CCUS Update

International CCUS & Hydrogen Symposium; Organised by the Japanese Ministry of the Environment

Alex Zapantis, General Manager Commercial

12 March 2021

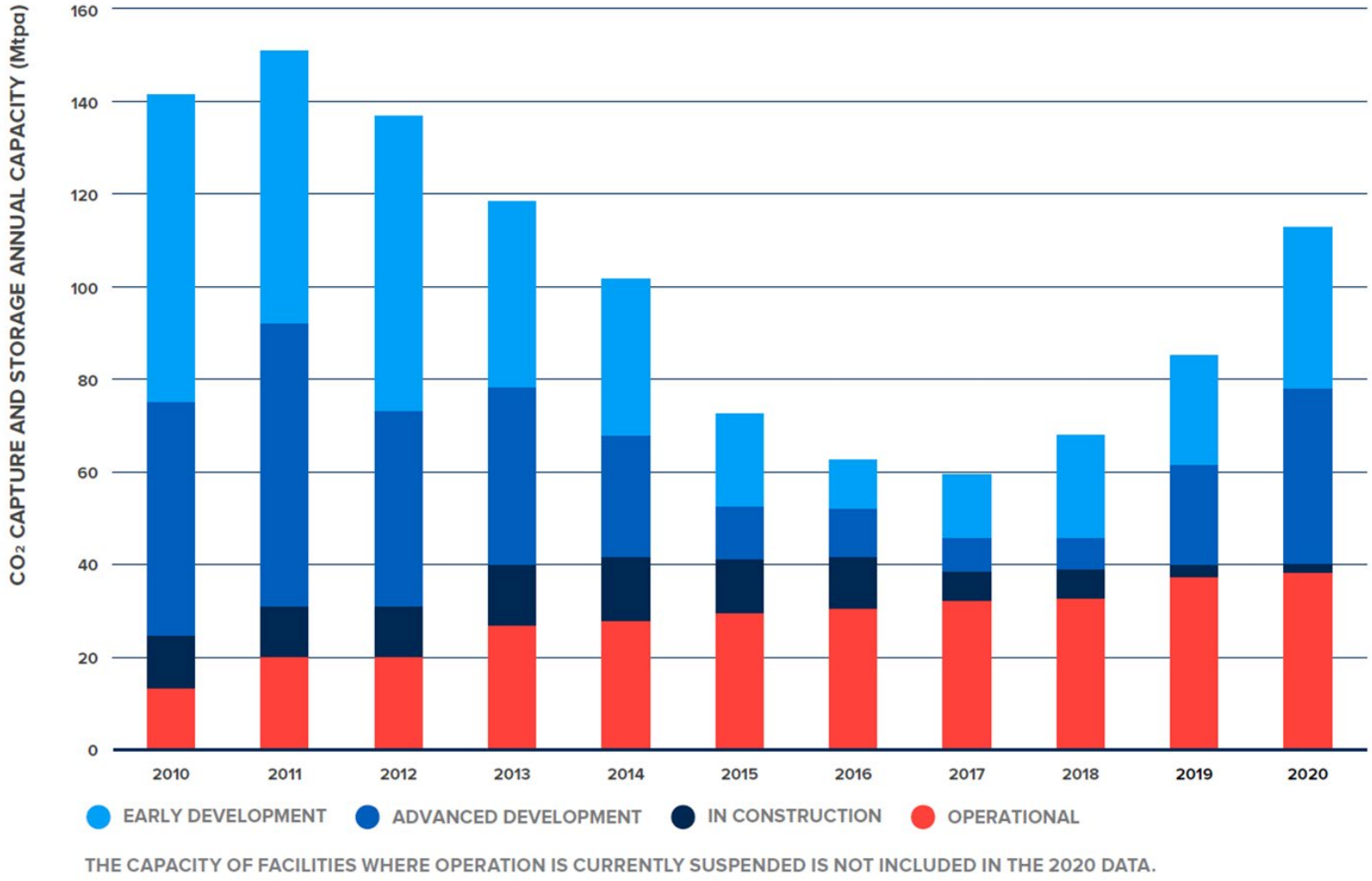
GLOBAL CCS INSTITUTE

CCS PIPELINE IS GROWING

Drivers

- Increasing community concern about climate change.
- Growing stakeholder and shareholder pressure on governments and private sector organisations to reduce GHG emissions
- Governments are responding through policy/regulation
- Private sector is responding through changes in investment (eg, ESG)
- Many governments and hundreds of companies now have Net Zero targets
- Expected demand for clean hydrogen
- Emergence of CCS Hubs
- Versatility of CCS

CCS Commercial Facility Pipeline as of November 2020



GLOBAL CCS INSTITUTE

CCS: VITAL TO ACHIEVING NET-ZERO

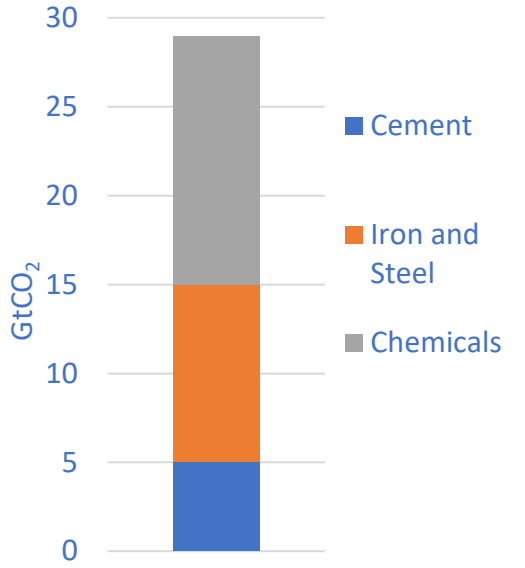
Achieving deep decarbonisation in hard-to-abate industry

