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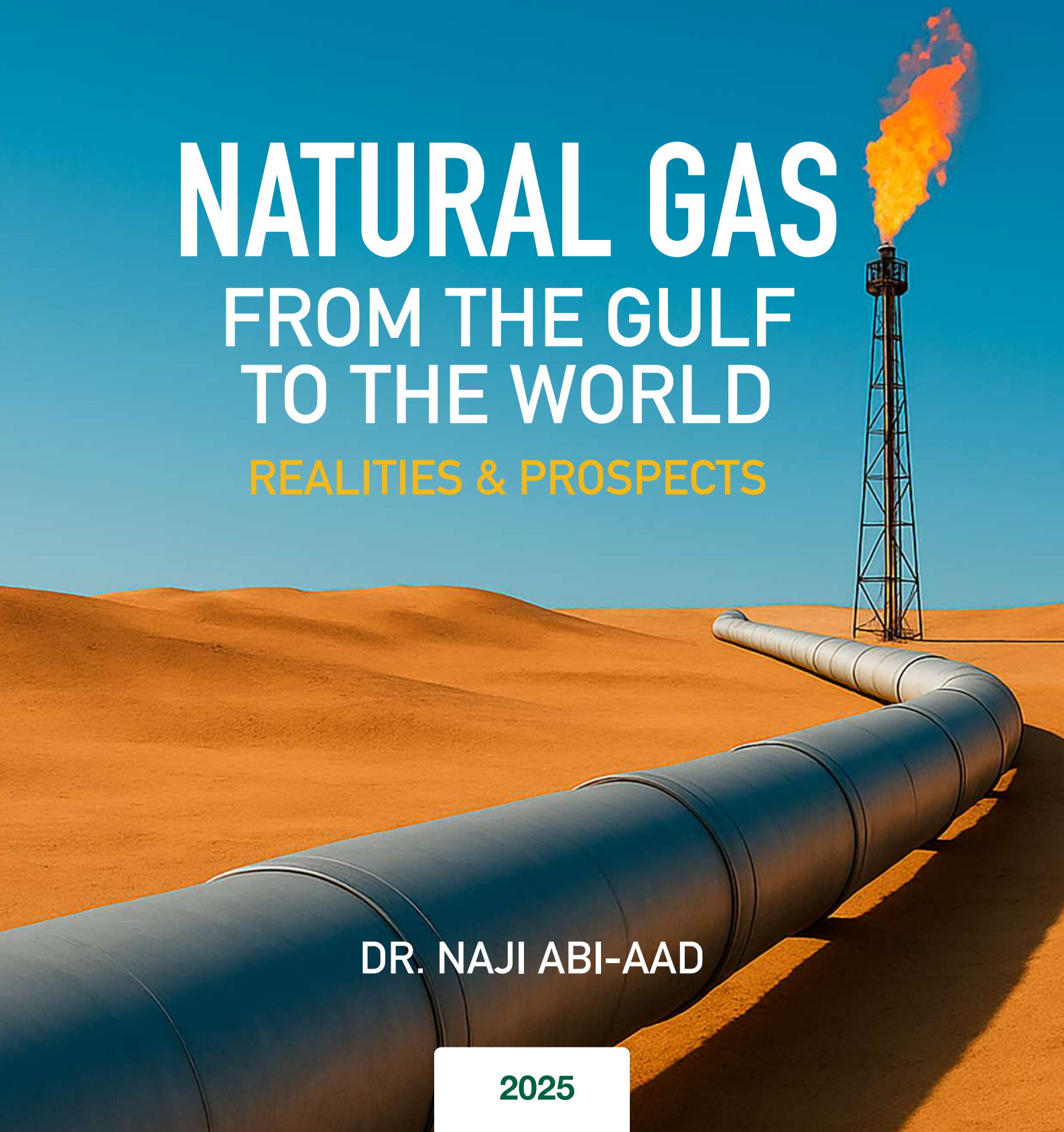
Gulf Research Center

NATURAL GAS
FROM THE GULF TO THE WORLD
REALITIES & PROSPECTS



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NATURAL GAS

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REALITIES & PROSPECTS

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EXECUTIVE SUMMARY

A wide range of reasons have been behind the success of natural gas in its rapid and increasing penetration of the global energy market and its capture of a growing share of energy markets from oil and other fuels. Natural gas has especially benefited from the fundamental evolution of its transportation economics, and in liquefied form in particular.
For the next few decades, it appears that natural gas will be among the winners in terms of its share in the market of primary energy sources and to play the role of transitional fuel on the road towards sustainable development which has been, and is likely to remain, a key issue on the agendas of the world's decision makers for the foreseeable future. This presents a historic opportunity for the global gas industry, both in terms of meeting the growing energy demand in the coming decades and living up to the expectation that natural gas is clean, safe, and reliable, and thus the transition fuel par excellence.

However, despite promising prospects, the natural gas industry needs to develop and implement a serious and coordinated action, with a number of activities to be initiated in parallel, in order to face the various actual and expected challenges, shield its gain, reap the latent benefits of the coming opportunities, and profit from embarking on a sustainable development agenda. This is especially true for the Gulf region, which comprises major gas producers and exporters.
The Gulf contains huge quantities of proven natural gas reserves, estimated at the beginning of 2024 at an aggregate figure of about 82,173 billion cubic meters (bcm). That accounts for more than 40 percent of the world's total, while the region's population represents less than 4 percent of the globe. In 2023, the average gas reserves-to-population ratio in the Gulf was high, covering around 120 years compared to a global average of some 51 years.
In addition to its huge conventional gas reserves, the Gulf has large resources of unconventional gas (including coal-bed methane, tight gas, and especially shale gas), estimated at 7 percent of the world's total.

Considering the enormous gas potential of the Gulf, little has been done so far to exploit its reserves. Gulf gas production pales in comparison to the region's reserves and potential, with gas output in the area representing around 17 percent of the world's total in 2023.
The bulk of marketed natural gas production in the Gulf has been consumed locally, with a minor, but growing portion exported into foreign outlets. Natural gas in the region is used as fuel and feedstock in many vital and critical applications such as power generation, water desalination, industries, petrochemicals and fertilizers, gas-condensate recycling, oil field uplift, and enhanced oil recovery.

Demand for natural gas in the Gulf has been affected by the availability of this source of energy, either locally or from regional and global markets through pipelines or in liquefied form. Gas demand is also shaped based on the availability and economics of other sources of energy, especially when comparing its price with those of alternative fuels. Actually, most Gulf countries have recently scaled up their interest in renewable sources of energy, especially in wind and solar power generation, which offer the highest technological and market maturity.

While the domestic gas consumption of the Gulf will not match its gas resources in the medium- and long-term, only exports to the major consuming zones will allow the full utilization and valorization of the region's vast reserves. The Gulf saw its share in the international gas trade increasing to around 13.5 percent in 2023 from less than 3 percent in 1998. Liquefied natural gas (LNG) from the Gulf countries amounted to some 20 percent of the world's total in 2023, when about 5 percent of the global piped gas originated from the region.

Gas trade between Gulf countries is still weak, representing just 20.8 percent of the total gas exchanges involving the region in 2023 and around 3.7 percent of the international gas trade. The inter-Gulf gas trade now mainly consists of significant volumes of LNG from Qatar to Kuwait, with minor quantities shipped to the UAE (Dubai). Meanwhile, large gas supplies are pumped through the Dolphin Pipeline from Qatar to the UAE and Oman, the only inter-Arab gas network still in operation. Iran is also exporting its gas to Iraq through a dual pipeline system to the towns of Baghdad and Basra.

Inter-Gulf gas trade could well grow in the near future. In fact, considering that gas output in most Gulf countries is in associated form, and that crude oil production and the subsequent output of associated gas in those countries in the foreseeable future are not anticipated to grow at the same rate as their gas demand, growing serious gas deficits are to be expected in the region. To face this mounting challenge, these countries are increasingly relying on imports, especially in the form of LNG. Kuwait, Dubai, and Bahrain have already built regasification terminals, while many others are considering the installation of such plants.

In developing their gas resources and exporting them to regional and global markets, Gulf gas producers have been facing many challenges, including the security of gas demand, the competition from other energy sources, and the growing rivalry from other exporting regions. In addition to exporting natural gas in its piped and liquefied forms, many projects have been seriously considered in the Gulf aimed at cheaply producing blue hydrogen from natural gas through the steam methane reforming (SMR) process, as well as blue ammonia and exporting these products into global markets. But while the region holds advantages in hydrogen production, challenges lie in efficient transportation to lucrative markets, often doubling initial output expenses, and in providing adequate volumes of water, crucially needed in the production process.

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The nine countries around the Gulf, namely Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, the United Arab Emirates (UAE[1]), and Yemen hold large proven reserves and undiscovered resources of natural gas, both in its conventional and unconventional forms, and includes both actual and potential major gas producers as well as large gas consumers.
The Gulf region, which recently increased its share of the world's gas market, has been playing a growing gas-consuming and importing role. In fact, at a time when huge volumes of liquefied natural gas (LNG) have been exported from the region, many countries there, in deep deficits of gas, started importing piped gas from neighboring states and LNG from the international market.

Within the Gulf, volumes and forms of gas reserves and resources, and the resulting gas aspirations and aims, differ from one country to another, with natural gas currently viewed through a number of diverse strategies such as using it domestically in order to release more crude oil and petroleum products for export, or utilizing it for building and developing a strong petrochemical and fertilizer industrial base.
Meanwhile, many nations in the Gulf have been planning to or are already enhancing their gas production with the aim of raising their export share in the global energy market at a time when their oil output (and revenues) are limited either by production quotas or technical and geological capacities.

Some other Gulf countries are using their more modest gas reserves to moderate their growing dependence on imported petroleum products and/or natural gas (in piped or liquefied form), thus minimizing their fuel imports and helping to achieve as much energy self-sufficiency as possible.

As a major part of the global gas industry, Gulf natural gas has been part of the energy transition process, both regionally and globally, with all its obvious advantages and mounting challenges. In the next section, the problematic and ambiguous relationship between energy transition and natural gas is explored.

1 Including the emirates of Abu Dhabi, Ajman, Dubai, Fujairah, Ras Al-Khaimah, Sharjah and Umm Al-Quwain

I. NATURAL GAS & THE GLOBAL ENERGY TRANSITION PROCESS

a. Role of Natural Gas as Transition Fuel

A wide range of reasons have been behind the success of natural gas in its rapid and increasing penetration of the global energy market and its capture of a growing share in energy markets from oil and other fuels.

Natural gas has benefited from the fundamental evolution of its transportation economics, somewhat resolving the main weakness of gas, which is the elevated cost of moving it, due principally to the high pressure of gas per unit of volume that requires much more steel in a pipeline or storage tank. The physical characteristics of natural gas also mean that much more horsepower is needed to transmit the same quantity of energy by pipeline compared with oil. As a result, it costs about four times as much to transport gas by overland pipeline as it does to move an equivalent amount (in energy content) of crude oil. Submarine pipeline gas transmission costs are even higher by a factor of three to four. In addition, it costs 12 times as much to move natural gas by carriers (in liquefied form) as it does to transport oil and petroleum products in tankers.[2]

These issues have been aggravated by the fact that more than 70 percent of gas reserves and many sources of gas supply are located in areas far from their actual and potential markets, and regions with hostile environments. The resulting difficulties led to the development of distinctive regional markets for natural gas (Western Europe, North America, and Asia-Pacific), in addition to which gas discoveries were written off in other parts of the world where, if gas happened to be produced with oil, it was either flared or reinjected.

Then came the period of high oil prices in the 1970s and early 1980s, which transformed the whole economics of natural gas. Higher oil prices meant higher burner tip values for gas, and those higher values meant the extension of the economic reach of gas. This justified huge capital investments in transporting natural gas by pipeline to Europe from North Africa and the former Soviet Union (FSU). These higher oil prices also substantially improved the economics of transporting natural gas in liquefied form, which, together with technological advances, have made additional markets accessible for gas, especially in East Asia, notably Japan.

The boost to gas due to the development of LNG technology and the improvement of its economics can be inferred from the statistics of liquefied gas trade over the past fifty years. By 1973, LNG was already established as a recognizable segment of the international gas industry, with shipments in that year totaling some 4 million tons. By 2023, the total LNG trade increased a hundred-fold, reaching around 400 million tons, representing an average annual increase of about 9.6 percent over the 50-year period.[3] During 2023, about 66 million tons of LNG, or some 16.5 percent of the world's total, were imported by Japan alone.[4] Without the technological advances in the liquefaction and subsequent transportation and regasification

2 "The Palgrave Handbook of International Energy Economics," Luciani Giacomo & Hafner Manfred, May 2022. (file:///C:/Users/User/Downloads/978-3-030-86884-0.pdf)

3 The LNG Industry, GIIGNL Annual Report 2024

4 Ibid.

of natural gas that occurred over this period, Japan would likely have consumed only negligible quantities of indigenous gas.

In addition, natural gas was stimulated — and will continue to be stimulated — by a symbiotic effect related to high oil prices. This is the spill-over impact upon gas exploration of higher oil prices. As oil-targeted drilling increased, more gas was discovered collaterally. Gas production benefited significantly when higher prices, through the mid-1980s, catalyzed an upsurge in oil drilling. Much gas is still found as the incidental result of oil exploration, even though improved seismic techniques and much advanced digital analytical methods have made the selective identification of gas vis-à-vis oil targets more accurate.

A number of other important factors provide strong opportunities for natural gas. In fact, natural gas is the cleanest and environmentally friendliest of all hydrocarbon energy sources, with very low emissions of pollutants such as sulfur and nitrogen oxides, while the carbon dioxide emissions of burning gas could reach less than half of those emitted by burning coal. New technologies for the conversion of natural gas into electricity and other secondary energy forms radically reduce most of the adverse environmental impacts.

In fact, natural gas has a relatively favorable position when compared to other fossil fuels in contributing to the ongoing decarbonization of global energy, simply because the carbon emissions per unit of energy are relatively low. Based on those characteristics, natural gas can be seen as the most suitable candidate for being the ideal transition fuel in the transition towards more sustainable energy futures.

The use of natural gas has also been boosted by the rapid expansion in the demand for electricity, which in turn creates a growing market for those fuels used to power electricity-generating plants. For some years now, the fuel of choice to satisfy this incremental demand has been natural gas, burned in both gas turbines and combined-cycle gas turbines (CCGT).[5]

Among other strong cards for natural gas is the fact that efficiency levels of its consumption technology are among the highest. Moreover, natural gas, unlike oil, seems to face much less serious reserve and resource constraints. In addition, natural gas, compared to most other primary energy sources (other than oil and coal), is relatively easy to store. Furthermore, natural gas can be seen as a precursor to hydrogen, and therefore as a way to prepare for long-term development towards alternative energy systems.

With all that in mind, the global gas industry has made a case in the past decade or so that natural gas can be a critical factor in the ongoing energy transition as a bridge fuel, primarily by displacing more-polluting coal (as well as some oil) in the energy system. Some success stories, like the wholesale displacement of coal-fired generation by a combination of gas and renewables in the US and the UK, and the policy-driven coal-to-gas switching in China, underline the environmental benefits of gas as a transition fuel.

For the next few decades, natural gas appears to be among the winners in terms of its share

5 "Natural Gas – Efficiency and Reliability in Power Generation," Woodway Energy, 26 April 2024. (https://www.woodwayenergy.com/natural-gas-efficiency-in-power-generation/)

in the market of primary energy sources and to play a significant role as a transitional fuel on the road towards sustainable development, a key issue on the agendas of the world's decision makers that is likely to remain important for the foreseeable future. This provides a historic opportunity for the global gas industry, both to meet the growing energy demand in the coming decades, and to live up to the expectation that natural gas is clean, safe, and reliable, and thus the ideal transition fuel.

b. "Gas Cannot Just Sit on Its Good Cards"

It is becoming clear that natural gas has good cards to play. However, one never wins the game "by just sitting on his cards." The global gas industry must always keep in mind that other energy sources also have some strong cards to put on the table, which may unexpectedly alter the way the game evolves. In addition, it should not be taken for granted that the global gas industry will automatically take the necessary measures and investment decisions that are needed to substantiate its prospective increasing role.

