GLOBAL CCS INSTITUTE

CARBON CAPTURE AND STORAGE (CCS) OVERVIEW

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Cover image: Aerial view of Tomakomai CCS Demonstration carbon capture facilities located at Tomakomai City, Hokkaido, Japan. Image provided by JCCS.

Agenda

The Global CCS Institute (GCCSI)

Carbon Capture and Storage (CCS) and CO_2 emission Reduction

The Current State of CCS

Obstacles to CCS Deployment

Changing the Narrative

The Global CCS Institute (GCCSI)

The Global CCS Institute

- International membership organisation.
- Offices in Washington DC, Brussels, London, Beijing and Tokyo. Headquarters in Melbourne.
- Our diverse international membership consists of:
  - governments,
  - global corporations,
  - small companies,
  - research bodies, and
  - NGOs.
- Specialist expertise covers the CCS/CCUS chain.

The Institute's Strategy

[OUR VISION]

CCS is an integral part of a low emission future

[OUR MISSION]

To accelerate the deployment and commercial viability of CCS globally

[OUR STRATEGIC IMPERATIVES]

We're a Member led organisation
We're a sensible, but bold, risk taker
We're agile and we embrace change
We're financially sustainable
We expand & leverage the CCS community
Our focus is on Valued & Impactful work

[OUR IDENTITY]

We're recognised and sought out as the premier CCS body

MEMBER LED | CCS COMMUNITY | BOLD | IMPACTFUL | AGILE | SUSTAINABLE

Resources on the Ground

Europe

Brussels – 5
- Member Services
- Climate Change
- Advocacy – EU
- Executive Advisor
- Administration

London – 5
- Member Services
- Advocacy – GM
- Economist
- Finance

Oslo – 1
- Member Services/ Legal

North America

Calgary – 1
- Rob Mitchell – MS/RM

Washington – 5
- Jeff Erikson – MS
- Patricia Loria – MS
- Ben Lanson – MS
- Lee Beck – Advocacy
- TBD – Capture

Houston – 1
- Michael Carney - CE

Middle East

Location TBD
- Country Manager 1H19

Asia

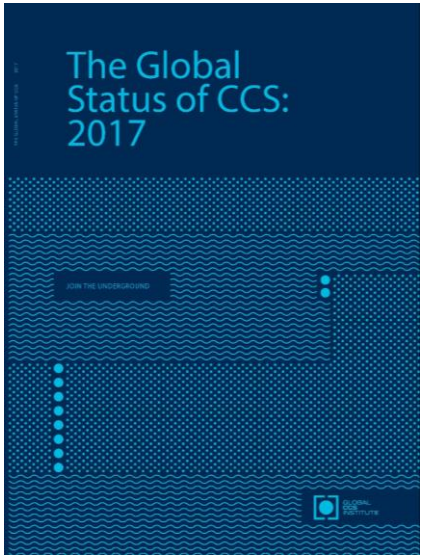
Tokyo – 3
- Country Manager
- Member Services

Beijing – 2
- Country Manager
- Member Services

Australia

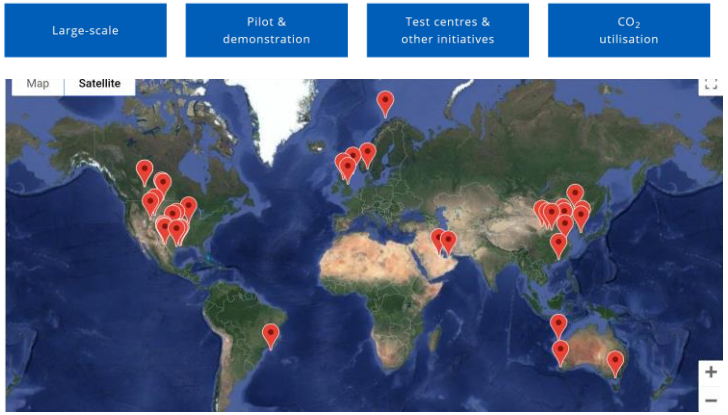
Melbourne – 18
- CEO/CFO
- Technical – GM
- Legal/Policy
- Storage
- Capture
- Facilities Database
- Advocacy
- Communications
- Administrative Services

