The Outlook of CCS and CCUS in The Middle East

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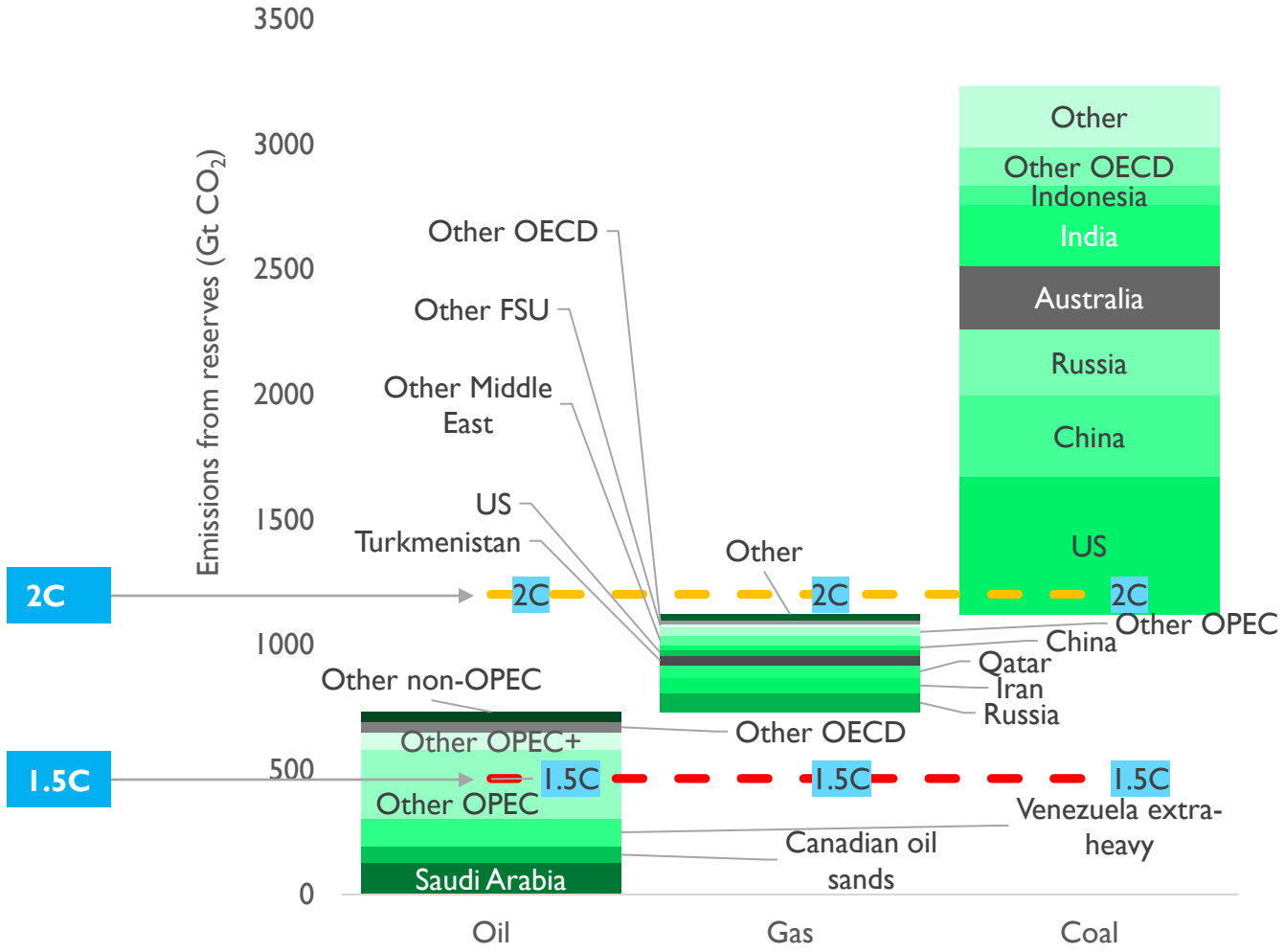
The scale of the challenge: >3200 Gt CO_2 of fossil fuel reserves, 460-1200 Gt of carbon budget



- The combustion of hydrocarbon fuels releases CO_2, as well as other GHGs that contribute to atmospheric pollution and climate change (methane, NOx, black carbon)
- Known reserves of fossil fuels vastly exceed the carbon budget for 1.5-2◦C of warming
- Additional resources can be added through exploration and improved / enhanced recovery
- Hydrocarbons remain competitive and essential in many end-uses
- Options to capture CO_2 emissions include:
  - capturing CO_2 from lower-emitting resources, projects, and operations
  - deploying CCS technologies in end-use (carbon reduction)
  - bio-sequestration and Bioenergy with CCS (BECCS)
  - direct air capture (DAC) – carbon removal

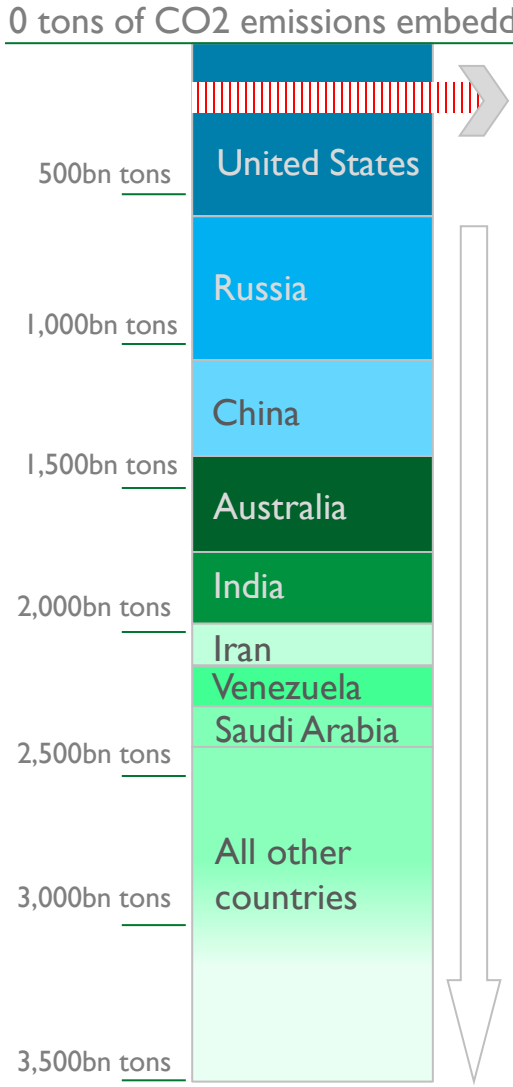
Sources: Internal research and analysis; BP Statistical Review of World Energy

Remaining Carbon Budget to 2050 vs. CO2 emissions embedded in fossil fuel reserves

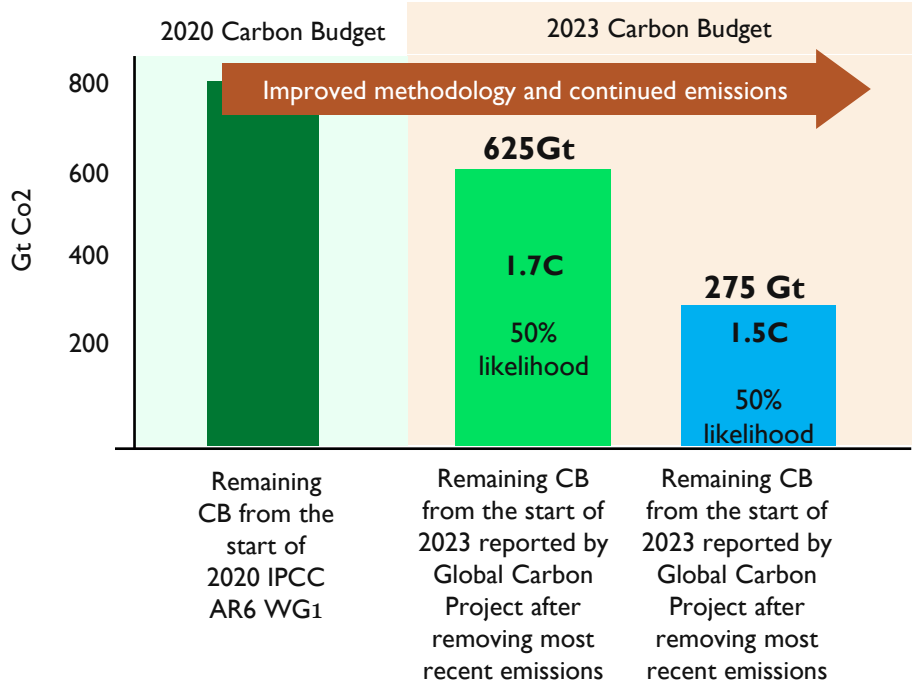
To have a chance of avoiding 1.5C or more of global heating, scientists have estimated the world can only emit **275 bn more tons** of greenhouses gases (50% confidence), and 625 bn for the 1.7C scenario.

2,590 Gt of CO2 have been emitted between 1850 and 2023,

The US alone has the potential to release 577 Gt of emissions, most of that from coal, through its known fossil fuel reserves.