Furthermore, the international gas industry faces some threats that, if not tackled well, may substantially disrupt the game, the most severe challenges probably being the growing concerns about security of gas supply (due to technical breakdowns and accidents, political instability, and commercial disagreement in relation to supplies, transit, and facilities), and the impacts of high prices of oil and gas on the future demand of those energy sources.[6]

In fact, a number of aspects may well threaten the quite rosy outlook for the conventional gas industry, including the energy transition to sustainable renewable energy; the tendency in many Western circles to base a major part of the energy future on renewable sources; the poorly-designed regulations in gas producing, transit, and consuming nations; the growing debate about resource recovery and transport operations, particularly in new, unspoiled, and frontier areas; the growing competition from other energy sources that are not remaining passive, such as coal (with rapidly evolving clean technologies), nuclear, and renewables; the production of gas from shale, coal, tar-sand, and coal-bed methane as well as from other unconventional fossil resources; the rising concerns about security of gas supply with some gas supplying nations being unstable, and many of the international gas transport systems being vulnerable; and the adverse impacts of high gas prices, resulting from oil prices being driven up due to geopolitical issues and capacity constraints.[7]

Moreover, while industry outlooks for natural gas and LNG demand remain buoyant, question marks have surrounded the role of gas in deep decarbonization scenarios consistent with the climate goals of the Paris Agreement of December 2015.[8] While the near-term prospects for gas seem strong, for reasons reflecting the fuel's superior air quality attributes in comparison to coal or liquid fuels, the credentials of gas as a transition fuel could be undermined if flaring, venting, and fugitive methane emissions along the natural gas supply chain are not significantly addressed. In the long-term, the imperative to eliminate most fossil fuel-related greenhouse gas emissions, not just those associated with coal and oil, but also most of those associated with the

6 "Advantages and Disadvantages of Natural Gas," Bank Bazaar, February 2025 (https://www.bankbazaar.com/gas-connection/advantages-and-disadvantages-of-natural-gas.html)

7 "What Influences Gas Demand?" Engie, 30 October 2023 (https://gems.engie.com/what-influences-gas-demand/)

8 "Key aspects of the Paris Agreement," UNFCCC (https://unfccc.int/most-requested/key-aspects-of-the-paris-agreement)

burning of gas, could pose a profound challenge to the global gas business.[9]
In fact, methane leaks, flaring, and venting, which have been receiving greater attention in recent years, have the potential to undermine the environmental bona fides of natural gas. While global understanding of the methane leakage problem is still limited, a study by the International Energy Agency (IEA)[10] indicates that the yearly methane emissions associated with oil and gas operations worldwide are quite significant, totaling the equivalent of around 2.4 billion tons of carbon dioxide. At that level, these emissions would be more than the energy-related carbon dioxide emissions of any country except the US and China. Moreover, a number of recent high-profile academic studies indicate that the environmental impact of oil and gas-related methane emissions could be worse than previously thought,[11] with a leak of one ton of methane, equivalent to emitting some 81.2 tons of carbon dioxide measured over 20 years.[12]

While the best available data on leakage rates globally indicate that the lifecycle of the greenhouse gas (GHG) footprint of natural gas is probably substantially lower than that of coal,[13] the lack of definitive data has generally not worked in favor of the gas industry. Some environmental activists and academics already assert that natural gas is hardly better than coal from a climate perspective,[14] and certain policymakers and philanthropists are increasingly calling for the elimination of all fossil fuels from the energy mix as soon as possible.[15] The risks of such a policy backlash against gas may intensify as the extent of the global methane leakage problem is more fully understood, and gas flaring volumes increase worldwide, especially in the US.

Indeed, the green credentials of the gas industry are also increasingly called into question due to its highly visible gas flaring activity. According to the latest World Bank data, global gas flaring activity increased 7 percent from 2022 to 2023 and reached 148 billion cubic meters (bcm),[16] much more than the 2023 total gas consumption of Canada (120.7 bcm) or Saudi Arabia (114.1 bcm).[17] Flaring has so far been viewed as a problem of economic waste and seen as less environmentally harmful than methane emissions because it produces carbon dioxide as a primary greenhouse gas.

c. "Greening" Natural Gas: Opportunities & Challenges

In order to reconcile the vision of a decarbonized energy system with projections of continued consumption of natural gas, the global gas sector has started to embrace the idea of "greening"

9 "The Role of Natural Gas in the Energy Transition," Centre on Global Energy Policy, September 2019. (https://www.energypolicy.columbia.edu/publications/role-natural-gas-energy-transition/)

10 "Tracking Clean Energy Progress: Methane emissions from oil and gas," International Energy Agency, 29 July 2019. (https://www.iea.org/tcep/fuelsupply/methane/)

11 "New Study Finds U.S. Oil and Gas Methane Emissions Are 60 Percent Higher Than EPA Reports," Environmental Defence Fund, 21 June 2018. (https://www.edf.org/media/new-study-finds-us-oil-and-gas-methane-emissio....)

12 "Global Warming Potential" (https://en.wikipedia.org/wiki/Global_warming_potential)

13 "Methane tracker: Reducing methane emissions from oil and gas operations," International Energy Agency, 2019. (https://www.iea.org/weo/methane/oilandgas/.) "Commentary: The environmental case for natural gas," International Energy Agency, 23 October 2017. (https://www.iea.org/newsroom/news/2017/october/commentary-the-environmen....)

14 "The New Gas Boom: Tracking Global LNG Infrastructure," Global Energy Monitor, June 2019. (https://globalenergymonitor.org/wp-content/uploads/2019/06/NewGasBoomEmb....) "A bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas," Energy Science and Engineering, Vol. 2, Issue 2, 15 May 2014, pp.47-60. (https://onlinelibrary.wiley.com/doi/full/10.1002/ese3.35.) "Fracking, methane and climate," Earthworks, 16 September 2019. (https://earthworks.org/issues/fracking_methane_and_climate/)

15 "Michael Bloomberg Promises $500 Million to Help End Coal," New York Times, 6 June 2019. (https://www.nytimes.com/2019/06/06/climate/bloomberg-climate-pledge-coal....)"Berkeley became first US city to ban natural gas. Here's what that may mean for the future," The Guardian, 23 July 2019. (https://www.theguardian.com/environment/2019/jul/23/berkeley-natural-gas....)"Beginning of the End of Natural Gas' in LA is Here," NBC Los Angeles, 13 February 2019. (https://www.nbclosangeles.com/news/local/Garcetti-Says-Beginning-of-the-....)

16 "Global Gas Flaring Tracker Report," World Bank, June 2024. (https://thedocs.worldbank.org/en/doc/d01b4aebd8a10513c0e341de5e1f652e-0400072024/original/Global-Gas-Flaring-Tracker-Report-June-20-2024.pdf)

17 Energy Institute, Statistical Review of World Energy, 2024.

natural gas. This can be done by using more biomethane from organic sources or by blending hydrogen, produced either from water using renewable electricity (green hydrogen) or from natural gas combined with carbon capture, utilization, and storage (CCUS, blue hydrogen), into existing natural gas networks. Some of these pathways could offer decarbonization at scale, including in hard-to-abate sectors,[18] while extending the use of existing natural gas grids into the future. However, none of these pathways is particularly easy from an energy economics point of view, and they are by no means guaranteed to succeed, as each of these technological pathways is fraught with difficulties.[19]

Biomethane, which can be produced from landfill gas, animal manure, and other agricultural waste products through biogas upgrading, has the same characteristics as conventional natural gas, minus the carbon footprint. This means that it can be transported, stored, and burned using the existing natural gas supply chain with no modification whatsoever. However, the biomethane production process faces serious scalability constraints due to land and feedstock availability issues and the inherent rate limitations of the anaerobic digestion process, among other factors. Biomethane production itself can be prone to methane leakage, and the lifecycle environmental impacts of the process, including the land-use change effects, are not fully mapped out.

Estimates of the sustainable potential of biomethane supply vary enormously, even within specific regions such as Europe.[20] But in all likelihood, it is fairly small compared to the scale of the existing natural gas system. The technology of producing biogas and upgrading it to biomethane is relatively well-established, so further cost declines from large-scale deployment are limited. Costs may even go up over time if biomethane gains widespread adoption and producers are gradually forced to utilize more marginal--and expensive--feedstock sources.

Low-carbon hydrogen pathways — whether from renewable electricity or from natural gas combined with CCUS — may not only enable the greening of gas supply via hydrogen blending in existing natural gas applications. They may also spur the development of a future hydrogen economy, eventually opening the possibility for deep decarbonization in hard-to-abate sectors, such as aviation, maritime shipping, long-haul trucking, industrial processes, and residential heating.

Hydrogen is notoriously difficult to handle, however. Storage and transport over long distances are highly expensive, and hydrogen may be even more susceptible to leakage than methane along the supply chain.[21] While hydrogen is less harmful than methane, it is nonetheless an indirect GHG with an estimated global warming potential 6 times greater than that of carbon dioxide over a 100-year time frame (vs. 28-34 for methane).[22]

18 Hard-to-abate sectors refer to industries where reducing carbon emissions is particularly difficult due to the nature of their processes and their heavy reliance on fossil fuels. These industries include shipping, aviation, heavy transport and steel and cement production, where the high energy inputs required and specific chemical reactions make decarbonization difficult.

19 "Greening Gas: Creating a Market for Low-Methane Natural Gas," Resources for the Future, 24 April 2020. (https://www.rff.org/events/rff-live/greening-gas-creating-market-low-methane-natural-gas/)

20 "Narratives for Natural Gas in Decarbonizing European Energy Markets," Jonathan Stern, Oxford Institute for Energy Studies, February 2019, pp.6. (https://www.oxfordenergy.org/wpcms/wp-content/uploads/2019/02/Narratives....)

21 "Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues," National Renewable Energy Laboratory, March 2013. (https://www.nrel.gov/docs/fy13osti/51995.pdf.)

22 "Global environmental impacts of the hydrogen economy," International Journal of Nuclear Hydrogen Production and Application, Vol. 1, No. 1, January 2006, pp.64. (https://pdfs.semanticscholar.org/68cb/15a0b9f62711a0310f17a9a2b32e139c28....)

Corrosion, embrittlement, and heightened safety risks are also issues that need to be addressed and could add to costs as hydrogen blending gains momentum.[23] The energy density of hydrogen is only about a third of methane,[24] so hydrogen blending into the natural gas stream will result in an inferior product (in terms of energy content) at a substantial additional cost. Beyond a relatively low threshold, it will also necessitate equipment upgrades on the end-use side. This means that low-carbon hydrogen will have to rely on some form of policy support. While the cost of producing hydrogen might fall substantially with widespread deployment, system costs can later reflate as the 10 to 20 percent maximum blending threshold for using current infrastructure is surpassed,[25] and substantial upgrades and new infrastructure become necessary.

Blue hydrogen, which uses natural gas as a feedstock, could be a real boon for the upstream gas industry, as the process could open up new markets in aviation, shipping, and trucking for natural gas-based hydrogen, thanks to the favorable physical properties of the fuel. But this pathway would require scaling up not one, but two challenging technologies — CCUS and hydrogen — simultaneously. On another plus side, where the geological storage of carbon dioxide is an option, such as in the North Sea or the Gulf of Mexico, blue hydrogen may prove relatively fast and inexpensive to deploy. In contrast, not all countries and markets have geological storage options, including large gas-consuming nations like Japan and South Korea.

d. Future of Natural Gas: A Continuous Struggle

It is clear that natural gas has played a role to date in addressing local air quality problems and reducing carbon dioxide emissions in many jurisdictions around the globe. But the gas industry has to continue tackling the leakage and flaring problems if gas is to be a viable and low-cost abatement option in the medium-term. In the longer term, the gas sector will also need a credible decarbonization strategy that addresses the inherent opportunities, challenges, and limitations of the current technological pathways on offer.

If the history of environmental progress is any guide, then voluntary actions alone will not be enough to clean up the natural gas mix. Given the multitude of market failures and infrastructure challenges standing in the way of decarbonizing gas on a meaningful scale, there will be ample room for smart policy intervention and more forceful regulatory actions in the years ahead. Historically, the oil and gas sector has been reluctant to advocate for policies that hasten the energy transition. It may be time to change that and embrace policies and technologies that can help the decarbonization of the natural gas supply chain. Without greater industry leadership and collaboration with governments, green gas may never become a commercial reality, and ultimately, there may be little room left for natural gas in low-carbon energy systems around the world.

That mixture of advantages and threats poses a series of dilemmas to natural gas, which demonstrate that the global gas industry, despite the promising outlook, needs to develop

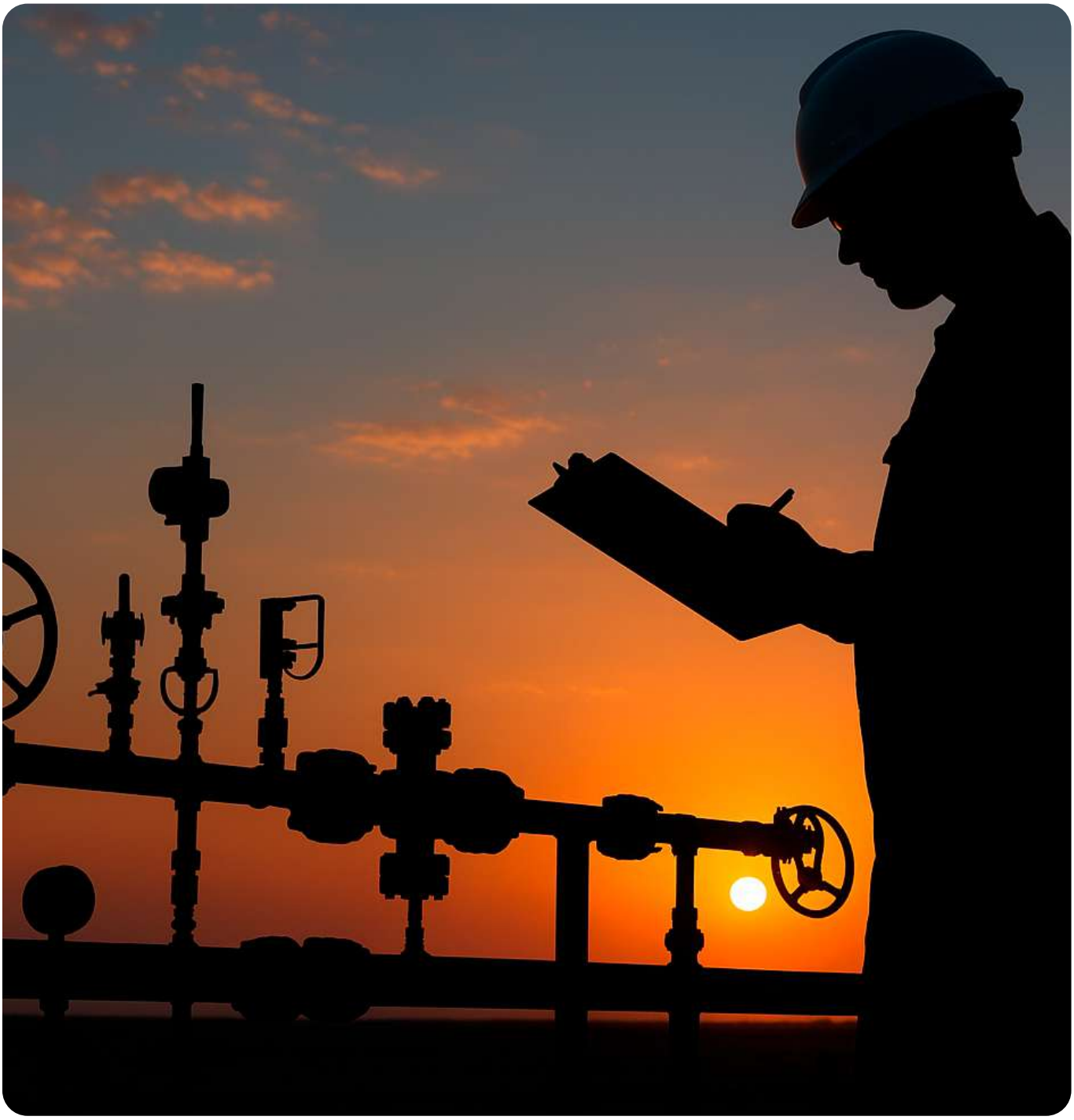
23 "Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues," National Renewable Energy Laboratory, March 2013. (https://www.nrel.gov/docs/fy13osti/51995.pdf.)

24 "The Future of Hydrogen," International Energy Agency, June 2019, pp.35. (https://webstore.iea.org/the-future-of-hydrogen.)

25 "Is Natural Gas the Transition Fuel for Hydrogen?" Council on Foreign Relations, 6 February 2018. (https://www.cfr.org/blog/natural-gas-transition-fuel-hydrogen.) "Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues," National Renewable Energy. Laboratory, March 2013 (https://www.nrel.gov/docs/fy13osti/51995.pdf.) "The future of gas: Transition to hydrogen in the gas grid," Dentons, 15 January 2019, pp.6. (https://www.dentons.com/en/insights/articles/2019/january/15/the-future-of-gas-t....)

and implement a serious and coordinated action, with a number of activities to be initiated in parallel, in order to face the various actual and expected challenges, shield its gain, reap the latent benefits of the coming opportunities, and profit from embarking on a sustainable development agenda.

This is especially true for the Gulf region, which contains major gas producers and exporters. And this is what the next sections of the present report aim to show; first, about the importance of Gulf natural gas within the region itself and worldwide, and then the crucial role this gas industry has been playing in providing such a vital energy source to the global markets and the various challenges facing it.



II. NATURAL GAS RESERVES & RESOURCES IN THE GULF

a. Proven Gas Reserves

The nine Gulf countries under study[26] hold huge volumes of proven natural gas reserves, estimated in early 2024 at an aggregate figure of 82,173 bcm.[27] This accounts for around 40 percent of the world's total, while the region's population represents less than 4 percent on a global scale[28] (Table 1).

A major portion of gas reserves in the Gulf is concentrated in a small number of super-giant fields,[29] a fact that makes the development of those structures more straightforward and less expensive to operate and maintain. The region has two such accumulations (including the North Field in Qatar, the world's largest non-associated gas structure, and the South Pars field, offshore Iran), out of ten such structures on our planet.

The size of proven natural gas reserves widely differs from one Gulf country to another, from as low as 68 bcm in Bahrain to as large as 33,988 bcm in Iran.[30] A simple calculation dividing the gas reserves of each country by its actual population[31] gives the gas reserves-to-population ratio, which also widely fluctuates from one country to another, going for the year 2023 from some 7 bcm/1 million inhabitants in Yemen to up to around 8,000 bcm in Qatar (Table 1). Nevertheless, the region's average gas reserves-to-population ratio for 2023 (352 bcm/1 million inhabitants) is more than 13 times larger than the global mean (26 bcm/1 million inhabitants).

In the Gulf countries, the average reserves-to-production[32] ratio for natural gas, a measure often used as an indication of near-term supply capability, is pretty high, estimated at around 120 years in 2023, as compared to the global average of some 51 years.[33] It is also interesting to note that the total proven reserves of natural gas in the region, as estimated in early 2024, are alone sufficient, even if no further discoveries are made, to satisfy current worldwide gas consumption for more than 20 years (Table 1).