Knowledge Resources

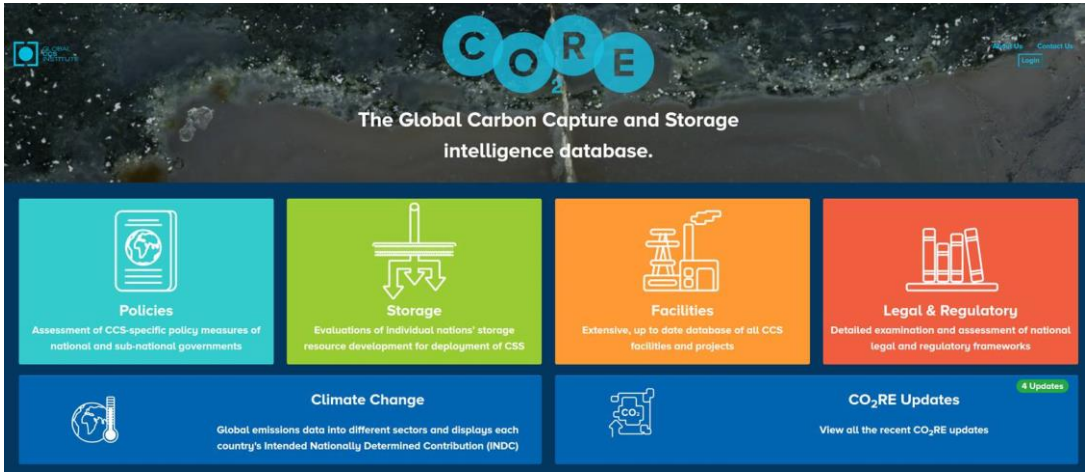


Annual CCS Status Report

CCS Facilities Database



CO2RE Database



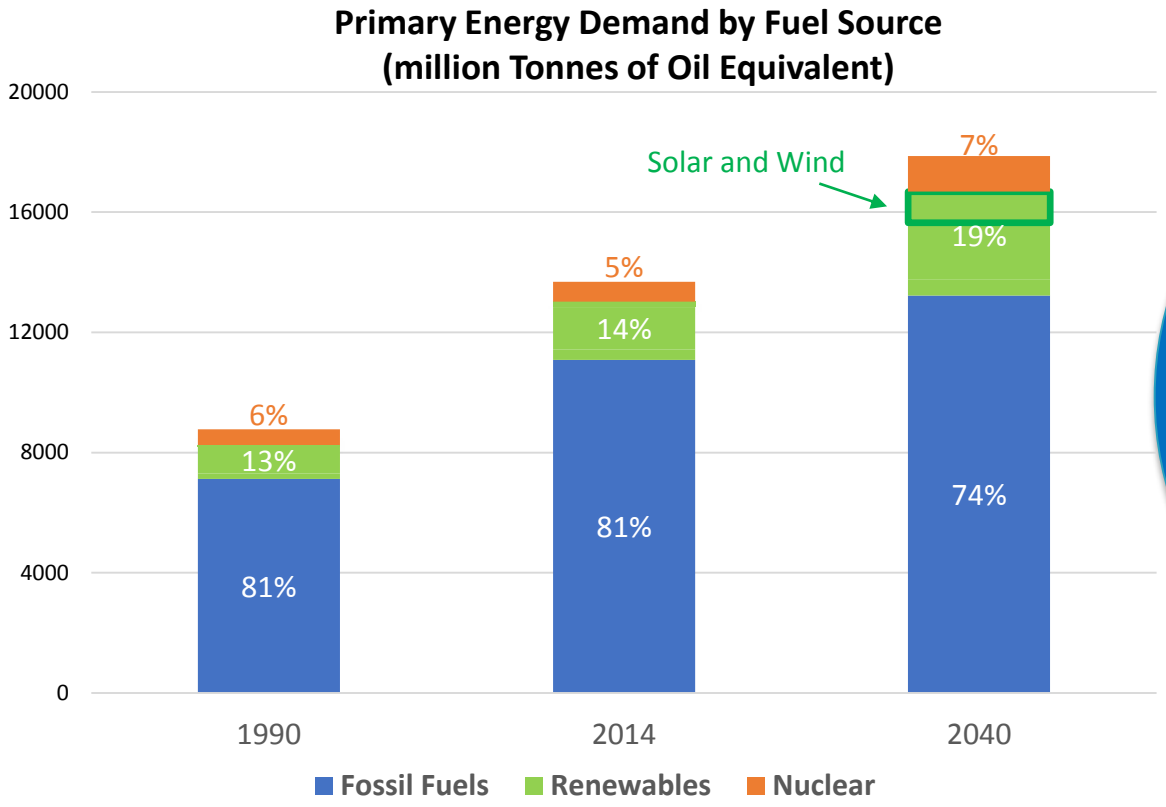
Consulting Services

Consulting Services

Fee for Service	Member Service
Applicability of Carbon Credits for CCS	Public Engagement at energy forum
Opportunities for Brown Coal in a Low-Carbon Economy	Critique of climate risk report
Transporting CO2 by Ship	Participate in CCS promotional video
Current State of CCS – Special Report to Government of Japan	Evaluate various monitoring techniques/protocols
Liability related to Off-Shore Storage of CO2	Provide input to CalEPA CCS protocol
Survey on CCS and ESG	Design and facilitate CCS conference

CCS and CO_2 emission Reduction

Fossil fuel demand growing and reserves robust



Source: *IEA World Energy Outlook*, 2016 (New policies scenario)

Fossil fuel proved reserves:

~7 trillion barrels of oil equivalent

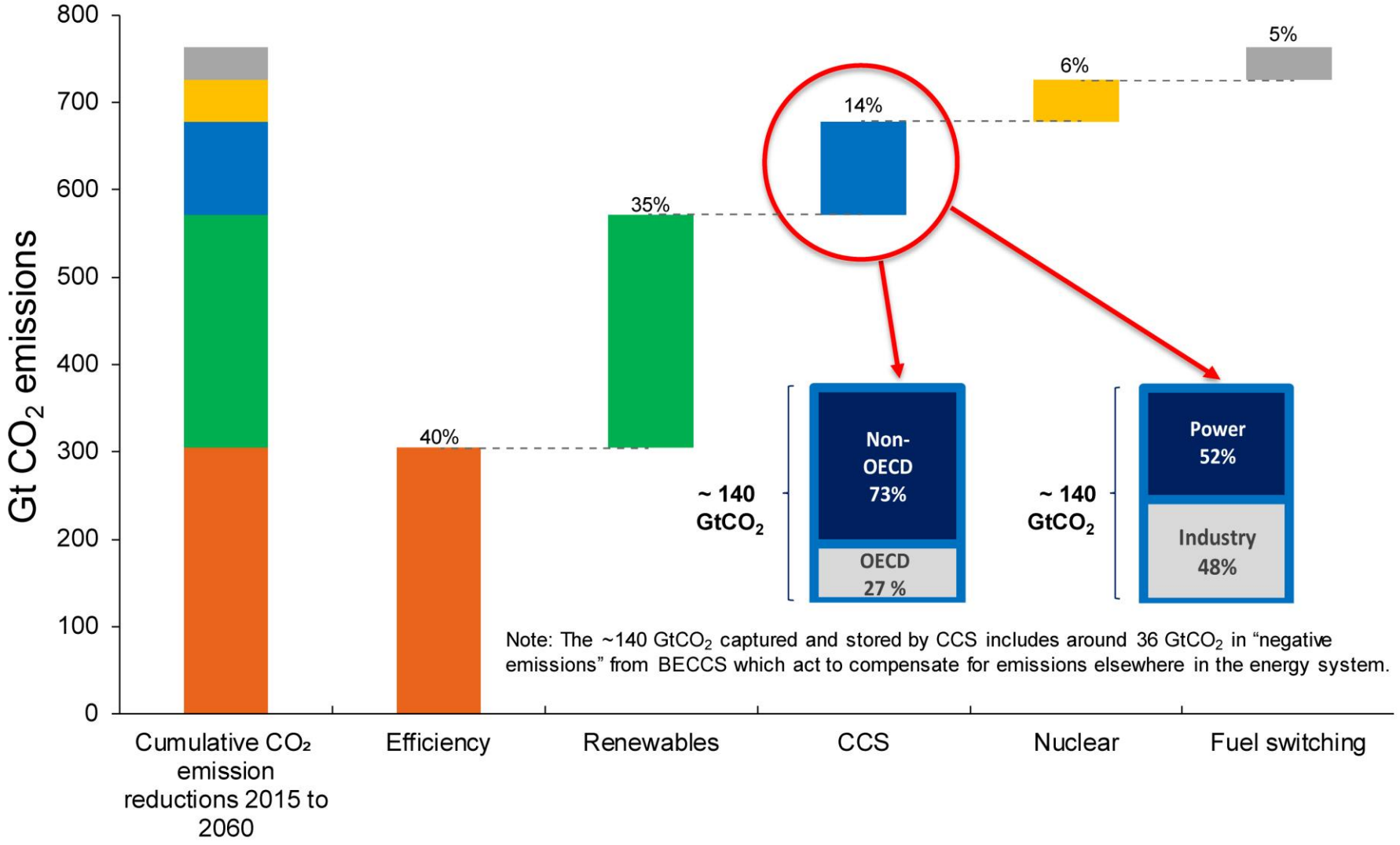
Reserves to production ratio:

~80 years

Source: *BP Statistical Review of World Energy* 2017

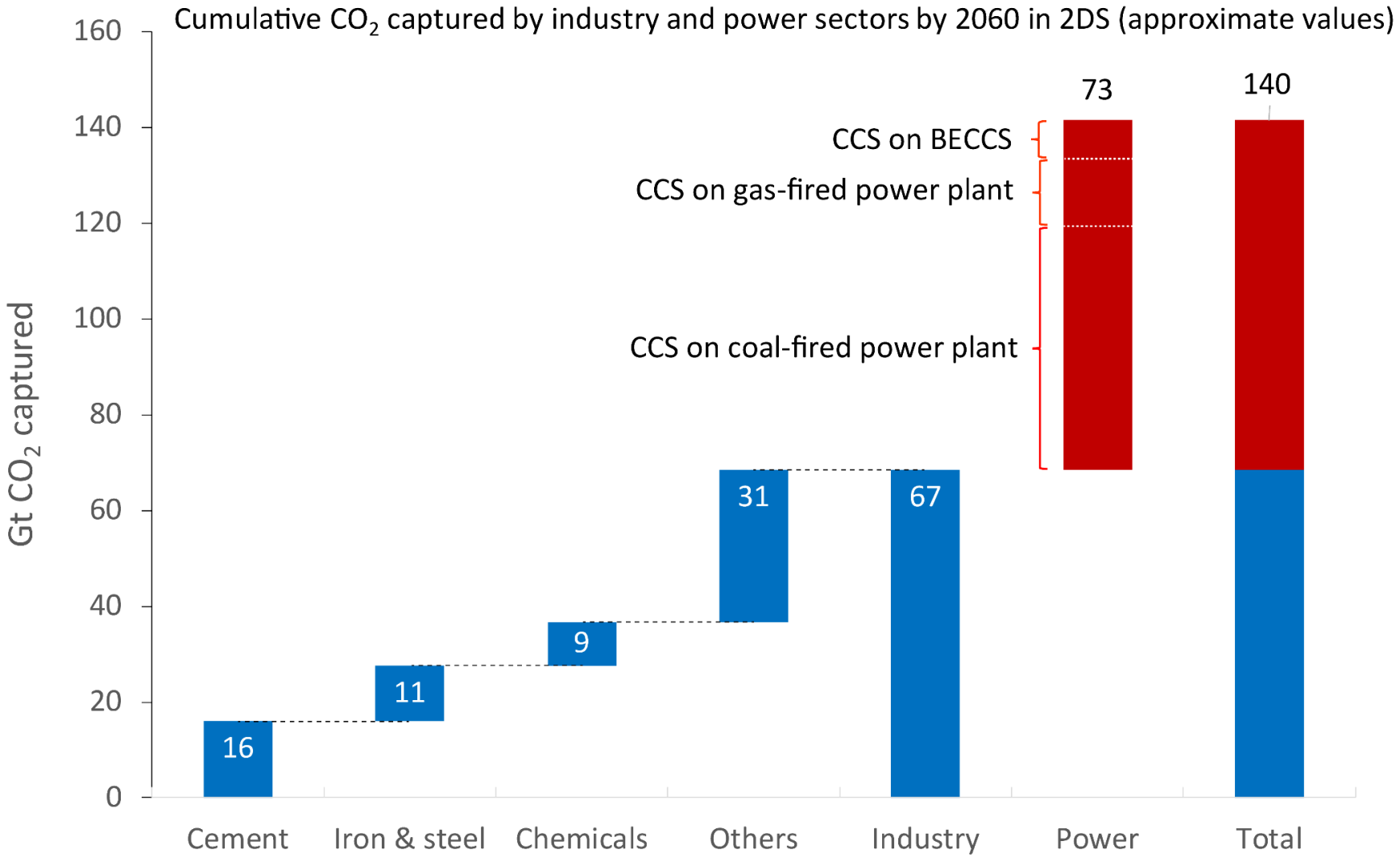
CCS critical in portfolio of low-carbon technologies