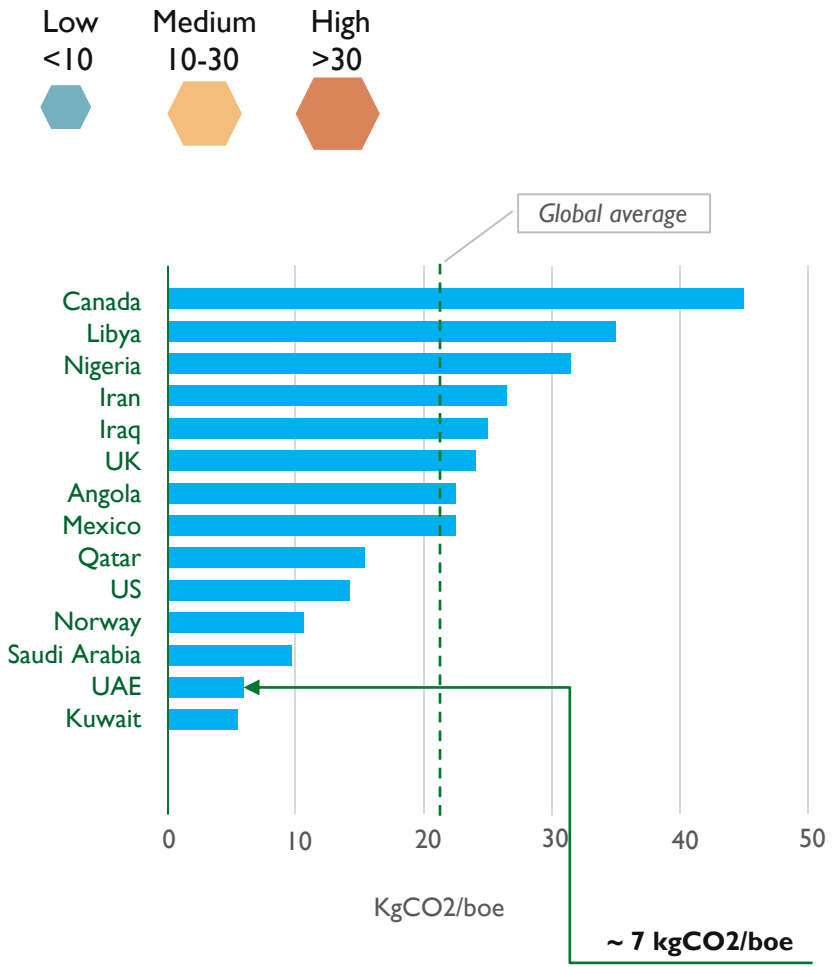
Carbon budget remaining before world reaches +1.5C warming.
275 Gt (IPCC and Global Carbon Project)

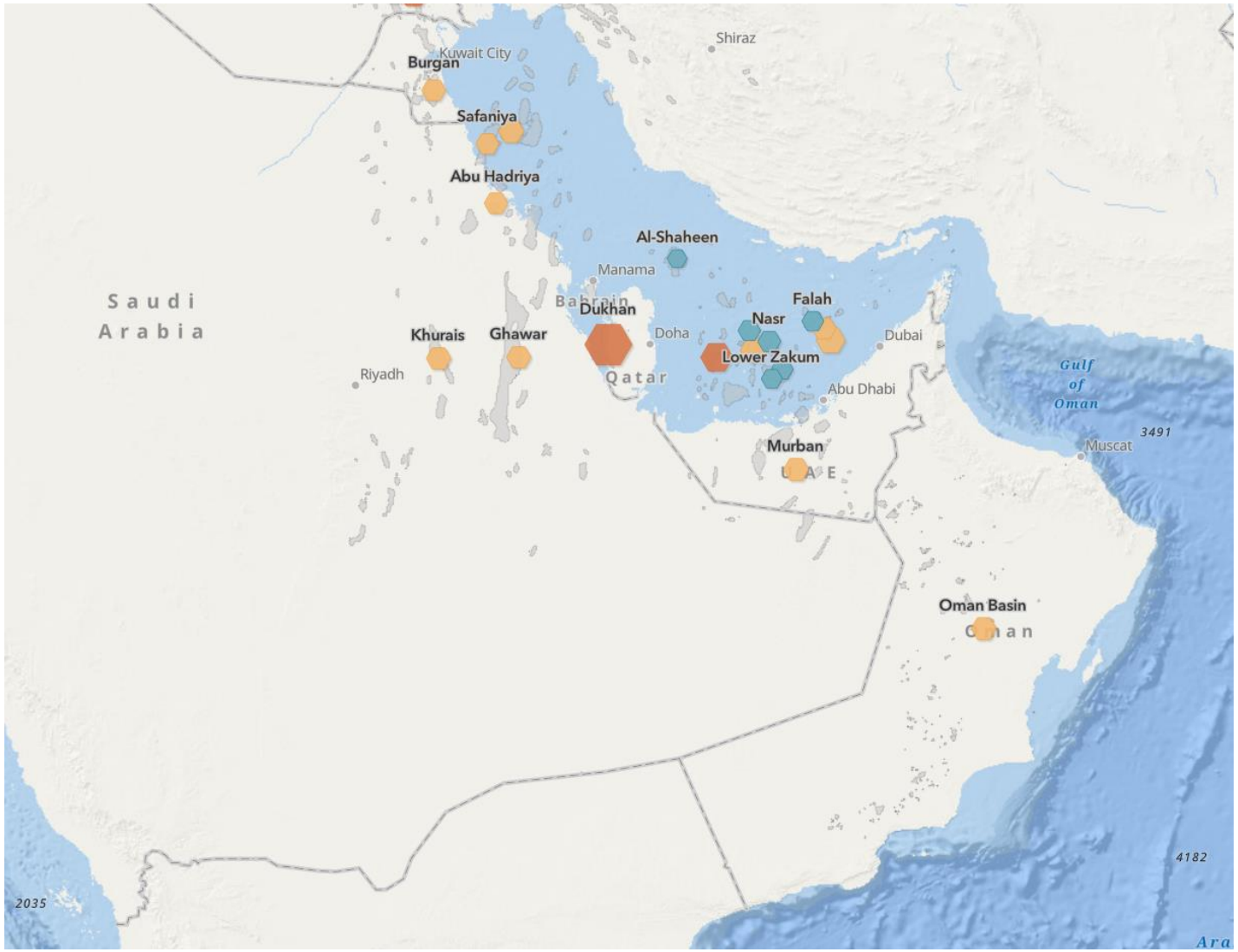


The Global Registry of Fossil Fuel. Note: Carbon Budget to reach +1.5C and +1.7C scenarios. Updated 2023 according to Friedlingstein et al. research paper. And Forster et al 2023

Carbon Intensities from upstream production. GCC has relatively low carbon intensities.

GCC Carbon intensities (upstream production)
(kgCO2eq/boe)



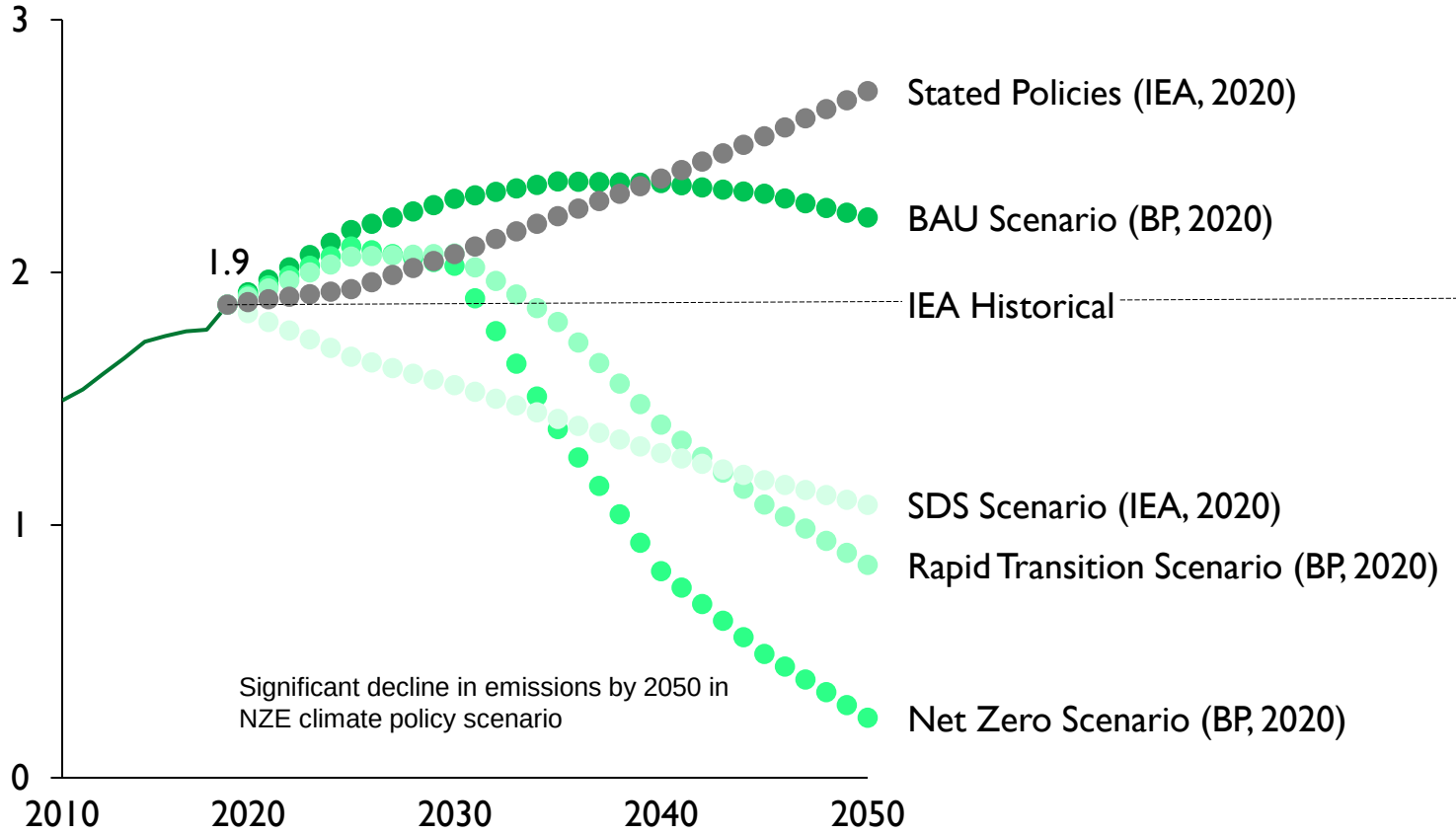


NOAA, USGS, Rystad, Internal Analysis

CO_2 emissions from the GCC account for ~3% of global GHG emissions, ~5% of global energy-related emissions and 54% of total CO_2 emissions from the Middle East.