With the exception of Qatar and, to a lesser extent, Iran, all other Gulf countries have most of their proven reserves in associated form, found and eventually produced together with oil. Natural gas output in these countries is thus closely linked to that of crude oil. That leaves Qatar the only Gulf country with a scope to expand gas output and export. Iran, to a lesser extent, could also be a major player on the international gas market, although it has first to fulfill its growing domestic needs (including gas reinjection), and to see an end to the sanctions affecting its petroleum industry.
Back to the Gulf gas reserves, which many believe to be underestimated--and underestimated to a large extent, in this context-- a comparison of the ratio of crude oil reserves to those of natural gas on a regional basis is very revealing. On an energy-equivalent basis, oil reserves in

26 Including Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, the United Arab Emirates (UAE), and Yemen

27 OPEC Annual Statistical Bulletin 2024

28 "Countries in the world by population (2025)," Worldometers (https://www.worldometers.info/world-population/population-by-country/)

29 A 'super-giant' field refers to a structure with estimated ultimate recoverable reserves of between 1,400 and 14,000 bcm, while a 'giant' field refers to one with reserves of between 140 and 1,400 bcm.

30 OPEC Annual Statistical Bulletin 2024.

31 "Countries in the world by population (2025)," Worldometers (https://www.worldometers.info/world-population/population-by-country/)

32 "Production" here equals gross production minus reinjection.

33 Author's calculations (rounded figures)

the Gulf are more than twice those of gas, the ratio being double that of the world as a whole, where oil and gas reserves are roughly equal. The Gulf might be a particularly "oily" province, but should the average global ratio of oil to gas reserves also hold for the region, then the potential for new gas discoveries is indeed enormous.

In addition, the ratio of natural gas reserves in associated form to non-associated (or dry/free) gas in the Gulf is higher than in most other regions of the world. This indicates that the potential for discovering significant volumes of non-associated gas in the region could be high.

Table 1: Proven Natural Gas Reserves in the Gulf End 2023

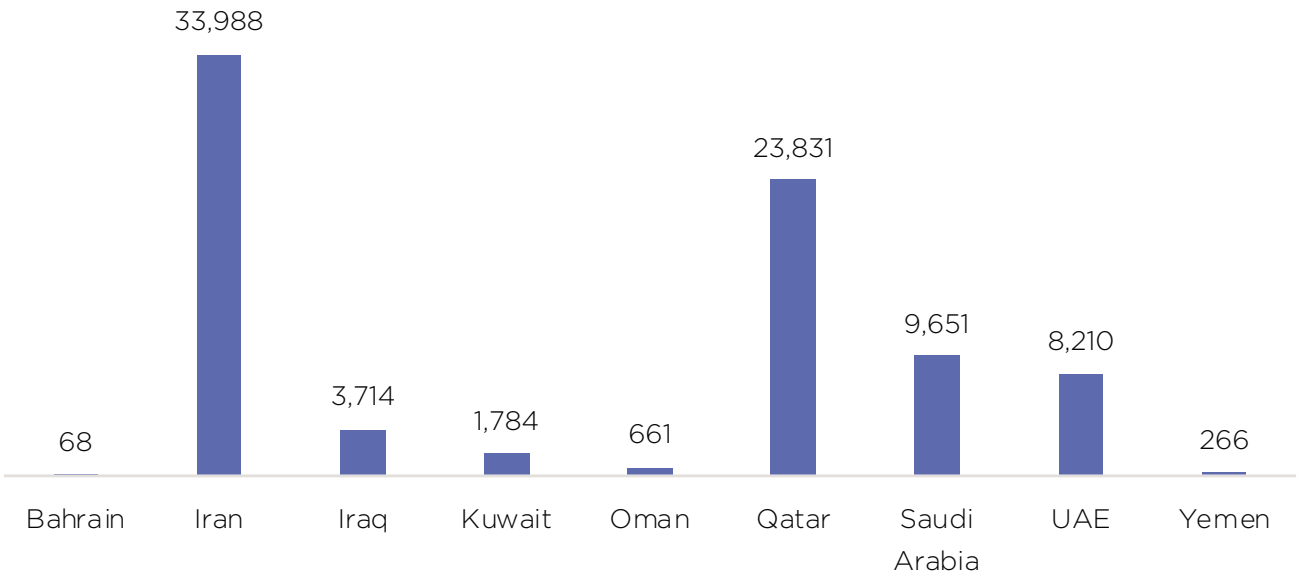
Country	Proven Reserves (End 2023)	Of Region's Total	Of World's Total	Reserves -to-Population (2023)	Reserves-to-Production (2023)
	Bcm (1)	% (2)	% (2)	Bcm/1 Ml Inhabitants (2)	Years (1,2)
Bahrain	68	*	*	43	4.1
Iran	33,988	41.4	16.5	375	135
Iraq	3,714	4.5	1.8	82	375
Kuwait	1,784	2.2	*	361	132
Oman	661	0.8	*	131	15.3
Qatar	23,831	29.0	11.5	8,000	131.7
Saudi Arabia	9,651	11.7	4.5	290	84.6
UAE	8,210	10.0	4.0	771	147.7
Yemen	266	*	*	7	n.a.
TOTAL	**82,173**	**-**	**39.8**	**352**	**119.8**
World	-	-	-	26	50.9

* Less than 0.5
n.a. Non-available

Sources: (1) OPEC Annual Statistical Bulletin 2024; Energy Institute Statistical Review of World Energy 2024; BP Statistical Review of World Energy 2021; OAPEC Annual Statistical Report 2023

(2) Author's Calculations (Rounded Figures)

Proven Natural Gas Reserves in the Gulf (End 2023) (Bcm)



Of course, those two ratios by themselves are not considered sufficient grounds for surely asserting that natural gas reserves in the Gulf are underestimated and undervalued. Nevertheless, there are a number of other factors that suggest that actual gas reserves may be far greater than presently reported.

In fact, the huge increases in petroleum reserves in the Gulf over the last 80 years or so have mainly been the result of development work, not of exploration activities. Drilling activities have become insignificant in the area: according to Statista, out of some 1,705 active oil and gas rigs in the world in November 2024, only about 336 were doing work in the region,[34] a disproportionately small figure (around 20
percent of the total) in relation to the area's existing petroleum reserve stock, production level, and discovery prospects.

Earlier exploration activities in the Gulf countries concentrated mostly on the search for crude oil rather than natural gas, and as a result, gas discoveries had occurred there more by chance than by design. In addition, discoveries of natural gas were often not accorded any value, and wells that encountered gas rather than oil were considered dry holes. Moreover, license areas found to contain large quantities of gas, but no crude, were largely relinquished by exploration companies.

Furthermore, gas fields that had been found were often not delineated or fully appraised, with only a preliminary estimate of reserves, if any, being made. In fact, there was little incentive to carry out the testing and further drilling necessary to evaluate the gas discovery at a time when natural gas was perceived as having little or no value, being regarded as an unwanted by-product of crude production, vast quantities of which were being flared in oil fields.

34 "Number of oil and gas rigs worldwide as of November 2024, by region and type," Statista. (https://www.statista.com/statistics/326727/global-gas-and-oil-rig-numbers-by-region/)

Nevertheless, for nearly four decades now, natural gas reserves have assumed significant importance worldwide and, in the Gulf, especially in those countries that also happen to have large reserves of crude oil. That explains why it is only in recent years that exploration specifically targeted at discovering gas has been undertaken in many Gulf countries. This effort, although still nascent, has involved exploring and drilling in previously identified, but unexplored, structures as well as undertaking the drilling of more sophisticated and deep wells. Deep horizons promise to hold more gas reserves than oil, and it is this fact that has discouraged the drilling of expensive deep wells in the past in many countries.

In a related context, many believe that a new and systematic review of the real potential of all petroleum structures in the Gulf could spring many positive surprises, especially since the presence of giant and supergiant fields made it unnecessary in the past to mobilize very fine approaches.[35] The proven natural gas reserves (and even those of crude oil) in the region would therefore be much higher when new and improved technologies are applied.

Besides, no serious exhaustive investigation has yet been attempted to identify the satellite accumulations of the main petroleum fields discovered in the Gulf. In the North Sea, for example, this type of approach has helped to double the producible reserves. Without drawing a parallel to that area, it is reasonable to assume that this approach should also benefit the Gulf region.[36]

With all these factors in mind, one can be fairly confident that proven reserves of natural gas in the Gulf will continue to grow, and that the region will account for a far larger share of the world's gas resources. That prompts an analysis of the prospects of undiscovered gas resources in the region, which are based on a purely geological concept that is concerned neither with technological and economic constraints nor with a time scale.

b. Undiscovered & Unconventional Gas Resources

There is only one public source estimating the world's undiscovered petroleum resources, namely the US Geological Survey (USGS, Charles Masters and others). The latest USGS figures were released in 2012 when the undiscovered gas resources of the nine Gulf countries were estimated at around 8,254 bcm (mean[37]), or nearly 5.2 percent of the world's total. Those conventional resources are mainly located in Iran, Iraq, and Saudi Arabia.[38] (Table 2)

35 "Arab Natural Gas to the World," Abi-Aad Naji, Arab Energy Conference, December 2023.

36 Ibid.

37 The USGS figures are recorded as low, most likely, and high estimates which are intended to reflect a 90 percent range of probability (95 to 5 percent) that the occurrences of natural gas will lie between the two stated values. The most likely occurrence is referred to as mode. If the consistency between the USGS assessors and average values produces a consensus, the estimates are then fit to a log-normal distribution to calculate the mean and other fractiles.

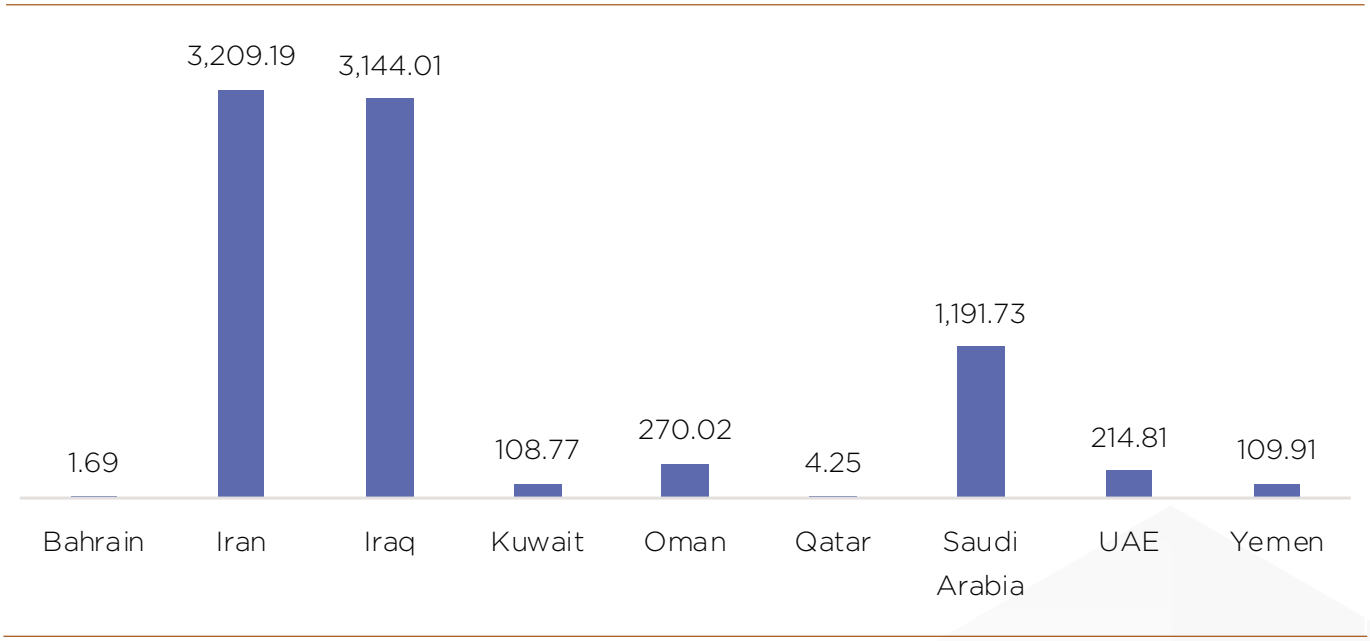
38 "World - USGS Undiscovered Oil and Gas Resources, Energy Data," April 2022. (https://energydata.info/dataset/world-usgs-undiscovered-oil-and-gas-resources)

Table 2: Undiscovered Gas Resources in the Gulf (As estimated in 2012)

Country	Undiscovered Gas Resources (mean, bcm)
Bahrain	1.69
Iran	3,209.19
Iraq	3,144.01
Kuwait	108.77
Oman	270.02
Qatar	4.25
Saudi Arabia	1,191.73
UAE	214.81
Yemen	109.91
TOTAL	**8,254.38**
World	158,799.60

Source: World - USGS Undiscovered Oil and Gas Resources, Energydata, April 2022 (https://energydata.info/dataset/world-usgs-undiscovered-oil-and-gas-resources)

Undiscovered Gas Resources (mean, bcm) (As estimated in 2012)

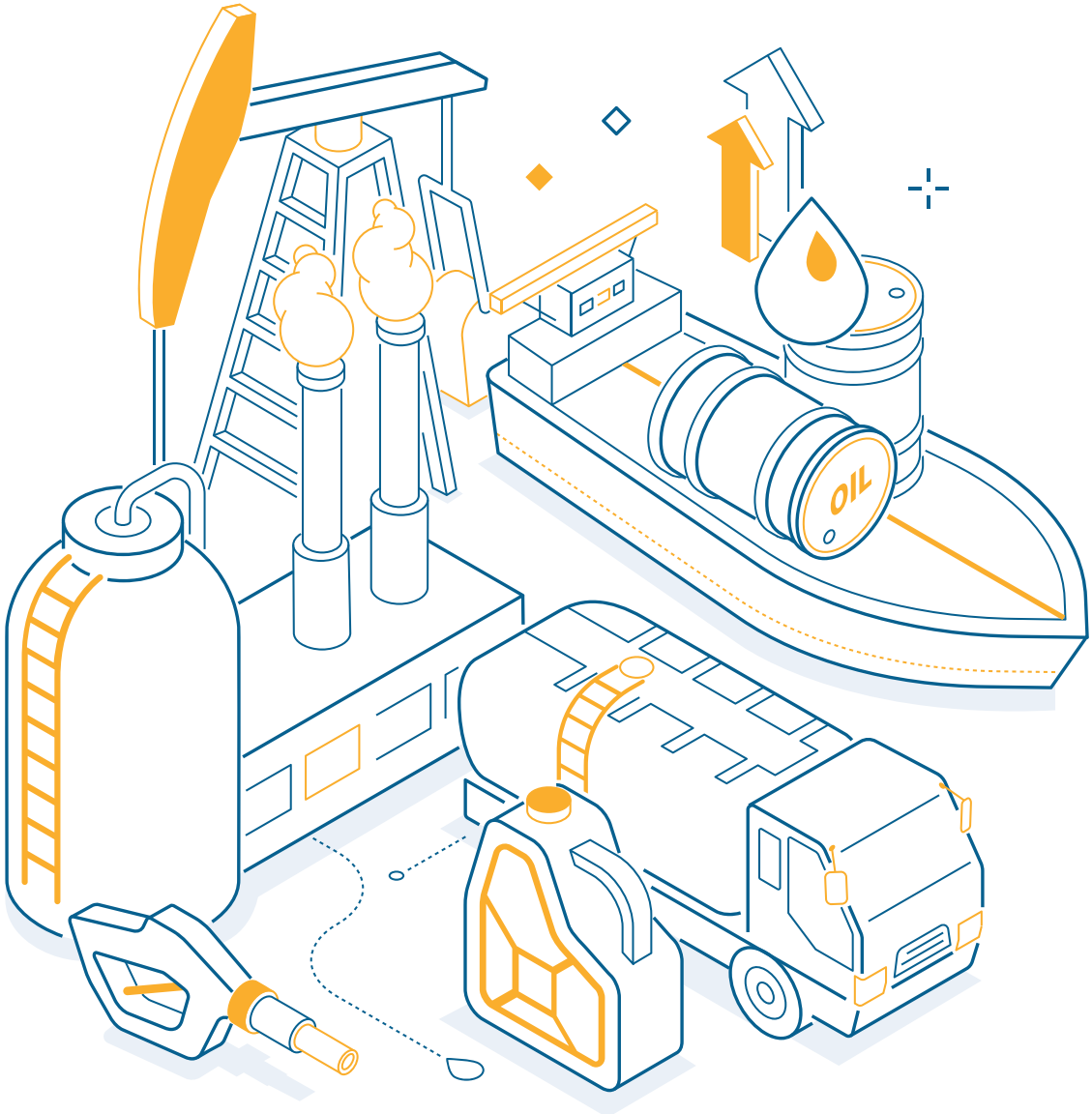


In addition to its huge conventional gas reserves, the Gulf has large resources of unconventional gas (including tight gas, but especially shale gas). The technically recoverable unconventional gas resources in the Gulf are estimated at some 24,500 bcm, including around 16,100 bcm of shale gas and about 8,400 bcm of tight gas, representing roughly 7 percent of the world's total.[39] Nonetheless, the total figure for unconventional gas resources in the Gulf represents just 30 percent of the estimates of conventional proven gas reserves in the region.

39 "Distribution of Oil and Gas Resources in the Middle East," Springer Nature Link, October 2024. (https://link.springer.com/chapter/10.1007/978-981-97-4756-6_8)

The Gulf recoverable unconventional gas resources are mainly found in Saudi Arabia, the UAE, and Oman.[40] The unconventional gas resources in Saudi Arabia are estimated at around 11,900 bcm, including some 8,700 bcm of shale gas and about 3,200 bcm of tight gas. Unconventional gas resources in the UAE are assessed at around 6,500 bcm, all of which are shale gas, while those in Oman are estimated at some 3,000 bcm, including about 2,350 bcm of tight gas.