CCS contributes 14% of cumulative reductions through 2060 in a 2DS world compared to 'current ambition' (Reference Scenario)



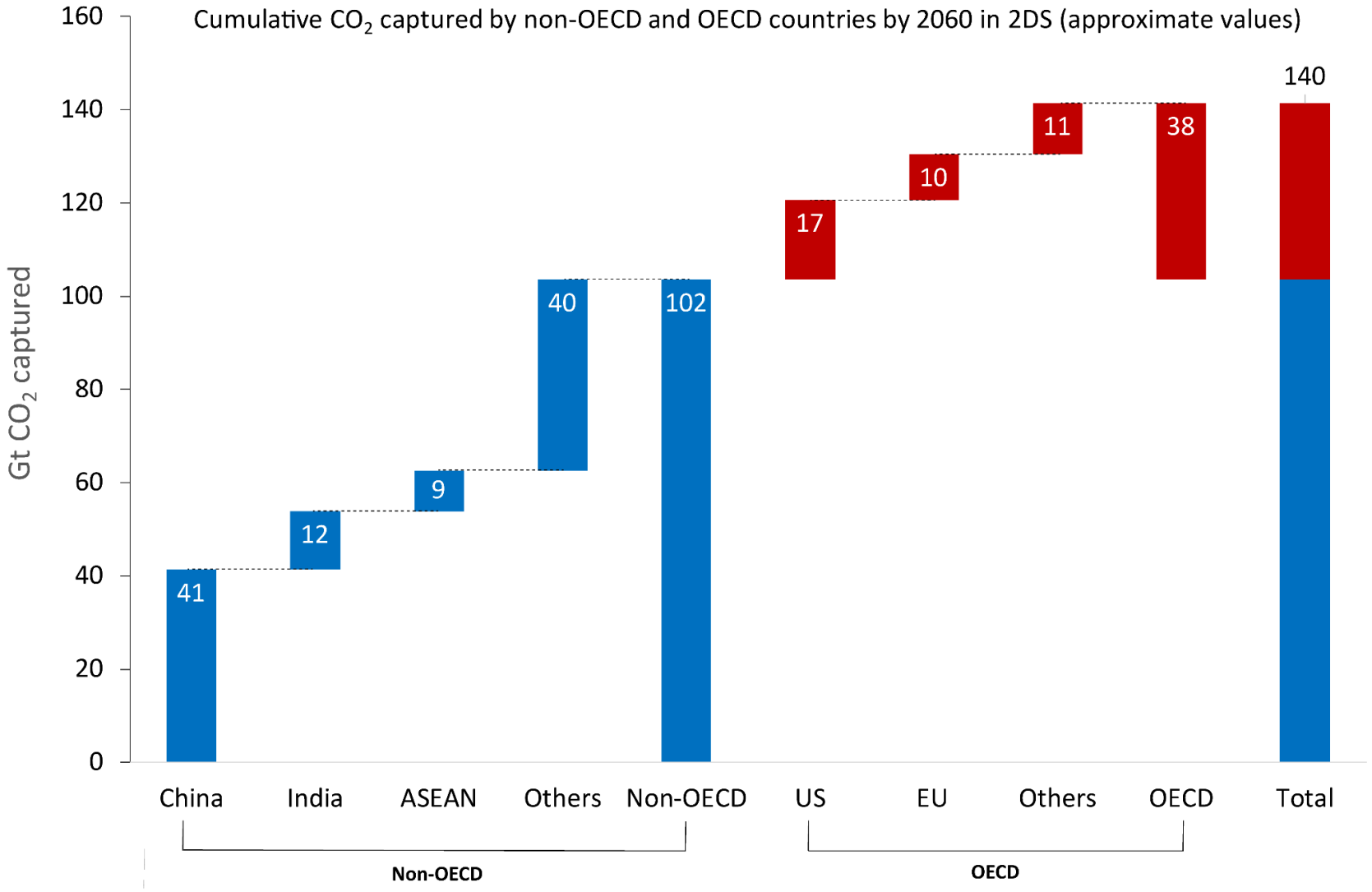
Source: *International Energy Agency (2017), Energy Technology Perspectives 2017, OECD/IEA, Paris*

CCS in industrial and power sectors in the 2DS



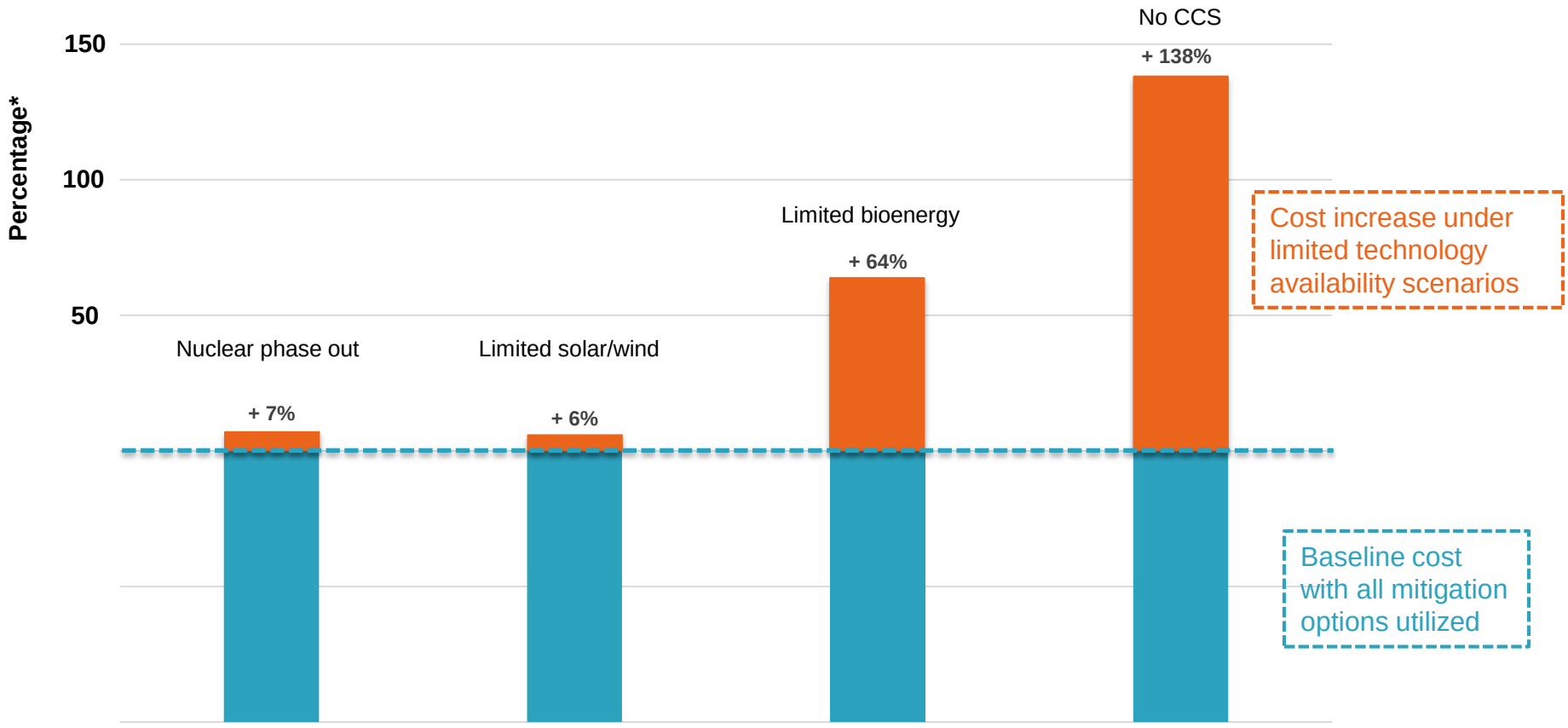
Source: *data sourced from International Energy Agency (2017), Energy Technology Perspectives 2017, OECD/IEA, Paris*