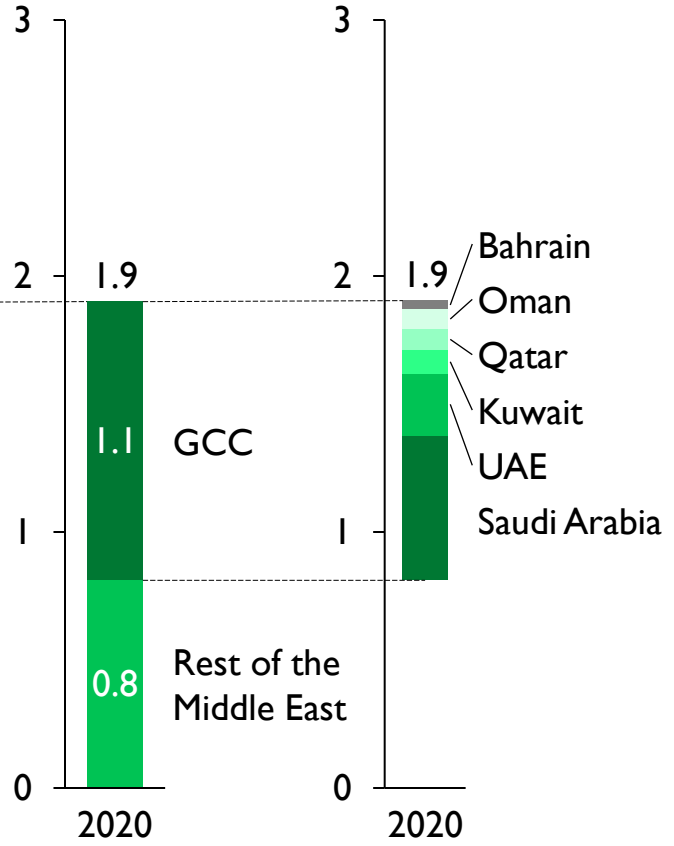
Outlook for CO_2 Emissions in the Middle East

Units: gigatonne (Gt)



CO_2 Emissions in the GCC

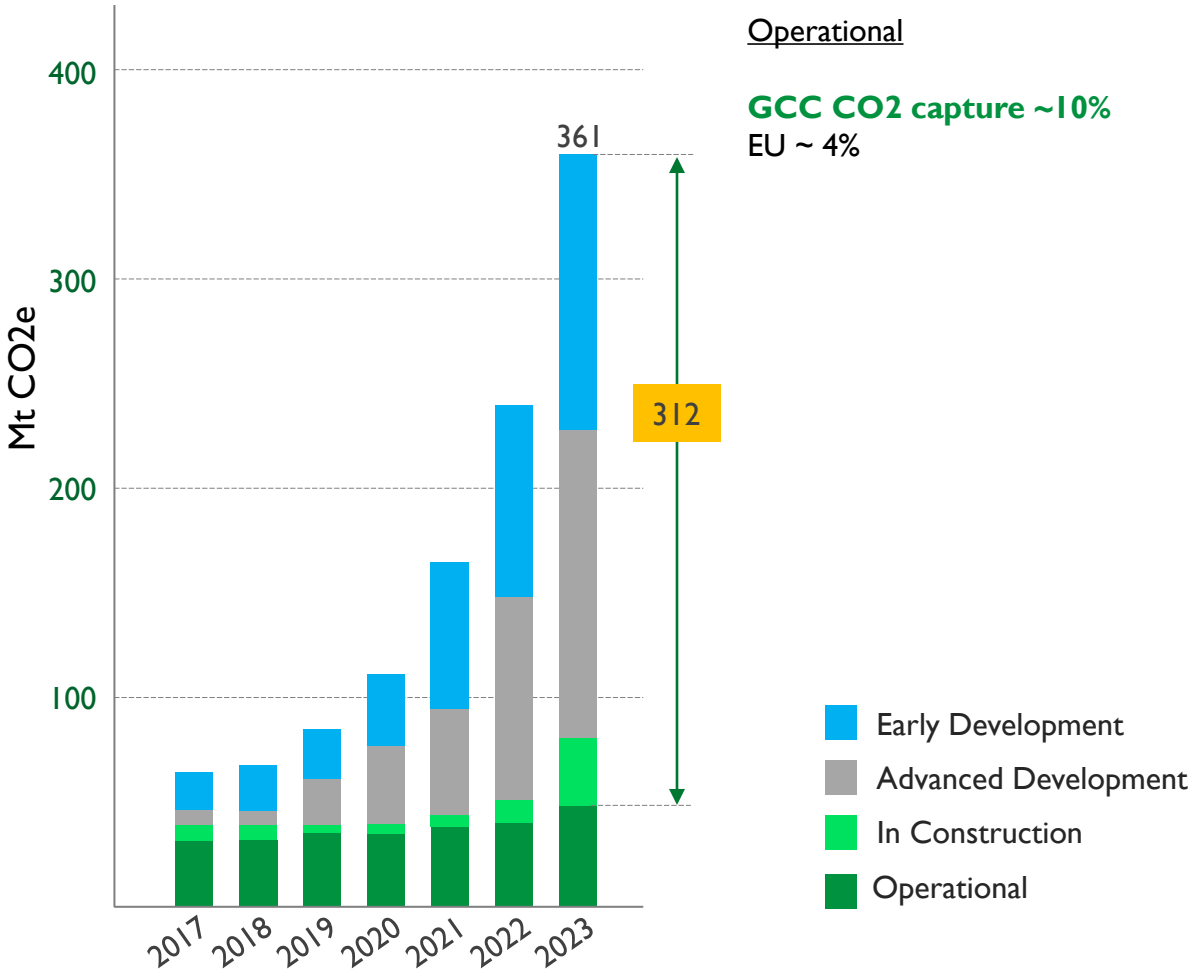
Units: gigatonne (Gt)



Sources: International Energy Agency, BP, BP Statistical Review of World Energy, and Internal Research and Analysis

Currently, just over 20 countries, 9 of which are in MENA, have mentioned CCS in their *NDCs

Pipeline of commercial facilities by capture capacity (as of Oct 2023)