After analyzing the estimates of both the proven reserves of natural gas in the Gulf in its conventional and unconventional forms, and those suggested for its undiscovered gas resources, it is time to review the historical course of gas production in the region and to project the likely supply in the region within the next 25 years.



40 Ibid.

III. NATURAL GAS PRODUCTION IN THE GULF

a. Historical Background

Considering the enormous gas potential of the Gulf, little has been done so far to exploit its reserves. It was only in the mid-1970s that countries in the region began to develop their gas resources, especially those in associated form, following a long period during which gas had been burned at the flare.

The exploitation of associated gas reserves was encouraged despite the drawbacks of establishing a gas industry purely on such resources. Although that gas is produced in association with crude oil, its utilization does not necessarily come at a low cost. In fact, associated gas may be economically less attractive than non-associated gas.[41] In particular, associated gas usually undergoes a number of gas/oil separation stages before it can be used and, consequently, it is only available at very low pressure — often just a little higher than atmospheric pressure — requiring the installation of compressors for its transmission. Non-associated gas, on the other hand, is generally available at much higher pressures.[42]

In addition, the output rate of associated gas is dependent, by definition, on that of crude oil, which leads to great fluctuations in supply. In the case of Gulf members of OPEC[43] (Iran, Iraq, Kuwait, Saudi Arabia, and the UAE, as well as Qatar until January 2019), the sharp drop in their oil output during the first half of the 1980s led to serious shortages in natural gas at a time when it had just become an important domestic fuel and industrial feedstock.

Concerted efforts followed, aimed at the development and exploitation of already discovered non-associated gas fields. Fortunately, those efforts have continued, unhampered by subsequent falling oil revenues and related declines in investment seen in the 1990s, given the fact that the development of non-associated gas is highly capital intensive — much more than the development of oil fields of comparable size — and must in most cases be undertaken together with the active involvement of the gas purchasers.[44]

As a result, huge gas developments have been seen in Qatar, Oman, and the UAE, among many other Gulf countries. Qatar is now among the world's largest exporters of LNG and is currently implementing a huge expansion project aimed at increasing its gas liquefaction capacity by 64 percent in 2026-27 and by another 32 percent in 2029-30.[45]

In Oman, the country has been exploiting its relatively modest gas reserves and exporting them in liquefied form mainly to Asian markets. The Omani LNG plant is now planning for a 33 percent expansion by 2029.[46] The neighboring UAE, Abu Dhabi in particular, which was the first

41 "Arab Natural Gas to the World," Abi-Aad Naji, Arab Energy Conference, December 2023.

42 "Unlocking the Potential of Non-Associated Gas: A Vital Energy Source," Tidjma, 2023. (https://www.tidjma.tn/en/glossary/o-g-non-associated-gas-8372/#google_vignette)

43 Organization of Petroleum Exporting Countries

44 Ibid.

45 "Qatar to increase LNG production capacity by nearly 85%," Energy Institute, 6 March 2024. (https://knowledge.energyinst.org/new-energy-world/article?id=138616)

46 "Oman LNG to boost capacity with new train," LNG Prime, 29 July 2024. (https://lngprime.com/middle-east/oman-lng-to-boost-capacity-with-new-train/118488/)

to export LNG from the Gulf through the Das Island plant in 1977, is now significantly increasing its total liquefaction capacity by 160 percent by 2028-29 through the construction of a new grassroots unit at Ruwais.[47]

Meanwhile, Saudi Arabia has been embarking on the extensive development of its non-associated gas reserves, while Kuwait has been working hard to develop its minor non-associated gas resources, especially those discovered in the Neutral Zone shared with Saudi Arabia.[48]

b. Actual Production & Future Prospects

With the gradual progress in natural gas exploitation in the Gulf (associated gas burned at the flare, then recovered and used, and finally the development of non-associated gas), marketed gas production in the region saw a steep annual growth of some 5.8 percent on average over the past 25 years, increasing from around 167 bcm in 1998 to some 686 bcm in 2023 (Table 3).

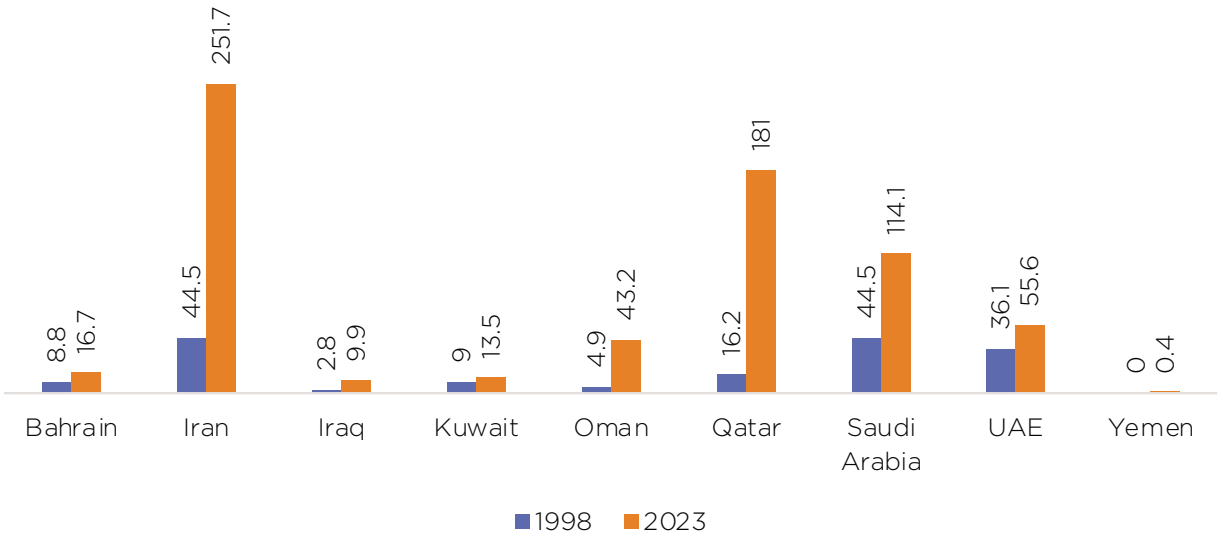
Table 3: Gas Production in the Gulf, Actual (1998-2023)

Country	1998 (bcm)	2023 (bcm)	AAGR (%) 1998-2023
Bahrain	8.8	16.7	2.6
Iran	44.5	251.7	7.2
Iraq	2.8	9.9	5.2
Kuwait	9.0	13.5	1.6
Oman	4.9	43.2	9.1
Qatar	16.2	181.0	10.1
Saudi Arabia	44.5	114.1	3.8
UAE	36.1	55.6	1.7
Yemen	-	0.4	-
Total	**166.8**	**686.1**	**5.8**
% Of the World	7.4	16.9	-

Sources: BP Statistical Review of World Energy, various issues;
Energy Institute Statistical Review of World Energy, various issues
Author's Calculations

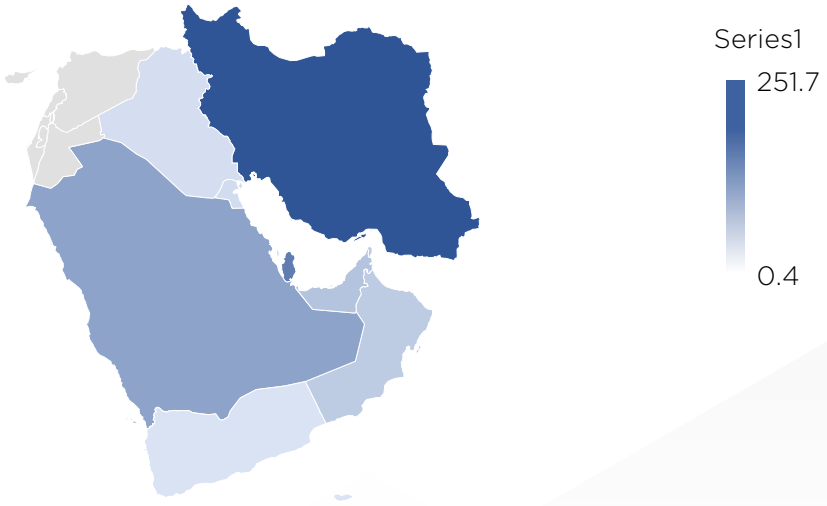
47 "Ruwais LNG," ADNOC (https://www.adnoc.ae/en/our-projects/ruwais-lng)
48 "Can Kuwait Grasp the Dorra Gas Pearl?" AGSIW, 10 July 2023. (https://agsiw.org/can-kuwait-grasp-the-dorra-gas-pearl/)

Gas Production in the Gulf, Actual (1998-2023) (bcm)



Despite this growth, Gulf gas production is still very limited when compared to the region's reserves and output potential. In fact, gas production in the area represented just 7.4 percent of the world's total in 1998 and around 17 percent 25 years later (compared to some 40 percent of the world's proven reserves), when the region produced only 0.83 percent of its natural gas reserves, compared to the world's ratio of 2 percent.[49]

Chart Ti Gas Production in the Gulf, Actual (2023) (bcm)



Of the total natural gas produced in many Gulf countries, associated gas still accounts for between 80 and 100 percent. Indeed, due to the fact that most of the proven natural gas reserves in the majority of Gulf countries — with the exception of those discovered in Qatar and to a lesser extent in Iran — are in associated form, found and eventually produced together with oil, natural gas output there is thus closely linked to that of crude oil.

49 Author's calculations using various issues of BP & Energy Institute Statistical Review of World Energy

In those countries, the development of the limited reserves of non-associated gas has been a difficult and costly undertaking. Indeed, most of the non-associated fields in the region have proved to be relatively small and well dispersed. In addition, there are technical limits to how much non-associated gas reserves, especially those found in Khuff reservoirs, can be produced or transported. Those field structures are usually extremely deep (between 12,000 and 17,000 feet), abnormally pressured, and contain as much as 13 percent nitrogen, 8 percent carbon dioxide, and a significant amount of flammable and highly toxic hydrogen sulfide, in addition to extremely corrosive fluids. They are, therefore, expensive to develop, especially when their development costs are compared to the current domestic gas price in the region.[50]

In addition to its growing production of conventional natural gas, both in its associated and non-associated forms, the Gulf region is seeing a gradually increasing portion of its gas production coming from unconventional sources, such as coal-bed methane, tight gas, and especially shale gas.

In fact, aggressive attempts to explore and develop unconventional gas have been seen in the Gulf, especially in Saudi Arabia, the UAE, and Oman. In Saudi Arabia, where vast potential for unconventional gas is believed to exist, Saudi Aramco has multiplied efforts in deploying state-of-the-art hydraulic fracking technology. The Kingdom is developing its Jafurah basin[51] with its promising shale gas deposits, which is expected to start production in 2025. Vast other potential for unconventional gas is believed to exist in the country, with many prospects identified on the Rhuddanian (Lower Qusaiba) Sandstone, the formations of Qalibah and Rayn, Khuff-C in the Ghawar field, the Manifa area, the lower Aruma shale formation, the Wasia formation in the Sanifiya and Khafiji fields, and the Tabuk formation-Qusaiba shales.[52]

In the UAE, where production has started from the Ruwais Diyab shale gas field in Abu Dhabi,[53] work has been underway to develop the recent discovery of unconventional gas at Jebel Ali in Dubai,[54] while Oman has been significantly involved in tight gas production at the Khazzan-Makarem gas fields[55] and Abu Butabul structures.[56]

Nevertheless, in order to start widespread and aggressive projects for developing the notably more expensive non-associated gas fields and unconventional gas structures, Gulf countries have to tackle the issue of low domestic gas prices by gradually or radically increasing them before reaching a full liberalization stage. But such a move is expected to face stiff resistance from the populations, which consider cheap prices to be part of the wealth distribution process, and from large industrial concerns, which are taking advantage of the low-price level to accumulate huge profits.[57]

50 "Arab Natural Gas to the World," Abi-Aad Naji, Arab Energy Conference, December 2023.

51 "Jafurah: The jewel of our unconventional gas program, the story of discovering the Kingdom's largest non-associated gas field," Saudi Aramco, 29 December 2022. (https://www.aramco.com/en/news-media/elements-magazine/2022/jafurah-the-jewel-of-our-unconventional-gas-program)

52 "Petrophysical Characterization of the Qusaiba Formation, Tabuk Basin, Northwest Saudi Arabia: Implications for Reservoir Dynamics in a Shale Play," Research Gate, February 2022. (https://www.researchgate.net/publication/358752872_Petrophysical_Characterization_of_the_Qusaiba_Formation_Tabuk_Basin_North_West_Saudi_Arabia_Implications_for_Reservoir_Dynamics_in_a_Shale_Play)

53 "Oil & gas field profile: Ruwais Diyab Unconventional Gas Field," Offshore Technology, 6 November 2024. (https://www.offshore-technology.com/marketdata/oil-gas-field-profile-ruwais-diyab-unconventional-gas-field-uae/?cf-view)

54 "Significant Jebel Ali Gas Discovery," Geo Expro, 21 December 2020. (https://geoexpro.com/significant-jebel-ali-gas-discovery-in-the-uae/)

55 "Khazzan-Makarem gas field," Wikipedia (https://en.wikipedia.org/wiki/Khazzan-Makarem_gas_field)

56 "Oil & gas field profile: Abu Butabul Unconventional Gas Field," Offshore Technology, 6 November 2024. (https://www.offshore-technology.com/marketdata/oil-gas-field-profile-abu-butabul-unconventional-gas-field-oman/)

57 "Arab Natural Gas to the World," Abi-Aad Naji, Arab Energy Conference, December 2023.

When looking at the projections for gas production in the Gulf countries for the years 2030, 2040, and 2050, and by using the same average growth rates registered for each country for the 25-year period 1998-2023, the below table (Table 4) can be drawn. According to these projections, annual gas production in the region could well reach around 1,115 bcm in 2030, some 2,310 bcm in 2040, and about 5,043 bcm by 2050.

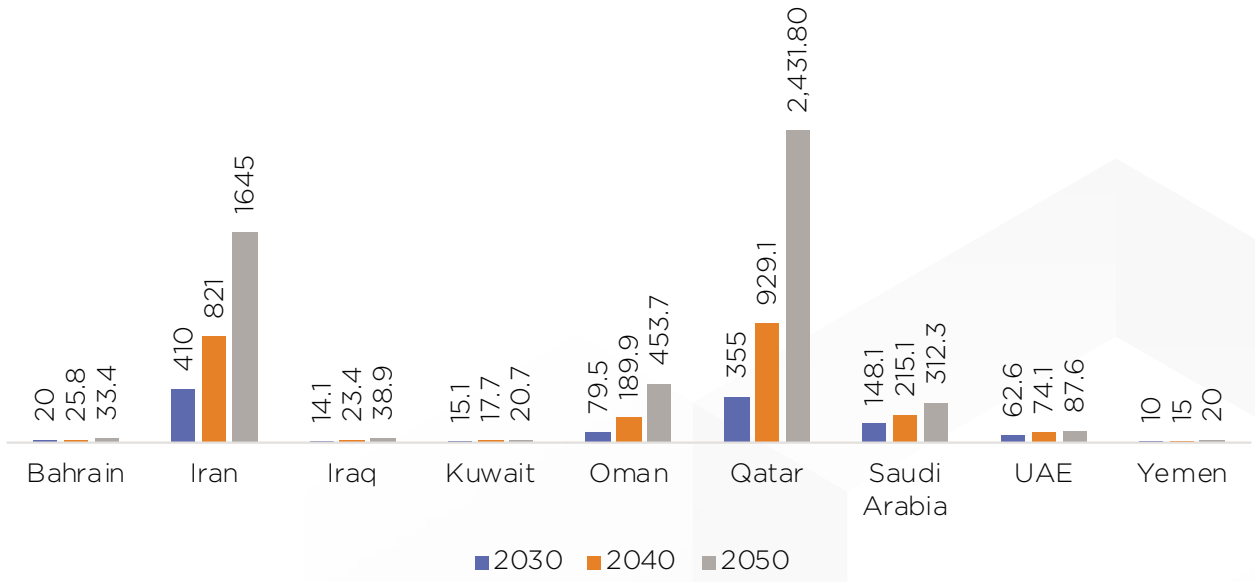
Table 4: Gas Production in the Gulf Projections (2030/2040/2050, bcm)

Country	2030	2040	2050
Bahrain	20.0	25.8	33.4
Iran	410.0	821.0	1645.0
Iraq	14.1	23.4	38.9
Kuwait	15.1	17.7	20.7
Oman	79.5	189.9	453.7
Qatar	355.0	929.1	2,431.8
Saudi Arabia	148.1	215.1	312.3
UAE	62.6	74.1	87.6
Yemen	10.0	15.0	20.0
Total	**1,114.4**	**2,311.1**	**5,043.4**

Sources: Table 3.
Author's calculations

The way the growing supply of natural gas in the Gulf has been consumed is discussed in the next section, with some projections for the future demand based on actual historical data, together with the factors affecting gas consumption, and the reasons pushing the countries in the area to use gas rather than the abundant oil and petroleum products.

Gas Production in the Gulf (Projections (2030/2040/2050, bcm)



IV. NATURAL GAS CONSUMPTION IN THE GULF

a. Factors Affecting Local Gas Demand

Demand for natural gas in the Gulf has been affected by the availability of this source of energy, either locally or from regional and global markets through pipelines or in liquefied form. Local prices of gas are also impacting on domestic demand and widely differ from one Gulf country to another. Many nations in the region, such as Kuwait, Qatar, Iran, and Saudi Arabia, have adopted fixed, mostly subsidized prices, while others, including Iraq and the UAE, have chosen to adopt variable prices which are usually linked to international prices and are different depending on every consuming sector.

