

Building Momentum for CCS in the Gulf Region and Around the Globe

PRESENTERS:

GULOREN TURAN, GCCSI, GENERAL MANAGER – ADVOCACY

ROBIN MILLS, CEO, QAMAR ENERGY

TIDJANI NIASS, SAUDI ARAMCO, TECHNOLOGY STRATEGY AND PLANNING

AAESHA AL KEEBALI, ADNOC, RESERVOIR ENGINEERING

MODERATED BY:

JEFF ERIKSON, GCCSI, GENERAL MANAGER – CLIENT ENGAGEMENT



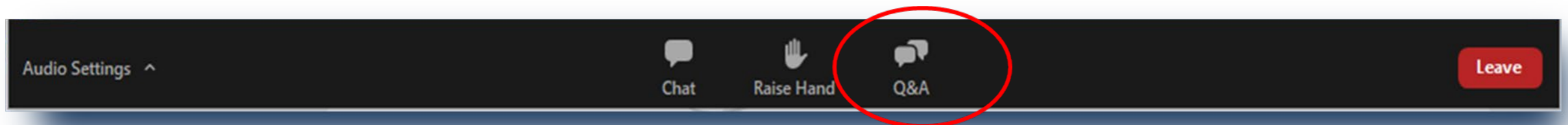
GLOBAL CCS
INSTITUTE

THE GLOBAL STATUS OF CCS



Before we start

- We will collect questions during the presentation.
- Moderator will pose questions to the presenters after the presentation.
- Please submit your questions through Q&A on Zoom control panel:



Agenda

- Welcome/Introduction – Jeff Erikson, GCCSI
- The Global Status of CCS – Guloren Turan, GCCSI
- CCS in the Gulf Region
 - Regional Overview – Robin Mills, Qamar Energy
 - Saudi Arabia – Tidjani Niass, Saudi Aramco
 - United Arab Emirates – Aasha Al Keebali, ADNOC
- Questions and Answers – Panel discussion
- Wrap-up – Jeff Erikson, GCCSI

THE GLOBAL STATUS OF CCS



THE GLOBAL STATUS OF CCS

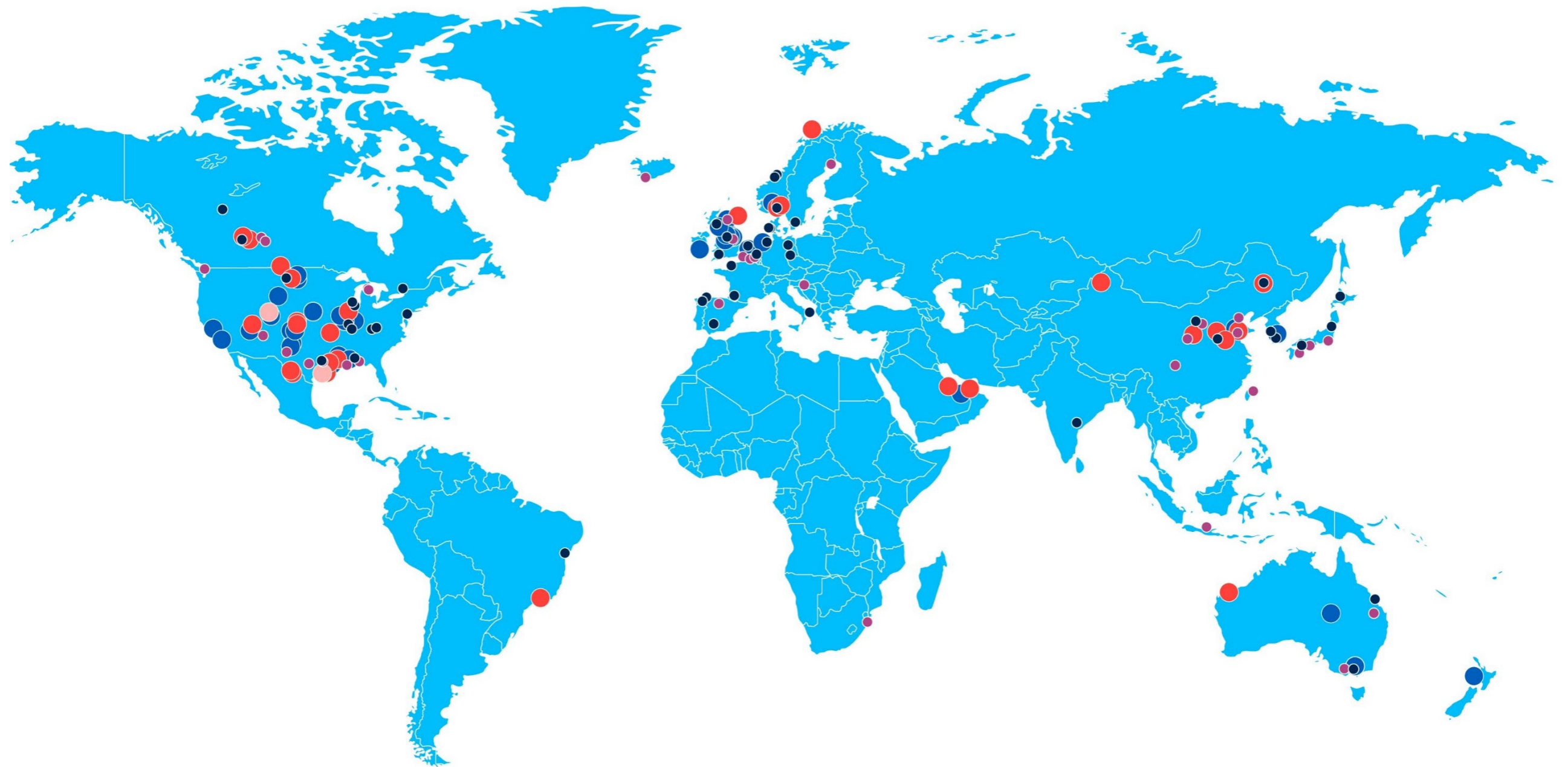
- In 2020, the pipeline of operational and under development CCS facilities continued to grow third year in a row.
- Number of countries, cities and companies committing to net-zero climate targets increased in 2020 despite the adversities faced, accelerating CCS development.
- Policy and funding support for CCS continued its momentum, most notably in the US, UK, Norway, EU, Japan and Australia.
- Three factors are enhancing the business case for CCS around the world:
 - Enhanced tax credit in the US
 - Hubs and clusters
 - Hydrogen, as the fuel of the future
- Despite the progress in 2020, to achieve net-zero emissions, CCS capacity must increase more than a hundredfold by 2050.

GLOBAL CCS FACILITIES UPDATE

MATURING INDUSTRY RESULTS IN UPDATED CLASSIFICATION SYSTEM

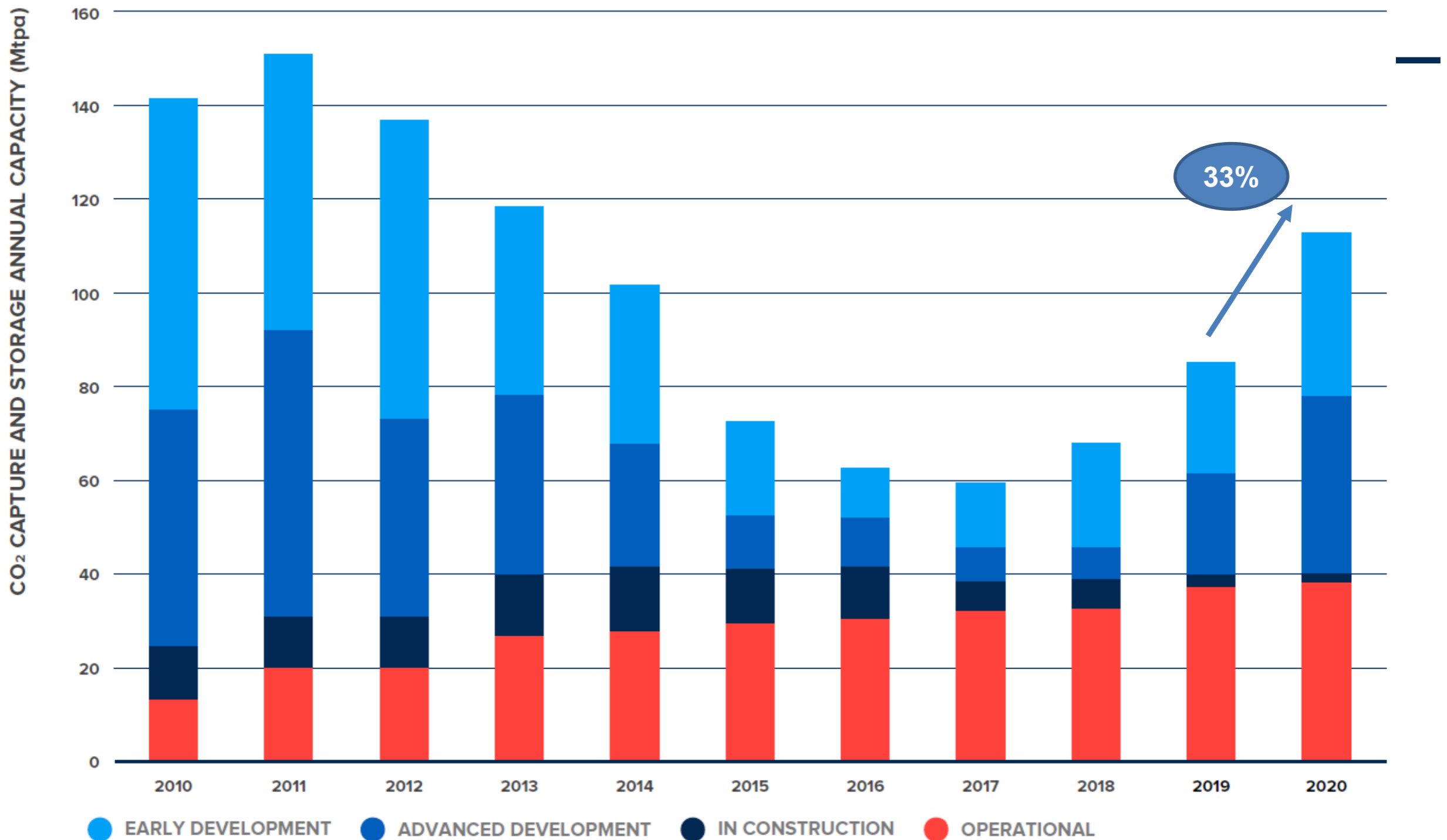
- New system introduced : classifies CCS facilities as 'Commercial' or 'Pilot and Demonstration'.
- 65 commercial CCS facilities operational or under development: 26 operating, three under construction, 34 under development, 2 with operations suspended.
- 17 totally new commercial facilities added in 2020; 12 of these are in the US.
- All facilities (operational and under development) have cumulative maximum capture capacity of around 115 million tonnes of CO₂ per annum.
- Almost 40 million tonnes of CO₂ captured annually from 26 commercial CCS facilities currently in operation.

