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
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 – Aaesha Al Keebali, ADNOC
- Questions and Answers – Panel discussion
- Wrap-up – Jeff Erikson, GCCSI
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.
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

<table>
<thead>
<tr>
<th>Application</th>
<th>1972</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
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<tr>
<td>CEMENT PRODUCTION</td>
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<td>IRON &amp; STEEL PRODUCTION</td>
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<td>WASTE TO ENERGY</td>
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<td>POWER GENERATION NATURAL GAS</td>
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<td>POWER GENERATION COAL</td>
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<td>HYDROGEN PRODUCTION IN REFINERY</td>
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<td>CHEMICAL PRODUCTION (OTHERS)</td>
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<td>ETHANOL PRODUCTION</td>
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<td>FERTILISER PRODUCTION</td>
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<td>NATURAL GAS PROCESSING</td>
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**Legend:**
- **IN OPERATION**
- **IN CONSTRUCTION**
- **ADVANCED DEVELOPMENT**
- **OPERATION SUSPENDED**

- Size of the circle is proportionate to the capture capacity of the facility.
- **0.2 Mtpa of CO₂**
- **1.0 Mtpa of CO₂**
- **5.0 Mtpa of CO₂**
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

1. ACTL
   - 1.7 - 14.6 MTPA
   - CCS HUBS: OPERATING OR IN DEVELOPMENT

2. NORTH DAKOTA CARBONSAFE
   - 3 - 17 MTPA
   - CCS HUBS: OPERATING OR IN DEVELOPMENT

3. CARBONSAFE ILLINOIS MACON COUNTY
   - 2 - 15 MTPA
   - CCS HUBS: OPERATING OR IN DEVELOPMENT

4. INTEGRATED MID-CONTINENT STACKED CARBON STORAGE HUB
   - 1.9 - 19.4 MTPA
   - CCS HUBS: OPERATING OR IN DEVELOPMENT

5. WABASH CARBONSAFE
   - 1.5 - 18 MTPA
   - CCS HUBS: OPERATING OR IN DEVELOPMENT

6. GULF OF MEXICO CCUS HUB
   - 6.6 - 35 MTPA
   - CCS HUBS: OPERATING OR IN DEVELOPMENT

7. PETROBRAS SANTOS BASIN CCS CLUSTER
   - 9 FPSOS - 3 MTPA
   - CCS HUBS: OPERATING OR IN DEVELOPMENT

8. NORTHERN LIGHTS
   - 0.8 - 5 MTPA
   - CCS HUBS: OPERATING OR IN DEVELOPMENT

9. NET ZERO TEESSIDE
   - 0.8 - 6 MTPA
   - CCS HUBS: OPERATING OR IN DEVELOPMENT

10. PORTHOS
    - 2 - 5 MTPA
    - CCS HUBS: OPERATING OR IN DEVELOPMENT

11. ZERO CARBON HUMBER
    - UP TO 18.3 MTPA
    - CCS HUBS: OPERATING OR IN DEVELOPMENT

12. ATHOS
    - 1 - 6 MTPA
    - CCS HUBS: OPERATING OR IN DEVELOPMENT

13. ABU DHABI CLUSTER
    - 2.7 - 5 MTPA
    - CCS HUBS: OPERATING OR IN DEVELOPMENT

14. XINJIANG JUNGGAR BASIN CCS HUB
    - 0.2 - 3 MTPA
    - CCS HUBS: OPERATING OR IN DEVELOPMENT

15. CARBONNET
    - 2 - 5 MTPA
    - CCS HUBS: OPERATING OR IN DEVELOPMENT

GLOBAL CCS INSTITUTE
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.