Enabling the production of low-carbon hydrogen at scale

Providing low carbon dispatchable power

Delivering negative emissions

CCS IN HARD TO ABATE INDUSTRY

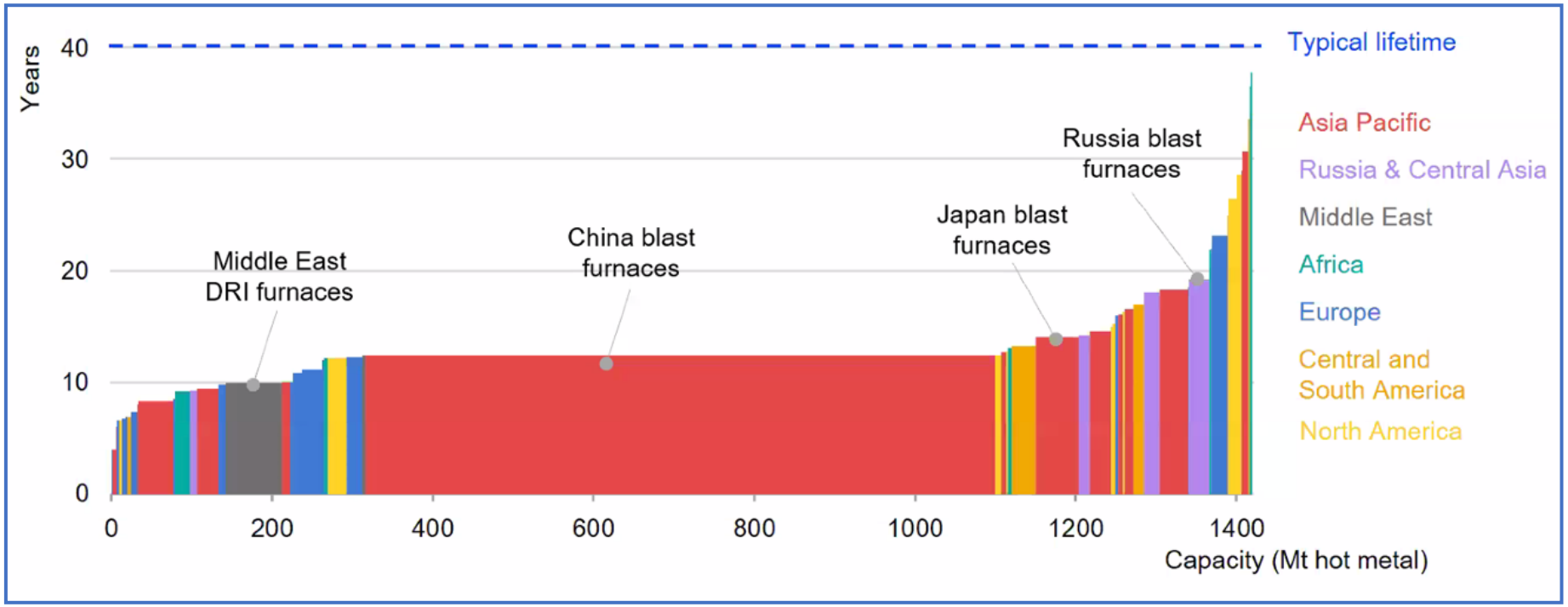


CCS Emission Reduction between 2017 and 2060

CCS must deliver 29Bt abatement in industry to meet Paris Agreement objectives

Source: IEA, 2019, Transforming Industry through CCS

Age profile of primary steel making infrastructure (mostly blast furnaces)