Gas demand is also shaped based on the availability and economics of other sources of energy, especially when comparing its price with those of alternative fuels, notably oil and petroleum products. In addition, the growing use of new and renewable energy sources, especially for power generation, has serious impacts on the gas demand in the region, which has huge potential for the deployment of renewable energy technologies on the ground.

Actually, most Gulf countries have recently scaled up their interest in renewable sources of energy, especially in wind and solar power generation, which offer the highest technological and market maturity. Most Gulf countries have, or are in the process of creating, a viable market for renewable energy investments. This is accomplished through enabling conditions (feed-in tariffs, net metering, auctions, etc.) and attractive tariffs in different segments to encourage private investors to enter the market. These enabling conditions are increasingly being supported by official, long-term renewable energy targets set by governments to ensure a tangible impact of scaled-up renewable energy investments in the region.

Meanwhile, many Gulf nations have been considering the introduction of nuclear into their energy mix, including Saudi Arabia and Iran. Nevertheless, the UAE is more advanced in its nuclear plans than others in the region, with many phases of its large nuclear power plant already operational. Nuclear power confers several benefits to the UAE beyond always-on, carbon-free electricity. These range from freeing domestic oil and gas for export, leveraging waste heat for desalination, and creating high-value employment.

b. Actual Gas Consumption & Future Prospects

A major portion of Gulf gas output has been consumed locally. Gas has been increasingly used as fuel and feedstock in many vital applications such as power generation, water desalination, petrochemicals and fertilizers, gas-condensate recycling, oil lifting, and enhanced recovery. In fact, the required re-injection of natural gas to maintain pressure in mature oil fields in the region, many of which have been in production for 70 years or more, has been an urgent necessity growing with every passing year.

The domestic demand for natural gas in the Gulf massively increased over the past 25 years, growing by an annual average rate of 5.2 percent from some 156 bcm in 1998 to about 559 bcm in 2023, compared to a global average of just 2.3 percent (Table 5). In contrast, local consumption of oil and petroleum products in the region over the same period saw a lower growth rate

(around 3.1 percent).[58] In 2023, Gulf gas consumption represented around 14 percent of the world's total compared to some 7.1 percent in 1998.

Over the past 25 years, the share of natural gas in the total primary energy consumption in the Gulf largely increased from around 41 percent in 1998 to about 51.4 percent in 2023. Meanwhile, during the same period, the share of oil steeply declined from some 56.4 percent to approximately 45.2 percent in 2023.[59]

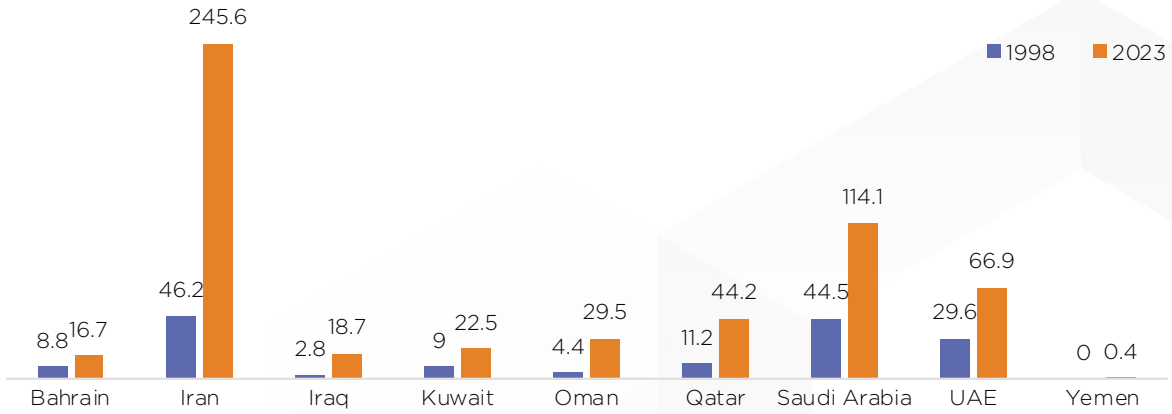
Power generation and water desalination have absorbed about half of the total demand for natural gas in the Gulf, with the industrial sector accounting for nearly 35 percent, and the balance (some 15 percent) being needed for petroleum operations and pressure maintenance in oil wells, and for new applications, such as the use of compressed natural gas (CNG) in the transport sector which have been increasingly introduced in the region.

Table 5: Gas Consumption in the Gulf, Actual (1998-2023)

Country	1998 (bcm)	2023 (bcm)	AAGR (%) 1998-2023
Bahrain	8.8	16.7	2.6
Iran	46.2	245.6	6.9
Iraq	2.8	18.7	7.9
Kuwait	9.0	22.5	3.7
Oman	4.4	29.5	7.9
Qatar	11.2	44.2	5.6
Saudi Arabia	44.5	114.1	3.8
UAE	29.6	66.9	3.3
Yemen	-	0.4	-
Total	**156.5**	**558.6**	**5.2**
% Of the world	7.1	13.9	-

Sources: BP Statistical Review of World Energy, various issues;
Energy Institute Statistical Review of World Energy, various issues;
Author's Calculations

Gas Consumption in the Gulf, Actual (1998 - 2023) (bcm)



58 BP & Energy Institute Statistical Review of World Energy, various issues

59 OAPEC, Annual Statistical Review, various issues

Gas Consumption in the Gulf, Actual (2023) (bcm)

The potential for future expansion in natural gas demand in the Gulf is considerable, as the region continues to witness economic and population growth at rates in excess of those in other areas of the world. Gas use by the power generation and water desalination sector is expected to keep growing at a high rate in parallel with the increase in electricity demand (around 8-10 percent annually) in most of the region's countries at least until the middle of the next decade. When looking at the projections for gas consumption in the Gulf countries for the years 2030, 2040, and 2050, and by using the same average annual growth rates registered for each country for the 25-year period 1998-2023, the table below (Table 6) can be drawn. As a result, demand for natural gas in the region could well reach around 820 bcm in 2030, some 1,450 bcm in 2040, and about 2,625 bcm by 2050.

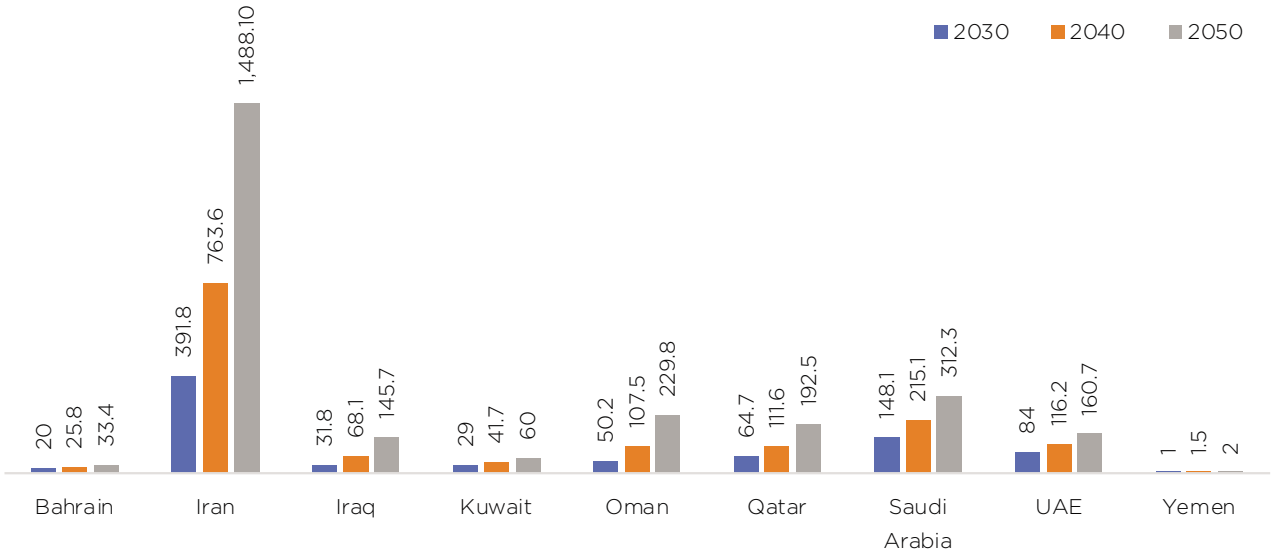
In those Gulf countries with modest gas reserves, or where such reserves and output are in associated form, and where crude oil production and the subsequent output of associated gas are not anticipated to grow in the foreseeable future at the same rate as domestic gas demand, growing gas deficits are taking place. To face this mounting challenge, these countries are exploring for and developing their gas reserves or increasingly relying on imports.

Table 6: Gas Consumption in the Gulf Projections (2030/2040/2050, bcm)

Country	2030	2040	2050
Bahrain	20.0	25.8	33.4
Iran	391.8	763.6	1,488.1
Iraq	31.8	68.1	145.7
Kuwait	29.0	41.7	60.0
Oman	50.2	107.5	229.8
Qatar	64.7	111.6	192.5
Saudi Arabia	148.1	215.1	312.3
UAE	84.0	116.2	160.7
Yemen	1.0	1.5	2.0
Total	**820.6**	**1,451.1**	**2,624.5**

Sources: Table 5.
Author's calculations

Gas Consumption in the Gulf Projections (2030/2040/2050, bcm)



c. Why Gas and Not More Oil?

One can rightly wonder why the Gulf region would not be more interested in domestically utilizing more crude oil and petroleum products rather than using natural gas, especially since it is a particularly oil-rich area, holding around 48 percent of the world's proven reserves of crude oil.[60]

While Gulf countries and manufacturers could well use crude oil and petroleum products rather than natural gas, especially in those facilities that have or seek to install the capacity to consume liquid fuels, this choice would raise political and social questions regarding the region's clean air, at a time when environmental issues are starting to get serious attention in this part of the world.

60 "Arab Natural Gas to the World," Abi-Aad Naji, Arab Energy Conference, December 2023.

In addition, a growing domestic consumption of crude oil and petroleum products in the Gulf OPEC member states (Iran, Iraq, Kuwait, Saudi Arabia, and the UAE, as well as Qatar until January 2019) is considered to be a costly one as local demand for crude and oil products is calculated on the basis of production quotas set by the Organization. In fact, the domestic consumption of crude oil and petroleum products is part of OPEC quotas, which are based on actual production and not on export volumes. Growing domestic demand for crude oil and petroleum products has therefore come at the expense of exports and their revenues. With crude and oil products increasingly used to satisfy domestic demand, export potential no longer appears as strong as it once was.

This logic gains more and more weight with most OPEC countries, including Gulf members, currently producing at their maximum capacities and selling their crude oil and petroleum products at relatively high prices. This fact points to the growing use of crude oil and petroleum products in those countries as resulting in an increasingly huge loss of revenue. These revenue losses of export sales, which currently yield somewhere between 100 and 2,000 percent (!) above actual returns from domestic sales, are certainly undesirable.

Indeed, most Gulf countries have to invest further in order to get the growing gas supplies needed, either by exploring and developing domestic resources or by importing gas in piped or liquefied form from regional and international suppliers. But using natural gas rather than petroleum products would save those countries the investments needed to build oil refineries to meet local demand and would keep both the feedstock and the “saved” products for exports.

The argument for using natural gas rather than crude oil and petroleum products in the Gulf countries is not only related to the reduction of environmental negative impacts and the lessening of the losses in export income, but is also due to the need to supply the growing manufacturing industry in the region with the fuel better suited for its development, and to put electricity production on a better footing from the point of view of efficiency and modernity. Natural gas is surely the best available energy source to be used in order to reach this goal.

Natural gas in the Gulf has not been used only domestically, but a growing portion of its production has been exported to both regional and international markets. Exports of Gulf natural gas shall be analyzed in the next section, together with the main markets for that gas, and the challenges facing the gas-exporting countries in the region.

V. NATURAL GAS EXPORTS FROM THE GULF

a. Inter-Gulf Gas Trade

Considering that gas output in most Gulf countries is still in associated form, and that crude oil production and the subsequent output of associated gas in those countries in the foreseeable future are not expected to grow at the same rate as their gas demand, serious growing gas deficits are to be expected in the region.

In a way to face the growing gas deficit in many Gulf countries, a few nations there have had recourse to gas resources in neighboring countries, establishing an inter-Gulf gas trade. Nevertheless, the gas trade between countries in the region is still weak, representing just 20.9 percent of the total gas trade involving the Gulf in 2023 and around 3.7 percent of the international gas trade.[61]

The inter-Gulf gas trade now mainly consists of significant volumes of LNG from Qatar to Kuwait, with minor quantities shipped to the UAE (Dubai). Meanwhile, large gas supplies are pumped from Qatar to the UAE and Oman through the Dolphin Pipeline, the only inter-Arab gas network still in operation. Iran is also exporting its gas to Iraq through a dual pipeline system to Baghdad and Basra. Another first-ever built inter-Arab and inter-Gulf gas line between Iraq and Kuwait has been the victim of a series of troubles and crises between the two countries.

Hopes were high at one time that gas pipelines in the region would be the precursor to establishing an inter-Gulf gas grid. Such a wider network shall increase the resources available to the internal Gulf economy and create a strong development drive. It shall boost intra-regional trade and be an important step towards the long-sought public objective of political cooperation and economic integration of the Gulf countries. Those nations that are already interlinked through various historical, cultural, economic, and political relationships will then be able to commonly enjoy the energy richness of their region in all its forms.

In reality, however, only a few regional gas pipelines have been built in the Gulf. In addition to the short-lived Iraq-Kuwait pipeline, which has been the victim of a series of troubles and crises between the two countries, and the much larger Dolphin pipeline connecting Qatar to the UAE and Oman, a small gas link was constructed between Oman and Ras Al-Khaimah. Recently, a dual pipeline system was built to pump Iranian gas to the Iraqi towns of Baghdad and Basra. Those pipelines were the ultimate result of political compromises and concessions, resulting in low prices for the pumped gas-prices that are very difficult to replicate considering the much higher netback values of the gas resulting from other applications and uses.

The price issue is not the only thing impeding the establishment of more regional gas pipelines and an integrated Gulf gas grid. In fact, for those pipelines to properly operate, many issues have to be addressed. To begin with, there is the swing nature of gas demand in the area and the way to handle it. Demand for electric power (and consequently for natural gas) peaks in summer, when all households maximize their air-conditioning needs. There is therefore a huge swing between summer and winter power and gas demand. Options to manage this swing by either

61 Energy Institute Statistical Review of World Energy 2023

creating storage facilities at the upstream producing end or on the downstream consuming side should be evaluated together with their impact on both the capital and operating costs.
Secondly, there is the issue of transit stability and fees, especially when a link between two countries passes through the territories of a third. First, the relationship between the exporting and importing countries and the transit nations in between has to be stable and constructive in order to avoid any danger of pipeline closure or pumping disruption. In addition, transit fees in terms of money or nature could well affect the whole economic feasibility of a pipeline network project, while indirectly helping to add more stability and security to the gas exchanges through what is called "the mutual dependency factor."[62]

A framework for negotiating gas supply, transit, and transportation agreements is fundamental to the feasibility of pipeline projects. Within the European Union (EU), the Gas Transit Directive sets out rules for ensuring gas transit through third-party states, but notwithstanding the efforts of the Energy Charter, this does not yet exist in a wider international context, such as in the Gulf region.

One more important issue related to the transit of natural gas (as well as crude oil and petroleum products) through pipelines is connected to the agreements and terms of the World Trade Organization (WTO). In fact, each member of the WTO has to allow the owner or operator of any pipeline passing through its territories full and free access to its domestic market. In the case of gas pipelines in the Gulf, that right for market access has not always been accepted by all its countries, for various reasons. This fact has led to the postponement of many interstate gas pipeline schemes in the region.[63]

There is finally the question of "energy independence and self-sufficiency." Usually, states do not want to depend on neighboring countries for their fuel supplies. Another related element to be taken into consideration is that all Gulf countries are oil producers, and there is a psychological desire for self-sufficiency among them, which promotes a greater willingness to burn more liquid fuels despite their higher relative costs and damaging environmental impacts. In fact, many countries in the region, proud of their large hydrocarbon reserves (including huge associated gas resources), find it difficult to "import" gas (or any other energy sources) from anywhere.

As a result of these and other factors, the prospects for reconsidering gas pipeline schemes in the Gulf have recently diminished, leading Bahrain, Dubai, and Kuwait to rely on LNG through import terminals, while Sharjah, Iraq, and Saudi Arabia have been seriously considering putting similar facilities in place. If and when Qatar is ready to supply its neighbors with LNG instead of the much cheaper piped gas, an intra-Gulf LNG market could ultimately take shape.

In fact, with the possible global development of competing energy sources, especially unconventional gas and clean coal in the main energy consuming markets (US, Europe, China, etc.), the possibility for the LNG market to become oversupplied from the second half of this decade, and the re-emergence of security of supply issues (i.e. the possibility of the Strait of Hormuz's closure), there could be a strong push for "reorienting" Gulf gas into the region itself to meet its growing energy needs.[64]

62 "Arab Natural Gas to the World," Abi-Aad Naji, Arab Energy Conference, December 2023.
63 Ibid.
64 Ibid.

b. Export of Gulf Gas

While the domestic consumption of natural gas in the Gulf will not match its large gas reserves and resources in the medium and long-term, only exports to the major consuming zones will allow the full utilization and valorization of the huge reserves of the region.

