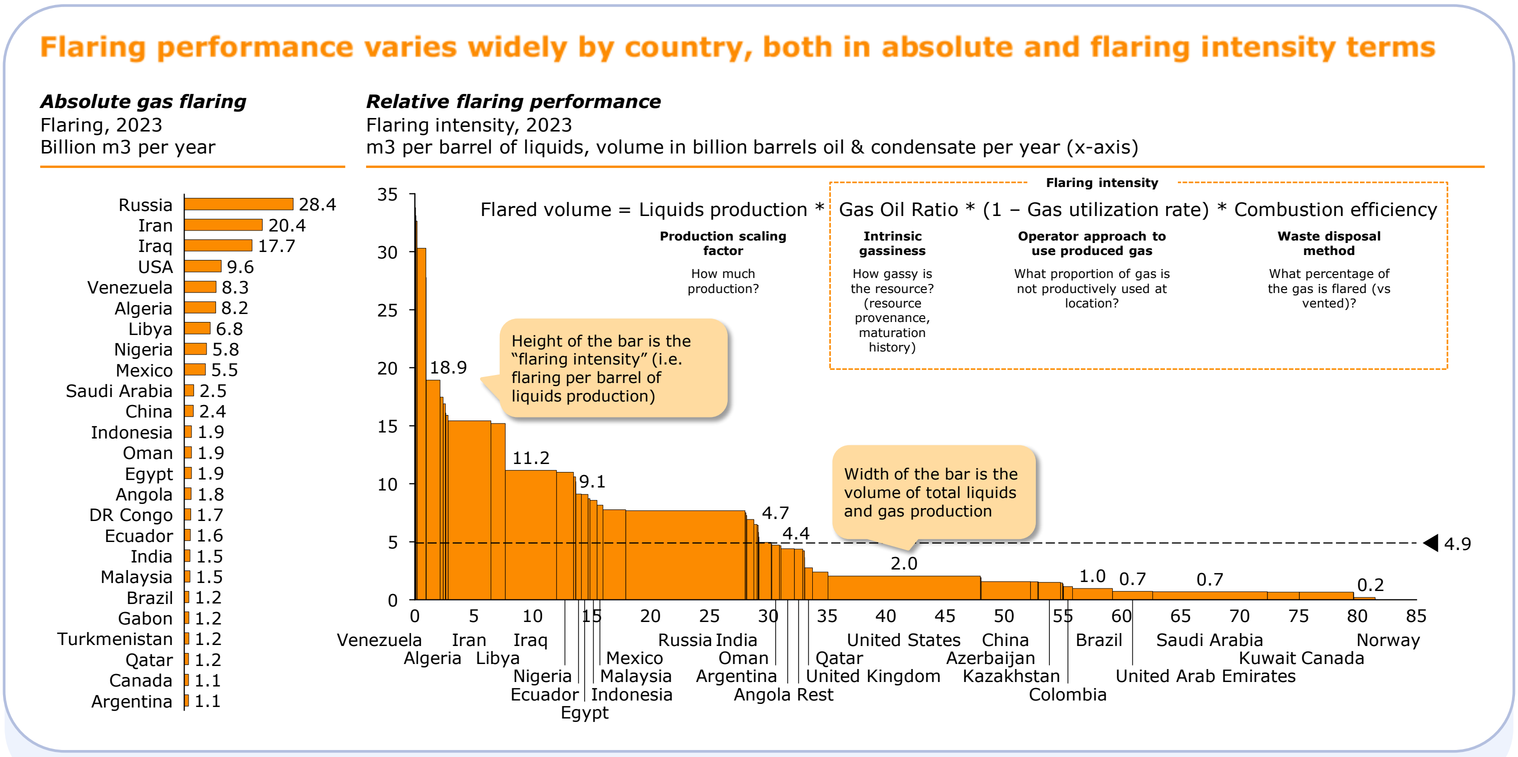
In part due to the complexities outlined above, flare reduction is not always treated as a core strategic priority by some NOCs and IOCs alike. In some instances, flaring is excluded from day-to-day operational planning or broader investment frameworks. Chronic flaring is sometimes classified as "exceptional," and opportunities for collaboration on shared solutions between IOCs and NOCs may go unrealized. Some IOCs do not access available dedicated mechanisms such as trust funds and/or resist reasonable penalties using stabilization clauses, and they rarely adapt infrastructure to accommodate third-party gas. Similarly, flare reduction in many cases is not treated as a priority by NOCs and others despite laudable commitments and strategic vision statements. By neglecting to lead on this issue—operationally, financially, and reputationally—they miss both mitigation opportunities and long-term value creation.

Addressing Flaring Complexity Globally

Despite their complexity, flare-capture projects can be done with proper leadership, determination, and policies. The best proof is that many oil-producing countries have successfully overcome barriers and limited flaring. Flaring varies widely by country, both on an absolute volume basis, and on a relative (i.e., flaring intensity) basis, as shown

31 International Energy Agency (IEA), Global Methane Tracker 2024, (2024), https://www.iea.org/reports/global-methane-tracker-2024.

in Figure 3. This variation in flaring intensity reflects both hydrocarbon chemistry (the "gassiness" of the oil) and operational performance (how produced associated gas is handled by the producing companies)—the latter is determined in part by regulation, policy, commitment, and leadership.



Source: World Bank; Capterio analysis.

Figure 3: Global country league table of flaring on an absolute basis (BCM per year) and a relative basis (i.e., flaring intensity, or flaring per barrel of oil and condensate produced). The large range in flaring intensity is driven by three main factors, namely the "gassiness" of the oil (its Gas-Oil ratio), the percentage of associated gas that is recovered and the percentage of the gas sent to the flare that is combusted (so called "combustion efficiency").

As the graphic shows, many of the countries that have successfully limited flaring are developed countries with diversified economies, with hydrocarbon sectors that rely to a large extent on the private sector or on national oil companies with listed shares that operate in a manner similar to private sector companies. While most of these countries could do more (particularly the United States), operators in all of them have managed to implement flare-capture projects despite their complexity.

- *Norway*[32] benefits from very low flaring volumes (0.1 BCM in 2023) and flaring intensity (approximately 0.2 m^3/bbl in 2023). Its hydrocarbon sector is operated by a mix of a publicly listed but majority state-owned company (Equinor), together with private sector participants. Operators own all produced associated gas, and have the opportunity to monetize it, through well-developed infrastructure that includes an undersea gas pipeline network into the European Union (EU) market. Norway imposes strict regulations on flaring, prohibiting both gas flaring and venting. Operators are required to have a solution in place for gas in their field development plans, with required measurement and reporting of flaring and venting. Norwegian authorities must approve any flaring and venting for operational safety. Norway also applies substantial financial incentives, including a CO_2 tax on flared or vented gas and CO_2 separated from petroleum, fines and penalties for gas emissions and combustion (equivalent of US$69 per metric ton of CO_2 in June 2023), and a requirement that operators participate in the EU emissions allowance scheme.

32 "Global Gas Flaring and Methane Reduction Regulations Norway," Case Studies, World Bank Group, December 2023, https://flaringventingregulations.worldbank.org/norway. See also, "Tackling flaring: Lessons from the North Sea," Capterio, October 2020, https://flareintel.com/insights/tackling-flaring-lessons-from-the-north-sea.

- In the *United States*, flaring volumes are significant, at 9.6 BCM in 2023, but flaring intensity is well below the global average at 2.0 m^3/bbl in 2023. The US hydrocarbon sector is subject to multiple regulatory schemes, depending on whether the resources are located on federal, state, or private land. Environmental issues are also regulated at both the federal and state levels. According to the World Bank, approximately 90% of US flaring occurs on state-regulated lands.[33] The industry is operated by the private sector, both in upstream production as well as transportation, processing, domestic use of gas, and (most recently) export of natural gas in the form of LNG (much of which is captured associated gas). Beyond the value to be captured from monetizing associated gas, a variety of fiscal measures provide financial incentives for gas capture, including royalties payable on gas considered to be wasted[34] as well as fees on unavoidable flaring and the release of methane (although methane fees adopted in 2024 were repealed by Congress in February 2025[35]). Under certain jurisdictional schemes, flaring requires government authorization, which can be granted where infrastructure is insufficient to allow the flared gas to be used.[36] Recent studies show that flaring in the United States is driven by sensitivity to oil prices and oil production, the availability of infrastructure or lack thereof (particularly in recent years, as oil production sharply increased in shale basins with high oil prices), insufficient independent regulatory limitations on flaring, and other operational factors.[37]
- *Brazil*[38] has low flaring rates, with 1.2 BCM of gas flared in 2023 and flaring intensity of only 1.0 m^3/bbl. Its hydrocarbon sector is dominated by Petrobras, which is state-controlled but with publicly listed shares. Private sector participation in the hydrocarbon sector has also grown significantly over the last two decades. About 80% of Brazilian natural gas production is associated gas, produced at offshore oilfields.[39] While Brazil has a substantial domestic gas sector, the majority of Petrobras' associated gas is re-injected for enhanced oil recovery or consumed in production operations—in 2023, Petrobras produced 31.4 BCM of gas and sold only 11.8 BCM.[40] Petrobras also re-injects CO_2 released directly from producing reservoirs to enhance oil recovery,[41] although it has announced plans to store CO_2 in depleted offshore reservoirs, or to deliver it onshore

33 The World Bank, 2024 Global Gas Flaring Tracker Report, p. 22.

34 U.S. Department of the Interior, Bureau of Land Management, Final Rule: Waste Prevention, Production Subject to Royalties, and Resource Conservation, 43 CFR Parts 3160 and 3170, 2024, BLM Waste Prevention Rules, https://www.federalregister.gov/d/2022-25345.

35 For a report on the repeal of these rules, see Michael Phillis and Matthew Daly, "Congress votes to kill Biden-era methane fee on oil and gas producers," AP News, February 2025, https://apnews.com/article/methane-fee-repeal-epa-oil-gas-drilling-4844558bece1e683da9246ee226c57b5.

36 For example, flaring in Texas (one of the US states with the largest volume of flared gas) requires authorization from the Texas Railroad Commissioners. The number of flaring permits in Texas substantially increased in 2022 and 2023 as oil production increased due to higher prices, while there was not sufficient gas pipeline infrastructure to absorb the associated gas. Andrew Wheat, Permission Granted: Texas Oil and Gas Regulators on Track to Allow More Flaring Waste than Ever (Commission Shift, Texans for Public Justice, and Rio Grande International Study Center (RGISC), September 2024), https://commissionshift.org/wp-content/uploads/2024/09/Permission-Granted-Texas-Oil-and-Gas-Regulators-On-Track-to-Allow-More-Flaring-Waste-Than-Ever.pdf.; "Global Flaring and Methane Regulations United States of America: Texas," Case Studies, World Bank Group, December 2023, https://flaringventingregulations.worldbank.org/united-states-texas.; "Our Estimated Rate of U.S. Natural Gas Flaring Declined in 2023," U.S. Energy Information Agency, June 2024, https://www.eia.gov/todayinenergy/detail.php?id=62383. Comparing historical flaring in various states of the United States of America.

37 For instance see: Nicholas Kusnetz, "Millions Pour In to Re-Elect Texas Oil and Gas Regulator," Inside Climate News, October 22, 2024, https://insideclimatenews.org/news/22102024/millions-pour-in-to-reelect-texas-oil-and-gas-regulator/; Commission Shift, "New Texas Flaring Website and Report Flags Regulatory Lapses that Hurt Texans' Health and Wealth," press release, March 27, 2025, https://commissionshift.org/news/new-texas-flaring-website-and-report-flags-regulatory-lapses-that-hurt-texans-health-and-wealth/.

38 "Gas Flaring and Methane Reduction Regulations Brazil," Case Studies, World Bank Group, December 2023, https://flaringventingregulations.worldbank.org/Brazil.

39 Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP), Pré-Sal Petróleo S.A., Empresa de Pesquisa Energética, and The Banco Nacional de Desenvolvimento Econômico e Social, Study on the Use of Natural Pre-Salt Gas (2020), https://www.gov.br/anp/pt-br/centrais-de-conteudo/publicacoes/livros-e-revistas/arquivos/inglesaproveitamentognpresal.pdf.

40 Petrobras, Annual Sustainability Report, p. 75, https://petrobras.com.br/en/sustentabilidade/relatorios-anuais. Figures are based on average daily production and sales gas reported by Petrobras of 83.1 MCM/d and 32.3 MCM/d, respectively.

41 Petrobras, Strategic Plan 2050: Business Plan 2025-2029 (November 2024), p.80, https://www.investidorpetrobras.com.br/en/presentations-reports-and-events/presentations/.; Jaime Naveiro, Offshore Technology Conference: Leading the Global Energy Evolution, Petrobras' Experience on CCUS (Houston: Petrobras, May 2024), https://www.investidorpetrobras.com.br/en/presentations-reports-and-events/presentations/.

for utilization or permanent storage.[42] Flaring is strictly prohibited by law in Brazil except for safety or emergency reasons, with substantial penalties payable for unauthorized flaring. Significantly, Brazilian authorities have levied significant fines on Petrobras for unauthorized flaring.[43] Petrobras reports that it has reduced its Scope 1 and 2 GHG emissions by 41% and methane emissions by 68%, in each case between 2015 and 2023, and that its upstream emissions intensity has declined by 54% from 2009 to 2023.[44]

As these examples show, success in capturing flared gas is not limited to a single model. In addition, some countries with state-dominated hydrocarbon sectors have low flaring volumes and intensities, largely resulting from decisions made decades ago to capture the value of associated gas through domestic industries and export opportunities. In particular, for the past half century the United Arab Emirates (UAE) and Saudi Arabia used their substantial associated gas resources as part of their initiatives to drive economic development. Their gas infrastructure today represents a highly valuable asset that both countries have leveraged to generate funding opportunities for further expansion.

The success of initiatives in UAE and Saudi Arabia was underpinned by leadership who made bold strategic decisions to monetize wasted gas and create a world-first industry. While both countries (like the others discussed above) could undoubtedly do more, their flaring intensity is well below the global average.

- *United Arab Emirates.* The UAE flared 0.9 BCM in 2023, with a flaring intensity of 0.7 m^3/bbl. It began to implement initiatives to capture associated gas in the 1970s, when it developed its first LNG facility and the first LNG facility in the region. In 1978, the Abu Dhabi Gas Industries Limited (GASCO) was established to monetize associated gas from onshore oil fields, supporting a growing petrochemicals industry. Significant investments followed in the early 1980s (including a spend of $2.1 billion – in money of the day – between 1977 and 1981) to gather and process flared gas (e.g., from the Umm Shaif, Uweinat, and Thamama fields) to provide domestic power, and to support new LNG export facilities and a growing LPG market. Soon to follow was the creation of Shalco (Sharjah Liquefaction Company in 1984), dedicated to recovering LPG from associated gas. The UAE has been a net gas exporter since 2008, with both associated and non-associated gas resources. In 2023 ADNOC (the state oil company) spun off an interest in its gas processing business, ADNOC Gas, in an initial public offering that raised US$2.5 billion for a 5% stake. ADNOC Gas reports processing capacity of around 10 billion standard cubic feet of gas per day (bscf/d) and 29 million metric tons per year (MTPA) of liquids, supplying 60% of the UAE's gas needs and exporting natural gas and related products to a diverse customer base in over 20 countries.[45]
- *Saudi Arabia.* Flaring in Saudi Arabia was 2.5 BCM in 2023, largely reflecting the size of its oil sector, as flaring intensity was only 0.7 m^3/bbl. Saudi Arabia began capturing associated gas to extract NGLs in the 1950s. Beginning in the 1970s, capturing flared gas became an essential part of the country's economic development, with major investments in the Master Gas System (MGS), an extensive network of pipelines that connects gas production and processing facilities throughout the Kingdom, initially designed mainly to utilize flared gas.[46] As a result, flaring declined from almost 5 BCM per year in the mid-1970s to today's level. Along with the MGS, Saudi Arabia developed industrial cities with

42 Jaime Naveiro, Petrobras' CCUS Presentation, 7.

43 "Global Gas Flaring and Methane Reduction Regulations Brazil," Case Studies, World Bank Group, December 2023, https://flaringventingregulations.worldbank.org/Brazil.