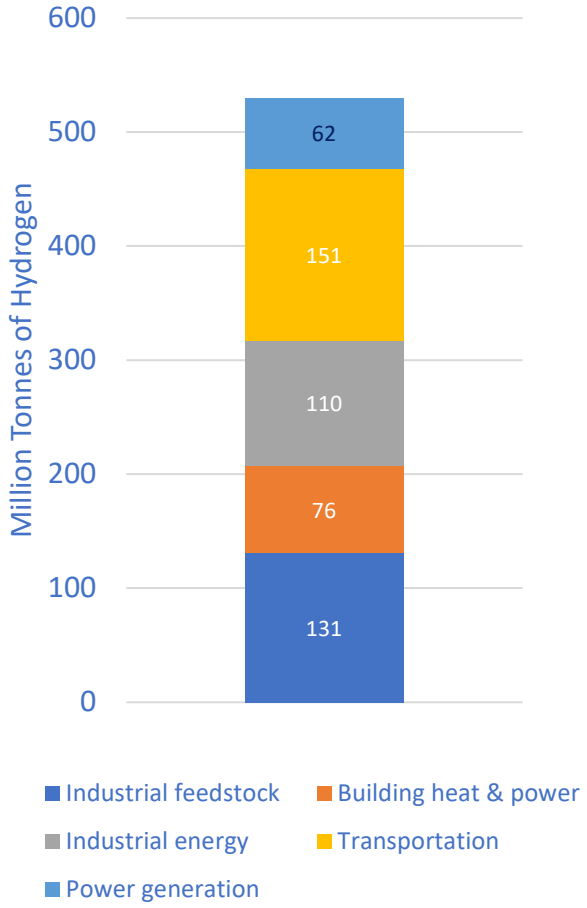


Source: IEA, 2020

GLOBAL CCS INSTITUTE

CCS ENABLING CLEAN H2 PRODUCTION

Potential clean H_2 demand in 2050 to deliver 6Bt CO_2 abatement



H_2 with CCS is mature at meaningful scale

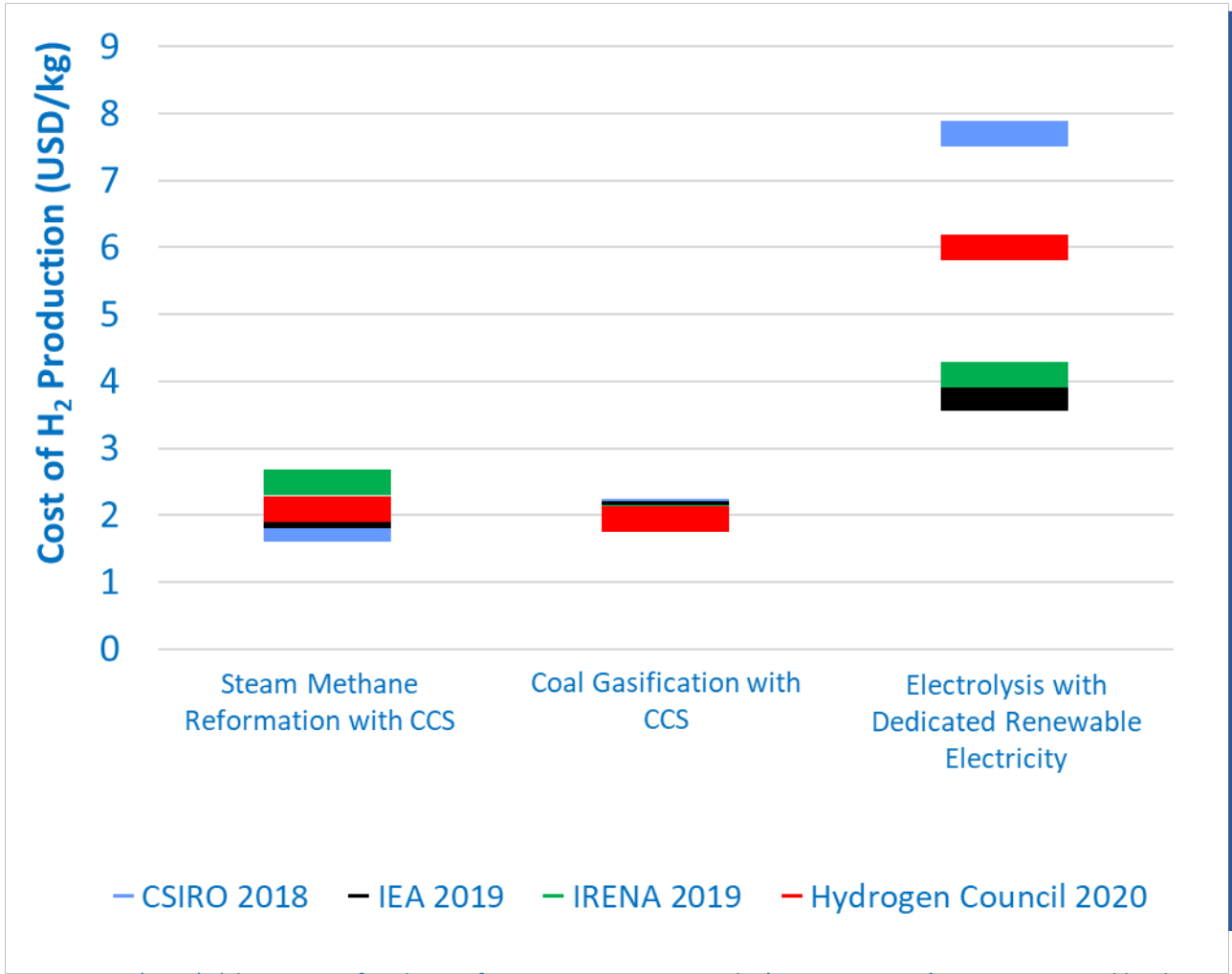
Facility	H_2 Production Capacity	H_2 Production Process	Operational Commencement
Enid Fertiliser	200 tonnes per day of H_2 in syngas	Methane reformation	1982
Great Plains Synfuel	1,300 tonnes per day of H_2 in syngas	Coal gasification	2000
Air Products	500 tonnes H_2 per day	Methane reformation	2013
Coffeyville	200 tonnes H_2 per day	Petroleum coke gasification	2013
Quest	900 tonnes H_2 per day	Methane reformation	2015
Alberta Carbon Trunk Line - Sturgeon	240 tonnes H_2 per day	Asphaltene residue gasification	2020
Alberta Carbon Trunk Line - Agrium	800 tonnes H_2 per day	Methane reformation	2020
Sinopec Qilu	100 tonnes H_2 per day (estimated)	Coal/Coke gasification	Expected 2021

Source: Adapted from Hydrogen Council (2017), Hydrogen scaling up, A sustainable pathway for the global energy transition, available from www.hydrogencouncil.com

Source: GCCSI CO2RE Database

GLOBAL CCS INSTITUTE

CCS ENABLING CLEAN H2 PRODUCTION

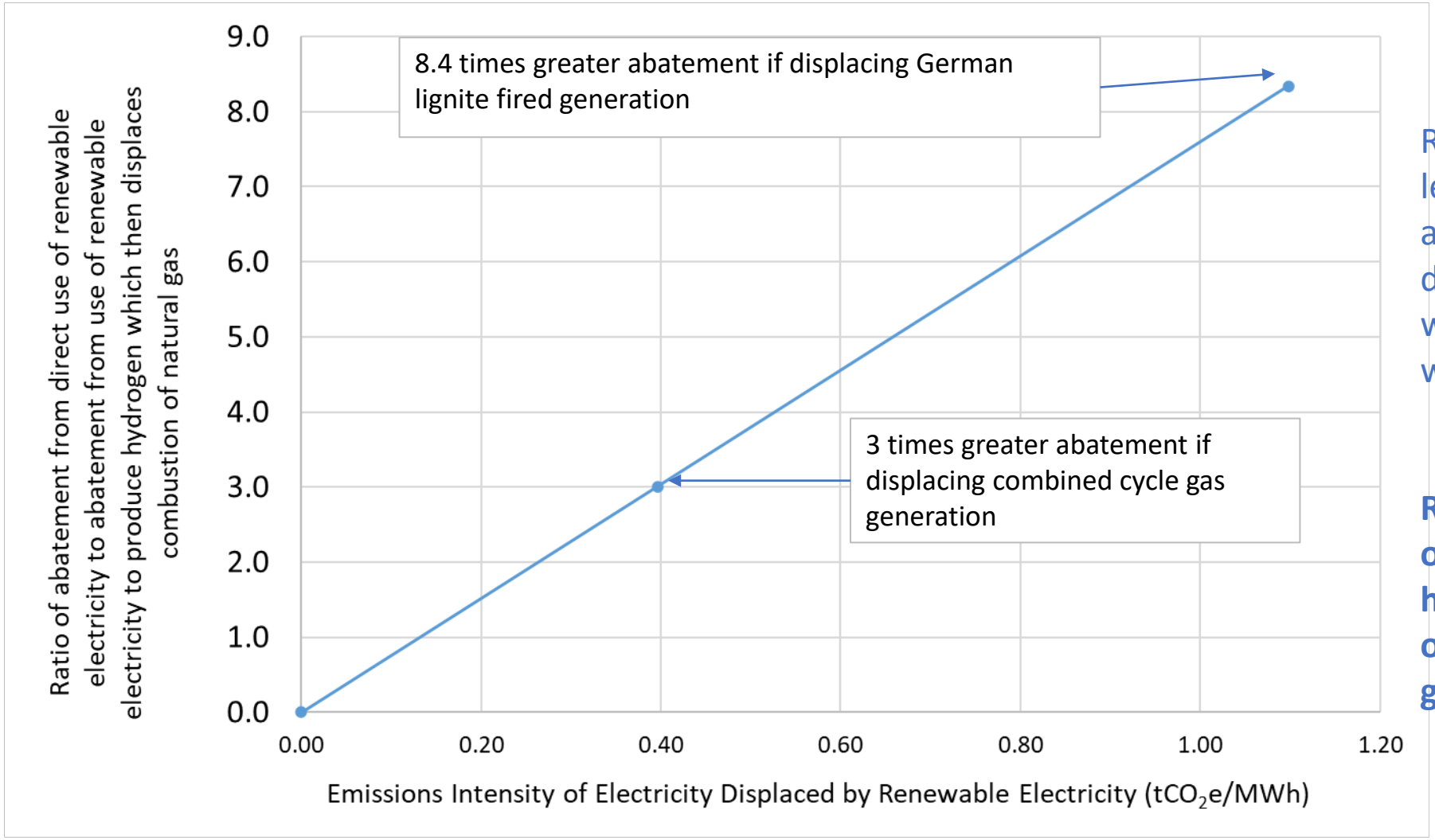


These estimates are indicative and should be treated with caution. The basis for each cost estimate (eg assumed capacity factors, fuel & electricity costs) differs between reports, and in some cases the report presents a range of costs. For example, the IEA figures are an average of costs contained in the 2019 report for different parts of the world.