CCS deployment by country in the 2DS



Source: *data sourced from International Energy Agency (2017), Energy Technology Perspectives 2017, OECD/IEA, Paris*

Mitigation costs more than double without CCS



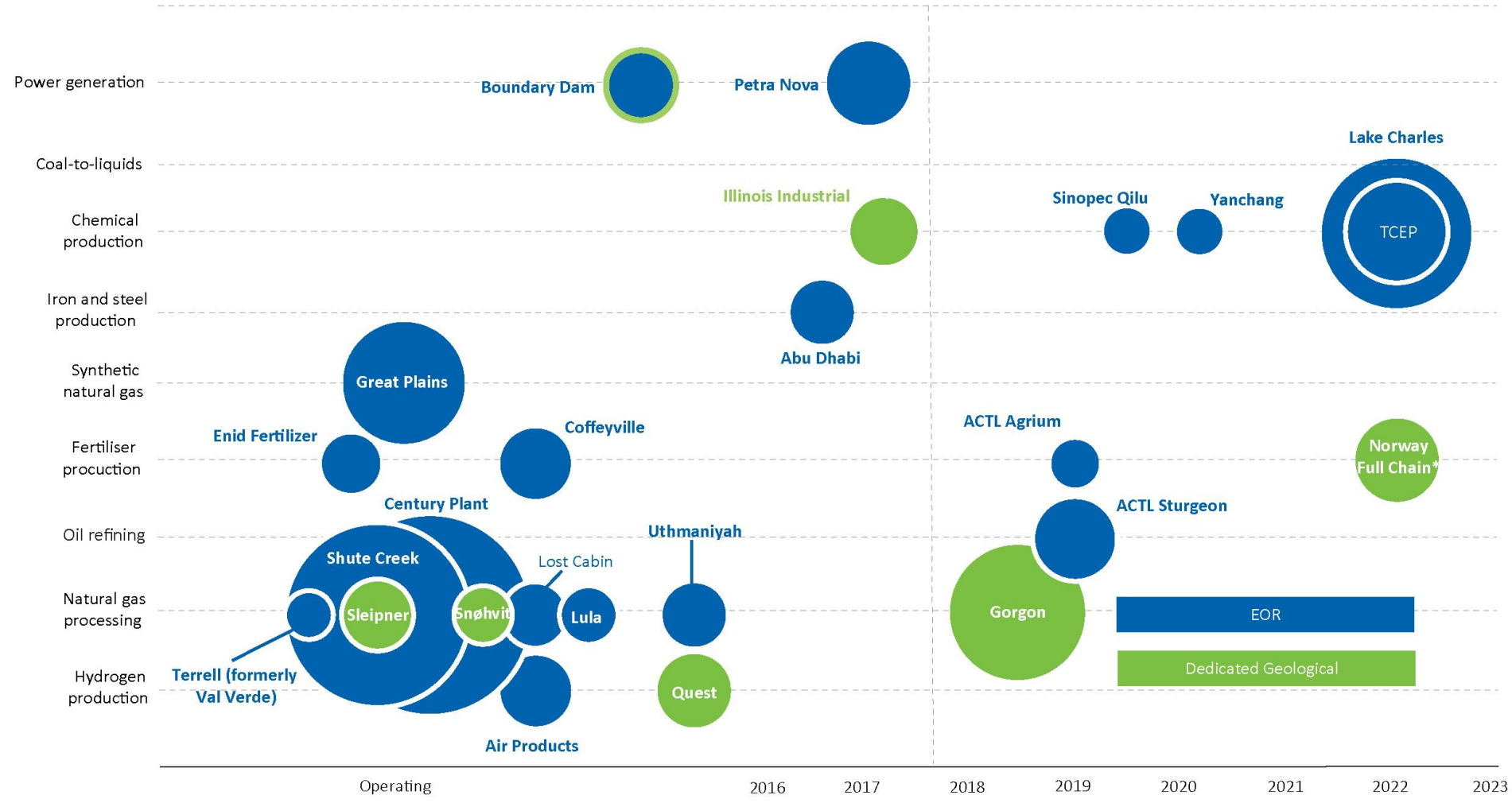
*Percentage increase in total discounted mitigation costs (2015-2100) relative to default technology assumptions – median estimate

Source: *IPCC Fifth Assessment Synthesis Report, Summary for Policymakers, November 2014.*

The Current State of CCS

18 large-scale facilities in operation

Carbon bubbles



= 1Mtpa of CO_2 (area of circles proportional to capacity)