CCS FACILITIES: OPERATIONAL & VARIOUS STAGES OF DEVELOPMENT



- COMMERCIAL CCS FACILITIES IN OPERATION & CONSTRUCTION
- COMMERCIAL CCS FACILITIES IN DEVELOPMENT
- OPERATION SUSPENDED
- PILOT & DEMONSTRATION FACILITIES IN OPERATION & DEVELOPMENT
- PILOT & DEMONSTRATION FACILITIES COMPLETED

UPWARD MOMENTUM CONTINUES: COMMERCIAL CCS FACILITIES PIPELINE



THE CAPACITY OF FACILITIES WHERE OPERATION IS CURRENTLY SUSPENDED IS NOT INCLUDED IN THE 2020 DATA.

COMMERCIAL CCS FACILITIES IN VARIOUS POWER AND INDUSTRIAL APPLICATIONS

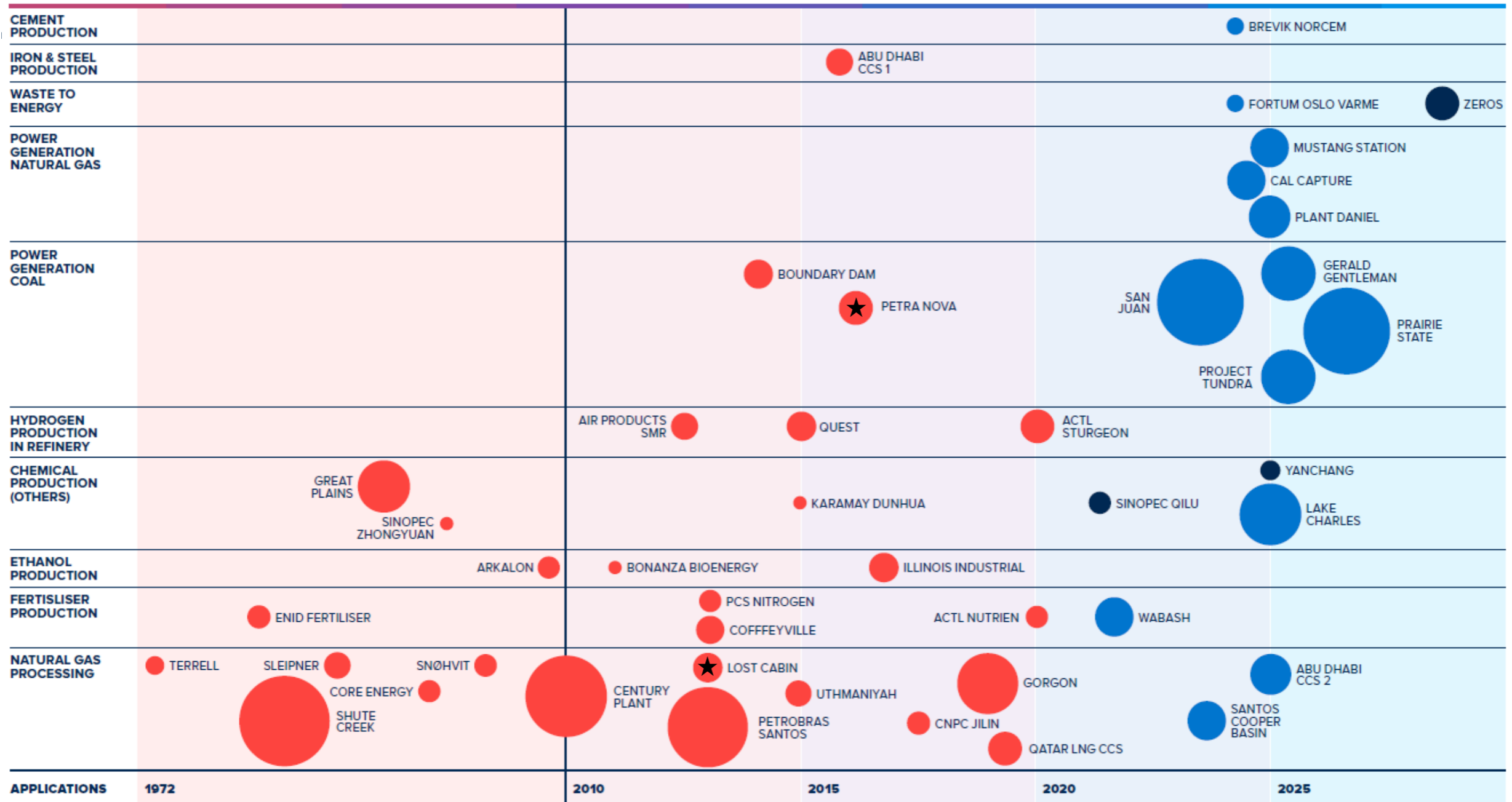
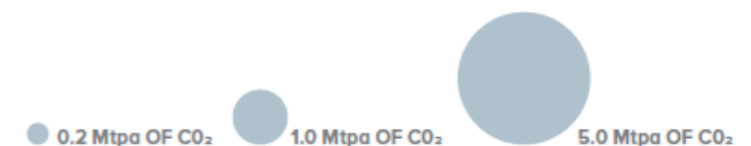


Chart indicates the primary industry type of each facility among various options.

- IN OPERATION
- IN CONSTRUCTION
- ADVANCED DEVELOPMENT
- ★ OPERATION SUSPENDED

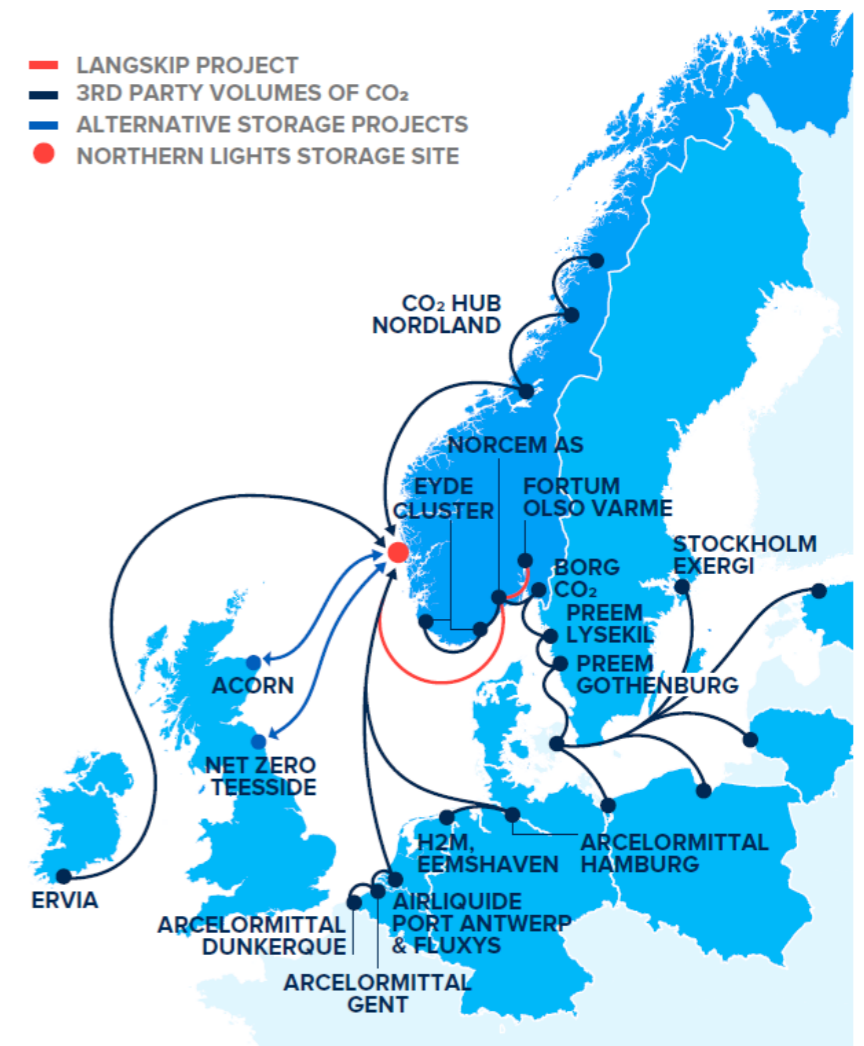
Size of the circle is proportionate to the capture capacity of the facility.



