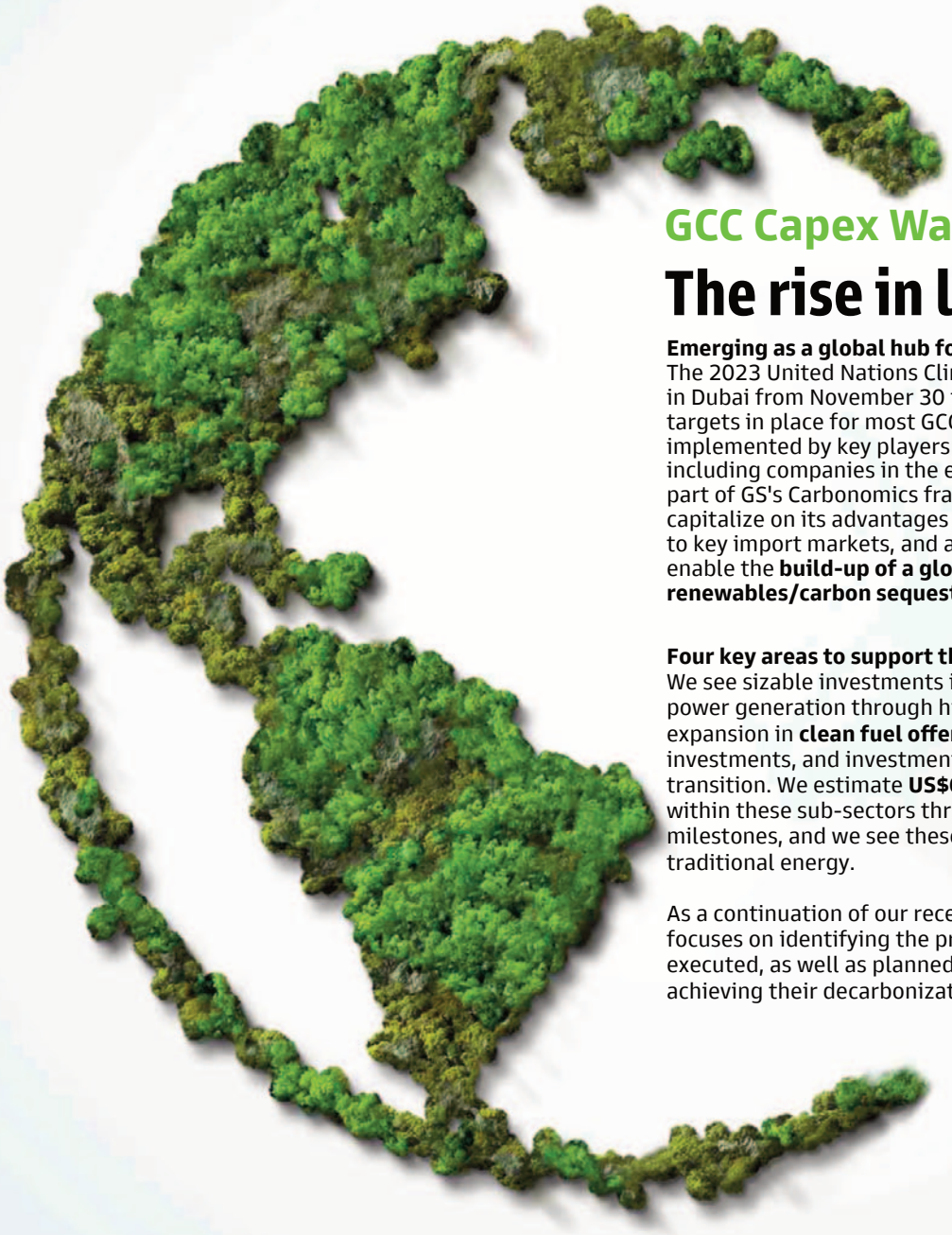
Goldman Sachs

EQUITY RESEARCH | November 28, 2023 | 7:36AM GST



GCC Capex Wave Series

The rise in low-carbon capex

Emerging as a global hub for clean energy

The 2023 United Nations Climate Change Conference (COP28) will take place in Dubai from November 30 to December 12, 2023. With net zero carbon targets in place for most GCC countries, ambitious plans are being implemented by key players in the market to facilitate decarbonization, including companies in the energy, industrials and infrastructure sectors. As part of GS's Carbonomics framework, we see the region as well positioned to capitalize on its advantages such as low-cost positioning in energy, proximity to key import markets, and a constructive regulatory backdrop, which should enable the **build-up of a global hub not just for fossil fuels, but also for renewables/carbon sequestration/clean fuels & technologies.**

Four key areas to support the transition

We see sizable investments in **four key strategic areas:** phase-out of liquids in power generation through higher **natural gas** and **renewables** capacities, an expansion in **clean fuel offerings** through a growing focus on clean technology investments, and investments in the necessary **infrastructure** to support this transition. We estimate **US$608-654bn of investments** could be required within these sub-sectors through 2030-35 to help the region achieve key milestones, and we see these investments closely matching those targeted in traditional energy.

As a continuation of our recently launched GCC Capex Wave Series, this report focuses on identifying the projects that have been completed or are being executed, as well as planned investments by GCC countries on the path to achieving their decarbonization targets.

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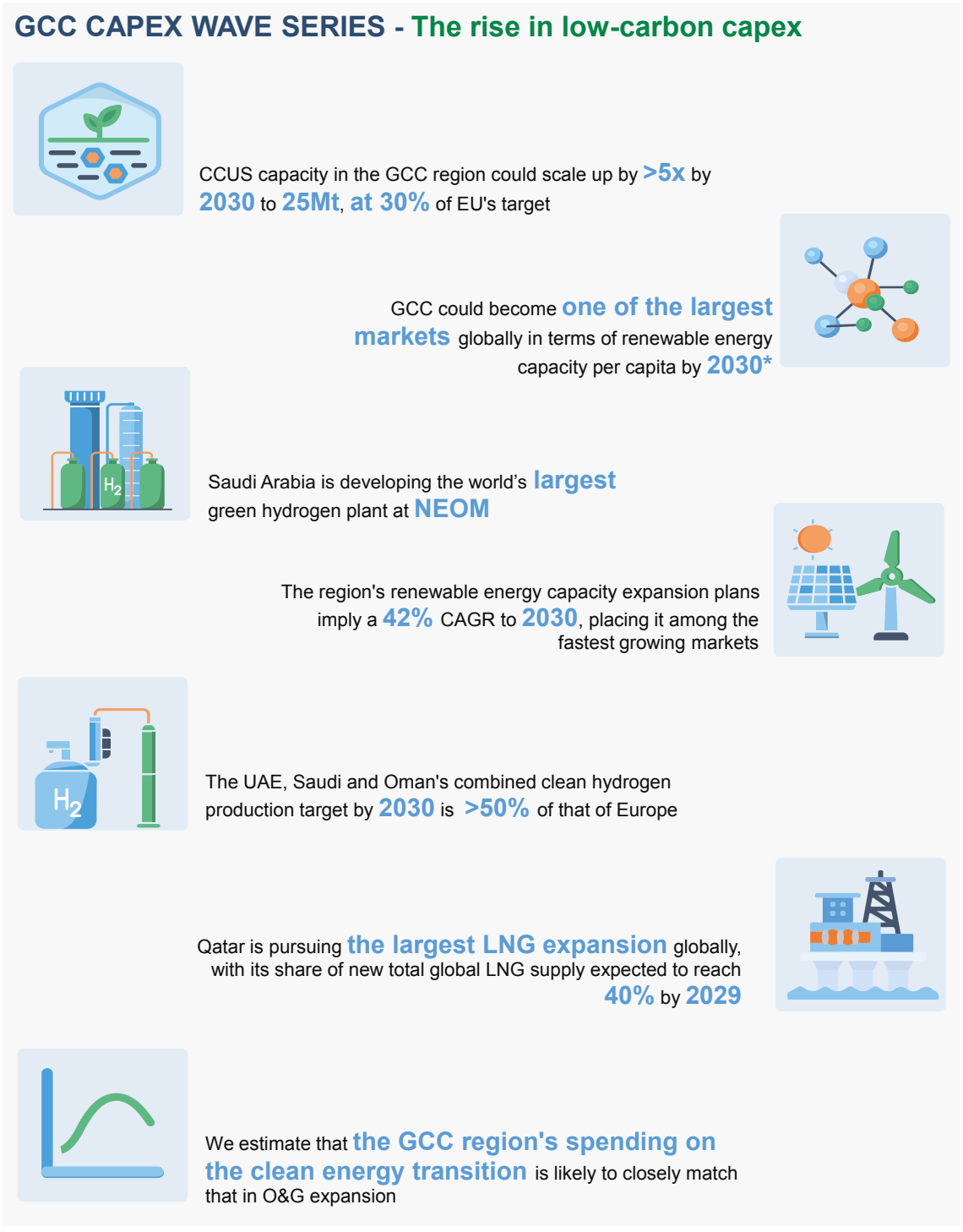
GCC countries are at the forefront of the clean energy transition in the Middle East

Exhibit 1: GCC Capex Wave Series: The rise in low-carbon capex - key figures



*Based on ambitious targets

Source: Goldman Sachs Global Investment Research, Bloomberg, Reuters

We believe **the GCC countries are strategically positioned to become global clean energy hubs** as they capitalize on: a constructive macro backdrop driving investments from public, private and foreign entities; increasingly supportive government policies; and the region's low-cost positioning across the value chain. Indeed, with carbon reduction becoming a key focus for the national vision of the countries, several key milestones have been set in areas that should facilitate the transition, including natural gas and renewables/clean energy, to gradually phase out oil/heavy liquids usage in power generation, carbon sequestration, clean hydrogen, and clean technologies as well as the necessary infrastructure (e.g. shipping, logistics and EV related infrastructure).

While these countries have ambitious targets through the end of the decade, we highlight that the accelerated tendering processes and auctions over the past couple of years have brought them a step closer to achieving their medium-term goals. Based on announced projects and forecasts, we estimate that **c.US$608-654bn in decarbonization investments** could be required across four key areas, and we see upside to these numbers as targets are revised, more projects are announced and there are further technological breakthroughs.

Key focus areas of investment for the GCC countries on the path to decarbonization

We identify four key areas of investment at the center of the GCC countries' energy transition plans: natural gas expansion, renewables/clean energy, clean fuels (hydrogen/ammonia) and technologies (carbon capture), and infrastructure (shipping, EVs), all of which are aimed at decarbonizing various high-carbon emitting sectors including upstream hydrocarbon production, power generation, industrial production, automotive and others.

1. Natural gas and carbon capture: The GCC's National Oil Companies (NOCs), some of the world's largest (and lowest carbon-emitting) producers of fossil fuels, are increasingly investing in upstream capacity growth following a long period of under-investment in the industry by non-OPEC players. The focus in the recent years has increasingly centered around gas self-sufficiency as several countries still rely on liquids for fueling power generation. The planned investment in oil capacity should increase associated gas production with a growing focus on scaling up non-associated and unconventional large gas fields. As the GCC countries move towards their decarbonization targets, we estimate upstream growth capex associated with gas investments of **US$165-175bn** through the end of the decade. This will play a vital role in gradually phasing out crude for power generation and increasing the contribution of low carbon gas in the mix over time. We note that Saudi Arabia, Qatar, the UAE and Kuwait have all announced ambitious production targets in this space.

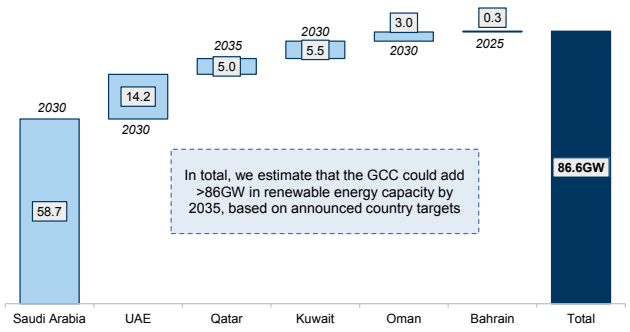
2. Renewables and clean energy: Government entities, NOCs and the private sector across the GCC countries have joined efforts over the past few years to decarbonize power generation by developing an attractive **renewable and clean energy market**. **We estimate that a total of US$190-212bn in investments would be required to achieve the GCC's renewable capacity installation targets by 2030-35.** Key targets include the following: Saudi's aim to generate 50% of its electricity requirements through renewable energy sources (RES) by 2030 through the installation of 58.7GW of solar and wind capacities, in addition to 2-3GW of nuclear energy (while it continues to make strides towards becoming a hub for the development and manufacture of solar panels); the UAE's plans to add 19.8GW of clean energy capacity (solar PV/CSP and nuclear) by 2030; Qatar's plans to add 5GW by 2035; and Oman's aim to source at least 30% of its power from renewable sources by 2030.

3. Carbon sequestration and clean fuels: We believe the region is well-placed to capitalize on its existing infrastructure and cost advantages, and it has been increasingly focused on positioning itself as a leading producer in the clean fuels market. Carbon capture has been prioritized, along with the potential for scaling up blue hydrogen and ammonia production, as well as green hydrogen and sustainable fuels, as investments in renewables build up overtime. We estimate investments within this space to range between **US$141-155bn** depending on the execution of the targets. The GCC countries are embarking on massive growth projects on the carbon capture and storage front with an aim to increase their capacity from 4.5mtpa to **25mtpa** by 2030 and more than **65mtpa** by 2035. On hydrogen: the UAE launched the UAE Hydrogen Leadership Roadmap targeting a 25% market share of low-carbon hydrogen and derivatives in key international markets by 2030; Saudi has announced plans to produce 2.9mtpa of clean

hydrogen by 2030, and is currently developing the world's largest single-site green hydrogen plant at NEOM; while Oman announced plans to produce at least 1Mt/year of green hydrogen by 2030, scaling it up to 3.25-3.75Mt/year by 2040, as per Oman's green hydrogen strategy. We note that the safe and cost-efficient transport, storage and distribution of hydrogen will be critical in setting the pace of its large-scale deployment across the region.

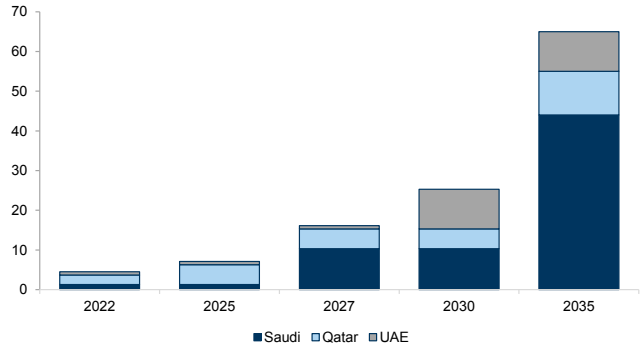
4. Infrastructure and logistics: To support the energy transition, the GCC countries are also planning major investments in infrastructure across different sectors, including transportation (EV charging infrastructure, aviation), gas pipelines, shipping and logistics. Overall, we identify **US$112bn** in investments announced so far across the region. We believe these investments are necessary to facilitate the different decarbonization targets, with upside stemming from a growing focus on developing the full value chain in areas such as EV manufacturing.

Exhibit 2: The GCC region could see >85GW in cumulative renewable energy capacity additions by 2030-35
GW



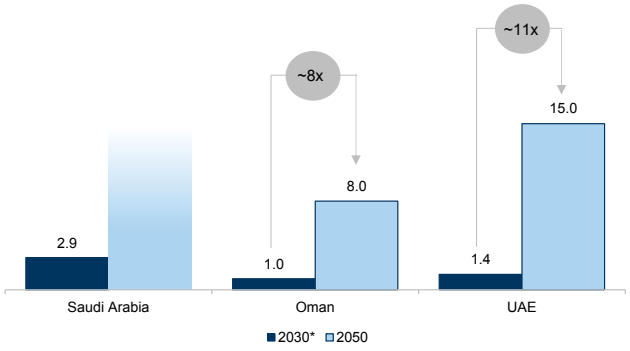
Source: Relevant ministries and government entities, Goldman Sachs Global Investment Research

Exhibit 3: In line with announced GCC growth targets, we expect CCUS capacity in the region to grow multi-fold to 65mtpa by 2035
CCUS capacity, mtpa



Source: Goldman Sachs Global Investment Research, Company data, Regional news outlets

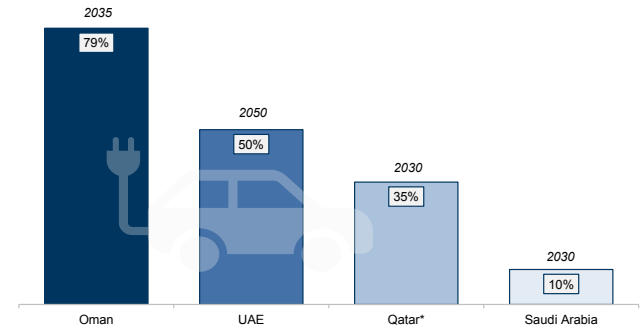
Exhibit 4: We estimate that the region will likely add ~5.3mtpa in clean hydrogen capacity based on announced plans through the end of the decade
Clean hydrogen capacity, GW



*For the UAE, by 2031

Source: Relevant ministries and government entities, Goldman Sachs Global Investment Research

Exhibit 5: This is while these countries also have ambitious EV penetration targets
% of total vehicles



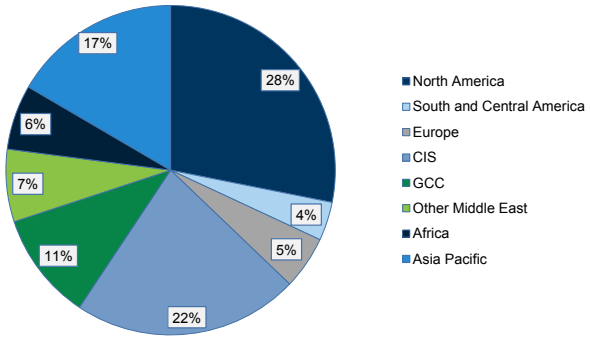
*For Qatar, the target is as a % of vehicles pertaining to the Qatar Ministry of Transport

Source: Compiled by Goldman Sachs Global Investment Research

Ambitious net zero targets for one of the world's largest oil economies

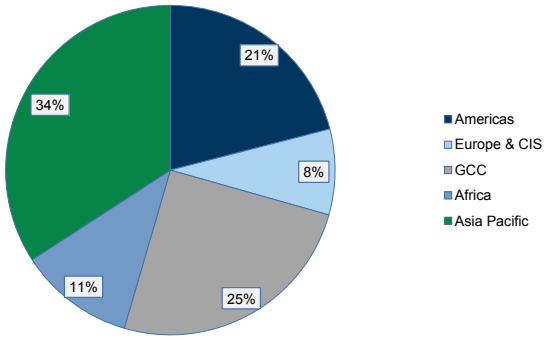
The GCC region is home to 11% of the world's natural gas production and 25% of the world's LNG exports (as of 2021, source: BP), and is a major exporter of hydrocarbon and downstream products. With global efforts towards the energy transition in mind, regulators and policymakers in the GCC have incorporated decarbonization plans and net zero targets into their economic transformation visions, such as the UAE's 2031 Vision (launched in 2022) and Saudi Arabia's Vision 2030 (launched in 2016). As investments in natural gas projects and clean technologies (renewables, blue/green hydrogen) continue to advance, the GCC countries move a step closer towards their net zero targets; in fact, ADNOC in the UAE recently announced moving its net zero target closer to 2045 (vs. 2050 previously), while Oman remains committed to its 2050 target, and Saudi Arabia/Kuwait/Bahrain to their 2060 targets. That said, we note that these targets are alongside the GCC's continuing large investments in growing upstream and downstream chains to ensure energy security. Nevertheless, to achieve net zero targets, substantial investments are being undertaken to decarbonize the high-carbon emitting sectors including manufacturing and power generation, among others, with execution remaining contingent on technological advancement and availability, as well as an increase in the participation of the private sector.

Exhibit 6: The Middle East accounted for 18% of natural gas production in 2021, while the GCC accounted for 11% of production...
Gas production (in bn cubic meters), 2021



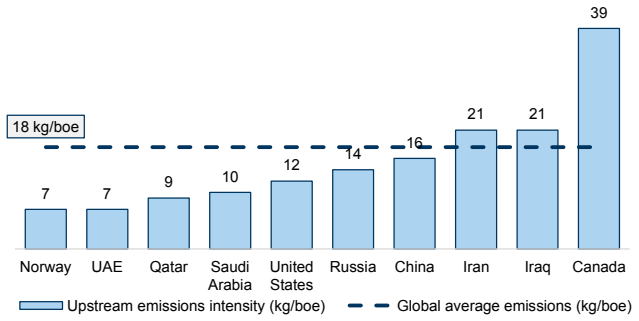
Source: BP

Exhibit 7: ...and 25% of total LNG exports
LNG exports (billion cubic meters), 2021



Source: BP

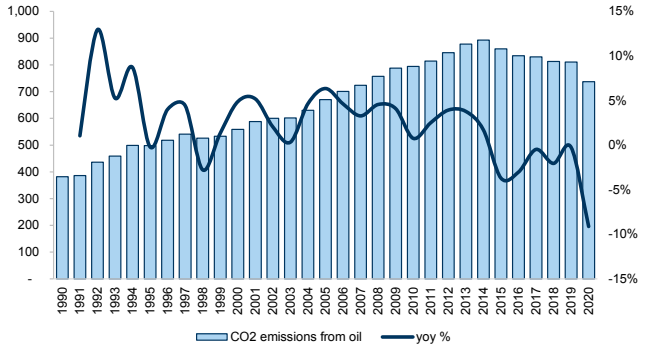
Exhibit 8: GCC markets have among the lowest upstream emissions per barrel of oil produced globally
Upstream CO2 emission intensity (kg CO2/boe)*



*Data based on the top 10 oil and gas-producing countries (Rystad Energy study)

Source: ADES, Rystad

Exhibit 9: YoY changes in CO2 emissions (from oil) in the Middle East have been trending lower in the last few years owing to decarbonization policies
CO2 emissions in mn tons/yoy change,%



Source: IEA

Some decarbonization roadmaps that have been adopted by the GCC countries include (1) **Saudi's *Green Initiative (SGI)*** inaugurated in 2021, which aims to reduce carbon emissions by 278mtpa by 2030, (2) the ***UAE's National Climate Change Plan 2050***, which plans to source 50% of power generation from clean sources by 2050, (3) ***Qatar's National Environment and Climate Change Strategy***, where the country pledged to reduce emissions by 25% vs. a BAU (Business as Usual) scenario in 2030, and (4) ***Oman's National Strategy for an Orderly Transition to Net Zero***, which could help the country abate 97 mt CO2e by 2050, with decarbonization initiatives through 2030 and 2040 accounting for 6% and 54%, respectively, of the total pathway relative to 2021 emissions. We note that this list of strategies is non-exhaustive and represents a sample of what has been announced at a country or even emirate/city level (Exhibit 11 highlights national, emirate and company-level initiatives announced by the UAE as part of its Net Zero Baseline). In our view, as the milestones in relation to these strategies are achieved, we could see further government support for the targets to be met by 2045-60.

Exhibit 10: All GCC countries have recognized the need for sustanability-related policies and strategies to achieve their net zero targets
Strategies and economic visions of the GCC countries (non-exhaustive list)

Kuwait
Kuwait Vision 2035, Kuwait National Adaptation Plan, Kuwait Environmental Governance Initiative

Bahrain
Bahrain Economic Vision 2030, National Strategy for Environment

Qatar
Qatar's National Environment and Climate Change Strategy, National Action Plan for Climate Change 2030

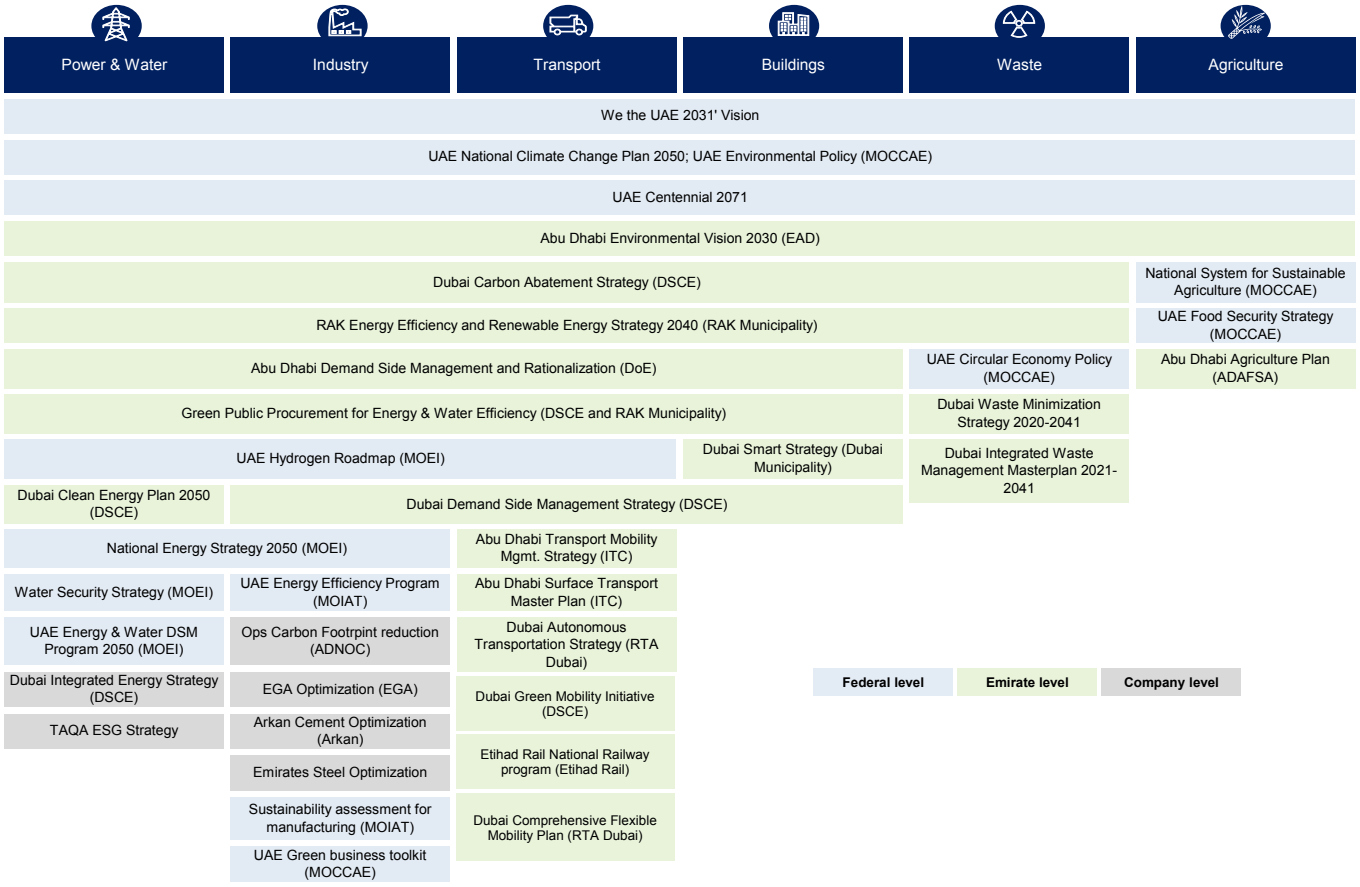
UAE
We the UAE 2031 Vision, UAE National Climate Change Plan 2050, UAE Environmental Policy, UAE Circular Economy Policy, UAE Hydrogen Roadmap, Dubai Clean Energy Plan 2050, Abu Dhabi Environmental Vision 2030

Oman
Oman's National Strategy for an Orderly Transition to Net Zero, Oman's National Adaptation Plan

Saudi Arabia
Saudi Vision 2030, Saudi Green Initiative, Middle East Green Initiative, Circular Carbon Economy National Program, National Renewable Energy Program, Saudi Energy Efficiency Program

Source: United Nations, Respective government websites

Exhibit 11: The UAE has adopted more than 30 national, emirate and company-level programs as part of its Net Zero Baseline



Source: UAE Ministry of Climate Change & Environment

While upstream production will remain strategically important for the region for the foreseeable future, the GCC, nevertheless, has been increasingly adopting a progressive approach towards reducing carbon emissions and improving energy efficiency. Indeed, when looking at recent announcements by NOCs and large chemicals players in the region, decarbonization has become a key focus area for players across the energy value chain.