Facilities in the Operating, In construction and Advanced development stages

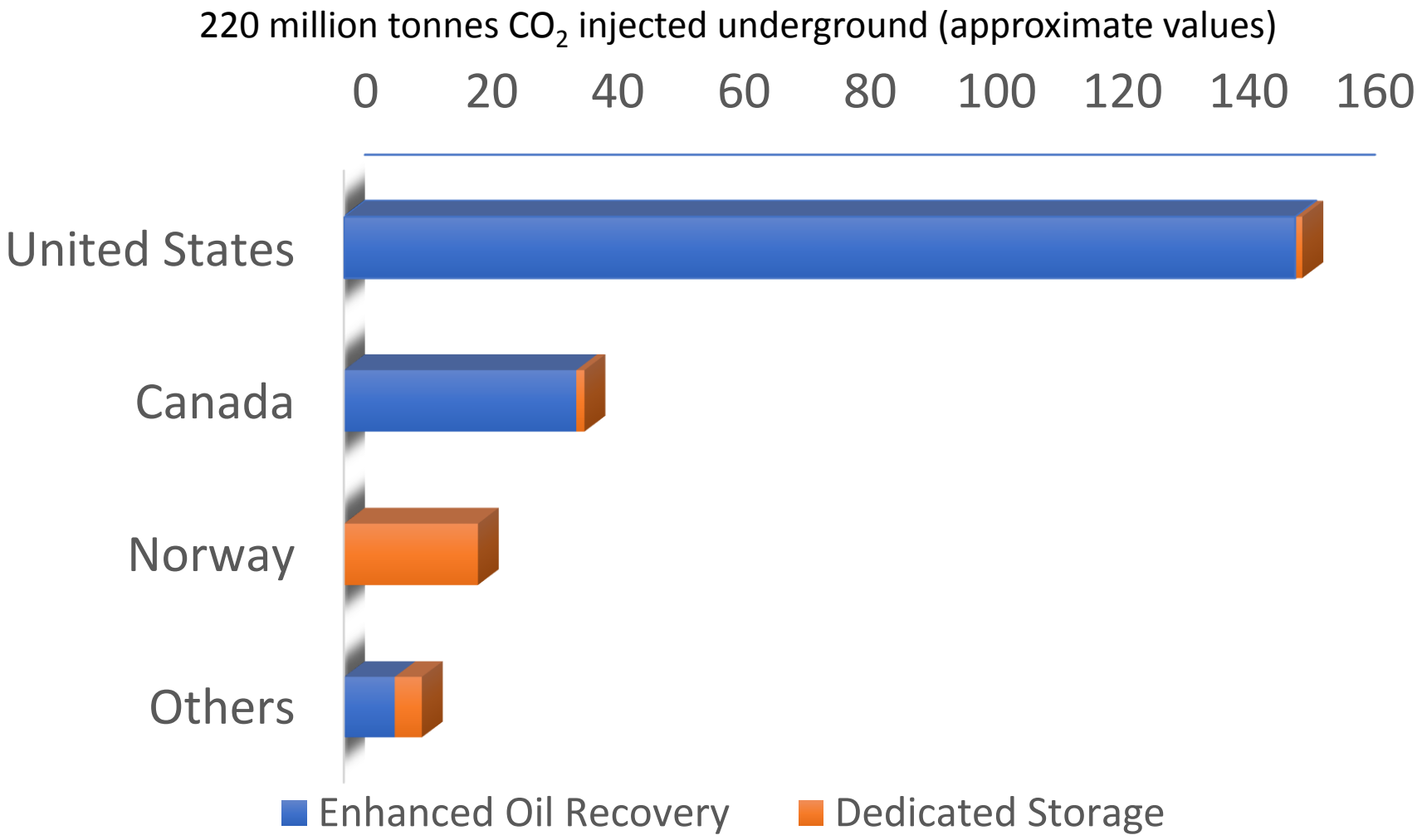
The CCS project pipeline is shifting

	Early development	Advanced development	Construction	Operating	Total
North America	-	2	2	12	16
China	6	-	2	-	8
Europe	2	1	-	2	5
Gulf Cooperation Council	-	-	-	2	2
Rest of World*	3	1	1	1	6
Total	11	4	5	17	37

** Includes facilities in Australia, Brazil and South Korea.*

North America dominates – 14 (of 21) facilities in operation or construction, China has most facilities in development, facility pipeline needs replenishment

Cumulative anthropogenic CO_2 injection



Note: *"Others" include Algeria, Brazil, China, Saudi Arabia, United Arab Emirates, Germany and France.*

Source: *Global CCS Institute estimates*

Key CCS Developments in North America

45Q

The FUTURE Act – 45Q

Level of credit available for different combinations of CO_2 sources and uses

IEA Analysis

Minimum size of eligible carbon capture plant by type ($ktCO_2/yr$)

Type of CO_2 storage/use	Power plant	Other industrial facility	Direct air capture
Dedicated geological storage	500	100	100
Storage via EOR	500	100	100
Other utilisation processes[1]	25	25	25

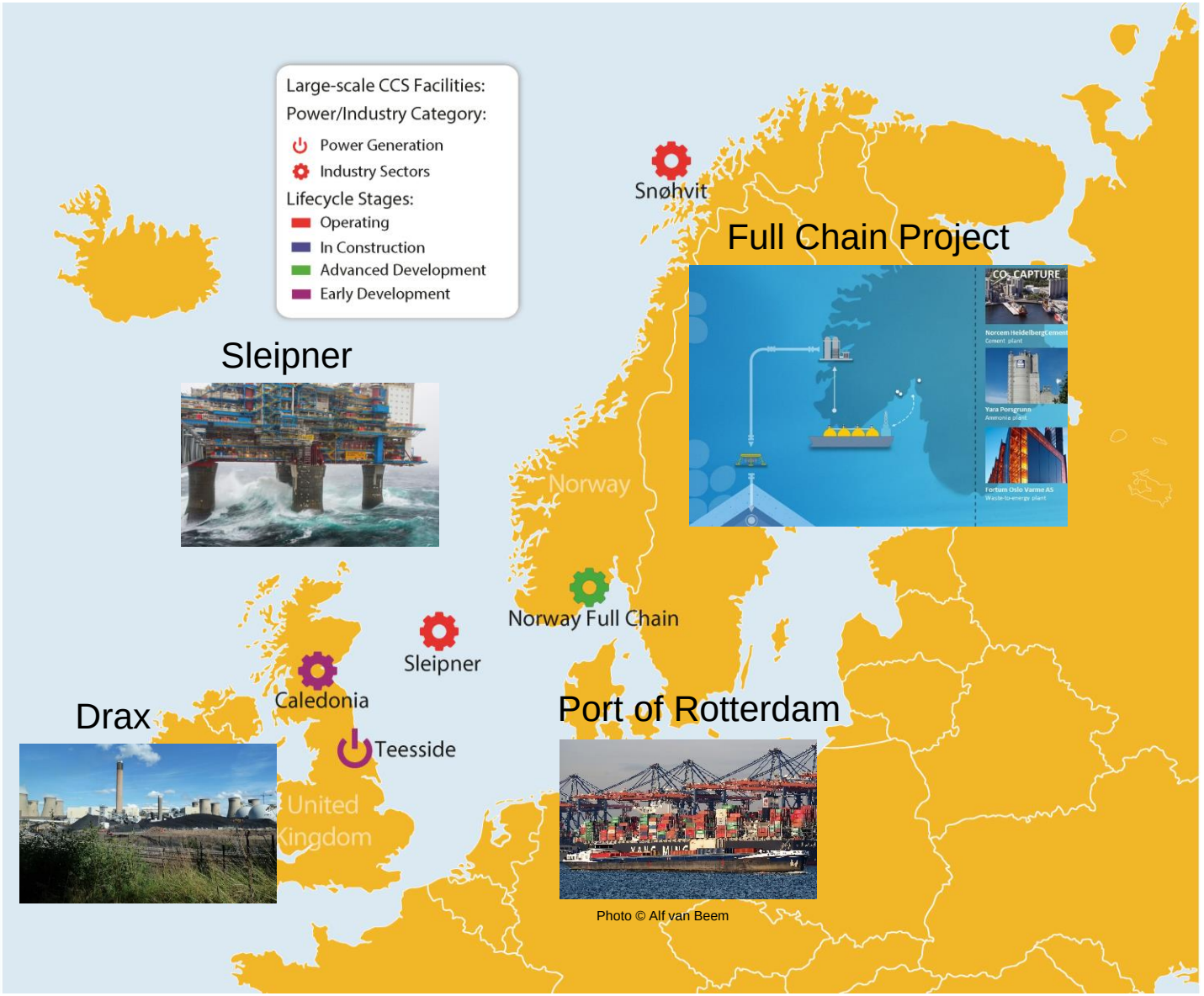
Relevant level of tax credit in a given operational year (USD/tCO_2)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	Later
Dedicated geological storage	28	31	34	36	39	42	45	47	50	Index linked
Storage via EOR	17	19	22	24	26	28	31	33	35	Index linked
Other utilisation processes[1]	17[2]	19	22	24	26	28	31	33	35	Index linked

[1] each CO_2 source cannot be greater than 500 $ktCO_2/yr$

[2] Any credit will only apply to the portion of the converted CO_2 that can be shown to reduce overall emissions

Key CCS Developments in Europe



Required scale-up is a monumental task

The Last 25 Years

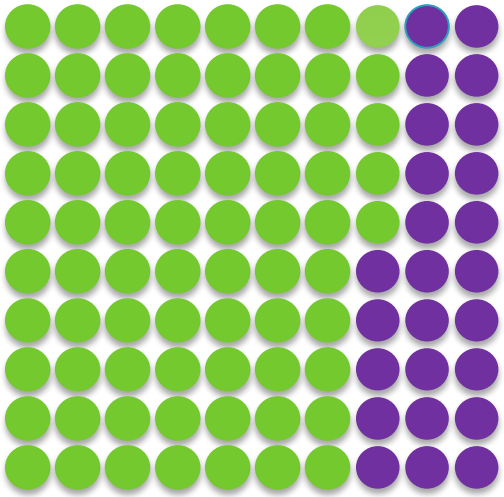
37 large-scale CCS facilities - combined CO_2 capture capacity of approximately 69 Mtpa*:

- 22 facilities in operation or construction (**~37 Mtpa**)
- 4 facilities in advanced development (~13 Mtpa)
- 11 facilities in earlier stages of development (~19 Mtpa)

37 Mtpa

The Next 25 Years

3,800 Mtpa of CO_2 captured and stored by 2040 (IEA 2DS)**



**Mtpa = million tonnes per annum*

***Source*: *International Energy Agency (2017), Energy Technology Perspectives 2017, OECD/IEA, Paris*

Note: 2040 IEA 2DS data includes ~0.6 Mtpa "negative emissions" from BECCS

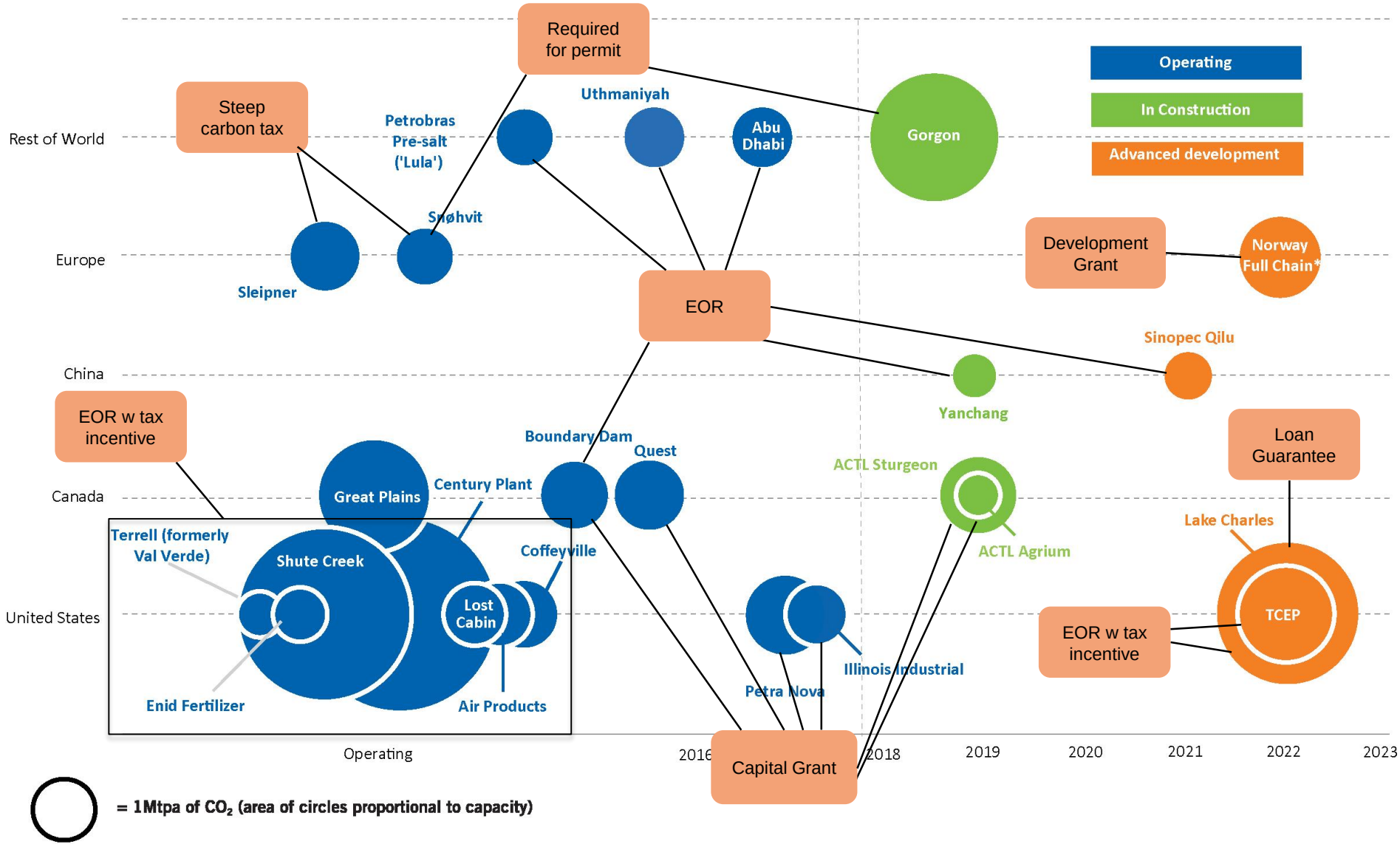
Obstacles to CCS Deployment

Obstacles to Deployment

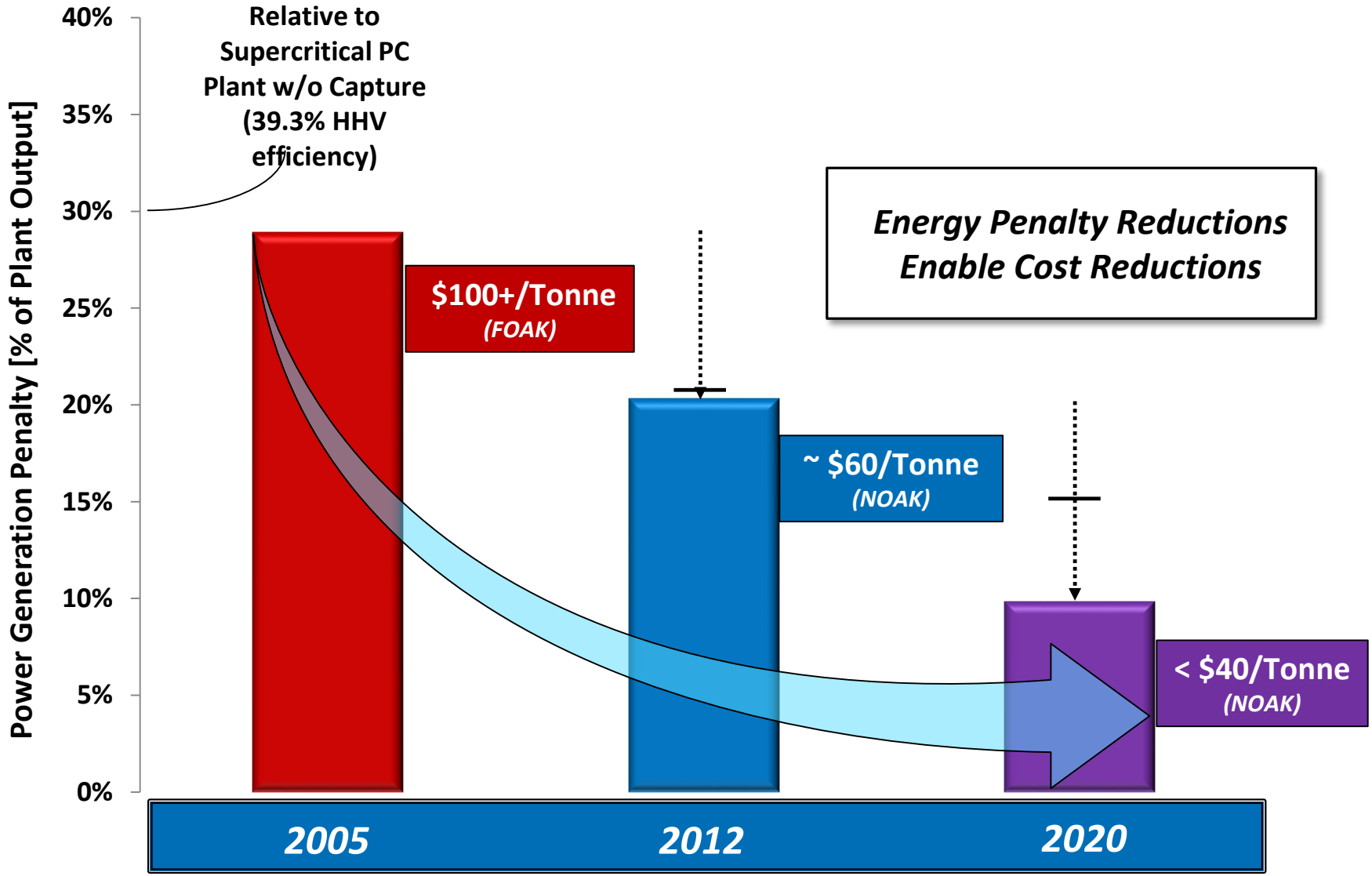
	#1 – Poor Project Economics	#2 – Perceptions, Risks, Uncertainties	#3 – Scale of Investment Required
Solutions	**Increase Income** – EOR, other CO2 markets, price premium for low-carbon energy, sell technology	Standards, knowledge sharing, research	Smaller projects, modularity
	Reduce Capital Cost – technology advances, subsidies/incentives, preferential financing	Communication, engagement	Industrial CCS
	Reduce Operating Cost – tax incentives, production tax credit	Guaranteed purchase of electricity, portfolio standards	Carbon utilization
	Price/limit on carbon emissions – Tax, cap/trade, emissions standards, permit requirement	Legislation, regulation	Loan guarantees