In the past 25 years, the Gulf saw its share in the international gas trade increasing from less than 5 percent in 1998 to around 13.5 percent in 2023. LNG from the Gulf amounted to about 24 percent of the world's total in 2023, when some 5 percent of the global piped gas originated from the region (Table 7).[65]

LNG from the Gulf in 2023 originated from Qatar, Oman, and the UAE and was shipped to markets in Asia, Europe, and the Middle East. Qatar was among the world's largest LNG exporters in 2023, channeling about 20 percent of the global total. Large gas liquefaction projects are currently operating in Qatar (with a total annual nominal capacity of 77 million tons), Oman (10.4 million tons), the UAE (Abu Dhabi, 5.8 million tons), and Yemen (7.2 million tons, currently non-operational).[66]

Around 5 percent of the piped gas traded worldwide in 2023 originated from Gulf producers, mainly channeled to regional gas consumers. During that year, Iran exported around 42 percent of the piped gas from the Gulf (Table 7), mainly channeled to Iraq (Baghdad and Basra) and Turkey, with minor volumes to Armenia. Meanwhile, Qatar pumped about 20 bcm of gas to the UAE and Oman through the Dolphin pipeline.

Table 7: Trade of Gulf Natural Gas, 2023

Pipeline Exports	(Bcm/year)	Notes
Iran	14.3	to Iraq, Turkey & Armenia
Qatar	19.5	to UAE & Oman
Sub-Total	33.8	5.0 % of the world
LNG Exports		
Oman	15.3	to Asia & Europe
Qatar	108.4	to Asia, Europe & Middle East
UAE	7.7	to Asia & Europe
Sub-Total	131.4	23.9 % of the world
TOTAL	**165.2**	**13.5 % of the world**

Source: Energy Institute Statistical Review of World Energy 2024

The Gulf is keen to play a growing role in the world gas market in the near future, based on important advantages including ample reserves and low development and production costs. Indeed, countries in the region have a strong will and the forceful and right policy to expand their natural gas exports, while possessing other important assets that contribute to promoting that growth in trade, including a significant margin for gas exports even with an increase in domestic consumption, a straightforward decision-making process, and a wide openness to foreign investment.

65 Energy Institute Statistical Review of World Energy 2023
66 The LNG Industry, GIIGNL Annual Report 2024

Based on these advantages, Qatar, already among the world's largest LNG exporters, is implementing a huge expansion program which will increase its annual gas liquefaction capacity from the current 77 million tons to 126 million tons by 2026-27 and 142 million tons by 2029-30.67 Abu Dhabi in the UAE is also working on a project to expand its annual gas liquefaction capacity from 5.8 million tons to 15.5 million tons by 2028-29.68 Within the same context, neighboring Oman recently announced a project to increase its annual gas liquefaction capacity to 15.2 million tons by 2029.[69]

In addition to its numerous competitive edges, the Gulf enjoys a strategic geographical location with proximity to both Europe and Asia, the two main gas-consuming markets. Markets in Asia-Pacific and Western Europe have been the main niches for Gulf gas. Other targets for Gulf gas expansion have been recently oriented towards market opportunities in India and South American countries, as well as within the Gulf and the Middle East.

c. Markets for Gulf Gas

1. The Gulf/Middle East

As already noted in previous paragraphs and sections, many countries in the Gulf and the wider Middle East are already fulfilling their gas demand by importing LNG through regasification terminals, including Kuwait, Dubai, Bahrain, Egypt, and Jordan. Others are increasingly relying on gas imports through pipelines, such as Iraq, the UAE, and Oman (both supplied by the Dolphin pipeline from Qatar), as well as Jordan (partly supplied by Egyptian gas through the Arab Gas Pipeline).

Many other countries in the region, especially those which are already suffering from actual or even latent gas deficits[70] due to the lack of enough gas resources or the fact that their gas reserves are in associated for, have been considering the import of LNG (such as Saudi Arabia, Iraq, and Sharjah) while waiting (without much hope) for the plans to come true for building an inter-Gulf (or inter-Arab/Middle East) gas grid which would supply gas-poor countries or regions with gas from gas-rich nations.[71]

2. European Countries

Before the Ukrainian-Russian crisis, the Old Continent was relying on piped gas from Russia at an average of around 40 percent of its total consumption and some 45 percent of its gas imports, with many countries there fully dependent on Moscow for their gas supply. The Ukrainian crisis has unsettled the global industry of natural gas and has badly affected the European gas market.[72]

67 Global Energy Monitor, "Qatar North Field LNG Terminal," 22 January 2025. (https://www.gem.wiki/Qatar_North_Field_LNG_Terminal)

68 Natural Gas World, "UAE's well-timed LNG expansion," 30 July 2024. (https://www.naturalgasworld.com/uaes-well-timed-lng-expansion-global-gas-perspectives-112390)

69 LNG Prime, "Oman LNG to boost capacity with new train," July 29, 2024. (https://lngprime.com/middle-east/oman-lng-to-boost-capacity-with-new-train/118488/)

70 Latent deficit results from latent demand which is the consumer desire to purchase a specific product that is not currently being offered on the market.

71 "Arab Natural Gas to the World," Abi-Aad Naji, Arab Energy Conference, December 2023.

72 "Impacts of the Ukrainian Crisis on the Global & Gulf Gas Industry," Abi-Aad Naji, Doha Institute, December 2022. (https://www.dohainstitute.org/en/Events/Gulf_Studies_Forum/9thround/Pages/VideoGalleryPage.aspx?VideoFolder=session5)

With disruptions occurring in Russian gas supply to many European countries, Europe has been forced to implement energy conservation measures, which led to a much lesser dependence on Russian gas and a larger reliance on its own energy sources, especially coal and nuclear, with a special attention to renewable energies, and to Europe depending more heavily on a mixture of piped gas and LNG imports from other suppliers, at least in the short and medium-term.

In the short-term, Europe would consequently rely more on LNG as a way to strengthen the security of its gas supply, and that LNG would be imported from Qatar, the UAE, Australia, Mozambique, Canada, and especially the US, which recently became the world's largest LNG exporter.[73] In 2023, European countries imported 15.6 million tons of LNG from the Gulf, or around 12.9 percent of their LNG trade.[74]

There is certainly an upside for LNG imports in Europe and high gas prices to attract cargoes as the market will be tight in the short-term (although much depends on the possibility for Europe to resume its imports of Russian piped gas), but in the medium- to long-term European gas and LNG demand are expected to follow a declining path.[75]

In fact, in the medium- to long-term, European energy plans and programs are to be affected by the Energy Strategy of the EU adopted by the European Commission in Brussels. In fact, according to this Strategy, natural gas shall continue to play an important role in terms of energy consumption and electricity generation in the European countries until 2030, after which its use there will decline in line with the EU climate neutrality commitment by 2050.[76]

3. China

China holds about 3,000 bcm of proven gas reserves as of early 2024, accounting for about 1.4 percent of the world's total.[77] In addition, the country has the world's highest shale gas reserves with around 31,000 bcm. This estimate has been derived from an assessment of seven major prospective shale basins distributed across the country.[78]

Nevertheless, China became the world's largest LNG importer in 2023, importing about 70.8 million tons, representing an increase of some 13 percent over 2022.[79] Countries supplying the most LNG to China were Australia (34 percent), Qatar (23 percent), Russia (11 percent), and Malaysia (10 percent).[80] In 2023, China imported 18.28 million tons of LNG from the Gulf, or some 25.8 percent of its total LNG trade.[81]

73 "The United States was the world's largest liquefied natural gas exporter in 2023," EIA, 1 April 2024. (https://www.eia.gov/todayinenergy/detail.php?id=61683)

74 The LNG Industry, GIIGNL Annual Report 2024

75 "Impacts of the Ukrainian Crisis on the Global & Gulf Gas Industry," Abi-Aad Naji, Doha Institute, December 2022. (https://www.dohainstitute.org/en/Events/Gulf_Studies_Forum/9thround/Pages/VideoGalleryPage.aspx?VideoFolder=session5)

76 "2050 long-term strategy," EU (https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy_en)

77 OPEC Annual Statistical Bulletin 2024

78 "China's Shale Gas, Digital Refining," July 2016. (https://www.digitalrefining.com/article/1001266/chinas-shale-gas)

79 "China's natural gas consumption, production, and imports all increased in 2023," EIA, 14 August 2024. (https://www.eia.gov/todayinenergy/detail.php?id=62804)

80 Ibid.

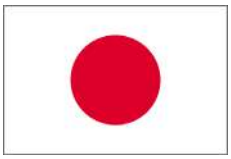
81 The LNG Industry, GIIGNL Annual Report 2024

China's regasification capacity is the fastest growing in the world. In 2023, China had around 129 million tons of annual capacity in 30 existing regasification terminals with a 55 percent utilization rate.[82] Meanwhile, Peking had approved an additional 10 regasification projects.[83]

China's annual imports by pipeline also increased by about 6 percent in 2023, reaching around 61 bcm. Pipeline imports increased mainly from Russia via the "Power of Siberia I" pipeline, which continued to ramp up to full production, with a target to annually reach about 40 bcm in export flows by 2025. A second pipeline from Russia to China — "Power of Siberia II" with a proposed design annual capacity of 50 bcm — is currently in the planning phase.[84]

Meanwhile, in the last 10 years, the Chinese government has actively supported the development of unconventional gas resources to reduce import dependency and enhance energy security. Its shale gas production reached around 26 bcm in 2023, representing a huge increase compared to just 0.2 bcm in 2013.[85]

4. Japan



Japan has very limited natural gas resources and its annual minor production has declined since reaching a high of about 3 bcm in 2017 to around 2 bcm in 2023. Thus, Japan relies on imports to meet demand and was the second-largest importer of natural gas in the world, after China, in 2023.[86]

During that year, Japan imported some 66 million tons of LNG, mainly from Australia (41.8 percent), Malaysia (15.8 percent), and the US (8.5 percent). It imported 5.8 million tons of LNG from the Gulf, or some 8.8 percent of its total LNG trade.[87] At an annual capacity of about 215 million tons in 37 regasification terminals, Japan had by far the world's largest regasification capacity in 2023, with an annual utilization rate of 31 percent.[88]
Meanwhile, natural gas demand in Japan has declined with every passing year since 2013, aside from 2017 when it slightly increased. Gas consumption decreased by around 2.9 percent annually on average between 2013 (123.5 bcm) and 2023 (92.4 bcm).[89] The main driver behind the decline was the electric power sector. In fact, increases in electricity generation from solar and nuclear, as well as better energy efficiency, have resulted in lower gas demand.[90]

5. India

The market for natural gas in India is the third largest in Asia, after China and Japan. Its gas demand kept growing despite Corona pandemic-related disruptions and the effects of increased costs of LNG. Much of this growth can be attributed to the extensive expansion of the country's natural gas

82 Ibid
83 "China's natural gas consumption, production, and imports all increased in 2023," EIA, 14 August 2024. (https://www.eia.gov/todayinenergy/detail.php?id=62804)
84 Ibid.
85 "China extracts commercially viable natural gas from deeper shale formations," EIA, 30 September 2024. (https://www.eia.gov/todayinenergy/detail.php?id=63284)
86 "Country Brief Japan," EIA, 7 July 2023. (https://www.eia.gov/international/content/analysis/countries_long/japan/japan.pdf)
87 The LNG Industry, GIIGNL Annual Report 2024
88 "Country Brief Japan," EIA, 7 July 2023. (https://www.eia.gov/international/content/analysis/countries_long/japan/japan.pdf)
89 Energy Institute Statistical Review of World Energy, 2024
90 "Country Brief Japan," EIA, 7 July 2023. (https://www.eia.gov/international/content/analysis/countries_long/japan/japan.pdf)

distribution infrastructure. The growth in gas demand was primarily driven by the industrial and oil refining sectors, followed by the residential, commercial, and transport sectors.

In 2023, India was the world's fourth-largest LNG importer, importing about 22 million tons. Qatar was the primary source of India's LNG imports (50 percent), followed by the US (14 percent), and the UAE (13 percent). India imported 14.6 million tons of LNG from the Gulf, or some 66.4 percent of its total LNG trade.[91] At the beginning of 2024, India's total annual regasification capacity was around 48 million tons, with a 46 percent utilization rate.[92]

Increasing demand for gas power generation and a rising number of LNG-fueled fleets is expected to drive the Indian market for liquefied gas during the period 2025-50. The Indian LNG market is therefore expected to register an annual average growth rate of some 8 percent during that period.[93]

6. Southeast Asia[94]

Against the backdrop of competition for LNG cargoes between Europe and Northeast Asia in the wake of Russia's war with Ukraine, Southeast Asia has emerged as a growing demand center, with falling domestic production, increasing power demand, and a desire to achieve their energy transition goals fueling its LNG interest.

91 The LNG Industry, GIIGNL Annual Report 2024

92 "India's Rising LNG Imports," Outlook Business, December 2024. (https://www.outlookbusiness.com/explainers/indias-rising-lng-imports-what-is-driving-demand-amid-falling-domestic-production)

93 "India LNG Market Size & Share Analysis - Growth Trends & Forecasts (2025 - 2030)," Mordor Intelligence, January 2025. (https://www.mordorintelligence.com/industry-reports/india-lng-market)

94 Including, Hong Kong, the Philippines, Singapore, Thailand and Vietnam

Southeast Asian LNG imports increased by nearly fourfold to around 17.3 million tons in 2023 (about 4.3 percent of global LNG trade)[95] from some 4.4 million tons in 2014 (just 1.5 percent). Thailand and Singapore have been pivotal in driving regional demand given their established demand outlets, ample regasification capacity, and long-term supply contracts. In 2023, Southeast Asia imported 5.2 million tons of LNG from the Gulf, or some 28.1 percent of its total LNGtrade.[96]

Robust growth is expected in the medium-term in the region's imports, continuing to be led by Thailand as its domestic gas reserves and pipeline gas imports dwindle amidst rising electricity demand. Singapore is poised to remain the second-largest driver of regional demand, driven by increasing gas consumption and an expanding LNG bunkering industry.

Recent start-ups of new LNG terminals in Vietnam and the Philippines, alongside plans for more terminals and gas-fired power plants there, have signaled stronger growth in the coming years, which should be underpinned by long-term supply contracts.[97]

7. South America

South America has long been isolated from other global gas markets, focusing instead on achieving self-sufficiency and regional integration. However, in 2008 the region started to turn to LNG to source an additional gas supply.

Natural gas demand in South America, which reached about 162 bcm in 2023,[98] is projected to increase and stabilize at around 250 bcm by 2035. With gas supply expected to decline at an annual average rate of some 5.6 percent during that time frame, the region will face growing challenges.[99] This could potentially be mitigated with new domestic gas developments or yet-to-find resources, but there are significant challenges with infrastructure restrictions and unfavorable exploration incentives.

With such challenges facing new local gas developments in South America, supply would be unable to keep up with demand, driving the need for expanded imports over the next decade. The likely result will be a steady increase in LNG imports in the region, which would potentially double by 2035, ranging between 70 and 120 bcm.[100]

95 The LNG Industry, GIIGNL Annual Report 2024

96 Ibid

97 "Room for growth in Southeast Asia?" LNG Industry, 9 May 2024. (https://www.lngindustry.com/special-reports/09052024/room-for-growth-in-southeast-a,sia/)

98 Energy Institute Statistical Review of World Energy 2024

99 "Latin America's natural gas deficit to grow as new resource production remains a challenge," Wood Mackenzie, 3 May 2024. (https://www.woodmac.com/press-releases/latin-americas-natural-gas-deficit-to-grow-as-new-resource-production-remains-a-challenge/)

100 Ibid.

d. Challenges Facing Gulf Gas Exporting Countries

In developing their gas resources and exporting them to regional and global markets, Gulf gas producers have been faced with many challenges, including the security of gas demand, competition from other energy sources, and growing rivalry from other exporting regions.

In fact, in order to secure adequate financing to develop and build the gas export infrastructure, Gulf gas exporters must get strong guarantees from consuming countries and companies that there is enough secured demand for the planned gas supply from the region, translated into large production and export infrastructure and installations.

However, demand for natural gas, including that exported from the Gulf, has been affected by strategies and policies adopted by the main global consumers. While Asian countries have been actively implementing programs aimed at substituting gas with other energy sources, such as nuclear and coal, the European Commission in Brussels and its energy strategy are drawing a declining path for the role of natural gas in the EU until 2050.[101]

Meanwhile, European countries have been carrying out projects to increasingly use domestically available energy sources, such as wind energy, coal, and even nuclear energy, instead of depending on the import of energy sources, including natural gas. In addition, many European nations have been considering the development of their unconventional shale gas resources, especially if there is a technological breakthrough for limiting the environmental impacts of developing this source of gas.

In fact, while hydraulic fracking is entirely irrelevant to the short and medium-term energy strategies of the EU, many politicians[102] and researchers there do strongly believe the development of shale gas in Europe is the most cost-effective and realistic way to satisfy the continent's demand and to reduce European gas imports. The same logic is followed in many Asian countries with large unconventional gas resources, including China and its huge gas market.