CCS HUBS

HUBS AND CLUSTERS ARE TAKING OFF GLOBALLY

- Multiple industrial point sources of CO₂ connected to a CO₂ transport and storage network.
- Access to large geological storage resources with the capacity to store CO₂ from industrial sources for decades.
- Economies of scale deliver lower unit-costs for CO₂ storage.
- Synergies between multiple CO₂ sources and the storage operator reduce cross chain risks and support commercial viability.



**Northern Lights Project –
Potential Sources Of CO₂**

CCS HUBS AND CLUSTERS: OPERATING OR IN DEVELOPMENT

STORAGE TYPE

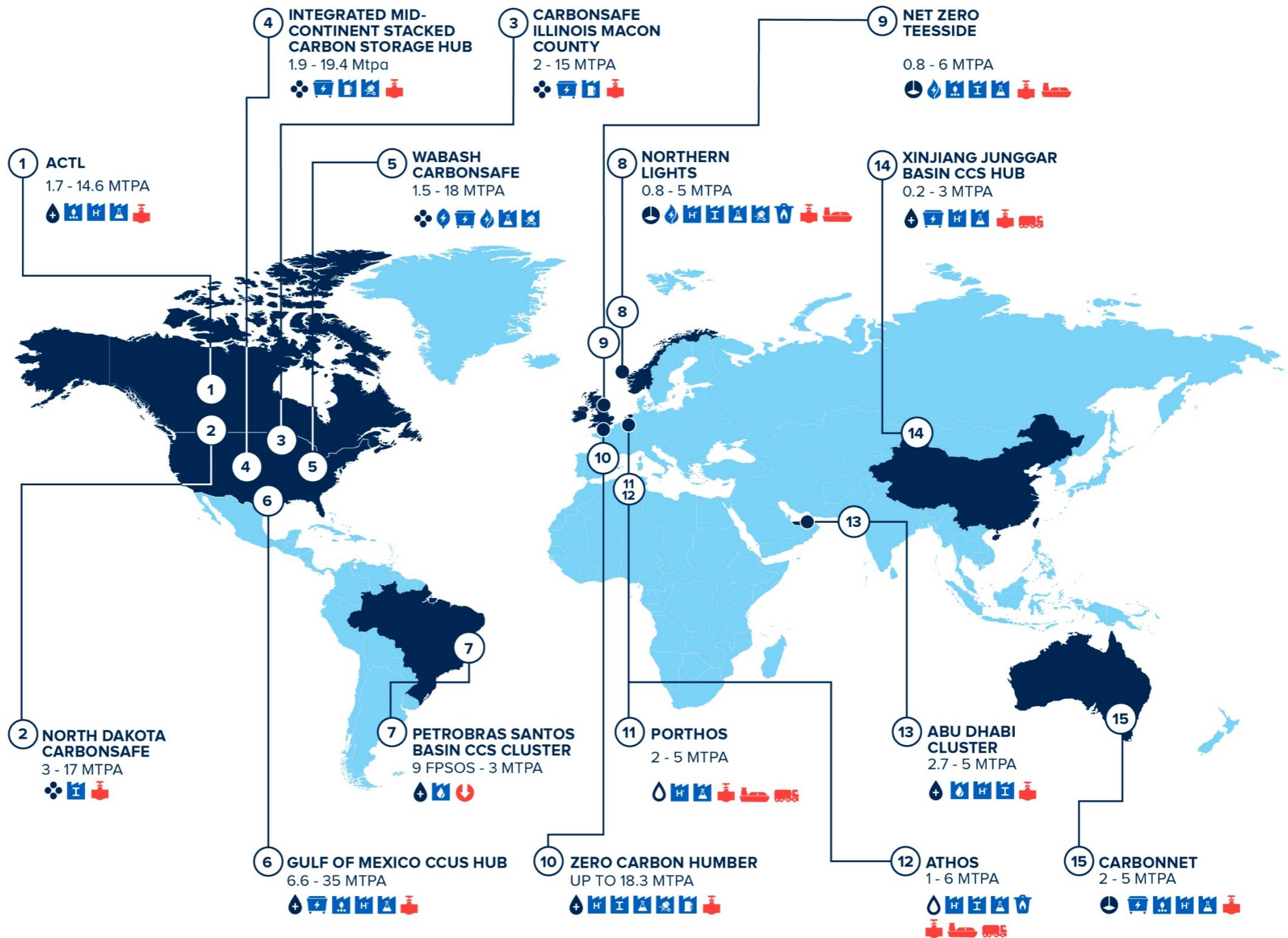
- DEEP SALINE FORMATIONS
- ENHANCED OIL RECOVERY
- DEPLETED OIL & GAS RESERVOIRS
- VARIOUS OPTIONS CONSIDERED

INDUSTRY SECTOR

- COAL FIRED POWER
- NATURAL GAS POWER
- NATURAL GAS PROCESSING
- FERTILISER PRODUCTION
- HYDROGEN PRODUCTION
- IRON & STEEL PRODUCTION
- CHEMICAL & PETROCHEMICAL PRODUCTION
- CEMENT PRODUCTION
- WASTE INCINERATION
- ETHANOL PRODUCTION
- BIOMASS POWER

DELIVERY

- PIPELINE
- SHIP
- ROAD
- DIRECT INJECTION



AMERICAS

NEW PROJECTS AND POLICY PROGRESS IN THE REGION

- 12 new commercial CCS projects added to our database in the Americas in 2020. 36 commercial facilities operating or in development, plus two currently idled.
- US: New projects largely incentivised by 45Q tax credit and the California Low Carbon Fuel Standard (LCFS). U.S Congress allocated \$217.8 million for CCUS development.
- Canada: Alberta Carbon Trunk Line began operating; a hub and cluster that saw over \$550 million in provincial and federal funding.
- Brazil: Offshore projects in Brazil continue, capturing over 14M tonnes of CO₂ to date.



EUROPE

CCS MOMENTUM ACROSS EUROPE

- 13 commercial facilities in operation or various stages of development across Europe.
- First call for projects under the EU's €10 billion Innovation fund; expected to be a major source of funding for CCS across the EU.
- The United Kingdom is set to establish the first net zero industrial cluster, with 1 billion pounds allocated to support CCS development.
- The Norwegian Government has moved forward with \$1.8 billion investment to further CCS development.



€10B

GULF COOPERATION STATES

GCC STATES EMERGING AS IMPORTANT FOR CCS DEVELOPMENT

- 3 CCS facilities in operation in the Gulf States, capturing 3.7 Mtpa of carbon dioxide.
- Circular carbon economy: CO₂ emissions are managed through a holistic approach to climate mitigation, including carbon removal.
- The development of up to 30 GT of storage to support the region's climate plans.
- Saudi Arabia and the UAE have the largest emissions in the region, with power generation the biggest contributor.

3.7 Mtpa



ASIA PACIFIC

THE EMERGING POWERHOUSE FOR CCS DEPLOYMENT

- 10 CCS facilities in operation or in development across APAC countries.
- Regional collaboration between governments has boosted storage potential and knowledge.
- Singapore, Malaysia, and Australia have newly established CCS strategies.
- The Australian government has established a \$50 million CCUS development fund.



**SINGAPORE
MALAYSIA
CHINA
AUSTRALIA**

CCS: VITAL TO NET-ZERO

SIGNIFICANT CCS POLICY VITAL TO ACHIEVE GLOBAL CLIMATE TARGETS

- To achieve net-zero emissions, CCS capacity must increase more than a hundredfold by 2050.
- Stronger policy to incentivise rapid CCS investment is overdue.
- Policy priorities include:
 - Creating conditions for investment
 - Facilitating development of CO₂ infrastructure
 - Clarifying key legal and regulatory issues

2,000+ 
**LARGE-SCALE FACILITIES
REQUIRED BY 2050**

CCS.
VITAL TO ACHIEVE
NET-ZERO



The Global Status of CCS 2020 Report can be downloaded from
<https://www.globalccsinstitute.com/rglobalstatusreport/>



