CCS & NET-ZERO

Webinar

1 December 2020

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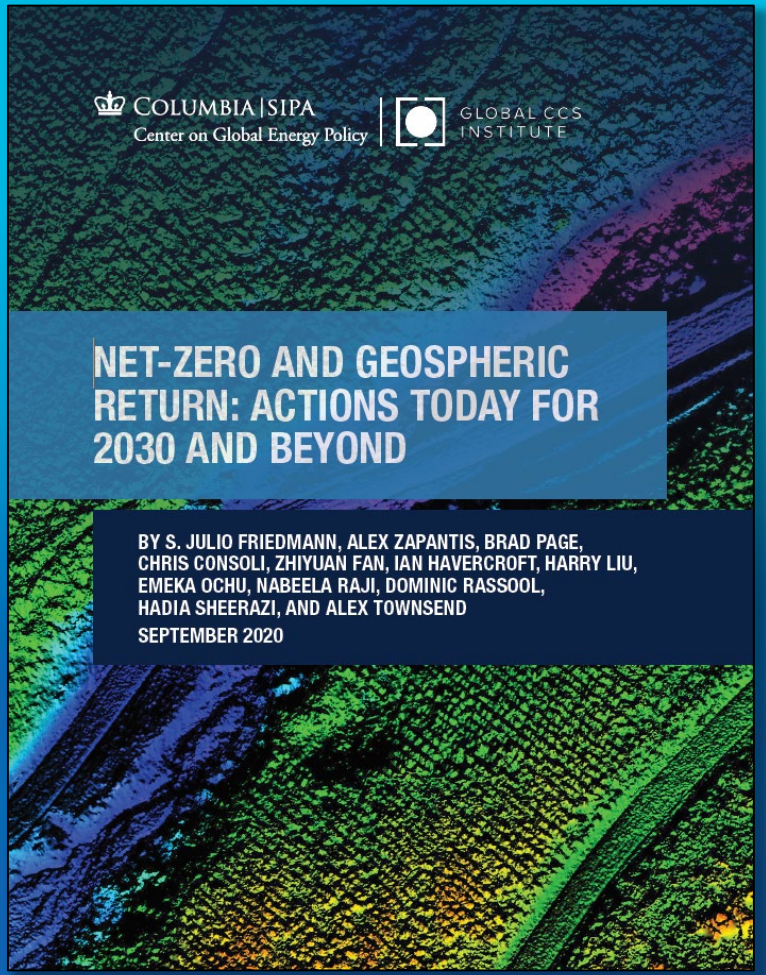
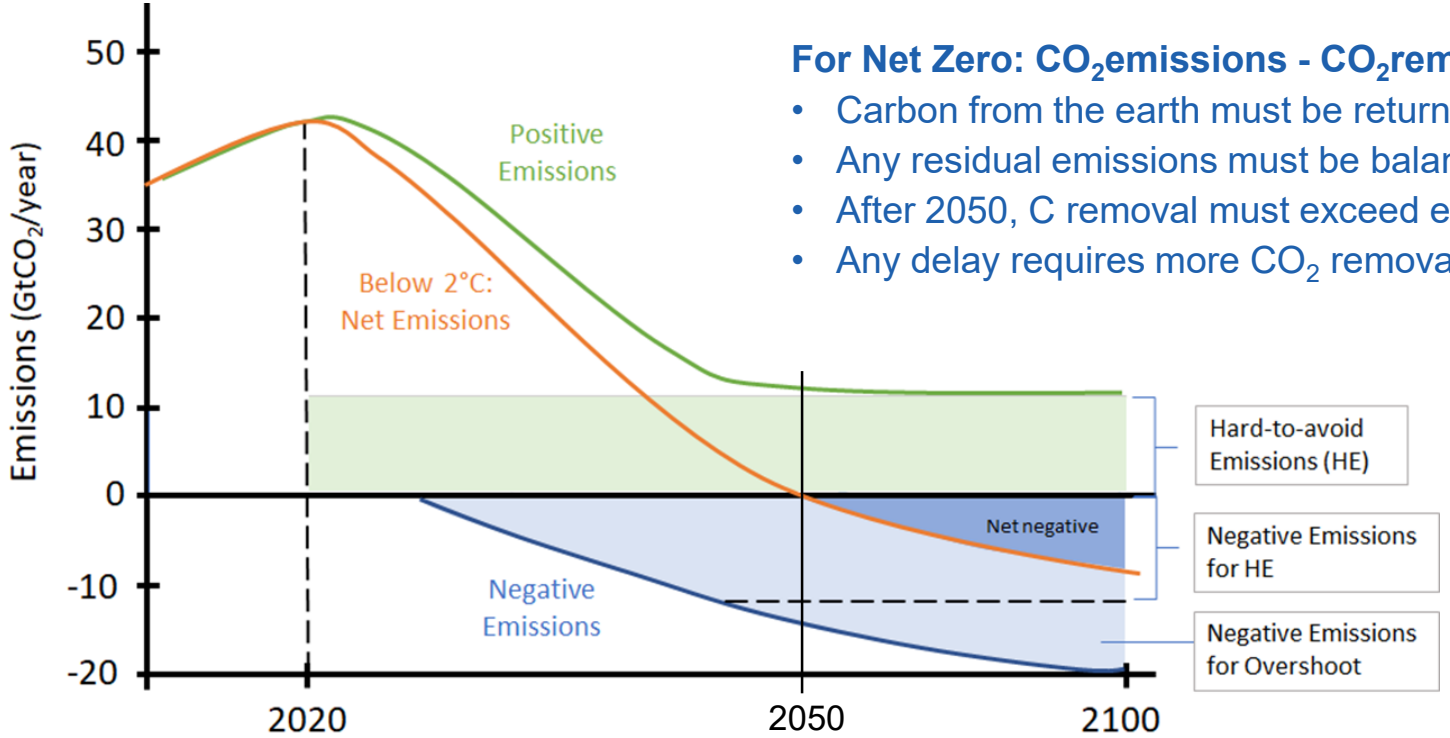
GLOBAL CCS INSTITUTE