Policy should focus on reducing or eliminating the barriers to private sector investment

Project Economics – policy measures that work



Project Economics – technology advances



Note: HHV = Higher Heating value, FOAK = First of a Kind, NOAK = Nth of a Kind.

Source: *Michael Matuszewski. "DOE/NETL CO2 Capture R&D Program". 2014 NETL CO_2 Capture Technology Meeting*

Changing the Narrative

The Current Narrative

E&E NEWS

Will CCS Ever Work?

HUFFPOST

Donald Trump Promised 'Clean Coal,' But It Doesn't Exist

The New York Times

Companies Struggle to Make Carbon Capture Viable

SCIENTIFIC AMERICAN

Carbon Capture May Be Too Expensive to Combat Climate Change

MORNING CONSULT

Congress, White House Drag Feet on Support for Carbon Capture Expansion

Bloomberg

Will Trump Make This $7 Billion Clean-Coal Plant Irrelevant?

Forbes

Carbon Capture: An Expensive Option For Reducing U.S. CO_2 Emissions

Mashable

Michael Bloomberg calls 'BS' on clean coal technology

FINANCIAL TIMES

Carbon capture and storage — too little, too late, too expensive

The Language We Use

It is better to be <u>understood</u>
than to be comprehensive

Congressional Survey – Does Carbon Capture Work?

- **Language** – “CCS” is not an easily identified term
- **Cost** – widely held belief that CCS is too expensive
- **Climate change**
  - extends use of fossil fuel
  - Important option to address climate change
- **Safety** – risks not well understood