Building momentum for CCS in the Gulf Region

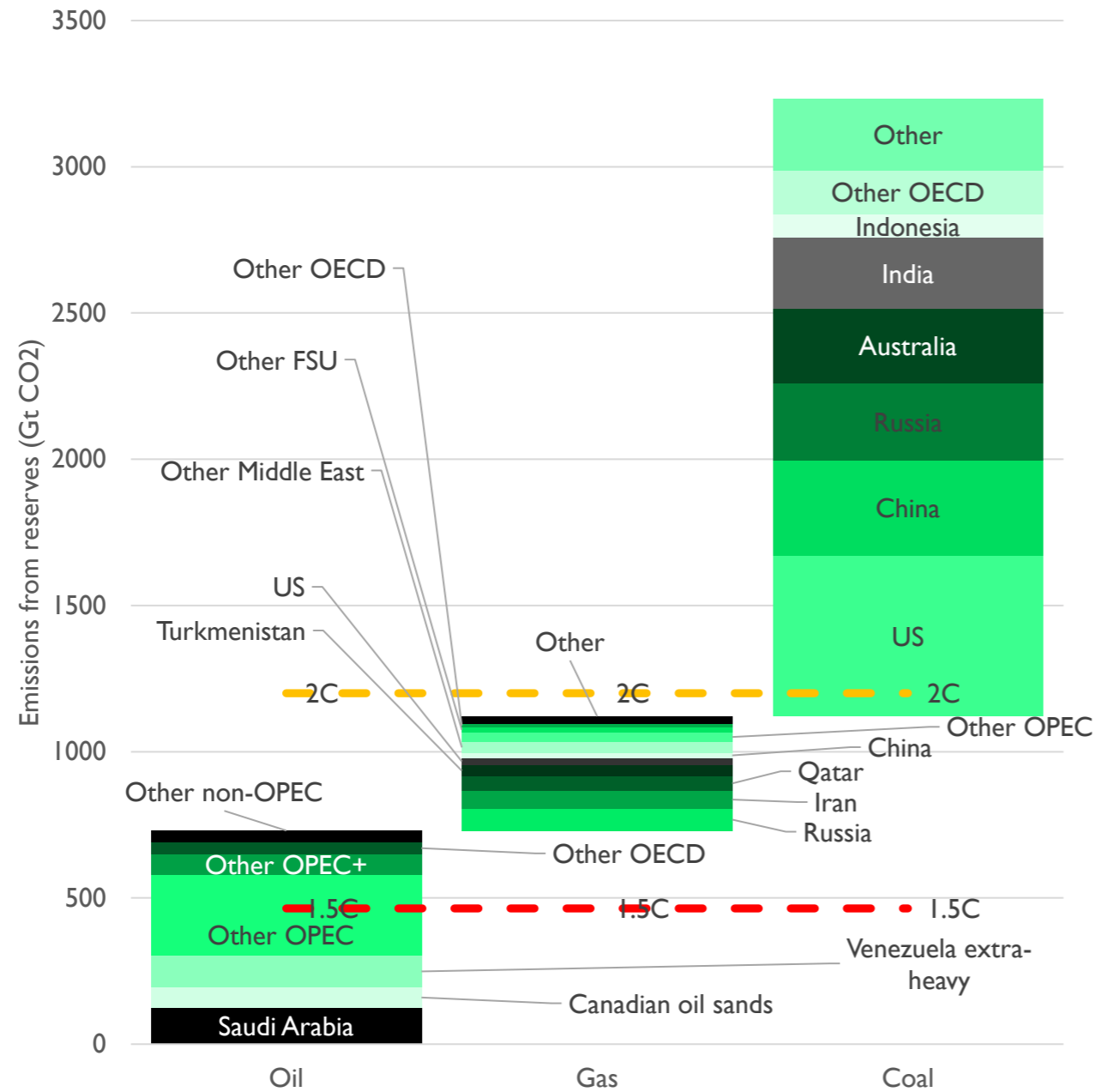
Presentation for the GCCSI Webinar

ROBIN MILLS | QAMAR ENERGY

23 February 2021

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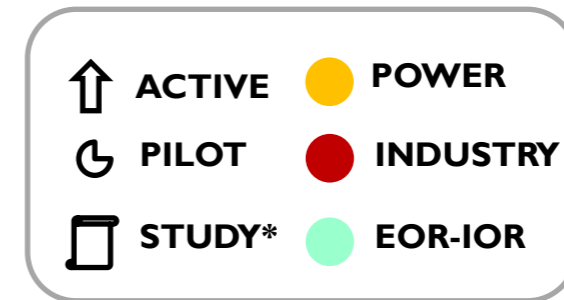
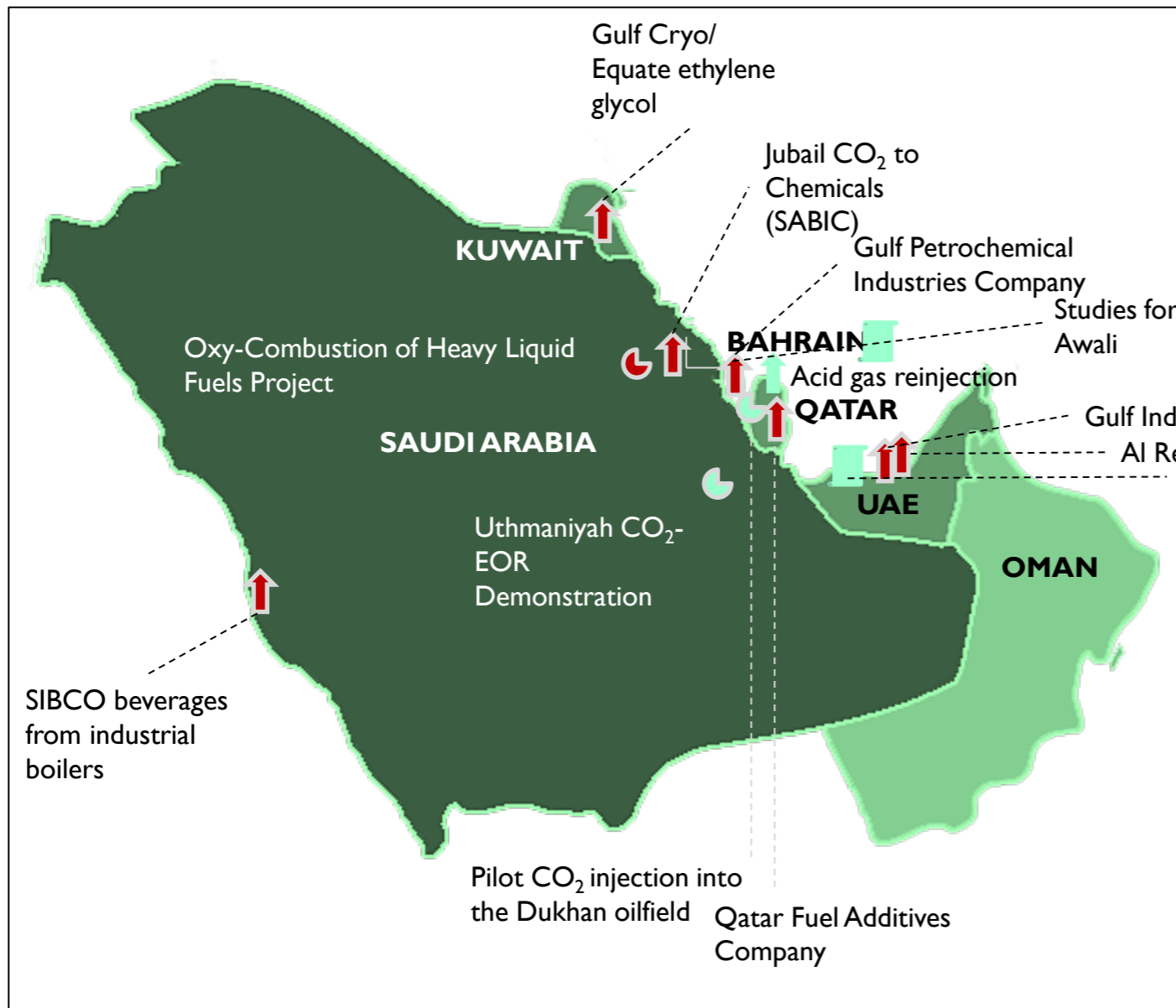
The scale of the challenge: >3200 Gt CO₂ of fossil fuel reserves, 460-1200 Gt of carbon budget



Options

- Focus on lower-emitting resources
- Non-emitting uses (e.g. petrochemicals)
- CCUS in end-use
- Bio-sequestration and BECCS
- Direct air capture

Limited existing CCUS operations in the GCC



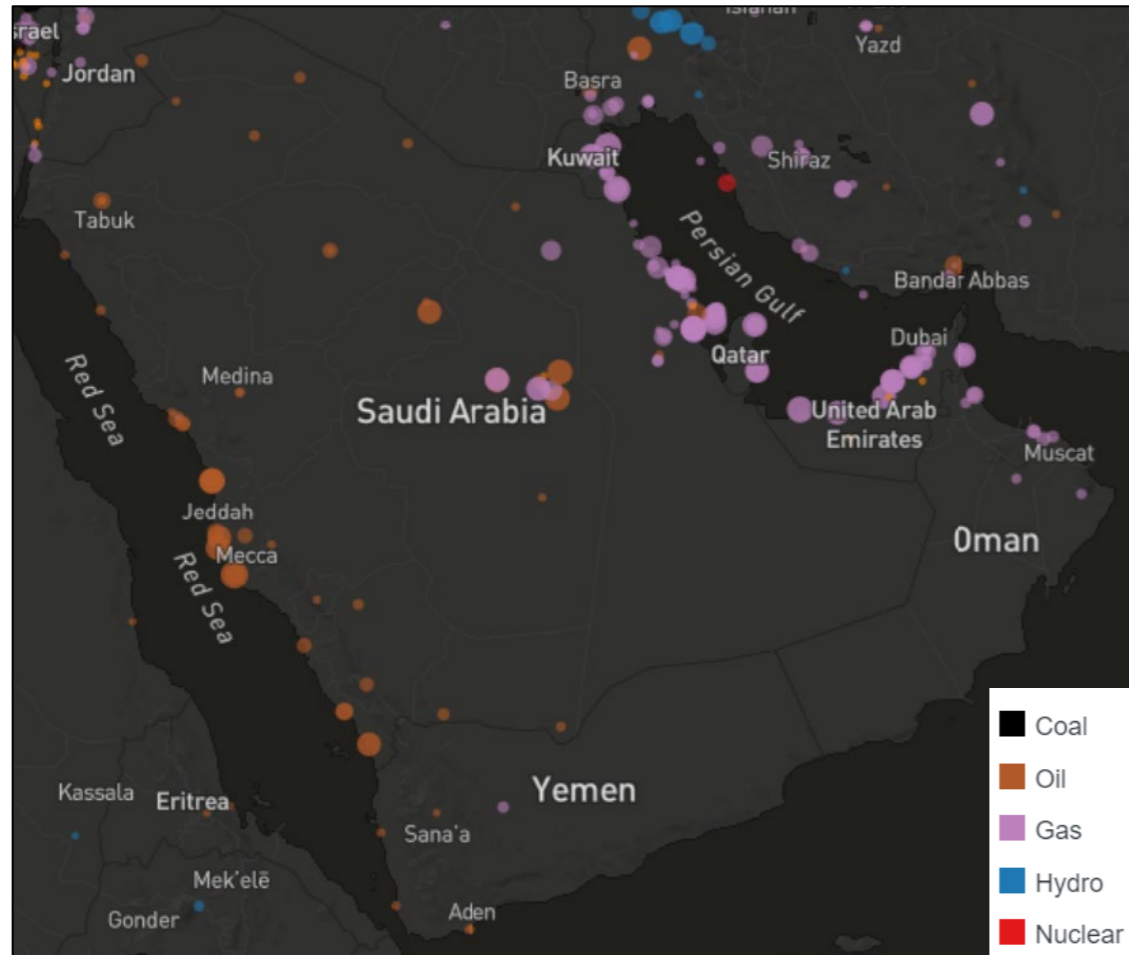
- Existing large projects are for CO₂- EOR
- Mid-scale plants for industry / chemicals
- Smaller plants for distribution to industrial, food & beverage, other users
- Ambitions
 - Saudi Arabia Circular Carbon Economy
 - Qatar CCS on LNG, 5 Mt/y by 2025 → 7 Mt
 - ADNOC 0.8 Mt/y → 5 Mt/y by 2030