It is true that the conditions that led to the US shale gas boom were unique and are extremely unlikely to be repeated in Europe, Asia, or other parts of the world. But nobody can ever be certain with energy markets; indeed, very few people predicted the shale gas boom in the US.[103]

The shale gas revolution in the US has remodeled the whole global gas scene, starting in the early years of the new century by converting the huge American market from a growing gas importer to a major exporter, with US LNG aiming to reach every consuming market around the globe.[104] The US became the world's largest LNG exporter in 2023, while numerous liquefied gas export projects are still under construction or awaiting regulatory approval.[105] This expanding

101 "2050 long-term strategy," EU (https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy_en)

102 Such as UK ex-Prime Minister David Cameron who declared in January 2014 that "shale gas has the potential to meet all UK gas needs for 30 years" and "accused some opponents of fracking of being irrational and "religious" in their opposition." (https://www.edie.net/fracking-opponents-are-being-irrational-says-david-cameron/)

103 "The US shale revolution has reshaped the energy landscape at home and abroad," IEA, 19 September 2019. (https://www.iea.org/news/the-us-shale-revolution-has-reshaped-the-energy-landscape-at-home-and-abroad-according-to-latest-iea-policy-review)

104 Ibid.

105 "U.S. Remains the World's Top LNG Exporter as Shipments Hit Record High," OilPrice.com, 17 December 2024. (https://oilprice.com/Latest-Energy-News/World-News/US-Remains-the-Worlds-Top-LNG-Exporter-as-Shipments-Hit-Record-High.html)

LNG leaning received a strong push from American President Donald Trump, who was keen to totally remove the cap on LNG exports from the US.

The growing role of the US in the global gas market, and the increasing number of LNG export projects around the world, have been eating into the current and future market share of the Gulf gas exporters and would most probably lead to a glut gas market in the second half of the 2020s. Such an expected surplus would push the prices lower and thus affect the economics of the capital-intensive gas export projects around the globe, including those installed in the Gulf region.

There is therefore an urgent need for the Gulf gas producers, especially those with large LNG export projects (Qatar, Oman, and the UAE), to coordinate their marketing policies rather than implicitly and increasingly compete for customers of liquefied gas, as each has worked to capitalize on growth in the global gas market by advancing a suite of projects, and by offering supply contracts with shorter terms and more destination flexibility.

Another challenge faced by the Gulf gas exporters, especially in liquefied form, is the security of the maritime waterways connecting the region to the global markets. The Gaza crisis in 2023-25 and the related attacks by the Houthi group in Yemen reminded the world of the vulnerability of maritime waterways in the region. The Houthi attacks have troubled shipping at the Strait of Bab Al-Mandeb, which links the Red Sea and the Gulf of Aden. Bab Al-Mandeb is of great importance to shipping and a key trade chokepoint between the Gulf and Asia, but especially Europe. Some 12 percent of seaborne oil and petroleum products and around 8 percent of global LNG passed through Bab Al-Mandeb in 2023.[106]

In addition to Bab Al-Mandeb, two other main maritime channels on major shipping lanes in the Gulf and the wider Middle East — the Suez Canal and the Strait of Hormuz — and their geographical constraints have resulted in shipping concentration. With respect to oil and gas shipments from the Middle East (especially to Europe and beyond), the Suez Canal linking the Red Sea and the Mediterranean has been playing a central role, although it was closed twice throughout its history (1956-57 and 1967-75).[107] Petroleum volumes transiting the Suez Canal are similar to those passing through Bab Al-Mandeb.

The Strait of Hormuz is the world's most important petroleum chokepoint when considering the significance of the maritime oil and gas supply from the Middle East through this channel. A daily average of around 20 million barrels of oil (about 30% of the global oil and refined products trade) transited the Strait in 2023,[108] while some 25 percent of the world's LNG and around 26 percent of liquefied gas[109] imported by the EU flowed through Hormuz.

The free flow of oil and gas through Hormuz is of vital interest not only to the West but to almost every country in the world. Closing Hormuz would be catastrophic for the regional and global oil and gas markets and could well open the door to a global war. The closure of the Strait or its blockade has never happened, but the threat has always been there.

106 "Red Sea Attacks Increase Shipping Times & Freight Rates," EIA, 1 February 2024. (https://www.energy.gov/sites/default/files/2024-02/047.%20EIA%2C%20Red%20Sea%20attacks%20increase%20shipping%20times%20and%20freight%20rates.pdf).

107 "Conflict & Instability in the Middle East," Abi-Aad Naji & Grenon Michel, Macmillan, 1997.

108 "Why Oil and Gas Markets are Dreading the Risk of Supply Disruption in the Strait of Hormuz," CNBC, 8 October 2024. (https://www.cnbc.com/2024/10/08/strait-of-hormuz-what-supply-disruption-could-mean-for-oil-markets.html).

109 Author's calculations

Those security issues regarding the transit of gas flows from the Gulf to the global markets could well push gas developers from the region to seek and acquire gas liquefaction assets outside the area, especially in the US. Already, Qatar has been developing the Golden Pass there, while Abu Dhabi recently acquired shares in the US Nextdecade plant[110] and in the Galp LNG unit in Mozambique,[111] and Saudi Arabia has been finalizing an agreement to get a portion of the US Sempra LNG assets.[112]

110 "Abu Dhabi's Mubadala Energy Buys First Stake in US Gas Output," Market Screener. (https://www.marketscreener.com/news/latest/Abu-Dhabi-s-Mubadala-Energy-to-Buy-Stake-in-US-Gas-LNG-Assets-49592610/)

111 "ADNOC to Acquire 10% Equity Stake in Major LNG Development in Mozambique," ADNOC, 22 May 2024. (https://www.adnoc.ae/en/news-and-media/press-releases/2023/adnoc-to-acquire-10-equity-stake-in-major-lng-development-in-mozambique)

112 Aramco and Sempra announce Heads of Agreement for equity and offtake from Port Arthur LNG Phase 2," Aramco, 26 June 2024. (https://www.aramco.com/en/news-media/news/2024/aramco-and-sempra-announce-heads-of-agreement-for-equity-and-offtake-from-port-arthur-lng-phase-2)

VI. EXPORT OF GULF NATURAL GAS AS BLUE HYDROGEN[113]

a. Blue Hydrogen & Ammonia in the Gulf

In addition to exporting natural gas in its piped and liquefied forms, many projects have been seriously considered in the Gulf aimed at cheaply producing blue hydrogen from natural gas through the steam methane reforming (SMR) process, as well as blue ammonia and exporting these products into global markets.

In fact, while natural gas has long been viewed by energy experts and governments as a cleaner and transitional energy source from oil and coal, calls for a global shift towards zero-emission energy sources also grow louder. To this end, hydrogen has emerged as a promising alternative. As a versatile energy carrier, hydrogen supports the storage and transportation of renewable energy and offers a potential pathway for natural gas exporters. Through innovative methods like the SMR process paired with carbon capture or methane cracking, hydrogen, the "blue" one, can bridge the gap between today's natural gas economy and a sustainable future.

Blue hydrogen is produced from natural gas with the SMR process, where gas is mixed with very hot steam and a catalyst. Blue hydrogen does not reduce gas dependency and produces carbon dioxide that has to be captured and stored. The cost of producing blue hydrogen is about half that of green hydrogen, which is yielded when the energy used to power electrolysis comes from renewable sources like wind, water, or solar power. In regions with low-cost fossil fuels and carbon capture and storage (CCS) resources, like the Gulf region, blue hydrogen remains a competitive option, allowing those regions to become market leaders in its production.

The Gulf region benefits from low-cost natural gas, as well as easy access to depleted oil wells, which are essential in the CCUS process for isolating the captured carbon dioxide. Therefore, utilizing these resources responsibly could catalyze petroleum-rich nations in the region to take accountability for their disproportionately high carbon footprints and contribute to global sustainability goals.

Blue hydrogen and ammonia, made by combining nitrogen with blue hydrogen, have a range of potential applications and uses, with the former being eyed for fuel cells in vehicles, especially heavy-duty transportation such as buses and trucks. Hydrogen also has applications in the industrial sector, particularly in steelmaking and refining processes, and can serve as a storage solution for renewable energy helping to balance supply and demand on electrical grids. Ammonia can be used as a low-carbon fuel across a wide range of industrial applications, including transportation and power generation and in industries including steel, cement, and fertilizer production. As a key component in fertilizers, the agriculture sector can also benefit from ammonia, thereby aligning with sustainable farming practices.

There can be no denying that there has been a global surge in investment in the hydrogen sector over the past few years, with many states also unveiling hydrogen strategies and developing relevant infrastructure and transportation links. For Gulf states, defining an influential position

113 In this section, blue hydrogen plans and projects in the Gulf are mainly analyzed, being related to the development of natural gas.

in this rapidly evolving landscape will be pivotal for the future prosperity of the countries in the region.

Overall, three 'high-potential' countries in the Gulf region have been identified for the development of low-carbon blue hydrogen production, including Saudi Arabia, the UAE, and Qatar.

The Saudi Vision 2030 aims to make the Kingdom the world's leading hydrogen supplier in a bid to reduce its reliance on domestic oil. In October 2021, Saudi Arabia announced the allocation of its eastern Jafurah gas field, the largest shale gas field in the country, for the purpose of producing blue hydrogen. Now currently in production, Saudi Aramco expects this ambitious project to generate the green energy equivalent of displacing around 500,000 barrels of crude oil daily, as well as producing 630,000 barrels of natural gas liquids (NGL) per day by 2030.[114]

Saudi Arabia sees huge economic potential in blue hydrogen, with the 2022 report by King Abdullah Petroleum Studies and Research Centre (KAPSARC, Saudi Arabia's top energy think tank) forecasting that the cost of producing blue hydrogen could fall from US$1.34/kilogram to US$1.13/kilogram by 2030. However, the same report also highlights the issue of the high costs of sea transport for liquid hydrogen in terms of exportation, which could add an additional cost of up to US$2/kilogram.[115]

The current focus is to gain a large market share in blue hydrogen, particularly in the form of blue ammonia, in the coming decade. Saudi Aramco is targeting the annual production of 11 million tons of blue ammonia by 2030. In September 2020, Saudi Arabia took a major step with Saudi Aramco shipping 40 tons of blue ammonia from the Kingdom to Japan. This was the world's first demonstration of blue ammonia supply chains, entailing its production and international maritimetransportation.[116]

In the UAE, since identifying hydrogen as the "fuel of the future" in their Nationally Determined Contribution (NDC) of the 2015 Paris Agreement, the country has demonstrated its commitment to hydrogen with the teaming up of Abu Dhabi National Oil Company (ADNOC), Abu Dhabi National Energy Company (TAQA), and Mubadala (Abu Dhabi's global investment company) These three entities are shareholders in 'Masdar,' Abu Dhabi's future energy company and global leader in renewable energy and hydrogen.

UAE plans were announced at COP26 in 2021 for a "hydrogen leadership roadmap" with the goal of promoting low-carbon domestic industries and competing in hydrogen exports. These three entities are shareholders in 'Masdar,' Abu Dhabi's future energy company and global leader in renewable energy and hydrogen. The Abu Dhabi Department of Energy is indeed targeting the production of over one million tons of hydrogen per year by 2030, which will be achieved by proportionately balancing both blue and green hydrogen production.[117]

114 "The Future of Blue Hydrogen in the Middle East," CMS Law-Now, 25 April 2023. (https://cms-lawnow.com/en/ealerts/2023/04/the-future-of-blue-hydrogen-in-the-middle-east)

115 Ibid.

116 "Blue hydrogen and blue ammonia: Pioneering the use of hydrogen as energy," Saudi Aramco. (https://www.aramco.com/en/what-we-do/energy-innovation/advancing-energy-solutions/blue-hydrogen-and-blue-ammonia)

117 "The Future of Blue Hydrogen in the Middle East," CMS Law-Now, 25 April 2023. (https://cms-lawnow.com/en/ealerts/2023/04/the-future-of-blue-hydrogen-in-the-middle-east)

Already, a world-class blue ammonia production facility is under construction at Ruwais in Abu Dhabi. The facility, which is being developed at the new Ta'ziz industrial ecosystem and chemicals hub, will have a yearly capacity of one million tons.[118] Meanwhile, BP joined ADNOC to evaluate a new blue hydrogen project in Abu Dhabi, while showing a keen common interest in investing in global blue hydrogen projects. In May 2022, ADNOC joined BP's 'H2Teesside' blue hydrogen project in the UK with a 25 percent stake, targeting the development of two 600-megawatt hydrogen production units by 2030.[119]

One of the central challenges that the UAE faces in terms of the domestic development of blue hydrogen is that the most accessible primary energy source, natural gas, is not sufficiently abundant to power the nation's optimistic hydrogen production targets. This means that the UAE will need to rely on purchasing natural gas from Qatar and other countries to meet these objectives. Therefore, moving forward, the UAE's utilization of blue hydrogen will be reliant on negotiating viable gas supply agreements.[120]

In neighboring Qatar, vast natural gas resources, solid international relationships, and cutting-edge infrastructure give the country a competitive edge in blue hydrogen production, helping it to diversify and optimize its renewable energy potential, enhance technological advancements, and gradually decrease its reliance on LNG.

Qatar's energy importers like Japan, South Korea, and Europe, which are moving towards cleaner energy sources, are potential buyers of blue hydrogen exports from the Peninsula. In response, Doha started a program aimed at diversifying its energy portfolio and developing a dedicated blue hydrogen and ammonia strategy to ensure consistent revenues and maintain its status as a trusted energy provider. This approach will guarantee ongoing economic growth and cement Qatar's place in future global energy markets.

With that in mind, QatarEnergy launched the construction of a massive blue ammonia plant in November 2024, set to cost around US$1.2 billion. The blue ammonia plant is to be the largest of its kind in the world with an annual capacity of 1.2 million tons, along with an additional 1.5 million-ton/year CCS unit.[121]

b. Future of Blue Hydrogen in the Gulf

If hydrogen is to be obtained from fossil fuels to reduce greenhouse gases, developing CCS/CCUS systems will be necessary. As a region, the Gulf currently accounts for around 10 percent of the world's CCUS capacity, as evidenced by the large-scale commercial CCUS storage sites in the UAE, Saudi Arabia, and Qatar. Given its abundant CCUS storage resources and access to low-cost natural gas, the Gulf therefore remains an ideal region to become a blue hydrogen marketleader.[122]

118 Ibid.

119 "UAE giants joining BP UK hydrogen developments," Offshore Mag, 24 May 2022. (https://www.offshore-mag.com/renewable-energy/article/14277079/uae-giants-joining-bp-uk-hydrogen-developments)

120 "The Future of Blue Hydrogen in the Middle East," CMS Law-Now, 25 April 2023. (https://cms-lawnow.com/en/ealerts/2023/04/the-future-of-blue-hydrogen-in-the-middle-east)

121 "Qatar starts construction on $1.2bn blue hydrogen-based ammonia plant," Hydrogen Insight, 29 November 2024. (https://www.hydrogeninsight.com/production/qatar-starts-construction-on-1-2bn-blue-hydrogen-based-ammonia-plant/2-1-1745821)

122 "The Future of Blue Hydrogen in the Middle East." CMS Law-Now, 25 April 2023. (https://cms-lawnow.com/en/ealerts/2023/04/the-future-of-blue-hydrogen-in-the-middle-east)

Obviously, several critical opportunities exist in the hydrogen strategy in the Gulf, which include the following:
Abundant resources: The Gulf has plentiful natural gas resources, both in conventional and unconventional forms, for blue hydrogen production.

Diversification: Hydrogen will allow the Gulf countries to expand the range of their energy mixes and lower their reliance on oil and gas exports.

Climate change: As hydrogen is a form of low-carbon energy, it can benefit countries in meeting the climate goals of the December 2015 Paris Agreement.[123]

Energy demand: The Gulf is predicted to see a sharp increase in energy demand soon. Adding hydrogen to the energy mix will allow countries in the region to better meet the growing demand while reducing reliance on fossil fuels.

Partnerships: Gulf nations need outside assistance to pursue their hydrogen strategies and develop the necessary infrastructure. Therefore, these countries will develop international partnerships to bring technology, investment, and expertise.

Export potential: The existing energy infrastructure and geographic positioning of the Gulf states mean they are well suited to become key exporters of hydrogen. Adding hydrogen to the mix would therefore mean less reliance on gas and oil exports.

Carbon capture and utilization: Gulf countries are on their way to becoming forerunners in carbon capture and utilization technology. Industrial emissions could be used to generate low-carbon hydrogen. Overall, hydrogen strategies within the region offer major opportunities for the Gulf to shift toward a diversified energy mix and more sustainable energy supply. Simultaneously, these nations can curb climate change and shrink their carbon footprints.

123 "Key aspects of the Paris Agreement," UNFCCC (https://unfccc.int/most-requested/key-aspects-of-the-paris-agreement)

c. Challenges Facing Blue Hydrogen in the Gulf

While the region holds advantages in hydrogen production, the challenges lie in its high capital, operational and maintenance costs, and in the doubling of its initial production expenses for ensuring efficient transportation to lucrative markets.

In fact, while hydrogen transportation holds great promise, it also faces several technical, infrastructural, and economic hurdles that need to be addressed in order to achieve widespread adoption. In addition, as discussions often center on cost and technical barriers, critical questions regarding water as a feedstock in hydrogen production are mostly neglected.

According to technical experts, freshwater is crucial in the hydrogen production process, requiring approximately 12-19 liters of water to produce just one kilogram of blue hydrogen. This is particularly critical for the arid Gulf countries positioning themselves as key hydrogen hubs, such as Saudi Arabia, Qatar, and the UAE.[124]

When the issue of water availability comes up, the go-to solution is to expand seawater desalination facilities. The UAE's hydrogen strategy, developed with input from the German Fraunhofer Institute,[125] tackles the water challenge, noting that seawater desalination would be adequate in supplying fresh water without hiking the costs of hydrogen production. Likewise, two recent studies (by KAPSARC[126] and the Emirates Policy Centre[127]) found that the costs of seawater desalination do not significantly affect hydrogen prices.

On the other hand, there is limited demand for hydrogen products across the Gulf. Hydrogen must therefore be reasonably priced to compete with more traditional fuels and to develop its own domestic market in the region.

