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King Abdullah Petroleum Studies and Research Center

Instant Insight

Assessing CCUS Potential for LNG in the GCC

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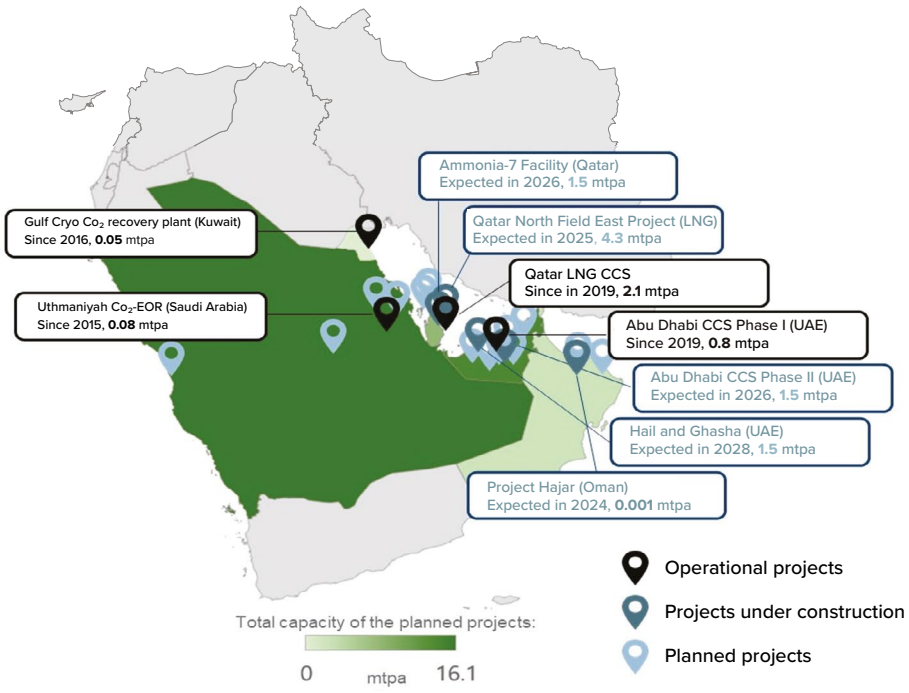
Introduction

As the world experiences the energy transition, traditional oil and gas producers are feeling a greater need to decarbonize their hydrocarbon production.

Figure 1. Operational and planned CCUS projects in GCC countries as of March 2024, with total planned capacity per country.



Source: Authors' calculations, based on IEA (2024), Global CCS Institute (n.d.), and Kourkejian (2023).

After the global gas crisis of 2022-2023, caused by an ongoing military conflict in Europe and the disruption of decades-long Russia-EU relationships, Gulf Cooperation Council (GCC) countries started to be seen by gas importers as the future of stable and secure gas supplies, mainly in the form of liquefied natural gas (LNG). However, considering the ambitious climate goals of gas-importing countries, it has become clear that the development of new gas projects should come hand-in-hand with decarbonization technologies.

To ensure stable supplies of affordable energy to their customers, traditional energy producers are increasingly attracted to implementing carbon capture, utilization, and storage technologies (CCUS). In this Instant Insight, we explore the most recent LNG and CCUS developments in the GCC region.

CCUS in the GCC: An Overview

As of March 2024, out of the six Gulf Cooperation Council countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates), Qatar, Saudi Arabia, Kuwait, and the UAE host operational CCUS projects (one each, so four in total). In addition, five more projects are under construction and are expected to be launched in 2024-2028, and thirteen more are planned (see Figure 1 for the locations and Table 1 for details). Out of these projects, only a small number are related to LNG specifically – two are in Qatar (one is operational, and the other is expected to be launched in 2025), and one, supporting Hail and Gasha offshore gas projects, is under construction in the UAE. Bahrain remains the only GCC country with no CCUS projects operational or under construction so far.