Limited number of large point emitters improves CCUS feasibility

SECTOR	SUB-SECTOR	ESTIMATED LARGE POINT EMISSIONS, 2025, MT CO ₂					
		BAHRAIN	KUWAIT	OMAN	QATAR	SAUDI ARABIA	UAE
Power plants	○ Gas (gas turbine, steam turbine, CCGT)	13.3	31.1	12.3	20.7	169.8	38.0
	○ Oil (fuel oil, diesel, crude)	0	12.1	0.2	0	44.9	0
	○ Coal	0	0	7.7?	0	0	15.4
Petroleum industry	○ Gas processing ○ Oil refineries ○ LNG plants ○ Gas-to-liquid plants	1.2	9.9	17.4	13.4	68.9	12.0
Other industry	○ Iron and steel plants ○ Cement plants ○ Aluminium smelters ○ Chemical and fertiliser plants						

- Most regional large point emissions of CO₂ from the power sector, but heavy industry also important
- Clustered in oil-field / industrial areas (Jubail, Yanbu', Musaffah, Habshan, Ruwais, Jebel Ali, Ras Laffan, Sohar, etc.)
- Coal plants to start in UAE and ?Oman in 2020s
- Oil power, including IGCCs, still significant, mostly in Saudi Arabia

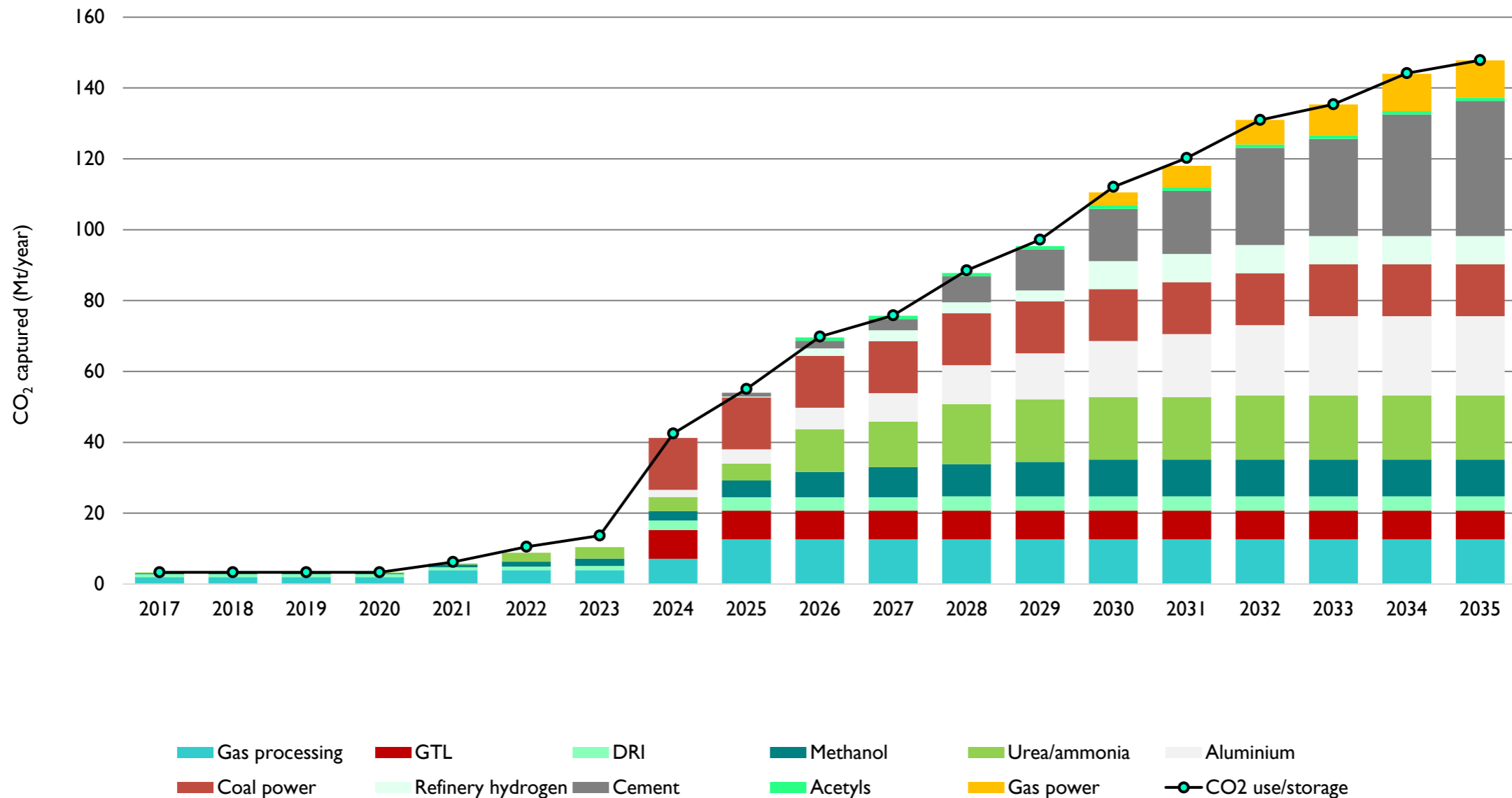
Limited number of large point emitters improves CCUS feasibility



- Power plants mostly clustered along the Gulf coast
- Close proximity to large onshore and offshore oil and gas fields
- Total upstream emissions from GCC-based oil and gas companies are equivalent to almost a third of the total emissions from the GCC
- These will increase by 20-30% in the next 10 years if no emission reduction initiatives are implemented
- US\$ 40-60 B investment in CCUS is required to reduce these emissions

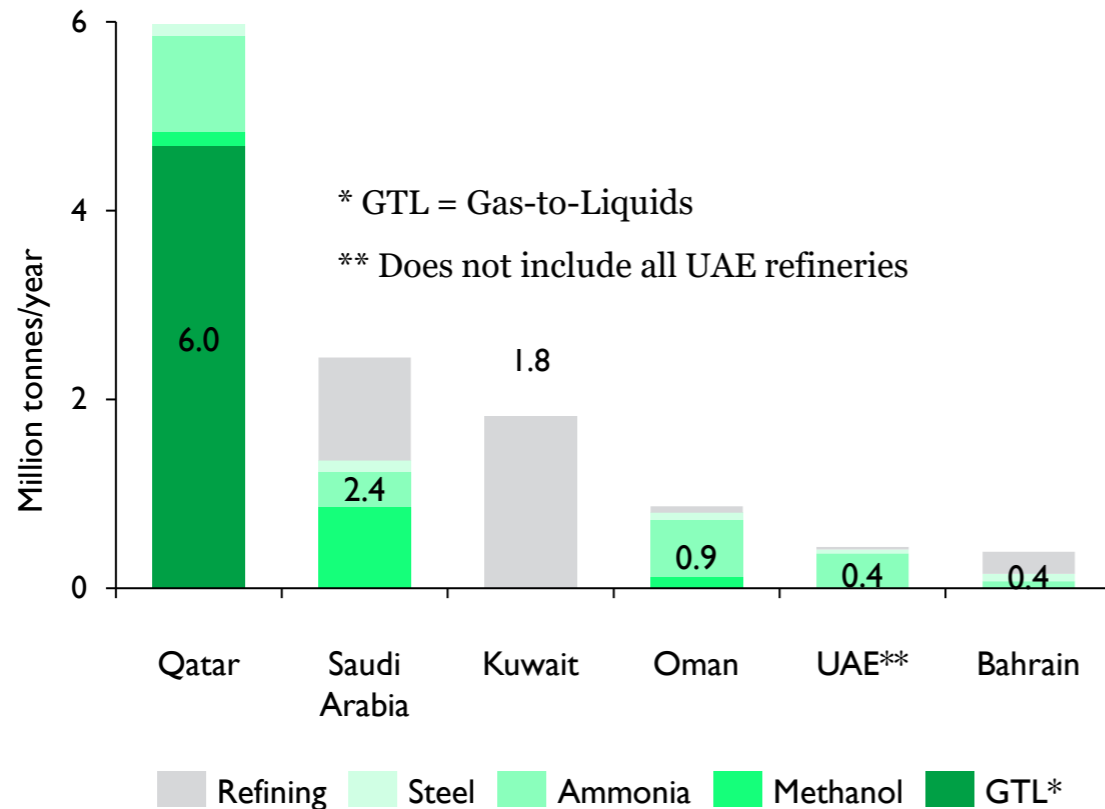
Major GCC technical potential for moderate cost CO₂ capture