124 "Water Challenges in the Emerging Hydrogen Economy," AGSIW, 13 February 2024. (https://agsiw.org/water-challenges-in-the-emerging-hydrogen-economy/) "Introduction, A New Hydrogen World," SWP Comment, # 58, December 2021. (https://www.swp-berlin.org/publications/products/comments/2021C58_HydrogenWorld.pdf)

125 "National Hydrogen Strategy of the United Arab Emirates," Fraunhofer Institute for Solar Energy Systems ISE, November 2023. (https://www.ise.fraunhofer.de/en/publications/studies/hydrogen-strategy-uae.html)

126 "Water Challenges in the Emerging Hydrogen Economy," AGSIW, 13 February 2024. (https://agsiw.org/water-challenges-in-the-emerging-hydrogen-economy/) "The Economics and Resource Potential of Hydrogen Production in Saudi Arabia," KAPSARC, 1 March 2022. (https://www.kapsarc.org/research/publications/the-economics-and-resource-potential-of-hydrogen-production-in-saudi-arabia/)

127 "GCC's Hydrogen Landscape: Challenges and Opportunities," Emirates Policy Centre, Dr. Umud Shokri,11 Apr 2023. (https://epc.ae/en/details/brief/gcc-s-hydrogen-landscape-challenges-and-opportunities)

Sources & References

- Abi-Aad Naji & Grenon Michel, "Conflict & Instability in the Middle East," Macmillan, 1997.
- ADNOC, "ADNOC to Acquire 10% Equity Stake in Major LNG Development in Mozambique," 22 May 2024. (https://www.adnoc.ae/en/news-and-media/press-releases/2023/adnoc-to-acquire-10-equity-stake-in-major-lng-development-in-mozambique)
- ADNOC, "Ruwais LNG." (https://www.adnoc.ae/en/our-projects/ruwais-lng)
- Al-Attiyah Foundation Research Series, "GCC Gas: Strategic Variations," Abi-Aad Naji, January 2017.
- Arab Energy Conference, "Arab Natural Gas to the World," Abi-Aad Naji, Doha, December 2023.
- Arab Gulf States Institute in Washington (AGSIW), "Can Kuwait Grasp the Dorra Gas Pearl?" 10 July 2023. (https://agsiw.org/can-kuwait-grasp-the-dorra-gas-pearl/)
- Arab Gulf States Institute in Washington (AGSIW), "Water Challenges in the Emerging Hydrogen Economy," 13 February 2024. (https://agsiw.org/water-challenges-in-the-emerging-hydrogen-economy/)
- Aramco, "Aramco and Sempra announce Heads of Agreement for equity and offtake from Port Arthur LNG Phase 2," 26 June 2024. (https://www.aramco.com/en/news-media/news/2024/aramco-and-sempra-announce-heads-of-agreement-for-equity-and-offtake-from-port-arthur-lng-phase-2)
- Asia Energy Security Summit, "Prospects of Gulf Gas Exports to Asia in Light of New Realities," Abi-Aad Naji, Goa, March 2016.
- Bank Bazaar, "Advantages and Disadvantages of Natural Gas," February 2025. (https://www.bankbazaar.com/gas-connection/advantages-and-disadvantages-of-natural-gas.html)
- Bensabt, Ali Sabt, "Natural Gas Industry in the Arab World," OAPEC, November 2020.
- BP "Statistical Review of World Energy," Various Issues.
- Cedigaz, "Natural Gas in the World," 2021.
- Centre on Global Energy Policy, "The Role of Natural Gas in the Energy Transition," Akos Losz & Jonathan Elkind, September 2019. (https://www.energypolicy.columbia.edu/publications/role-natural-gas-energy-transition/)
- CMS Law-Now, "The Future of Blue Hydrogen in the Middle East," 25 April 2023. (https://cms-lawnow.com/en/ealerts/2023/04/the-future-of-blue-hydrogen-in-the-middle-east)
- CNBC, "Why Oil and Gas Markets are Dreading the Risk of Supply Disruption in the Strait of Hormuz," 8 October 2024. (https://www.cnbc.com/2024/10/08/strait-of-hormuz-what-supply-disruption-could-mean-for-oil-markets.html)
- Council on Foreign Relations, "Is Natural Gas the Transition Fuel for Hydrogen?" Amy M. Jaffe and Joan Ogde, 6 February 2018. (https://www.cfr.org/blog/natural-gas-transition-fuel-hydrogen.)
- Dentons, "The future of gas: Transition to hydrogen in the gas grid," Charles Wood and Adam Brown, 15 January 2019, pp.6. (https://www.dentons.com/en/insights/articles/2019/

january/15/the-future-of-gas-t....)

- Digital Refining, "China's shale gas," July 2016. (https://www.digitalrefining.com/article/1001266/chinas-shale-gas)
- Doha Institute, "Impacts of the Ukrainian Crisis on the Global & Gulf Gas Industry," Abi-Aad Naji, October 2022. (https://www.dohainstitute.org/en/Events/Gulf_Studies_Forum/9th-round/Pages/VideoGalleryPage.aspx?VideoFolder=session5)
- Doha Institute, "Natural Gas in the Arab Gulf States Rising Consumption and Major Future Challenges," Abi-Aad Naji, October 2018. (https://istishraf.dohainstitute.org/ar/issue03/Pages/Istishraf03_2018_02_Abi-Aad.pdf)
- Earthworks, "Fracking, methane and climate," 16 September 2019. (https://earthworks.org/issues/fracking_methane_and_climate/)
- Emirates Policy Centre, "GCC's Hydrogen Landscape: Challenges and Opportunities," Umud Shokri, 11 Apr 2023. (https://epc.ae/en/details/brief/gcc-s-hydrogen-landscape-challenges-and-opportunities)
- EIA, "China extracts commercially viable natural gas from deeper shale formations," 30 September 2024. (https://www.eia.gov/todayinenergy/detail.php?id=63284)
- EIA, "China's natural gas consumption, production, and imports all increased in 2023," 14 August 2024. https://www.eia.gov/todayinenergy/detail.php?id=62804
- EIA, "Country Brief Japan," 7 July 2023. (https://www.eia.gov/international/content/analysis/countries_long/japan/japan.pdf)
- EIA, "The United States was the world's largest liquefied natural gas exporter in 2023," 1 April 2024. (https://www.eia.gov/todayinenergy/detail.php?id=61683)
- Energy Data, "World - USGS Undiscovered Oil and Gas Resources," April 2022. (https://energydata.info/dataset/world-usgs-undiscovered-oil-and-gas-resources)
- Energy Institute, "Qatar to increase LNG production capacity by nearly 85%," 6 March 2024. (https://knowledge.energyinst.org/new-energy-world/article?id=138616)
- Energy Institute "Statistical Review of World Energy," Various Issues.
- Energy Science and Engineering "A bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas," Robert W. Howarth, Vol. 2, Issue 2, 15 May 2014, pp.47-60. (https://onlinelibrary.wiley.com/doi/full/10.1002/ese3.35.)
- Engie, "What Influences Gas Demand?" 30 October 2023. (https://gems.engie.com/what-influences-gas-demand/)
- Environmental Defence Fund, "New Study Finds U.S. Oil and Gas Methane Emissions Are 60 Percent Higher Than EPA Reports," 21 June 2018. (https://www.edf.org/media/new-study-finds-us-oil-and-gas-methane-emissio....)
- EPOCH 2019, "Natural Gas in The East Med, Russia, and the Gulf: Competition or Cooperation?" Abi-Aad Naji, Thessaloniki, September 2019. (https://www.youtube.com/watch?v=M-FvabInU3mk)
- EU, "2050 long-term strategy." (https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy_en)

- Fraunhofer Institute for Solar Energy Systems ISE, "National Hydrogen Strategy of the United Arab Emirates," November 2023. (https://www.ise.fraunhofer.de/en/publications/studies/hydrogen-strategy-uae.html)
- The Guardian, "Berkeley became first US city to ban natural gas. Here's what that may mean for the future," 23 July 2019. (https://www.theguardian.com/environment/2019/jul/23/berkeley-natural-gas....)
- Gulf Research Centre, "Gas in the GCC," Abi-Aad Naji, in Araa Magazine, Issue 101, November 2015.
- Gulf Research Centre, "Natural Gas in the Gulf Cooperation Council," Abi-Aad Naji, The Gulf in 2015-16, 2016.
- Gulf Research Centre, "Towards an EU-GCC Project for Developing the Gas Sector in the Gulf Region," Abi-Aad Naji, November 2009.
- GGC Forum, "Gas in the East Mediterranean: Need for New Political & Commercial Approaches," Abi-Aad Naji, Athens, September 2023.
- GGC Forum, "Role of East Mediterranean in Supplying Europe with Gas," Abi-Aad Naji, Cairo, December 2022.
- GIIGNL, "The LNG Industry," Annual Report 2024.
- Global Energy Monitor, "The New Gas Boom: Tracking Global LNG Infrastructure," Ted Nace, Lydia Plante, and James Browning, June 2019. (https://globalenergymonitor.org/wp-content/uploads/2019/06/NewGasBoomEmb....)
- Global Energy Monitor, "Qatar North Field LNG Terminal," 22 January 2025. (https://www.gem.wiki/Qatar_North_Field_LNG_Terminal)
- Hydrogen Insight, "Qatar starts construction on $1.2bn blue hydrogen-based ammonia plant," 29 November 2024. https://www.hydrogeninsight.com/production/qatar-starts-construction-on-1-2bn-blue-hydrogen-based-ammonia-plant/2-1-1745821
- IEA, "Commentary: The environmental case for natural gas," Tim Gould and Christophe McGlade, 23 October 2017. (https://www.iea.org/newsroom/news/2017/october/commentary-the-environmen....)
- IEA "The Future of Hydrogen," June 2019, pp.35. (https://webstore.iea.org/the-future-of-hydrogen.)
- IEA, "Methane tracker: Reducing methane emissions from oil and gas operations," 2019. (https://www.iea.org/weo/methane/oilandgas/.)
- IEA, "Red Sea Attacks Increase Shipping Times & Freight Rates" 1 February 2024. (https://www.energy.gov/sites/default/files/2024-02/047.%20EIA%2C%20Red%20Sea%20attacks%20increase%20shipping%20times%20and%20freight%20rates.pdf)
- IEA, "Tracking Clean Energy Progress: Methane emissions from oil and gas," 29 July 2019. (https://www.iea.org/tcep/fuelsupply/methane/)
- IEA, "The US shale revolution has reshaped the energy landscape at home and abroad," 19 September 2019. (https://www.iea.org/news/the-us-shale-revolution-has-reshaped-the-energy-landscape-at-home-and-abroad-according-to-latest-iea-policy-review)

- International Journal of Nuclear Hydrogen Production and Application "Global environmental impacts of the hydrogen economy," Vol. 1, Richard Derwent et al., No. 1, January 2006, pp.64. (https://pdfs.semanticscholar.org/68cb/15a0b9f62711a0310f17a9a2b32e139c28....)
- KAPSARC, "The Economics and Resource Potential of Hydrogen Production in Saudi Arabia," 1 March 2022. (https://www.kapsarc.org/research/publications/the-economics-and-resource-potential-of-hydrogen-production-in-saudi-arabia/)
- LNG Industry, "Room for growth in Southeast Asia?" Jessica Casey, 9 May 2024. (https://www.lngindustry.com/special-reports/09052024/room-for-growth-in-southeast-asia/)
- LNG Prime, "Oman LNG to boost capacity with new train," 29 July 2024. (https://lngprime.com/middle-east/oman-lng-to-boost-capacity-with-new-train/118488/)
- Luciani Giacomo & Hafner Manfred, "The Palgrave Handbook of International Energy Economics," May 2022. (file:///C:/Users/User/Downloads/978-3-030-86884-0.pdf)
- Market Screener, "Abu Dhabi's Mubadala Energy Buys First Stake in US Gas Output", 10 April 2025.
- (https://www.marketscreener.com/news/latest/Abu-Dhabi-s-Mubadala-Energy-to-Buy-Stake-in-US-Gas-LNG-Assets-49592610/)
- Mordor Intelligence, "India LNG Market Size & Share Analysis - Growth Trends & Forecasts (2025 - 2030)," January 2025. (https://www.mordorintelligence.com/industry-reports/india-lng-market)
- National Petroleum Council, "Unconventional Gas Worldwide," 2015.
- National Renewable Energy Laboratory, "Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues," M. W. Melaina, O. Antonia, and M. Penev, March 2013. (https://www.nrel.gov/docs/fy13osti/51995.pdf.)
- Natural Gas World, "UAE's well-timed LNG expansion," 30 July 2024.
- (https://www.naturalgasworld.com/uaes-well-timed-lng-expansion-global-gas-perspectives-112390)
- NBC Los Angeles, "Garcetti Says 'Beginning of the End of Natural Gas' in LA is Here," 13 February 2019. (https://www.nbclosangeles.com/news/local/Garcetti-Says-Beginning-of-the-....)
- New York Times, "Michael Bloomberg Promises $500 Million to Help End Coal," Lisa Friedman, 6 June 2019. (https://www.nytimes.com/2019/06/06/climate/bloomberg-climate-pledge-coal....)
- OAPEC, "Annual Statistical Report," Various Issues.
- OilPrice.com, "U.S. Remains the World's Top LNG Exporter as Shipments Hit Record High," 17 December 2024. (https://oilprice.com/Latest-Energy-News/World-News/US-Remains-the-Worlds-Top-LNG-Exporter-as-Shipments-Hit-Record-High.html)
- OPEC, "Annual Statistical Bulletin," Various Issues.
- Outlook Business, "India's Rising LNG Imports," December 2024. (https://www.outlookbusiness.com/explainers/indias-rising-lng-imports-what-is-driving-demand-amid-falling-domestic-production)

- Oxford Institute for Energy Studies, "Narratives for Natural Gas in Decarbonising European Energy Markets," Jonathan Stern, February 2019, pp.6. (https://www.oxfordenergy.org/wp-cms/wp-content/uploads/2019/02/Narratives....)
- Pipeline Technology Journal, "Security of Petroleum Pipelines in the Middle East," Abi-Aad Naji, 2/2023. (https://www.pipeline-journal.net/articles/security-petroleum-pipelines-middle-east)
- Qatar University, "Challenges for Middle Eastern Petroleum Exports: Regional Conflicts or Internal Instability?" Geopolitics of the Gulf Energy, Abi-Aad Naji, November 2019.
- Resources for the Future, "Greening Gas: Creating a Market for Low-Methane Natural Gas," 24 April 2020. (https://www.rff.org/events/rff-live/greening-gas-creating-market-low-methane-natural-gas/)
- Saudi Aramco, "Blue hydrogen and blue ammonia: Pioneering the use of hydrogen as energy." (https://www.aramco.com/en/what-we-do/energy-innovation/advancing-energy-solutions/blue-hydrogen-and-blue-ammonia)
- Springer Nature Link, "Distribution of Oil and Gas Resources in the Middle East," October 2024. (https://link.springer.com/chapter/10.1007/978-981-97-4756-6_8)
- Statista, "Number of oil and gas rigs worldwide as of November 2024, by region and type." (https://www.statista.com/statistics/326727/global-gas-and-oil-rig-numbers-by-region/)
- SWP Comment, "Introduction, A New Hydrogen World," # 58, December 2021. (https://www.swp-berlin.org/publications/products/comments/2021C58_HydrogenWorld.pdf)
- TRT World Forum, "Disputed Energy Resources in the Eastern Mediterranean: A Geopolitical Puzzle," Abi-Aad Naji, Istanbul, December 2023. (https://www.instagram.com/trtworldforum/p/C0pH8t5NXWo/)
- USGS, "World Petroleum Assessment," 2000.
- World Bank, "Global Gas Flaring Tracker Report," June 2024. (https://thedocs.worldbank.org/en/doc/d01b4aebd8a10513c0e341de5e1f652e-0400072024/original/Global-Gas-Flaring-Tracker-Report-June-20-2024.pdf)
- Worldometers, Countries in the world by population (2025). (https://www.worldometers.info/world-population/population-by-country/)
- Wood Mackenzie, "Latin America's natural gas deficit to grow as new resource production remains a challenge," 3 May 2024. (https://www.woodmac.com/press-releases/latin-americas-natural-gas-deficit-to-grow-as-new-resource-production-remains-a-challenge/)
- Woodway Energy, "Natural Gas – Efficiency and Reliability in Power Generation," 26 April 2024. (https://www.woodwayenergy.com/natural-gas-efficiency-in-power-generation/)

About the Author

Dr. Naji Abi-Aad began his role as COO at Petroleb, a Beirut-based oil company active in petroleum exploration offshore the East Mediterranean and the Gulf in September 2012. He also served as Senior Advisor for the Middle East with American natural gas company, Tellurian, from December 2016 to March 2020. He has also been engaged with many other companies interested in expanding their businesses in the Gulf and the East Mediterranean regions.

Prior to his move to Lebanon, Dr. Abi-Aad spent eight years in Qatar, first as Research Advisor for Qatar Petroleum (QP) and its Board of Directors and as Media and Research Strategist in the Office of HE Qatar's Deputy Premier, Minister of Energy & Industry, before being appointed to top positions in Qatar Petroleum International (QPI).

Dr. Abi-Aad studied in Beirut at the American University (Petroleum Studies) and Universite St. Joseph (Law) before been awarded a Ph.D. in Energy Economics from Grenoble University in France. Throughout his 40 years of experience, he has been involved in extensive consultations, conferences, and studies, particularly on oil and gas in the Middle East, and their resource and supply prospects. He has authored over 100 reports and studies on Middle East energy issues, as well as a book on security of petroleum supply from the region *(Instability & Conflict in the Middle East: People Petroleum & Security Threats,* Macmillan, London 1997).

Areas of Dr. Abi-Aad's expertise include issues of security of oil and gas supplies from the Middle East, the local and international markets for natural gas produced in the region and the source thereof, the development of gas sales, and supply contracts in all its forms and prices at the local and global levels.

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