Table 1. CCUS projects in GCC countries, as of March 2024.

Country	Project name	Status (start year if known)	Sector	Announced (estimated by IEA) capacity, million t CO_2/year
Bahrain	Aluminum Bahrain MHI Capture	Planned	Aluminum production	N/A
	Bapco MOL CCUS value chain	Planned	Transportation and storage	N/A
	Bahrain total:			**N/A**
Kuwait	Gulf Cryo CO_2 Recovery Plant	Operational (2016)	Chemical	0.055

Qatar	Ammonia-7 (blue ammonia) Facility	Under construction (2026)	Hydrogen or ammonia	1.5
	Qatar LNG	Operational (2019)	Natural gas processing / LNG	1.23-2.1 (2.1)
	Qatar North Field East Project CCS	Under construction (2025)	Natural gas processing / LNG	2.9-4.3 (4.3)
	Qatar total: **Natural gas / LNG-focused:**			**5.63-7.9** **4.1-6.4**
Saudi Arabia	Jubail CCS Hub agreement	Planned (2027)	Transportation and storage	9
	Gulf Cryo MEG Plant	Planned	Chemical	0.6
	Nairyah 1 and Nairyah 2 plants	Planned	Power and heat	N/A (2.861)
	Rumah 1 and Rumah 2 plants	Planned	Power and heat	N/A (2.861)
	Uthmaniyah CO_2-EOR demonstration	Operational (2015)	Natural gas processing / LNG	0.8
	Saudi Arabia total: **Natural gas / LNG-focused:**			**10.4 (16.1)** **0.8**

United Arab Emirates (UAE)	Emirates Steel Industries (Abu Dhabi CCS Phase 1)	Operational (2016)	Iron and steel	0.8
	Habshan-Bab gas plant (Abu Dhabi CCS Phase 2)	Under construction (2026)	Natural gas processing / LNG	1.5
	ADNOC CO_2 storage hub (Phase 2 of fertiglobe pilot)	Planned (2030)	Storage	5
	Hail and Gasha CO_2 Management	Under construction (2028)	Natural gas processing / LNG	1.5
	MoU ADNOC ENEOS Mitsui Ruwais Industrial Area	Planned	Chemicals	0.46
	Oxy/ADNOC UAE DAC	Planned	Direct Air Capture	1
	Shah gas plant (Abu Dhabi CCS Phase 2)	Planned (2030)	Natural gas processing / LNG	2.3
	Sharjah Hub	Planned	Transportation and storage	N/A
	TA'ZIZ blue ammonia	Planned (2025)	Hydrogen or ammonia	N/A (1.658)
	UAE total: **Natural gas / LNG-focused:**			**12.6 (14.2)** **5.3**
Total GCC existing and planned CCUS capacity: **Natural gas / LNG-focused:**				**28.6-30.9 (40.3)** **10.2-12.5**

Source: Authors' calculations, based on IEA (2024) and Global CCS Institute (n.d.).
Note: In this table, the numbers in brackets are IEA estimates.

Three of the GCC countries are known LNG exporters, albeit in significantly different volumes – in 2022, the UAE exported 5.46 million tons (mln t) of LNG, Oman totaled 11.14 mln t, and Qatar reached 79.04 mln t, becoming the number one global exporter by volume (GIIGNL 2023). In 2023, Qatar moved down to third place in the world, losing the lead to the USA and Australia (Shell 2024). However, Qatar is expected to catch up with its main competitors in the near future, as it will almost double its capacity to 142 mln t per annum (mtpa) by 2030 (GIIGNL 2024).