Current plans suggest about 11 Mt/y CO₂ captured by 2026, about half for EOR

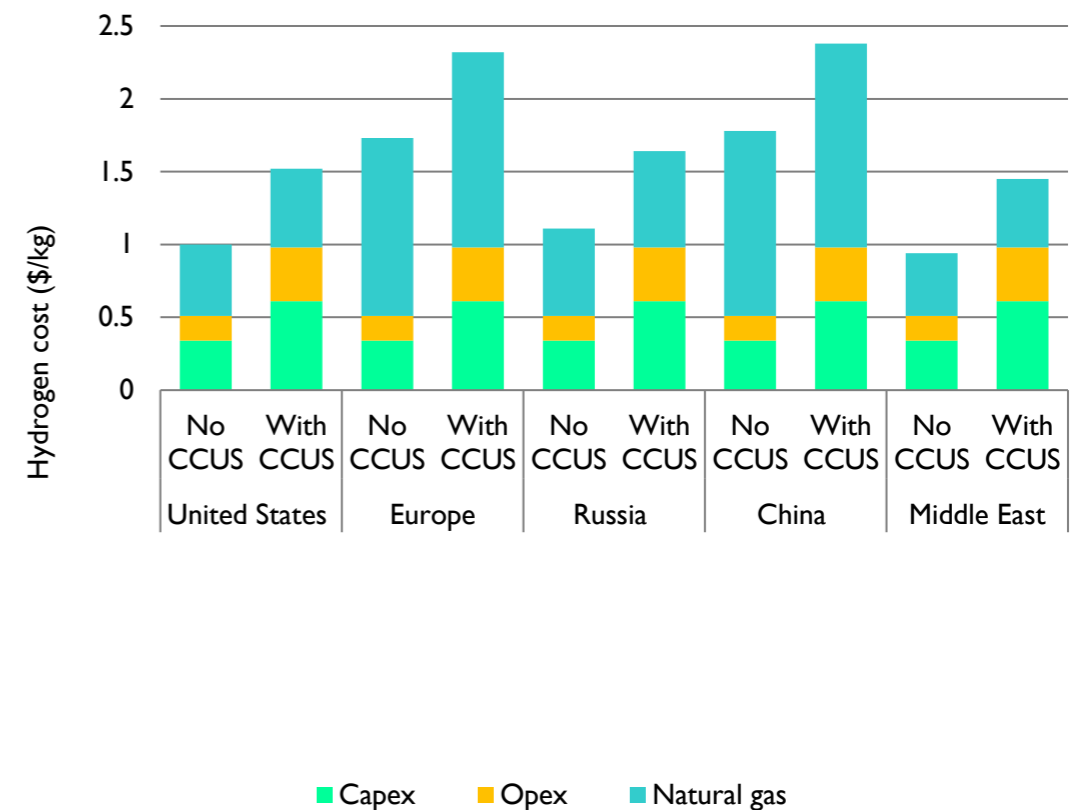


Middle East potential competitive advantage in blue hydrogen – with CCUS

GCC already uses large amounts of hydrogen in industry – but currently all ‘grey’



Blue and grey H₂ production costs by region



- Global annual hydrogen export market projected to reach US\$ 300 B by 2050, with global green hydrogen demand reaching 530 Mt
- MENA’s strategic location, high solar radiation, hydrocarbons production, carbon capture potential, and very low LCoEs should enable competitive hydrogen costs for export, both blue and green



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CCUS in the Gulf Region

View from Saudi Arabia

GCCSI Webinar, February 23, 2021

Tidjani Niass

Technology Strategy & Planning Department

Saudi Aramco

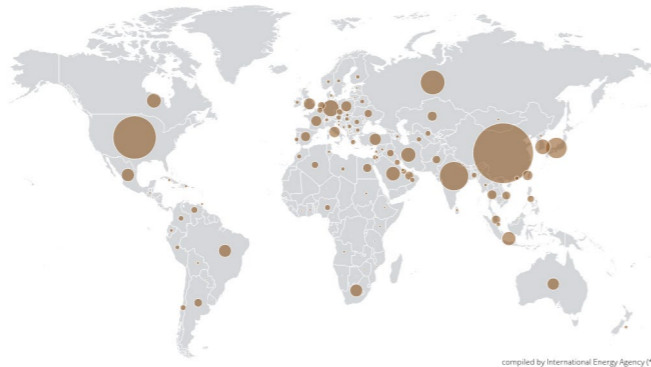
Saudi Arabia

energy & environmental challenges and opportunities

- **Energy Abundance**



- **Emissions**



- **Harsh and hot environment**



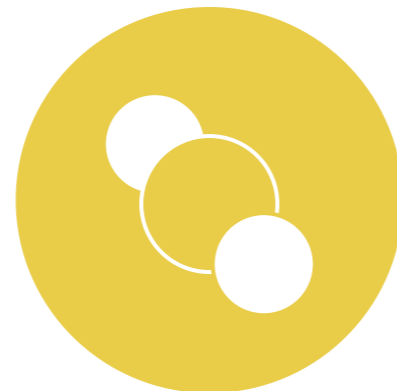
- CCUS aligns economic development aspirations and environmental imperatives
- Emissions management requires a holistic approach that integrate natural resources and environmental challenges

Circular Carbon Economy

offers a holistic and pragmatic approach to climate & energy



Reduce



Reuse



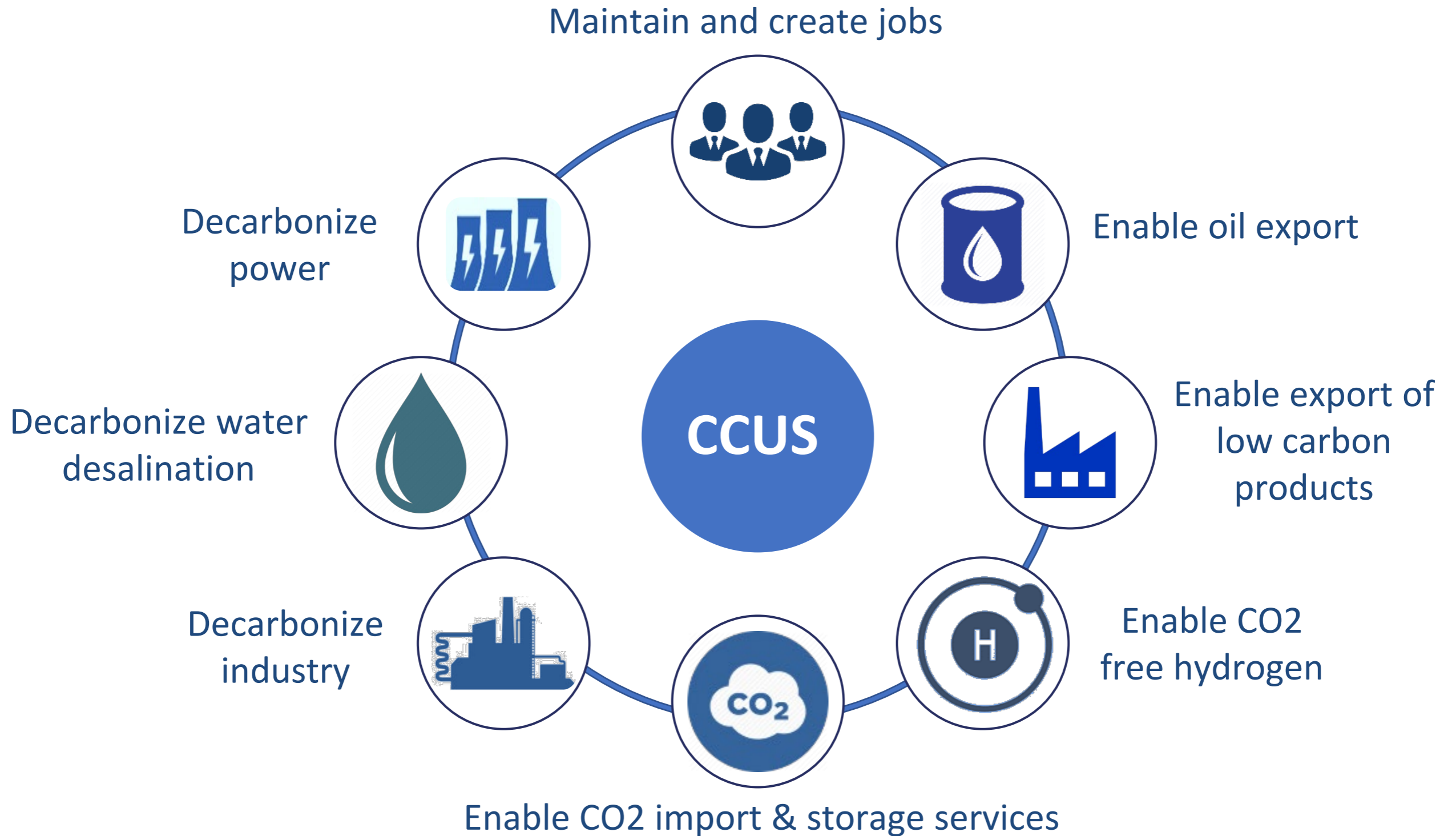
Recycle



Remove



CCUS can unlock significant values for Saudi Arabia, spanning: Climate, economic diversification and clean oil export