44 Petrobras, Webinar: Climate Change Supplement Presentation (May 2024), p. 14, https://www.investidorpetrobras.com.br/en/presentations-reports-and-events/presentations/.; Petrobras, 2025-2029 Business Plan, p. 84.

45 Historical Information and information on ADNOC Gas current capacity is taken from <ADNOC Gas, Annual Report 2023, p.5, 7, https://adnocgas.ae/en/investor-relations/results-reports.>

46 "Gas Production," Saudi Aramco, Saudi Arabian Oil Company, https://www.aramco.com/en/what-we-do/energy-products/gas-production.; Rebecca Wallace, "Master Gas System: Fueling a Nation," Saudi Aramco, 2020, https://www.aramco.com/en/news-media/elements-magazine/2020/master-gas-system-fueling-a-nation.

users of natural gas for power generation, petrochemicals, and other industries, and in 1976 it created a company, SABIC, to turn waste gas into chemicals. Today SABIC is one of the world's largest chemical producers.[47] By 1986, the MGS had been expanded to include offshore fields, allowing the state-owned Aramco to produce up to 21 BCM per year. Aramco reports that the MGS now enables the company to utilize all the gas it produces domestically, with the main consumers being the power generation industry, followed by petrochemical and refining industries, cement and desalination plants, and fertilizer and steelmaking facilities. In 2021, Aramco raised $15.5 billion through a sale-and-leaseback transaction with BlackRock for the natural gas pipeline network.[48] In June 2024 Aramco announced the award of contracts worth more than $25 billion to progress its strategic gas expansion, targeting sales gas production growth of more than 60% by 2030, compared with 2021 levels.[49]

These examples show that it is not only possible to capture and utilize associated gas, but that doing so can be highly lucrative. Not only does the sale of associated gas generate direct revenues, but revenue-generating companies and assets associated with the flare-reduction value chain, once they are operational and relatively mature, can be packaged and sold (or leased) to investors for substantial sums.

47 "Our History," Integrated Report 2023, SABIC, https://www.sabic.com/en/reports/integrated-report-2023/at-a-glance/our-history.

48 "Saudi Aramco Announces $15.5 Billion Landmark Gas Pipeline Deal with Global Consortium," Saudi Press Agency, 2021, https://www.spa.gov.sa/w1661232.

49 Saudi Aramco, "Aramco's Strategic Gas Expansion Progresses with $25B Contract Awards," news release, June 30, 2024, https://www.aramco.com/en/news-media/news/2024/aramcos-strategic-gas-expansion-progresses-with-25bn-contract-awards.

3. Case Studies

The countries discussed in the prior section have had success overcoming the complexity of flare reduction, and as a consequence they all have flaring intensity well below global averages. Other countries have experienced more mixed results. We focus on some of these in our case studies.

Of course, not all countries have the benefit of large, diversified economies or the wealth of countries such as the UAE and Saudi Arabia. Many oil-producing countries with hydrocarbon sectors concentrated in state bodies struggle to contain associated gas flaring. Countries such as the Russian Federation, the Islamic Republic of Iran, and the Bolivarian Republic of Venezuela, which are three of the five largest flaring countries in the world, have been impacted in recent years by international sanctions.[50] Still other countries have grappled with issues such as regional and local conflicts and geopolitical issues, the need to employ and provide for large population bases, a lack of diversified economic opportunities, political inertia and corruption, and high sovereign debt burdens.

Our case studies show that even in these countries, capturing and utilizing flared gas represents a major opportunity to generate wealth, enhance energy security (particularly in countries with increasing gas and power demand and declining production), and foster decarbonization.

We start with three examples of projects that have captured and utilized associated gas in these types of countries, although each in very different circumstances:

a) Angola LNG, where IOCs and the government created conditions for a major infrastructure project—an LNG facility—to use associated gas and generate export revenues (the project also provided butane and natural gas for the domestic market).

b) Sarqala, a field in Iraqi Kurdistan, where the regional government saw a need to satisfy local demand for power generation and recognized that putting in place modular power capacity fueled with associated gas was the most effective way to do this.

c) Los Toldos Este II, a project in a remote location in Argentina, where the most feasible solution to produce oil without flaring was to use associated gas in an innovative manner, to power a cryptocurrency mining data center[51]

We also present three country-based case studies of flaring in three hydrocarbon-producing countries which have seen moderate success in reducing flaring, but they have also had opportunities to do more:

a) The Republic of Iraq (excluding the Kurdistan Region), which is making progress (after years of ineffectiveness following the creation of a major gas capture project in 2011) toward its announced goal of eliminating routine flaring by 2028, spearheaded by the multi-faceted Gas Growth Integrated Project established in 2021, with the benefit of strong leadership commitment.

b) The Arab Republic of Egypt, which has achieved modest success in reducing flaring in recent years, but has the opportunity to do more, addressing its energy security and domestic gas needs (as Egypt's gas exports have significantly declined in recent

50 We have not done case studies on these countries due to the complicating factor of international sanctions. Many of the recommendations in this report would be useful in these countries if the sanctions were eased or lifted. A prior CCSI study conducted in 2016 (before severe sanctions were applied) included an analysis of efforts to capture and use associated gas in the Russian Federation. See Shayan Banerjee and Perrine Toledano, A Policy Framework to Approach the Use of Associated Petroleum Gas (Columbia Center on Sustainable Investment, Columbia University, 2016). A recent article discussed the potential for flare reduction (largely through reinjection) in the Islamic Republic of Iran. Also see Ali Mohammadi Dinani, Amin Nassaji and Tayebeh Hamzehlouyan, An optimized economic-environmental model for a proposed flare gas recovery system (2023), https://www.sciencedirect.com/science/article/pii/S2352484723001129?via%3Dihub.

51 The authors of this report do not endorse cryptocurrency mining, but believe that if it is to occur, the substantial power usage it requires should be generated in as GHG-friendly a manner as possible.

years, while domestic demand has increased). Egypt's national model is a single state-owned purchaser system. While reforms could be beneficial, Egypt can reduce flaring under its current model with a robust national roadmap that includes prioritizing purchases of associated gas, utilizing underused transport and export infrastructure, and developing common processing and connection infrastructure among multiple flare sites to realize economies of scale.

c) The People's Democratic Republic of Algeria, where flaring intensity is particularly high by global standards despite some progress in capturing gas in recent years. Through improvements in data availability, profitable flare-capture opportunities have been identified in Algeria, which has both substantial domestic gas demand and underutilized export infrastructure. Algeria could incentivize flare reduction by enforcing existing substantial flaring penalties. Solving flaring (and venting) will be crucial for Algeria as the European Union (its major export customer) will restrict the import of oil and gas with high flaring intensity in the coming years.

The case studies are also selected from countries that have wide variations in average flare size (according to the World Bank): 9 million scf/day in Iraq, 4 million scf/day in Angola and Algeria, 1.3 million scf/day in Egypt, and 0.7 million scf/day in Argentina. Naturally, there is also a large variation in flare size by country, but the reader might draw inspiration from the fact that solutions are possible over a range of scales.

The case studies are based to a large extent on the direct experience of the authors of this article with the projects and countries reviewed, complemented by primary and secondary sources, as well as interviews with project participants (on an anonymous basis, as the people involved were concerned about the sensitivity of the projects). The in-depth studies also include detailed flaring data captured and analyzed with Capterio's FlareIntel platform, excerpts of which are presented in the summaries.

Our primary conclusion is that the main factor driving successful flare reduction is committed leadership and determination, on the part of governments, NOCs, and IOCs. This was crucial in each of the three project-based case studies, and in achieving a degree of success in each of the three countries that we studied. While there are many technical and economic factors at play, we believe they can be addressed and the complexities can be overcome with commitment and focus.

Our full in-depth case studies are in the Annex to this report, which is available here.[52] In the remainder of this Section we provide brief summaries of the case studies and our main conclusions, followed by a discussion of key insights from the case studies in the next Section.

52 For simplicity, our case study summaries do not include citations to sources, and we refer readers to the in-depth studies in the Annex for source information.

A. Republic of Angola (ALNG)

Angola's LNG (ALNG) project was a first-of-its-kind LNG initiative designed principally to monetize flared associated gas for domestic use and international export.

Success was driven by strong leadership, project design (with built-in alignment along the value chain), and government fiscal flexibility.

Economic returns were impacted by delays and operational issues (including a lack of promised top-up non-associated gas), but the project nonetheless provided a much-needed flaring solution.

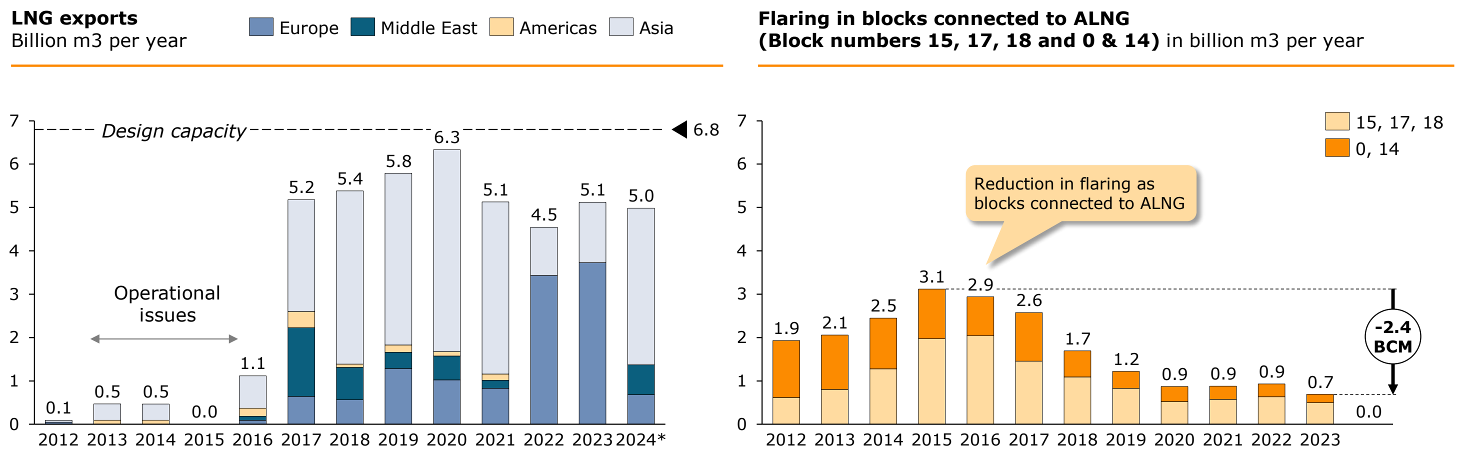
At a Glance:

2023 Flaring Volume in Angola has reduced to 1.8 BCM per year (from nearly 7 BCM in the late 1990s). Flaring declined dramatically after ALNG came on line fully in 2017.

Flaring Volume Global Ranking: 16th

2023 Flaring intensity in Angola was 4.4 m^3 per barrel, below the global average of 4.9 m^3 per barrel.

Flaring at the fields supplying gas to Angola's LNG plant dropped - after a rocky start



* Annualized rate based on Jan-Aug data

Source: Kpler; Author analysis; World Bank.

Figure 4: Angola's LNG output from ALNG by destination, plus gas flaring from the blocks that supply gas to the LNG project and the flaring from the designated blocks.

Flaring Context in Angola

Today, Angola is the 18th largest oil producer globally, with production of 1.1 million barrels per day. Its flaring was 1.8 BCM in 2023, ranking 16th globally. Angola's flaring intensity is modestly lower than the global average at 4.4 m³ per barrel. Angola's rise as a major oil-producing nation began in the 1960s but accelerated significantly after the country's civil war, with the discovery of numerous prolific deepwater fields in the 1990s. International multinationals helped propel Angola—and its NOC (Sonangol)—into the international spotlight.

Around this time, several operators began focusing on solutions for flaring. By the late 1990s, flare mitigation efforts were centered on gas re-injection and gas and limited condensate recovery. Although penalties for flaring were written into Production Sharing Agreements, they were not enforced. However, with a new deepwater province on the cusp of development, the government identified a major opportunity to implement a structural solution.

Overview of the ALNG Project

As plans to develop several large deepwater discoveries took shape in the early 2000s, the government and Sonangol adopted a more proactive approach to flare reduction. In the late 1990s, Sonangol issued a call to the industry for creative solutions to the national flaring challenge, which had risen to over 6 BCM per year by 1998. The proposal from Texaco (now Chevron)—to create a new LNG export terminal (called Angola LNG or ALNG)—was the most attractive and received strong support from Sonangol and the government. International partners were mobilized, driven in part by a new directive that deepwater developments planned by ExxonMobil, bp, ENI, Total (now TotalEnergies), and Statoil (now Equinor) could not progress without robust plans to commercialize the associated gas.

The ALNG project involved gathering flared gas from numerous upstream fields and transporting it via 500 km of new pipelines to a liquefaction and storage facility in Soyo, Angola. ALNG was designed to process 1.1 bcf/day (approximately 11 BCM annually), producing up to 5.2 million metric tons per year of LNG (equivalent to approximately 6.8 BCM of gas), along with 63,000 barrels per day of NGLs/LPG and 125 million scf/day of domestic gas.

ALNG Project and Outcomes

Despite significant capital cost overruns and many operational challenges in its early years, ALNG has been operational since 2013. It has supplied LNG to 26 countries and generated over $20 billion in cumulative revenue from LNG, LPG, and domestic gas sales. ALNG helped Angola reduce flaring by 73% since its peak in 1998. Additionally, ALNG has decarbonized Angola's oil production by (depending on the assumptions made and the counterfactual comparator) 14 million to 39 million CO_2-equivalent metric tons per year, lowering the CO_2-equivalent intensity per barrel by up to 10%–15%. The project's commercial performance has, however, been underwhelming, mainly due to many technical challenges in the early years (leading to an average utilization rate around 10% in the first five years), and it has never reached design capacity (average utilization was around 80% from 2017 to 2023).

Key Success Factors and Broader Learnings

Despite the challenges, the success of ALNG in capturing and utilizing associated gas was made possible by overcoming fierce technical, commercial, organizational, and political challenges in three key areas. First, Sonangol and the government demonstrated strong, committed leadership with a relentless focus on finding a solution. Second, the project design was both complex and unique, requiring close collaboration and integration across the supply chain, from diverse upstream fields to the onshore liquefaction plant. Third, although the government faced economic hurdles and a strong dependence on oil revenues, its flexibility and creativity in fiscal frameworks, cost-recovery mechanisms, and capital allowances were critical (we discuss the details of these in our full in-depth case study). Additionally, the government de-risked gas supply by committing to use "make-up" gas from non-associated fields if necessary (although to date this has not been forthcoming).

B. Kurdistan Region of Iraq (Sarqala Field)

A significant gas-to-power project capturing up to 40 million scf/day of flared gas and generating up to 165 MW of power to the regional grid was delivered at the Sarqala field in the Kurdistan Region of Iraq.

Project success was attributed to the need for power addressed by government leadership, and the deployment of a modular and scalable solution.

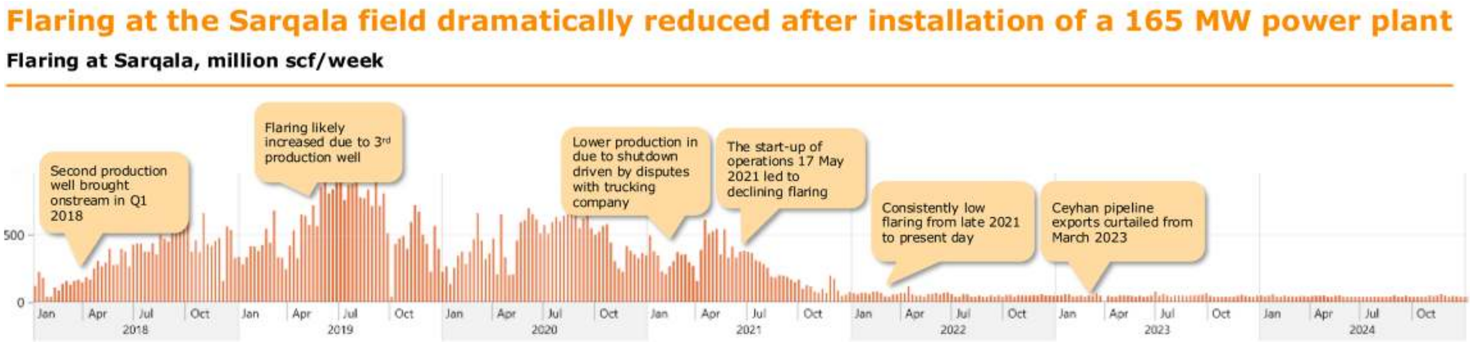
Flared gas from the Sarqala field was identified as a source to fuel the badly needed power generation capacity.