Sustainable smart cities on the rise: NEOM to attract sizable investments

NEOM, Saudi Arabia's flagship mega-project under Vision 2030, is a smart, sustainable city covering a planned 26,500km2 in land area, with a budget of US$500bn. The city is home to several major developments so far, including (1) **Oxagon**, an advanced and clean industrial ecosystem based on accelerating the approaches of Industry 4.0 and the principles of circularity; (2) **The Line**, a 170km linear city which aims to run on 100% renewable energy and preserve 95% of land, with a goal to eventually accommodate 9mn residents; (3) **Trojena**, a 1,400+ km2 mountain region with 36km of ski slopes and 47km of retail and dining outlet space planned, aiming to attract 700k tourists annually by 2030; and (4) **Sindalah**, a luxury island destination in the Red Sea, amongst other regions. As per NEOM's CEO, around 20% of the project's infrastructure has been completed as of January 2023. NEOM has attracted sizable investments so far: (1) in May 2023, it secured a SAR3bn loan from Riyad Bank for the development of Sindalah; (2) in June 2023, it secured a SAR21bn project investment for a social infrastructure project that will house the region's growing workforce; and (3) in October 2023, it announced along with DSV the establishment of a US$10bn logistics JV to support the development of the projects taking place in the region, among many other announcements. NEOM also recently established the NEOM Investment Fund (NIF), its strategic investment arm and a wholly owned subsidiary, to support the development of NEOM's 14 priority sectors (including Design & Construction, Education, Energy, Entertainment & Culture, Financial Services, Manufacturing, Tourism and others).

Decarbonization initiatives in the region are centered not only in high energy-intensive areas but also in other sectors. The region's commitment towards supporting and enabling climate-related national strategies, policies and programs can also be seen through the respective exchanges launching carbon credit trading platforms. Indeed, in 2024, Saudi Arabia will launch the Greenhouse Gas Crediting and Offsetting Mechanism (GCOM), which follows the establishment of the Regional Voluntary Carbon Market Company (RVCMC) in 2022 - a JV between the Public Investment Fund and Saudi Tadawul Group that aims to support regional businesses as they contribute to the global transition towards net zero. In the UAE, the Abu Dhabi Global Market (ADGM) launched the world's first fully regulated carbon trading exchange and carbon clearing house in 2022 and the first regulated voluntary carbon market (VCM) in the MENA region. Regional banks also have a role towards the journey to Net Zero through the issuance of green bonds / sukuks and increasing their green / sustainable financing portfolios.

Five global themes of affordable decarbonization that can drive progress towards net zero

Looking back at the past couple of years, many challenges have emerged on the path to net zero carbon, as highlighted by our energy team in their latest Carbonomics report, with three being: (1) direct hydrocarbon subsidies reaching US$1tn in 2022 (4x the 6-year average); (2) a +3.4% yoy increase in coal consumption; and (3) the Nationally Determined Contributions (NDCs) still needing an extra 54% reduction of 2030e CO2eq emissions to remain on track for 1.5°C. That said, there is room for optimism, and the key themes of affordable decarbonization that the team believes can drive progress include:

(1) Policy: Government incentives can unlock large-scale clean tech development. The US Inflation Reduction Act (IRA) is, in the team's view, a powerful example of the most comprehensive and impactful legislation to be implemented on clean tech. This attractive regulatory backdrop will drive, on their estimates, US$3tn of investments across renewable electrons and molecules, including the first deployment at large scale of green hydrogen and carbon capture.

(2) Technological innovation: As of October 2023, the team calculates that c.$500bn has been announced in new private clean energy investments, despite the fact that several sectors, including hydrogen and carbon capture, are still waiting for important clarifications on the IRA tax credits. The impact of policy support is best reflected in higher-cost technologies, such as EVs, CCS (Carbon Capture and Storage) and Green Hydrogen, which are at the higher end of the cost curve in comparison to solar and on-shore wind, and require more subsidies to help drive technological innovation and reduce cost.

(3) Financial markets: Capital markets pressure on decarbonization has been on the rise in recent years. Today, c.$120 trn of global assets under management have signed up to UN PRI and are implementing ESG metrics as part of their investment process. This wave of "green" investments is driving capital towards decarbonization technologies through a divergence in the cost of capital of high carbon vs. low carbon investments.

(4) Carbon market: Carbon pricing is a crucial instrument for decarbonization, but it also needs to be fair, prevent carbon leakage, and provide greater confidence and transparency for voluntary offsets. At present, 73 carbon pricing initiatives are under way, covering 39 national and 33 regional governments worldwide, mostly through cap-and-trade systems.

(5) Consumer choice: Governments could mandate carbon footprint disclosure on products/services and set standards in a globally coordinated fashion, empowering consumers to choose low-carbon goods.

Nationally Determined Contributions (NDCs)

NDCs are self-defined climate mitigation plans and the decarbonization roadmap that are submitted to the UN by countries which are Parties to the Paris Agreement. These include emissions reduction targets and intended policy measures as well as actions towards building climate resilience to adapt to rising temperatures. The Paris Agreement requires NDCs be updated and submitted every five years.

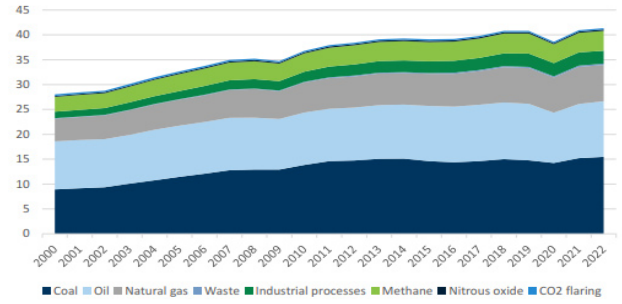
UN Framework Convention on Climate Change (UNFCCC)

The UNFCCC is the global convention on climate change with the ultimate objective to "achieve the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system". There are 197 countries that are Parties to the Convention, with the UNFCC the parent treaty of the 2015 Paris Agreement and the 1997 Kyoto Protocol.

Intergovernmental Panel on Climate Change (IPCC)

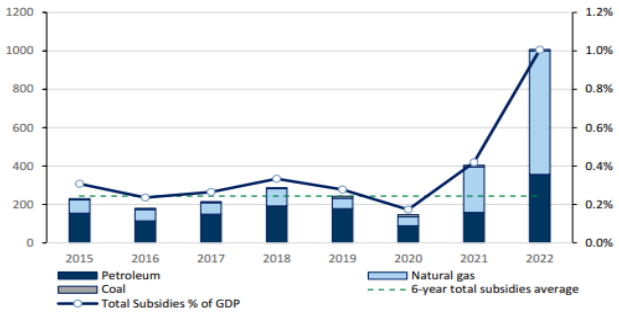
The IPCC is an intergovernmental body of the United Nations that is dedicated to providing an objective, scientific view of climate change and its political and economic impacts. IPCC assessments provide a scientific basis for governments at all levels to develop climate-related policies and underpin negotiations at the UN Climate Conference.

Exhibit 12: 2022 was a challenging year for decarbonization, with rising emissions (+1.0% yoy)...
Global energy-related greenhouse gas emissions, 2000-22



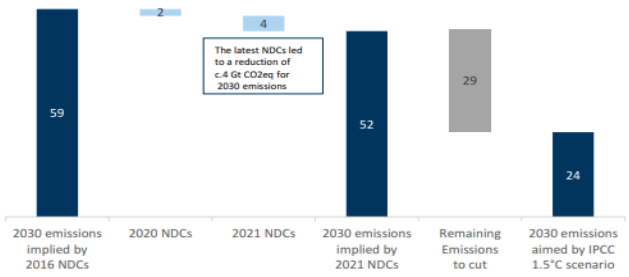
Source: IEA

Exhibit 13: ...and a 4x increase in fossil fuel subsidies globally driven largely by the Russia-Ukraine war...
Breakdown of explicit subsidies per fossil fuel ($ mn)



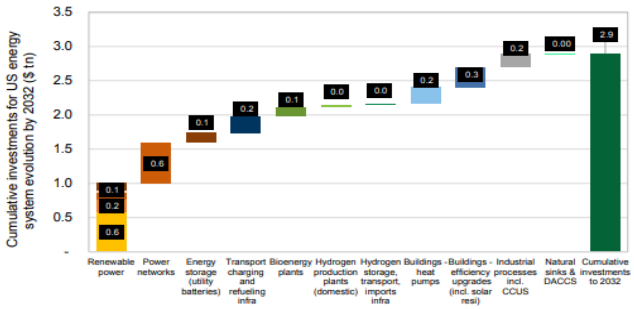
Source: IMF

Exhibit 14: ...posing significant challenges to the goal of containing climate change to 1.5°C
Total GHG emissions in 2030 implied by the NDC pledges overtime (Gt CO2 eq)



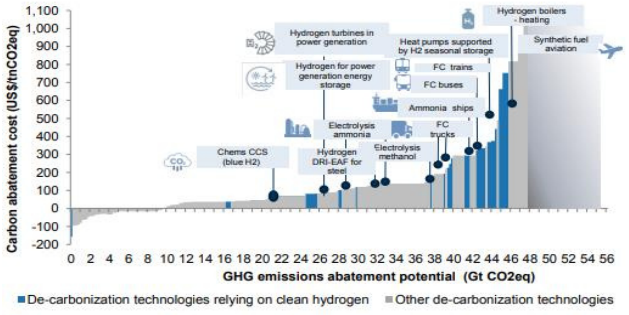
Source: UNFCCC

Exhibit 15: Despite this challenging background, our energy team identifies five key themes of progress
IRA cumulative investment opportunity across sectors for the restructuring of the US energy system by 2032 (US$ trn)



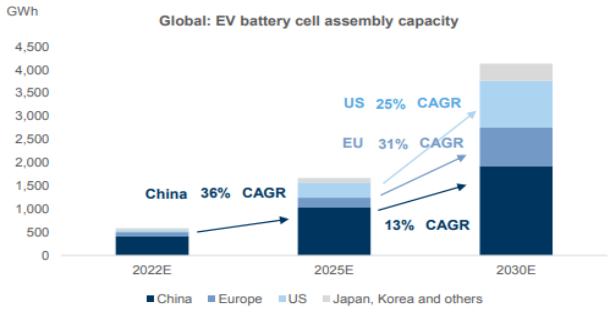
Source: US Treasury, Congressional Budget Office, Goldman Sachs Global Investment Research

Exhibit 16: They estimate that c.15% of global GHG emissions could be abated through technologies that rely on clean hydrogen



Source: Goldman Sachs Global Investment Research

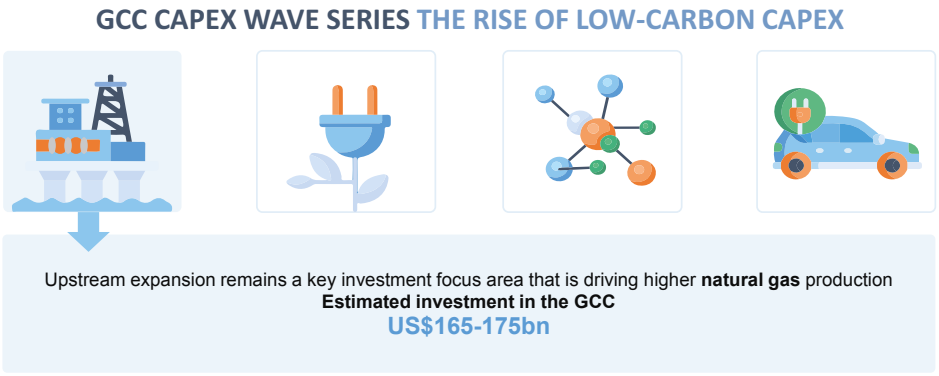
Exhibit 17: US EV battery capacity additions are accelerating



Source: Company data, Goldman Sachs Global Investment Research

Natural Gas: Gradually phasing out oil usage in power generation

GCC National Oil Companies (NOCs), one of the world's largest producers of fossil fuels, are increasingly investing in upstream capacity growth following a long period of under-investment by non-OPEC players. This is while they continue to be among the world's lowest emitters on a per barrel basis. We believe these investments will continue to play a big role in ensuring energy security while also facilitating an expansion in natural gas production (through higher associated gas and non-associated gas investments, and an increasing focus on unconventional fields), which will help enable the phase-out of crude for power generation and increase the contribution of low carbon gas in the mix over time. Looking at 2023-30, we see scope for upstream growth capex of US$165-175bn, mainly across Saudi Arabia, Qatar, and the UAE (based on project announcements), with potential upside from Kuwait, which also has expansionary initiatives in both oil and non-associated gas.



Source: Goldman Sachs Global Investment Research

Upstream expansion is mainly focused on (1) **catering to structurally tight supply** post a multi-year period of under-investment globally; (2) **utilizing hydrocarbon resources in more value-add products** such as petrochemicals; (3) **lowering carbon emissions from power generation** by switching to gas; and (4) **providing the base for the build-up of clean fuels** exports. Overall, we see multiple factors driving upstream growth over the medium to long term, including an upgrade to oil production targets (Aramco intending to expand its maximum sustainable capacity (MSC) to 13mmbpd and ADNOC planning to expand to 5mmbpd, both by 2027), an increase in gas production (from both conventional and unconventional sources, such as Jafurah in Saudi Arabia, Fujairah LNG in the UAE and North Field exploration in Qatar), and an enhancement of exploration efforts with meaningful potential volumes across natural gas liquids (NGLs), LNG, and condensates.

Most GCC countries made several announcements over the past 24 months on expanding their oil and natural gas production capacities with an aim to either grow market share or improve their domestic energy consumption mix. In terms of targets, Saudi Arabia, Qatar, the UAE and Kuwait have all set plans to grow their hydrocarbon capacity from current levels while maintaining a focus on relatively low carbon intensity.

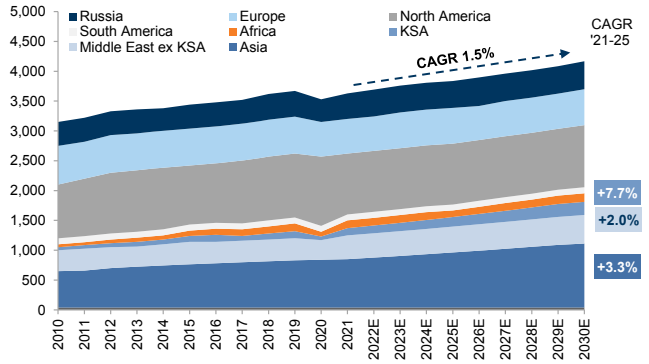
We detail below the upstream (gas-related) growth ambitions and estimate the potential capex spending that is likely through 2030 (based on project announcements).

Saudi Arabia: Natural gas expansion a key focus area within the upstream space

The Saudi government has placed gas at the center of its energy transition strategy as it aims to reduce its carbon footprint meaningfully by 2030 and reach net zero by 2060. Demand for natural gas in the country is expected to grow at a 5% CAGR through 2030 (source: Rystad), meaningfully outpacing the global average of 1.5% over the same period. Additionally, Saudi aims to increase its gas production by more than 50% to c.15bsfd by 2030, with incremental volumes expected from natural gas and ethane.

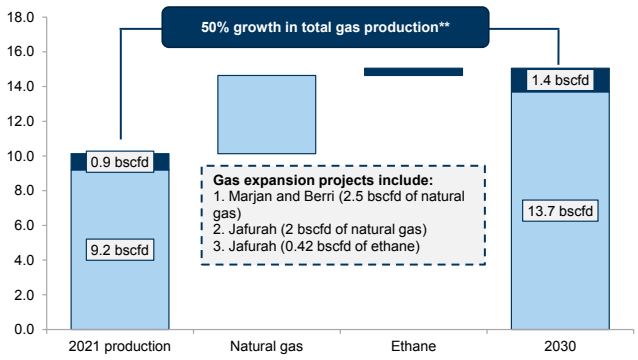
With regard to expansionary projects, Jafurah's unconventional field development stands out as one of the largest in terms of incremental capacity addition and investment size. Jafurah is forecast to add 200msfd by 2025, scaling up to a sustainable 2.0bsfd by 2030, and 2.2bsfd by 2036, in addition to 420msfd of ethane and 630kbpd of NGLs and condensate. Besides Jafurah, Aramco expects to add 2.5bsfd of incremental gas production capacity by 2025 from the Marjan field. Towards the end of the decade, we see scope for Saudi to become a net exporter of natural gas mainly via blue hydrogen and blue ammonia (with natural gas a key input for both products). **Overall, we estimate c.US$83-91bn in gas-related investments through 2030** (as highlighted in our GCC Capex Series note), based on available data on investment costs and project targets.

Exhibit 18: Rystad sees growing demand globally for hydrocarbons through 2030, in particular gas
Global natural gas demand by continent, in bcm per year



Source: Rystad market report

Exhibit 19: Saudi Aramco aims to grow its gas production by 50% by 2030
Saudi Aramco's gas production (both natural gas and ethane), bscfd



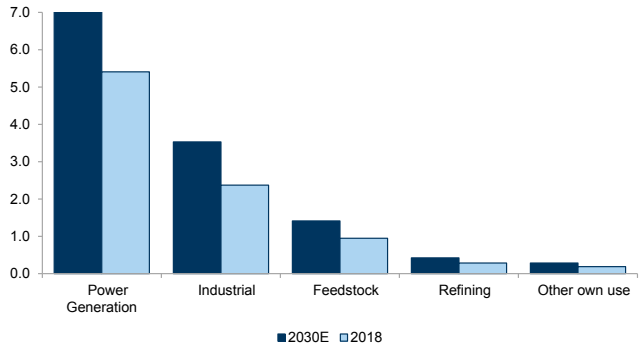
**Includes both natural gas and ethane production

Source: Regional news outlets, Company data, compiled by Goldman Sachs Global Investment Research

We highlight that a sizable part of the incremental gas from the aforementioned growth projects is likely to be allocated to power generation as well as refining and industrial sectors. Saudi's Ministry of Energy (MoE) has plans to steer away from generating electricity using oil liquids (including fuel oil); as such, it aims to primarily use natural gas, which has relatively lower carbon emissions vs oil liquids, as well as renewables, to achieve a cleaner power generation mix by the end of the decade. In addition, the gas and gas liquids produced are likely to be directed towards building Saudi's capabilities in the clean hydrogen/ammonia space and expanding downstream petrochemicals

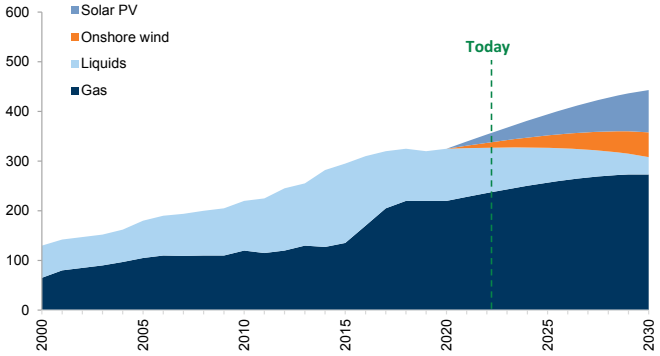
production.

Exhibit 20: We see Saudi's shift towards clean energy by 2030 driving meaningful demand for gas in power generation
Saudi gas demand by end use, bscfd



Source: Company data, Goldman Sachs Global Investment Research

Exhibit 21: Saudi aims to increase the contribution from gas in the energy mix towards 2030 given its lower carbon emissions relative to other hydrocarbon liquids
Saudi's energy mix, in TWh



Source: Arabian Drilling , Rystad, Reuters, Saudi Aramco

Qatar: Leading the next wave of global LNG volume expansion

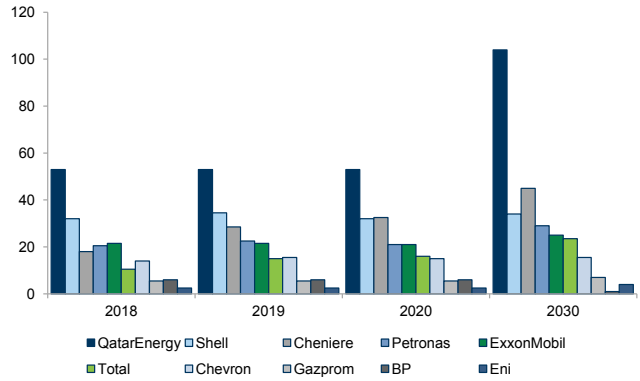
In **Qatar**, QatarEnergy is undertaking an expansion to build the world's largest LNG project, which is expected to increase the country's LNG production by 64% by 2027 (largest LNG expansion globally), from 77mtpa to 126mtpa under two phases: the **North Field East (first phase expansion from 77mtpa to 109mtpa by the end of 2025)** and the **North Field South (second phase expansion from 109mtpa to 126mtpa by 2027).** Partners in the expansionary project include Sinopec, TotalEnergies, Eni, Exxon Mobil, and ConocoPhillips.

QatarEnergy's legacy assets have one of the lowest production costs globally, as shown in Exhibit 24; according to the company, the long-term FOB breakeven price of the NFE expansion is just over US$4/mmBtu, which would continue to place it at the bottom end of the LNG cost curve. The national oil company will also be focused on GHG emissions with an aim to reduce carbon intensity; in this regard, certain elements in the project are expected to be powered by solar energy, while carbon capture and sequestration will also be utilized to reduce scope 1/2 emissions.

As per QatarEnergy, the expansionary **projects are expected to cost around a combined US$50bn**, split US$28.75bn for the NFE project and the remaining for the NFS one.

Exhibit 22: Post the North Field expansion, QE is likely to have a consolidated net production capacity of 104mtpa by 2030, well ahead of its closest peer

Aggregate gas liquefaction capacity net to company's ownership (based on operational, under construction and probable LNG projects), mtpa

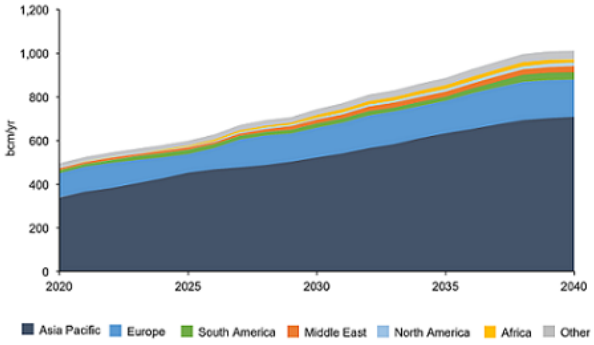


Assumes QE will own 70% of NFE and NFS

Source: QatarEnergy, Wood Mackenzie

Exhibit 23: Demand for LNG is expected to grow at an annualized rate of around 3.6% over 2020-40

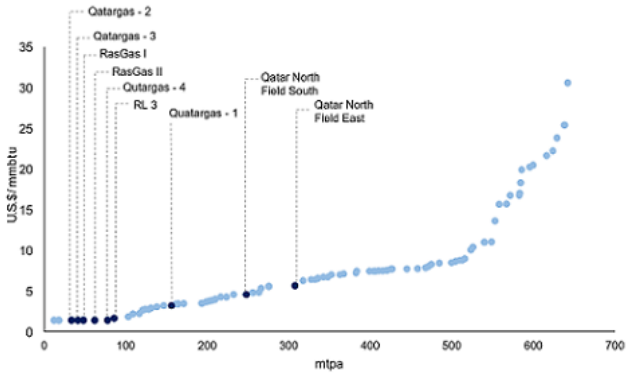
LNG gas demand over 2020-40, bcm/yr



Source: QatarEnergy

Exhibit 24: NFE is likely to be towards the bottom end of the curve in terms of cost...

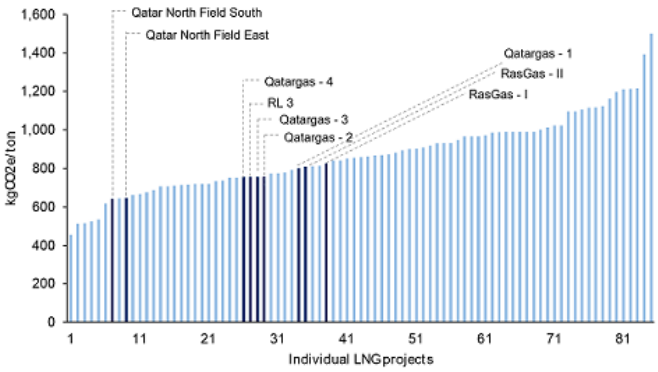
Global LNG cost curve



Source: QatarEnergy

Exhibit 25: ...as well as carbon intensity, largely enabled by solar-powered electricity grids and the use of CCS to reduce scope 1/2 emissions

Global LNG carbon intensity curve



Source: QatarEnergy

The UAE: A growth story in both associated and non-associated gas

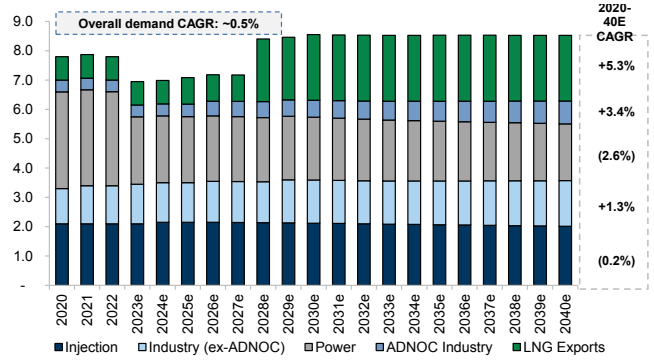
In 2022, ADNOC announced that it aims to spend around **US$135bn** between 2023-27 (inclusive) to accelerate its energy-related growth projects. The national oil company expects this program to result in over 30% growth in associated and non-associated gas production by 2030, mainly via: (1) growing its oil production from 4mbpd to 5mbpd by 2027, which is expected to unlock incremental associated gas from these fields, and (2) developing non-associated gas fields (such as Hail and Ghasha) and exploring new hydrocarbon prospects including sour gas and unconventional sources. **We see scope for around US$32-34bn of capex to be incurred on gas expansion by Abu Dhabi between 2023-30**.