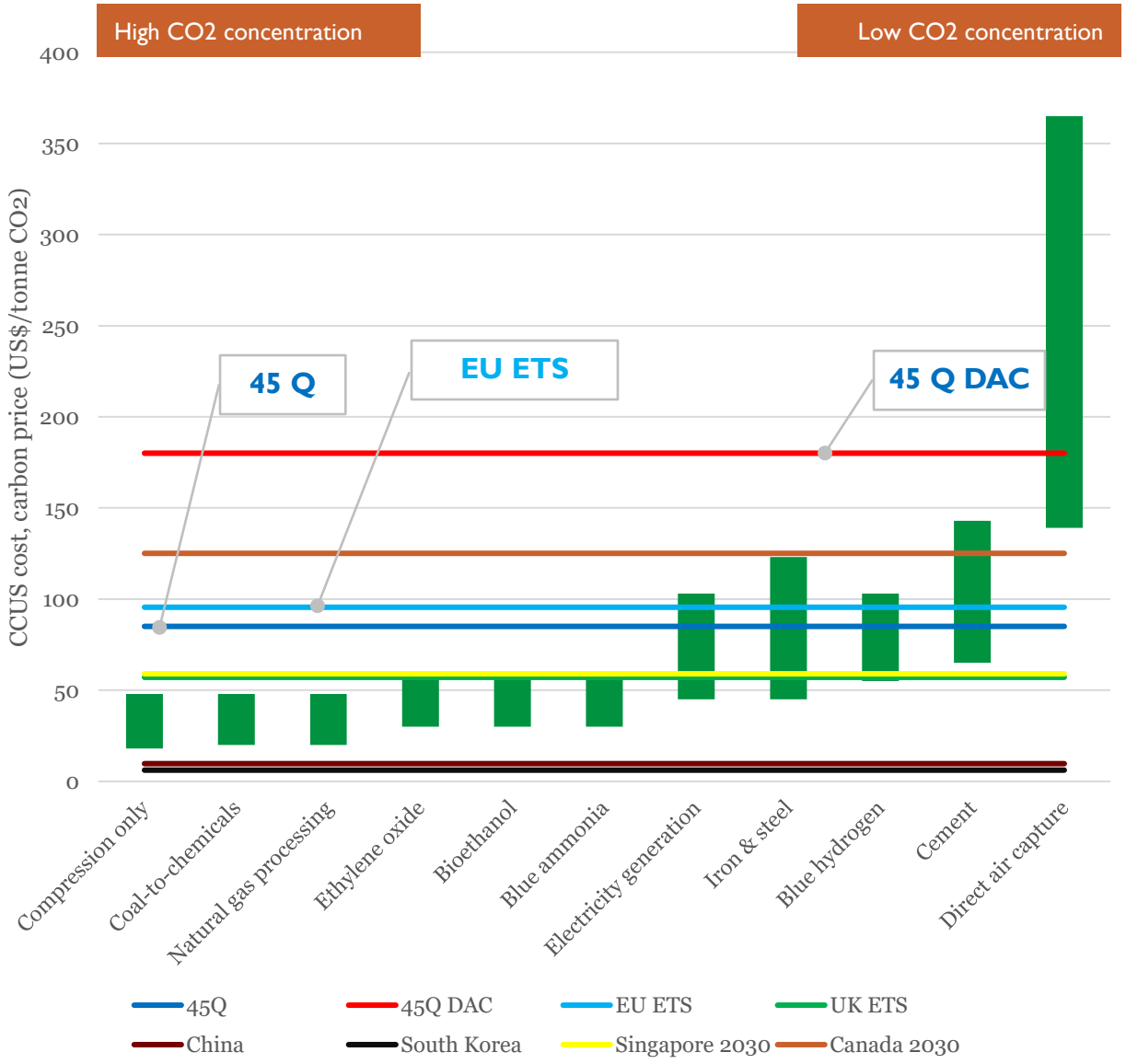


	Country	CCS in NDCs	Emissions Reduction Targets
GCC	Saudi Arabia	✓	• Reduction of 278 Mtpa by 2030 • Carbon neutrality by 2060 • Aramco net-zero by 2050
	UAE	✓	• 23.5% below BAU (310 Mt) by 2030 • Net-zero by 2050
	Bahrain	✓	• Net-zero by 2060
	Qatar	✓	• Reduce 25% of GHG emissions by 2030
	Kuwait	✓	• Net-zero by 2060
	Oman		• Net zero by 2050 • 20% of electricity from renewables • Zero routine flaring by 2030
	Iraq	✓	• 15% CO2 emissions reduction by 2030 • 30% Methane emissions by 2030 (from 2020)
	Egypt	✓	• 20% below BAU (250 Mt) by 2030
	Iran	✓	• 4% below BAU by 2030
	Iraq	✓	• 15% reduction compared to BAU by 2030
	Tunisia	✓	• 45% reduction compared to its 2010 baseline by 2030

Source: GCCSI; UN * Nationally determined contributions

However, global carbon pricing now in the range to encourage CCS/CCUS

- Carbon pricing varies widely even in jurisdictions which have it
- Pricing is source dependent
- US uniquely has specific amounts for different CCUS methods
- Carbon prices in Europe, North America & prospectively in Singapore now enough to encourage some CCUS methods
- EU Carbon Permits ("allowances") trade at **~$95 /tonne**
- Industrial processes: pure $13-25/t vs diluted $40-120/t
- Learning will play a role



Sources: GCCSI, Platts, Ember, official reports. Costs include $5-18/tonne for storage

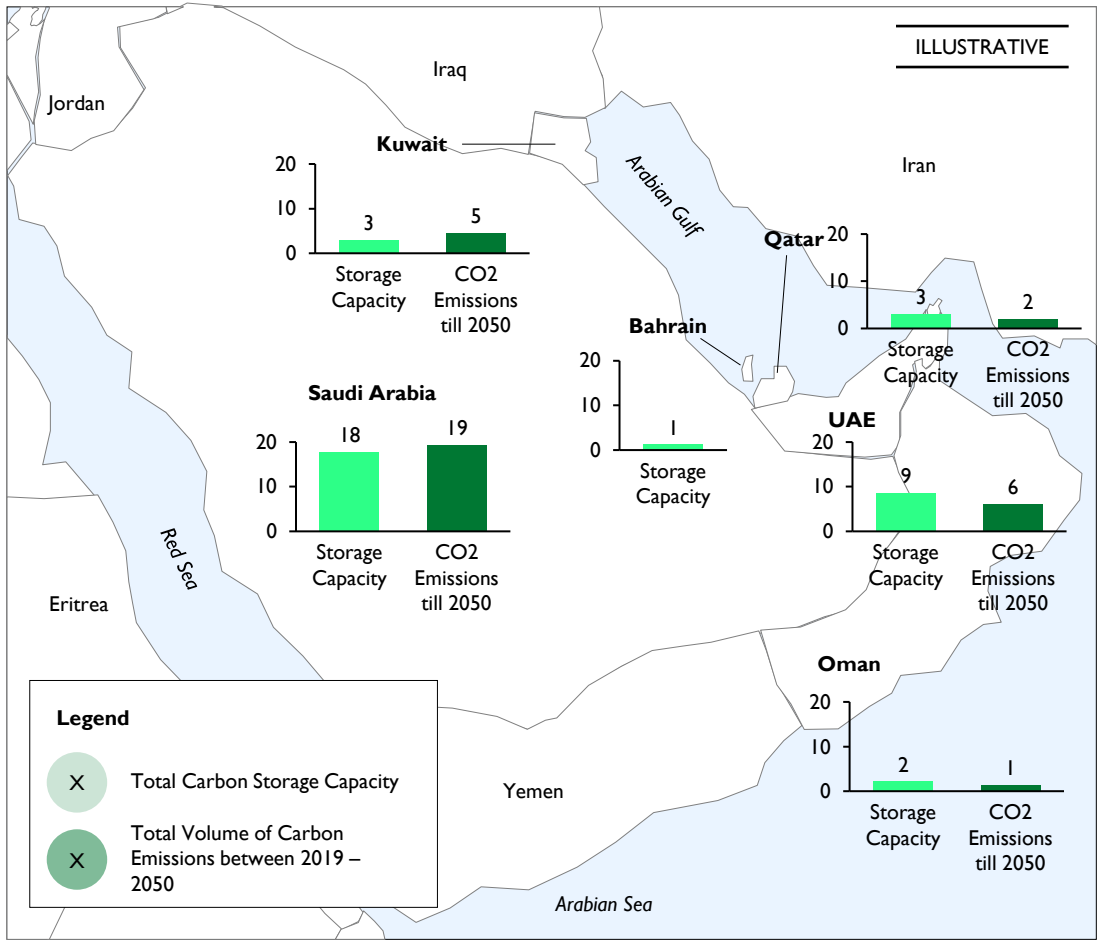
Carbon capture, use & storage (CCUS) is already significantly developed in the GCC

The GCC has around 4.7 Mtpa of CCUS capacity and plans to reach at least 60 Mtpa by 2035.

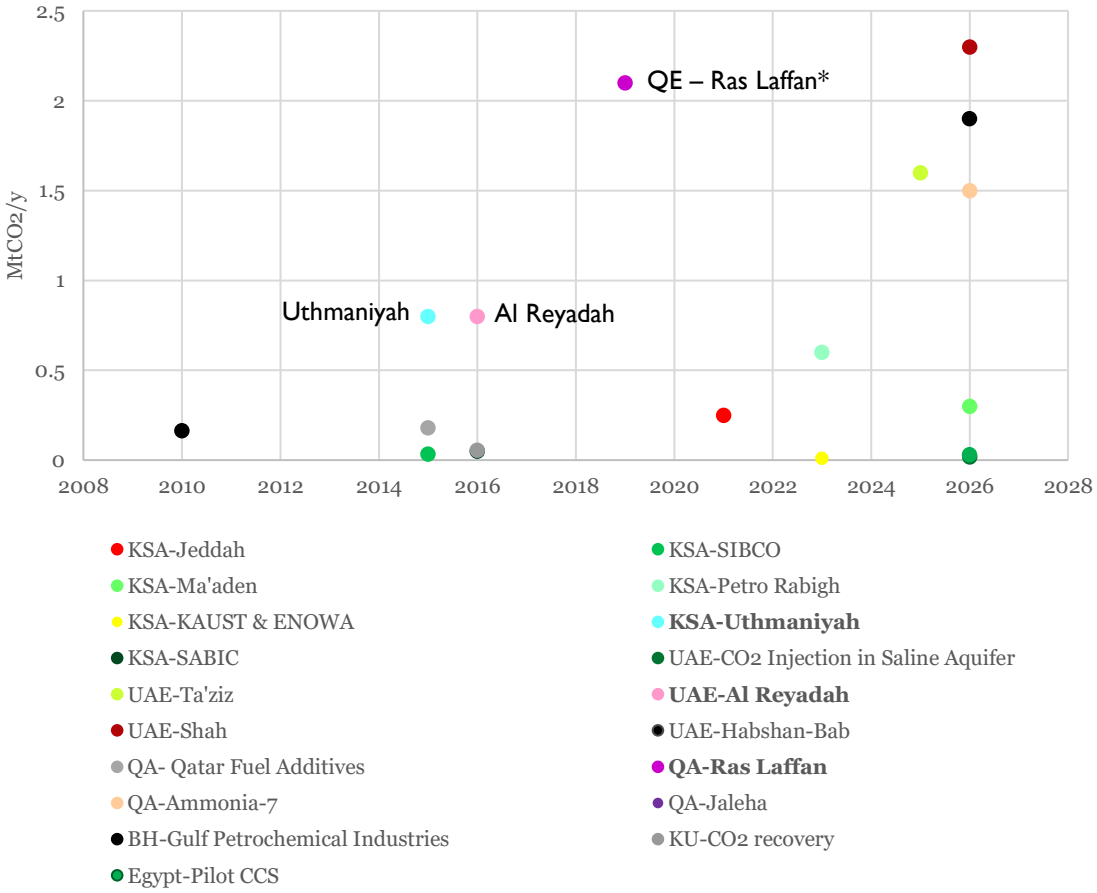
KSA alone announced target of 44 Mtpa by 2035 (Jubail in pre-FEED)