At a Glance:

2023 Flaring Volume: 5 million scf/day, down from a peak of 50 million in 2020.

Modular power plant has generated stable electricity for regional population.

Repeatability in other fields is somewhat constrained by unreliability of KRG in making payments to operators, and challenges around high H2S content of gas from the other fields.



Source: Capterio FlareIntel.

Figure 5: Profile of gas flaring at Sarqala from FlareIntel Pro. The dramatic reduction in flaring, of up to 40 million scf/year since the start of operations on May 17, 2021, has been sustained, suggesting a combination of continued strong operational performance. Its continuation depends on whether the lease for the modular power plant is extended beyond its scheduled end in 2025.

Flaring Context in Iraq and Kurdistan:

In 2023, the Kurdistan Region of Iraq (KRI) contributed 8% of Iraq's 17.7 BCM of flaring (1.4 BCM, down from 2.2 BCM in 2022, due largely to reduced oil production, as the export pipeline through Türkiye was shut from March 2023). In 2022, the region's flaring intensity was 14.0 m^3 per barrel (2.8 times the global average). The KRI has substantial power demand driven by domestic (summer air-conditioning) and local industry (cement and steel) needs, most of which is met by gas (generating around 85% of the region's electricity). Motivated largely by the objective of the Kurdistan Regional Government (KRG) to create a reliable power source, and also by a government push to reduce flaring, companies have tried to accelerate flare-reduction projects in order to reduce wasted gas. Despite these efforts, progress has been stifled by certain political, economic, and commercial challenges.

Overview of the Situation

The Kurdistan Region Parliament adopted a 2007 Oil and Gas Law aimed at creating an independent regional oil and gas sector. Although this law was ruled unconstitutional, the sector's activities continue to operate under it. Flaring is not regulated under the law, but instead is covered in Production Sharing Contracts (PSCs) that in most cases provide the regional Ministry of Natural Resources (MNR) with substantial discretion regarding the use of associated gas. Under most PSCs, the KRG not only has all the rights to associated gas at no cost, but it also has the responsibility to fund any required gas infrastructure. The PSCs prohibit the operator from flaring for more than 12 months, although the KRG does not regularly enforce this, and there are no financial penalties for flaring.

Main Flare Challenges in the Kurdistan Region of Iraq

Several challenges to flare reduction are worth considering in the KRI's context. First, the unconstitutionality of the 2007 Oil and Gas Law has made operating PSCs risky for international players. Second, subsidized (and low) power prices, as well as outdated infrastructure, pose economic challenges to successful flare-reduction projects. Third, the development of a proposed gas export pipeline to Türkiye has been stalled. Lastly, the presence of sour gas (i.e., gas with high H_2S content) in some of the oil fields adds complexity and cost.

Sarqala Project and Outcomes

The Sarqala field, located in the Garmian PSC block of eastern Kurdistan and operated by Gazpromneft, saw a successful flare-capture project that overcame some of the challenges outlined above. Fundamentally, the project was kick-started by a strong top-down push from the Kurdistan Regional Government, which was keen to reduce civil unrest from poor electricity delivery.

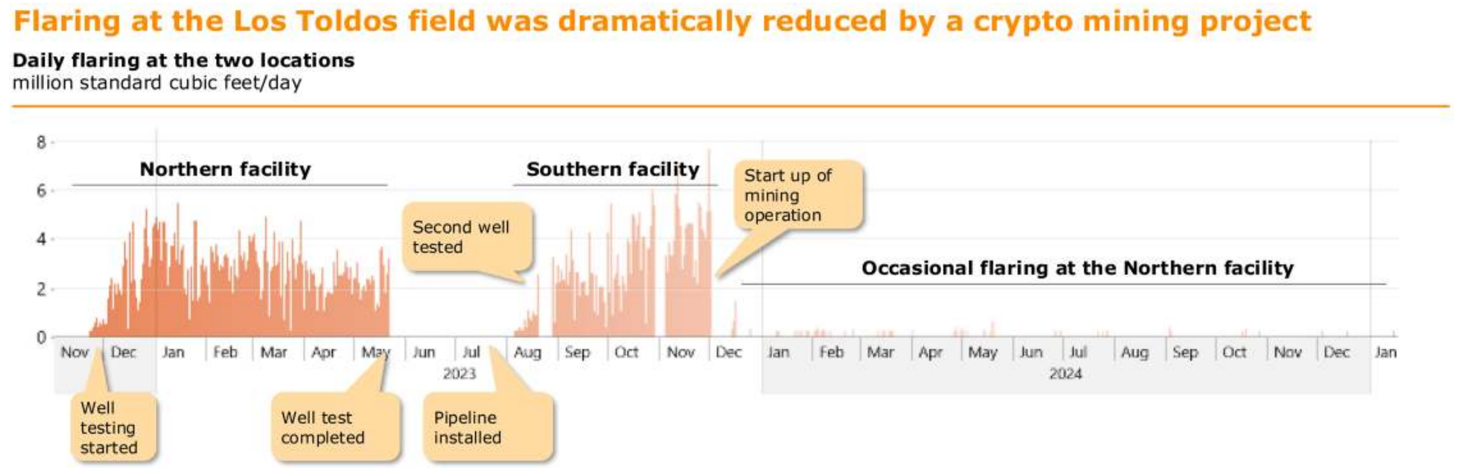
Before the project, the field flared up to 50 million scf/day, making it the second-largest flaring block in the region. However, in 2020, the KRG contracted Aggreko to construct a modular 165 MW gas-to-power facility, along with a 65 km pipeline to transport raw gas to the power plant. Aggreko also upgraded the regional power grid, adding a 33 km network of cables to connect nearby towns and overhead power conductors to support increasing power demand. The project was completed in seven months. Independent satellite-derived data confirm that flaring declined by over 40 million scf/day, leading to a lowering of gross CO_2-equivalent emissions by 800,000 metric tons annually. The project generated up to 1.3 TWh of electricity per year and annual power revenues of up to $90 million. Most importantly for the people of the KRI, the project delivered stable and reliable power and calmed civil unrest (although it remains to be seen whether this will continue, as it will require the extension of the lease of the modular power station, which expires in 2025).

Key Success Factors and Broader Learnings

The success of the Sarqala project starts with the determination of several individuals in regional government who were determined to address problems with power generation and stimulate the local economy. Second, the process was accelerated by interministerial collaboration. Third, both project delivery and economic viability were significantly helped by using a modular and scalable power solution, which could be delivered quickly. Opportunities to generate power and reduce emissions are present in the KRI (especially for low H_2S fields), but commitments from the KRG to ensure regular payments to power generation investors and upstream operators are a prerequisite to realizing those opportunities.

C. Argentine Republic: Los Toldos Este II (Flare Gas Recovery Through Cryptocurrency Mining)

Flaring at a new oil field development at Los Toldos in Argentina was significantly reduced by an innovative flare gas to cryptocurrency mining project. Project success attributed to strong local knowledge, relationships and expertise, support of national and provincial government, and leadership of the upstream operator.	At a Glance: This new oil field could have led to significant flaring throughout its life, but flaring was dramatically reduced once the cryptocurrency mining project was installed.



Source: Capterio FlareIntel.

Figure 6: Daily flaring at Los Toldos project. Significant flaring occurred during the early project setup and testing phase, but flaring has been minimal since the successful installation of the mining operation in December 2023.

Flaring Context

Argentina, Latin America's second-largest oil producer and its largest gas producer, is experiencing a shale boom driven by the prolific Vaca Muerta basin. This surge is powered by technologies pioneered in the United States, especially fracking and horizontal drilling. With production accelerating and flaring already reaching 1.1 billion m^3 annually (and poised to rise further), the issue is becoming an increasing focus for both national and provincial regulators.

Main Flare Challenges

Many areas in the rapidly developing shale region lie far from major demand centers or gas pipeline infrastructure. As a result, creative solutions are being explored for both legacy production and new projects. One such example is Los Toldos Este II, a new oil field where a flaring solution was built in from the outset.

In the absence of gas transport infrastructure, operator Tecpetrol partnered with project developer Unblock Computing and Crusoe Energy Systems to install 12 modular data centers, powered by eight 1.5 MW engines, to mine the cryptocurrency Bitcoin. Bitcoin mining was chosen over more conventional flaring monetization options for its economic simplicity. With no pipelines or nearby population, the ability to monetize gas with only a low-bandwidth satellite connection to the internet made it the most viable choice. A modest 15 km pipeline was constructed to connect a peripheral well site to the central processing facility.

Main Outcomes

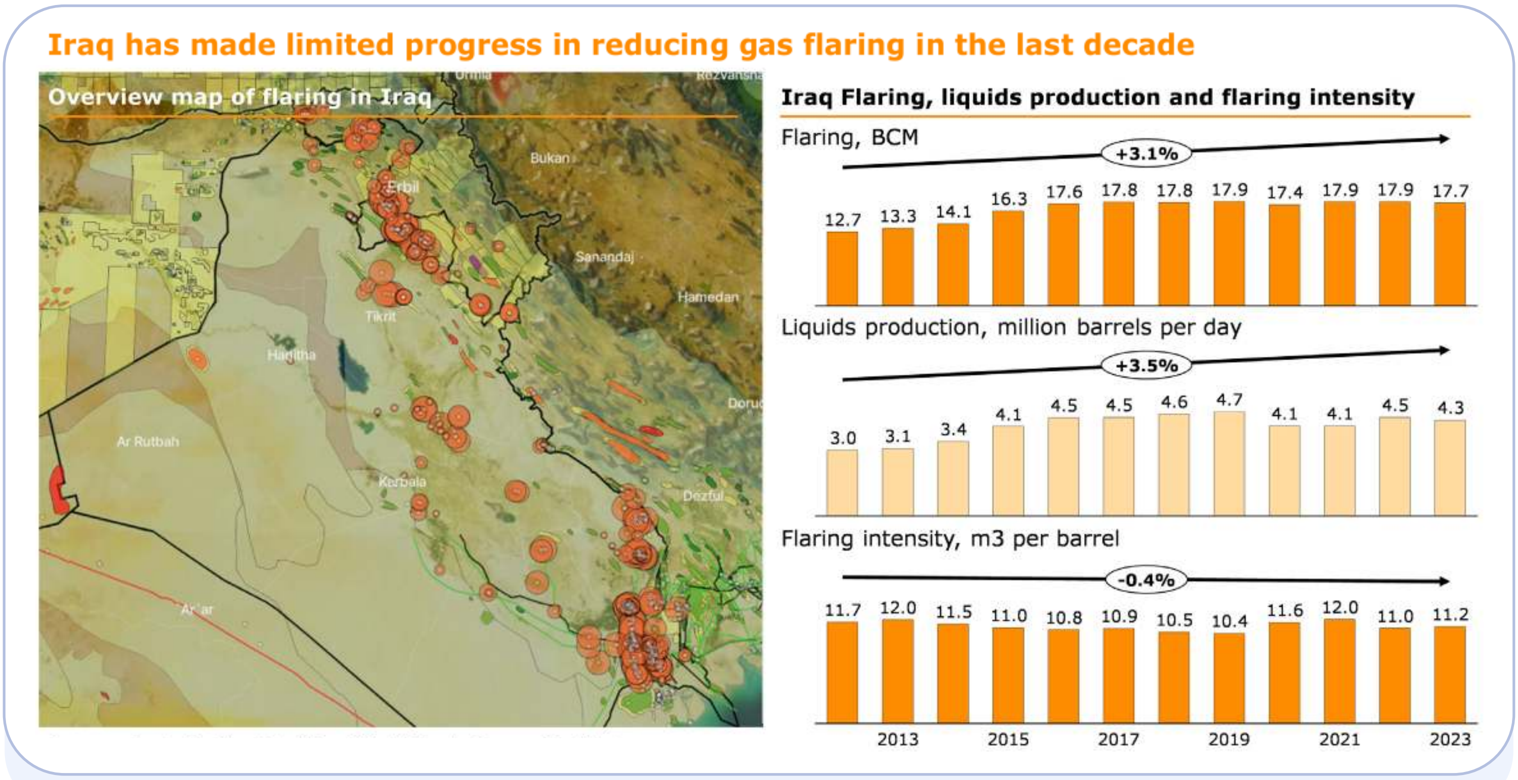
While the authors of this report do not endorse Bitcoin mining, it is recognized that the practice consumes large amounts of power and requires a GHG-friendly solution. At Los Toldos, the Bitcoin mining solution is estimated to have reduced emissions (including methane) by around 100,000 metric tons of CO_2-equivalent emissions, while also delivering attractive economics with a three-year payback. Some critics might argue that the project indirectly enabled increased oil production (and thus higher overall emissions), but a more pragmatic view is that this oil would have been produced anyway—and that reducing flaring represents genuine progress over the credible alternative.

Success Factors

Four key factors contributed to success. First, strong local relationships and deep regional knowledge simplified recruitment, regulatory approvals, and fundraising. Second, there was clear support from both national and provincial governments. Third, leadership from Tecpetrol was essential in driving the project forward. And fourth, the modularity and speed of deployment of the chosen technology allowed for rapid implementation in a challenging setting.

D. Republic of Iraq (Federal Iraq)

Iraq should be an ideal country for flaring reduction: substantial flared volumes, underutilized transport and power infrastructure, significant and growing demand for gas. Yet for years, Iraq's efforts to capture flared gas stagnated under financial and geopolitical pressure, coupled with ineffective decision-making. The trend is improving, with several major projects underway, spearheaded by the multi-faceted Gas Growth Integrated Project, as well as other recent projects. With its new momentum, Iraq may be on track toward its stated goal of eliminating routine flaring by 2028.	At a Glance: 2023 Flaring Volume: 17.7 BCM* Global Volume Rank: 3rd 10-year Flaring Trend: increasing early, then flat 2023 Flaring Intensity: 11.2 m^3/bbl Global Intensity Rank: 3rd 10-year Intensity Trend: Flat/Slight Decrease *16.3 BCM excluding the semi-autonomous Kurdistan Region, which administers its oil and gas sector separately.



Source: Capterio FlareIntel; World Bank.

Figure 7: Overview of flaring in Iraq (left) and profiles of gas flaring for Iraq (including Kurdistan Region), oil and condensate production and derived flaring intensity (flaring per barrel), right. Sourced from Capterio FlareIntel and the World Bank.

Flaring Context

Iraq has been one of the world's largest gas flaring nations for many years, behind only Russia and Iran, with 17.7 BCM flared in 2023 (or 16.3 BCM excluding the Kurdistan region, which has a separately administered oil sector). The government has pledged multiple times to eliminate routine flaring, but it has repeatedly missed deadlines. The country has struggled to reduce flaring due to financial constraints, political instability, and (until recently) a lack of effective policies. Fortunately, the situation has been improving, with several projects scheduled to come online in the next few years.

Iraq has an urgent need for gas to fuel power plants that currently run primarily on inefficient liquid fuels, and to reduce costly imports of gas and power from Iran. This is particularly critical during the summer months where extreme temperatures (up to 50° C) coupled with unreliable power generation and undersized power grids frustrate the population and create civil unrest. The government is arranging temporary LNG import facilities for the summer of 2025, although it is unclear whether these will be available on time.

Iraq's flagship flare-reduction project, Basrah Gas Company (BGC) (a joint venture between Shell, Mitsubishi and state-owned South Gas Company) began operations in 2013. It has had some success, capturing approximately 1 bcf/day (10.3 BCM/a) in 2023, which is impressive but only half of its initial objective. Flaring in the three fields supplying this project has increased after the project started, driven by increased oil production, but flaring has decreased in recent years as BGC's processing capacity has increased.