TO STABILISE AT 1.5°C:
NET ZERO BY 2050 AND NET NEGATIVE EMISSION AFTER 2050



For Net Zero: CO_2emissions - CO_2removals = 0

- Carbon from the earth must be returned to the earth
- Any residual emissions must be balanced by removal
- After 2050, C removal must exceed emissions
- Any delay requires more CO_2 removal

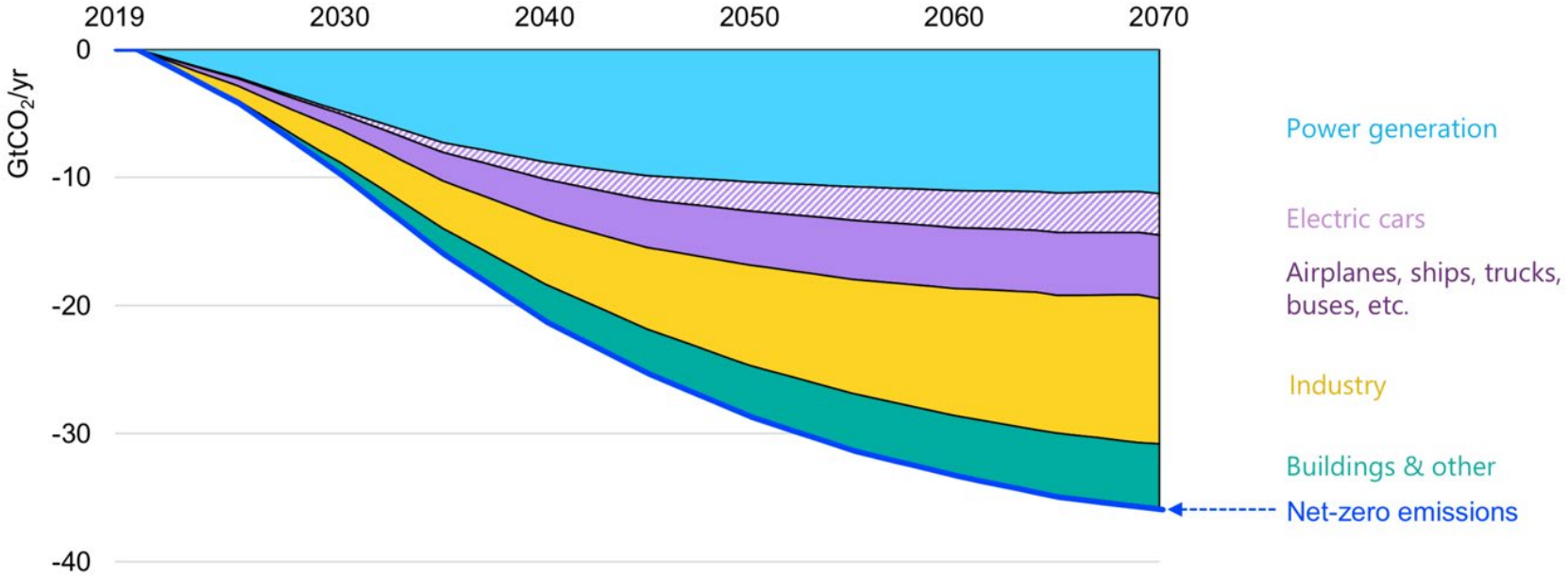
5 to 10Gtpa

- 5 to 10Gtpa

Source: J. Wilcox et al 2020

EMISSIONS ACROSS ALL SECTORS MUST BE NET-ZERO

Global CO_2 emissions reductions in the IEA Sustainable Development Scenario (2 °C) relative to baseline



Source: IEA 2020

CCS HAS BROAD APPLICATION

26 commercial CCS facilities are operating today

Power Sector

Coal (Bound. Dam)
Gas (Peterhead)
Biomass (Drax)

Industry

Steel (Al Reyadah)
Fuels (ADM, Qatar)
Chemicals (Enid)

Zero-C Hydrogen

Port Arthur (USA)
Quest (Canada)
Sinopec Qilu (China)

CO_2 removal

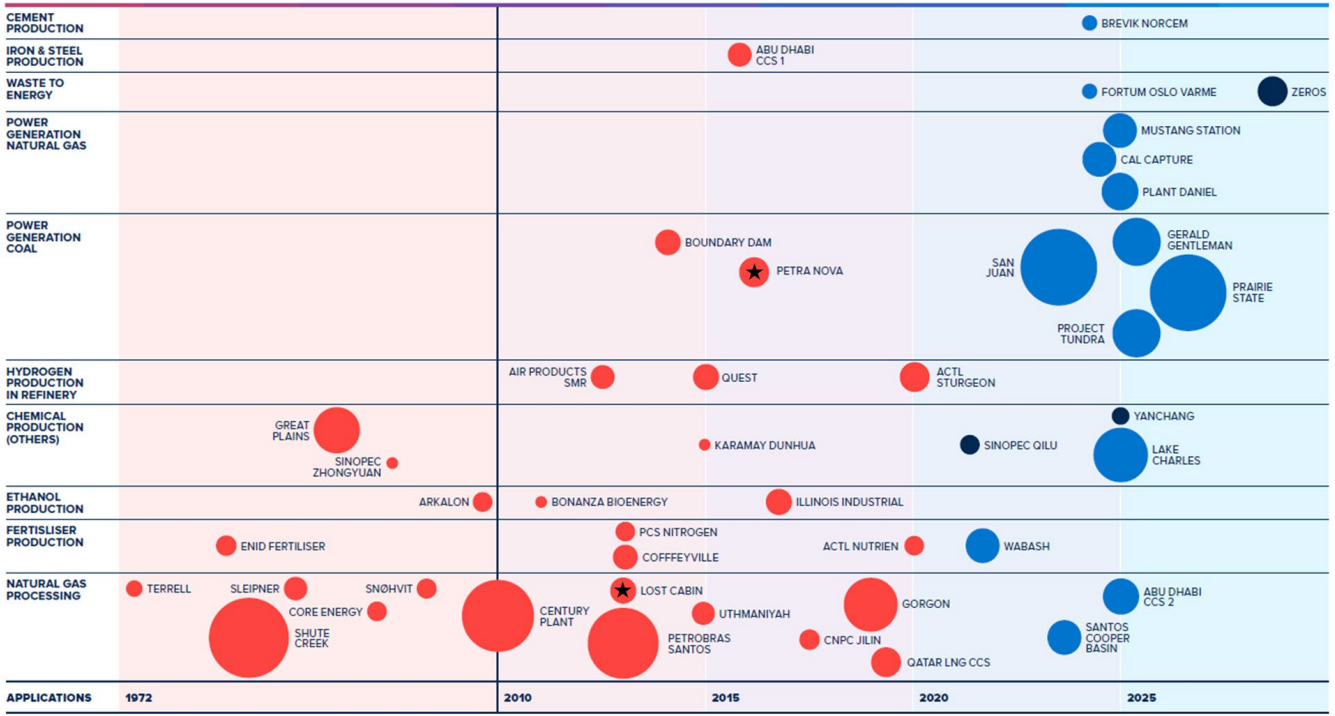
Direct Air Capture
Bioenergy + CCS
C Mineralization