CO_2 Storage Capacity and Volume of CO_2 Capture

Units: gigatonne (Gt)



Units: $MtCO_2$

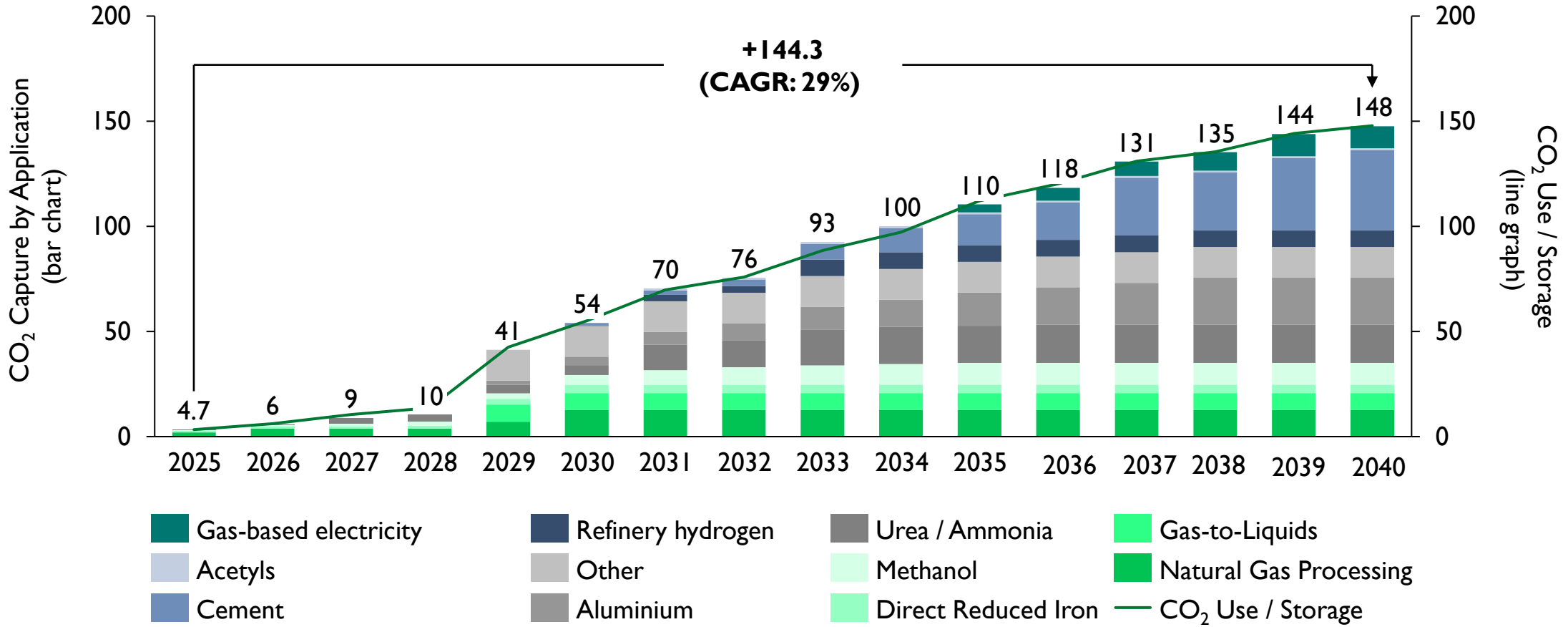


Sources: Internal Research and Analysis

GCC countries have technical potential to capture 10 Mt / year of CO_2 by 2028, 50% for enhanced oil recovery or geological storage, and remaining as feedstock for various industrial processes

Annual CO_2 Captured by Application

Units: millions of tonnes / year



Sources: Internal Research and Analysis

CO_2 capture in the GCC is facilitated by small number of point emitters and a dense concentration of large point emitters, that mainly operate in the electricity, oil & gas, and industrial sector

Sector	Sub-Sector / Industry	Estimated Large Point Emissions, 2025					
		Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	UAE
Electricity Generation	Natural Gas	13.3 Mt	31.1 Mt	12.3 Mt	20.7 Mt	169.8 Mt	38.0 Mt
	Fuel Oil, Diesel, and Crude Oil	-	12.2 Mt	0.2 Mt	-	44.9 Mt	-
	Coal	-	-	7.7 Mt	-	-	15.4 Mt
Oil & Gas	▪ Natural Gas Processing ▪ Crude Oil Refineries ▪ LNG Projects ▪ Gas-to-Liquids Projects	1.2 Mt	9.9 Mt	17.4 Mt	13.4 Mt	68.9 Mt	12.0 Mt
Others	▪ Iron and Steel Production ▪ Aluminium Smelters ▪ Chemicals / Fertilisers						

- Most of the regional large point emissions of CO_2 are from electricity generation and the industrial sector.
- Oil (inc. diesel and fuel oil) accounts for 39% of the electricity generation mix in Saudi Arabia
- Natural gas accounts for 67% of electricity generation mix in Saudi Arabia and 83% in UAE
- Opportunity for material CCUS hubs/clusters
- Attraction of gas power CCUS to balance renewables

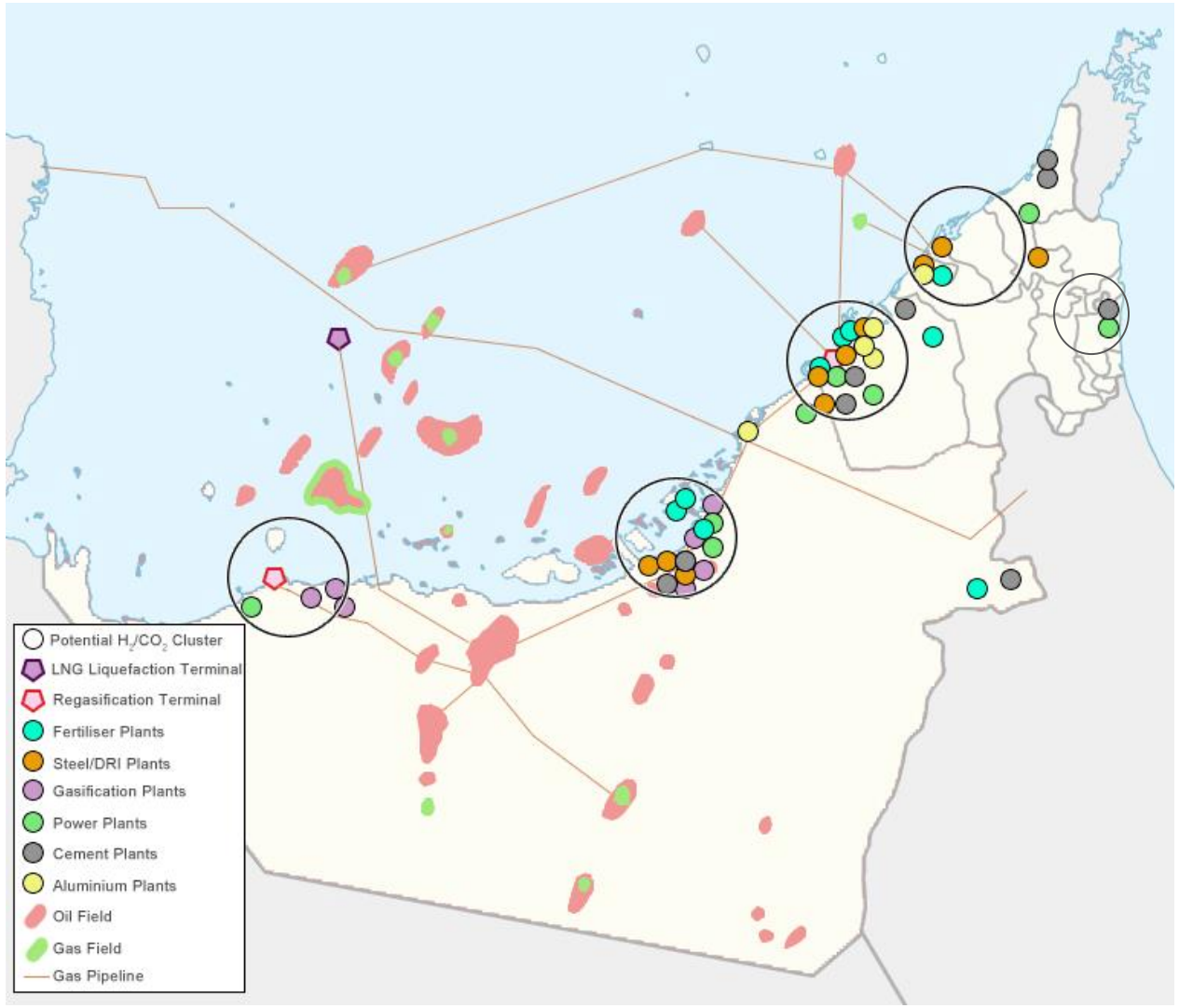
Sources: Internal Research and Analysis

Several challenges are hindering CCUS's uptake – how do we go from here?