Starting in 2014, Iraq reduced investments in gas capture and processing under pressure from low oil prices (oil represents over 90% of the federal budget) and the need to devote resources to combating the Islamic State. Subsequent efforts to attract flare-reduction investments, starting in 2017, were hampered by disorganization and indecision, as Iraq's Ministry of Oil solicited investment proposals for gas processing facilities without providing guidance on its objectives and desired investment structures. The Ministry of Oil received multiple proposals with structures that required complex negotiation and could not be compared from one to the other (some of which were proposed by unqualified companies). A proposal by the World Bank to liberalize the Iraqi gas market was adopted in 2018 but never implemented.

An Accelerating Turnaround With Several Recent Projects

Things began to change in 2021, as the Ministry of Oil took a more determined approach. It signed agreements for the Gas Growth Integrated Project (GGIP), spearheaded by TotalEnergies, which was later joined by partners QatarEnergy and state-owned Basra Oil Company. The project aims to capture and process associated gas from three major fields—West Qurna 2, Majnoon, and Ratawi—eliminating up to 3.1 BCM/a of flaring by 2028–2029 (and possibly double that if a second phase goes forward). The project also includes a seawater treatment facility to free up fresh water currently used to maintain reservoir pressure for oil production, as well as a 1 GW solar power facility. With total capital expenditures estimated at US$10 billion, the project will be funded by increased oil production at the Ratawi field, which will be operated on a zero routine flaring basis. An accelerated gas processing unit to process 50 mmscf/day is scheduled to begin operations in 2025.

The GGIP is one of several projects inaugurated by the Iraqi Ministry of Oil in the last five years. Recent projects include a 300 mmscf/d facility at the Halfaya field; a planned 150 mmscf/d facility at the Nahr Bin Umar field; a 200 mmscf/d facility serving the Nasiryah and Gharraf fields; and an additional integrated project with bp at the giant Kirkuk fields. Other projects have been announced and are under study. Iraq is also initiating the development of its non-associated gas fields.

The Prime Minister has announced that two-thirds of associated gas is currently captured, and set a new deadline of 2028 to eliminate all routine flaring.

Broader Learning

The GGIP could represent a turning point, potentially showing that successful flaring reduction is possible even in a country with a heavily state-dominated hydrocarbon sector. Success in this context requires primarily a strong government commitment to back project implementation, going beyond announcements and studies. While Iraq's flare reduction ambitions might have been achieved more rapidly with a market-oriented approach incorporating financial incentives and flaring penalties, this is not within the country's tradition and, therefore, was not a realistic option.

In this context, although Iraq had opportunities to reduce flaring in earlier years, it was not until the government decided to push strongly for project implementation that it was able to move toward achieving its goals. Its ambitions are supported by determination from TotalEnergies, QatarEnergy, and Basra Oil Company, as well as the companies involved in other recent projects, giving Iraq prospects for near-term and medium-term success.

Iraq's recent projects also show that the country requires oil revenues to fund flare reduction, raising questions about the net GHG benefits it will be able to achieve after accounting for oil combustion (although arguably the increased oil production would occur with or without the flare-reduction projects). At the same time, by better utilizing its gas resources, Iraq should sharply reduce its consumption of heavy fuel oil and crude oil to generate power, increasing its electricity output while reducing its overall GHG emissions.

E. Arab Republic of Egypt

Egypt has had some recent success in reducing flaring, but it has shifted from a net exporter to a net importer of LNG in recent years. Additional flaring reduction could be part of the solution, but this will require determination from the government and Egypt's state-owned companies, which need to provide creditworthy offtake arrangements at acceptable prices and approve technical solutions, such as "cluster" facilities, to process and transport gas from scattered, small volume flares.

At a Glance:

2023 Flaring Volume: 1.9 BCM

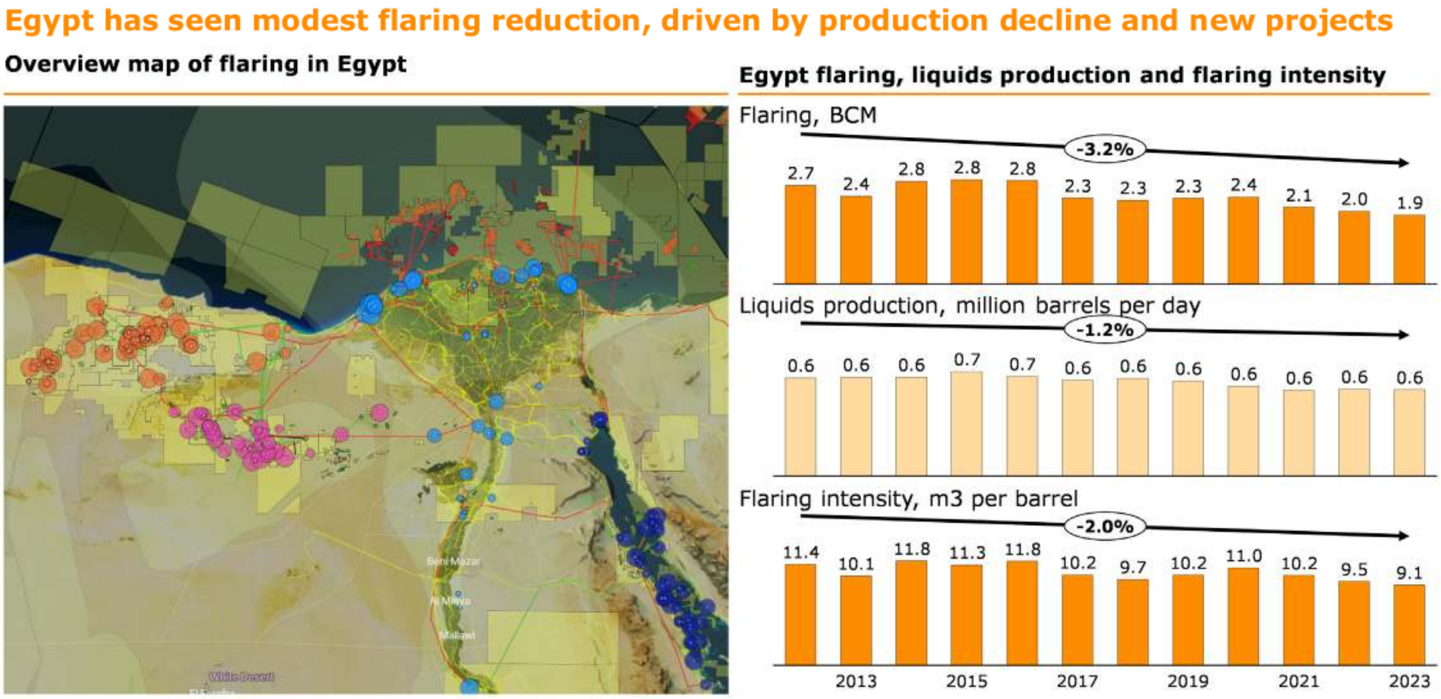
Global Volume Rank: 14th

10-year Flaring Trend: Modest decrease

2023 Flaring Intensity: 9.1 m^3/bbl

Global Intensity Rank (among top 20 by volume): 9th

10-year Intensity Trend: Flat, with recent modest decrease



Source: Capterio FlareIntel; World Bank.

Figure 8: Overview map of flaring in Egypt (color-coded by basin/region, left) and its underlying driver (oil and condensate production) and the derived flaring intensity (right). Map from FlareIntel shows the pipelines (green for oil, red for gas) the fields and the major powerlines (yellow). Flaring is modestly lower, driven mostly by improving flaring intensity (a measure of performance) but also partly by declining oil and condensate production.

Flaring Context

According to the World Bank, Egypt flared 1.9 BCM of associated gas in 2023, making it the 14th-largest flaring country globally. While this marks a modest improvement compared with prior years, Egypt's flaring intensity remains high at 9.1 m^3 per barrel, nearly double the global average of 4.9 m^3 per barrel.

The Egyptian government has made numerous public commitments to reducing flaring, signing the World Bank's Zero Routine Flaring by 2030 initiative and integrating flare reduction in the latest update of its Nationally Determined Contribution, and in its Petroleum Sector Energy Efficiency Strategy (2022–2035). However, implementation has been sporadic, and the regulatory framework remains restrictive. This is a missed opportunity when Egypt is importing LNG due to declining domestic non-associated gas production. A number of successful flare-capture projects have been delivered in recent years, including both gas-to-pipe projects and gas-to-(in-field) power projects, displacing existing diesel generators and diverting diesel to alternative markets.

Main Flare-Reduction Challenges

First, there are regulatory and contractual barriers: Egypt's concession agreements require operators to sell all gas to a state-owned company (usually the Egyptian Natural Gas Holding Company, or EGAS), or to obtain government permission to sell to other customers (losing fiscal benefits applicable to sales to EGAS). Concession agreements also provide for a heavy infrastructure approval processes, with no clear mechanism to develop common infrastructure for multiple contract areas (except in the case of LNG liquefaction facilities).

Second, the financial capacity of EGAS to commit to purchasing gas is limited, in part because it is required to resell gas for power and residential use domestically at regulated below-market prices. This means EGAS needs subsidies to buy gas from operators at prices that can support investments. Payment delays to international operators (approximately $6 billion in arrears reported in 2024) of non-associated gas fields is already limiting the appetite of operators to engage new investments in flare reduction without clear credit support.

Third, offtake infrastructure is limited in some regions, even though 75% of flaring sites are within 20 km of a gas pipeline. Many projects lack direct connections, making capture projects costly. Many flares in the Western Desert region are modest in size and scattered, making flare gas capture economics dependent on either using gas to generate power for local oil field operations, or on developing common (or "cluster") infrastructure to consolidate gas for efficient processing and transport.

Driving Flare Reduction in Egypt

Egypt depends on gas for power generation, residential heating, and industrial applications. Its current gas crisis—marked by falling production and rising and expensive imports—makes flare gas capture more urgent than ever. Its announced strategy is offshore non-associated gas licensing rounds, which are uncertain and require long lead times. By using flared gas, Egypt could increase domestic gas supply, reduce emissions, and enhance energy security while also unlocking new revenue streams.

Egypt should be able to overcome many of its challenges. Studies sponsored by the European Bank for Reconstruction and Development have suggested broad market reforms, and while these might be desirable (and are in part underway), significant progress can be made in the current context, before any major reforms are adopted.

The first step is for EGAS to stand ready to purchase captured associated gas at prices sufficient to generate investment. These should effectively be self-funding, reducing LNG imports or expanding exports. To facilitate the transition, international financial institutions should be ready to finance EGAS-associated gas purchases, to be repaid from revenue generated (or import costs saved) later.

From a technical perspective, Egypt can expand and optimize infrastructure with "flare clusters" to collect gas from multiple sources. It can also upgrade gas pipelines and compression facilities to enable wider gas utilization. Capterio data highlight that 75% of all flaring is less than 20 km from existing gas pipelines, which should provide opportunities for investments in facilities. Where this is not feasible, associated gas can generate power for in-field operations (already delivered at some fields), or possibly for innovative applications, such as data centers. At a minimum, NGL extraction can be considered so that any flares at least burn cleaner (while the NGLs generate value).

To achieve success, Egypt must move beyond its laudable public statements, reinforcing its institutional capacity to drive project implementation. It could establish a dedicated flare reduction task force drawn from government, EGAS, and IOC operators, supported at the highest levels of government, pursuing an aggressive strategy to incentivize and approve projects under existing concession agreements while broader market reforms are implemented.

F. People's Democratic Republic of Algeria

Algeria has a unique opportunity to significantly cut gas flaring—and associated venting and leaking—while capturing up to $2 billion in additional annual revenue, boosting energy security, and cutting emissions.

Seizing this opportunity will require strong leadership, a clear national road map, innovative business models, and more effective incentives.

At a Glance:

2023 Flaring Volume: 8.2 BCM

Global Volume Rank: 6th

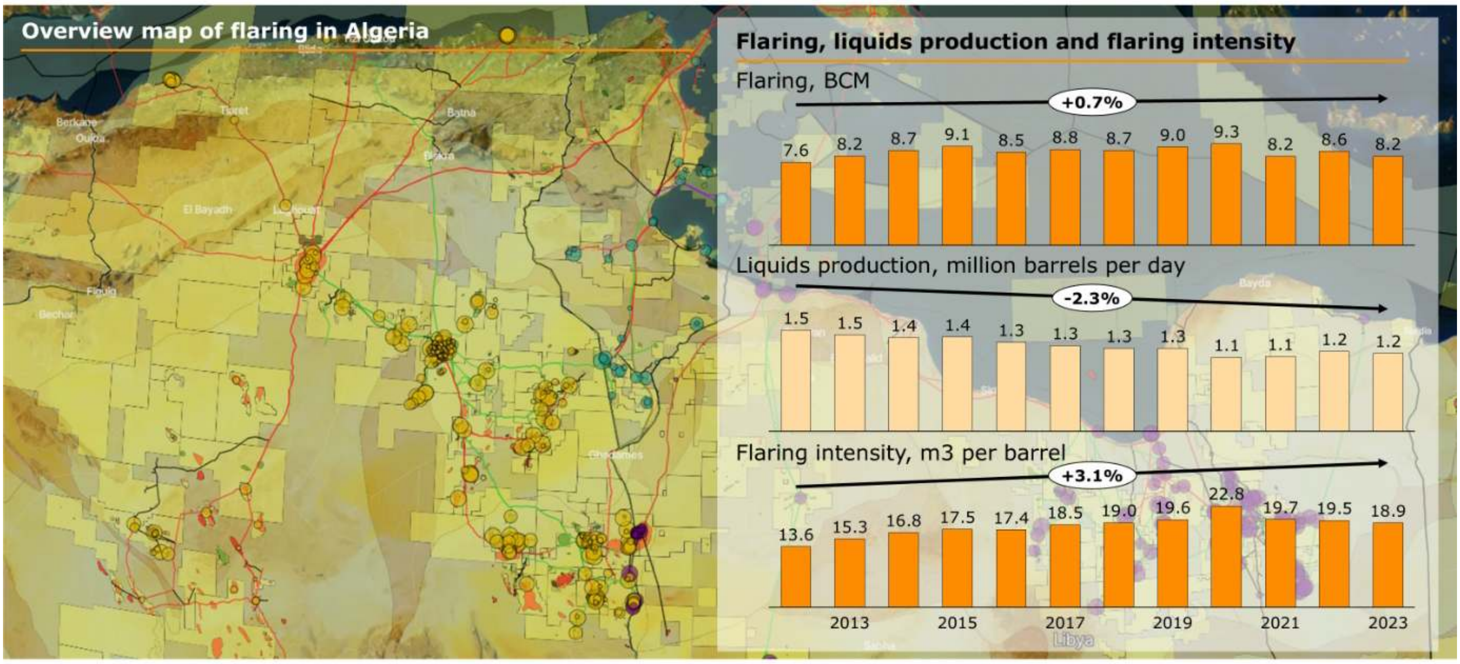
10-year Flaring Trend: Broadly flat

2023 Flaring Intensity: 18.9 m^3/bbl

Global Intensity Rank: 2nd

10-year Intensity Trend: Increasing (flat in most recent years)

Algeria's flaring has shown limited improvement, despite falling oil production



Source: Capterio FlareIntel; World Bank.

Figure 9: Map of flaring and the major infrastructure in Algeria (left) and profiles of flaring, oil, and condensate production and derived flaring intensity over time (right). Flaring has generally been flat, and flaring intensity has modestly increased since 2012 while remaining at high levels by global standards.

Flaring Context in Algeria

In 2023, Algeria was the world's 10th-largest gas producer (at 102 billion m³ per year) and 17th-largest oil producer (at 1.2 million barrels of oil and condensate per day). Yet, challenged by rising domestic power consumption (especially for cooling) and production issues, Algeria's gas exports via its two LNG terminals and three pipelines (one of which, to Morocco, is shut in) are declining.

One solution is to capture and monetize flared, vented, and leaked gas. According to the World Bank, Algeria was the world's sixth-largest gas flaring nation in 2023, at 8.2 billion m³, although both the government and Algeria's NOC, Sonatrach, report lower flaring volumes. Sonatrach has endorsed the World Bank's Zero Routine Flaring by 2030 initiative. Its major buyers—EU companies, to which Algeria is now the second-largest gas supplier—are strongly focused on decarbonizing imports, supported by the EU's "You Collect, We Buy" scheme as well as restrictions on importing oil and gas with high flaring and methane intensity that will apply from August 2030. Flaring regulation in Algeria is strict, with penalties up to $2.5 per MMBtu, though enforcement remains limited, and there are exceptions where offtake infrastructure is unavailable.