COMMERCIAL CCS FACILITIES IN OPERATION, CONSTRUCTION AND ADVANCED DEVELOPMENT

28 operating (including 2 that have temporarily suspended operation).

3 in construction.

13 in advanced development.

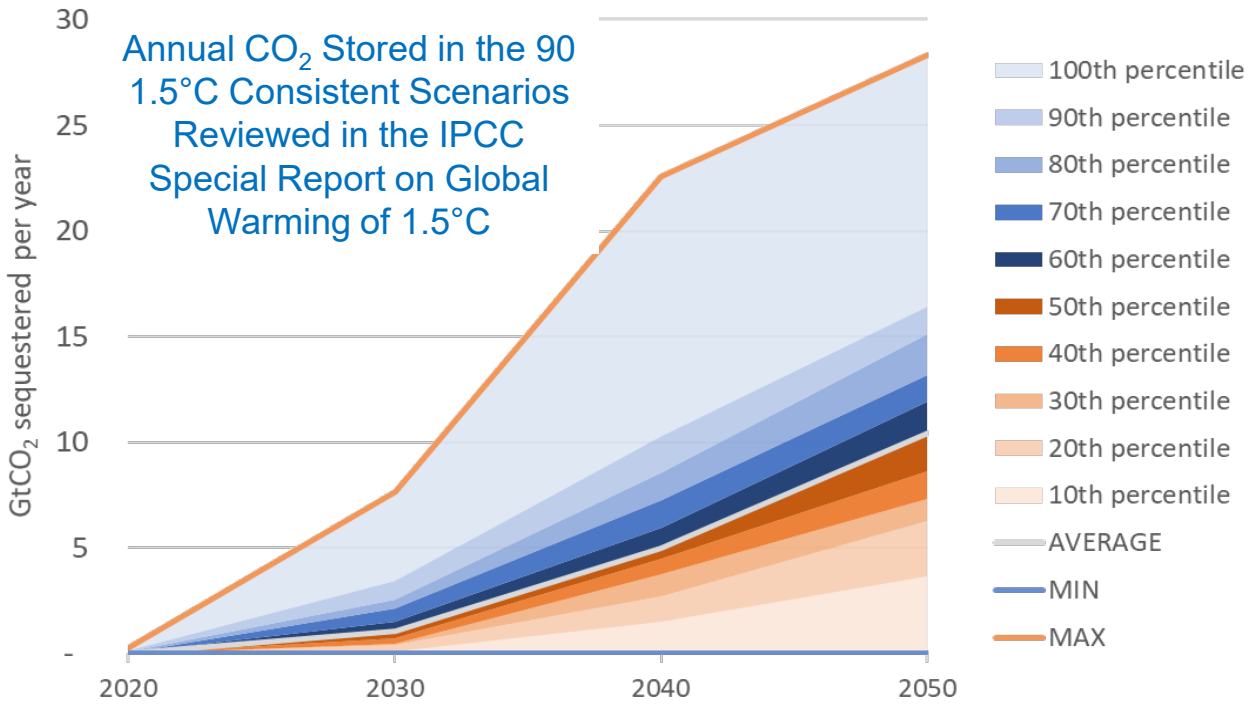


C MANAGEMENT POTENTIAL: >1000GtCO_2 THIS CENTURY

Almost all scenarios required CCS

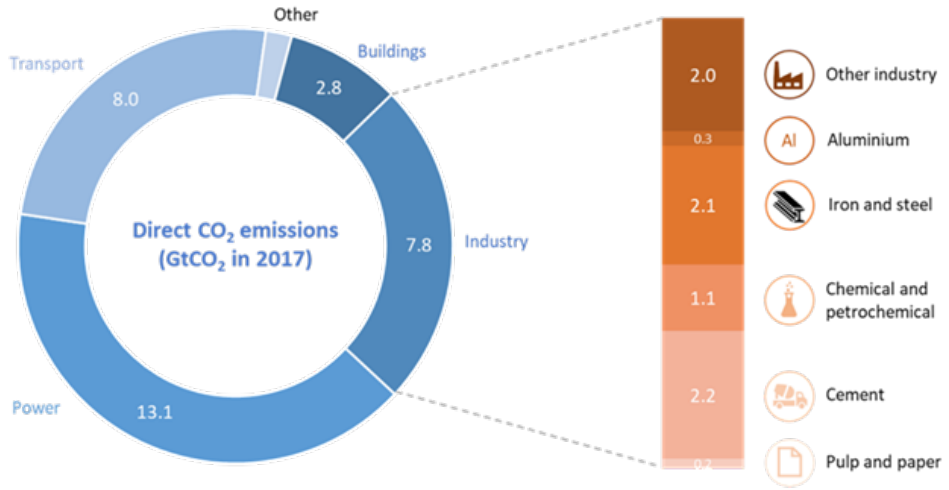
3 of 4 Illustrative Pathways required 348Gt to 1,218Gt CO_2 to be stored this century.

The 4th Illustrative Pathway required final energy demand to reduce by one third by 2050 compared to 2010.