Other GCC countries are also increasing their LNG ambitions. Bahrain, which currently possesses only an LNG import terminal, recently started to consider constructing an LNG export facility (Offshore Technology 2023). Oman has increased its gas production in recent years, and it is now considering adding a fourth LNG train with a capacity of 3.6-3.7 mtpa to its existing 11.4 mtpa facilities (Carpenter 2024). ADNOC, the Abu Dhabi National Company, is planning to invest $13 billion in gas project expansion in the UAE and abroad, and to develop the low-carbon Al Ruwais LNG project of 9.6 mtpa, which will increase ADNOC's domestic capacity to around 15 mtpa (Habibic 2024). Interest in LNG exports from Saudi Arabia has been quite moderate so far, yet a high-level Aramco representative recently hinted at the possibility of developing domestic LNG export facilities (Ingram 2024).

This indicates that interest in CCUS deployment for LNG will likely grow in the GCC – especially in Qatar, which plans to compete as the number one global LNG exporter. The following sections of this paper will help us better understand the GCC's potential compared to other LNG producers.

CCUS Capacity Needed for LNG in the GCC

So, how much carbon capture and storage capacity are required to decarbonize all of these existing and planned LNG volumes? As we explored in detail in the KAPSARC paper, "Carbon Capture, Utilization, and Storage (CCUS) Solutions to Decarbonize LNG: Why, Where and How Much?", the current technical and economic development level of CCUS technology makes its deployment most feasible for managing upstream emissions in the LNG value chain (from exploration to liquefaction) (Sergeeva and Ward 2024).

As data on the intensity of the CO_2 emissions of each element of the LNG value chain is barely available on the producers' level, it has become a common industrial practice to estimate overall well-to-wheel emissions at 3.42 ton CO_2/ ton LNG, with roughly 0.73 tons CO_2/ton LNG (21.3%) coming from the exploration and production and the liquefaction stages (Sergeeva and Ward 2024). We will use this general estimate to determine the need for CCUS capacity for minor GCC LNG producers – the UAE and Oman. For Qatar, we will use more precise estimates based on data from open sources. In 2023, the emissions intensity of Qatar LNG for the exploration and production and the liquefaction stages was estimated at 0.44 tons CO_2/ton LNG (North Sea Transition Authority 2023).

Table 2. Existing and planned liquefaction facilities in the GCC with corresponding CCUS capacity needed to manage upstream emissions (including liquefaction).

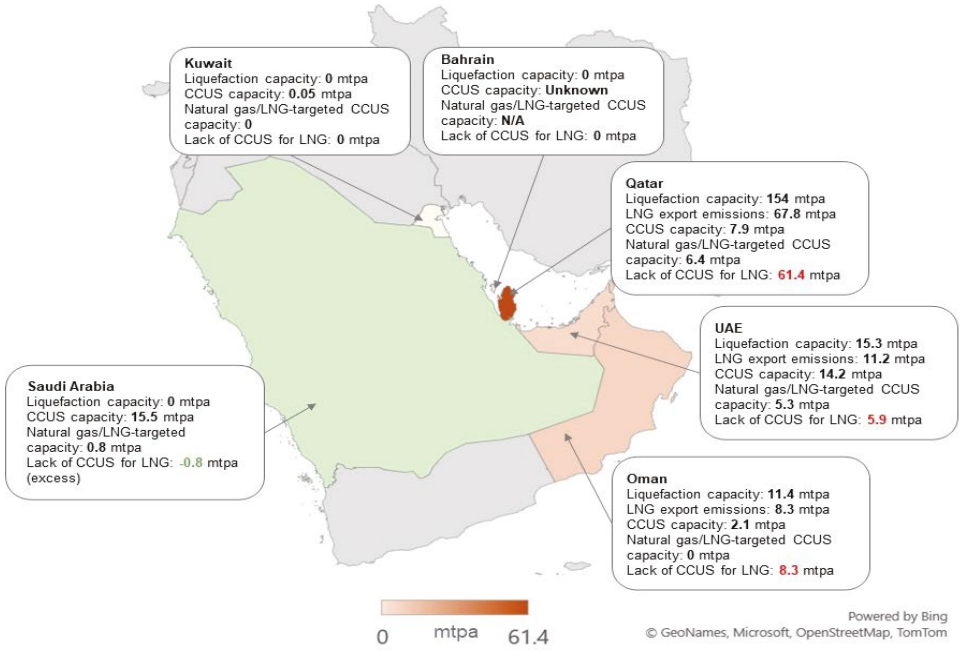
Country	Terminal	Status (start year if known)	Nominal capacity, mtpa*	CCUS capacity needed to manage LNG emissions, mtpa
Oman	Oman LNG	Operational (2000, debottlenecking in 2021)	8.10	5.9
	Oman LNG (Qalhat LNG)	Operational (2005)	3.30	2.4
	Oman total:		**11.4**	**8.3**