- Generally good agreement on cost of fossil fuel production pathways with CCS
  - Decades of commercial scale operational experience for all elements
- All costs are reducing

Sources: IEA (2019), 'The Future of Hydrogen for G20. Seizing today's opportunities', Report prepared by the IEA for the G20.
Bruce, S, Temminghoff, M, Hayward, J, Schmidt, E, Munnings, C, Palfreyman, D & Hartley, P (2018), 'National Hydrogen Roadmap', accessed from <https://www.csiro.au/.
IRENA (2019), 'Hydrogen: a Renewable Energy Perspective', accessed from <www.irena.org>.
Hydrogen Council (2020), 'Path to hydrogen competitiveness: a cost perspective', accessed from <www.hydrogencouncil.com.>.

CCS ENABLING CLEAN H2 PRODUCTION



Renewable electricity delivers at least three times more emissions abatement when used to displace fossil generation, than when used to produce hydrogen which then displaces natural gas.

Renewable electricity should only be used to produce hydrogen where there is no opportunity to displace fossil generation.

GLOBAL CCS INSTITUTE

CCS ENABLING LOW C POWER

Coal Utilisation Reductions Assumed in IPCC Illustrative Pathways

IPCC Illustrative Pathway to 1.5 degrees C	Pathway 1	Pathway 2	Pathway 3	Pathway 4
Reduction in primary energy from coal in 2030 compared to 2010	-78%	-61%	-75%	-59%
Reduction in primary energy from coal in 2050 compared to 2010	-97%	-77%	-73%	-97%

Actual Coal Fleet Development

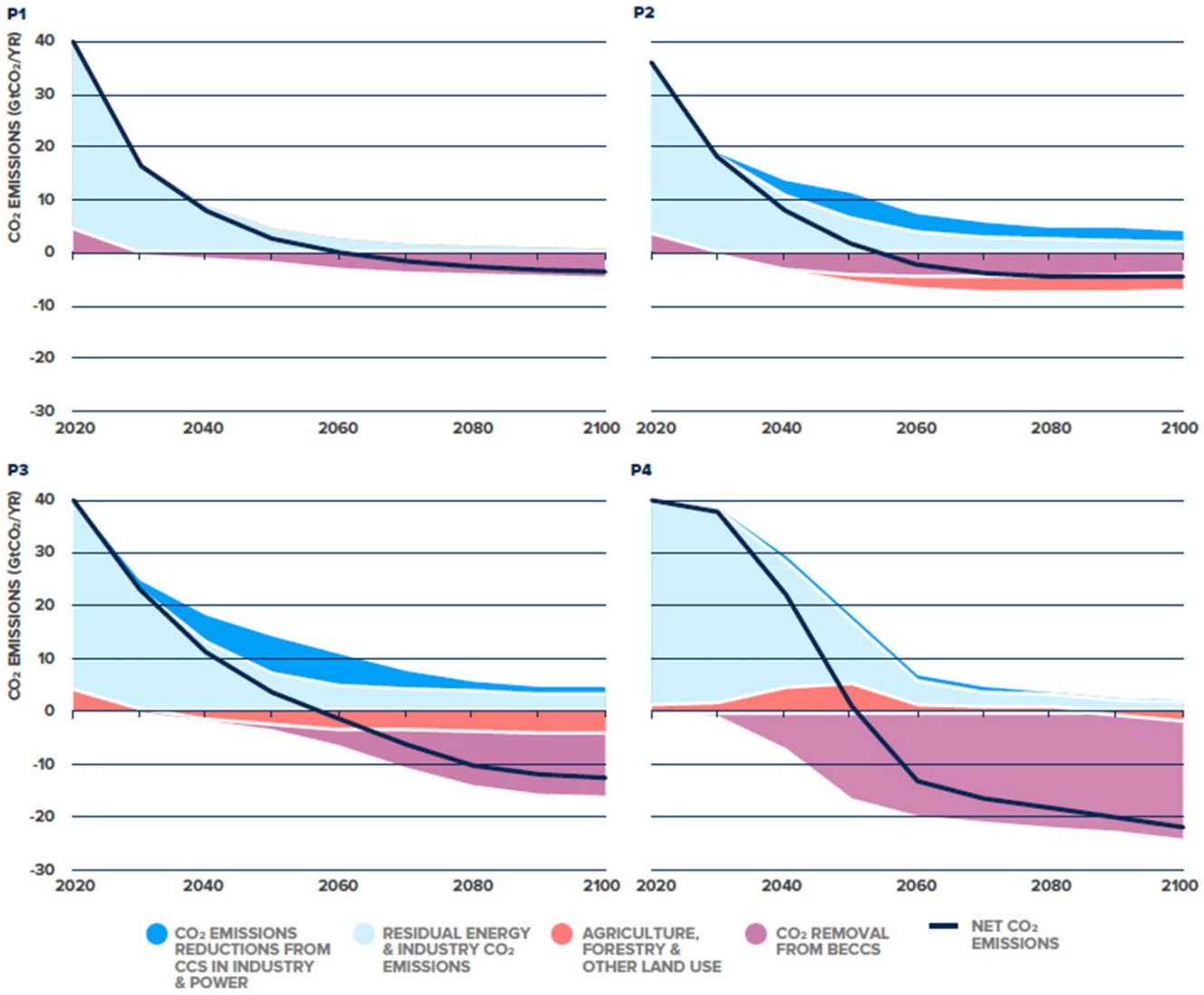
- ~2000GW operating
- ~500GW expected to come online before 2030
- ~200GW already under construction
- 40-50 year operational life

Considering only plants that are currently operating and under construction, and expected retirements, CO_2 emissions from the global coal fleet are expected to approach $10GtCO_2$ in 2030 and exceed $7GtCO_2$ in 2050. To achieve a 1.5 degree Celsius climate target, around 90% of those emissions must be captured and stored in 2030, and effectively all emissions must be captured and stored in 2050.