Saudi Arabia CCUS capabilities

Research, Technology, Policy Studies, Demonstration Pilots



أرامكو السعودية
Saudi Aramco

سابك
SABIC



KAPSARC
مركز الملك عبدالله للدراسات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center



جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

مدينة الملك عبدالعزيز
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وزارة الطاقة
MINISTRY OF ENERGY



MISSION
INNOVATION
accelerating the clean energy revolution



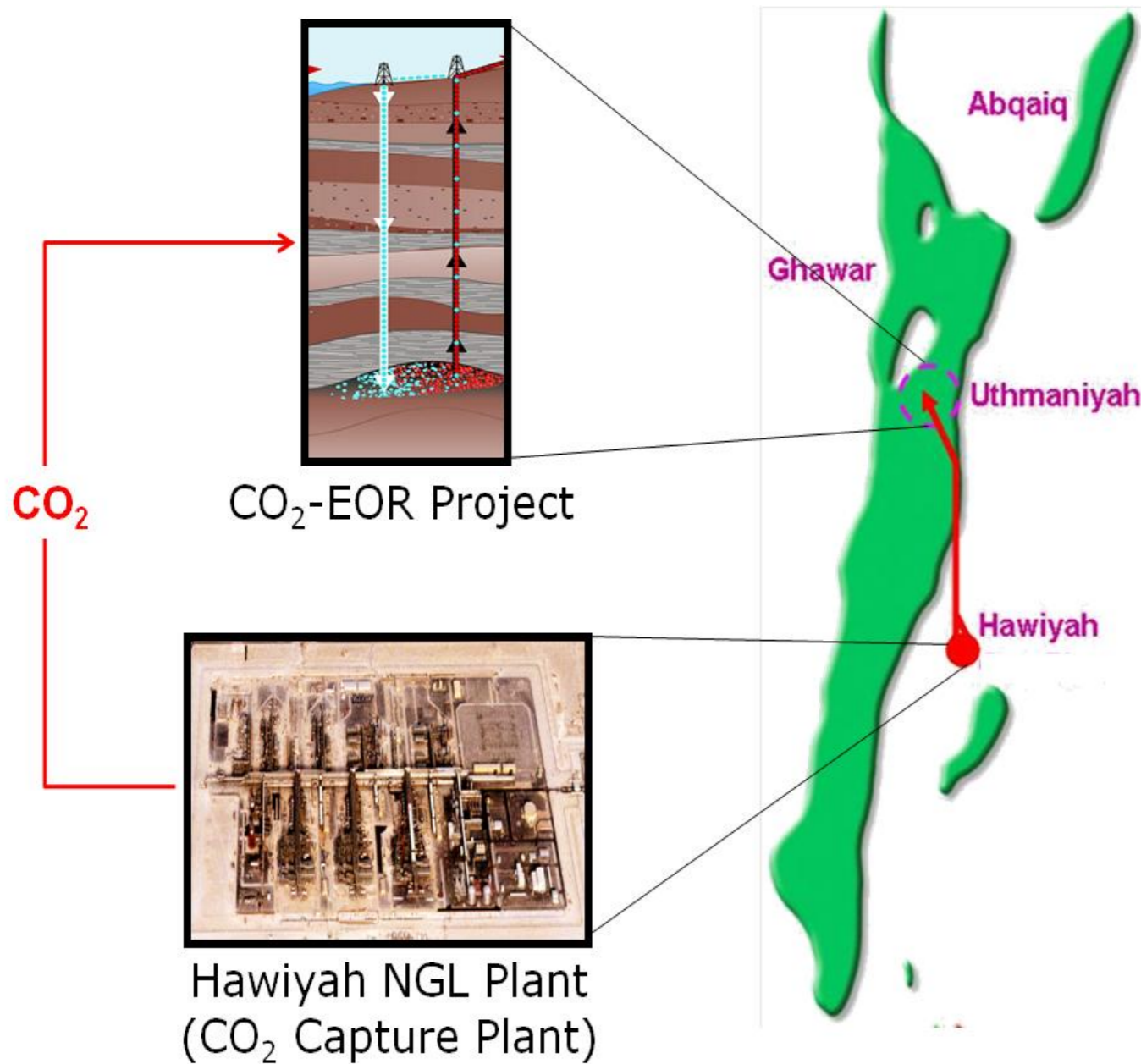
CO₂ CARBON CAPTURE,
UTILIZATION & STORAGE
ACCELERATING CCUS TOGETHER
AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL



carbon
sequestration leadership forum

Large scale CCUS plants in operation in Saudi Arabia

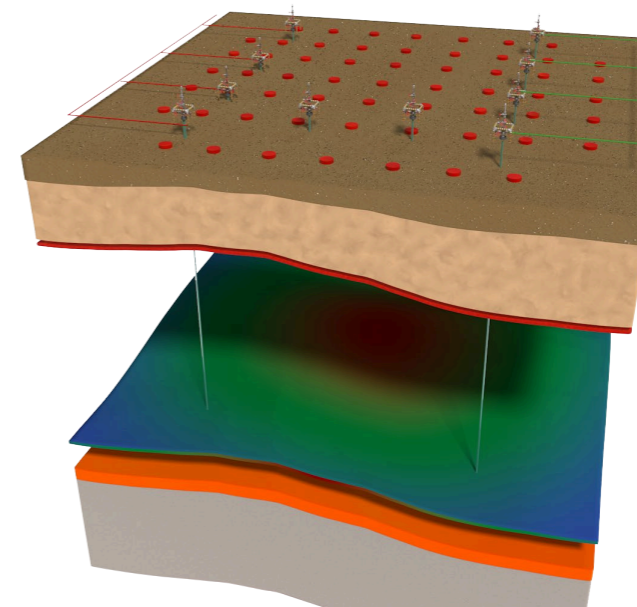
Uthmaniyah CO₂-EOR by Saudi Aramco



0.8 MMT CO₂/yr
Injected since 2015

85 km
pipeline CO₂ transport

Monitoring & Surveillance



Large scale CCUS plants in operation in Saudi Arabia

CO2 to Chemicals by Sabic



0.5 MMtCO₂/yr

Since 2015



Thank you

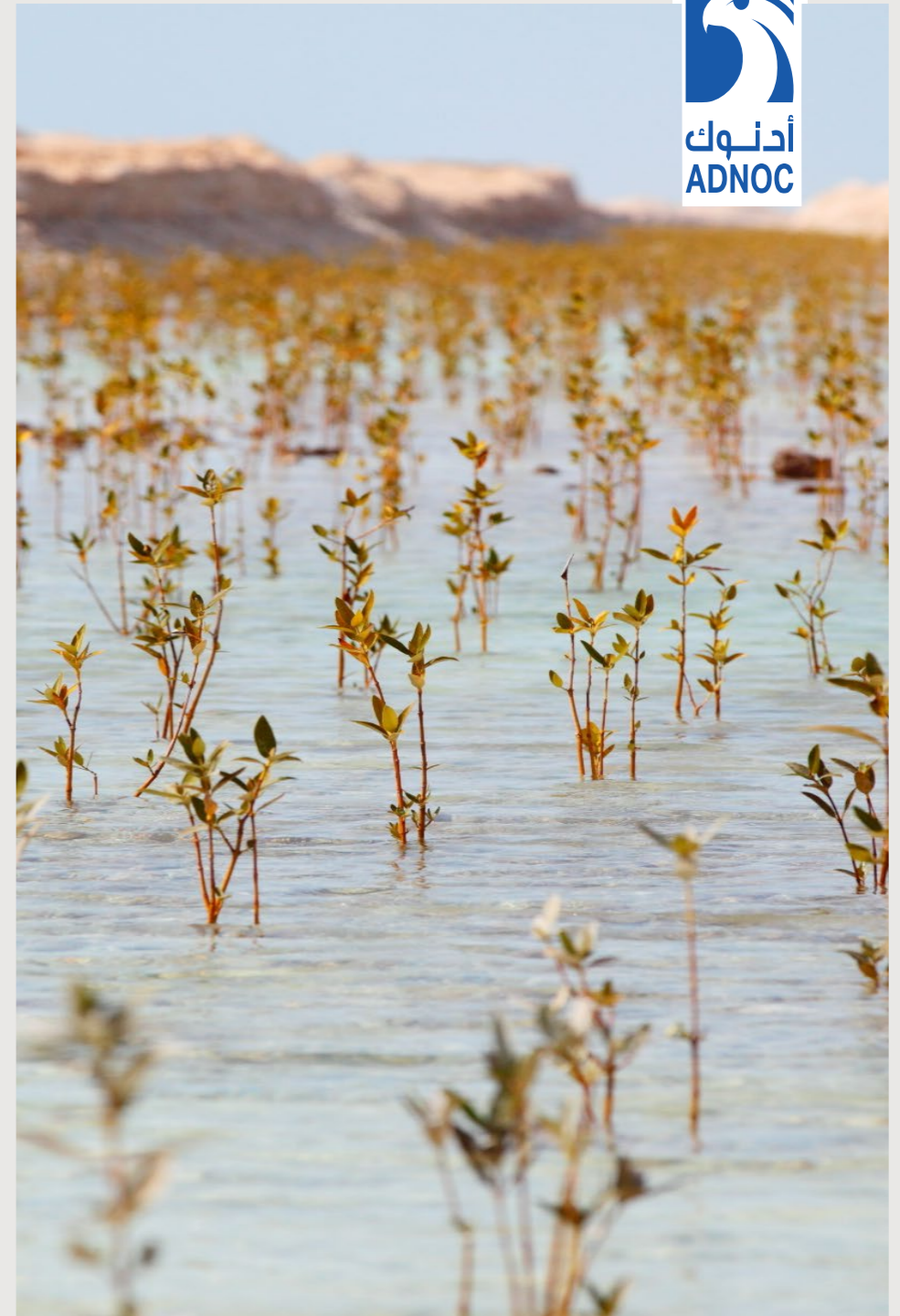
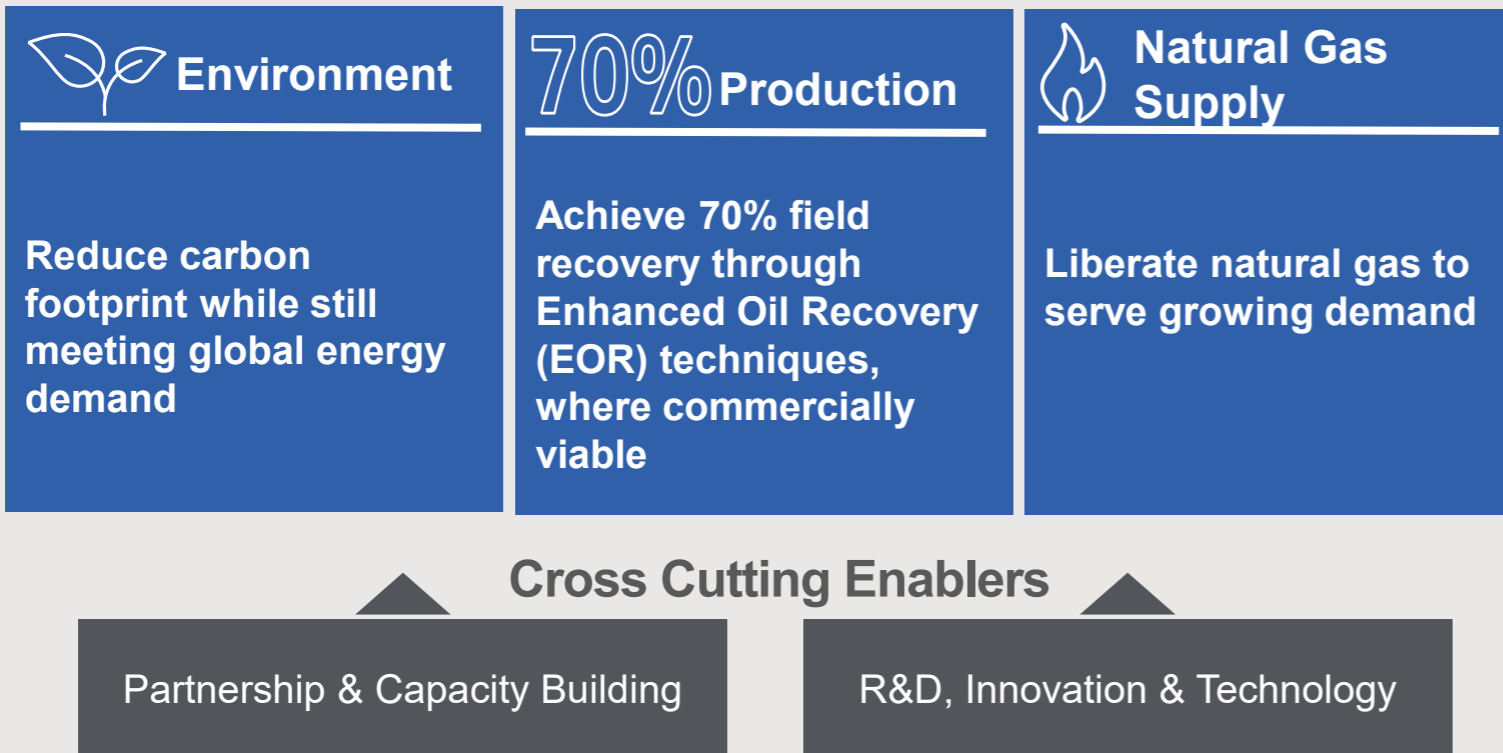


BUILDING MOMENTUM FOR CCUS IN THE GULF REGION AND AROUND THE GLOBE: ADNOC AND THE UNITED ARAB EMIRATES

AAESHA KHALFAN AL KEEBALI
SPECIALIST, RESERVOIR ENGINEERING
ENHANCED OIL RECOVERY DIVISION



OUR PRIMARY DRIVERS FOR CCUS



ADNOC CO₂ PROJECTS AT A GLANCE



2009-2011

CO₂ Rumaitha Pilot

- **1st Oil & Gas Company in Middle East to pilot CO₂ EOR injection**



2011-2016

AI Reyadah & CO₂ Expansion

- **Execution of ADNOC's AI Reyadah Project**
- **World's 1st commercial-scale CCUS facility capturing CO₂ from steel industry**
- **Largest CO₂ project in the region**



2016-2019

CO₂ Projects Assessments

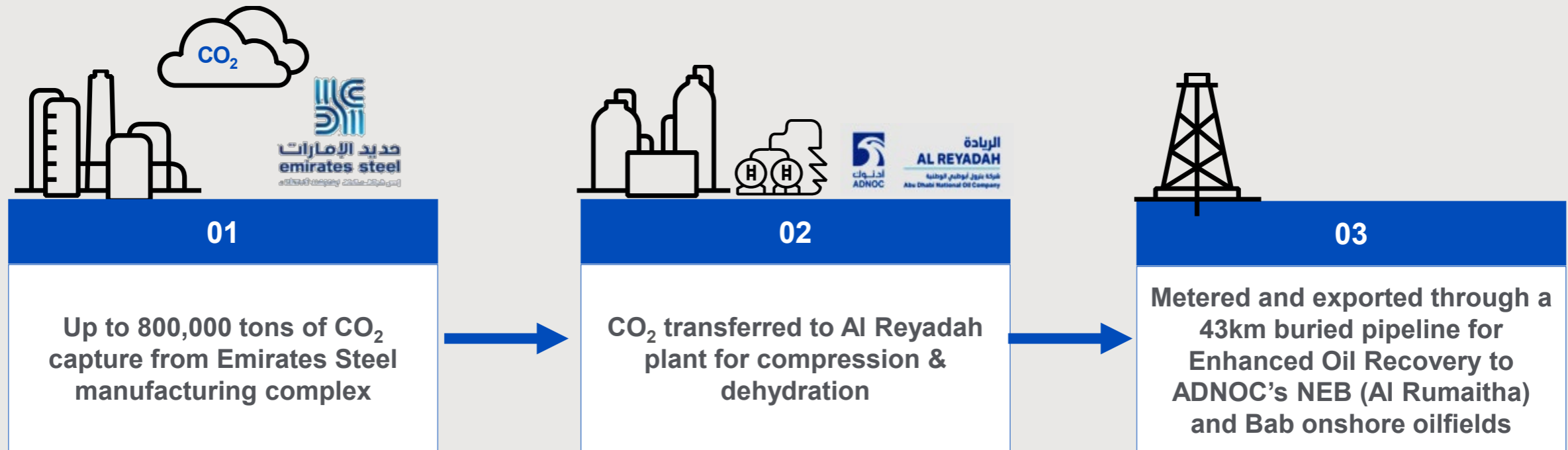
- **Production start-up in Bab & Rumaitha**
- **CO₂ added value with incremental oil production**
- **CO₂ strategy development**



2020-2030 CO₂ Deployment Strategy

- **Expected 6-fold increase in CO₂ demand**
- **Envisioned CO₂ Hub & Network**
- **CO₂ Technology Breakthrough & Partnership strategy**
- **1st industry hybrid concept of CO₂ injection with chemical planned**
- **Becoming one of the lowest cost and largest producers of blue hydrogen**

AL REYADAH – A WORLD FIRST



Objectives:

- Supply on-spec CO₂ for EOR
- Free-up critical natural gas
- Reduce carbon footprint

Unique Project:

- World's 1st fully-commercial CO₂ capture from iron & steel Industry
- Middle-East's 1st commercial-scale CO₂ capture plant, started in 2016
- Operating highest pressure (240 bar) CO₂ transfer pipeline in the world
- Addresses climate change by eliminating CO₂ equivalent to emissions of 170,000 automobiles
- Captures 0.8 MM tons/year (41 MMSCFD) of CO₂

ADNOC CCUS 2020-2030 SUPPLY PLANS

SHAH: 2.3 MILLION TONNES

Shah ultra-sour gas plant could enable over 2.3 million tonnes per year of CO₂ to be captured



HABSHAN & BAB: 1.9 MILLION TONNES

Habshan and Bab gas complex could enable the capture of 1.9 million tonnes of CO₂ per year





THANK YOU

Questions & Answers



UPCOMING EVENTS

25 February: EU Industry Week: CCS and Reaching Net-Zero Targets in Europe

Register: globalccsinstitute.com/news-media/events

Follow us: @GlobalCCS #CCSTalks

Further questions: webinar@globalccsinstitute.com

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THANK YOU

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