The UAE's target of reaching self-sufficiency in natural gas lies at the core of its growth ambitions in areas such as LNG exports, petrochemicals and clean fuels including hydrogen. As of 2022, demand for natural gas in the UAE stood at nearly c.8bscfd, which predominately arose from power generation, injection, and industrial uses (including ADNOC affiliates). Over the long term, demand for lean gas is expected to grow by +3.4%/1.3% CAGR for ADNOC and non-ADNOC related industrial entities, respectively, between 2020-40 (source: Wood Mackenzie). This is while demand from the power sector is expected to decline by 2.6% over the same period, as the country gradually transitions to renewable energy. LNG exports emerge as a key driver, expected to drive +5.3% CAGR in demand growth through 2040, with a noticeable acceleration post 2027, as shown in Exhibit 26.

In terms of the country's current supply dynamics, the UAE currently relies on imports of around 1.9bscfd from Qatar via the Dolphin project. The Dolphin gas project involves the production of natural gas from Qatar's North Field which is then processed at Ras Laffan industrial City and then transported (as dry gas) by a sub-sea export pipeline to gas-receiving facilities at Taweelah in Abu Dhabi. The gas pipeline carried the first gas shipment from Qatar in 2007 under a 25-year agreement. While this source of natural gas is critical in meeting domestic demand, the UAE aims to ramp up its exploration efforts in extracting incrementally higher production volumes from its proven reserves (seventh largest in the world). The UAE currently has total supply of around c.9bscfd, including the c.2bscfd currently imported from Qatar via the Dolphin pipeline. ADNOC is currently pursuing multiple growth projects, which include: (1) Hail and Ghasha which is targeting 1bscfd of natural gas from its ultra-sour offshore fields, (2) Ruwais Diyab's unconventional resources which have the potential to lift its natural gas production volume by another 1bscfd, and (3) the Shah gas development's planned expansion by 0.4bscfd to 1.85bscfd.

Exhibit 26: Overall demand for lean gas in the UAE is expected to see a 0.5% CAGR through 2040, with growth in LNG exports and industrial demand offsetting a decline in demand from the power sector

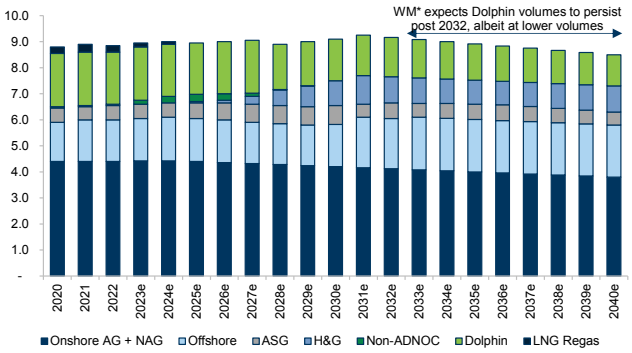
Demand (bscfd) and 2020-40E CAGR %



Source: Company data, Wood Mackenzie

Exhibit 27: The gas supply outlook in the UAE is forecast to remain steady overall through 2040, with a decline in the outer years post the end of the Dolphin agreement

Gas supply outlook (bscfd)



*WM refers to Wood Mackenzie

Source: Company data, Wood Mackenzie

Exhibit 28: Overview of ADNOC gas supply sources (excluding the Dolphin pipeline and non-Abu Dhabi based production)

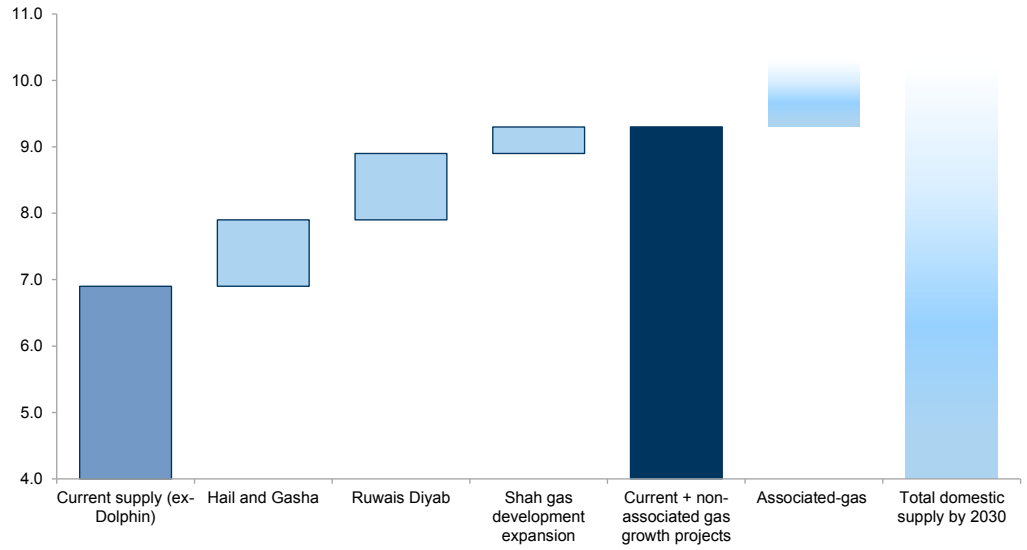
Source	Type	Details
Onshore AG	Associated gas	ADNOC has sole rights to the gas; acreage occupies 1/3 of Abu Dhabi's territory
Onshore NAG	Non-associated gas	Includes Asab and Bab; lean gas is injected at several of Onshore AG and NAG reservoirs
Offshore	Associated and non-associated gas	ASR fields and concessions awarded after the integration of ADMA-OPCO; AG and NAG piped to ADNOC Gas facilities in Das Island, where the gas is distributed between ALNG liquefaction plants and export facilities that transfer volumes to onshore gas processing facilities
ASG	Non-associated gas, sour gas	JV between Occidental Petroleum and ADNOC, comprises the Shah development (Al Hosn)
H&G (Ghasha Concession Area)	Sour gas	Comprises several fields with interests held by ADNOC, Eni, OMV, Wintershall Dea and LUKOIL; outlook includes production from the Dalma project and Hail and Ghasha fields, two large ultra-sour gas fields

Source: Company data, Wood Mackenzie

However, as we highlighted in our GCC Capex Series report, upstream natural gas growth targets cannot be considered without associated sources. We also note the UAE's intention to grow its oil production capacity by 1mbpd by 2027 which would add to the country's potential associated-gas developments as new exploration and discoveries begin to accelerate. The country has made strides in utilizing this source of gas and has already reached a world-class gas-flaring intensity of 0.7 cubic metres/bbl vs a global average of around 4.7 cubic metres/bbl, on par with that of Saudi and Norway. The UAE now has zero routine flaring as a strategic objective.

For the purposes of our calculations for overall investments likely in the UAE, we use the implied capex/boe of other UAE gas field developments from our energy team's Top Projects analysis to which we apply the expected incremental volume growth from conventional gas field projects by 2030; as for unconventional developments, we sensitize capex/boe in a range of 10%-20% vs conventional fields as we adjust for potentially higher technical requirements and other associated costs. In aggregate, we see scope for around c.US$15bn, on average, to be spent on gas field-related development capex. In addition, we assume growth capex required for processing/pipeline/other infrastructure at US$17-19bn, broadly in line with ADNOC Gas's growth capex guidance.

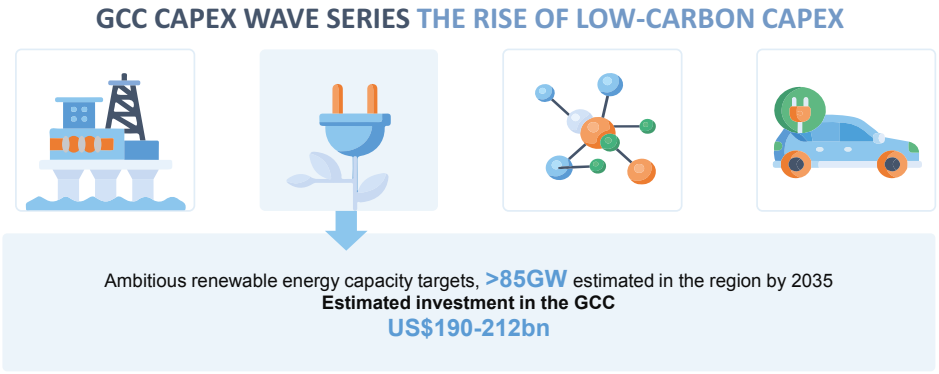
Exhibit 29: We expect the UAE's natural gas supply to meaningfully grow from current levels, mainly as a result of growth from non-associated gas projects, with upside from associated gas
UAE's natural gas supply, bscfd



Source: Company data, Goldman Sachs Global Investment Research, Regional news outlets, Wood Mackenzie

Renewable Energy: Ambitious capacity targets

In tandem with the investment efforts on the upstream energy front, GCC countries have also accelerated investments in clean energy sources, namely renewables and nuclear, to decarbonize the power generation sector. The region's rich non-carbon natural (solar/wind) resources have made renewable electricity generation among the most cost competitive sources globally. As such, the GCC countries have set ambitious targets around capacity installations over the medium to long term, and accelerated their tendering processes over the past 12 to 24 months. We estimate US$190-212bn in investments as likely based on renewable energy capacity installation targets by 2030-35.

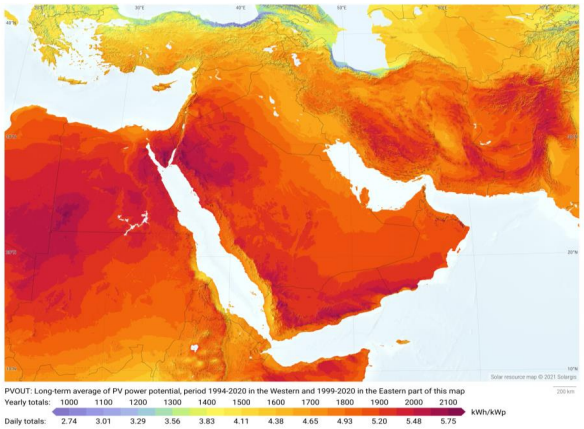


Source: Goldman Sachs Global Investment Research

The GCC region is well positioned geographically to produce low-cost renewable power

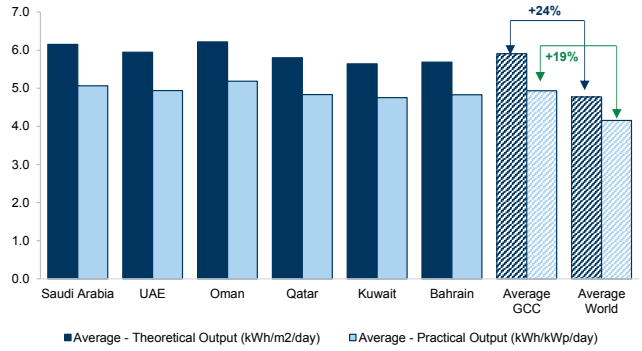
Given the abundance of solar irradiation and natural resources such as wind, GCC countries are well positioned to produce low-cost renewable energy and accelerate decarbonization across carbon-emitting sectors, mainly power generation. Indeed, the GCC region is located in the Global Sunbelt, and is endowed with solar resources that parallel those of North African countries (see Exhibit 30), while parts of Kuwait, Oman and Saudi Arabia's red coast hold significant wind resources with relatively high speeds.

Exhibit 30: The GCC region enjoys high solar irradiation...
Solar PV power production (kWh/kWp), long-term average (1994-2020)



Source: World Bank, Solargis

Exhibit 31: ...resulting in 24%/19% higher theoretical/practical solar PV output for the region vs. the world average
As of March 2020

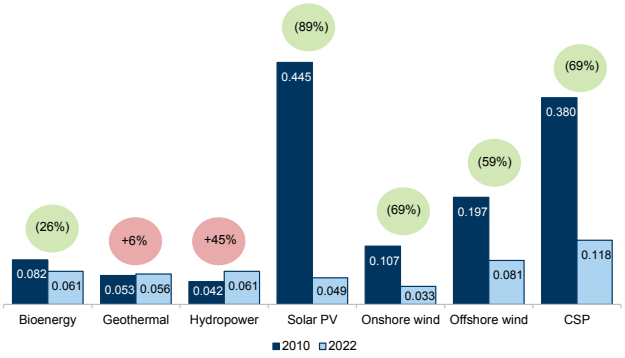


Source: World Bank, Solargis

Additionally, we note that the region has seen increasing cost competitiveness, with some recent solar PV projects achieving one of the lowest LCOEs (Levelized Cost Of Electricity) in the world. Globally, the rise in renewable energy's cost competitiveness has been mostly prevalent in the large-scale grid connected market segment, with access to funding, enhanced technologies and faster rates of deployment all contributing to the decline in the cost of renewable-based utility projects. As per IRENA, despite the increase in costs for equipment and key commodities like steel and polysilicon in 2022 (owing to supply chain challenges), the period between 2010 and 2022 still represents a massive shift in the competitiveness between renewable sources and fossil fuel/nuclear options. As fossil fuel prices remain elevated, policymakers have shifted their focus to energy efficiency as well as solar and wind power, given their relatively short project lead time (2-3 years from financial close to operational stage on average), as a means to reduce economic exposure to hydrocarbons, while also moving towards decarbonization targets.

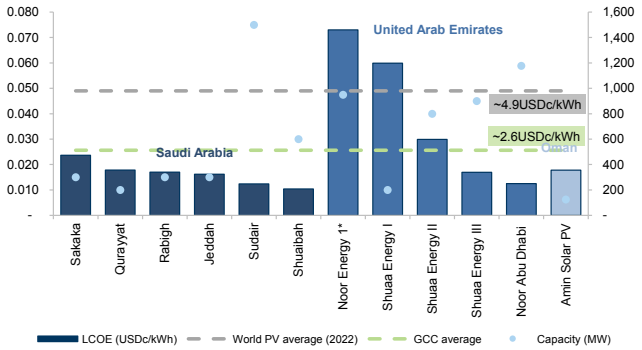
Indeed, the global weighted average LCOE of onshore wind stood at an 85% premium to the lowest cost fossil fuel-based energy in 2010; by 2022, the global weighted average LCOE of new projects fell to a 52% discount, with the drop also significant for offshore wind. Solar PV LCOEs also stood at a 28% discount vs. the cheapest fossil fuel based option, as of 2022, vs. a 670% premium in 2010.

Exhibit 32: Solar PV, onshore wind and CSP have seen a strong decline in average LCOE globally between 2010-22
Global weighted average LCOE of newly commissioned, utility-scale renewable power generation technologies, 2010-22, US$/kWh



Source: IRENA

Exhibit 33: Solar PV projects in the GCC rank competitively on cost when compared to the global weighted average LCOE
Capacity (MW, RHS), levelized cost of energy (LCOE in USDc/kWh, LHS), and global average weighted LCOE for PV (USDc/kWh, 2022)



*Noor Energy 1 is a hybrid project with 950MW in capacity, of which 250MW is solar CSP and rest is solar PV

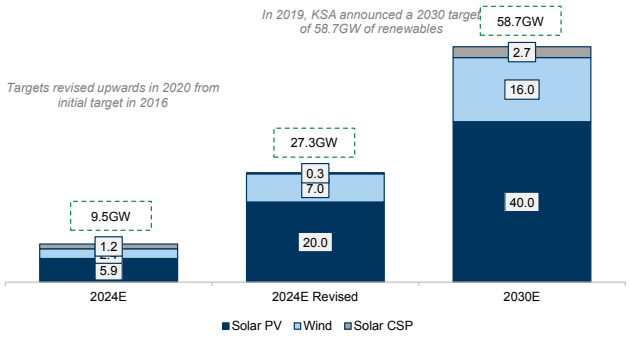
Source: IRENA, ACWA Power, DEWA, Masdar, Oman Power and Water Procurement (PWP), Data compiled by Goldman Sachs Global Investment Research

Saudi Arabia: Targeting >58GW in renewable energy capacity by 2030

As highlighted in our previous GCC Capex Wave report, **Saudi Arabia** aims to generate 50% of its electricity requirements through renewable energy sources (RES) by 2030 through the installation of 58.7GW of solar/wind capacities, in addition to 2-3GW in nuclear capacity, as stated under Vision 2030 and supported by several green initiatives including the National Renewable Energy Program (NREP) and the Renewable Energy Initiative (2017). Within four years of launching these programs, Saudi inaugurated the Sakaka solar PV plant (300MW) and Dumat Al Jandal onshore wind farm (400MW) in 2021, bringing the total operational capacity to 700MW connected to the grid by year-end.

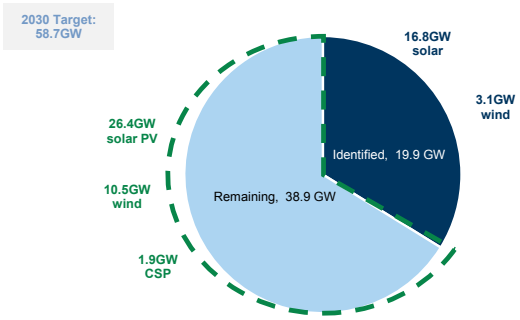
Over the past 12-24 months, the country has engaged in accelerated tendering processes to achieve its renewable energy targets of 27.3GW in installed capacity by 2024, and 58.7GW by 2030, with the latter broken down into: (1) c.40GW in solar PV (photovoltaic, 68%), (2) c.16GW in wind (27%) and (3) c.2.7GW in solar CSP (concentrated solar power, 5%).

Exhibit 34: Saudi's 2024 renewables targets were revised upwards in 2020 from the initial targets set in 2016
Renewable energy targets (GW)



Source: ACWA Power

Exhibit 35: The projects announced so far account for 34% of Saudi's 2030 RE target; we expect the remaining capacity to come mainly in solar PV
Identified capacity additions vs those remaining to reach Saudi's 2030 RE target (GWs)



Source: Vision 2030, Goldman Sachs Global Investment Research

REPDO (Saudi's Renewable Energy Project Development Office) was tasked by the Saudi government to procure 30% of the 58.7GW renewable power target through public tenders, while the remaining 70% will be developed by the PIF via a Strategic Framework Agreement (SFA) signed with ACWA Power. The company and the PIF have already identified 11.5GW to be developed by 2025. Sudair solar PV (1.5GW) is the first project to be developed under the SFA pipeline; it achieved financial close in mid-2021 and moved to the construction phase, with an expected commercial operational date in 4Q2024.

We note that to date there are 19.85GW worth of RE projects in Saudi (as of July 2023), split between completed (c.7%), in execution phase (c.16%) and announced (c.78% or 15.5GW, of which most projects have been tendered so far - see Exhibit 36 below for details). The most recently awarded project is Al Hanaka (bid winners announced on November 7), where Masdar, EDF Renewables and Nesma Company signed a PPA with the SPPC to develop the 1.1GW solar PV plant. Once operational, it is expected that the plant will displace >1.8mn tons of CO2 per annum.

Exhibit 36: List of projects identified in Saudi Arabia
As of July 2023

	Project	Type	Size (MW)	Commissioning Year	Partners
Complete	Sakaka	Solar PV	300	2020	ACWA Power & Others
	Dumat Al Jandal	Wind	400	2021	Masdar & EDF Renewables
	Jeddah	Solar PV	300	2022	Masdar & EDF Renewables, NESA Holding
	Rabigh	Solar PV	300	2023	China Energy Engineering Group (CEEG)
In execution	Qurayyat	Solar PV	200	2024	ACWA Power, Al Babtain, Gulf Investment Corp.
	Al Faisaliyah (Shuaibah)	Solar PV	600	2023	ACWA Power, Al Babtain, Gulf Investment Corp.
	Rafha	Solar PV	20	2024	Tamasuk Holding Company, Alfanar Group, Desert Technologies
	Madinah	Solar PV	50	2024	Al-Balagha, Alfanar Group, Desert Technologies
	Ar-Rass	Solar PV	700	2024	ACWA Power & others
	Yanbu 4 iwp	Solar PV	20	2023	Engie SA, Nesma, Mowah
	Sudair	Solar PV	1,500	2024	ACWA Power, PIF
Announced/ planned	Saad	Solar PV	300	2023	Jinko Power Technology Co
	Shuaibah 2	Solar PV	2,060	2025	ACWA Power, The Water and Electricity Holding Company (Badeel)
	Rabigh 2	Solar PV	300	TBD	ACWA Power
	Layla	Solar PV	80	2024	ACWA Power, Ministry of Energy
	Wadi Al Dawaser	Solar PV	120	TBD	REPDO
	Ar Rass 2	Solar PV	2,000	TBD	ACWA Power, Badeel (PIF owned)
	Saad 2	Solar PV	1,125	TBD	ACWA Power, Badeel (PIF owned)
	Al Kahfah	Solar PV	1,425	TBD	ACWA Power, Badeel (PIF owned)
	NEOM	**Solar PV**	**3,900**	**2026**	**ACWA Power, NEOM, Air Products**
	Yanbu	Wind	700	2026	Saudi Power Procurement
	Al-Ghat	Wind	600	2026	Saudi Power Procurement
	Waad Al Shamal	Wind	500	2026	Saudi Power Procurement
	Yanbu Wind Power Plant	Wind	850	TBD	REDPO
	Al Hanaka	Solar PV	1,100	TBD	Masdar, EDF Renewable, Nesma
	Tabarjal	Solar PV	400	TBD	TBD

Total Capacity Identified (GSe), MW	**19,850**
Solar, % of identified	85%
Wind, % of identified	15%
Complete, % of total	7%
In execution, % of total	16%
Announced, % of total	78%
% identified vs. 2024 target	73%
% identified vs. 2030 target	**34%**

Source: ACWA Power, Masdar, EDF Renewables, PIF, Ministry of Energy, REDPO, compiled by Goldman Sachs Global Investment Research

Furthermore, we note that NEOM itself could require initially up to 20GW in solar energy capacity, with room for more capacity requirements as the mega-project progresses. NEOM's utility subsidiary Enowa appointed a France-based company (Assystem) to conduct pre-development and preliminary design and planning studies for seven planned solar PV projects in the Tabuk and Duba regions in Saudi. This is in line with NEOM's strategy to be 100% powered by RE by 2030; it is also expected to contribute to Saudi's target to reduce its emissions by 278mt of carbon dioxide equivalent annually from 2020 to 2030.

We also note that **Aramco** announced in 2022 its intention to **generate 12GW** in RE by 2030, using the allocation of energy credits from investments to decarbonize power supply across the company's operations, while **SABIC** highlighted that it plans **to use 4GW of RE by 2025** and 12GW by 2030 to reduce scope 2 emissions. In fact, Saudi Aramco Power Company, a subsidiary of Aramco, joined in 2021 a consortium led by ACWA Power to develop the previously mentioned Sudair project, which marks Aramco's first participation in the clean energy program.

Lastly, we highlight that Saudi has **been making strides towards becoming a developer and manufacturer of solar PV equipment**. The Solar PV Cell & Module Manufacturing Plant, established by the King Abdulaziz City for Science and Technology (KACST), is the first factory to produce solar panels and cells in the country, with >35k panels produced locally since its establishment in 2010. Through this plant, Saudi aims

to gradually localize solar PV systems development and manufacturing, create country-specific technical standards to test solar panel reliability, and foster private sector investments in solar tech manufacturing and supply chain. Additionally, as highlighted by Desert Technology (a leading renewable energy solutions company, and the first Saudi company to manufacture and export solar panels), the solar panel market in Saudi is expected to grow at a 30% CAGR up to 2024, supported by investments from international entities, technology transfers to Saudi companies, and improved localization strategies, among other enablers. The company recently signed an MoU with Goldi Solar with the goal of cooperating in the evaluation and development of original equipment for PV Module manufacturing, PV cell production and other technologies, with an aim to localize a sizable part of the renewable energy value chain including R&D and manufacturing.

UAE: Accelerated deployment brings the country a step closer to its targets

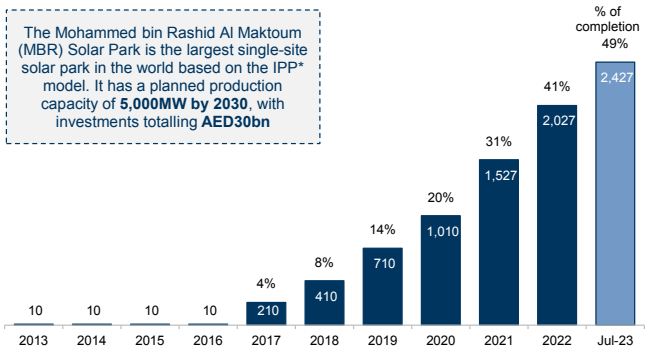
The **UAE** has accelerated its investments in renewable energy over the last decade, a core focus of its decarbonization roadmap. Since 2006, the Abu Dhabi Future Energy Company (Masdar) has become one of the largest renewable energy developers globally (c.20GW in renewable energy capacity), and has led many efforts in the development and installation of solar power in the country over time. Indeed, the company plans to further contribute to the UAE's solar scale-up plans, and aims to invest an additional US$8bn by 2030 in domestic renewable energy projects as part of the Abu Dhabi solar program. We note that Masdar is a JV between ADNOC (24% ownership), Mubadala (33%) and Abu Dhabi National Energy Company (TAQA, 43%) which has the exclusive rights to participate in all future power and water generation projects tendered in Abu Dhabi over the next 10 years with a minimum 40% stake, with all renewable projects to be executed through Masdar.

In addition to Masdar, Emirates Water & Electricity Company (EWEC) announced plans to increase Abu Dhabi's total solar power generation capacity to 7.3GW by 2030 (vs. ~2.0-2.5GW as of July 2023), supplying 60% of Abu Dhabi's total power demand from renewable and clean energy sources by 2035. We note that EWEC operates the Barakah Nuclear Energy Plant (located in Abu Dhabi), designed to supply up to 25% of the UAE's electricity once fully operational by 2030 (5.6GW nameplate capacity), and prevent up to 22mn tons of carbon emission per year (equivalent to removing 4.8mn cars from the roads). The nuclear plant, which obtained a license from the Federal Authority for Nuclear Regulation (FANR), has so far been brought online in phases, with the latest phase 3 inaugurated in 1Q23, bringing the total onstream capacity to ~4.2GW (vs. total nameplate capacity of ~5.6GW).

In Dubai, Dubai Electricity and Water Authority (DEWA), the emirate's sole provider of power and water, is in charge of developing the Mohammed bin Rashid Al Maktoum (MBR) Solar Park, the world's largest single-site solar park based on the IPP (Independent Power Producer) model. The first phase of 10MW became operational in October 2013; 4 years later, Phase 2 of 200MW came online, and since 2017, DEWA has accelerated the deployment of solar PV to reach ~2.4GW (~50% completion rate of the entire project) as of July 2023. This, alongside Masdar and EWEC's solar and nuclear capacity, brings the **total clean energy capacity (including nuclear) online today in the UAE to ~8.0GW**, on our calculations (Exhibit 38).

Overall, the **UAE aims to generate 50% of its electricity from carbon-free sources by 2050, and raised its renewable energy capacity target to 14.2GW by 2030**; in Abu Dhabi, the plan is to install >7GW in solar PV by 2030, while Dubai aims to generate 27% of its energy mix from renewables by 2030, and gradually transition to 100% clean energy by 2050.