Sources: Cui et al, 2019, Quantifying operational lifetimes for coal power plants under the Paris Goals, Nature Communications 10:4759. IPCC, "Global Warming of 1.5 degrees C; Summary for Policy Makers", 2018

CCS DELIVERING NEGATIVE EMISSIONS

4 Illustrative Pathways to 1.5°C Developed by the IPCC



Source: IPCC, "Global Warming of 1.5 degrees C; Summary for Policy Makers", 2018

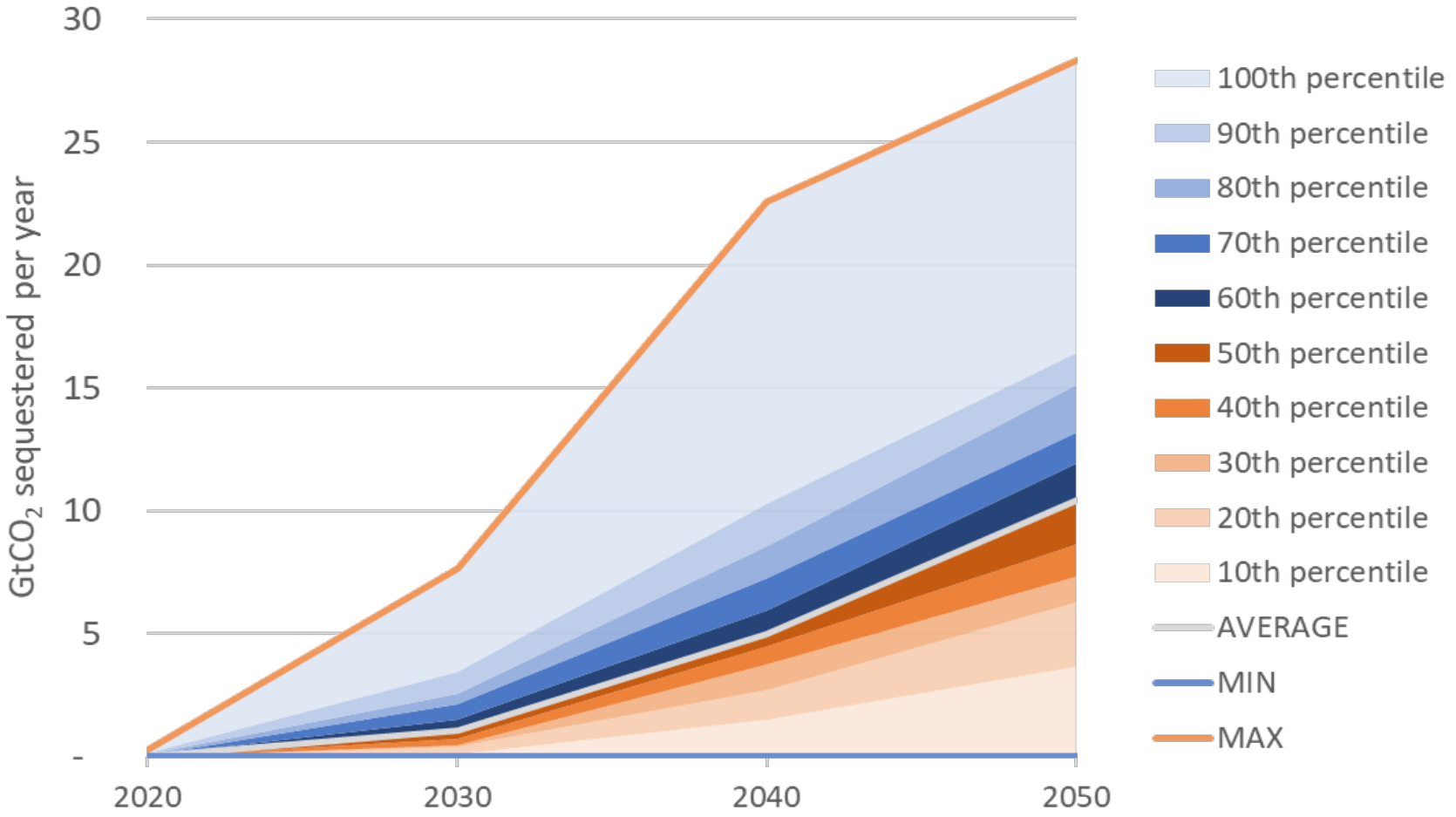
BioEnergy with CCS (BECCS) is required to remove between approximately 2 and 22 billion tonnes per year of CO_2 from the atmosphere (depending on assumptions) to achieve a 1.5 degree Celsius climate outcome

GLOBAL CCS INSTITUTE

CCS IS ESSENTIAL TO MEET CLIMATE TARGETS

The average mass of CO_2 required to be stored in the year 2050, across all 90 scenarios studied by the IPCC in its Special Report on Global Warming of 1.5 Degrees C was 10Gt.

Annual CO_2 Stored in the 90 1.5°C Consistent Scenarios Reviewed in the IPCC Special Report on Global Warming of 1.5°C



Source: GCCSI analysis of IIASA 1.5C Scenario Explorer

GLOBAL CCS INSTITUTE

COMMERCIAL CCS FACILITIES

In 2020, the Institute introduced an updated CCS Facility classification system to reflect the industry's development.

Old

Large scale: CO_2 capture capacity from industrial sources greater than 400ktpa or power generation greater than 800ktpa

Pilot & Demonstration: Facilities which capture CO_2 from industrial sources or power generation that do not meet large-scale CCS facility capacity thresholds.

New – from 2020

Commercial:

- CO_2 captured for permanent storage as part of an ongoing commercial operation
- Storage may be undertaken by a third party or by the owner of the capture facility
- Generally have economic lives similar to the host facility whose CO_2 they capture
- Must support a commercial return while operating and/or meet a regulatory requirement.

Pilot & Demonstration:

- CO_2 captured for testing, developing or demonstrating CCS technologies or processes
- Captured CO_2 may or may not be permanently stored
- Generally short life compared to large commercial facilities – determined by the time required to complete tests and development processes or achieve demonstration milestones
- Not expected to support a commercial return during operation.