Overview of the Situation

Flaring in Algeria is concentrated in 10 main fields, including Hassi Messaoud (the mega oil field), Tin Fouye Tabankort, and Hassi R'Mel (surprisingly, a gas field), among others. Of the total volume, we estimate that 73% is within 20 km of an existing gas pipeline, many of which have spare capacity. Flaring was slightly lower in 2023 than in 2022, due to a combination of lower oil production, improved operational performance (reducing "upset" flaring in key assets), and some (albeit limited) structural flare-reduction projects—such as those at Hassi Guettar and Hassi Messaoud.

Sonatrach is the sole purchaser of gas for the domestic Algerian market, but it is required to sell gas for power generation at prices that reportedly do not cover costs, let alone generate a return. This may explain why most flaring in Algeria occurs at fields operated by Sonatrach.

Main Opportunities

Several large-scale projects (with potential volumes up to 50 mmscf/d (0.5 BCM per year) and possible revenues of around $100 million annually) near existing pipelines were identified by Capterio over five years ago and confirmed more recently by Algerian authorities, but they remain unaddressed. While these projects involve some complexity—including both Sonatrach-operated assets and joint ventures with international oil companies—their economic and environmental potential should be enough to justify accelerated action.

Enablers of Accelerated Action

To drive meaningful change, Algeria should consider: First, defining a national integrated flaring roadmap, driven by the best available data (reported accurately and transparently), a credible and creative team, and strong leadership backing; second, attracting new capital and development capabilities (along with fresh ideas and business models), taking advantage of its substantial capacity to increase exports and generate revenue, while freeing other gas resources to meet increasing domestic demand; and, thirdly, enhancing both "carrot" and "stick" mechanisms, through more rigorous enforcement of anti-flaring laws and penalties and reinvestment of recovered funds into a dedicated flare-reduction initiative.

With the August 2030 deadline for the full application of the EU's restrictions on importing oil and gas with high flaring and methane intensity fast approaching, Algeria has a limited window to act decisively by strengthening both its economic resilience and energy security.

4. Insights and Critical Factors From Case Studies

The case studies show that the barriers and obstacles identified earlier in this report can be overcome, not only in countries with diversified economies or vast wealth but also in middle-income countries with state-dominated hydrocarbon sectors. This can be done under existing regulatory, contractual, and fiscal systems—while broad market reforms might be ideal in these countries, the case studies show that flare reduction is possible without them, so long as there is commitment and determination.

In our three project case studies—Angola LNG, Sarqala, and Los Toldos Este II—the parties were able to implement creative solutions to capture associated gas rather than flare it, through a combination of public and private sector efforts. In our three country case studies—Federal Iraq, Egypt, and Algeria—we see progress in bringing flaring under control, as well as many more valuable opportunities that undoubtedly can and should be exploited.

Using the learnings from our case studies, we elaborate on each of the main insights and the critical factors for successful flare reduction below.

1. Flare Reduction Requires an Accessible Market or Offtake Solution

Successful flare-reduction projects require that investors have the ability and legal right to build or access infrastructure, and to deliver captured associated gas to a purchaser against payment. In the alternative, states and NOCs must be prepared to offtake and pay for associated gas at reasonable prices.

We cannot overstate the importance of this condition—and should not be surprised when flare reduction is not achieved without it. The quote from our Sarqala case study is not atypical: "*We were incredibly unhappy to be flaring …, but we are unable to act without a commercial framework, something that the government must provide*."

- In Angola, the government and Sonangol pushed IOCs to pool their resources in order to implement a major clustered infrastructure development project—Angola LNG—to provide a marketing solution for associated gas produced at the offshore fields operated by the companies. This determination was coupled with fiscal incentives and the imposition of concession conditions that allowed the final investment decision to be made. Although the economic and operational results were disappointing due to project execution issues, the driver to effective implementation was a combination of a push to create an outlet for the associated gas in the form of a pooled infrastructure investment, along with fiscal incentives.
- At Sarqala, the project was driven in the first instance by the need for the regional government to find a solution to provide power for the local market to quell civil unrest. The government first negotiated the terms of a modular power facility. Once the offtake solution was identified and made available to the operator, the regional government was able to require the upstream operator to reduce flaring and to deliver associated gas as fuel for the power facility.

Where reasonable offtake solutions do not exist, it will be difficult for operators to exploit the opportunities to utilize associated gas. In Egypt, upstream operators are effectively required contractually to sell their gas to EGAS and also benefit from fiscal incentives that apply when they sell gas to EGAS (at somewhat unattractive prices) but not when they sell directly in the domestic market or for export. An operator will invest in the capture and processing of associated gas only if it has assurance that EGAS will agree to purchase the gas, and if they believe EGAS will have the financial resources to make required payments. Another example is Federal Iraq, where all investments are planned by the federal government and implemented on an individually negotiated basis, with all gas taken by a state-owned company and operators compensated with export oil. This can be successful, although it is a lengthy process that depends on case-by-case negotiations and the capacity of the State to stand as off-taker.

Where the offtake solution involves the state or state-owned companies, creditworthiness is a significant consideration. In Federal Iraq, state-owned companies are credible off-takers only because the government is willing to use Iraq's oil resources (or oil revenues) to pay for captured and processed gas. The financial difficulties experienced by EGAS have been cited as a constraint on flare reduction in Egypt. Similarly, the ability of the Kurdistan Regional Government to replicate its success in the Sarqala project (or even to renew the Sarqala power facility lease when it expires in 2025) is limited by the KRG's history of delayed and missed payments to operators.

2. Flaring Restrictions and Penalties are Effective Only When Applied

Many of the countries where our case studies are based restrict flaring or impose financial penalties for flaring. While flaring restrictions and penalties have proven effective in countries like Norway and Brazil (where they have been applied against the state-owned company Petrobras), our case studies show they are less effective when they are not fully applied.

It is striking that Algeria restricts flaring and imposes flaring penalties that are similar to those in Norway (equivalent to $2.6 per MMbtu in Algeria, compared with $3.6 per MMBtu in Norway as of June 2023[53]), but the two countries have had starkly different experiences, including with penalty enforcement.

Both countries have pipelines connecting to the EU market, with available capacity, and yet Algeria flares significant volumes of gas (in addition to venting methane), while Norway has very limited flaring. It is understandable, however, that Algerian authorities are willing to forego applying flaring restrictions and collecting flaring penalties (which we think could be up to $900 million per year). This would ostensibly apply exceptions for gas flared where infrastructure is lacking, because it would be impossible for Sonatrach to recover investments in such infrastructure (or to finance such investments) from the domestic sale of gas at regulated prices. This shows that restrictions and penalties can be part of the solution, but only where operators have a real economic choice between capturing, processing, and selling gas at reasonable prices and paying flaring penalties.

The operator of the Los Toldos Este II field had to find a flaring solution in order to have the development plan for its oil project approved. It developed a creative solution to power cryptocurrency data centers, allowing its project to go forward in compliance with governmental flaring restrictions. At Sarqala, the Kurdistan Regional Government was able to take advantage of contractual flaring restrictions and clauses giving it title to the associated gas in order to provide fuel for its modular power generation project, although it has not always applied these clauses to the same effect at other fields. While contractual clauses giving state-owned companies the right to receive all associated gas for free can present opportunities, they also transfer the problem of what to do with "waste gas" from international operators to national companies. When the State is constrained in its ability to finance associated gas solutions, it is unable to realize the benefit of these favorable contractual provisions.

53 Mark Davis and John-Henry Charles, How a focus on gas flaring at COP26 can accelerate decarbonisation, (Capterio, September 8, 2020), https://flareintel.com/insights/how-a-focus-on-gas-flaring-at-cop26-can-accelerate-decarbonisation.

3. Committed Leadership Is Needed to Turn Visions Into Real-World Actions

As our Angola, Sarqala, and Federal Iraq cases particularly highlight, strong, committed leadership is a key success factor. It is imperative to align diverse stakeholders and overcome operational and political challenges. Visionary statements such as "*We will eliminate all flaring by 2028*" are important, but they count for little unless supported by a focus on day-to-day problem-solving and issue resolution. Teams of qualified specialists must be constituted – and supported at the highest levels – to focus full-time not just on studies but on concrete results.

Where we saw success, particularly in Angola LNG, Sarqala, and Federal Iraq, key individuals from both the government and companies took it upon themselves to get personally involved, mobilize teams, generate high-level political support, accelerate problem-solving, and drive a spirit of collaboration between government ministers and departments. In Angola's case, when the government insisted that a flare-reduction plan was a prerequisite to developing the lucrative deepwater oil fields, it galvanized the industry to respond in its own self-interest. The same degree of focus has not always been observed in Egypt and Algeria, both of which are seeking to address domestic gas shortfalls with new licensing rounds for non-associated gas fields and/or shale gas, while leaving unexploited several flare-reduction opportunities that could be attractive and undoubtedly could come online much more quickly—with lower technical and commercial risk.

Commitment to achieving meaningful flare reduction must come from all parties—governments, NOCs, and IOCs. In Federal Iraq, the driver for the signature of contracts for the Gas Growth Integrated Project was, after years of hesitation, the determination of the Minister of Oil and the CEO of TotalEnergies to push the project forward. And as noted above, the operator at Los Toldos Este II in Argentina was also focused on capturing and using associated gas as part of its field development planning.

4. Data Is the Game Changer For Projects and Improve Operations

Each of our case studies has demonstrated the critical importance of using data to differentiate between routine and upset flaring modes. In some cases this is to identify and prioritize projects, and in others data is helpful to demonstrate the successful delivery of project objectives (or prove otherwise). Data is crucial for project definition and design, which are necessary (albeit not sufficient) drivers of success. Equally, data helps ensure a laser-like focus on continued operational performance and to identify—and ultimately reduce—upset flaring.

Our Algeria case study has highlighted how data has helped the authorities to publicly identify major flare reduction opportunities. After years of reporting flaring figures well below those published independently, Algeria improved its data capture with strategic collaborations between Capterio and the NOC (Sonatrach). This allowed Sonatrach and the Algerian Space Agency[54] to develop and analyze concrete opportunities that have been proposed publicly, with some hope they can move forward in the short- or medium-term.

The Sarqala project shows how data can be used to demonstrate concrete results, as the independent data shown in our case study was solicited by project investors to validate progress. In Federal Iraq, independent data has also been instrumental in monitoring the net impact of the world-class Basrah Gas Company flare-capture project (although data highlights, despite its success, that flaring at the three fields supplying gas *increased* over the initial period of BGC's operation, driven by greater underlying oil production at the fields feeding gas to BGC).

54 Mustapha Iderawumi, "SONATRACH and ASAL Collaborate to Reduce Carbon Footprint," Space in Africa, June 27, 2022, https://spaceinafrica.com/2022/06/27/sonatrach-and-asal-collaborate-to-reduce-carbon-footprint/.

Beyond addressing routine flaring, data plays a critical role in identifying and reducing upset flaring. Our example from one of the offshore fields associated with Angola's LNG project highlights how data can be used not only to identify operational upsets, but also to demonstrate their elimination. In many cases we have noted that reduced overall flaring results from having (a) fewer operational upsets, of (b) shorter duration and with (c) lower intensity. The availability of information allows parties to remedy upset flaring on a timely basis and, more generally, to progress on critical operational performance. This in turn allows operators to develop a mindset and culture akin to the substantial recent attention they have paid to HSE issues (health, safety, environment).

5. Commercial Innovation and Flexibility Are Key to Unlocking Solutions

Creative and agile thinking from both governments and operators is crucial to finding structural solutions to gas flaring. The starting point is to identify the range of possible options, and then to conduct a data-led detailed analysis of the potential to realize attractive projects from an economic and technical perspective, as well as the contractual, legislative, regulatory, and fiscal environment, treating difficult issues not as barriers to flare reduction but as obstacles that can and should be overcome.

In many cases, creative solutions can address the barriers identified earlier in this report. This is not to say it is easy. Unlike upstream oil developments, there is no standard contractual and fiscal model that reflects generally accepted structures for gas capture projects. A desired "cookie-cutter" approach with standardized models is hard to achieve given the widely varying surface and subsurface characteristics of flare-capture projects and the fiscal environments applicable to them (which are often uncertain). But our case studies at least show how creative thinking can help:

- Los Toldos Este II: Innovating through the use of associated gas to generate electricity to power computing capacity needed for cryptocurrency mining that would otherwise be conducted elsewhere, consuming power from alternative sources.
- Sarqala: A creative solution to addressing local power needs through modular facilities fueled by associated gas, generating substantial revenues in the process.
- Angola LNG: The world's first LNG investment project designed specifically to absorb associated gas. The government and Sonangol were able to think flexibly about how commercial frameworks can be adjusted to accelerate action, offering preferential tax treatment yet still preserving limited capture of some price upside.
- Federal Iraq: the Gas Growth Integrated Project is based on an innovative, integrated structure designed to facilitate gas capture within the traditional contractual scheme used by the Iraqi government for projects with international investors. Here, the government has devoted a portion of its oil revenues (its only significant source of available funding) to pay the costs of gas capture and processing and a return to the operator, with the potential to recover some or all of those revenues (and perhaps more) by reducing expensive imports of gas, liquid fuels, and electricity.
- Egypt: Modest success has been achieved in capturing flared gas through innovation, such as a project to use associated gas for in-field power generation, displacing the use of highly polluting diesel. Additional opportunities could be exploited with more creative thinking, particularly regarding the financing of EGAS purchase commitments and the application of fiscal incentives to all associated gas, wherever it is sold.
- Algeria: The potential for creative solutions is demonstrated in our in-depth study by a gas rim project operated by an international company without significant flaring, adjacent to an oil project operated by the NOC that could (but so far does not) capture

its flared gas and have it processed at the facilities of the gas rim operator. So far, this opportunity has not been realized, but it demonstrates potential that can be unlocked with creative contractual solutions involving multiple operators and/or commercial structures, which can and should be supported by the Algerian authorities.

5. Recommendations Part 1: A Holistic Approach to Flare Reduction and GHG Emissions

Our case studies and the insights we draw from them show that parties can overcome barriers to flare reduction and drive projects forward. To a large extent, the analysis reflects economic factors: investments, funding, revenue generation, and returns. Indeed, the motivating factor behind many flare-capture projects is economic, as operators and governments seek to generate revenues from associated gas that is otherwise wasted through flaring. This is why, for example, fiscal incentives and flaring penalties can be effective tools to reduce flaring.

We provide detailed recommendations on these economic factors in Section 6 of this report. We believe, however, that it is crucial to focus first on the greenhouse gas benefits of flare-reduction projects. After all, this is the key reason why flare reduction has been a global priority for at least the past two decades. For this reason, we begin our recommendations in this section by developing a holistic framework for analyzing the net climate benefits of flare-capture projects.

Nearly every study of gas flaring (including this one) begins by recounting figures on the estimated volume of GHG emissions associated with flaring.[55] Either explicitly or by implication, many studies suggest that capturing and utilizing associated gas rather than flaring it will effectively eliminate these emissions. The same is true of many international initiatives. Yet in the end, the captured gas is still combusted.

As with substantially everything involving gas flaring, the reality is more complex. Eliminating flaring effectively reduces (or avoids, for new projects) Scope 1 emissions associated with the related oil production project. Yet the construction and operation of infrastructure to capture, transport, and utilize associated gas will produce their own Scope 1 emissions, while the combustion of the associated gas and extracted NGLs by end users will produce Scope 3 emissions. Where a flare-reduction project leads to increased oil production, Scope 1 and 3 emissions associated with the production and combustion of the additional oil also need to be taken into account.

As a consequence, the net climate impact of a flare-reduction project depends on several factors, including: (i) the original combustion efficiency of the flare (as inefficient flares release methane), (ii) the volume of gas being flared, (iii) GHG emissions associated with capturing, transporting, processing and liquefaction of the associated gas, (iv) emissions associated with the combustion of processed gas and NGLs by end users, (v) the benefits of substituting (indeed, if this occurs) gas for higher-carbon energy sources in destination markets, and (vi) the potential for increased oil production associated with a flare-reduction project, whether intentional or incidental.

In this section we begin by illustrating how these factors can be analyzed in a hypothetical project to calculate GHG benefits on a net basis. We then recommend a multi-factor approach that can be used to prioritize flare-reduction projects and to determine how best to allocate capital to them in order to promote decarbonization.