Exhibit 37: In Dubai, MBR Solar Park is on track to achieve its target by 2030, with already c.50% of it operational as of July 2023
MBR Solar Park (MW) and % completion



*IPP = Independent Power Producer

Source: Dubai Electricity and Water Authority (DEWA), Mohammed bin Rashid Al Maktoum Solar Park

Beyond solar and nuclear, we note the plans for power generation by waste-to-energy power plants to reduce emissions from landfills. Today, there is one operational 30MW plant in Sharjah, and two additional plants are planned in Dubai (200MW) and Abu Dhabi (70MW), as per the Ministry of Climate Change & Environment (MOCCAE).

Exhibit 38: List of projects identified in the UAE
As of November 2023

	Project	Type	Size (MW)	Commissioning Year	Partners
Operational	Shams Abu Dhabi	Solar PV	100	2013	Masdar, EWEC
	Noor Abu Dhabi	Solar PV	1,177	-	TAQA, Marubeni, JinkoSolar, EWEC
	MBR Phase 1	Solar PV	13	2013	DEWA
	MBR Phase 2	Solar PV	200	2017	DEWA
	Shuaa Energy 2 (MBR Phase 3)	Solar PV/CSP	800	2020	DEWA
	MBR Phase 4 (Noor Energy 1)	Solar PV	950	2023	ACWA Power, Shanghai Electric, ICBC and Abengoa
	Barakah Nuclear Power Plant	Nuclear	4,180	Partial	Emirates Nuclear Energy Corporation (ENEC), EWEC
	Other small PV projects (Abu Dhabi)	Solar PV	25	-	Masdar
	UAE Wind Program	Wind	100	2023 (Partial)	Masdar
	Shuaa Energy 3 (MBR Phase 5)	Solar PV	464	2023 (Partial)	DEWA, ACWA Power, Gulf Investment Corporation
In execution	Al Dhafra Solar Project	Solar PV	2,000	2023	TAQA, Masdar, Jinko Power and EDF Renewables
	Hatta Wind Power Project	Wind	28	-	DEWA
	Shuaa Energy 3 (MBR Phase 5)	Solar PV	436	2024	DEWA. ACWA Power, Gulf Investment Corporation
	MBR Phase 6	Solar PV	1,800	2024	DEWA, Masdar
	Barakah Nuclear Power Plant	Solar PV	2,780	Partial	Emirates Nuclear Energy Corporation (ENEC), EWEC
Announced/planned	Sharjah solar project	Solar PV	60	2024	SNOC, Masdar
	Al Ajban solar project	Solar PV	1,500	-	EWEC
Total Capacity Identified (GSe), MW			**16,613**		
Solar, % of identified			69%		
Nuclear, % of identified			25%		
Wind, % of identified			6%		
Complete, % of total			48%		
In execution, % of total			42%		
Announced, % of total			9%		

Source: Masdar, Dubai Electricity and Water Authority (DEWA), Emirates Water and Electricity Company (EWEC), compiled by Goldman Sachs Global Investment Research

Qatar: Targeting 5GW by 2035, with multiple projects in execution

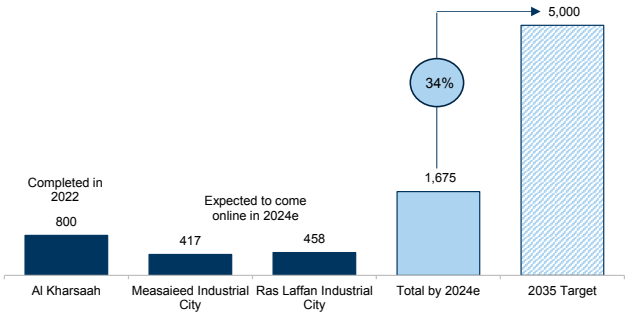
In **Qatar**, the first major solar PV plant, Al Kharsaah (2 phases totaling 800MW), was inaugurated in October 2022 and developed by Siraj Energy (60%) as well as TotalEnergies and Marubeni (40%), a JV between QatarEnergy and Qatar Electricity and Water Company (QEWC). The plant is estimated to cover 10% of Qatar's peak electricity demand, and represents the first major milestone towards the country's target to generate 20% of its electricity from renewable sources by 2030 and install 5GW in renewable energy capacity by 2035. Furthermore, the country announced a US$630mn investment in two additional solar plants in Mesaieed Industrial City (MIC, 417MW) and Ras Laffan Industrial City (RLIC, 458MW), which are expected to have a combined capacity of 880MW and become operational by the end of 2024. These new plants, once completed, would take the country's solar output to 1.67GW, at ~34% of its 2035 target, and would further reduce the carbon intensity of Qatar's LNG and upstream facilities by 35%/25% (by 2035) respectively, compared to the previous targets of 25% and 15% (per QatarEnergy).

In addition to solar power, Qatar is also exploring waste-to-energy solutions to further diversity its energy portfolio. Today, the Domestic Solid Waste Management Centre in Mesaieed generates 50MW of electricity/day, and Qatar announced in June 2022 its plans to further enhance recycling efforts by establishing another waste management center that could be used to generate electricity.

Oman: Advancing towards its renewable generation targets

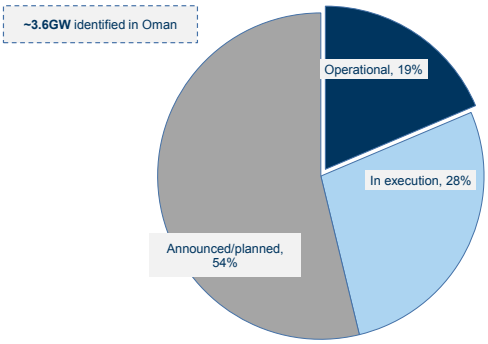
For **Oman**, while domestic natural gas accounted for >95% of electricity generation (as of 2022), the country announced ambitious targets to drive lower emissions and achieve net zero by 2050, including deriving at least 30% of its power from renewable sources by 2030 (with an interim target of 16% by 2025) as stated under Oman Vision 2040 and the National Energy Strategy. The country already has two solar PV projects (Amin and Ibri II, 125MW and 500MW respectively) and a wind farm (Dhofar, 50MW) that are currently online, and it is in the process of constructing two large solar PV projects (Manah I and II IPPs) with a combined capacity of 1GW (500MW each) that are expected to come on stream in 2025. Additionally, we have identified c.2GW of projects planned over the next few years, including two solar PV and five wind projects and one CSP project (see Exhibit 41 for details). This brings the total capacity identified in Oman to **~3.6GW**, of which 19% is operational and the rest is in execution (28%) or being planned (54%).

Exhibit 39: Qatar plans to add two additional solar PV plants by 2024, bringing its total online capacity to c.1.7GW, c.34% of the 2035 target
Solar PV capacity, in MW



Source: QatarEnergy, TotalEnergies

Exhibit 40: We identify ~3.6GW in solar/wind projects in Oman, of which ~46% are currently in operation or in execution phase
% of total capacity identified



Source: Oman Power and Water Procurement (PWP), Zawya, compiled by Goldman Sachs Global Investment Research

Exhibit 41: List of projects identified in Oman
As of November 2023

	Project	Type	Size (MW)	Commissioning Year	Partners
Operational	Amin Solar PV	Solar PV	125	2020	Marubeni, Oman Oil Facilities Development, Bahwan Renewable Energy, Nebras Power
	Ibri II Solar PV	Solar PV	500	2021	ACWA Power, Gulf Investment Corporation (GIC), Alternative Energy Projects Co. (AEPC)
	Dhofar Wind IPP	Wind	50	2019	Masdar
In execution	Manah Solar I IPP	Solar PV	500	2025	EDF Renewables, Korea Western Power
	Manah Solar II IPP	Solar PV	500	2025	Jinko Power Technology, Sembcorp Utilities
Announced/ planned	Duqm Wind IPP	Wind	200	2026	TBC
	Jaalan Bani Bu Ali Wind IPP	Wind	100	2026	TBC
	Suhar Industrial City IPP	Solar PV	100	2025	Madayn, Mubadrah, Solar Wadi
	Dhofar II Wind IPP	Wind	150	2026	TBC
	Dhofar III Wind IPP	Wind	200	2026	TBC
	Duqm Solar CSP	CSP	600	TBC	TBC
	Ras Madrakah Wind IPP	Wind	100	TBC	TBC
	Ibri III Solar IPP	Solar PV	500	2026	TBC

Total Capacity Identified (GSe), MW	**3,625**
Operational, % of identified	19%
In execution, % of identified	28%
Announced, % of identified	54%

Source: Oman Power and Water Procurement (PWP), Masdar, ACWA Power, EDF Renewables, Zawya, compiled by Goldman Sachs Global Investment Research

Kuwait: Deployment to accelerate towards the end of the decade

In **Kuwait**, the existing renewable capacity stands at 200MW today, split between the Shagaya pilot project (combined 70MW, of which 50MW in CSP, 10MW in wind and 10MW in solar PV), KPC (Kuwait Petroleum Company) projects, residential rooftop projects and others. In order to achieve its target of sourcing 15% of energy from renewables sources by 2030, Kuwait is expected to launch the RFQ (Request for Qualification) for multiple phases of the 4GW Shagaya solar project by the end of 2023, with a plan to connect the various phases of the grid by 2027-28. As per the Ministry of Electricity and Water (MEW), Phase 1 of the project will be a 1.1GW solar PV farm, while Phase 2 will comprise a 200MW CSP plant with an estimated five hours of storage capacity. In addition to this project, the government is planning to launch a series of solar projects at utility scale, including rooftop solar projects (5MW and below) and larger projects of around 10-150MW. Overall, we see scope for **5-6GW** in capacity to be connected by 2030, including the 4GW Shagaya project and other distributed solar projects, with potential for further announcements of new projects as the market

gradually becomes more accessible to the private market.

Lastly, **Bahrain** targets to achieve 250MW from renewable sources by 2025, and has recently signed a deal for the Sakhir project, expected to be the country's largest and intended to generate **72MW**, contributing 28% towards the overall renewable target.

Overall, based on the announced targets, we see potential for the GCC to become one of the largest markets globally in terms of renewable energy capacity by 2030, and one of the fastest growing with renewable energy capacity slated to grow at a 42% CAGR through the end of the decade.

Estimating the size of renewable energy investments in the GCC

In **Saudi Arabia**, excluding transmission and distribution costs, we estimate that the installation of the remaining portion of 38.9GW in RE would require **c.US$38-57bn** in investments by 2030, and **US$54-73bn** including the nuclear energy target, based on current investment costs of existing projects in Saudi and the UAE. Beyond adding GWs, investments would also be required for transmission and distribution (T&D), as well as modernizing the grid to allow for the export of energy, which could entail **c.US$38bn** in investments, as per the MoE, bringing the total average investment to **US$120bn**, including **US$17.4bn of announced investments**. We flag that these calculations are based on projects that have achieved financial close and announced GWs and therefore could be subject to change as more projects are announced.

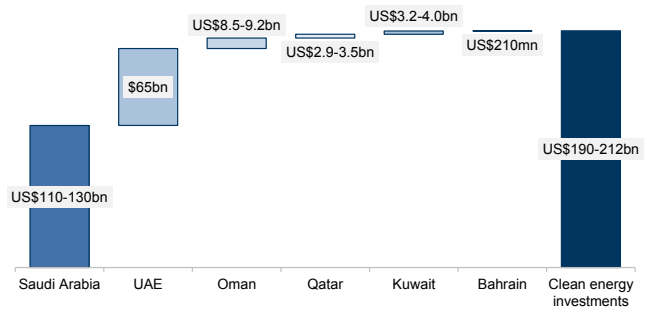
The **UAE** announced plans to invest as much as **US$54bn** on renewable energy over the next seven years to achieve its installation targets; this is while TAQA announced plans to invest **c.US$11bn** in T&D by 2030, which brings total investments that are likely in the country to **c.US$65bn**.

Qatar's estimated electricity generation capacity stands at ~11GW (source: IEA). Based on Qatar's 20% renewable energy target by 2030, and projects that have recently had FID (in Mesaeeid and Ras Laffan), we estimate the need for an additional **US$1.5bn** in solar PV-related investments; we see potential for this to increase to **c.US$2.2-2.6bn** by 2035 as the country aims to achieve 5GW in renewable energy capacity by then (c.47% of electricity generation capacity). We assume an additional c.US$730-870mn in transmission and distribution related investments, bringing our **total estimated spending to US$2.9-3.5bn** by 2035.

In **Oman**, based on the financial close project costs of online renewable energy projects (Amin Solar PV, Ibri II Solar PV and Dhofar Wind IPP), we estimate that the 2.95GW of projects in execution and/or being planned would require **c.US$6-6.2bn** in investments, of which we estimate c.US$3.0bn relates to the proposed Duqm Solar CSP project. We also assume c.US$2.5-3.0bn in transmission and distribution related investments, which brings our total spending forecast to **c.US$8.5-9.2bn** through the end of the decade.

In **Kuwait**, looking at the recent average cost/GW across other GCC countries, we estimate that the installation of c.5-6GW by 2030 could cost **c.US$2.4-3.0bn**, in addition to **US$800mn-1.0bn** in T&D (GSe), bringing the total estimate to **US$3.2-4.0bn** by 2030. Lastly, in **Bahrain**, we estimate a total investment of **c.US$210mn** would be needed to achieve the 250MW target by 2025, inclusive of capex as well as T&D costs.

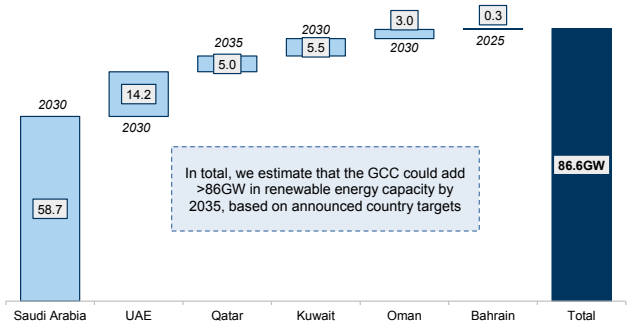
Exhibit 42: We see potential for c.US$190-212bn in renewable/ clean energy related investments in GCC...
US$bn



Qatar by 2035, Bahrain by 2025, rest by 2030

Source: Goldman Sachs Global Investment Research

Exhibit 43: ...this is while we note that the region is expected to add >85GW in RE capacity by 2030-35, based on announced plans and our estimates
GW

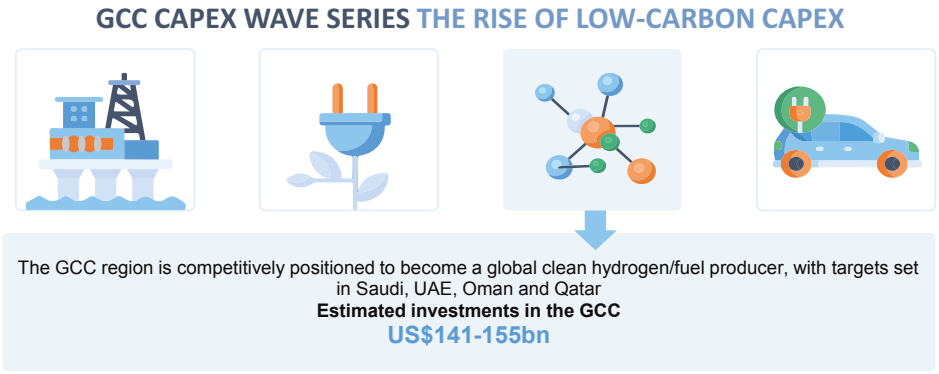


Qatar by 2035, Bahrain by 2025, rest by 2030

Source: Relevant ministries and government entities, Goldman Sachs Global Investment Research

Carbon sequestration and clean fuels: A focus on carbon capture and capitalizing on low-cost positioning

We believe GCC countries are embarking on multiple efforts to expand their clean fuels offerings and decarbonize their existing production processes. This entails a growing focus on investment in clean technologies that would facilitate growth in clean hydrogen, carbon capture, and other sustainable fuels. As highlighted in The Rise of Clean Hydrogen, hydrogen has the potential to decarbonize the most challenging parts of the Carbonomics cost curve, including long-haul transport, steel, chemicals, heating and long-term power storage. We believe the GCC region is competitively positioned to be a global clean hydrogen producer, owing to its relatively low cost of renewable electricity (green hydrogen) and sizable projects on the carbon capture front (blue hydrogen). We expect Saudi, the UAE and Oman to play an active role in rolling out new clean hydrogen capacity by 2030, which should further contribute to the reduction in carbon emissions. We estimate a total of c.US$141-155bn in likely investments in clean tech, hydrogen and fuels efforts through the end of the decade.



Source: Goldman Sachs Global Investment Research

Carbon sequestration: Decarbonizing hard-to-abate sectors and paving the way for blue hydrogen production

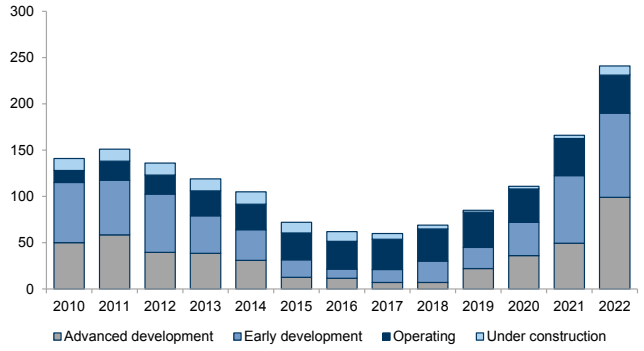
We believe carbon capture is likely to be a key lever in decarbonizing regional economies in the GCC as well as reaching net zero targets. We expect an acceleration in deployment of carbon capture projects towards the end of the decade with sizable investments likely in scaling up capacity to meet national targets set by the GCC countries. The region is embarking on massive growth projects on the carbon capture and storage front with an aim to increase capacity from 4.5mtpa to **25mtpa by 2030** and **more than 65mtpa by 2035, on our calculations**. We expect around **c.US$20bn** to be spent in this area between 2023-30 based on the announced targets, **or c.US$3bn per annum, on average**, with potential for this to scale up to **c.US$8bn pa between 2031-35**.

Carbon capture: A largely under-invested technology coming back after a 'lost decade'

CCUS technologies can be an effective route to global decarbonization for some of the 'harder-to-abate' emission sources: they can be used to significantly reduce emissions from coal and gas power generation, as well as across industrial processes, with emissions characterized as 'harder to abate' in areas such as iron & steel, cement and chemicals. CCUS can also facilitate the production of clean alternative fuels such as blue hydrogen.

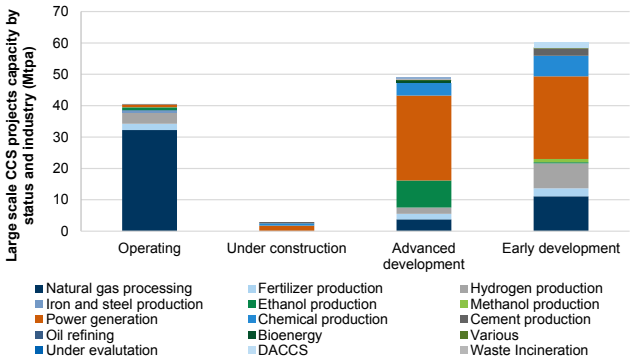
Despite its critical role in any aspirational path to net zero by 2050, carbon capture technologies have been to date largely under-invested. Our European energy team nonetheless expects a return of interest in the technology following a lost decade with more projects under development. Currently, they identify more than 47 large-scale CCS facilities operating globally (mostly in the US, Canada and Norway), with a total capacity of c.40mtpa.

Exhibit 44: The pipeline of large-scale CCS facilities is regaining momentum after a 'lost decade'...
Annual CO2 capture & storage capacity of large-scale CCS facilities, mtpa



Source: Global CCS Institute Status Report 2022

Exhibit 45: ...as more projects in the development stage start to focus on industries with lower CO2 stream concentrations (industrial & power generation as opposed to natural gas processing)
Large-scale CCS projects by status and industry of capture (mtpa, 2021)



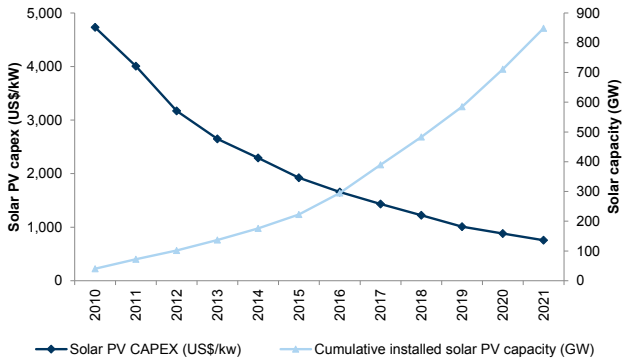
Source: Global CCS Institute, Goldman Sachs Global Investment Research

Cost remains the primary barrier to the deployment of CCS technologies. The incremental costs of capture and the development of transport and storage infrastructure are not sufficiently offset by government and market incentives, albeit efforts have intensified in regions such as Norway (where carbon prices are at the higher end of the global carbon price spectrum) and the US (with the introduction of the 45Q scheme). The cost of individual CCS projects can vary substantially depending on the source of the carbon dioxide to be captured, the distance to the storage site and the characteristics of the storage site, although the cost of capture is typically the largest driver of the total expense and it shows an inverse relation to the concentration of CO_2 in the stream of capture.

Although carbon sequestration has seen a revival in recent years, it **has not yet reached large-scale adoption and economies of scale that traditionally lead to a breakthrough in cost competitiveness**, especially when compared with other CO_2-reducing technologies such as renewables. Despite the key role of sequestration in any scenario of net carbon neutrality, investments in CCS plants over the past decade

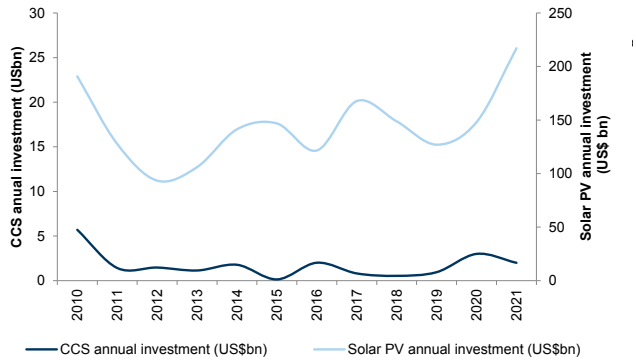
have been <1% of the investments in renewable power. Although we are seeing a clear pick-up in CCS pilot plants after a 'lost decade', we do not yet know where costs could settle if CCS were to attract similar economies of scale as solar and wind. The vast majority of the cost of carbon capture and storage comes from the process of sequestration and is inversely related to the CO_2 concentration in the air stream from which CO_2 is sequestered. The cost curve of CCS therefore follows the availability of CO_2 streams from industrial processes and reaches its highest cost with direct air carbon capture and storage (DACCS), where economics are highly uncertain, with most estimates at US$40-400/ton and only small pilot plants currently active. The importance of DACCS lies in its potential to be almost infinitely scalable and standardized, therefore setting the price of carbon in a net zero emission scenario.

Exhibit 46: Solar PV cost per unit of electricity has fallen 70%+ over the last decade as cumulative solar capacity has increased exponentially...
Solar PV capex (US$/kW) vs. global cumulative solar PV capacity (GW)



Source: Company data, Goldman Sachs Global Investment Research

Exhibit 47: ...while the languishing investment in CCS sequestration technologies has possibly prevented a similar cost improvement
Annual investment in solar PV (LHS) and large-scale CCS (RHS)



Source: Company data, IEA, IRENA, Goldman Sachs Global Investment Research, KAPSARC

CCUS capacity in the GCC to scale up by more than c.14x by 2035E

While the region has historically made some effort in CCUS, the continued decline in costs and new business models have made this route more attractive for several companies in the GCC. Using CCUS, the GCC countries can continue to leverage their rich hydrocarbon resources while accelerating the decarbonization process, especially in hard-to-abate sectors like power generation or end-industries such as petrochemicals, steel, and cement. We believe most of this opportunity could come from the power generation sector, which currently emits around 417 mn tonnes of CO2, or 45% of the region's total footprint (globally, 40% of global emissions come from power generation) (source: IEA). As detailed below, the countries in the region are embarking on massive growth projects on the carbon capture and storage front with an aim to increase **capacity from 4.5mtpa** to more than **65mtpa by 2035, on our calculations.** We expect around **c.US$20bn** to be spent in this area through 2030 based on the announced targets and costs of current projects.

As of 2022, there were around 40 commercial capture facilities in operation globally, capturing more than 45mtpa of carbon (source: Global CCS Institute). The GCC (mainly Saudi, the UAE, and Qatar) accounts for almost 10% of global carbon captured annually with meaningful upside potential as the region embarks on its decarbonization plans and

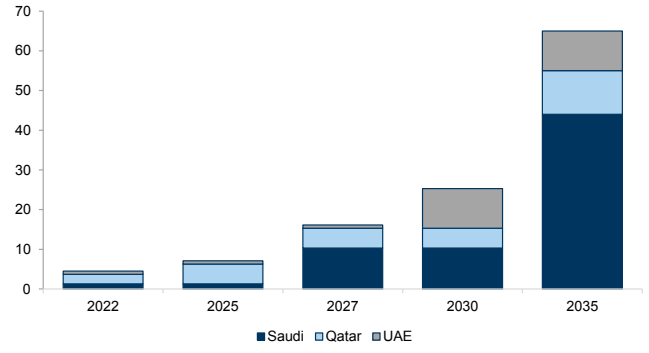
explores clean energy technology options. The region currently has three operational projects spread around Qatar, Saudi, and the UAE, with a total capacity of about c.3.8mtpa of carbon. Saudi currently captures around 0.8mtpa of carbon at the Hawiyah NGLs plant where the carbon has been mainly used to test the viability of enhanced oil recovery at the Uthmaniyah oil field. Abu Dhabi currently captures around 0.8mpta at its Emirates Steel Plant. This is while Qatar Gas operates the largest plant at its Ras Laffan gas liquefaction plant which captures around 2.2mt of carbon annually. In terms of carbon capture and utilization facilities, SABIC currently captures 0.5mtpa of carbon at its Jubail ethylene facility. In Qatar, Qatar Fuel Additive Company also captures 0.2mtpa of carbon for its methanol refinery.

In Saudi, the country aims to grow its carbon capture and storage capacity from **1.3mtpa currently** up to **10.3mtpa by 2027** and around **44mtpa by 2035.** Aramco has signed a joint development agreement with SLB and Linde to establish a carbon capture and storage hub in the Jubail industrial zone, which could potentially store up to 9mn tons of CO2 p.a. by 2027; Aramco is set to contribute 6mn tons, with the rest expected to come from other industrial sources. A CCUS hub allows industrial emitters to share the carbon transport and storage infrastructure, thereby reducing risks and costs while leveraging economies of scale.

In addition, Qatar expects its CCS capacity to grow from **2.4mtpa currently** to around **5mtpa by 2025** and **11mtpa by 2035.** QatarEnergy's North Field East LNG liquefaction project is expected to capture and store around 2.9mtpa of carbon by 2025.