GLOBAL CCS INSTITUTE

COMMERCIAL CCS FACILITIES

Impact of new Classification System

- 6 Pilot and Demonstration facilities re-classified to Commercial Facilities
- Sturgeon Refinery and Nutrien facilities now 2 separate facilities
- 6 storage or hub projects no longer classified as facilities – now Hubs

65 Commercial CCS facilities operating, under development, or idle

26 Operating

3 In construction

34 Under development

2 Operations suspended

17 New commercial facilities added in 2020

12 New in US

115Mt CO_2 Annual capture/storage capacity of all facilities in the pipeline

40Mt CO_2 Annual tonnes CO_2 captured and stored by operating facilities

GLOBAL CCS INSTITUTE

CCS ACROSS NUMEROUS INDUSTRIES

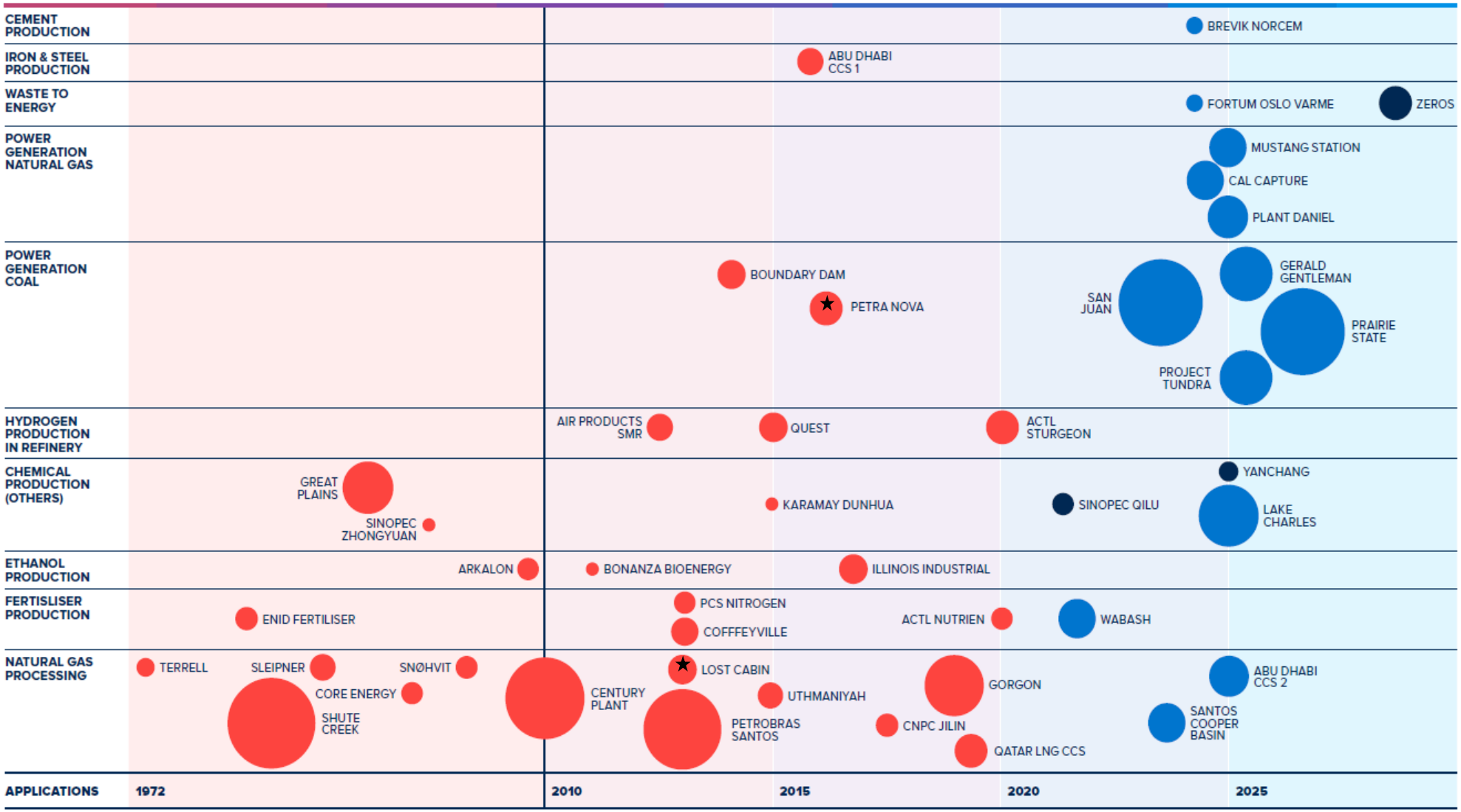


Chart indicates the primary industry type of each facility among various options.

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

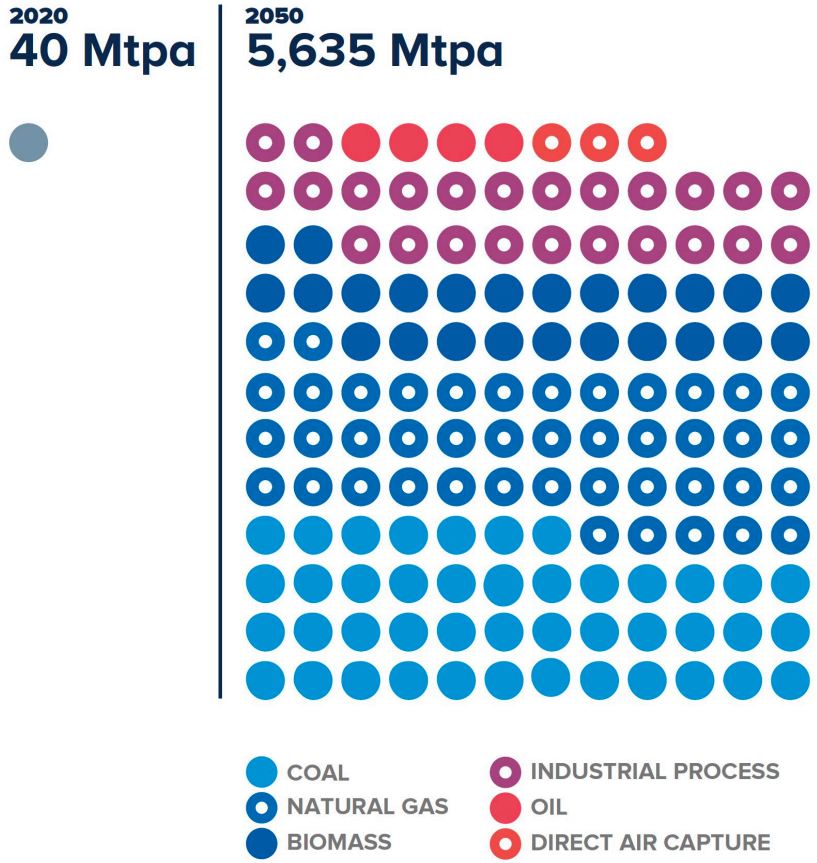
Size of the circle is proportionate to the capture capacity of the facility.