Qatar	Qatar Energy LNG I-IV (Trains 1-7)	Operational (1996-2010)	40.70	18.0
	Rasgas I-III (Trains 1-7)	Operational (1999-2010)	36.30	16.0
	Qatar Additional Trains 1-6	Construction (2024-2026)	48.75	21.5
	QatarEnergy LNG Debottlenecking	Planned	6.0	2.6
	QatarEnergy LNG Debottlenecking	Planned	6.0	2.6
	Qatar Additional Trains 7-8	Planned (2030)	16.25	7.1
Qatar total:			**154.00**	**67.8**
United Arab Emirates (UAE)	Das Island	Operational (1977)	5.80	4.2
	Ruwais LNG	Planned	9.50	6.9
	UAE total:		**15.3**	**11.2****
Total for GCC countries:			**180.7**	**87.3**

Source: Authors' calculations, based on NexantECA (2024).
*Note: * mtpa stands for million tons per annum*
*** Insufficient differences may be present due to rounding.*

After comparing Table 1 (CCUS projects) and Table 2 (liquefaction facilities), we can see that the likely demand for decarbonization will be significantly higher than the existing and planned capacity of CCUS facilities. For example, total CCUS capacity in the GCC region, both existing and planned, is expected to amount to 40.3 mtpa in a best-case scenario. Only roughly a quarter of this, or a maximum of 12.5 mtpa, is the capacity of CCUS projects targeting natural gas / LNG. At the same time, GCC LNG projects will require almost 90 mtpa of CCUS facilities by the end of the decade. Figure 2 shows the lack of CCUS capacity for upstream decarbonization of LNG in the GCC on a national level. Cross-border collaboration between the GCC nations could significantly increase the adoption of CCUS as a value-added option for LNG by sharing the costs and benefits. For instance, Saudi Arabia's massive geologic storage capacity, paired with Qatar's current role as a major LNG exporter, could be a natural match if regulatory and financial hurdles are overcome.

Figure 2. Extra CCUS capacity needed to decarbonize GCC LNG exports.