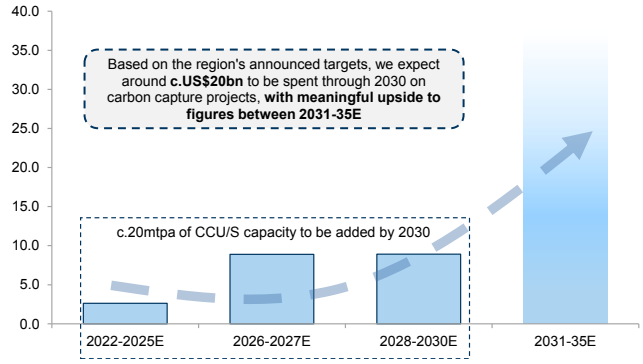
Lastly, the UAE plans to grow its CCS capacity from c.**0.8mtpa currently** to c.**10mtpa by 2030.** ADNOC Group recently announced a final investment decision to develop one of the largest carbon capture projects in MENA at its planned Habshan gas processing plant (which ADNOC Gas will build, operate, and maintain), capturing up to 1.5mtpa of carbon which is expected to be permanently stored in reservoirs through the deployment of closed-loop carbon capture and reinjection technology at the well site. This is while a partnership between Fertiglobe, ADNOC, ADQ, Mitsui, GS Energy, and Ta'ziz is planning to build a world-scale 1mtpa blue ammonia plant in Abu Dhabi, which, on our estimates, could require between c.1.5-1.6mtpa of potential carbon capture capacity. Furthermore, ADNOC's Hail and Gasha conventional gas project is expected to capture 1.5mtpa of carbon while also leveraging clean power from nuclear and renewable sources from the grid. ADNOC is also seeking carbon injection instead of natural gas reinjection to maintain pressure in the oil reservoirs; this way, the national oil company would free up additional gas volumes for the domestic market, which falls in line with the UAE's aim to reach gas self-sufficiency. Overall, we see potential for CCUS capacity in the GCC to scale up by more than 14x by 2035 to 65Mt, 1.3x the UK's target.

Exhibit 48: In line with announced GCC growth targets, CCUS capacity in the region could grow multi-fold to 65mtpa by 2035
CCUS capacity, mtpa



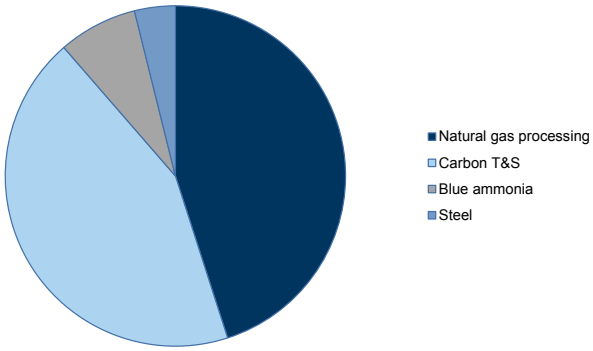
Source: Goldman Sachs Global Investment Research, Company data, Regional news outlets

Exhibit 49: We expect cumulative capex of around c.US$20bn between now and 2030 on carbon capture utilization and/or storage projects
Carbon capture-related capex, US$bn



Source: Company data, Goldman Sachs Global Investment Research, Regional news outlet

Exhibit 50: We expect the majority of future CCUS projects in the GCC to be mainly centered around natural gas processing and carbon transport and storage
Operational and announced CCUS projects in the GCC by sector, split by carbon capacity (mtpa)



Source: IEA, Goldman Sachs Global Investment Research, Global CCS Institute

Technology improvements, scale, and supportive policies could drive further cost reductions

Costs related to CCUS have already begun to show signs of improvements over the last few years. This has been evident in the trend of carbon capture costs of large-scale coal-fired power plants, which have seen almost a 35% reduction from 2014 to 2017, with current announced projects pointing to further reduction over the medium term, per IEA. Moving forward, we believe the combination of continued maturing of the market and the development of technology, economies of scale, and experience in building and operating such facilities should drive further cost reduction and commercialization over time.

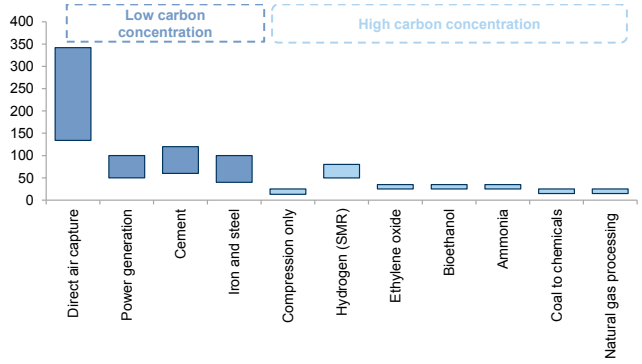
While costs may vary by the sector in which CCUS is being used (direct air capture can be several times higher than single point capture in low carbon concentration sectors such as natural gas processing), we believe the aforementioned drivers of cost

reduction should lead to a similar trend across different applications of CCUS. The variance between different applications lies primarily on the ease of extracting "pure" or highly concentrated carbon streams (such as in ammonia or ethanol production) as opposed to lower concentrated carbon streams (such as in power generation or cement production).

While transport costs vary depending on distances, storage costs will be influenced by volumes and storage conditions. We highlight that storage costs can sometimes be negative should the carbon injected and permanently stored in oilfields lead to enhanced production, thereby generating additional revenues from oil sales.

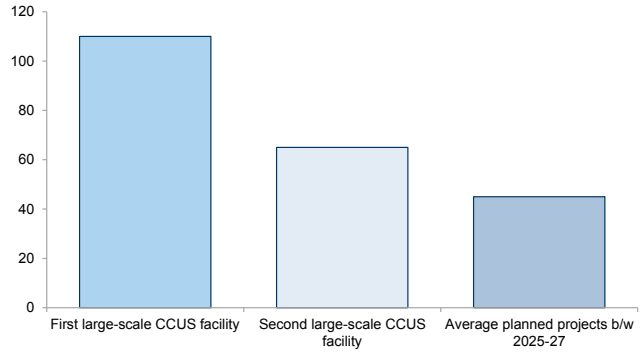
The Inflation Reduction Act (IRA) has been a key enabler of the improving economic feasibility for carbon capture and clean hydrogen projects in the US. Industrial gas producers that already have grey hydrogen production capacity can earn either the 45V or the 45Q by adding carbon capture to their facilities to produce blue hydrogen; OCI's management, which is currently in the process of developing a large-scale blue ammonia plant in Texas, has highlighted that the IRA policy is expected to provide US$85 for every ton of sequestered carbon, which could translate into nearly US$150-160mn in potential credit for this project. Should similar policies continue to roll out across other regions globally, we believe commodity producers (and technology/infrastructure enablers) would have further incentive to expand their exposure to the CCUS space.

Exhibit 51: Carbon capture costs vary widely by carbon source
Levelized cost of carbon capture by sector (2019), US$/t



Source: IEA

Exhibit 52: Cost reductions have already been achieved at large-scale CCUS projects, with further improvements expected as the market expands
Cost of carbon capture from large-scale coal-fired power plants, US$/tonne

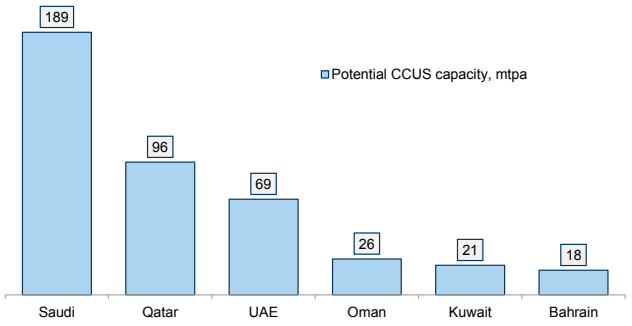


Source: IEA

Power generation driving significant CCUS growth

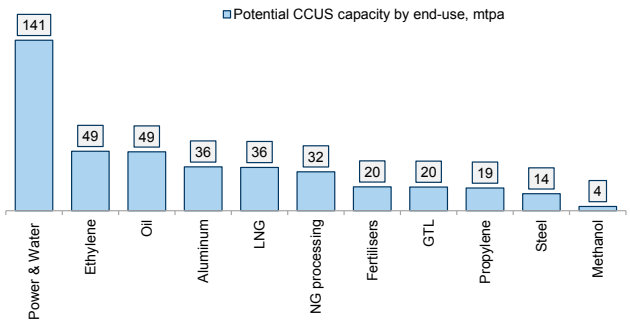
CCUS is one of multiple cost-efficient strategies to tackle emissions from existing coal and gas fired power plants. According to IEA, around one-third of today's coal and gas plants were built only in the last decade; retrofitting such units with CCUS could allow them to continue operations while avoiding costs related to potential early retirement. We highlight that given that the majority of the GCC's carbon is emitted largely from power generation, we expect this sector to be the largest driver for CCUS capacity growth going forward, followed by the production of oil and ethylene.

Exhibit 53: We see CCUS in Saudi, Qatar, and the UAE playing a key role in achieving decarbonization targets with a growing pipeline of projects
Potential CCUS capacity by GCC country, mtpa



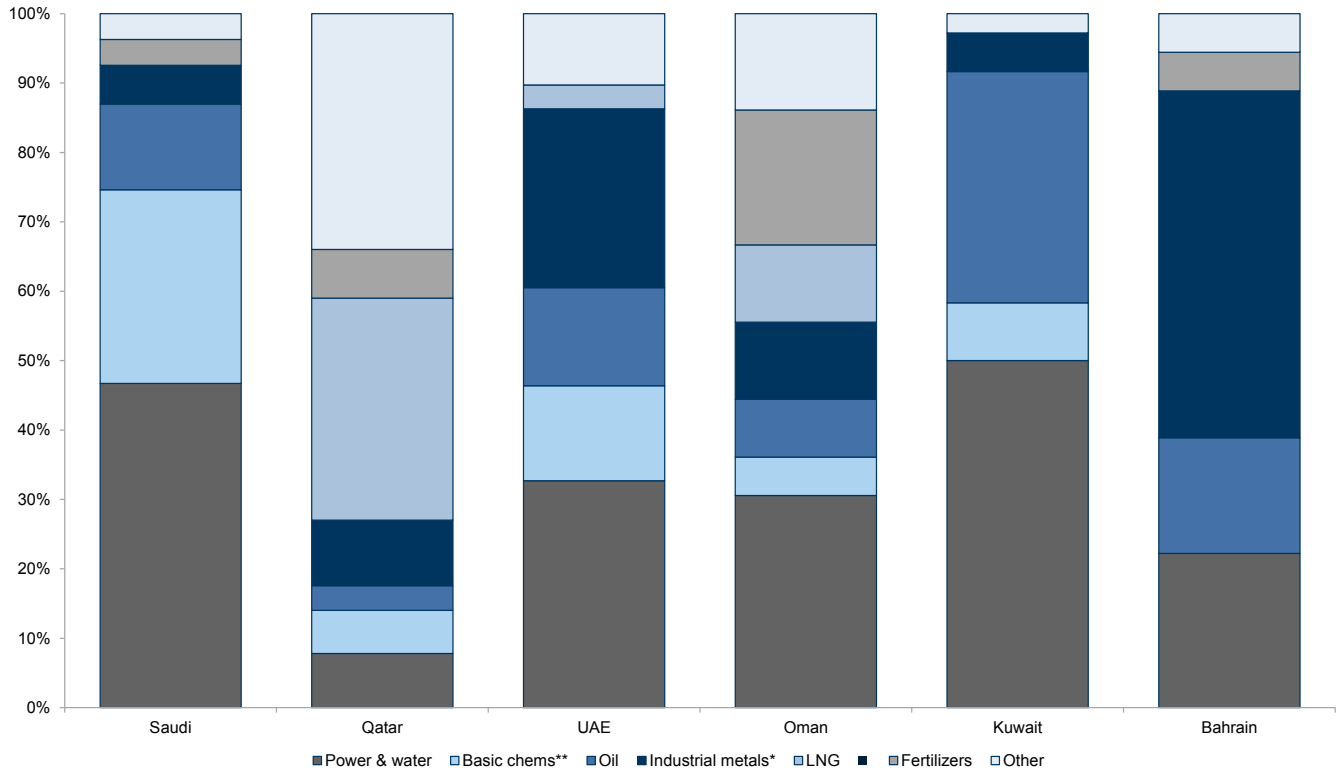
Source: Global CCS Institute Status Report 2022, Data compiled by Goldman Sachs Global Investment Research

Exhibit 54: We see the power sector holding the highest potential for CCUS capacity growth given its meaningful contribution to the region's emissions mix
Potential CCUS capacity in the GCC region by end-use, mtpa



Source: Global CCS Institute Status Report 2022, Data compiled by Goldman Sachs Global Investment Research

Exhibit 55: Power generation, oil, and basic chems are likely to be the key areas for carbon capture growth potential in the GCC region
Carbon capture potential capacity by end-use by GCC country



Other sectors include gas-to-liquid and natural gas processing; *Industrial metals include aluminum and steel; **Basic chems include ethylene, propylene, and methanol

Source: Global CCS Institute Status Report 2022, compiled by Goldman Sachs Global Investment Research

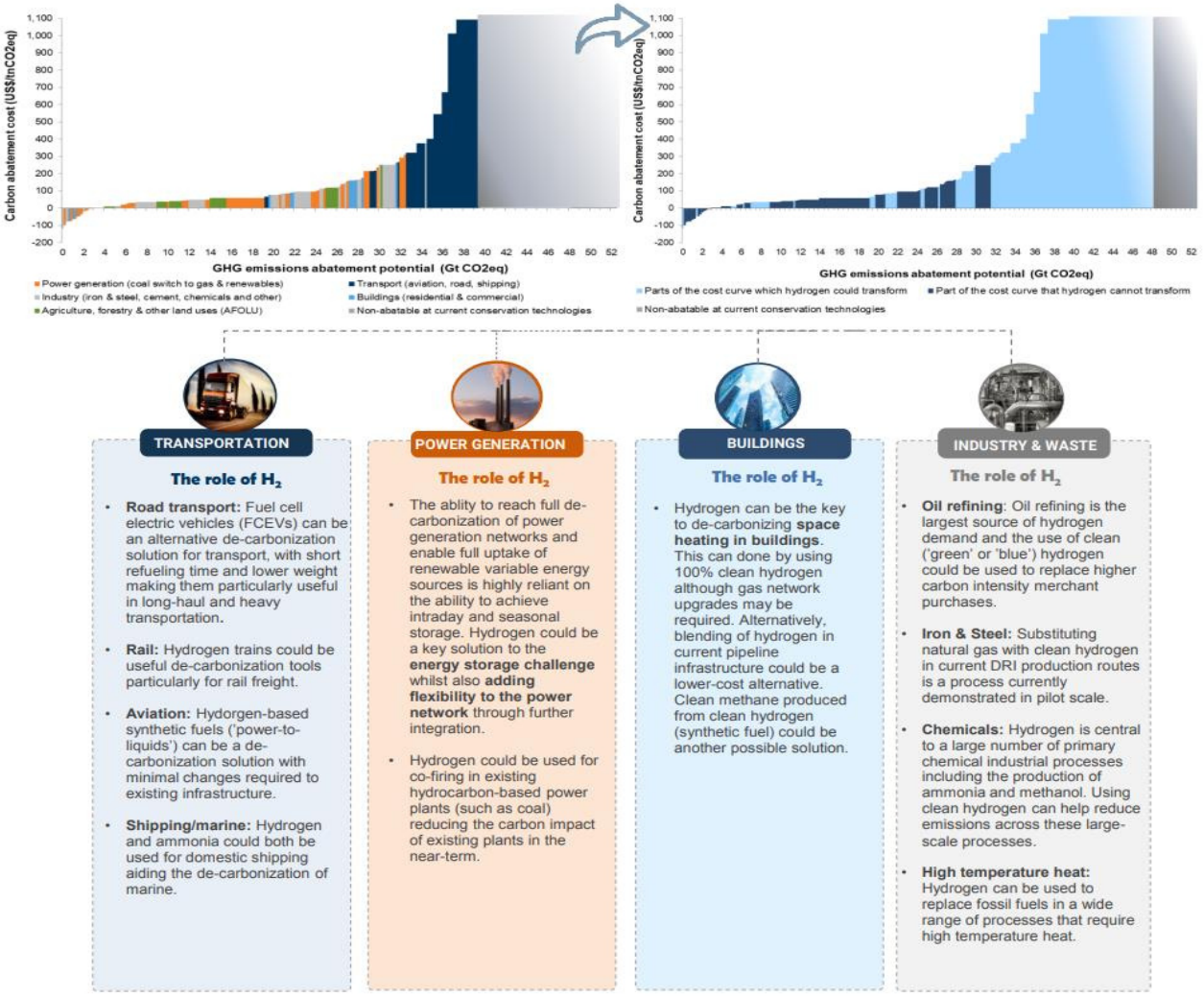
Clean Hydrogen: Higher affordability and low cost of production to facilitate growth in the medium term

Hydrogen screens attractively as a fuel when compared to other conventionally used fuels owing to its low weight (lightest element) and high energy content per unit mass (>2.5x the energy content per unit mass of both natural gas and gasoline). Over the past few years, the intensified focus on decarbonization and climate change solutions has begun to translate into renewed policy action aimed at the wider adoption of clean hydrogen. Our global energy team expects 'green' hydrogen to become the ultimate decarbonization tool with significant longer-term potential.

While 'blue' and 'green' hydrogen are the lowest carbon intensity hydrogen production pathways, both technologies are more costly when compared to traditional hydrocarbon-based 'grey' hydrogen production, based on our energy colleagues' hydrogen cost of production analysis. Our global team estimates the cost of production of green hydrogen can be 1.3-5.5x that of blue hydrogen depending on the price of natural gas and LCOE. Opex improvements driven by improved utilization levels from integrated design optimization, centralization of production, and economies of scale will be key for higher adoption in the future, according to our global energy team. This leads them to conclude that both 'blue' and 'green' hydrogen will form key pillars of the low carbon transition, but with 'blue' facilitating the near- and medium-term transition until 'green' reaches cost parity longer term.

Exhibit 56: Hydrogen has the potential to transform c.45% of the cost curve of decarbonization (45% of global anthropogenic GHG emissions) across four key and highly emitting sectors

Addressing the non-abatable GHG emissions under current large-scale, commercially available technologies



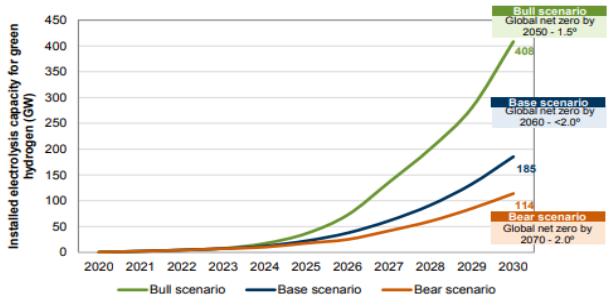
Source: Goldman Sachs Global Investment Research

In the GCC, on our analysis, Saudi Arabia, the UAE and Oman are set to play an active role in rolling out new clean hydrogen facilities by 2030 as part of their decarbonization plans. All three countries have announced either nation-wide hydrogen strategies or production targets to be achieved over the medium term, with sizable investments in renewable energy and/or CCUS already in place. Supported by their access to low-cost renewable electricity, strategic location and abundant natural gas, the GCC markets can substantially capitalize on the clean hydrogen economy and become one of the largest exporters of the low-emission fuel in the form of ammonia through the end of the decade and beyond (by 2040-50), in our view.

Status of the global hydrogen economy

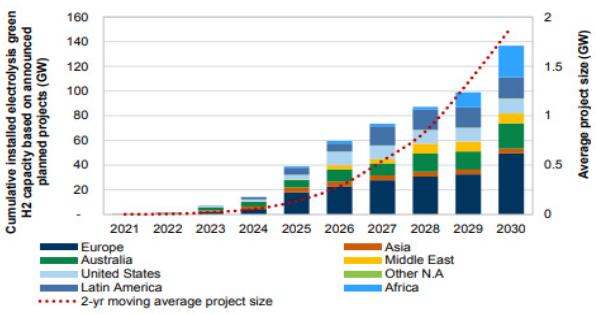
While an increasing number of countries are showing strong interest in scaling up the use of low-emission hydrogen to decarbonize industrial sectors, the pace of project roll-out has differed from one region to another. As suggested by our energy team in their latest note, in the US, the hydrogen industry is still waiting for the US Treasury Department to issue some important clarifications on the IRA (Inflation Reduction Act) tax credits, mainly in relation to the calculation of carbon intensity and local content requirement. The team believes that this uncertainty has been holding back major new projects from moving forward in the US, as no major contracts were announced during 3Q23; this is while medium-scale projects in Europe continue to progress, especially for refineries and bio-refineries. The slower project roll-out momentum is reflected in our colleagues' GS electrolyzer demand forecasts, where their base case demand for installed electrolysis capacity decreased by c.36% for 2024-30E. This, however, still suggests robust growth in capacity installation by the end of the decade to ~185GW globally (Exhibit 57). We flag that globally, per the IEA and based on the current project pipeline, 12Mt of low-emission hydrogen could be exported annually by 2030, of which 2.4Mt is planned to come online by 2026; this is while the global green hydrogen market could potentially grow to almost €10tn by 2050 for the utilities industry alone, as discussed in our EMEA utilities team's Green Hydrogen report.

Exhibit 57: The slower-than-anticipated project roll-out, especially in the US, is reflected in our energy team's global GS electrolyser demand forecasts
Global installed green H2 electrolysis capacity, GW



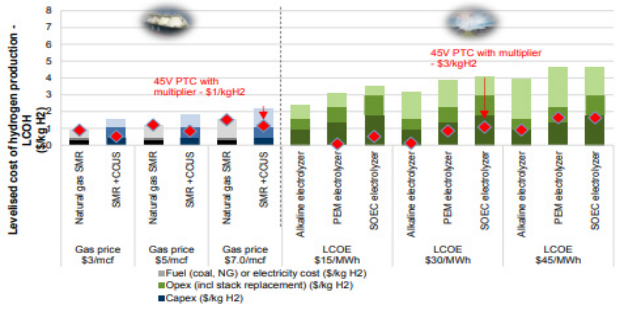
Source: Goldman Sachs Global Investment Research, IEA

Exhibit 58: Our energy team's volume estimate for green hydrogen by 2030 is 3x last year's and fully supported by announced projects, and does not yet reflect the full upside from the US IRA...
Cumulative installed electrolysis capacity



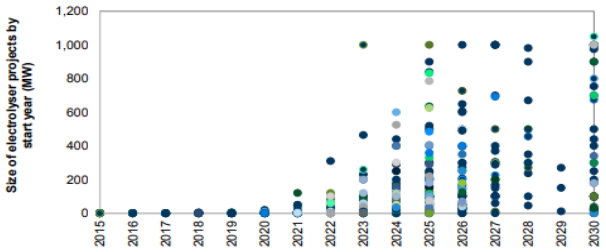
Source: Goldman Sachs Global Investment Research, IEA

Exhibit 59: ...which has transformed the economics of green hydrogen in North America
Levelized cost of hydrogen production - LCOH ($/kgH2)



Source: Goldman Sachs Global Investment Research

Exhibit 60: This is while hydrogen projects are becoming larger in scale
Size of electrolyzer projects by project start year (MW)



Source: IEA, compiled by Goldman Sachs Global Investment Research

The hydrogen supply chain: Transport, storage and distribution

- **Storage:** Hydrogen is primarily stored in a gaseous or liquid form in storage tanks at present. Ammonia offers a liquid alternative for hydrogen storage (ammonia is formed from hydrogen combined with nitrogen through a reversible reaction), yet energy losses during conversion and re-conversion add to costs and reduce overall energy efficiency. The need for large-scale storage solutions that enable longer-term storage is increasingly important for hydrogen to become more widely employed, including storage in refueling stations, export terminals and energy storage in power generation.
- **Long-distance transmission:** Transporting hydrogen fuel over longer distances typically occurs in four distinct forms: hydrogen, ammonia, liquid organic hydrogen carriers (LOHCs such as toluene) and liquefied hydrogen. Ammonia and LOHCs (such as toluene) for hydrogen transport by ship are the preferred options, as per industry players, as they do not require cryogenic conditions for liquefaction or handling, and are among the commonly used methods for long-distance transport today.
- **Local distribution:** Pipelines are commonly used for local distribution of hydrogen. The distinct properties of hydrogen, however, require low-pressure distribution pipes made from polyethylene or fibre-reinforced polymers. Hydrogen blending in existing gas infrastructure is currently being tested in several countries globally, even beyond the current upper threshold of 5%-6%. New dedicated distribution pipelines are likely to be a material infrastructure challenge.

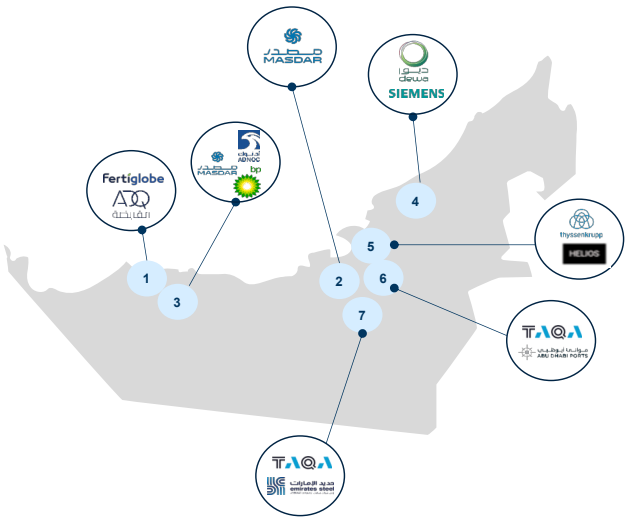
UAE: Scaling up clean hydrogen production

As part of its updated Energy Strategy, the **UAE** announced plans to scale up clean hydrogen production to 1.4Mt/year by 2031, and 15Mtpa by 2050. Of the 2031 target, Masdar expects to produce 1Mt/year in green hydrogen with the remaining 0.4Mt/year in blue hydrogen. We highlight that the UAE already has a pilot project online as part of the Mohammed bin Rashid Al Maktoum (MBR) Solar Park in Dubai, producing 20kg of green hydrogen per hour. The UAE is also working on establishing a hydrogen R&D center, as well as two hydrogen oases (i.e. production hubs) by 2031 located in Ruwais and in the Khalifa Industrial Zone Abu Dhabi (KIZAD); by 2050, the UAE plans to have a total of five hubs or oases, per the strategy.

In addition to the production targets, the UAE is also targeting a 25% market share of low carbon hydrogen and derivatives in key import markets by 2030, with an initial focus on Japan, South Korea, India and Europe, while also pursuing export opportunities in other markets. As per the Ministry of Energy, the country is well on track to achieve its 2031 target, with more than 7 projects already planned with a total capacity of 0.5Mt/year in clean hydrogen.