- 0.2 Mtpa OF CO_2
- 1.0 Mtpa OF CO_2
- 5.0 Mtpa OF CO_2

GLOBAL CCS INSTITUTE

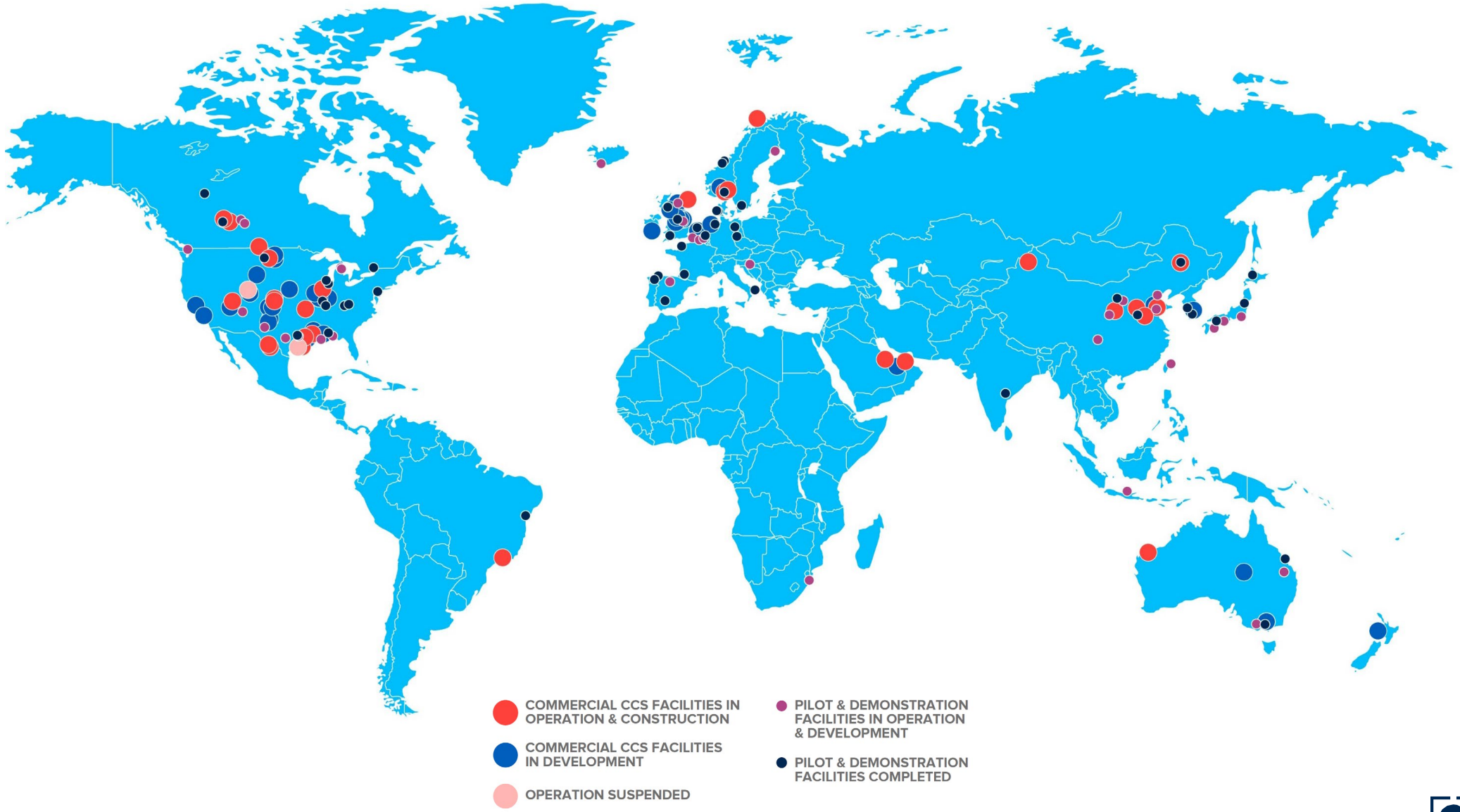
BUT… A STEEP HILL TO CLIMB

TO ACHIEVE NET-ZERO EMISSIONS, >100X INCREASE REQUIRED



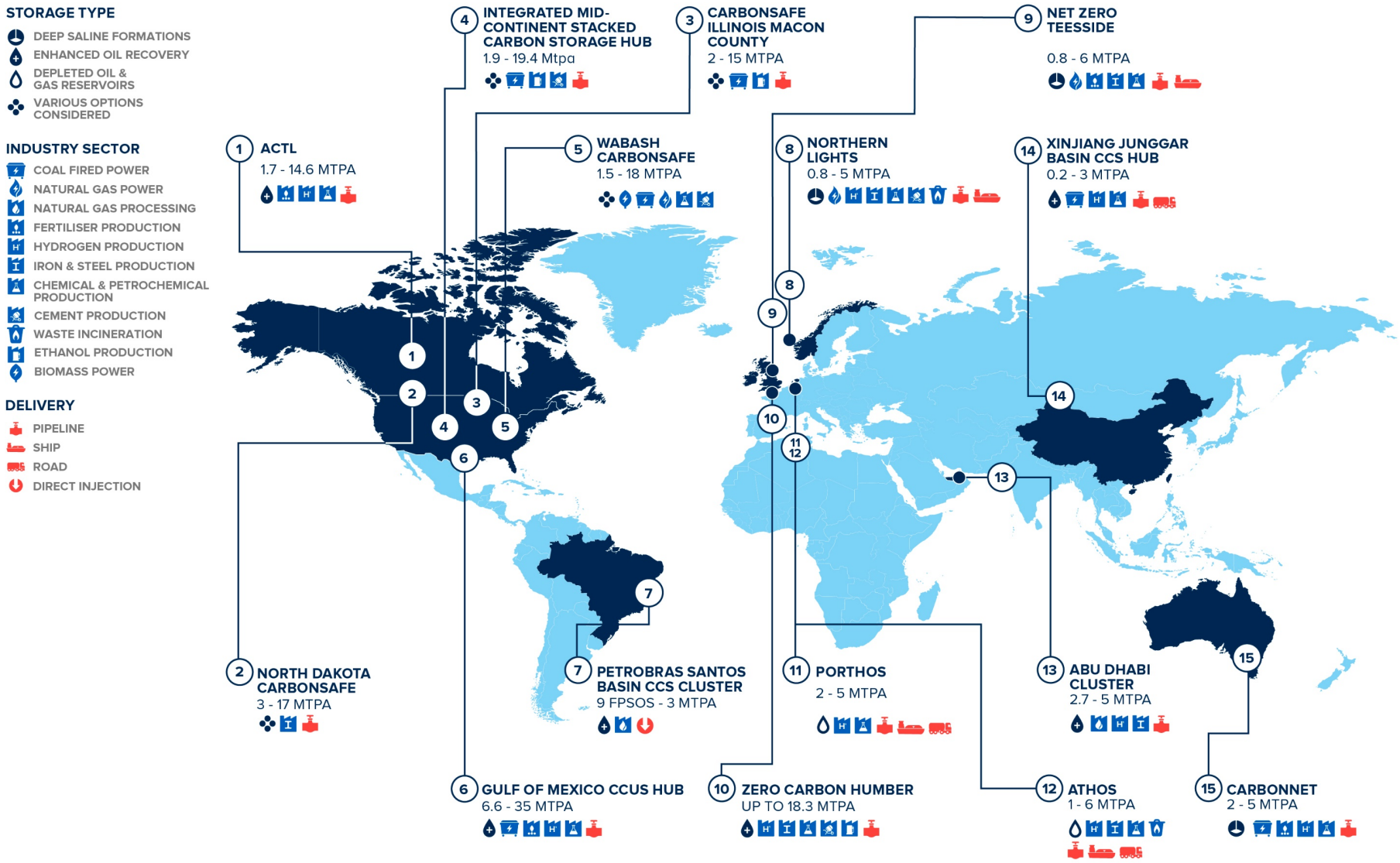
GLOBAL CCS INSTITUTE

THE BIG PICTURE



GLOBAL CCS INSTITUTE

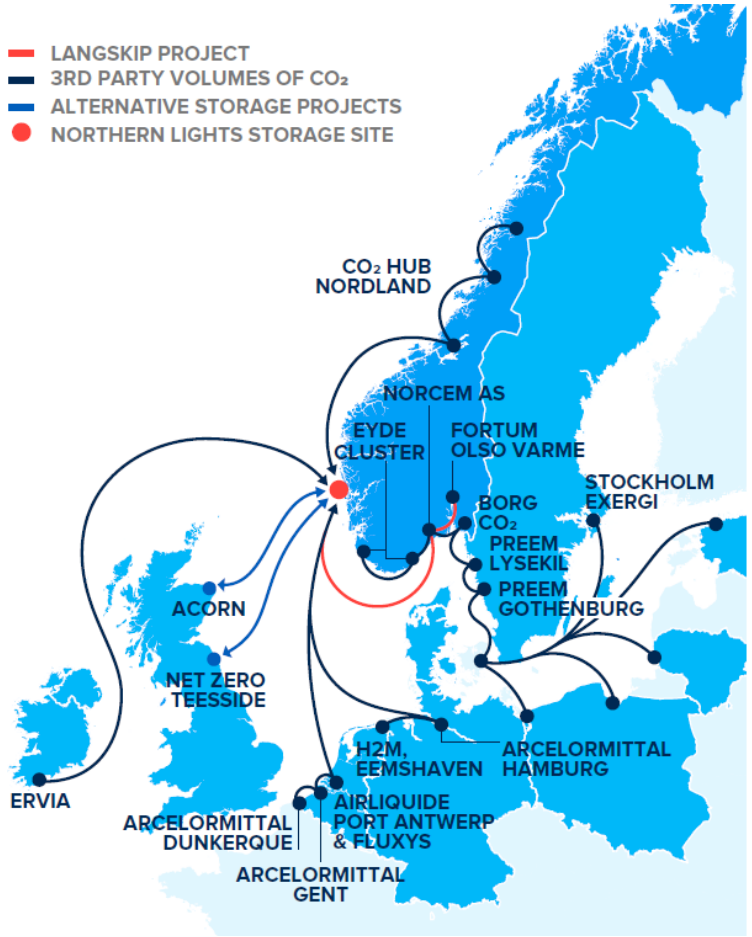
HUBS AND CLUSTERS



GLOBAL CCS INSTITUTE

HUBS AND CLUSTERS

- Multiple industrial point sources of CO_2 connected to transport and storage network
- Access to large geological storage resources with capacity to store CO_2 from industrial sources for decades
- Economies of scale deliver lower unit-costs for CO_2 storage
- Synergies between multiple CO_2 sources and storage operator reduce cross chain risks, support commercial viability



GLOBAL CCS INSTITUTE

ASIA-PACIFIC – EMERGING POWERHOUSE

- 10 CCS facilities in operation or in development
- Regional collaboration between governments, e.g. bilateral agreements with Australia and Singapore
- Japan driving clean hydrogen production using CCS
- Malaysia, Singapore, and Australia have newly established CCS strategies
- Australian government established a $50 million CCUS development fund

Thank you

GLOBAL CCS INSTITUTE

Additional slides for reference

GLOBAL CCS INSTITUTE

EUROPE – GROWING POLICY SUPPORT

- 14 commercial facilities in operation or various stages of development
- New European jurisdictions in the CCS market: Wales, Denmark, Sweden and Italy
- EU's €10 billion Innovation fund – first call for projects; expected to be a major CCS funding source across the EU
- United Kingdom to establish first net zero industrial cluster; 1 billion pounds allocated to support CCS development
- Norwegian Government has moved forward with $1.8 billion investment to further CCS development

GULF STATES – A CRITICAL REGION

- 3 CCS facilities in operation, capturing 3.7 Mtpa of carbon dioxide
- Circular carbon economy: CO2 emissions managed through 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 UAE have largest emissions in the region; power generation the biggest contributor

AMERICAS – SUSTAINED LEADERSHIP

- 12 new commercial CCS projects added; 36 commercial facilities operating or in development, plus two currently idled
- US: New projects largely incentivized 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; over $550 million in provincial and federal funding
- Brazil: Offshore projects continue, 14M+ tonnes of CO_2 to date