Factors	Challenges	Required Actions
Policy and Regulations	▪ MENA countries **do not have a carbon pricing mechanism** ▪ Fossil fuel **subsidies** across GCC countries **disincentivise CCUS uptake** ▪ Most countries in the MENA region have introduced **climate policies, but not CCUS specific policies.** ▪ **Lack of transparency** and statistical figures on carbon emissions ▪ The GCC countries lack specific regulations for private sector access NOC-owned pipelines and infrastructure. In some cases, such as with Saudi Aramco and ADNOC, third-party access rights or capacity expansion may be granted on a contractual basis	▪ Create regulations for the monitoring, reporting and verification (MRV) of captured CO_2, (ii) operational and safety regulations that allocate liabilities across the value chain, (iii) and financial incentives and sustainability frameworks ▪ Implement a **carbon pricing mechanism** to incentivise low-carbon technologies' uptake, and **limit exposure to CBAM**
Technical	▪ Limited understanding of cost-reduction potential of CCUS costs, technologies, and **business models** ▪ Some NOCs have limited knowledge and technical expertise in CO_2-EOR applications	▪ Governments need to develop **capacity building programmes** for public and private stakeholders to advise on CCUS strategies, technologies, uses, and costs ▪ Connected **CCUS hubs of the scale of 10s of $MtCO_2$/year** each, rather than small individual projects, are essential to deliver rapid, wide-scope decarbonisation and create economies of scale
Economic	▪ Initial capital cost of CCUS is still high ▪ There is a lack of clear CCUS business models	▪ The nascent CCUS regulatory landscape creates an opportunity for companies and governments to pioneer **cross-border CCUS policy** cooperation, including establishing carbon pricing and/or trading schemes, carbon credits for CO_2 sequestration, and other incentives ▪ The deployment of **carbon pricing** would be very helpful in supporting the business case for CCUS, as for other low-emitting technologies.

Sources: Internal Research and Analysis

Hydrogen with CCUS can encourage the development of combined CO_2 and H_2 clusters



UAE Potential H_2 / CO_2 Clusters

Illustration

- UAE targets a 38% share of natural gas in its clean energy targets for 2050, hence it needs to decarbonise NG in Power generation.
- UAE enjoys a sophisticated, large-scale network of refining and petrochemical facilities,
- Existing natural gas infrastructure suitable for processing / transportation / storage of hydrogen and/or CO_2
- CCUS can encourage development of combined **clusters** and **hubs** in key industrial and port cities. Follows KSA lead.

Sources: Internal Research and Analysis

United Arab Emirates' profile: CCUS projects.

CO_2 Pilot Project at Rumaitha Field

- Developer: ADNOC and Masdar
- Industry: Enhanced Oil Recovery
- Capacity: 21,900 tonnes / year
- Status: Operational since 2012

Ta'ziz Project

- Developer: ADNOC and Fertiglobe
- Industry: Petrochemicals
- Capacity: 3 MT
- Status: Operational in 2025

Bab / Habshan Project

- Developer: ADNOC and Robt Stone
- Industry: Enhanced Oil Recovery
- Capacity: 1.9 MT / year (?2.3 MT)
- Status: Planned (FID)

Shah Project

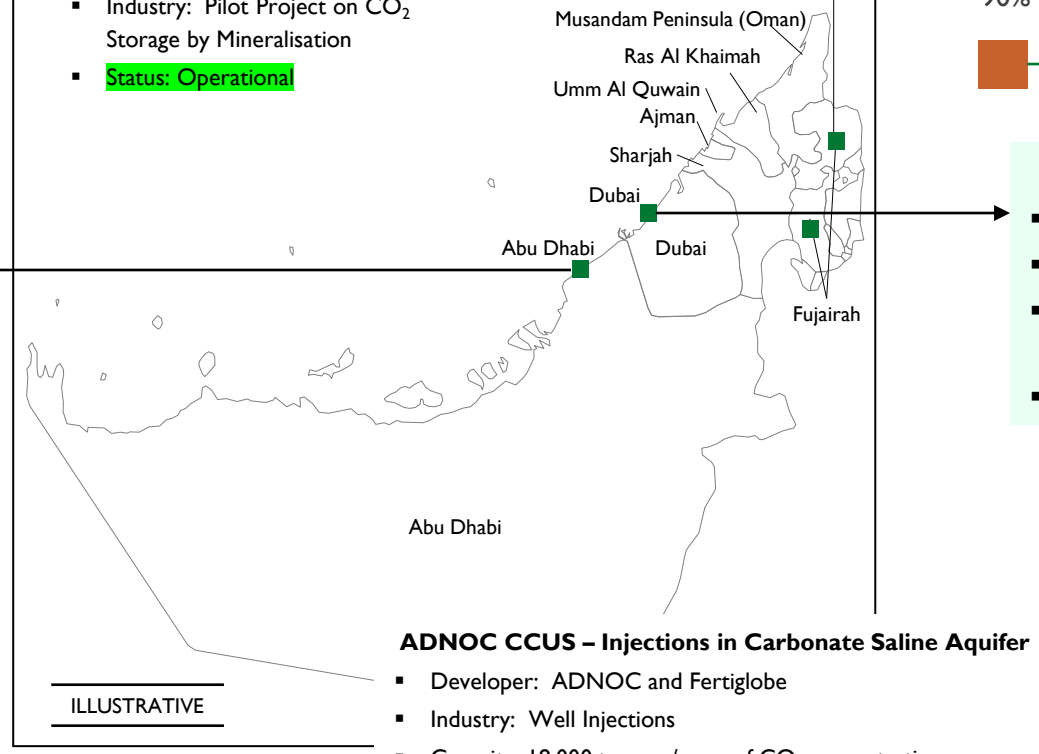
- Developer: ADNOC and Masdar
- Industry: Enhanced Oil Recovery
- Capacity: 2.3 MT / year
- Status: Planned

Ghasha Project

- Developer: ADNOC
- Industry: Enhanced Oil Recovery
- Capacity: 1.5 MT
- Status: Planned (FID)

ADNOC and 44.01 Mineralisation Project

- Developer: ADNOC and 44.01
- Industry: Pilot Project on CO_2 Storage by Mineralisation
- Status: Operational



PS:
Emirates Steel,
90%

43km

EOR
Rumaitha & Baab

Al Reyadah Project

- Developer: ADNOC and Masdar
- Industry: Iron and Steel
- Capacity: 0.8 MT / year with plans to expand to 5 MT / year by 2030
- Status: Operational since 2016

ADNOC CCUS – Injections in Carbonate Saline Aquifer

- Developer: ADNOC and Fertiglobe
- Industry: Well Injections
- Capacity: 18,000 tonnes / year of CO_2 sequestration
- Status: Under Development

BP joined ADNOC to evaluate a new blue hydrogen (low-carbon hydrogen) project in Abu Dhabi.
Ta'ziz will produce 1Mtpa low-carbon ammonia.
ADNOC $15bn in decarbonization projects / 5Mt CO2 by 2030

Sources: Internal Research and Analysis, KAPSARC, ADNOC

Saudi Arabia's profile: CCUS projects. Plans to develop **CCS Hub @ Jubail of 9 MTPA.**

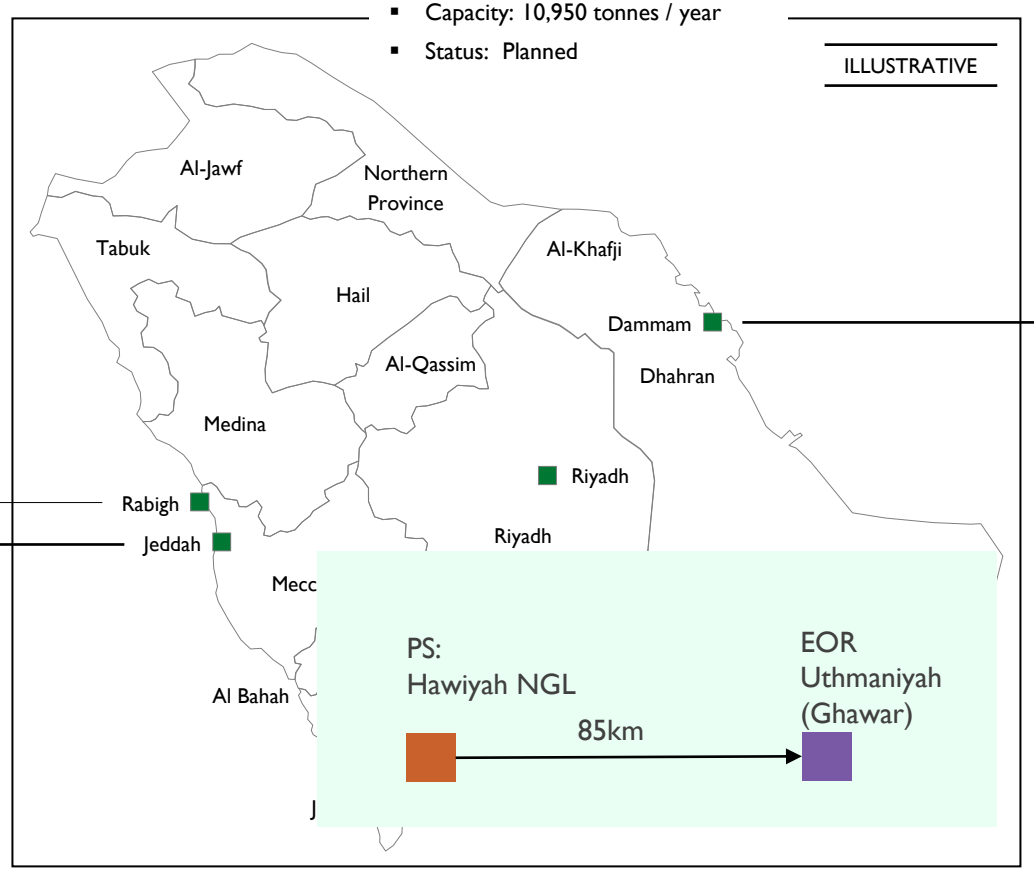
KAUST, ENOWA, SEC Project
- Developer: Unannounced
- Capacity: 10,950 tonnes / year
- Status: Planned