We note that there are several key government and private entities supporting the country's strategic hydrogen roadmap. For instance, TAQA (Abu Dhabi National Energy Company), Mubadala and ADNOC have invested in Masdar, which is spearheading the efforts of the country on the hydrogen front. **Masdar** has signed partnerships with several local and international players including Siemens Energy, TotalEnergies, Etihad Airways, Lufthansa and Khalifa University to explore the hydrogen potential; it also signed a US$5bn strategic alliance with ENGIE to develop green hydrogen plants. Beyond Masdar, **Emirates Steel** has also announced plans to invest in low-carbon hydrogen (Exhibit 61) as it seeks to reduce its Scope 1 & 2 emissions by 40% by 2030 (vs. 2019 baseline), while **Fertiglobe** announced a clean ammonia execution roadmap in 2021. The company is (1) partnering with Masdar and ENGIE to develop a 200MW renewable hydrogen facility to produce ammonia by 2025, and (2) pursuing a large-scale blue ammonia (deploying carbon capture and storage, or CCS, technologies) production facility in Abu Dhabi with a capacity of 1Mt/year, expected to come online post 2025, both of which are forecast to contribute to the company's aim to reduce absolute Scope 1 & 2 emissions by 20% by 2030 (vs. 2019 baseline) and achieve carbon neutrality by 2050, in line with the broader country ambitions.

Exhibit 61: List of hydrogen projects in the UAE



1 **Taziz (ADNOC and ADQ) Ruwais chemical hub**
- 1 mtpa blue ammonia production plant located in the Taziz chemicals hub
- 0.2 mtpa H2 equivalent

2 **Masdar - Demonstration plant**
- Green H2 initially for road transport, then expanding to e-kerosene synthesis and ocean shipping
- Demonstration scale

3 **UAE Hydrogen Hub**
- Initial development of 1 GW of low carbon hydrogen together with BP as well as pioneering decarbonized air corridors between the UK and UAE
- 0.1 - 0.2 mtpa H2 equivalent capacity

4 **Mohammed bin Rashid Al Maktoum Solar Park**
- First solar PV and green hydrogen producing facility in the MENA region
- Demonstration scale

5 **Abu Dhabi, Khalifa Industrial Zone**
- Final goal of 200 kt of ammonia and 40 kt of H2 annual production
- 0.1 mtpa H2 equivalent capacity

6 **TAQA and Abu Dhabi Ports**
- Green ammonia project under discussion powered by a 2 GW solar based electrolyzer facility
- 0.1 mtpa H2 equivalent capacity

7 **TAQA and Emirates Steel**
- MOU for large scale green hydrogen project enabling the production of first green steel in the MENA region

Source: UAE Energy Strategy 2031

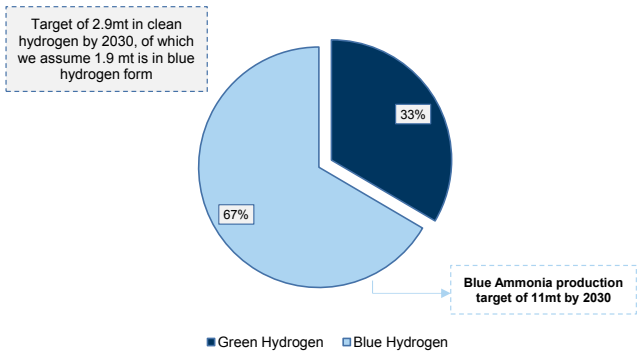
Saudi Arabia: Developing the world's largest green hydrogen plant in NEOM

In **Saudi Arabia**, we see several trends shaping the future hydrogen economy: (1) there is an increasing focus on decarbonization as a driving force behind clean tech investments; (2) the rise of renewable energy sources should facilitate the production of green hydrogen (e.g. NEOM Green Hydrogen); and (3) we believe Saudi is strategically positioned to export blue/green ammonia (as ammonia offers an alternative for hydrogen storage, allowing transportation over longer distances) given the existing infrastructure (e.g. Aramco's CCUS capabilities) and the competitive production cost positioning.

In terms of government targets, Saudi has announced its aim to produce 2.9mtpa of 'clean' hydrogen by 2030 (scaling it up to 4.0mtpa by 2035), and 11mt of blue ammonia. Based on the latter, we assume c.1.9mtpa of blue hydrogen production and the remaining c.1mtpa by 2030 to come in green form.

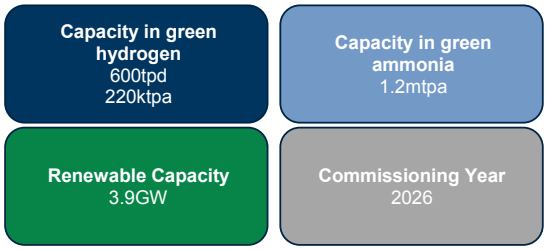
The country is currently developing the world's first large-scale green hydrogen plant in the smart city NEOM in an equal JV between NEOM, Air Products and ACWA Power, with a capacity of 600tpd (c.220ktpa) and a project cost of US$8.4bn. The plant will be powered by 3.9GW of renewable power, and when commissioned in 2026, would produce up to 1.2mtpa of green ammonia, mitigating the impact of 5mn metric tonnes of CO2 emissions per year.

Exhibit 62: Saudi is targeting 2.9mt of clean hydrogen by 2030, of which we assume c.1.9mt would come in blue hydrogen form
% of total



Source: Argus Media

Exhibit 63: NEOM Green Hydrogen key details



Source: ACWA Power

NEOM Green Hydrogen Company (NGHC) execution update

NEOM Green Hydrogen Company (NGHC) announced in May 2023 that it has **reached financial close** following the signing of financial agreements with 23 local, regional and international banks and investment firms, covering the project cost for the integrated green hydrogen project to be established in NEOM, Saudi Arabia.

The company also **concluded the EPC** (engineering, procurement and construction) **agreement** with Air Products, valued at US$6.7bn. The total financing was constructed on a non-recourse project finance basis, with US$1.5bn provided by the National Development Fund (on behalf of the National Infrastructure Fund), US$1.25bn by the Saudi Industrial Development Fund, and the rest from a consortium of financiers.

As a reference, the project's total cost has been revised to US$8.4bn (vs. US$5.0bn initially), with the increase accounting for inflation.

As per Air Products, land preparation for the project has been completed, along with 30% of the engineering phase, with all major sub-contracts awarded. Additionally, the contract covers the construction of a 2.93GW solar power generation plant, a 1.37GW wind power farm, and a 400MW battery energy storage system, with a power transmission network extending 190km. Furthermore, the project comprises 2GW of electrolyzers (to be supplied by German-based ThyssenKrupp) to produce 650t of H2/day, and air separation units to produce nitrogen for the conversion of hydrogen into 1.2mn tons of ammonia/year.

Oman: On the path to becoming a sizable clean hydrogen hub

Our analysis indicates that **Oman** is also well positioned to produce sizable quantities of renewable hydrogen at competitive pricing, and become one of the region's largest exporters by 2030, while simultaneously increasing the share of renewable energy sources in the power generation mix. Indeed, Oman aims to produce **at least 1Mt/year** of green hydrogen **by 2030,** scaling it up to **3.25-3.75Mt/year by 2040** and **7.5-8.5Mt/year by 2050**, as per Oman's green hydrogen strategy announced in October 2022. According to the IEA, meeting Oman's 2040 hydrogen target would represent **80% of LNG exports** today, while achieving the 2050 target would imply almost **double the level.**

We note that Oman benefits from high-quality renewable resources (solar PV/onshore wind mainly), its strategic location which gives it access to hydrogen import markets such as Japan and Europe, as well as experience in handling and exporting LNG and ammonia; this is while it can capitalize on sizable land areas suitable for large-scale project developments and its existing fossil fuel infrastructure that could be repurposed for hydrogen and hydrogen-based fuels.

Based on the IEA project database, an estimated 1,500km2 of land has been set aside for development, with potential to produce 1Mt/year of green hydrogen; this compares to 50,000km2 of land area identified as suitable for long-term project developments, translating into 25Mt of hydrogen production potential, ~3x the size of Oman's 2050 target. We highlight in Exhibit 64 the list of planned hydrogen and ammonia projects in Oman by the end of the decade, most of which are currently undergoing feasibility studies. The earliest projects expected to come online in 2024 are Salalah H2 and Sohar port Phase I, with a production capacity of 69kt H2 and 6kt H2 per year, respectively, with the former's production planned to be export-oriented.

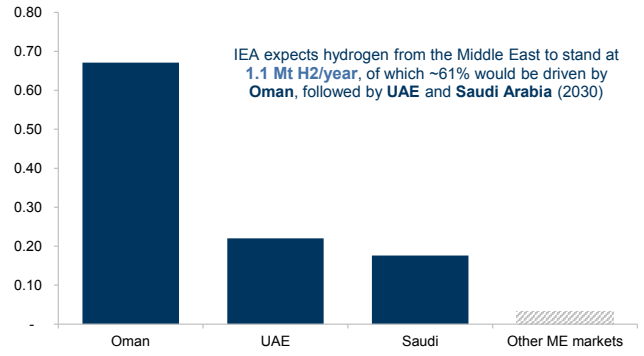
Exhibit 64: Planned hydrogen and ammonia projects in Oman (2022-30)

Name of project	Status	Date online	Electrolysis capacity (MW)	Production capacity (kt H2) per year	Export oriented (Y/N)
Hyport@Duqm, Phase I	Feasibility study	2026	500	87	Yes
Green Hydrogen Oman (GEO) project	Feasibility study	2028	4,700	809	Yes
Salalah H2	Feasibility study	2024	400	69	Yes
Sohar port, Phase I	Concept	2024	35	6	No
Green Hydrogen and Chemicals SPC	Feasibility study	2026	300	52	Yes
Sur Hydrogen Cluster	Pre-feasibility study	2030	1,300	225	No
H2Oman (Dhofar)	Concept	2030	1,040	180	Yes
BP alternative Energy Investments Limited - Duqm	Feasibility study	2030	-	150	No
BP alternative Energy Investments Limited - Dhofar	Feasibility study	2030	-	150	No

Source: IEA

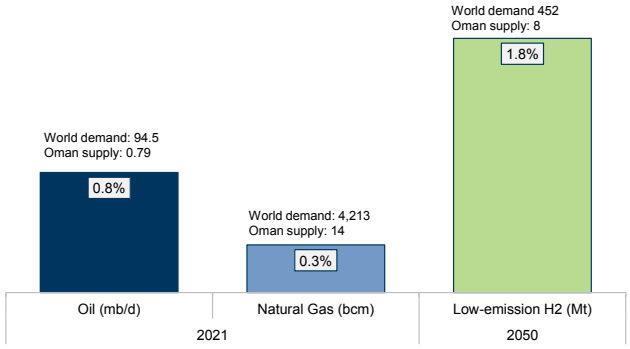
Exhibit 65: Oman is expected to be the largest Middle Eastern producer of renewable hydrogen by 2030, followed by the UAE and Saudi Arabia

Export volumes for hydrogen in the Middle East based on planned projects, 2030



Source: IEA

Exhibit 66: Comparison of Oman's share of the world's oil and natural gas demand in 2021 vs. the share of the world's low-emission hydrogen demand in the IEA's Net Zero by 2050 scenario



Source: IEA

We highlight that Hydrogen Oman (Hydrom), a subsidiary of Energy Development Oman, recently signed (June 2023) **three agreements** to grant the first green hydrogen blocks, with a value exceeding US$20bn. Cumulatively, the projects are expected to yield a total production capacity of 0.5mn tons of renewable hydrogen per annum from 12GW of renewable energy capacity at three sites within the Al Wusta governorate. As per the announcement, the first project was launched through a public auction in 2022, and was won by a consortium of Copenhagen Infrastructure Partners, Blue Power Partners and Al Khadra (a subsidiary of Hund Bahwan Group in Oman). The consortium is expected to generate around 200kt per annum of renewable energy, from 4.5GW of renewable energy capacity, to be used in green steel plants located in the port of Duqm. The second project was signed with BP Oman to develop a green hydrogen plant for ammonia production and export, with a forecast capacity of 150Kt per annum using 3.5GW in renewable energy capacity. Lastly, the third project was signed with a consortium including Oman's OQ, Oman Shell, EnerTech (Kuwait), InterContinental Energy and Golden Wellspring Wealth for Trading, and is likely to produce 150Kt per annum of green hydrogen from 4GW of RE capacity.

Furthermore, we note that beyond the planned hydrogen production projects, Oman is also investing in building the needed infrastructure for hydrogen exports, capitalizing on its existing ports and experience in exporting LNG. We highlight five key current and planned handling points across Oman's main ports listed in Exhibit 67, with the largest ones in Duqm and Salalah. At Duqm, there are plans to develop hydrogen and ammonia facilities that are able to handle 1.2Mt of renewable ammonia and 0.87Mt of green hydrogen, while at Salalah, there are plans to expand the renewable ammonia facilities to cater to 1Mt of additional capacity.

We note that building additional renewable capacity remains pivotal to realizing Oman's hydrogen targets. As per the IEA, ~50TWh of electricity would be required to meet its 2030 hydrogen target, already larger than the current size of the electricity market in Oman; as a reference, the country aims to increase renewable energy to 20% of the power mix by 2030 (10TWh), rising to up to 39% by 2040. Based on the current projects

in planning and under development highlighted previously, the bid prices for utility solar PV and wind suggest an already competitive renewable market vs. natural gas prices in Oman. This is while renewables and the domestic use of green hydrogen could reduce the need for natural gas in the country, with potential for total annual gas savings to reach up to 3bcm by 2030, of which ~50% could be achieved by replacing 20% of natural gas used in power generation with renewable sources, and the rest achieved by replacing fossil fuel hydrogen in the refining industry (per the IEA). Reducing natural gas consumption in power by ~3bcm/year could lower Oman's total CO2 emissions by 7MtCO2 (~7% of baseline emissions by 2030), per IEA estimates.

Exhibit 67: Current and planned handling in Oman's main ports

Port	Current handling	Current capacity (Mt)	Planned handling	Planned renewable H2 and NH3 capacity (Mt)
Duqm	Existing refinery	0.28	Developing hydrogen and ammonia facilities	1.2MT of ammonia and 0.87MT of hydrogen
Sohar	Existing ammonia, urea and methanol facilities	0.19	-	-
	Existing refinery	0.16		
Salalah	Existing methanol and ammonia facilities	0.25	Developing renewable ammonia facility	1MT of ammonia
Sur	Existing ammonia and urea facilities	0.20	-	-
Muscat	Existing refinery	0.02	-	-

H2=hydrogen, NH3=ammonia

Source: IEA

We note that the combined clean hydrogen production target of the UAE, Saudi Arabia and Oman stands at >50% of that announced by Europe by 2030.

Lastly, while **Qatar** has announced sizable plans for carbon capture as highlighted in earlier sections (with a target to sequester as much as 11mn tons of CO2 by 2035), the country has not yet set clear clean hydrogen production ambitions. QatarEnergy, however, has announced the signing of agreements with Industries Qatar to develop a 1.2Mt/year US$1bn blue ammonia plant, which is expected to become operational in 1Q26. Germany-based ThyssenKrupp AG and Greece-based Consolidated Contractors Co. have been awarded a contract for the blue ammonia plant (Ammonia-7), per QatarEnergy.

Estimating the size of clean hydrogen investments in the GCC

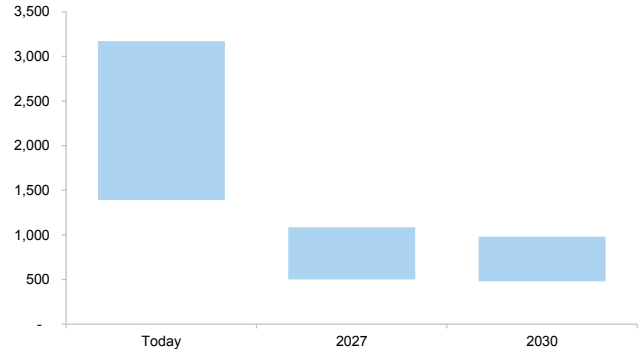
There are two main components that are needed to produce green, electrolytic hydrogen: electrolyzers and electricity. Today, the cost of an electrolyzer ranges between **US$1,400/kW to US$1,770/kW**, inclusive of equipment, gas treatment, plant balancing, and EPC costs, per the IEA. As more electrolyzer capacity is built and rolled out by 2030, the costs are expected to decline considerably benefiting from manufacturing scale, as well as technological advancement and innovation. Indeed, the relationship between deployment and the decline in equipment cost has been seen historically for other technologies such as solar PV, where PV module costs fell by ~90% between 2010 and 2021 to <US$0.5/W, a result of the massive increase in cumulative installed capacity from <8GW to ~500GW over the same period.

The installed capacity for electrolyzers is set to increase from 0.5GW in 2021 to 35GW in 2024 and 134GW by 2030 (source: IEA); as a result, the capital cost of these electrolyzers is expected to decline by 68-72% by 2030e, to ~US$440-500/kW, as highlighted in Exhibit 68.

Additionally, access to low-cost, low-emission electricity creates a meaningful advantage in producing economically competitive green hydrogen. For instance, reducing the cost of electricity from US$35/MWh to US$25/MWh is forecast to reduce the levelized cost of hydrogen (LCOH) by c.30% to ~US$1.9/kg by 2030 (per the IEA).

Exhibit 68: As a result of electrolyzer capacity expansion through 2030, the capital cost is expected to decline by 64%-67% by 2027, and by 68%-72% by 2030

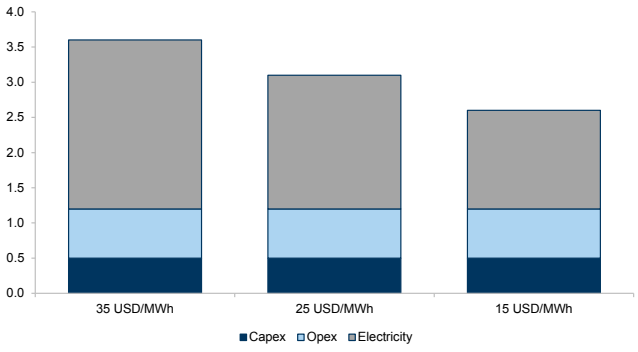
Evolution of electrolyzer capital costs based on global project pipeline, 2027 and 2030; US$/kW



Source: IEA

Exhibit 69: As per the IEA, access to low-cost, low-emission electricity is a significant advantage for competitive production of hydrogen

Production cost variations for renewable hydrogen as a function of electricity cost, 2030; US$/MWh



Following assumptions were used for 2030: Technical lifetime 25 years; electrolyzer efficiency: 69%; CAPEX US$ 320/kWe, annual OPEX 3% of CAPEX, Solar PV capacity factor 29%

Source: IEA

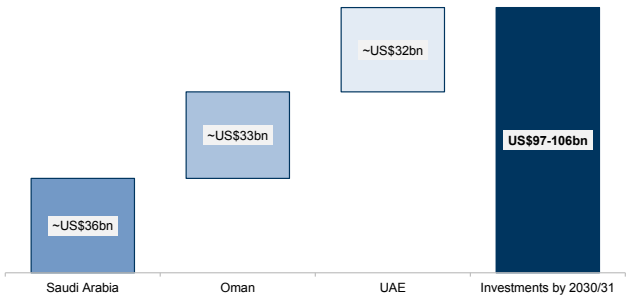
In **Saudi Arabia**, as we highlighted in our previous GCC Capex Wave note, we estimate between **US$33bn-39bn** in investments related to blue/green hydrogen production, in line with the country's planned investments of **c.US$36bn** in clean hydrogen by 2030.

In **Oman**, the current project pipeline suggests the need to build sizable renewable energy and electrolyzer capacity; as per the government, the cumulative investment needs by 2030 could stand at **~US$33bn**, of which **~US$20bn** would be required for renewable energy dedicated for the production of green hydrogen, and **~US$13bn** for

electrolysis and ammonia conversion by 2030. Looking beyond 2050, the government has estimated that a cumulative investment of US$140bn by 2050 would be required to achieve the target of 7.5-8.5Mt/year in green hydrogen production, which comes as incremental to the US$190bn estimated in cumulative investments needed to achieve the country's National Strategy for an Orderly Transition to Net Zero.

In the **UAE**, in line with our estimates for clean hydrogen investments in Saudi and announced spending targets in Oman, we estimate that **~US$30.8-33.5bn** in investments would be required to produce 1.4Mt of clean hydrogen by 2031, of which 1Mt would be in green hydrogen (~US$29.1-31.5bn, GSe) and the rest in blue form (~US$1.7-2.0bn, GSe).

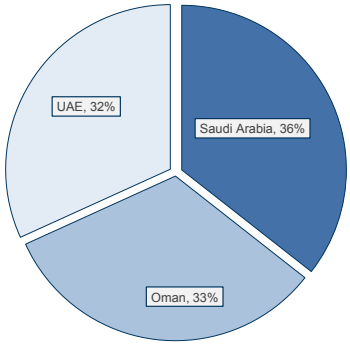
Exhibit 70: We estimate that clean hydrogen investments in the GCC could reach US$97-106bn by 2030/31, based on our estimates and country targets...
US$bn



Estimates for Saudi and the UAE are averages

Source: Goldman Sachs Global Investment Research

Exhibit 71: ...with investments almost equally split between Saudi Arabia, Oman and Qatar
% of total investments



Source: Goldman Sachs Global Investment Research

Clean Fuels: Investing in ammonia and sustainable aviation fuels

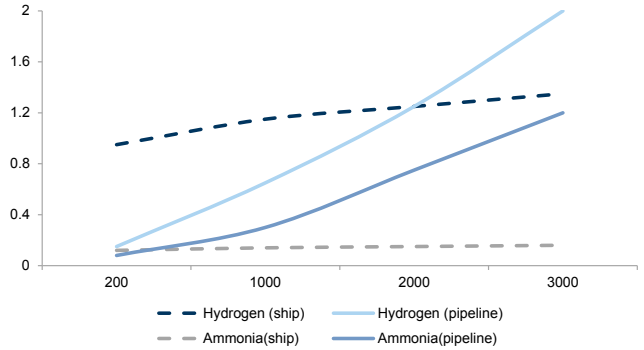
Clean Ammonia: A growing interest in ammonia as a hydrogen carrier

Ammonia and LOHCs (such as toluene) are the preferred options (as per industry players) as they do not require cryogenic conditions for liquefaction or handling. In addition, they are two of the most commonly used methods for long-distance transport today. Indeed, using ammonia as a hydrogen carrier could be advantageous from different perspectives. First of all, ammonia has a high energy density which makes it ideal for hydrogen storage. Second, ammonia's supply chain is already well-established globally and it can be transported over large distances with good economics.

Additionally, we note that there is a growing interest in ammonia in the transportation sector, both as a shipping and marine fuel, owing to its zero-sulphur content, which results in lower emissions of particulates and improved air quality, and ensures compliance with IMO standards/targets. In addition, ammonia is an ideal fuel alternative if produced via renewable power. Several projects are currently testing the use of ammonia as a marine fuel. Yara is planning to supply a retrofitted North Sea supply vessel with ammonia as a marine fuel by 2024. In addition, a cross-industry consortium of Japanese companies (including Mitsui and Itochu) is considering launching ammonia-fuelled commercial vessels and developing ammonia supply infrastructure in Japan to provide the shipping industry with an alternative, lower-carbon marine fuel.

Indeed, even as a fuel for power generation, demand for ammonia is gaining global attraction. Japan recently announced that it will target consuming around 5mn t/y of ammonia by 2030 and 30mn t/y by 2050 as a way to reduce its carbon emissions. In addition, it expects two co-firing units (ammonia along with coal) to enter commercial phase of production by 2025-26 and could consume 500,000t-1mn t /year of ammonia, as per Argus.

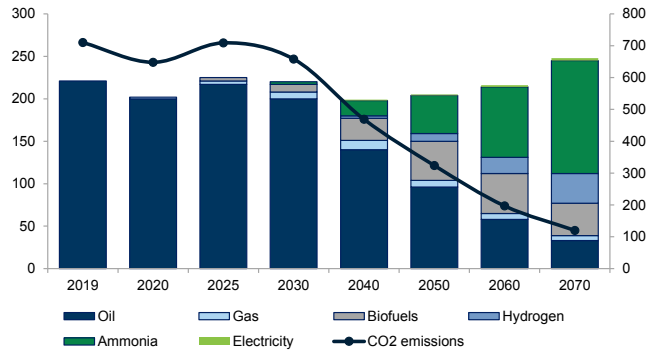
Exhibit 72: Shipping hydrogen via ammonia is the most cost-efficient method for long distances
Landed cost of hydrogen (US$/kg), vs distance travelled (km)



Costs include both the transport and storage required

Source: The Royal Society

Exhibit 73: Developments across global energy consumption point to a promising demand trajectory for ammonia
Energy consumption by fuel (in mt) and carbon emissions (secondary/in mt)



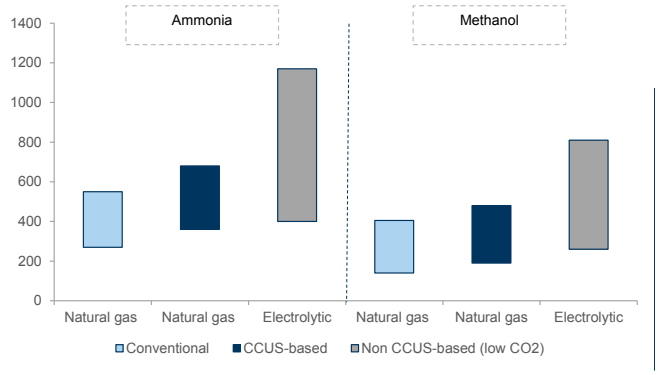
Source: IEA

Blue/green ammonia cost curve to flatten over time

As highlighted previously, ammonia is regarded as one of the most preferred means to transport hydrogen. While green/blue ammonia economics remain disadvantaged compared to fossil fuel-based alternatives, we could see future scenarios where technology improvements and adequate carbon taxes potentially improve its overall demand. We believe the GCC has the potential to be one of the lowest-cost producers as the following three factors drive the cost curve lower: 1) **lower opex** (on the back of cheaper renewable electricity input), 2) **electrolyzer cost improvement**, and 3) a **potential carbon tax**.

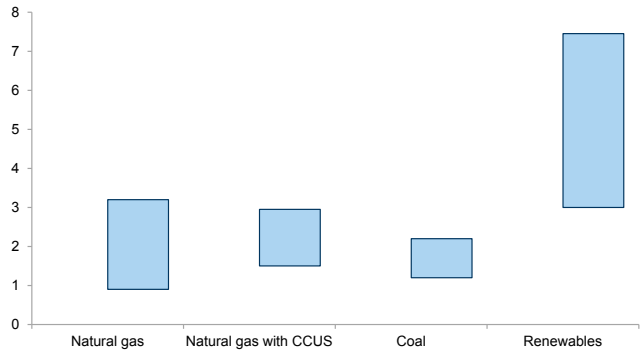
Green ammonia's cost curve is mainly driven by green hydrogen's economics, as it accounts for c.65%-80% of total production costs. The cost of green hydrogen (and thus green ammonia) is thus likely to be mainly favorable for low-cost renewable electricity producers such as those in the GCC.