• 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.
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.
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.
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
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

Sources: Internal research and analysis; BP Statistical Review of World Energy
Limited existing CCUS operations in the GCC

- **Sources**: Internal Research & Analysis

1. **SAUDI ARABIA**
   - Oxy-Combustion of Heavy Liquid Fuels Project
   - Uthmaniyah CO₂-EOR Demonstration
   - Pilot CO₂ injection into the Dukhan oilfield
   - SIBCO beverages from industrial boilers

2. **QATAR**
   - Uthmaniyah CO₂-EOR
   - CO₂ injection into the Dukhan oilfield
   - Qatar Fuel Additives Company
   - Acid gas reinjection

3. **KUWAIT**
   - Active

4. **BAHRAIN**
   - ACTIVE
   - PILOT
   - STUDY
   - Gulf Cryo/Equate ethylene glycol
   - Jubail CO₂ to Chemicals (SABIC)
   - Gulf Petrochemical Industries Company
   - Studies for Awali
   - Acid gas reinjection

5. **UAE**
   - Gulf Industrial Gases

6. **OMAN**
   - CO₂ or CO₂-WAG injection in Al Reyadah/Emirates Steel
   - CO₂-EOR at Upper Zakum

- **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

<table>
<thead>
<tr>
<th>SECTOR</th>
<th>SUB-SECTOR</th>
<th>ESTIMATED LARGE POINT EMISSIONS, 2025, MT CO₂</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>BAHRAIN</td>
</tr>
<tr>
<td>Power plants</td>
<td>o Gas (gas turbine, steam turbine, CCGT)</td>
<td>13.3</td>
</tr>
<tr>
<td></td>
<td>o Oil (fuel oil, diesel, crude)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>o Coal</td>
<td>0</td>
</tr>
<tr>
<td>Petroleum industry</td>
<td>o Gas processing</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>o Oil refineries</td>
<td></td>
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<tr>
<td></td>
<td>o LNG plants</td>
<td></td>
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<tr>
<td></td>
<td>o Gas-to-liquid plants</td>
<td></td>
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<tr>
<td>Other industry</td>
<td>o Iron and steel plants</td>
<td></td>
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<tr>
<td></td>
<td>o Cement plants</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Aluminium smelters</td>
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<tr>
<td></td>
<td>o Chemical and fertiliser plants</td>
<td></td>
</tr>
</tbody>
</table>

- 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

Sources: Internal Research & Analysis
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

Sources: Internal Research & Analysis; Oil and Gas Middle East; BCG
Major GCC technical potential for moderate cost CO₂ capture

Current plans suggest about 11 Mt/y CO₂ captured by 2026, about half for EOR
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
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
CCUS can unlock significant values for Saudi Arabia, spanning:
Climate, economic diversification and clean oil export

- Maintain and create jobs
- Decarbonize power
- Decarbonize water desalination
- Decarbonize industry
- Enable oil export
- Enable export of low carbon products
- Enable CO2 free hydrogen
- Enable CO2 import & storage services
Saudi Arabia CCUS capabilities
Research, Technology, Policy Studies, Demonstration Pilots
Large scale CCUS plants in operation in Saudi Arabia

Uthmaniyah CO2-EOR by Saudi Aramco

0.8 MMtCO2/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 MMT CO2/yr
Since 2015

Methanol
Urea
CO2 for F&B
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

- **Environment**
  Reduce carbon footprint while still meeting global energy demand

- **Production**
  Achieve 70% field recovery through Enhanced Oil Recovery (EOR) techniques, where commercially viable

- **Natural Gas Supply**
  Liberate natural gas to serve growing demand

**Cross Cutting Enablers**
- Partnership & Capacity Building
- R&D, Innovation & Technology

ADNOC | GCSSi WEBINAR – 23 FEBRUARY 2021
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
Al Reyadah & CO₂ Expansion
• Execution of ADNOC’s Al 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

01
Up to 800,000 tons of CO₂ capture from Emirates Steel manufacturing complex

02
CO₂ transferred to Al Reyadah plant for compression & dehydration

03
Metered and exported through a 43km buried pipeline for Enhanced Oil Recovery to ADNOC’s NEB (Al Rumaitha) and Bab onshore oilfields
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

ABU DHABI NATIONAL OIL COMPANY
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

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