Source: GCCSI analysis of IIASA 1.5C Scenario Explorer

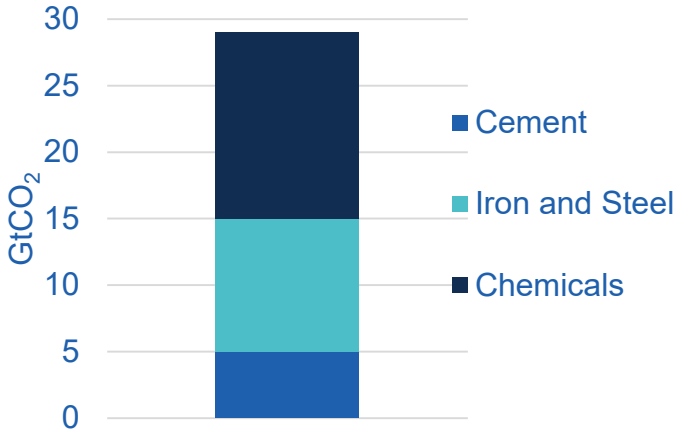
CCS PLAYS AN IMPORTANT ROLE IN INDUSTRY



Global Direct CO_2 Emissions from Industry in 2017

- Approximately 1.9Bt are process emissions

Source: GCCSI analysis of IEA Data



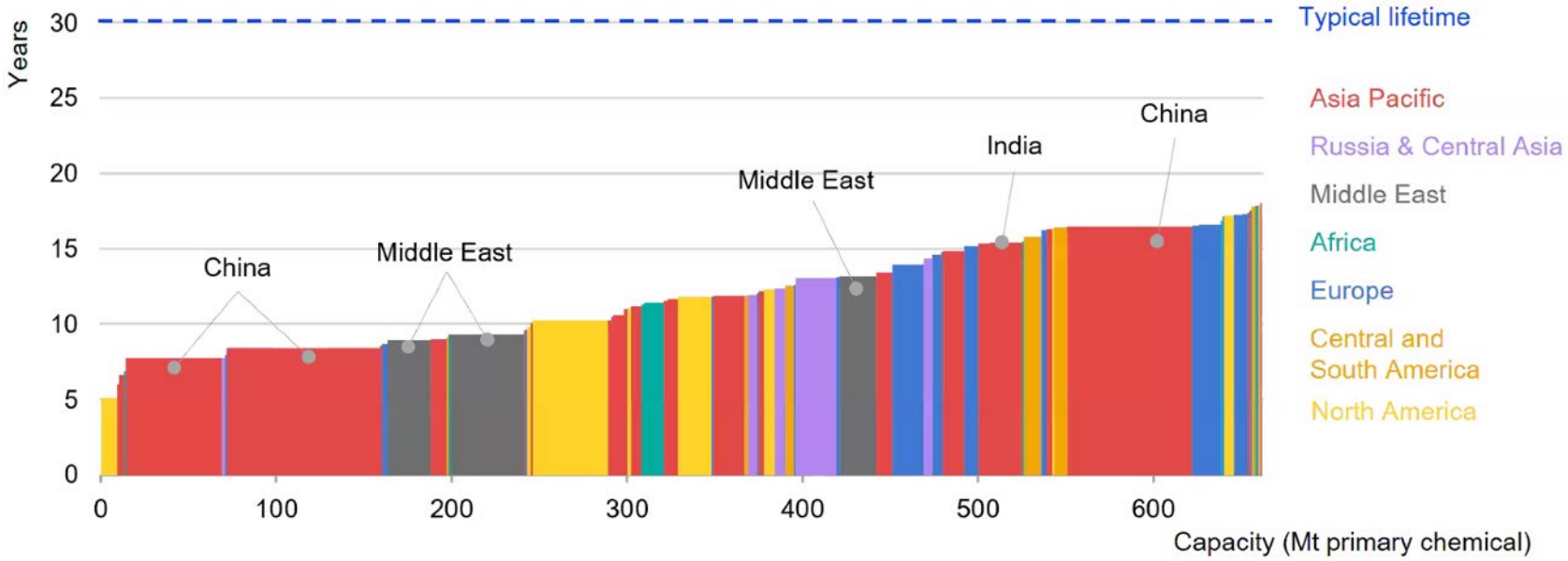
CCS Emission Reduction between 2017 and 2060

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

Source: IEA, 2019, Transforming Industry through CCS

CCS IS NEEDED FOR EXISTING INDUSTRIAL FACILITIES

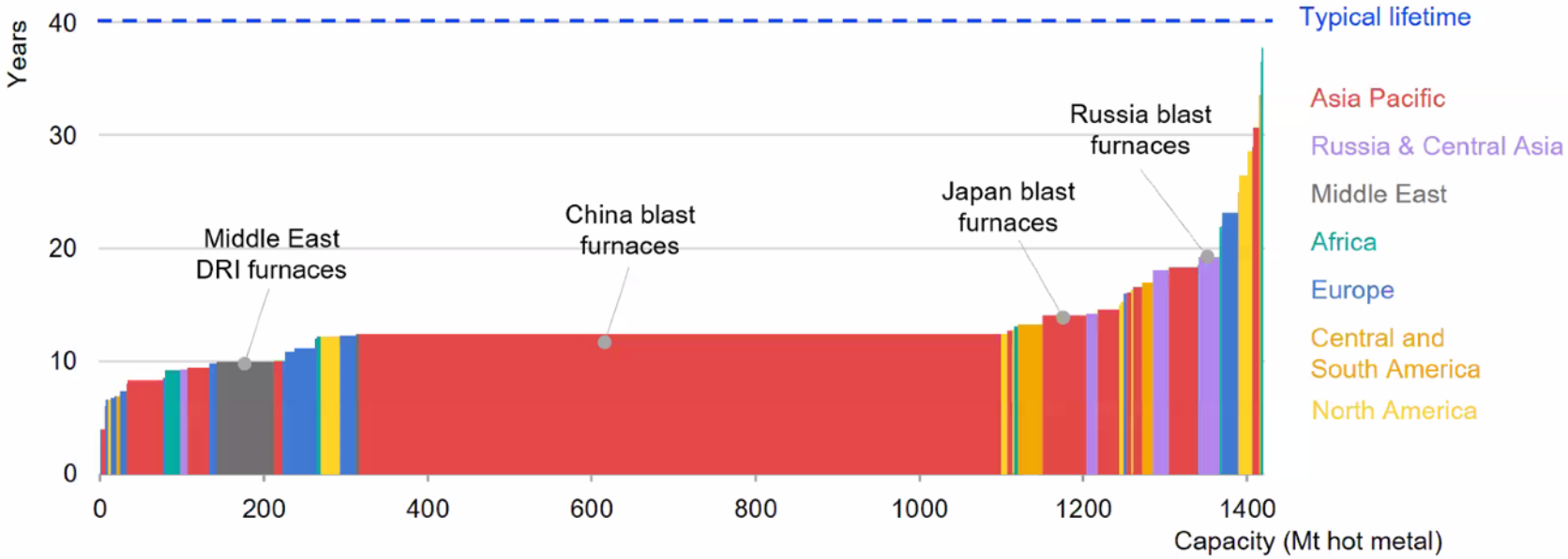
Age profile of primary chemical production facilities