Exhibit 74: Cash cost of producing ammonia/methanol using existing technologies
Cost range (US$/t)



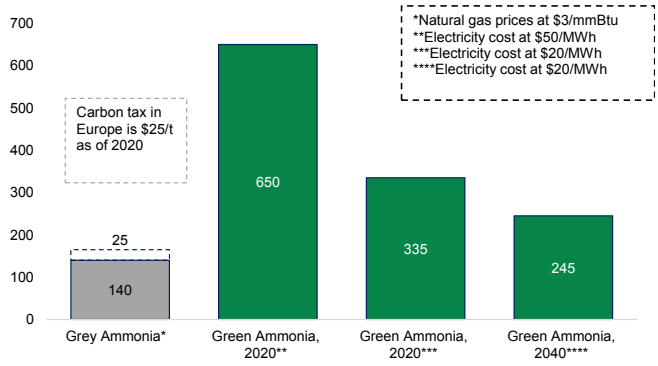
Source: IEA

Exhibit 75: Further cost improvements are needed in renewable power generation before the switch to electrolyzers for hydrogen production
Cost range of producing hydrogen per source (US$/kg)



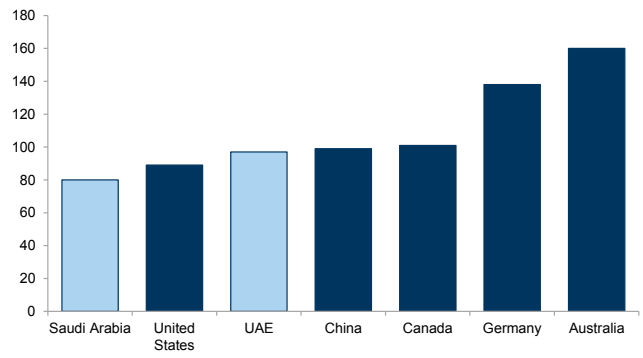
Source: IEA

Exhibit 76: A wide OPEX difference between green and grey plants (even post carbon tax) poses a challenge for wide adoption
Ammonia plant cash costs (US$/t)



Source: Argus

Exhibit 77: Saudi and the UAE lag behind other countries in terms of avoided CO2 cost (2017), implying more room for potential growth of CCUS technologies in the region
Cost of CO2 avoided per location (USD/tonne)

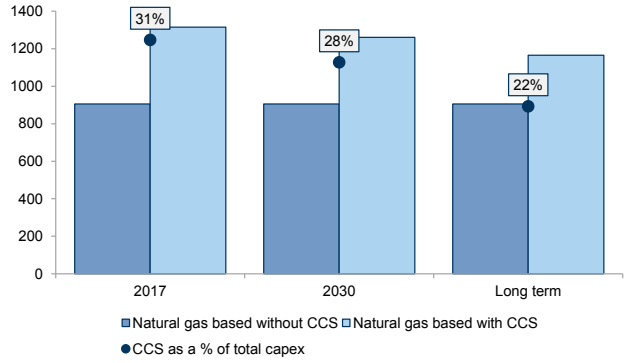


Source: Global CCS Institute

The main capex component for **blue ammonia plants** is the CCUS technology associated with blue hydrogen production (main feedstock for blue ammonia). According to IEA, CCUS accounts for c.30% of total blue ammonia capex, but it could decline over time on technological improvements, as shown in Exhibit 78. Furthermore, blue ammonia represents a more economically realistic, short-term solution to reducing emissions as it currently costs less on average to set up and operate than the green alternative.

Regions with cheap natural gas, as in the Middle East (fixed at US$1.25/mmBtu in Saudi), could be among the most competitive ones in terms of producing blue ammonia. We believe that blue ammonia's cost parity with grey ammonia could be reached in the near term should we see any further improvements in CCUS costs or an adequate application of carbon taxes. As previously mentioned, CO2 that is captured in the process can be recycled and used for enhanced oil recovery and methanol production.

Exhibit 78: Blue ammonia capex should decline with time on the back of advancements in carbon capture technology, per IEA
Capex for ammonia unit (US$/ton of ammonia)

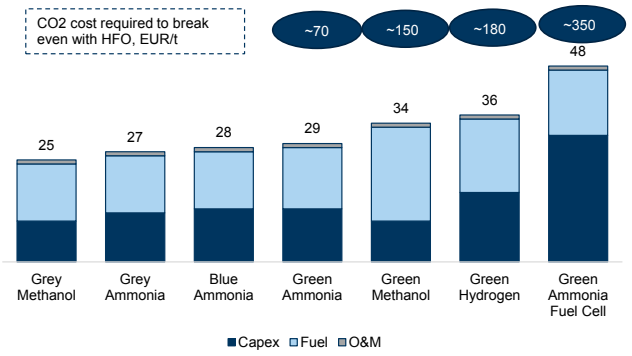


Source: IEA

Crucial steps to achieving cost parity: carbon tax and avoiding cracking

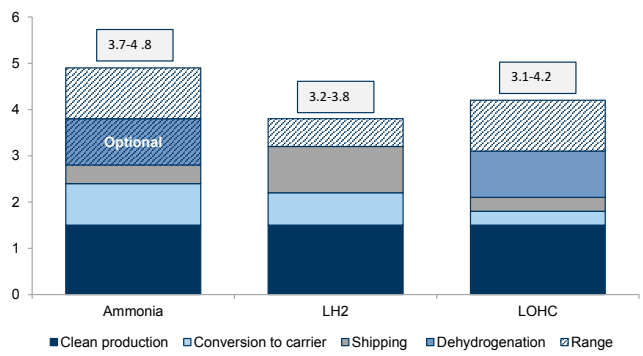
Carbon emission taxes could greatly influence the breakeven economics of grey/green hydrogen. While hurdles to using green fuels remain higher production costs and insufficient renewable capacity, a carbon cost of about <US$50/tCO2e by 2030 could lead to a breakeven for renewable hydrogen between 2028-34, depending on the region's resources, as per Hydrogen Council. Green ammonia also becomes particularly attractive if used directly as a feedstock as it eliminates the need of dehydrogenation (or cracking to convert into hydrogen) and significant associated costs, as shown below in Exhibit 80. Such end-uses could be in areas such as fertilizers, shipping fuel, and co-firing/ammonia combustion for power generation.

Exhibit 79: OCI believes that when carbon taxes reach >EUR70/t, green shipping could reach cost parity with carbon-emitting fuels
Cost of container ship and bunkering location in the Middle East from 2030E (€ mn per annum)



Source: Company data

Exhibit 80: Green ammonia could potentially be the cheapest hydrogen carrier if used directly as a feedstock
Cost of green hydrogen shipped from Saudi to Rotterdam (in US$/kg)



Source: Hydrogen Council

Blue and green ammonia projects identified in the GCC

In the GCC, we highlight several announcements and projects currently in design and/or execution phase as the countries continue to move ahead on the energy transition path. In the **UAE**, Fertiglobe signed an agreement with TA'ZIZ for the former to join the world-scale blue ammonia production project at TA'ZIZ in Ruwais, Abu Dhabi, expected to come online by 2025 and with a 1mtpa low carbon ammonia capacity. The company announced in 2Q23 that it expects the final investment decision (FID) to be concluded in the coming months, and it is making progress with its other projects, including commencing the Front End Engineering Design (FEED) process for its green hydrogen to ammonia project in the UAE.

Additionally, the country's Khalifa Industrial Zone Abu Dhabi (KZIAD, owned by Abu Dhabi Ports) announced plans to build a **c.US$1bn** green ammonia facility in the free zone, targeting regional and international markets. The plant is expected to produce 200mt of green ammonia (produced from 40kmt of hydrogen), to be powered by an 800MW solar power plant.

In **Saudi Arabia**, SABIC Agri-Nutrients and Aramco announced the world's first commercial accredited low-carbon 25kmt shipment of blue ammonia to South Korea, reflecting a milestone in both companies' journey toward carbon neutrality and low-carbon fuel investments. Saudi Arabia Mining Company (Maaden) also announced in November 2022 that it exported its first blue ammonia shipment of 25kt to South Korea; it also shipped 25kt of blue ammonia to China in May 2023. As of YE22, around 138kt of the company's blue ammonia has been accredited by TUV Rheinland. Additionally, Sipchem announced in September that it had received approval from the Ministry of Energy for feedstock allocation to set up a blue ammonia plant with a 1.2mtpa capacity.

Qatar more recently (July 2023) unveiled QatarEnergy's plans to build the world's largest blue ammonia plant, with an annual production capacity of c.1.2mn tons, expected to come online in 1Q26. The cost of the project, called Ammonia-7, is **c.US$1.06bn**, as announced by Industries Qatar (IQCD). The project will be located in Mesaieed Industrial City (MIC), and will be operated by QAFCO (Qatar Fertiliser Company) as part of its integrated facility. Additionally, it has a strategic partnership with QERS (QatarEnergy Renewable Solutions) for expanding blue ammonia, whereby QERS will (1) develop and manage integrated CCS facilities, (2) supply more than 35MW of renewable electricity to the Ammonia-7 project from its solar PV power plant in MIC currently under construction, (3) develop and lead the process for certifying the product produced by the Ammonia-7 facility as blue ammonia, and (4) be the sole off-taker and marketer of the entire blue ammonia produced by the new facility.

Lastly, in **Oman**, a project to produce 220ktpa of green hydrogen and 1.2mtpa of green ammonia was awarded by Hydrom (Hydrogen Oman) to a consortium including South Korea's POSCO and France's Engie. The **c.US$7bn** project is set to be located in Duqm region, and other companies involved include Samsung Engineering, Korea Southern Power, Korea East-West Power and PTTEP (Thailand's government-run petroleum exploration and production company).

With the announcements made so far, we highlight **c.US$9-10bn** of blue/green

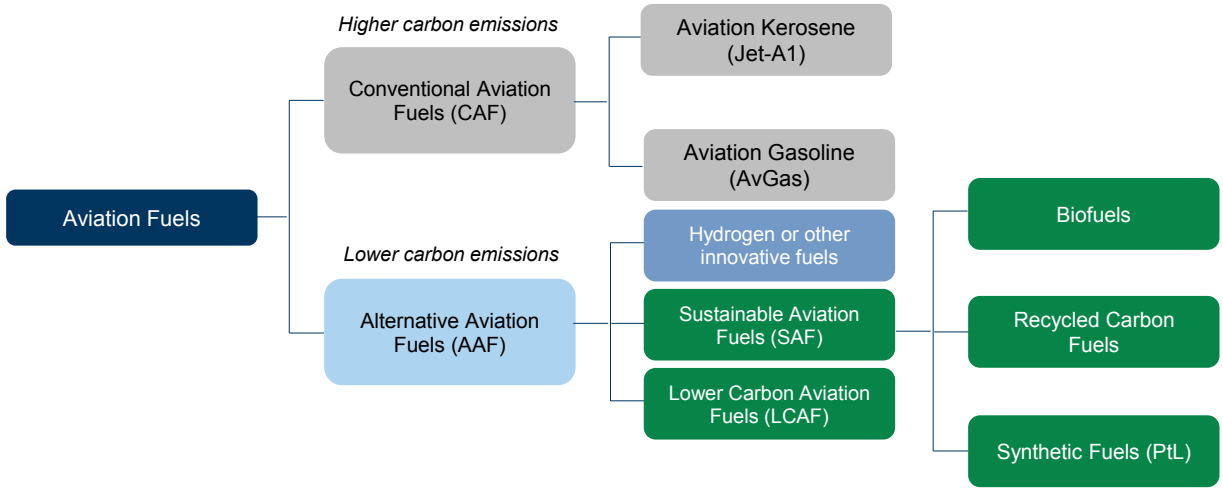
ammonia projects in the GCC that are slated to come online in the next few years, with further upside to this as the countries ramp up their clean hydrogen production through the end of the decade.

Sustainable Aviation Fuel (SAF): Decarbonizing the aviation sector

Aviation is one of the most prominent industrial sectors in the UAE, as highlighted by the Ministry of Energy and Infrastructure (MOEI), with the contribution to GDP expected to grow by ~170% in 20 years (vs. a 2018 baseline, based on forecasts from the International Air Transport Association, IATA). The decarbonization of the aviation sector is a key focus area under the Nationally Determined Contributions (NDCs). By 2030, the country plans to spend **US$7.0-9.0bn** in investments in Sustainable Aviation Fuel (SAF) facilities to have a 700mn liters per year production capacity. This volume would reduce an estimated 4.8mn tons of CO2 cumulatively through the end of the decade, and will be produced at up to five facilities. As per the Ministry's study, achieving this target would position the country as a regional and global leader, slightly exceeding the EU's 2030 SAF target of 6%, as well as IATA's estimate of 5.2% SAF required globally to set the industry on the path to net zero by 2050.

The UAE has significant potential to become a large producer of SAF, particularly through the power-to-liquid (PtL) method, which synthesizes clean hydrogen and captured carbon. The country benefits from one of the world's lowest renewable electricity costs, and growing hydrogen production, which could allow it to produce up to 11mn tons of PtL SAF per year by 2050, as per the Ministry of Energy and Infrastructure. Although the PtL technology is less mature than some other forms, it can achieve higher emission reductions and production is less restricted by feedstock availability (see Exhibit 82).

Exhibit 81: SAF pathways for the UAE



Source: Ministry of Energy and Infrastructure (MOEI)

Exhibit 82: The most developed SAF production pathways as of 2022 are HEFA, gas and FT synthesis, AtJ and PtL

	Biofuels	Advanced Biofuels	Synthetic Fuels
Sustainability	Emissions savings expected at 85% with used cooking oil and 76% with tallow	Emissions savings expected at between 91-94%	Emissions savings of up to 100%
Market readiness	Available on commercial scale	Ongoing commercial pilots	In development
Key production pathways	Hydrogenated Esters and Fatty Acids (HEFA)	Gas and Fischer-Tropsch (FT) synthesis Alcohol to Jet (AtJ)	Power to Liquid (e.g. hydrogen from electrolysis, CO2 capture then FT synthesis and upgrading, **or** hydrogen from electrolysis, CO2 capture then methanol synthesis and conversion)
Feedstock	First generation: Vegetable oils, waste and residue lipids Constrained by resource availability and demand competition with other sectors	Second generation: Forestry and agricultural residues (including lignocellulosic material) Algae and biowaste (including municipal solid waste) Constrained by resource availability and demand competition with other sectors	Renewable hydrogen and CO2 Least restricted feedstock availability, due to large hydrogen production potential

Source: Ministry of Energy of Infrastructure UAE (MOEI)

Additionally, we highlight that the country's two flag carrier airlines (Emirates and Etihad) have been actively engaged in initiatives to decarbonize operations by 2050. Emirates supports the IATA's collective industry commitment to reach net zero by 2050 and is exploring opportunities across operational fuel efficiency, SAF, LCAF (Lower Carbon Aviation Fuel) and renewable energy. The company recently announced (1) an agreement with Shell Aviation for the supply of >300k gallons of blended SAF for use at the airline's international hub in Dubai, with the first delivery expected to commence by year-end, and (2) 3-year US$200mn R&D projects focused on advanced fuel technologies including SAF production. Etihad has also committed to achieving net zero by 2050, with interim milestones including a 20%/50% reduction by 2025/2035 (vs. 2019 baseline),

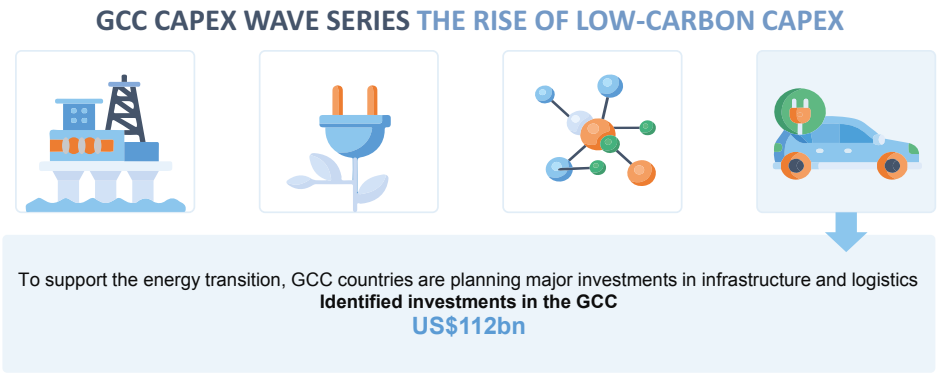
and announced in November 2022 an MoU with Cepsa, a Mubadala group company, where both aim to prioritize the development of SAF. The airline signed earlier (in 2021) a Joint Project Development Agreement with Abu Dhabi Waste Management Centre (Tadweer) to facilitate the first waste-to-SAF plant in the region, with a capacity to convert up to 4.0mn tons of MSW (municipal solid waste) into SAF per year; ADNOC, BP and Masdar joined forces with the entities as well. In early 2022, Masdar, TotalEnergies and Siemens Energy signed a collaboration agreement to develop a green hydrogen-to-SAF production plant.

Qatar is also pursuing several efforts towards sustainable aviation, such as the gradual implementation of the International Civil Aviation Organization's (ICAO) comprehensive measures including improved air traffic management, infrastructure enhancement, modern aircraft technologies, and the usage of SAF and LCAF. In October 2022, Qatar Airways and SAF producer Gevo Inc. signed an offtake agreement where the airline will purchase 25mn US gallons of neat SAF over 5 years with deliveries expected to start in 2028. The partnership is part of the airline's previous commitment (along with other oneworld Alliance members) to buy up to 200mn US gallons of SAF from Gevo. The airline also signed a deal with Shell in May 2023 to source 3,000 metric tons of neat SAF (at least 5% of its jet fuel requirement) in 2023-24 at Amsterdam Schiphol airport. We estimate that, in total, investments of **c.US$7.6-9.8bn** would be required to source the announced SAF volumes (based on announced target investments and metric tons in the region), and flag that there is upside to this estimate as more agreements are potentially announced.

In **Oman**, a start-up (Wakud) announced plans in late 2023 to develop two major bio-refineries for the production of SAF at Sohar Port and Salalah Port for a total investment of **US$630mn**. The first of the two projects is planned to come online in 2026 with an annual capacity of 250mn litres of SAF, while the one at Salalah is planned for 2027, reflecting an additional 200mn litres in capacity.

Infrastructure and logistics: Supporting the energy transition

Investments in transportation and logistics stand at the heart of decarbonization strategies. From expanding ports, procuring LNG vessels, growing cargo capacity, and investing in EV production and/or charging infrastructure, the GCC countries have been increasingly focused on modernizing logistics and investing in greener transportation. While EV adoption in the region remains early, Saudi/the UAE and other markets have started laying the foundation for the growth opportunities that the market holds. The UAE has also announced sizable growth plans to cater to gas and LNG demand, and we believe this paves the way for further investments in logistics (clean hydrogen/ammonia) as production grows. We identify c.US$112bn in investments announced so far in the GCC across infrastructure-related sectors by 2030.



Source: Goldman Sachs Global Investment Research

Electrification: A growing focus on energy efficiency

Electrification involves replacing technologies and processes that rely on fossil fuels, like internal combustion engines and gas boilers, with electrically powered equivalents such as electric vehicles or heat pumps. As per the IEA, these replacements are generally more energy efficient and have a growing impact on reducing CO2 emissions as electricity generation is gradually decarbonized. The GCC countries have embarked on several plans and initiatives to reduce demand for energy and drive electrification where possible.

Saudi Arabia: Growing focus on electrification through renewable power and battery manufacturing

In **Saudi Arabia**, Aramco has been focused on energy sufficiency through the deployment of co-generation plants that allows it to produce electricity as a byproduct. The company as such harnesses what would otherwise be waste energy by maximizing the conversion of energy released from the combustion of fuel into power and steam to achieve better thermal energy efficiency and reduce overall emissions. Additionally, the company aims to design new facilities to be energy efficient, with the implemented initiatives so far resulting in a 3% yoy reduction in energy intensity in 2022. Some of the

planned initiatives include (1) upgrading simple cycle gas turbines to energy efficient combined cycle systems; (2) replacing older, inefficient boilers with highly efficient ones; and (3) implementing digital solutions. Furthermore, Aramco remains committed to investing in 12GW of solar and wind energy by 2030 for its business, and approved the installation of renewable systems to power 20 offshore water injection wells at Berri and Zuluf in 2022, while it also installed PV systems to power its remote pipelines load.

Additionally, Saudi aims to become a key player in the automotive sector, with the development of light vehicles and batteries spearheaded by the Ministry of Industry and Mineral Resources (MIM) and the PIF. As per the IHS, Saudi accounts for >50% of total vehicles sales in the GCC, making it one of the top 20 markets globally. While the country does not have a history in ICE manufacturing, it is strategically looking at BEV production. Indeed, a range of incentives and measures are currently in place to encourage investments in the country's BEV industry; these include (1) 20-year loans from SIDF, (2) low cost of industrial land, (3) exemption from import duties on machinery and equipment for the plant and on raw materials/components for local production, and (4) low electricity/gas costs, among others. As the country looks to create a wider network of suppliers around its nascent automotive industry, the PIF has signed a deal with Pirelli SpA to build a >US$550mn plant that would serve companies including Lucid Group and Hyundai Motor.

Exhibit 83: Recent announcements around Saudi Arabia's investments in the EV battery production supply chain

Source: Bloomberg, Reuters, Zawya

In the **UAE**, ADNOC Group is one of the first major O&G companies to decarbonize its electricity supply at scale, sourcing 100% of its grid power from nuclear and solar since January 2022. The group also aims to electrify its LNG production through a low-carbon intensity growth project, which will play a key role in the energy transition process and provide one of the world's lowest-carbon LNG once operational. The NOC also invested **US$600mn** in a waste heat recovery project that supplies electricity and water to Al Ruwais Industrial City by driving two steam-powered turbines (producing 64,400 cubic meters of distillate water per day, and 230MW of power); once completed, the project is expected to reduce the dependence on the national grid by c.30% and improve thermal efficiency.

Furthermore, ADNOC is currently building a **US$3.8bn** sub-sea transmission network that would connect the company's offshore operations to onshore grid power (nuclear/solar energy), reducing the carbon footprint by up to 50% once completed.

As per the updated **UAE energy strategy**, the country is also investing in large-scale energy storage technology. Abu Dhabi is home to one of the world's largest virtual battery plants globally (108MW), reducing the need for additional gas power plants further. The batteries of Abu Dhabi's virtual battery plant are distributed over 10 sites across the emirate, but are connected and controlled as one plant, making it a large 'virtual' battery plant. A further 300 MW in battery energy storage system is under development and will become operational in 2026.

Additionally, a 250MW pumped-storage hydropower plant is expected to come on stream in Dubai by the end of 2024. The emirate is also developing a 700MW molten salt thermal energy storage system which will be commissioned in 2023/2024, and support the integration of renewables into the grid.

In **Oman**, OQ (Oman's oil company) has engaged in several energy efficiency measures, including process optimization, flare recovery and electrification projects, among others. In the downstream space (refining/petrochemical), the energy intensity index slightly declined yoy in 2022 supported by the implemented process optimization projects. This is while the company aims to reduce energy consumption in downstream buildings by c.30%.

Transportation: Electric vehicles under the spotlight

While EV adoption in the Middle East and the GCC is still nascent, its growing penetration globally, coupled with government-led energy transition initiatives, has been accelerating its adoption regionally. In COP27 last year, several countries pledged to transition to EVs by 2040 as a way to accelerate their decarbonization plans.

Saudi Arabia: Massive investments to build the EV ecosystem

Saudi Arabia has announced multiple initiatives around the future of cars in the region given the meaningful contribution of cars to the country's total energy consumption (21%, per Saudi Energy Efficiency Center). In terms of expected capex, **Saudi could see around US$50bn being spent on EV production over the next decade** (per the Ministry of Investment). This is while total capacity in the country is expected to reach over 300k vehicles per year over the same period (source: SIDF (Saudi Industrial Development Fund)). Saudi also set up a new EV infrastructure company in October 2023, which aims to establish a presence in >1k locations and install >5k fast chargers across cities by 2030. The PIF and SEC (Saudi Electricity Company) will own a 75%/25% stake in the company, respectively.

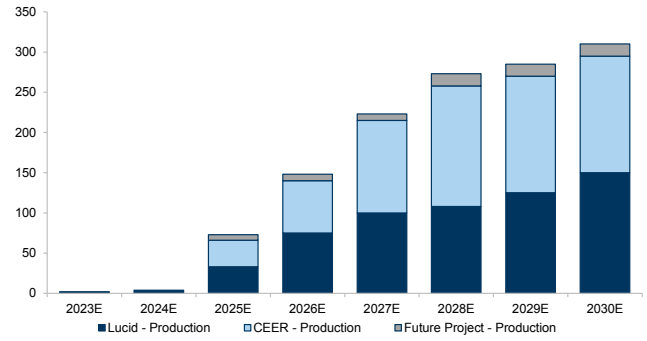
By 2030, Saudi aims to have 30% of cars in Riyadh (and c.10% of cars in Saudi) powered by electricity. In May 2022, Saudi announced plans to invest around c.US$2bn (or c.SAR.8bn) in an EV battery plant, in line with the country's broader plans to diversify its economy away from hydrocarbons and develop the industrial sector as part of the Saudi Vision 2030 and National Industrial Development and Logistics Program (NIDLP); the project is currently underway.

Saudi also recently launched Ceer, the country's first EV maker; according to the Saudi government, the company is expected to produce around 150k cars per annum and contribute around US$8bn to the country's GDP by 2034. In addition, vehicles produced by Ceer are expected to be available by 2025. The company is expected to design, manufacture, and sell vehicles in Saudi as well as the broader MENA region.

Lucid also signed an agreement with the Saudi government to build its first overseas production factory in Saudi where it could potentially manufacture up to 150k vehicles per year. Furthermore, Saudi Arabia agreed to purchase between 50-100k EVs over a ten-year period; delivery of the vehicles is expected to start this year with an initial order ranging between 1-2k vehicles annually, scaling to 4-7k beginning in 2025.

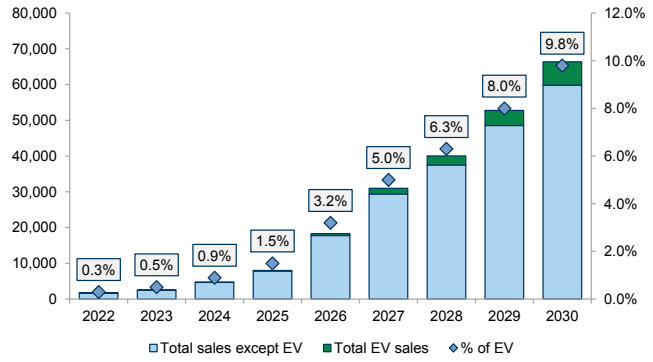
We believe Saudi could potentially be a key player within the EV space partly driven by its diversification efforts, economic resources, and proximity to input-exporting countries (Saudi's position at the intersection of Africa, Asia, and Europe positions it competitively to import minerals from mines in Africa, produce vehicles domestically, and finally export to international markets). The country's giga-projects, such as Qiddiya, Roshn and NEOM, have plans to deploy fleets of EVs produced by the Lucid and Ceer factories in King Abdullah Economic City.