Ma'aden Project
- Developer: Gulf Cryo
- Capacity: 300,000 tonnes / year
- Status: Planned

Petro Rabigh Project
- Developer: Gulf Cryo
- Capacity: 109,500 tonnes / year
- Status: Operational

Gulf Cryo Jeddah Project
- Developer: Gulf Cryo, Tecno Industrial Projects, and SIAD Group
- Industry: Beverages
- Capacity: 250,000 tonnes / year
- Status: Operational

SIBCO Project
- Developer: Gulf Cryo
- Industry: Beverages
- Capacity: 35,000 tonnes / year
- Status: Operational since 2016



SABIC CO_2 Capture Project
- Developer: Gulf Cryo
- Industry: Beverages
- Capacity: 55,000 tonnes / year
- Status: Operational since 2013

Oxy – Combustion of HFL
- Developer: Aramco, Net Power, and General Electric
- Industry: Petrochemicals
- Capacity: 30-60 MW pilot project; 90% CO2 capture for EOR; 50% NOx emissions reduction
- Status: Completed 15 MWh pilot testing; plan for 60 MWh demonstration at a Saudi Aramco refinery with process synergies

Uthmaniyah CO_2 – EOR Project
- Developer: Aramco
- Industry: Petrochemicals
- Capacity: 0.8 MT / year
- Status: Operational since 2015

Huge economic potential in blue hydrogen (low-carbon hydrogen), with cost of producing blue hydrogen falling from $1.34/kg to $1.13/kg by 2030.

Sources: Internal Research and Analysis

Qatar's profile: CCUS projects

Project	Capture Capacity	Use	Developer	Status
Ras Laffan CO_2 Recovery and **Sequestration Project**	2.1 million tCO_2 / year	Acid disposal and storage	Qatar Petroleum (QatarEnergy)	Operational since 2019
North Field Expansion (NFE) CCUS Project	-	Liquified Natural Gas Production Expansion Plans	Chiyoda Corporation and Technip Energies	Operational by 2025
Qatar Fuel Additives Company Capture Project	180,000 tCO_2 / year	Petrochemicals (Methane) Production	Mitsubishi Heavy Industries	Operational since 2015
CO_2 Water Alternating Gas (WAG) Injection Pilot Project at Jaleha, Dukhan	500,000 tCO_2 / year	Enhanced Oil Recovery	ConocoPhillips	Planned

- **Hydrocarbons (mainly natural gas and LNG) account for ~70% of Qatar's total government revenue.**
- The country holds 14% of world's total natural gas reserves as of 2021.
- Qatar is the world's largest LNG exporter (2025), with export capacity expected to increase to 110 MTPA by 2025, from current levels of 78 MTPA.
- Carbon captured from large-scale CCUS projects is mainly used for enhanced oil recovery across maturing fields and acid gas re-injection.
- **CCUS is not a major part of Qatar's Vision 2030, but is considered an integral component to its overall climate plans.**
- The country's drive for CCUS is also supported by broader climate diplomacy and foreign policy directives.

Sources: Internal Research and Analysis

Kuwait's profile: CCUS projects

Project	Capture Capacity	Use	Developer	Status
Gulf Petrochemicals Industries CO_2 Recovery Project	55,000 tCO_2 / year	Petrochemicals Production	Gulf Cryo	Operational

- Hydrocarbons account for ~95% of Kuwait's total fiscal revenues
- The country is the 9th largest oil producer in the world, and holds 7% of the world's total oil reserves as of 2021.
- **CCUS interest in Kuwait is very low**, as renewable energy policies and target are yet to be fully enforced.
- Under Kuwait's Vision 2035, the country has some energy efficiency aims (such as lowering electricity demand), but these are repeatedly delayed due to internal political opposition.

Sources: Internal Research and Analysis

Bahrain's hydrogen profile: CCUS projects

Project	Capture Capacity	Use	Developer	Status
Gulf Petrochemicals Industries CO_2 Recovery Project	160,000 tCO_2 / year	Petrochemicals, Urea, and Methanol Production	GPIC and Masdar	Operational since 2010

- Bahrain is still primarily a hydrocarbon-dependent economy with 80% of fiscal budget dependent on oil & gas revenues.
- The country's economy is more diversified than Kuwait.
- The country's energy portfolio is managed by Bahrain Petroleum Company (BAPCO) and includes the onshore Awali oilfield and the offshore Abu Sa'afah oilfield.
- Even though CCUS recognition is slow-paced, Bahrain intends to expand the CCUS recognition especially in order to manage GHGs under the Bahrain Vision 2030
- Bahrain was the first country in the Middle East to deploy a CCUS industrial capture facility.
- **Bahrain announced plans to study the implementation of CCUS for aluminium smelting.**
- Currently, Nogaholding is studying the feasibility of developing one of the world's largest CCUS projects, based on depleted onshore natural gas reservoirs.
  - Preliminarily estimates envisage a CCUS facility that could potentially store 10 – 12 million tonnes / year of CO_2.

Sources: Internal Research and Analysis

Exports to EU – CBAM, Policy. Part of "fit-for-55"

- The EU Carbon Border Adjustment Mechanism (CBAM) will enter into force on January 1, 2026 after a transition period that started in October 2023.
- The CBAM covers iron and steel, aluminum, cement, **fertilizers** and electricity..
- CBAM could have a significant impact on the competitiveness of MENA.
- The Commission will also investigate **including indirect emissions** to the requirements
- Clear signals: by 2030 EU plans to extend CBAM to cover oil refining and upstream
- UAE and KSA: balance of trade with EU

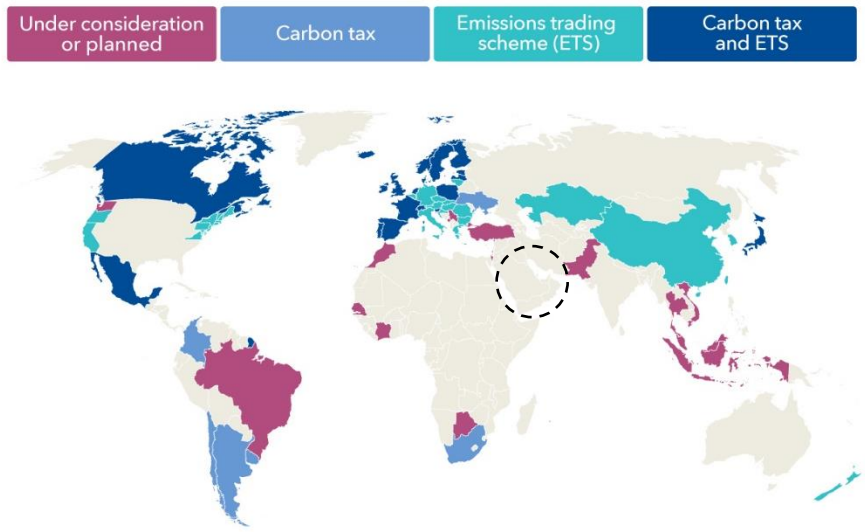
CBAM is an example directionally of changes that could be on the horizon for natural gas, crude and petroleum products.

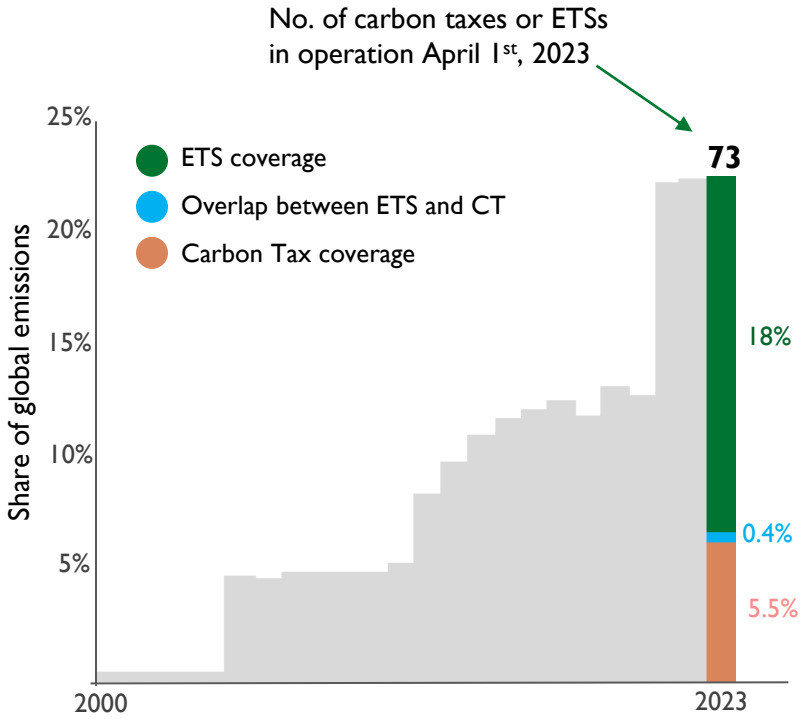
The policy is, in effect, a tariff intended to compensate for the fact that foreign firms may face no carbon price, or one that is lower than Europe's.