We believe it is important, in prioritizing projects, to combine this with an honest reckoning of the decarbonization impact of flare reduction, which is the objective of the discussion in this Section.

55 See 2024 Global Gas Flaring Tracker Report, p. 14; Shayan Banerjee and Perrine Toledano, A Policy Framework to Approach the Use of Associated Petroleum Gas, 8; Clean Air Task Force, Flaring Accountability: Global gas flaring, p. 8; "Gas Flaring," International Energy Agency (IEA), 2023, https://www.iea.org/energy-system/fossil-fuels/gas-flaring.; Magnus Kjemphol Lohne, Sebastian Eklund and Elliot Busby, "Moving in the wrong direction: Flaring emissions on the rise, reversing a positive trend," Rystad Energy, October 24, 2024, https://www.rystadenergy.com/news/flaring-increase-emissions-oil-gas-upstream.

Analyzing the Net Climate Benefits of an Illustrative Project

To put the emissions reduction opportunity from flare gas capture projects in context, we illustrate the approximate emissions associated with two common flare-capture scenarios and compare the CO_2-equivalent emissions of the "before" (i.e., flaring) case with those of the "after" case on project completion.[56] Since every flare project will be different, and since some simplifying assumptions are made below, these analyses should be considered as indicative illustrations only. We perform a similar analysis on an actual project in the in-depth Angola LNG case study.

Scenario 1: Gas to power combined with coal substitution. We also assume that the gas flare project does not lead to additional oil production (and therefore higher Scope 3 emissions from oil combustion):

- In the "before" case, we illustrate the emissions associated with an observed 15 million scf/day flare that operates with an average combustion efficiency of 92%[57] (meaning that only 92% of the gas is burned and the other 8% is released to the atmosphere unburned as methane slip). We also assume that a coal plant is currently delivering power in the market to which the recovered gas will be destined. To calculate the emissions from this power plant, we incorporate the fact that coal typically has a CO_2 intensity per kWh that is 2.3 times[58] greater than gas (the equivalent for diesel is 1.3 times greater).
- In the "after" case, the gas is captured and delivered to the destination market where it is combusted in a gas-fired power plant that burns the gas into electricity (with a conversion efficiency of, conservatively, 99.5%), resulting in the previously supplied coal generation being shut in and substituted (thereby enabling coal-to-gas switching to occur).[59] Our analysis accounts for the greater thermal conversion efficiency of a gas plant versus coal.

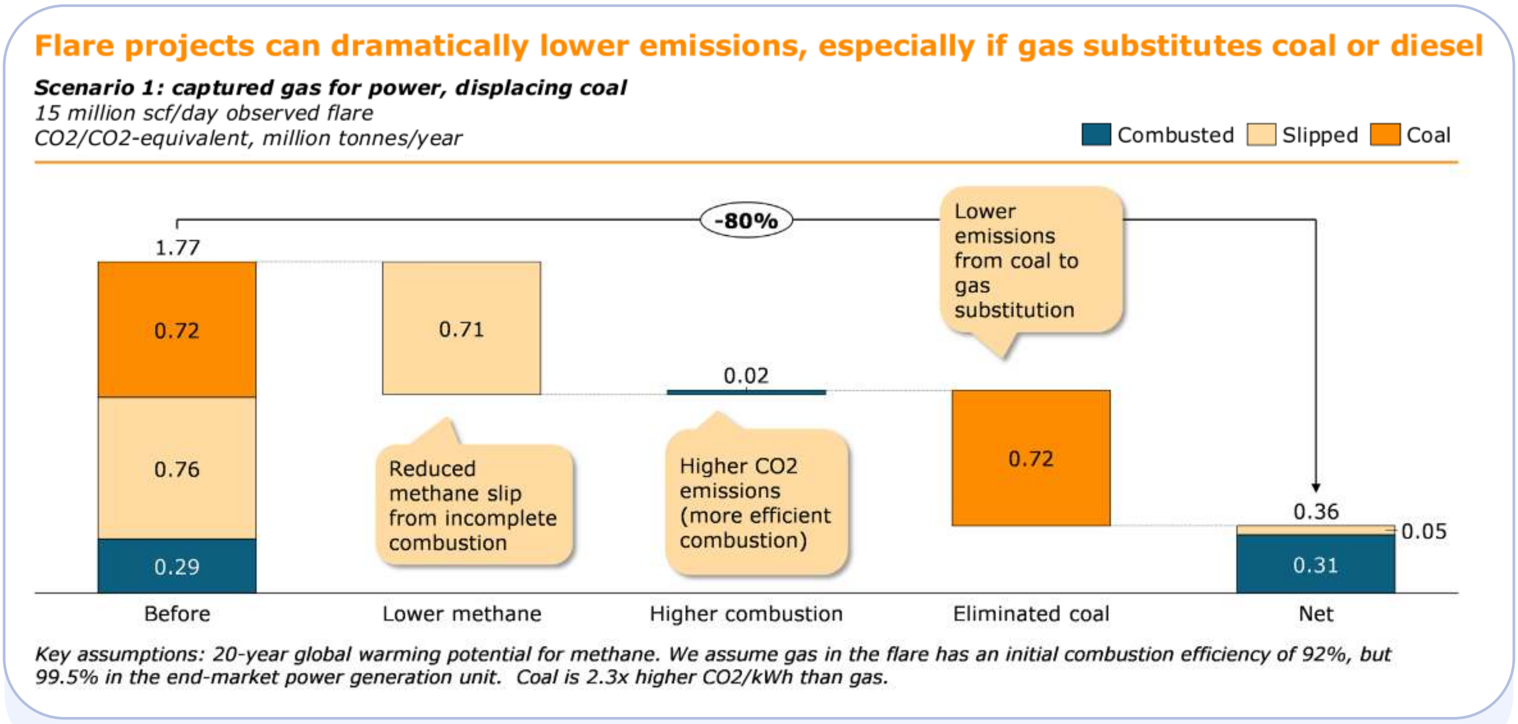
As Figure 10 shows, even though the gas is ultimately combusted, this hypothetical project generates a net emissions reduction of 80% from three levers: (a) lower CO_2-equivalent emissions from methane reduction (since uncombusted gas is reduced from 8% to less than 0.5%, and methane is much more potent than CO_2 as a climate-forcing agent), and (b) lower emissions from the elimination of an equivalent amount of power generation from a higher carbon source (coal), which is partly offset by (c) slightly higher emissions from the combustion of an additional 7.5% of methane (previously 8% was unburned, but now we assume 0.5%).

56 This work builds on earlier analysis presented in, e.g., "Why flare capture projects make sound ESG investments," Capterio, August 2020, https://flareintel.com/insights/why-flare-capture-projects-make-sound-esg-investments.

57 Consistent with the estimated global weighted average combustion efficiency,< International Energy Agency, Global Methane Tracker 2024, Data Explorer (Paris: International Energy Agency, March 2024), https://www.iea.org/data-and-statistics/data-tools/methane-tracker-data-explorer. > See also Genevieve Plant, et al., "Inefficient and Unlit Natural Gas Flares Both Emit Large Quantities of Methane," (September 2022), Science, Vol. 377, Issue 6614,1566–1571, https://www.science.org/doi/10.1126/science.abq0385.

58 "Electric power sector CO2 emissions drop as generation mix shifts from coal to natural gas," U.S. Energy Information Administration (EIA), June 9, 2021, https://www.eia.gov/todayinenergy/detail.php?id=48296.

59 We exclude, for simplicity, any impact from "lock in" of the gas power plant or the transition to closure of the coal power plant. In addition, this example is intended to be illustrative and not exhaustive. We do not, for example, explicitly account for losses of associated gas in its transport to the end market, or non-combustion related emissions (e.g., associated with coal production, including methane venting). However we are somewhat conservative with our assumption of only 99.5% combustion efficiency in the end-use gas plant.



Source: Capterio analysis.

Figure 10: Illustration of the net emissions in the before-and-after situation of a flare gas capture project. Flare projects that displace coal in power generation can lead to substantial emissions reduction, particularly when they also address methane slip.

An interesting variant of Scenario 1 is when the captured gas is used to generate power and displace the burning of diesel (or heavy fuel oil), rather than coal. We see examples of this in countries such as Iraq and Egypt, and we estimate the emissions reduction to be slightly lower (a reduction of 75%, versus 80% in the coal substitution case), mostly because substitution of coal has a greater climate impact (since it has a higher carbon intensity per kWh of delivered power).

Scenario 2: Gas to power combined with coal substitution (identical to Scenario 1), plus Scope 3 emissions from additional oil production resulting from the flare-reduction project. We use this case (illustrated in Figure 11) to explore the situation where a successful flare-capture project is associated—directly or indirectly—with an increase in oil production.

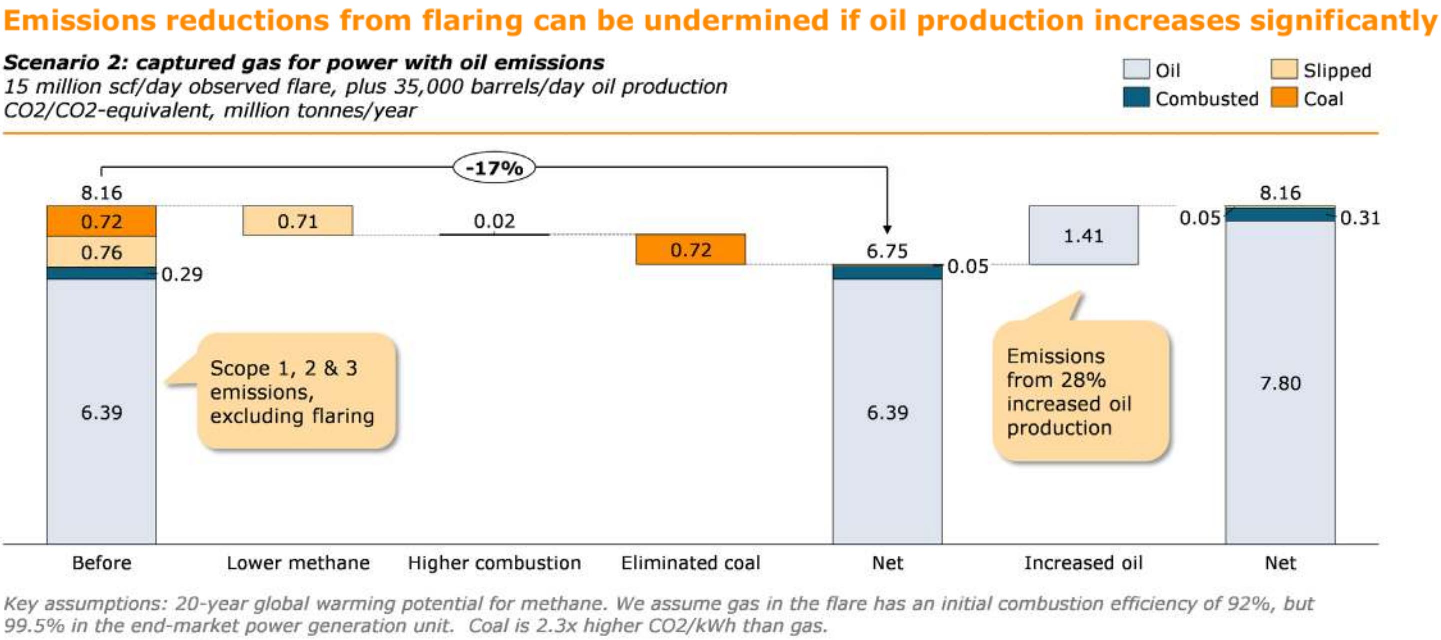
- In the "before" case, we illustrate a flare of the same size as Scenario 1, coming from a modest-size oilfield with the production of 35,000 barrels per day in a country with a moderately high flaring intensity of 12.1 m^3 per barrel (consistent with, say, Iraq or Nigeria), with the same 92% combustion efficiency. We also include the Scope 1, 2, and 3 emissions associated with the oil (end use, transport, refining, etc.[60]), which are some 500 kg per barrel.[61]
- In the "after" case, as in Scenario 1, the gas is captured, methane slip is reduced, and coal is displaced, leading to a net emissions reduction of 17% after including emissions from previously existing oil production. The absolute amount of emissions reduction is the same as in Scenario 1, but it is lower in percentage terms because the oil is taken into account in both the "before" and "after" cases.

Since flare-reduction projects are often also coupled with increased oil production, it is instructive to calculate the break-even point where the reduction of emissions from lower

60 Data taken from the NDC Partnership OCI-plus gas climate index (based on data from the Rocky Mountain Institute), <"Mapping Oil and Gas Emissions Intensities," April 2024, https://ndcpartnership.org/knowledge-portal/climate-toolbox/oci-oil-and-climate-index-plus-gas#:~:text=Developed%20from%20the%20Rocky%20Mountain,processing%2C%20midstream%20refining%2C%20and%20downstream.> illustrated for Angola's Girassol crude, excluding flaring-related emissions (since we calculate these).

61 For a typical Middle Eastern crude from <"Profiling Supply Chain Emissions Intensities," Oil Climate Index plus Gas, Rocky Mountain Institute, April 2024, https://ociplus.rmi.org/supply-chain.>

flaring is offset by increased emissions from greater oil production. We estimate that the net emissions are greater if oil production increases by a modest 28%.[62] While this analysis is inevitably a simplified version of reality, it nevertheless gives directional clarity.



Source: Capterio analysis.

Figure 11: Illustration of the net emissions in the "before" and "after" situation of a flare gas capture project where the recovered gas not only displaced diesel but was associated with incremental oil production. We show that if oil production were to increase by 28% the increased scope 3 emissions from incremental oil would offset the lower scope 1 emissions from the lower flaring, methane slip and coal substitution.

Framework for Project Analysis and Capital Allocation

As the hypothetical scenarios illustrate, not all flare-capture projects offer the same climate benefits, as their emissions impact varies based on multiple factors. Below, we present an analytical framework to help prioritize flare-reduction projects, particularly when climate mitigation is the primary objective. While project rankings will depend on specific circumstances, we propose a general prioritization based on the following criteria:

- Eliminating operational and performance-related flaring,
- Reducing methane slip,
- Avoiding infrastructure lock-in,
- Minimizing new oil development, and
- Substituting gas for more carbon-intensive energy sources.

Flare-capture projects should be assessed within the broader context of regional energy dynamics and national energy strategies. An integrated planning approach—one that considers the full energy mix, especially the role of renewables and their interconnections—should be encouraged to ensure that flare reduction aligns with long-term decarbonization goals and national energy security objectives. This requires a holistic analysis taking into

62 This figure reduces slightly, to 20%, if a 100-year GWP is used rather than our preferred 20-year GWP. While the analysis above attempts to account for the "equivalence" of methane versus CO2 by using the so-called "Global Warming Potential", we are aware of its limitations. Indeed, as a 2014 study points out, "because of the fundamentally different nature of the climate response to long- versus shortlived gases, there is no way to express emissions of short-lived gases [such as methane] in terms of an equivalent in emissions of long-lived gases [such as CO2] without seriously misrepresenting some aspect of the climate response." Raymond Pierrehumbert, "Short-Lived Climate Pollution" (Annual Review of Earth and Planetary Sciences Volume 42: 2014), https://www.annualreviews.org/content/journals/10.1146/annurev-earth-060313-054843).

account not only the direct GHG emissions eliminated through flare reduction, but also the remaining (or increased) GHG emissions—Scope 1 and Scope 3—that take place after the flare-reduction project is implemented. In prioritizing projects and determining how to allocate capital to them, the analysis will, in many cases, require a difficult task of predictive estimation and evaluation. But even if imperfect, the exercise is in our view essential.

Based on these principles, we believe the net GHG benefits from flare-capture projects should be evaluated on the basis of the following factors.