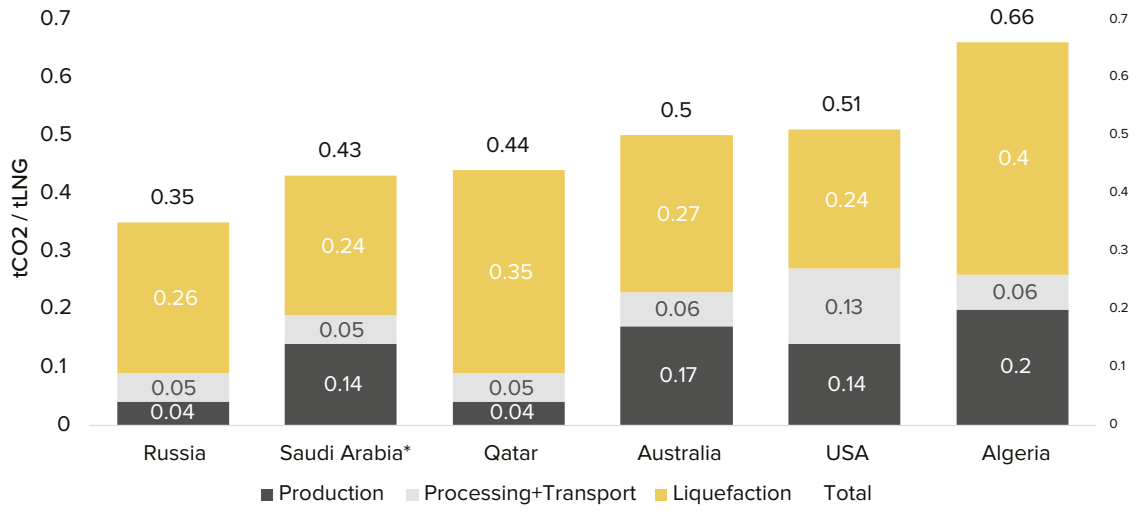


Source: Authors' calculations, based on IEA (2024) and Nexant (2024).
Notes: Liquefaction and CCUS capacity include both operational and planned.
"Lack of CCUS for LNG" was calculated as CCUS capacity needed to manage the country's upstream (from exploration and production iquefaction) LNG emissions minus CCUS capacity targeted for the natural gas / LNG sector.

Decarbonization of LNG in the GCC: A Competitive Advantage

As briefly discussed in the previous section, some of the GCC countries can be highly competitive in the global gas market due to the low carbon intensity of their LNG. Figure 3 shows the CO_2 emissions intensity of 1 ton of LNG from global producers, which we presented in the aforementioned KAPSARC paper (Sergeeva and Ward 2024). This time, we added the estimates for Saudi Arabia. Our analysis showed that, with its unconventional fields, the Kingdom's emissions from natural gas production will be similar to those of U.S. producers. Processing and transport parameters are more geographically determined and, therefore, are comparable to Qatar. Emissions on the liquefaction stage will likely be closer to those of U.S. producers, since recently built facilities focus more on environmental performance.

Figure 3. CO_2 emissions intensity of 1 ton of LNG from different producers on selected stages of the value chain.



Source: Authors' calculations, based on the North Sea Transition Authority (2023).
*Note: *These are preliminary estimates for Saudi Arabia, which has not exported LNG yet.*

Recent abundant gas discoveries made in Saudi Arabia in 2023-2024 make the country more likely to entertain the idea of LNG exports. In June 2024, indeed, the Kingdom's energy company, Aramco, awarded construction contracts worth $25 billion for developing the Jafura gas project.

In addition to the discoveries within the Kingdom, Aramco recently demonstrated interest in the global LNG business. In June 2024, the company signed a non-binding agreement with a U.S. LNG producer, Sempra Energy, that entails a potential acquisition of 25% in the Port Arthur LNG Phase II project (Kennedy 2024). Earlier that month, Aramco signed an LNG non-binding Heads of Agreement for 20 years to offtake 1.2 mtpa LNG from the U.S. NextDecade Corporation's planned Train 4 at the Rio Grande LNG export facility. The delivery terms are Free on Board (FOB), which means that Aramco will have almost complete destination freedom of the cargo (Paraskova 2024; ACER 2023).

In 2023, Aramco already acquired a strategic minority stake in another LNG company, MidOcean Energy (Aramco 2023). One potential explanation of this growing interest in the international LNG business is that the Kingdom is "testing the waters" before entering the global market with its natural gas.

In addition to LNG's lower carbon intensity, GCC countries have a few other advantages that make deploying CCUS economically favorable. We explored them in detail in the previously mentioned KAPSARC paper (Sergeeva and Ward 2024). Here, we will briefly list them. Among these advantages are low electricity prices (which drive OPEX costs), low labor costs (which drive both OPEX and CAPEX), low tax rates, and a favorable regulatory environment. As a result, the costs of implementing CCUS solutions for LNG in Qatar (and potentially Saudi Arabia) are roughly half of that in Australia and 30% less than in the USA. All of these factors make the GCC a highly competitive location for large-scale CCUS projects.

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