The GCC could introduce a Gulf - ETS (GETS) targeting largest emitters to incentivise the deployment of low-carbon tech and limit CBAM exposure

Carbon price

Countries and states are choosing different approaches to carbon pricing based on their own national and economic circumstances and objectives.





Key Takeaway

- Most global jurisdictions do not have a **carbon pricing mechanism**;
- Only 11GT covered by ETS and/or CT
- Even in the EU, the ETS was launched in 2005 but the price only consistently exceeded US$ 50 per tonne from mid-2021 onwards.
- The US introduced the 45Q tax credit only increased it to levels high enough to encourage CCUS in 2018. Start by 2033.
- So there has been almost no direct economic incentive for CO_2 storage, and there still is not to this day in most parts of the world, incl the MENA region

Sources: World Bank, IMF

Contacts and Disclaimer

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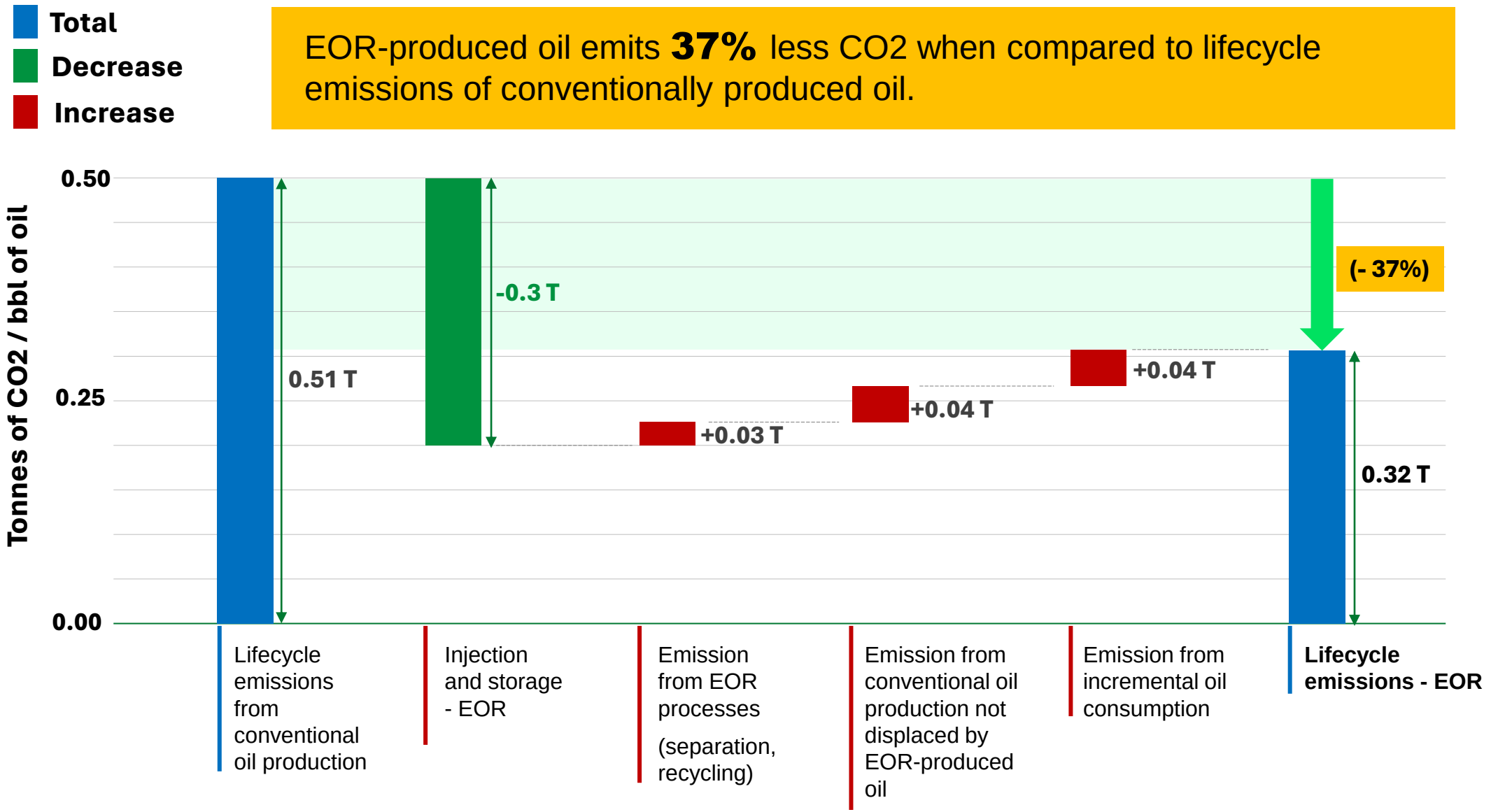
Thank you.

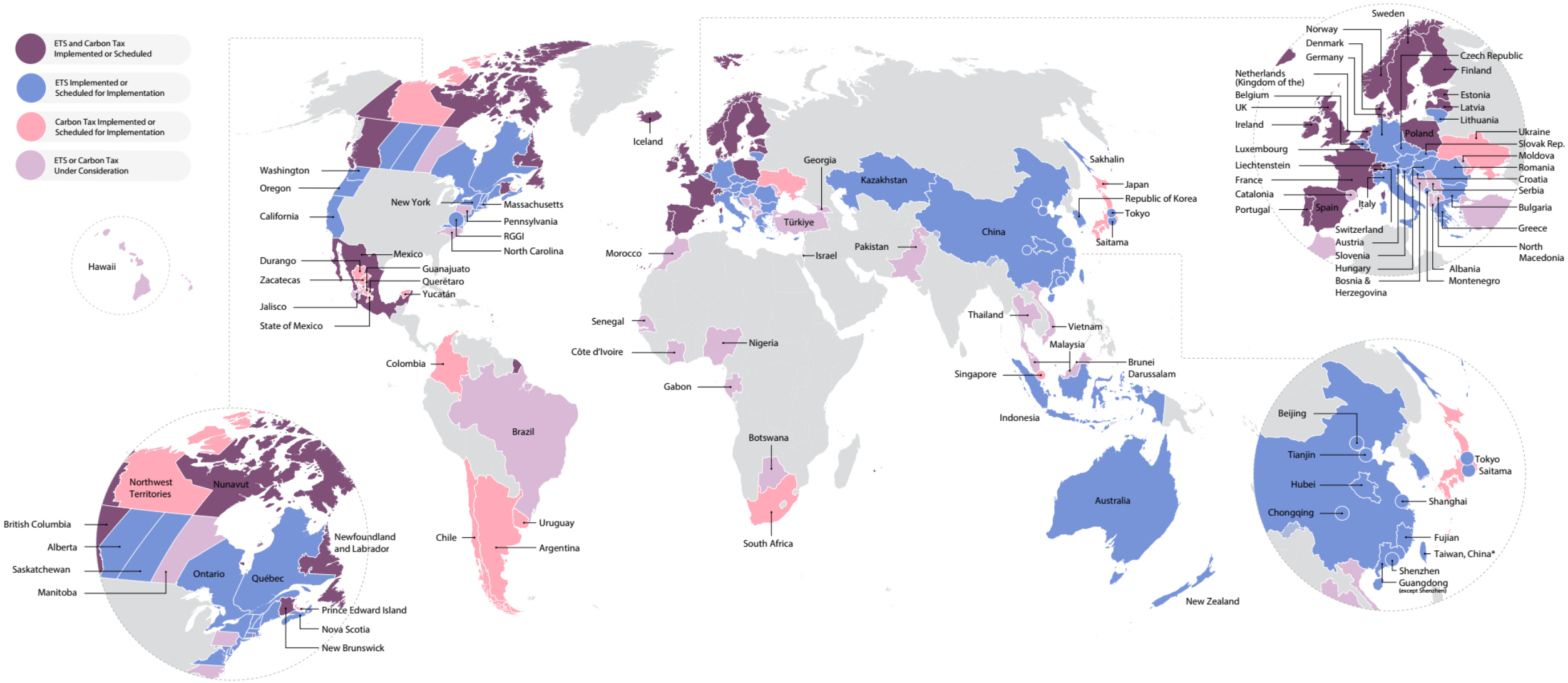
The Maths of CCUS – EOR. Lifecycle Method

EOR-produced oil emits **37%** less CO2 when compared to lifecycle emissions of conventionally produced oil.



Clean Air Task Force, LAVAUX Analysis

Map of Carbon Taxes and ETSs



World Bank report 2023