Source: IEA, 2020

CCS IS NEEDED FOR EXISTING INDUSTRIAL FACILITIES

Age profile of primary steelmaking from iron ore (mostly blast furnaces)



Source: IEA, 2020

CCS PLAYS AN IMPORTANT ROLE IN POWER; eg Coal

Assumed in Modelling

Coal utilisation reduces by ~60% to 80% by 2030 compared to 2010

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%

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

Actual

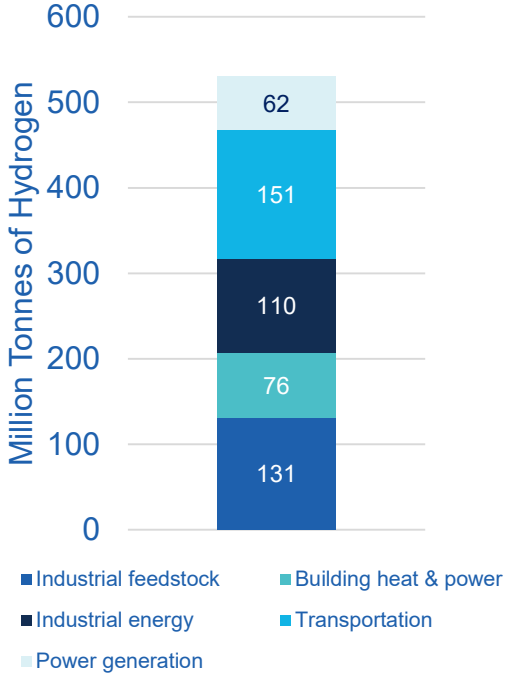
Coal utilisation is growing

- ~2000GW operating
- Over 500GW new capacity expected before 2030
- Over 200GW new capacity under construction
- Economic life of 40-50 years
- Considering only operating and under construction, and assuming early retirements and low capacity factors reduce emissions from this fleet to half of what is expected, approximately 85Gt of CO_2 must be captured and stored between 2030 and 2050 to achieve a 1.5 degree outcome.

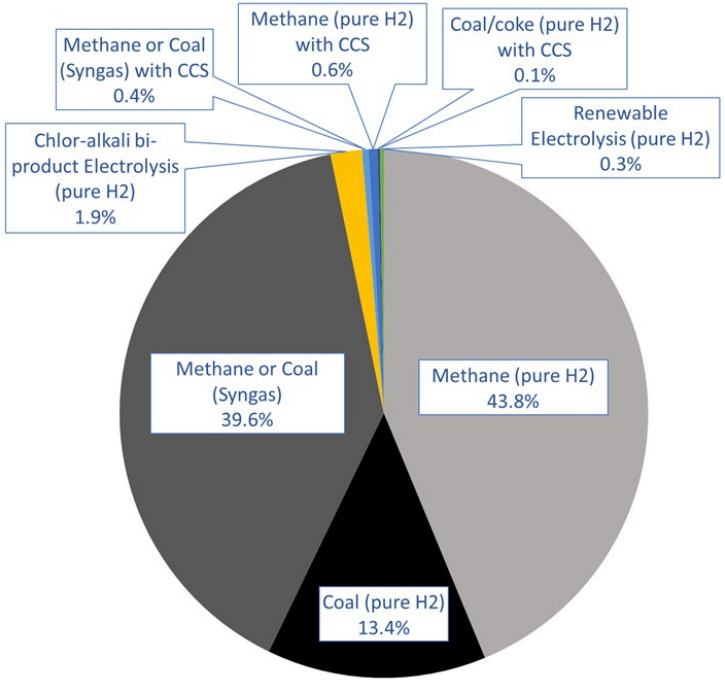
Source: GCCSI analysis of Cui et al, 2019, Quantifying operational lifetimes for coal power plants under the Paris Goals, Nature Communications 10:4759

CLEAN H_2 IS AN IMPORTANT PART OF THE SOLUTION

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



Current H_2 production ~120Mtpa; <2% is clean



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

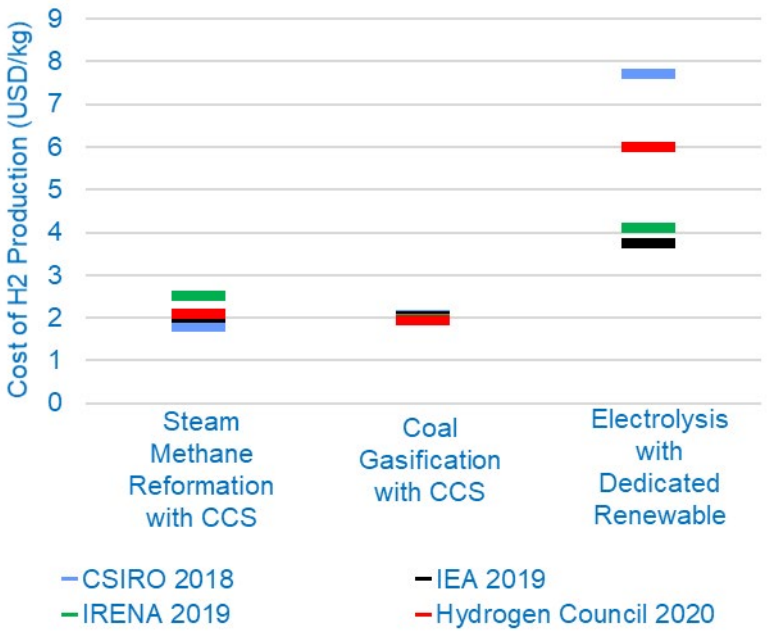
Sources: Global CCS Institute CO_2RE Database, IEA (2019), 'The Future of Hydrogen for G20. Seizing today's opportunities', Report prepared by the IEA for the G20.