1) **Focus on material flare-capture projects in which oil production will go ahead or continue regardless.** The hypothetical case shows how increased oil production can dramatically impact the net climate benefits of a flare-reduction project, yet the cause-and-effect analysis is not always obvious. This can be illustrated with one of our recommendations set out in Section 6 of this report—that governments not approve new oil developments unless an associated gas solution is in place. In principle, this means the flare-capture project directly results in the increased oil production, since the oil development is assumed not to be approved without a flaring solution. However, in many cases our recommended path will not be followed, and oil production will go ahead regardless of whether a flare-capture project is delivered. Similarly, oil will often continue to be produced at existing oil production facilities (or even increase), whether or not a flaring solution is implemented. These are typically oil projects with low unit operating costs and/or where oil revenues make up the bulk of government revenues of an oil-dependent developing country (or the political orientation favors oil).

   The implication is that flare projects should be prioritized where governments or regulators are otherwise minded to relax their flaring constraints in order to prioritize oil production and, therefore, government revenues. Under these circumstances, a typical flare-capture project will likely still deliver net emissions reduction when compared with a business-as-usual case (effectively, our Scenario 1). On the other hand, capturing flared gas for purposes of reinjection to facilitate Enhanced Oil Recovery would likely increase net GHG emissions in most if not all cases.

   Interestingly, Iraq's flagship flare-capture project at its Rumaila/West Qurna and Zubair fields (with associated gas processed by Basrah Gas Company) is a case in point, as highlighted in the Federal Iraq case study: flare reduction was offset by increased oil production in the initial years of BGC's operations (by considerably more than the 28% we cite above as the notional break-even point), leading to much higher total emissions. Yet it is likely that this increased oil production would have been authorized and would have occurred whether or not the associated gas had been captured. (Indeed, this happened at other fields in Iraq in 2014, when gas processing investments were canceled due to the government's inability to pay for them in a low oil price environment.) From this perspective, the flare-capture project can be said to produce a beneficial net climate impact despite an overall increase in emissions from greater oil production. Moreover, once BGC was able to make investments to increase its processing capacity, flaring at the three fields declined significantly, suggesting that the GHG analysis needs to look at a flare-reduction project not only at the outset of operations, but over its operational life.

2) **Reduce upset flaring through improvements in operational performance and better data reporting.** Through better maintenance and planning, upset flaring can be substantially reduced. Similarly, if data on flaring is properly collected and reported, the opportunities associated with flare reduction can be properly analyzed, with a higher potential for action. A focus on operational excellence and improved information will likely make a dramatic reduction in greenhouse gas emissions without increasing oil production. As we highlight in Section 1 of this report, *if* the data reported to World

Bank by the endorsers of its Zero Routine Flaring by 2030 initiative are correct, then fixing upset flaring would make a dramatic reduction in Scope 1 emissions.

3) **Use existing and underutilized gas infrastructure.** Whether for domestic or export uses (such as pipelines or LNG terminals), exploiting existing infrastructure can enable gas capture and utilization to be conducted without major new capital investment (or with lower investment), and therefore with less risk of infrastructure lock-in. Indeed, the construction of costly new infrastructure could require that the life cycle of gas (and possibly oil) production be extended over long periods in order to allow financing to be repaid and investment returns to be generated. This is even more true if new non-associated gas development is required to mitigate the risk of variability of associated gas production. The additional oil and gas production beyond that strictly associated with flare capture can be said to result in an increase in total project emissions.

   North Africa is a case in point for the potential to use existing infrastructure and not create lock-in. Here, some 25 BCM[63] of gas (based on 2023 flaring, venting, and leaking data) is potentially available for export through existing infrastructure (four pipelines and four LNG export terminals) that is dramatically underutilized.[64] Another possible solution to the lock-in issue is to prioritize modular solutions, such as portable (skid-mounted and containerized) power or gas processing plants, which can be installed quickly and redeployed when not needed. The potential for modular infrastructure is illustrated by our Sarqala and Los Toldos Este II case studies.

4) **Substitute captured gas for a high carbon intensity source.** An obvious example is illustrated in our hypothetical (Scenarios 1 and 2), where gas is assumed to be substituted for coal (or diesel or heavy fuel oil) to generate electric power. In addition to reducing direct emissions from the combustion of these fuels, substitution of gas can also indirectly reduce the emissions associated with the production and refining of the legacy fuel—such as methane emissions associated with the mining of coal. An example could be where a flare-capture project reduces the use of diesel that had previously been used to supply the power (as has happened in Egypt), or where the recovered gas supports coal-to-gas switching in the destination markets or mitigates the need to develop an alternative supply of fuel. In a complete project analysis, the incremental emissions that occur during a transition phase – where both the legacy power plant and the new one are in operation—need to be taken into account. The analysis might be different where new power generation is needed, in locations where renewables are an option. In that case, capturing associated gas to facilitate the development of new gas power generation capacity might increase emissions compared with a scenario where the new power is generated with renewables. In this case the new gas capacity should at least serve as a source of flexibility for renewables, facilitating their greater integration in the energy mix.

5) **Target reductions in methane slip.** Capturing associated gas can reduce methane emissions from inefficient combustion of gas (or flares that are unreliable and are sometimes unlit), or where it is associated with the capture of gas that was otherwise being vented or leaked, provided that the project is *additional* (i.e., the reduction in methane emissions would not have happened without the flare-capture project). Projects that address poorly functioning (or unreliable) flares are likely to have the greatest potential to reduce GHG emissions. Given the paucity of credible data on combustion efficiency, this is likely also an urgent research priority.

63 This includes flaring, venting and leaking gas from Algeria, Libya, Egypt and Tunisia, as per < Mark Davis, Perrine Toledano and Thomas Schorr, North Africa can reduce Europe's dependence on Russian gas by transporting wasted gas through existing infrastructure (Capterio and Columbia Center on Sustainable Investment, 2022), https://scholarship.law.columbia.edu/sustainable_investment_staffpubs/217/. > Updated data for 2023 bring the total to 25 BCM (12.3 for Algeria, 9.3 for Libya, 3.1 for Egypt and 0.3 for Tunisia, source Capterio analysis (derived from the World Bank Gas Flaring Tracker and the IEA's Methane Tracker, referenced elsewhere).

64 Mark Davis, Perrine Toledano and Thomas Schorr, North Africa can reduce Europe's dependence on Russian gas by transporting wasted gas through existing infrastructure (Capterio and Columbia Center on Sustainable Investment, 2022), https://scholarship.law.columbia.edu/sustainable_investment_staffpubs/217/.

6) **Consider projects that also sequester CO_2.** While we believe it is unlikely that a flare capture project would be coupled directly to a carbon capture and sequestration (CCS) facility, it is now possible to convert flared gas through a plasma process to solid carbon (which can then be embedded into soils or tires, thereby being sequestered) with a hydrogen as a by-product. If this technology develops substantially, it could present an additional option for the use of flared gas with net GHG benefits.

6. Recommendations Part 2: Actionable Steps for Each Stakeholder Group to Achieve Flare Reductions

Our second set of recommendations derives directly from the insights and critical factors we found in our case studies. As outlined in Section 4, these show that each party plays a critical role, individually and in coordination with others, in successfully structuring and implementing flare-reduction projects. Governments, NOCs, and IOCs have for many years pledged to make progress in reducing gas flaring (and, more recently, in reducing emissions of methane), often under the auspices of international institutions, but flaring remains stubbornly high.[65] To transform those pledges into concrete action, each of them must be properly incentivized and fully assume its responsibility, as engagement by only some parties without others is unlikely to achieve substantial results. In addition, while governments, NOCs, and IOCs are the main protagonists, it is critical to engage the broader ecosystem, which also includes consuming countries, international financial institutions, multilateral financing institutions, non-governmental organizations and more.

We emphasize that this is not just an altruistic endeavor: With the right structures, flare-capture projects can create value for countries and for investors, provide energy security, improve a country's investment reputation, and accelerate the national and global energy transition. All parties must re-frame their mindset from thinking of associated gas as merely an inconvenient by-product of oil production (or a liability to be ignored or denied) to recognizing it as it is, an attractive opportunity.[66] Similarly, we should re-frame flaring as a financially risky alternative to be avoided whenever possible.

In this section, we provide recommendations for each major stakeholder group, designed to maximize the likelihood that investments in capturing and utilizing associated can go forward with the proper mindset from all parties. The list is representative but certainly not exhaustive.

Governments and Regulators

- ***Focus on implementation and achievement.*** The first and most significant step that host governments must take is to prioritize the achievement of concrete results, going beyond international pledges and political statements. Host countries should create, empower and support teams within ministries and new or existing regulatory bodies (including with both financial and human resources, as well as senior level political support) to focus on plans for structuring and implementing flare-reduction projects. The teams must have clear targets and incentives, motivated by the national interest: creating revenues and value, monetizing associated gas rather than wasting it, ensuring that domestic gas resources contribute to energy security, and reducing greenhouse gas emissions in line with national objectives. The teams would work together with NOCs and IOCs to achieve results, which should be publicized and celebrated, creating a virtuous circle that inspires others to act.
- ***Define and communicate a national flare-reduction road map.*** A critical function for the flare-reduction team would be to develop a full road map for flare reduction, again working with NOCs and IOCs. The team would be responsible for integrating flare reduction into the national energy strategy, based on a proper inventory derived

65 The best known and most widely signed pledge is the World Bank's Zero Routine Flaring by 2030 initiative. See "ZBF Initiative Endorsers," World Bank Group, https://www.worldbank.org/en/programs/zero-routine-flaring-by-2030/endorsers. A more recent pledge is the Oil and Gas Decarbonization Charter, with 50 signatories from 30 countries, <Oil and Gas Decarbonization Charter, Oil and Gas Decarbonization Charter, (2024), https://www.ogdc.org/signatories/.>

66 As Capterio and co-authors from the Atlantic Council proposed in their paper <Mark Davis, Landon Derentz, and William Tobin, Why COP28 is right to prioritize global methane and flaring reduction (Atlantic Council Global Energy Center, October 2023), https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/why-cop28-is-right-to-prioritize-global-methane-and-flaring-reduction/.

from accurate (and transparently reported) data. The strategy would seek to eliminate or at least reduce infrastructure bottlenecks, identify investment opportunities (particularly where there is underutilized infrastructure), develop plans to reduce flaring, and ensure the effective execution of those plans. The effectiveness of the strategy would be monitored and measured against national key performance indicators, with results reported to ministers, NOC CEOs, and senior IOC country or regional officials. The strategy should also be communicated publicly, with a clear explanation of the benefits of flare reduction for the domestic market and local population – whether from increased power generation capacity, reduced government financial burden (particularly if captured gas is substituted for expensive imported LNG or fuel oil), employment opportunities, or reduced pollution, and improved health (particularly in areas near flare stacks). In this way, flare reduction can be a "political win" domestically.

- ***Enable an investable environment.*** A clear condition to realizing flare-reduction projects is for host governments to create an investable environment, in which operators of upstream projects, investors in midstream processing and transportation facilities, and end users are able to make investments and realize risk-appropriate returns. The investments should be aligned with public interest objectives, but not constrained in an unnecessary manner. This means host countries should identify obstacles to structuring projects and work with NOCs and IOCs to achieve concrete solutions, adopting necessary modifications to regulations and policies.

  We call this an "initiate and respond" approach because the first step is for government to "initiate" by creating an environment in which investment is feasible. If this is in place, then government can implement policies to generate a "response" from operators and investors in the form of investments to capture and use associated gas.

  We emphasize that this does not necessarily mean major market reforms or legislative transformation. While reforms may often be beneficial, they can be politically difficult to implement, particularly where they involve elimination of subsidies, and take time. Governments can and should be able, within a short time horizon, to establish "investable" (even if not perfect) environments within the context of their existing economic traditions and political cultures.

  As a particularly poignant example, a government seeking to reduce flaring must ensure that upstream operators have access to a market or a financially credible offtake solution—without that, they cannot invest in flare reduction. If a state company has a monopoly on gas purchases or transportation infrastructure, government policy must either remove the monopoly or place the monopoly company in a position to take gas captured by upstream operators at reasonable prices.

  Another example is the need to enable parties to develop common infrastructure outside the upstream "ringfence," to allow them to realize economies of scale and reduce costs. The host country implementation team can work with operators and investors to identify how that can be structured, and then work within the government to align regulations, contract requirements and policies to facilitate the common projects and arrange any necessary approvals.

  Going further, it is also important—as part of creating an investable environment—that governments are reliable payers. Large accounts receivable owed (or unpaid cost or profit oil) to international companies by governments (directly or through state-owned companies), unsurprisingly, do little to inspire further investment.

- ***Provide incentives and enforce penalties.*** When an investable environment exists or is being established, the host government should ensure that all parties have proper incentives to realize flare-reduction investments. This may mean providing fiscal incentives for gas capture or midstream infrastructure investments (or at least confirming they are subject to ordinary corporate tax rather than an upstream fiscal regime). For new projects, governments should use their contractual or statutory authority to grant approval only to those plans of development that include environmentally and commercially sound, measurable, and enforceable associated gas utilization solutions. For existing projects, governments can consider contractual amendments to incentivize flare-reduction projects. When authorizing transfers of interests in projects, host governments should require that transferees commit to maintaining or ideally reducing flaring volumes.

Host governments also should set significant but realistic fees, taxes, or penalties for flaring, ensuring that exceptions are limited and do not reduce incentives to make infrastructure investments (and appropriate transition periods should be allowed so investments can be made). Once established within an investable environment, the penalties must be supported by credible data and enforced and collected against both IOCs and NOCs. Amounts collected can then be used to finance a portion of the investment requirements of flare-reduction or methane-capture projects.

Incentives can also be created by the re-orientation of existing subsidies to favor flare reduction (taking care not to create new subsidies in the process) in countries where gas and electricity prices are regulated at below-market levels. For example, in Egypt EGAS purchases non-associated gas from the Zohr field for a reported US$4.00 to US$5.88 per MMBtu (depending on production levels), while gas is sold to power producers for US$3.00 per MMBtu.[67] If EGAS instead were to purchase captured associated gas at the same price, the subsidy would not be increased, but it would instead be used to reduce flaring at no additional cost. Indeed, re-orientation of subsidies in this manner can generate net revenue where, for example, associated gas is substituted in the domestic market for non-associated gas that can be redirected to export markets, or where associated gas processing delivers NGLs that can be sold to generate revenue, reducing the amount of subsidies required.

- ***Align government "take" objectives with the nature of flare-reduction projects*.** In traditional upstream projects, host governments are generally encouraged to capture the economic rent and maximize government "take" —the portion of project net revenue captured by the government. Flare-reduction projects are partially upstream, but they also involve significant industrial investments that might not produce upstream returns. They might not be able to support typical upstream fiscal structures and should more properly be subject to ordinary corporate tax regimes (around 35%, versus the typical 65%–85%). They also serve purposes beyond pure economics, including ensuring energy security and reducing greenhouse gas emissions. Host governments can effectively use hydrocarbon rents to promote flare reduction, including structuring investments inside and outside the upstream ring-fence to achieve optimal fiscal terms. Governments also need to take measures to ensure their NOCs have sufficient financing to invest in flare reduction and to meet associated gas purchase obligations. Governments can consider innovative structures, such as trust funds (or sovereign wealth funds), or dedicated flare-capture funds (capitalized from hypothecated flaring penalties or government revenues from associated gas and NGL sales, perhaps) to support fiscal incentives for investments or commitments by state companies to purchase captured associated gas. While government take should in all cases be appropriate and avoid excessive private returns, given the complexity of flare-reduction projects, the fiscal terms applicable to them should generally provide greater flexibility than those typically present in upstream projects.

67 Economic Consulting Associates, Environics, and Carbon Counts, APG Flaring in Egypt: Addressing Regulatory Constraints, Submitted to the European Bank for Reconstruction and Development (London: November 2017), p.40-41, https://www.almendron.com/tribuna/wp-content/uploads/2020/07/egypt-gas-flaring-options-report-final-clean-1.pdf.

- ***Prepare for an increasingly competitive international market.*** Host country governments must regard the need to implement flare-reduction solutions with urgency given the increased focus on flaring among international buyers and consuming countries. While the priority given to emissions reduction varies, governments in countries that export oil and gas to the EU need to focus promptly on reducing flaring and methane intensity in order to avoid being shut out of the EU market when import restrictions begin to apply in earnest in August 2030. Countries that require significant investments in flare reduction to meet this deadline have to act swiftly if they are to meet this rapidly approaching deadline. Those that fail to take advantage of a limited window of opportunity to reduce flaring (and venting) risk loss of revenue and market access and will be strategically disadvantaged.