Exhibit 84: The supply of battery EVs locally built in Saudi is expected to grow...
Number of vehicles (thousands)



Source: SIDF

Exhibit 85: ...with EV penetration expected to reach around c.10% by 2030
Car sales (excluding EV) and EVs in Saudi



Source: SIDF

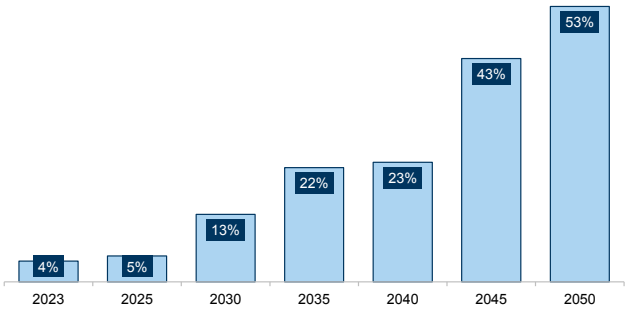
UAE: Efforts ongoing to build EV charging infrastructure in Dubai and Abu Dhabi

The **UAE** has proactively promoted EV adoption and advanced on its EV agenda over the past couple of years through initiatives like the Dubai Green Mobility Strategy 2030, which aims to have c.42k cars on the roads of the emirate by the end of the decade. A key aspect of the strategy is the EV Green Charger initiative, which has meaningfully expanded the availability of charging stations in the country to around 700. We note that in January 2023, Regeny and EvGateway announced a partnership through which they aim to deploy 10k EV charging networks throughout the UAE by 2030.

The country has also announced several other targets to be achieved in the medium term, including (1) increasing the share of electric and hybrid vehicles in the domestic fleet to 13% by 2030 (vs. c.4% today), (2) transforming Dubai taxis into 100% eco-friendly (hybrid, electric and hydrogen-powered) vehicles by 2027 (per the Road and Transport Authority, or RTA), and (3) reducing the consumption of energy by 40% by 2050 as stated by the National Demand Side Management Program for the transport sector. As per the Ministry of Energy and Infrastructure (MoEI), there were >20k EVs registered in the UAE in 2022, and this is expected to reach >100k by 2025 and >1mn by 2030.

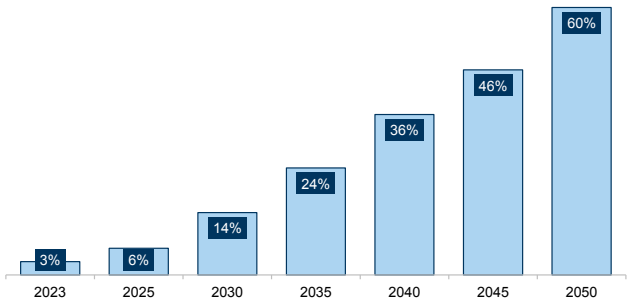
Additionally, the Ministry of Energy and Infrastructure recently unveiled (May 2023) its Global EV Market transformational project, where it aims to create a favorable environment for growth of the EV market in the country through supportive policy levers for investment, as well as socio-economic and environmental incentive schemes. Under the project, the Ministry aims to increase the share of EVs to >**50% of total vehicles by 2050**.

Exhibit 86: The UAE plans to increase the share of EV and hybrid vehicles to >50% by 2050...
Share of EV and hybrid vehicles, % of total



Source: UAE Energy Strategy 2050

Exhibit 87: ...and that of electric hybrid buses to c.60%
Share of electric and hybrid buses, % of total



Source: UAE Energy Strategy 2050

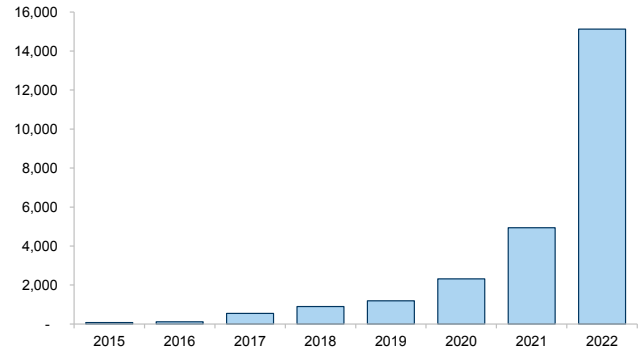
While these plans remain at nascent stages, we note that efforts are ongoing, with ADNOC announcing a partnership earlier this year (January 2023) with TAQA to create a mobility JV called E2GO, which will build and operate BEV infrastructure in Abu Dhabi and the broader UAE. With an expected 70k charging points considered to be required in Abu Dhabi by 2030 to meet the growing demand, this could require up to **US$200mn in capex to build the infrastructure.** Additionally, we highlight that an investment vehicle owned by Abu Dhabi has invested **US$738.5mn** for a 7% stake in Nio, an electric car company based in Shanghai.

With respect to Dubai, in line with the emirate's 2030 Integrated Energy Strategy (which aims to achieve 30% annual electricity savings by 2030), increasing penetration of electric vehicles (EVs) supports the city's gradual transition towards sustainability. The number of EVs in Dubai stood at 4,500 in 2021, and is expected by FTI to see a 50% CAGR through 2025, reaching c.23k vehicles. Furthermore, based on demand projections for Dubai, infrastructure players, including EV charger providers, are positioning themselves competitively to ensure the ratio of charging outlets to EVs is at least at a minimum level of 1:7, as per DEWA. Taking this ratio into account, and the emirate's ambition to reach a 13% EV penetration by 2030, we estimate that Dubai could require on average c.42k charging points, which could cost **US$120mn** on average, on our estimates.

DEWA is playing an increasingly important role in supporting the gradual switch to EVs in the emirate; it installed 325 EV chargers, as of 2021, in partnership with fuel stations and additional third parties across Dubai. The company aims to increase the number of chargers installed to 1,056 by 2025 (vs 620 at the end of 2022, ~800 as of May 2023). This should see DEWA benefiting from incremental electricity consumption over time.

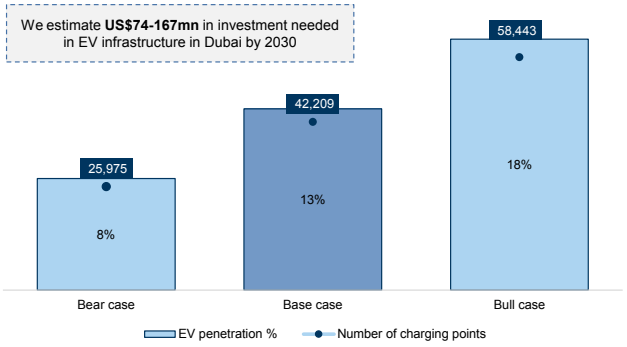
Despite the relatively small size of the EV market when compared to fuel-driven cars in Dubai, we believe it presents a new leg of growth, and we see EVs catching up as the transition towards clean energy accelerates.

Exhibit 88: The number of registered EV vehicles reached 15.1k as of 2022
Number of registered EV vehicles



Source: DEWA

Exhibit 89: We estimate on average the need for c.US$120mn in EV infrastructure to support a 13% EV penetration
Flexing EV vehicle penetration % and estimated number of charging points



Source: Goldman Sachs Global Investment Research

Qatar and Oman: At a nascent stage, but ambitious targets

In **Qatar**, despite its relatively small market size, the automotive sector has been undergoing a transformation over the past 1-2 years, with a strong government push towards EVs. Indeed, government entities and private corporations have been working on building the physical infrastructure needed for EVs, as well as working on providing a wider EV selection. In terms of targets, the Qatari Ministry of Transport has targeted to switch **35% of total vehicles in its fleet and 100% of public transport buses to electric vehicles by 2030**. Additionally, the country aims to have 10% EV sales as a share of all vehicle sales by 2030 (vs. 800 EVs sold in 2022), and 30k electric charging stations by 2027 (vs. 100 stations in 2022); this is while EV charging is free of charge at designated charging stations until 2029 as a means to boost demand over the medium term. We also note that during the FIFA World Cup which was hosted by Qatar in 2022,~25% of the transportation buses were electric.

Furthermore, we highlight that the government has partnered with several private entities including Volkswagen, Gaussin and Yutong to transform the country's mobility scene; for instance, Yutong signed an MoU with Mowasalat, a Qatari leading transportation company, for joint research and development of EVs for logistics. Additionally, EcoTranzit Company unveiled Qatar's first EV brand, VIM, with exclusive intellectual property. We expect that investments into the EV market will remain focused on batteries, safety and charging infrastructure and accessibility over the medium term as demand gradually picks up.

Lastly, **Oman** plans to phase out fuel-based vehicles gradually, targeting a **79% EV share in the country by 2035** as announced by the Ministry of Transport, Communications and Information Technology (MTCIT) in early 2023. Additionally, the Ministry estimates that Oman will have at least **22k EVs on roads by 2040**, and it aims to phase out all fossil fuel-operated vehicles by 2050 through a series of projects and initiatives aimed at the transport, communications and IT sector, which accounts for ~20% of the country's total carbon emissions. To further incentivize demand, the Omani Taxi Authority announced that EVs and EV parts' manufacturers will be exempt from VAT

customers tax and registration fees, while the Authority for Public Services Regulation introduced a new regulation governing the charging of EVs. As of June 2023, MTCIT has already installed 90 charging stations across different locations within Oman in an effort to encourage adoption.

Shipping & logistics: Investing in LNG shipping and logistics infrastructure

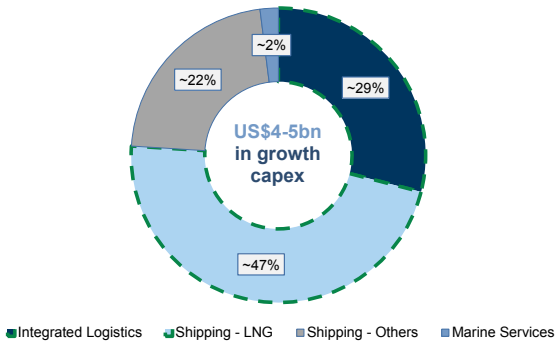
Our analysis suggests that the GCC countries are also investing in growing their infrastructure and logistics capabilities to support the spending on various decarbonization initiatives. Beyond EV charging, the UAE, Saudi and other GCC markets are increasing their investments in gas/LNG shipping, ports and warehouse expansion. We look at both direct and indirect investments in shipping and logistics, with direct spending being related to decarbonziation (e.g. LNG carriers, gas pipeline extensions) and indirect spending to various growth plans over time (e.g. port expansion, logistics capabilities).

Direct investments: Spending on gas infrastructure on the rise

In terms of **direct investments** we see in the **UAE,** spending on shipping and gas infrastructure is being undertaken mainly by ADNOC L&S and ADNOC Gas. The former, which listed on the ADX in June 2023, announced a growth capex program aimed at enhancing the company's fleet and logistics capabilities. The entity is currently expecting 6 new build LNG carriers to be delivered between 2025/26 and has a 10-year contract in relation to the Hail and Ghasha gas field exploration, with an 8-year initial term and 2-year extension option. ADNOC L&S plans to spend **US$4-5bn** in growth capex over the next 5 years, with the spending aimed at sustaining and supporting the logistics growth required as part of ADNOC Group's US$150bn 2023-27 investment program. Of the US$4-5bn, the company plans to spend 29% in expanding its integrated logistics capabilities, and 47% in LNG shipping (inclusive of the 6 new build carriers). Overall, the company plans to grow the number of owned ships to support higher LNG and bulk sales, as well as increase volumes, services and integrated logistics fleet to deliver further operational efficiencies. We also highlight that the company committed to **US$2bn** in capex related to environment-friendly vessels ordered between 2021-22, with delivery dates between 2023-25.

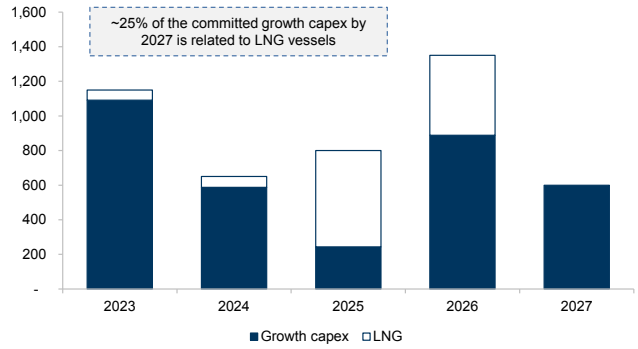
ADNOC Gas is also investing in extending the gas pipeline infrastructure in the country to supply higher volumes to the Northern Emirates as part of the ESTIDAMA project, for which the company has awarded a **US$1.34bn** contract.

Exhibit 90: ADNOC L&S aims to spend US$4-5bn in growth capex over the next 5 years, of which c.47% will be in LNG shipping
% of total



Source: ADNOC L&S

Exhibit 91: From the committed growth capex, c.25% is related to LNG vessels
Committed growth capex spending (US$mn), 2023-27E



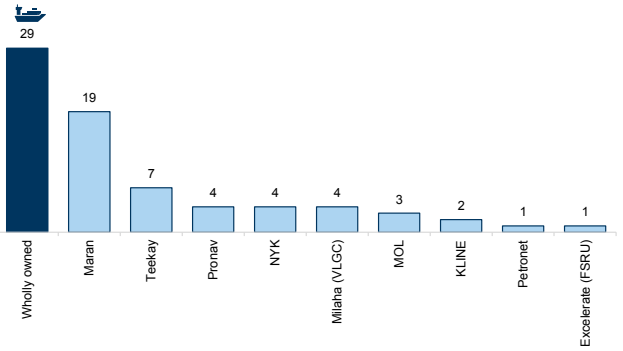
Source: ADNOC L&S

We note that the Dubai-based energy consultancy Synergy Offshore's CEO noted during the Saudi Maritime Congress held in September that the new energy supplies (hydrocarbon and green) planned in **Saudi Arabia** would underpin demand for offshore support vessels throughout the decade. Utilization of vessels in Saudi is indicated to be at around 90%, with a few new vessels available, which we think could drive higher supply over the next few years.

Qatar, as highlighted previously, is expected to see a sizable jump in its LNG production post the expansion projects planned in the North Field, while QatarEnergy's share of new total global LNG supply is expected to reach 40% by 2029. This increase in production is set to move in tandem with investments in related infrastructure; the NOC revealed in 2020 that it had signed shipbuilding agreements with several companies in South Korea (Daewoo Shipbuilding & Marine Engineering (DSME), HD Hyundai Heavy Industries and Samsung Heavy Industries), to acquire >100 new ships for >**US$19bn**, which reflects c.60% of the scheduled global LNG carrier building capacity by 2027, as per QatarEnergy. These new LNG ships are expected to have superior performance and efficiency that would help reduce GHG emissions, in line with the environmental targets stated under Qatar National Vision 2030. In the first phase of the program, QatarEnergy expects to add 60 contracted tankers, growing to 77 in the second phase, and to more than 100 in the future.

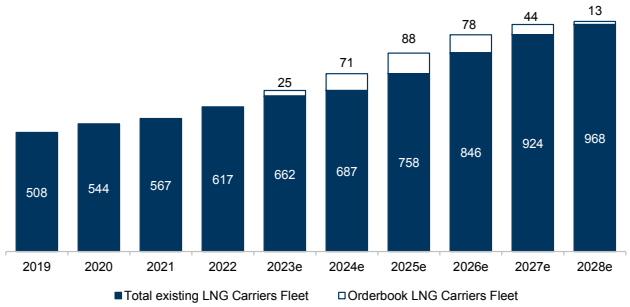
Nakilat, a Qatari maritime and shipping company established in 2004, with one of the world's largest LNG shipping fleets (69 carriers), provides the essential transportation link in the country's LNG supply chain. The company operates one floating storage regasification unit (FSRU), 4 large LPG carriers (VLGCs) and 24 LNG carriers, through its 100%-owned subsidiary Nakilat Shipping Qatar Limited (NSQL). In addition, Nakilat operates a shipyard (Erhama Bin Jaber Al Jalahma Shipyard) located in Ras Laffan Industrial City, which provides ship repair and offshore fabrication services through strategic JVs (N-KOM and Qatar Fabrication Company or QFAB).

Exhibit 92: Nakilat wholly owns 29 LNG carriers
Wholly and jointly owned fleet, number of vessels



Source: Nakilat

Exhibit 93: The LNG carriers fleet orderbook is expected to increase in the coming years
Development of global LNG carriers fleet* (2019-2028E)



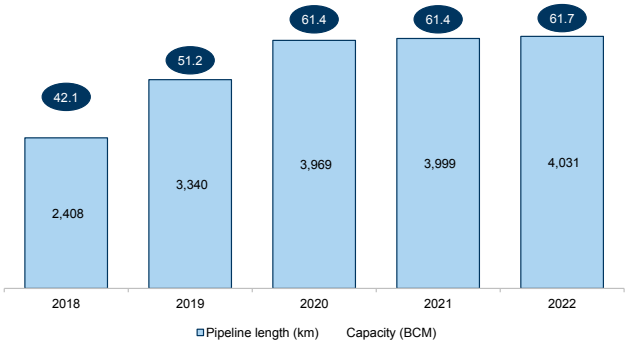
*As of 3Q23, World live LNG fleet (excl. vessels <100,000cbm, FSRUs, FSUs, and FLNG, no assumption for scrapping, or LNGC conversion to FSRUs)

Source: Nakilat

Oman's national oil company OQ's gas networks business, OQ Gas Networks SAOG (OQGN), listed recently. It holds a natural monopoly over the essential gas transportation infrastructure in the country, and is the exclusive owner and operator of the Natural Gas Transportation Network (NGTN). The latter is a comprehensive gas transportation network encompassing a system of pipelines, metering facilities, gas supply stations and others. It serves as an essential link connecting gas producers to consumers operating across sectors that require gas as a critical production feedstock, including power generation LNG, water desalination, O&G and industrial areas (petrochemical, fertilizer, aluminium and steel plants).

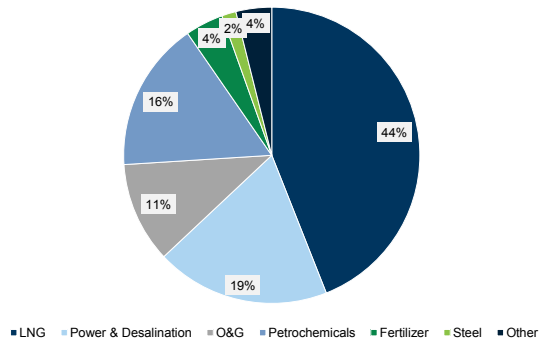
The company's NGTN encompasses >4,000km of gas pipelines and 25 supply stations that connect to various customers, as of 2022. The network also includes a pipeline link to the UAE, and connects to the Dolphin gas network. Through the link, Oman imports around 2BCM/year from the UAE.

Exhibit 94: OQGN has grown its pipeline network over time, reaching >4,000km by 2022
Pipeline length (km) and capacity (BCM)



Source: OQGN

Exhibit 95: OQGN transported 39BCM in gas volumes through the pipeline network, of which 44% was driven by LNG
Gas consumers breakdown by industry, based on volumes transported as of 2022, % of total



Source: OQGN

OQGN's growth strategy is based on 3 key pillars: (1) continued investment in NGTN

growth, debottlenecking and upgrades; (2) acquisition of gas transportation assets; and (3) expansion into the transportation of other energy sources. The company is in the process of executing several projects between 2023 and 2024, with estimated costs of those expected to be completed this year taken into account in the capex budget of **US$160mn**, which covers both growth and sustenance capex.

In the medium term, the company is targeting between **US$600-750mn** in growth and sustenance capex (at 9-13% of total); additionally, the company is targeting asset acquisitions amounting to c.US$45mn in 2023, and between **US$130-230mn** relating to further potential acquisitions in the medium term.

Exhibit 96: OQGN's capex budget for 2023 and 2024 includes the following projects

Name of project	Project Size	% completed as of June 2023	Estimate completion date
Network Development Projects:			
South Grid De-Bottlenecking Phase 2	Major	93%	Oct-23
Central 48 Rich & Lean Segregation	Major	70%	Oct-24
Sohar Phase 7 (Gas Supply to MISCO & Keryas)	Medium	95%	Jul-23
SLIA GSS De-Bottlenecking	Medium	99%	Jul-23
SIE De-Bottlenecking	Medium	88%	Dec-23
Connection Projects:			
Duqm SEZAD Phase II Pipeline Project	Medium	14%	Oct-24
Gas Supply to Oman Oil Seed Crushing Factory & Oman Sugar Refinery	Medium	79%	Sep-23
Gas supply to Keryas Paper Industries	Minor	96%	Jul-23
Salalah Free Zone Bulk	Minor	82%	Oct-23
OMIFCO GSS Update	Minor	91%	Oct-23
Gas Supply to Global Development & Cont.	Minor	95%	Dec-23
Gas Supply to Saheer Al Maaden	Minor	70%	Dec-23
Gas Supply to Al Namariq	Minor	95%	Sep-23
Gas Supply to Pride Packaging	Minor	59%	Dec-23
Gas Supply to Bolten Beads & Horizon (HID)	Minor	91%	Jul-23
Gas Supply to Salalah Mills	Minor	9%	Dec-23
Gas Supply to Dhofar Fishers	Minor	8%	Dec-23
Gas Supply to Gulf Gypsum Products	Minor	9%	Dec-23

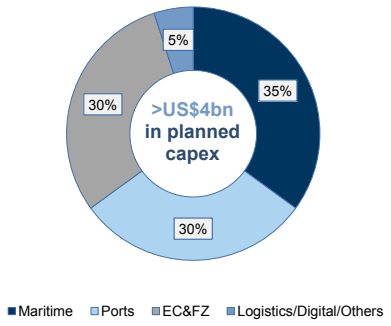
"Major" projects include projects with estimated capital expenditure of OMR 25 million or more, "Medium" projects include projects with estimated capital expenditure between OMR 5 million to OMR 25 million and "Minor" projects include projects with estimated capital expenditure of less than OMR 5 million.

Source: OQGN

Indirect investments: Supporting the GCC's growth ambitions across the board

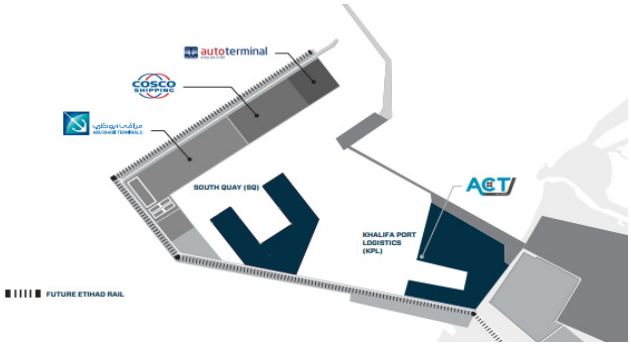
In the context of **indirect investments** in other types of logistics capabilities, which we expect could further support both growth plans and energy transition goals, Abu Dhabi Ports in the UAE is a key entity investing in growing the logistics sector in the country. The company is targeting **>AED15bn** (**>US$4bn**) in organic (excluding M&A) capex in 2023-27, with spending focused on maritime services, improving economic and free zones, and expanding the Khalifa Port (~US$1bn). As per the company, the latter is expected to broaden the range of port and marine logistics services offered, from container and cargo handling to vessel maintenance. Additionally, according to AD Ports, the addition of drydock services will enable the Khalifa Port to meet growing demand for these services from regional and international clients. The expansion plan is set to increase the handling capacity to 15mn TEU by year-end, and general cargo handling capacity to 25mn tons.

Exhibit 97: AD Ports is planning >US$4bn in capex to be spent on maritime services, ports and others
% of total



Source: AD Ports

Exhibit 98: Khalifa Port is currently seeing a c.US$1bn investment in container operations and expansion of South Quay and Khalifa Port Logistics for multi-purpose use
Khalifa Port map



Source: AD Ports

Lastly, we note that Dubai announced its Salik Road Strategy in March 2019, which comprised 9 initiatives and 33 projects that would involve the collaboration of Emirates Airlines, Dubai Airports, Dubai South, Dubai Free Zones (DFZ) Council, Dubai Maritime City Authority, DP World, Jebel Ali Free Zone, Dubai RTA and the Dubai Municipality.

In **Saudi Arabia**, the Ministry of Transport and Logistics Services announced in 2021 its plans to invest **>US$133bn** in airports, sea ports, rail and other infrastructure by 2030 to transform the country into a global transportation and logistics hub. As part of the strategy, Saudi aims to increase the number of international aviation routes from 99 to >250, and more than triple total annual passenger traffic, as highlighted in our previous note. We flag that of the **US$133bn, ~US$100bn** is earmarked for the Saudi Aviation Strategy announced by GACA (General Authority of Civil Aviation), **and which we exclude from our total investment estimates.** Additionally, Saudi announced in May 2023 that its new Port of NEOM, located in Oxagon (NEOM's advanced and clean industries cluster), has begun operations. The country invested c.US$2bn in the first phase of development, with the first container terminal scheduled to open in 2025.

In late 2022, Mawani (The Saudi Ports Authority) signed an agreement with Maersk to establish an integrated logistics park at the Jeddah Islamic Port (JIP), which broke ground in February 2023. Additionally, the Dubai-based logistics firm DP World is aiding the expansion and modernization of the South Container Terminal at JIP in a US$500mn agreement, which will increase container-handling capacity at the terminal from 2.4mn TEUs to 4mn TEUs in 2024. Saudi Arabia is targeting a national annual container capacity of more than 40mn containers by 2030 as per the National Transport and Logistics Strategy (NTLS).

Additionally, an MoU was signed in September 2023 between shipping and logistics company Bahri and SAIL, a subsidiary of Saudi Investment Recycling Company (SIRC), to foster collaboration in the field of sustainable shipping and advance sustainable practices within the maritime industry. Mawani and SIRC also signed a partnership agreement targeting similar objectives.

Disclosure Appendix

Reg AC

We, Faisal AlAzmeh, CFA, Michele Della Vigna, CFA, Dalal Darwich, Waleed Jimma, Waleed Mohsin, Neil Mehta, Jerry Revich, CFA, Harsh Mehta, Anastasia Shalaeva and Yulia Bocharnikova, hereby certify that all of the views expressed in this report accurately reflect our personal views about the subject company or companies and its or their securities. We also certify that no part of our compensation was, is or will be, directly or indirectly, related to the specific recommendations or views expressed in this report.

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Growth is based on a stock's forward-looking sales growth, EBITDA growth and EPS growth (for financial stocks, only EPS and sales growth), with a higher percentile indicating a higher growth company. **Financial Returns** is based on a stock's forward-looking ROE, ROCE and CROCI (for financial stocks, only ROE), with a higher percentile indicating a company with higher financial returns. **Multiple** is based on a stock's forward-looking P/E, P/B, price/dividend (P/D), EV/EBITDA, EV/FCF and EV/Debt Adjusted Cash Flow (DACF) (for financial stocks, only P/E, P/B and P/D), with a higher percentile indicating a stock trading at a higher multiple. The **Integrated** percentile is calculated as the average of the Growth percentile, Financial Returns percentile and (100% - Multiple percentile).

Financial Returns and Multiple use the Goldman Sachs analyst forecasts at the fiscal year-end at least three quarters in the future. Growth uses inputs for the fiscal year at least seven quarters in the future compared with the year at least three quarters in the future (on a per-share basis for all metrics).

For a more detailed description of how we calculate the GS Factor Profile, please contact your GS representative.

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	Buy	Hold	Sell	Buy	Hold	Sell
Global	48%	36%	16%	62%	56%	44%

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