H_2 PRODUCTION 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: GCCSI CO2RE Database

COST OF CLEAN HYDROGEN PRODUCTION

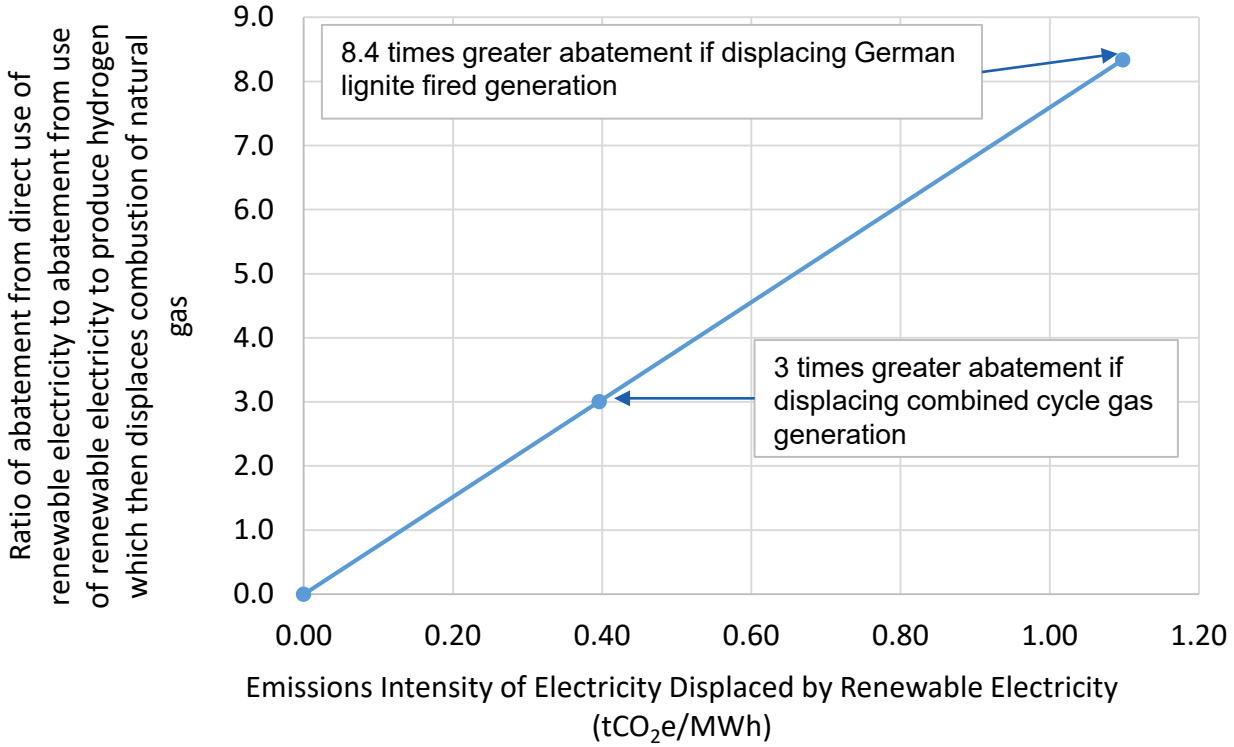


These estimates are indicative and should be treated with caution. The basis for each cost estimate (eg assumed capacity factors, fuel & electricity costs) differs between reports, and in some cases the report presents a range of costs. For example, the IEA figures are an average of costs contained in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