National Oil Companies (NOCs)

- ***Prioritize flare reduction.*** This may be easier said than done, as NOCs often serve multiple roles beyond that of an operator of an upstream project or midstream infrastructure—generating revenues for the State, channeling subsidies for domestic power generation, industries, businesses, and individuals, and providing a range of social functions (housing, education) that represent quasi-governmental functions. Nonetheless, a focus by NOCs on flare reduction and elimination of investment obstacles is crucial. This effort should be fully supported by top management and relevant ministries and regulators, with the constitution of dedicated teams motivated by clear incentives that are focused on the positive revenue-creating opportunities that exist to achieve flare reduction objectives, and possibly the establishment of a separate NOC subsidiary focusing on generating value from associated gas, a structure that has proven highly successful in the UAE.
- ***Promote accountability and transparency.*** Flare-reduction efforts must be supported with transparent and credible measurement and regular (ideally, daily) reporting. This will allow management to establish targets and key performance indicators, and to measure concrete progress of implementation teams. Data on flaring should be made public on an aggregated basis, at least annually. NOCs should also accept that it is in their own best interests to be subject to flaring penalties on a basis similar to IOC operators, possibly subject to transition periods to allow operations to be properly adapted.
- ***Recognize associated gas as a key resource.*** For NOCs that purchase, transport, and distribute gas, associated gas should be treated as a priority resource that creates value and is fully factored into plans and commitments. When feasible, NOCs should give priority to associated gas for purchases and access to infrastructure, with variability of supply managed as much as possible using other available resources (non-associated or imported gas).
- ***Drive collaboration with governments and IOCs.*** NOCs are often best-placed to identify opportunities for flare reduction, including under-utilized infrastructure and potential sources of demand for associated gas. NOCs should set up and staff a dedicated "flare reduction task force" that works with governments to identify opportunities and obtain robust political support. They should also lead IOCs toward investment opportunities and establish partnerships to take advantage of IOC technology and know-how and financing support.

International Oil Companies (IOCs)

- ***Prioritize flare reduction while sharpening operational focus.*** IOCs should publicly adopt aggressive flare-reduction strategies at a corporate level and at a local subsidiary level (including for their non-operated assets), which in turn will lead them to prioritize flare-reduction projects with dedicated teams, similar to the emphasis they currently place on health and safety. Their efforts should promote operational excellence, leveraging data, resources, and incentives to optimize outcomes, which in turn should enhance financial returns from flare reduction. IOCs should integrate flare reduction in all development plans for new projects and significant project expansions, whether or not strictly required by regulations or contractual terms. Upset flaring should be dramatically reduced through better planning and equipment maintenance. Long-term upset flaring from operational failure should be treated as routine flaring, and should be substantially reduced or eliminated. Even where flaring occurs, operational focus is needed to maximize combustion efficiency to avoid methane slip.

- ***Drive collaboration with governments and NOCs.*** IOCs bring unique global expertise they can use to promote host government initiatives relating to flare reduction. While IOCs will naturally assist governments in structuring fiscal incentives for flare-capture projects, they can and should do more—encompassing comprehensive assistance in identifying investment opportunities and obstacles, coupled with concrete proposals for solutions, both within the upstream ring-fence and in midstream and downstream markets (even when the investments would more naturally be made by third parties). IOCs should be willing to partner with NOCs to develop new flare-reduction schemes, including making their IOC-operated processing and transportation facilities available for associated gas from fields operated by NOCs. They should also support gas marketing, offtake, and infrastructure development on the basis of sharing of expertise.

- ***Allocate financial resources to reducing flaring.*** It is important that the commitment of IOCs to flare reduction be backed by their substantial capital resources, which are likely to be the most accessible source of financing for flare gas capture projects. This is particularly true so long as external financing for flare reduction is limited by restrictions placed by financial institutions on hydrocarbon funding (which we discuss below). In addition to funding their own shares of project investments, IOCs should when feasible make funding available at a reasonable cost (or zero cost) for "carrying" (or financing) NOC investments in flare capture projects as well as considering the use of their oil to provide security for flare project financing, which in turn will reduce the cost of capital. IOC operators can also limit financial foreign exchange risk by incurring costs to the greatest extent possible in the same currency in which revenues are generated (local currency, where the domestic market is a substantial outlet for the flared gas).

- ***Shape the narrative, and drive engagement.*** IOCs, with high standards of reporting and disclosure driven by home country regulation, shareholder pressure, and reputational issues, are well placed to use their influence to drive change within NOCs and host governments, including in projects operated by NOCs with IOCs as partners. IOCs should work constructively and collaboratively with NOC and government leadership to shape the narrative so that the profile of flaring—as a risk today but an opportunity tomorrow—is clearly seen. IOCs can use their influence to drive change in partner NOCs and governments way beyond just the assets from which they share revenues.

- ***Instill transparency and measurement.*** IOCs should commit to accurate and real-time internal reporting of flaring and venting data, including satellite monitoring, shared with NOCs and governments to enhance accountability. They should consent to government publication of flaring information on an aggregated basis, at least annually. Their own flaring reporting should also be clearly broken out into routine versus upset flaring. Today most companies report flaring (e.g., to the World Bank's Zero Routine Flaring by 2030 program, or to the Oil and Gas Climate Initiative) only from their *operated* assets (at 100% equity). We believe IOCs should start taking more accountability for their non-operated flaring—those where they have an equity stake but are not accountable for day-to-day operations. A recent report from the Clean Air Task Force highlighted that for many companies, non-operated flaring is as high (on an equity basis) as operated flaring.[68] Industry reporting practices are increasingly requiring clearer and more comprehensive disclosure, and those that fail to act on the challenges revealed will inevitably face unwelcome scrutiny.

- ***Encourage flexible contracting and economic hurdle rates.*** IOCs can explore innovative mechanisms like contributions to flare-reduction trust funds (similar to abandonment funds) that can be made available to finance infrastructure for the processing, transportation, and offtake of captured associated gas. IOCs can also make clear and public commitments not to use stabilization clauses to challenge the initiation of realistic flaring penalties or restrictions when viable offtake solutions exist or can be developed. Additionally, IOCs can utilize flexible hurdle rates for investments in flare reduction that are different from those for upstream oil projects, effectively creating mini-ring-fencing to isolate project returns and investment decisions. This will in turn make the fiscal incentive negotiation more balanced and reasonable.
- ***Develop innovative structures.*** Where there are no feasible options to utilize associated gas in conventional solutions, such as gas to pipeline, gas to power, or LNG applications, IOCs can consider alternatives such as data centers for cryptocurrency mining, alternative protein synthesis, graphene and H2 production which may work in niche environments. IOCs can also prioritize NGL-extraction projects that will at least result in flaring of "less dirty" gas, even where commercialization options for the gas are not available. Innovative structures that make the recovered liquids available to the flare-capture project partners, for example, could help unlock financing.
- ***Support new business models.*** Since flaring reduction may be perceived as a non-core activity by many IOCs—albeit erroneously in our view—the IOCs should consider being more agile in their collaboration with other players to drive flare-reduction projects. This includes the service sector, where opportunities exist for leverage by offering service providers investment opportunities or other upside, such as an interest in NGL revenue. IOCs can also foster access to capital for flare-reduction projects by collaborating with NOCs and governments to identify dedicated flare-solution groups or other investors (e.g. Sovereign Wealth Funds) whose investment objectives more nearly match the anticipated cash-flow streams from flare reduction projects, thereby "outsourcing" the solution to those best able to deliver, repeat, and scale such projects.

Consuming Countries

- ***Develop market incentives.*** Consuming country governments can foster flare reduction in partner countries that supply them with gas by encouraging purchasers, possibly with financial incentives, to offer premiums or improved market access for low flaring-intensity gas. They can also—within World Trade Organization rules—impose import fees for oil and gas from countries with high flaring volumes or intensity, or that fail to properly report flaring or to levy their own flaring penalties. An optional first step would be to encourage the expansion of voluntary certification schemes to start to form a differentiated market. On a more controversial basis, countries could seek to limit or prohibit imports of oil and gas from countries that fail to meet flaring thresholds or adopt similar restrictions. The EU, for example, will require importers of oil and gas to demonstrate, beginning in August 2030, that the methane intensity of the imported products is below regulatory limits (which remain to be defined), failing

68 Lesley Feldman, Heny Patel, and James Turitto, Flaring Accountability: Global gas flaring by major oil and gas companies and their partners (Clean Air Task Force, November 2024), https://www.catf.us/resource/flaring-accountability/.

which they will face highly dissuasive penalties.[69] Given that such restrictions may be perceived as too harsh, countries could instead favor regimes that apply emissions-based penalties or fees, with credits for penalties paid in the home country (similar to the EU's existing Carbon Border Adjustment Mechanism, which is scheduled to apply beginning in 2026, although not to oil and gas imports).[70] Indeed, we would argue that the EU should consider modifying its legislation to move from prohibitive financial penalties to an emissions-based import fee or penalty regime, as part of its ongoing efforts to introduce flexibility in the EU Green Deal without abandoning its objectives.

- ***Fund project and/or infrastructure development.*** Where a consuming country decides to impose import fees or limitations on oil and gas from companies that do not meet its flaring criteria, the consuming country should be willing to provide financing to assist producing countries in developing infrastructure to reduce flaring. Otherwise, there is a significant risk that import fees or limitations might unduly penalize producing countries that may have financial or technical difficulties achieving the flaring objectives. In this regard, proceeds from import fees could be dedicated to funding infrastructure on a low-cost basis for the capture, processing, and transport of associated gas in producing countries, aligning trade policies with environmental objectives in a more equitable manner. Buying countries could develop ideas such as the EU's "You Collect, We Buy" policy – by making capital financing available to supplying countries through, for example, using pre-purchased gas to fund capital investment (at concessional interest rates).

International Financial Institutions

- ***Accelerate financing support.*** International financial institutions (multilateral, governmental, and private) should consider providing funding for flare-reduction projects and infrastructure, adopting any necessary exceptions to policies that would otherwise prohibit or restrict financing for hydrocarbon projects. We need a reframing here: Over-restrictive policies today need to adjust to fully recognize the positive net greenhouse gas benefits of flare-reduction projects (as we discussed in the Section 5 of this report), rather than shun projects because they are associated with fossil fuels. Equally, multilateral and government financial institutions should find innovative ways to reduce country and project risk for lenders, so as to reduce the overall cost of capital and incentivize spending on flare-capture projects.

- ***Consider sovereign debt flexibility.*** When feasible, financing structures for flare reduction should be implemented in a manner that will not unduly impact sovereign debt sustainability. This may require financial institutions to rely on project-financing techniques, with limited recourse to host governments and NOCs, and revenues from projects dedicated to paying principal and interest in priority to other uses. (This may require exceptions to negative pledge clauses that otherwise might limit these structures.)[71] It may also require flexibility in debt sustainability accounting for sovereign guarantees of domestic off-taker commitments, perhaps by crediting anticipated savings on imported (dirtier) fuel facilitated by flare-reduction projects, potentially enabled by

69 European Parliament and Council, Regulation (EU) 2024/1787 of 13 June 2024 on the Reduction of Methane Emissions in the Energy Sector and Amending Regulation (EU) 2019/942, Official Journal of the European Union, L, 2024, http://data.europa.eu/eli/reg/2024/1787/oj.

70 European Parliament and Council, Regulation (EU) 2023/956 of 10 May 2023 Establishing a Carbon Border Adjustment Mechanism, Official Journal of the European Union, L, 2023, http://data.europa.eu/eli/reg/2023/956/oj.

71 Negative pledge clauses in financing agreements prohibit borrowers from pledging assets to secure other financings, without equally securing the financings that contain the negative pledge undertakings. Some negative pledge clauses allow limited exceptions for project financings, with security typically limited to revenues specifically attributable to the projects being financed. Since flare-reduction projects can be embedded in broader oil and gas developments, it may be difficult to segregate flare-reduction revenues. Where flare-reduction projects are supported by the reallocation of subsidies, it may be difficult to attribute the subsidies to the projects so as to fall within exceptions to negative pledge restrictions. International financial institutions should show a willingness to waive negative pledge clauses or to modify them to accommodate the specific needs of flare-reduction projects.

carbon markets and Article 6 of the Paris Agreement. Ideally, financing structures should be as simple as possible in order to avoid excessive cost (avoiding expensive instruments such as pre-payment facilities provided by international traders). Innovative financing products could also be considered, such as reductions of sovereign debt in exchange for flare reduction (similar to debt-for-nature swaps), or products that bear reduced interest rates so long as flare-reduction targets are met.

- ***Support currency risk management.*** Currency exchange rate risks represent a significant obstacle to flare reduction, as domestic off-takers are likely to pay for gas in local currency, while expenditures on infrastructure are often made in foreign currency. International financial institutions can consider tools such as denominating some financing in local currency (even when used for foreign currency expenditures) or providing swap or similar facilities to allow this risk to be managed.
- ***Ensure that consultant studies are actionable.*** Financial institutions provide valuable expertise to producing countries in the form of studies commissioned from qualified international consultants. At the same time, it is important that these studies and their recommendations be systematically targeted to actionable strategies that lead to clear implementation commitments.

Conclusions

It has been more than two decades since the Global Gas Flaring and Venting Reduction Voluntary Standard was unveiled at a May 2004 conference in Algeria by the Global Gas Flaring Reduction Public-Private Partnership, comprising governments from oil-producing countries, state-owned oil companies, international oil companies and the World Bank Group.[72]

By continuing to flare and vent billions of cubic meters of gas—277 BCM globally in 2023, including flaring, venting, and leaking—all parties lose opportunities to generate billions of dollars of revenues, while increasing energy security and reducing emissions of greenhouse gases. These opportunities are lost not because of any issues of technical or economic infeasibility but simply because parties are not taking the right measures to exploit them. As the IEA stated in its 2023 Global Methane Tracker report:

> More than 260 BCM of natural gas is wasted through flaring and methane leaks, but with the right policies and on-the-ground implementation on both flaring and methane emissions, an estimated 200 bcm of additional gas could be brought to markets. Stopping this waste would also reduce global temperature rise by nearly 0.1°C by mid-century, [equivalent to] eliminating the GHG emissions from all of the world's cars, trucks, buses and two- and three-wheeler vehicles.[73]

Our *repo*rt reaches the same conclusion. Its title is "Igniting Action to Reduce Gas Flaring" because that is precisely what is needed: the right policies to ensure effective implementation of the objectives endorsed publicly for years by governments, NOCs, IOCs, and others.

Our case studies show it is eminently feasible to capture the opportunities wasted through flaring with the right leadership, incentives, and collaborative frameworks—insisting on associated gas solutions before approving new projects (as in Angola and Argentina), finding solutions to electricity generation shortfalls (as at Sarqala), substituting flared gas for dirtier fuels used to generate power (as in Egypt), applying creative structures to exploit opportunities (as in Federal Iraq's Gas Growth Integrated Project) and improving data transparency to identify potential projects (as in Algeria).

Gas is more complex than oil, and associated gas is more complicated than non-associated gas. This may be the primary reason why results have not matched the lofty objectives announced for years, undoubtedly in good faith but without the resources necessary to turn them into concrete projects. We have shown in this report that complexity requires work and creativity but should not be regarded as a barrier or obstacle to implementing attractive flare-reduction projects.

While some of our recommendations have been published before (including in the 2004 World Bank Voluntary Standard), many of them go beyond the standard fare—our emphasis on formation of national task forces, our in-depth focus on making flaring penalties effective and enforceable, and our creative "inside and outside the ring-fence" approach to fiscal structuring, for example. We also believe our framework for analyzing the net climate benefits of flaring reduction, including a key focus on avoiding methane slip in flaring operations, represents a novel way to prioritize resources allocated to flare reduction.

Our hope is that this report and its recommendations will represent a significant incremental contribution to global efforts toward make flaring reduction a reality.

72 Lisa Campbell, Freya Phillips, John Lague, and Jacob Broekhuijsen, Global Gas Flaring Reduction: Voluntary Standard for Global Gas Flaring and Venting Reduction (World Bank Group, May 2004), https://documents1.worldbank.org/curated/en/342761468780614074/pdf/295550GGF0a0pu1ship10no10401public1.pdf.

73 International Energy Agency (IEA), Global Methane Tracker 2023: Overview, https://www.iea.org/reports/global-methane-tracker-2023/overview.

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