Positive Language, Supported by Facts

Proven

Affordable

Versatile

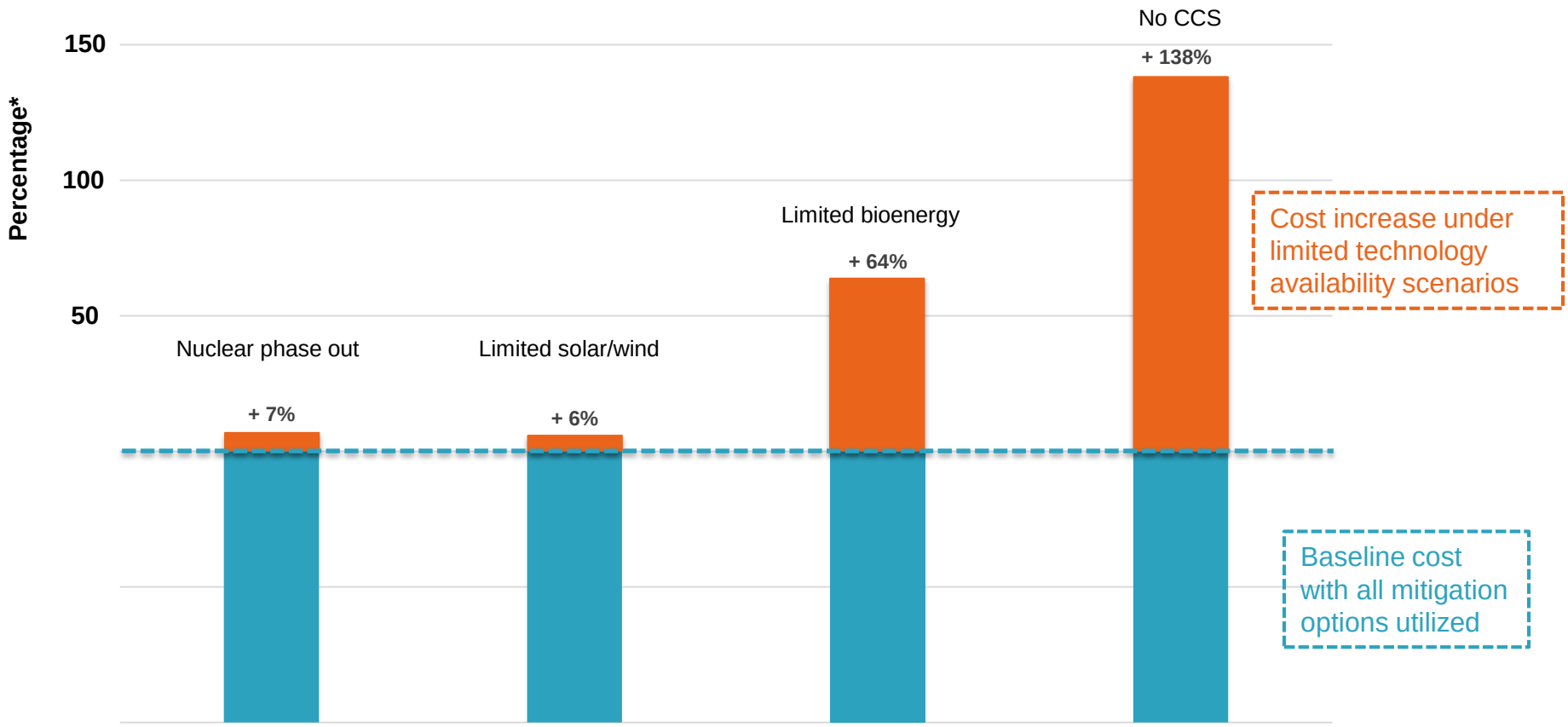
Essential

Proven

18 large-scale facilities
37+ million tonnes/yr

Affordable

Without CCS, cost of mitigation more than doubles

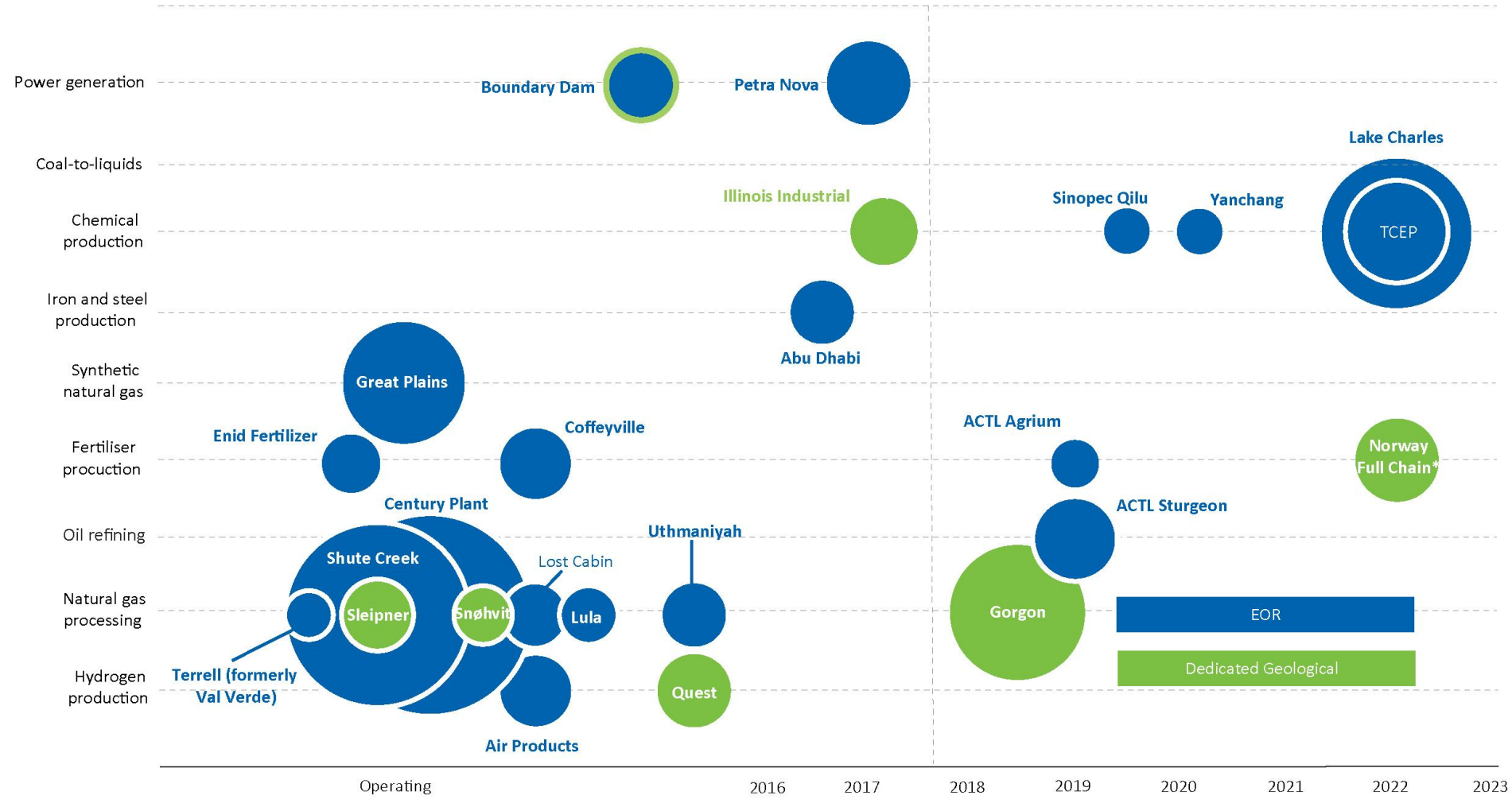


*Percentage increase in total discounted mitigation costs (2015-2100) relative to default technology assumptions – median estimate

Source: *IPCC Fifth Assessment Synthesis Report, Summary for Policymakers, November 2014.*

Versatile

CCS can be used across many industries

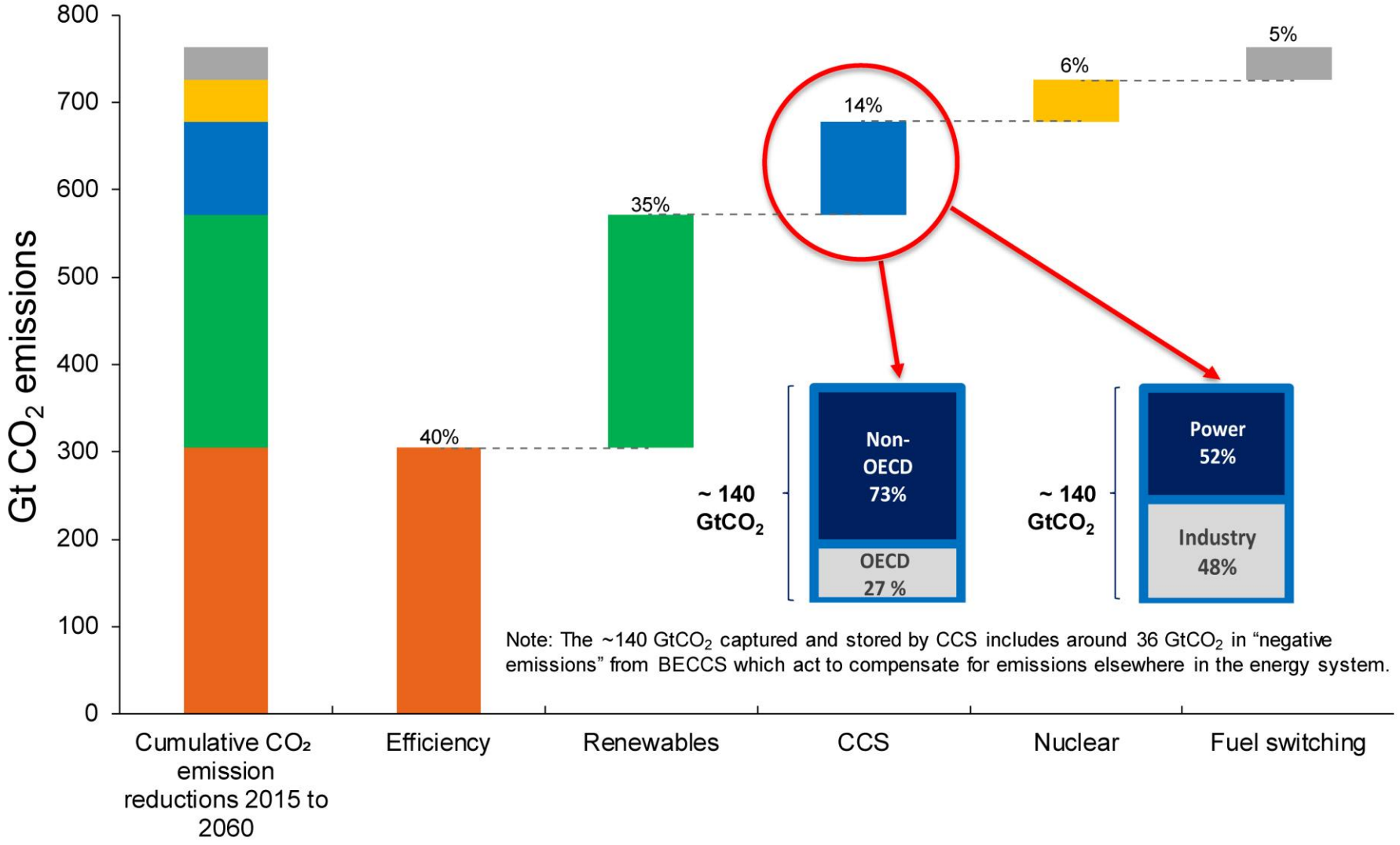


= 1Mtpa of CO_2 (area of circles proportional to capacity)

Facilities in the Operating, In construction and Advanced development stages

Essential

Numerous authorities say we can't achieve 2DS without it



Key Messages

1. Paris **climate change targets** cannot be reached without -CCS没有CCS，**巴黎协定2度目标**将无法实现

2. CCS is the only **proven clean technology** capable of decarbonizing major industry-CCS技术是主要工业行业唯一能**证明脱碳的清洁技术**

3. CCS is creating a **new energy economy** of hydrogen production, bio-energy with CCS (BECCS), Direct Air Capture, and Carbon to Value representing a raft of CO_2 re-use applications-CCS正在创造一种新的氢能源经济、生物能源与CCS结合（BECS）、直接空气捕集以及代表了碳能产生价值的一系列CO_2再利用

4. CCS is **creating jobs**, sustaining communities and strengthening nations-CCS正在**创造就业**、维持社区和使得国家强大

5. The storage of CO_2 is the **most effective option** available to reduce emissions and meet international climate change targets- CO_2封存是减少排放和满足国际气候变化目标的**最有效的选择**

BREAK THE CARBON CYCLE

GLOBAL CCS INSTITUTE

WWW.GLOBALCCSINSTITUTE.COM

JOIN THE UNDERGROUND

PARIS CLIMATE CHANGE TARGETS
CANNOT BE MET WITHOUT CARBON CAPTURE AND STORAGE