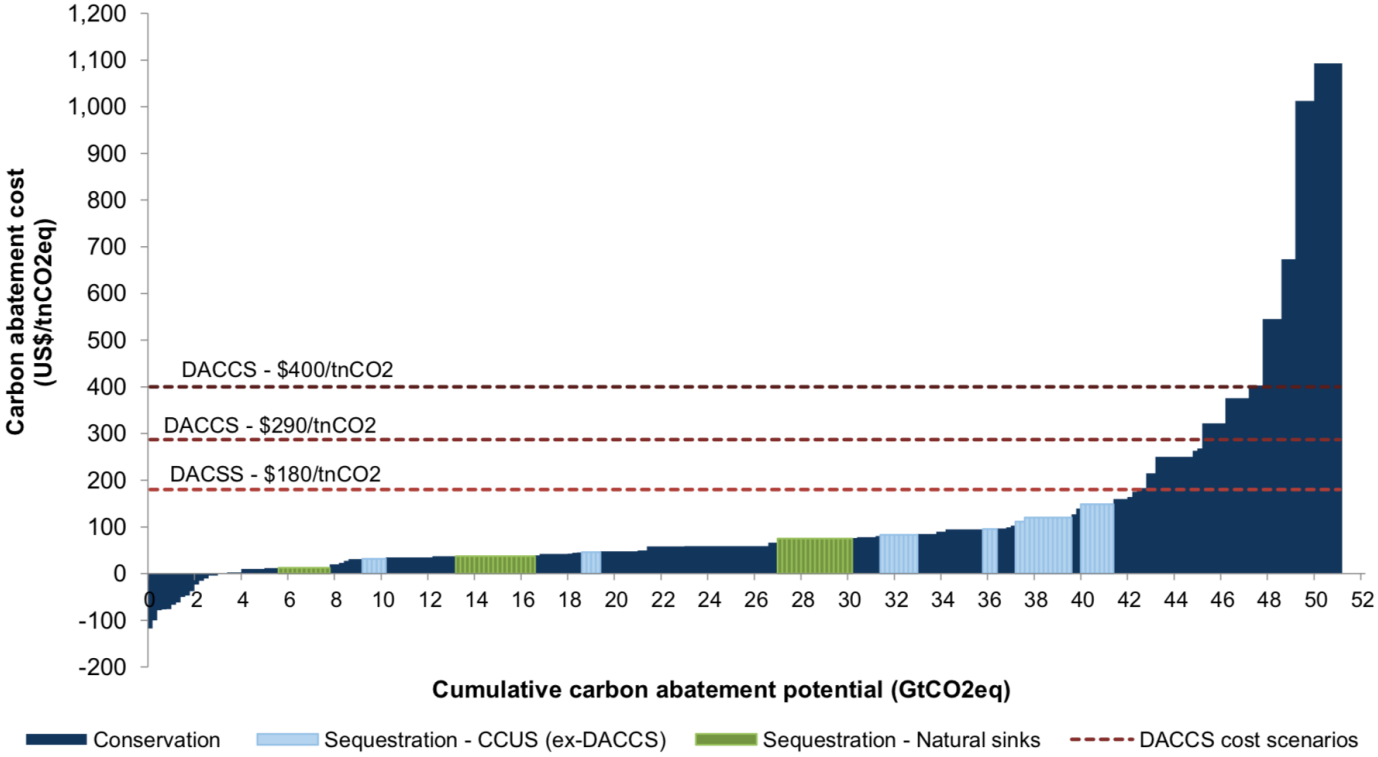
EMISSIONS ABATEMENT OPPORTUNITY COST OF RENEWABLE HYDROGEN



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.

DIRECT AIR CAPTURE WITH STORAGE CAPS MITIGATION COST

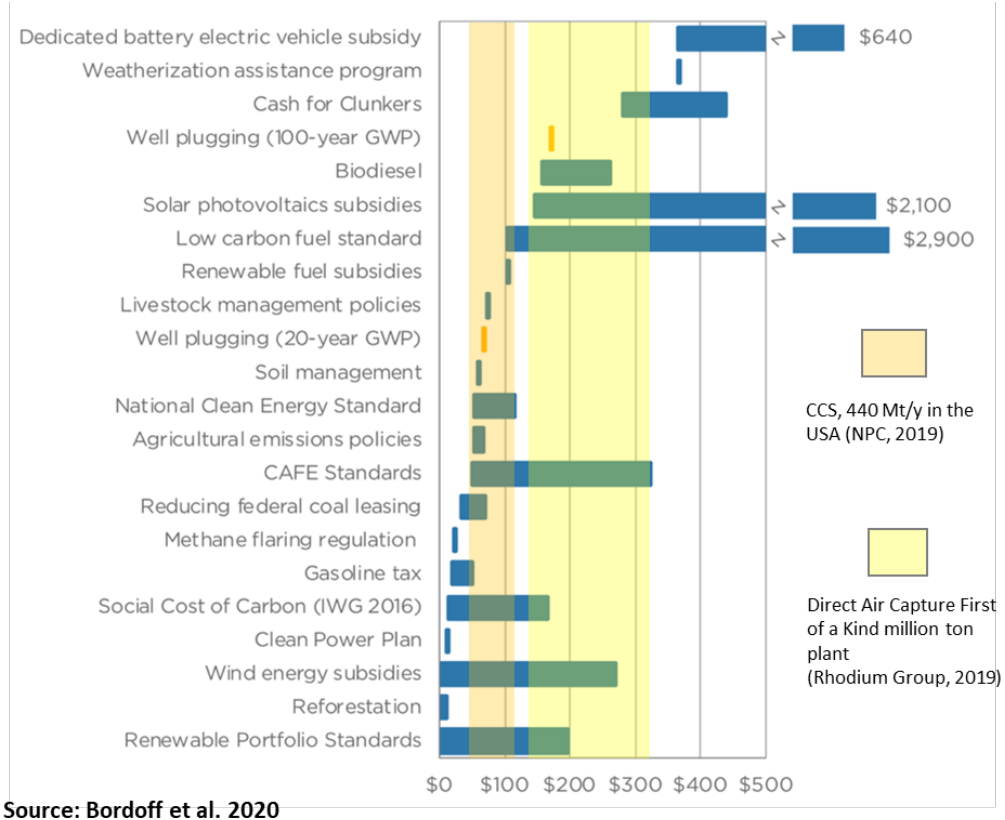


Source: GoldmanSachs 2020

CCS & DACS COSTS COMPARED TO EXISTING POLICIES

CCS and Direct Air Capture with Storage are cost effective mitigation options.

This chart compares the cost of CCS and DACS with the cost of existing policies in the USA.



Source: Bordoff et al. 2020
Data: Gillingham & Stock 2018

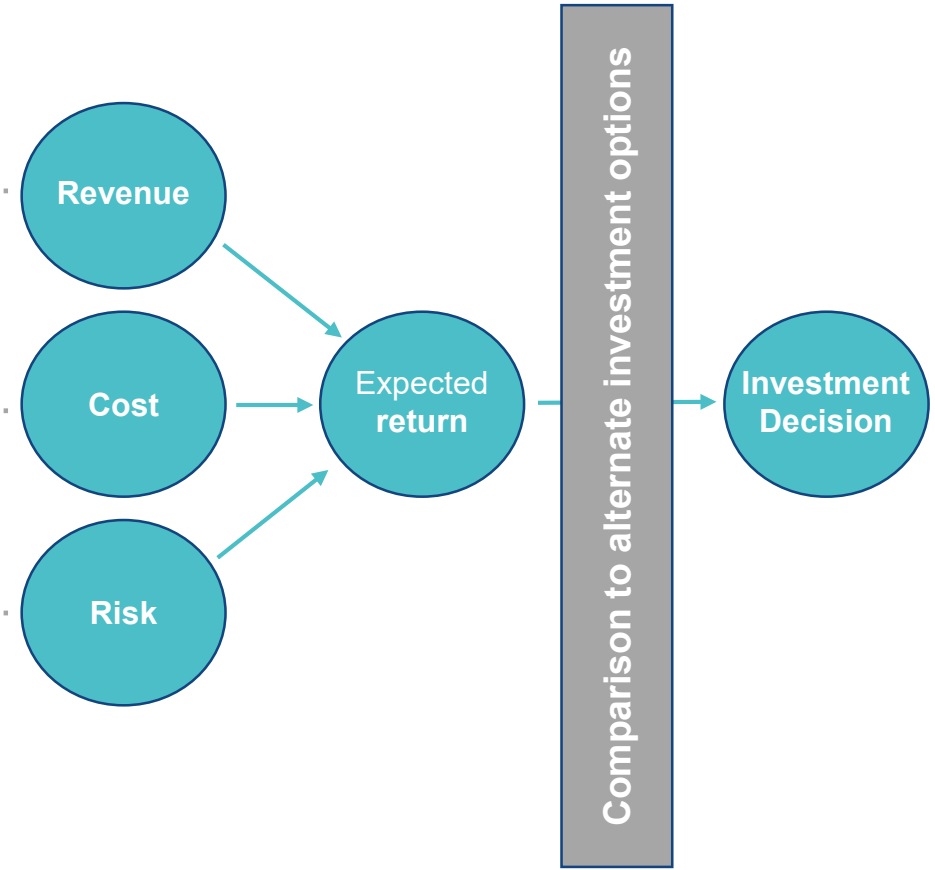
Source: GoldmanSachs 2020

POLICY CAN INCENTIVISE INVESTMENT

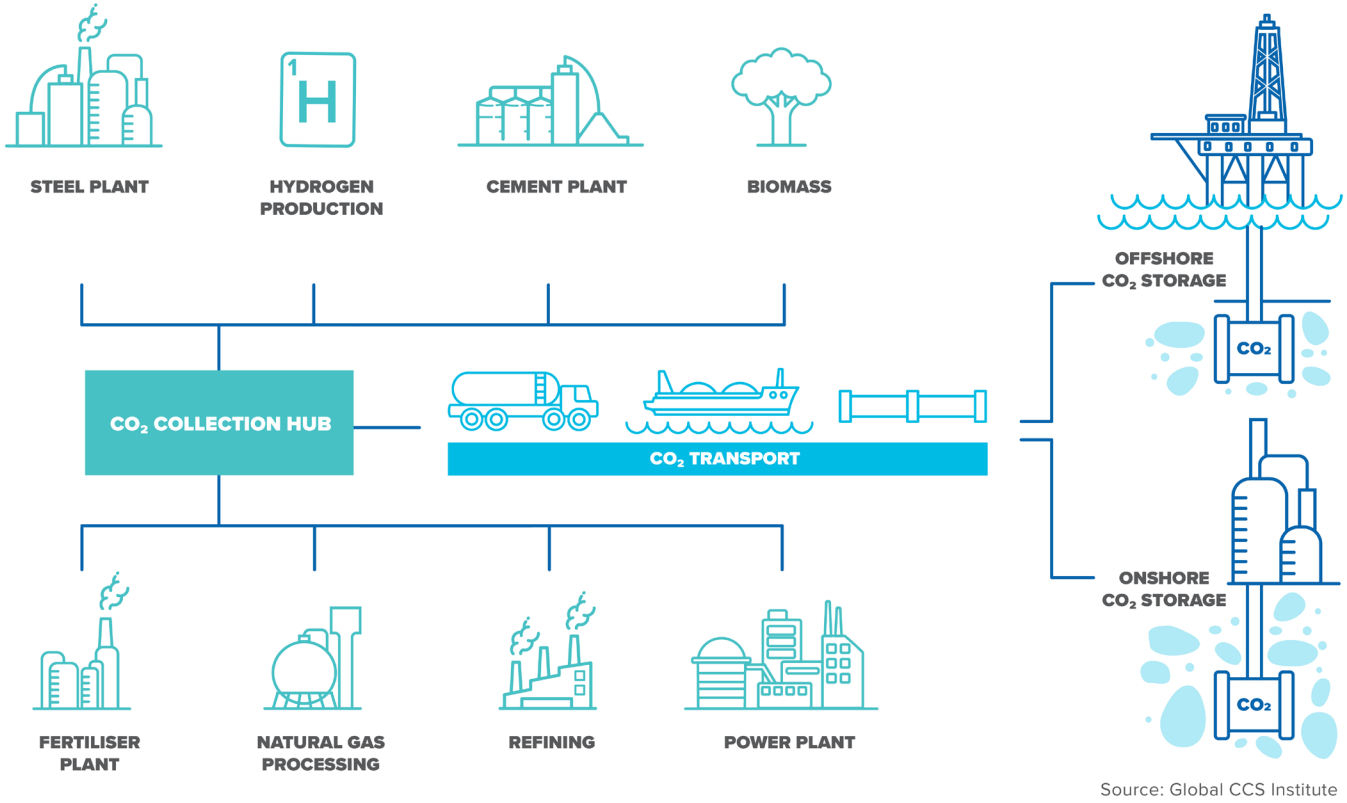
Bankable long-term value on CO_2
C price, CO_2 storage bounty, Tax Credit, Regulation, Govt. procurement policy

Reduce Cost to Investors
Material capital grants, Concessional finance/guarantees, Support geological storage resource appraisal

Reduce Risk to Investors
Support CCS hubs and CO_2 transport and storage infrastructure. Clear & predictable regulation. Long term liability management.



INVESTMENT IN INFRASTRUCTURE IN CRITICAL



Source: Global CCS Institute

Economies of scale in CO_2 transport and injection infrastructure

Multiple counterparties reduces cross-chain risk and delivers higher utilization of assets

WE KNOW HOW TO DEPLOY CCS

CCS is an anchor of the zero-carbon global economy

- Power sector, heavy industry, zero-C hydrogen
- CO_2 removal with direct air capture, BECCS, C mineralization

Policy support is essential

- Infrastructure first:
  - Hubs & Clusters
  - CO_2 pipelines
- Project finance support – ***many, many mechanisms***
- Ecosystem cultivation
  - Innovation policy
  - Pore volume access & long-term liability clarity
  - London Convention Amendment

THANK YOU

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