Global Update on CCUS and Higher Capture Rates

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IEA Greenhouse Gas R&D Programme

2018 NETL CO_2 Capture Technology Project Review Meeting

13 August 2018, Pittsburgh, USA

iea Energy Technology Network

Membership

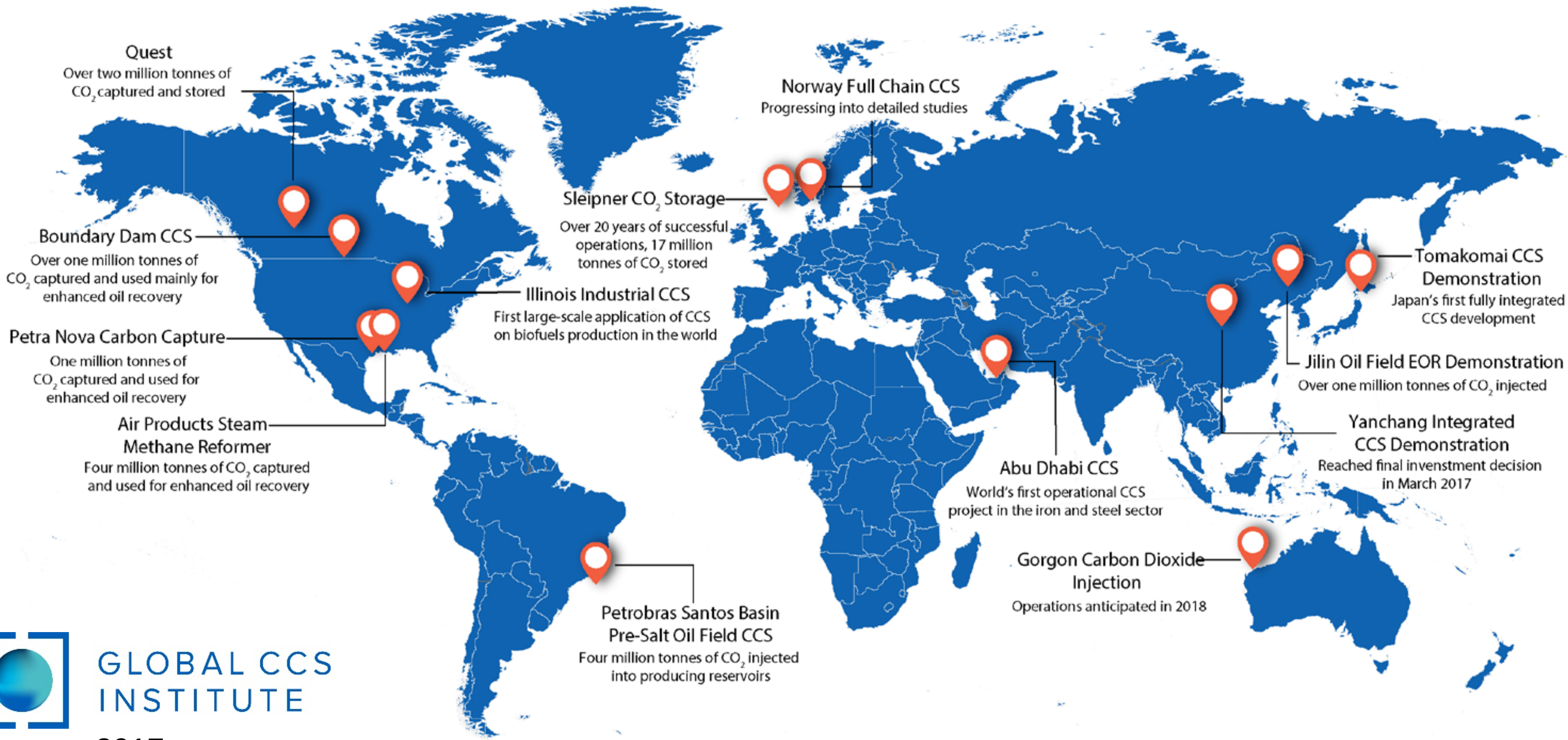
Cost-shared Technology Collaboration Programme

Global Update on CCUS - Projects

- **21** large-scale CCS projects in operation or under construction globally
  - CO_2 capture capacity of **37** Mt/yr
- 4 projects in construction as of November 2017
- 5 more large-scale CCS projects at an advanced stage of development planning
  - CO_2 capture capacity of ~ 8 Mt/yr
- 11 more large-scale CCS projects are in earlier stages of planning
  - CO_2 capture capacity of ~21 Mt/yr
- Cumulative injection >**220** Mt CO_2

Source: Global CCS institute 2017

Key CCS facility developments globally



GLOBAL CCS INSTITUTE

2017

INTERNATIONAL
CCS KNOWLEDGE
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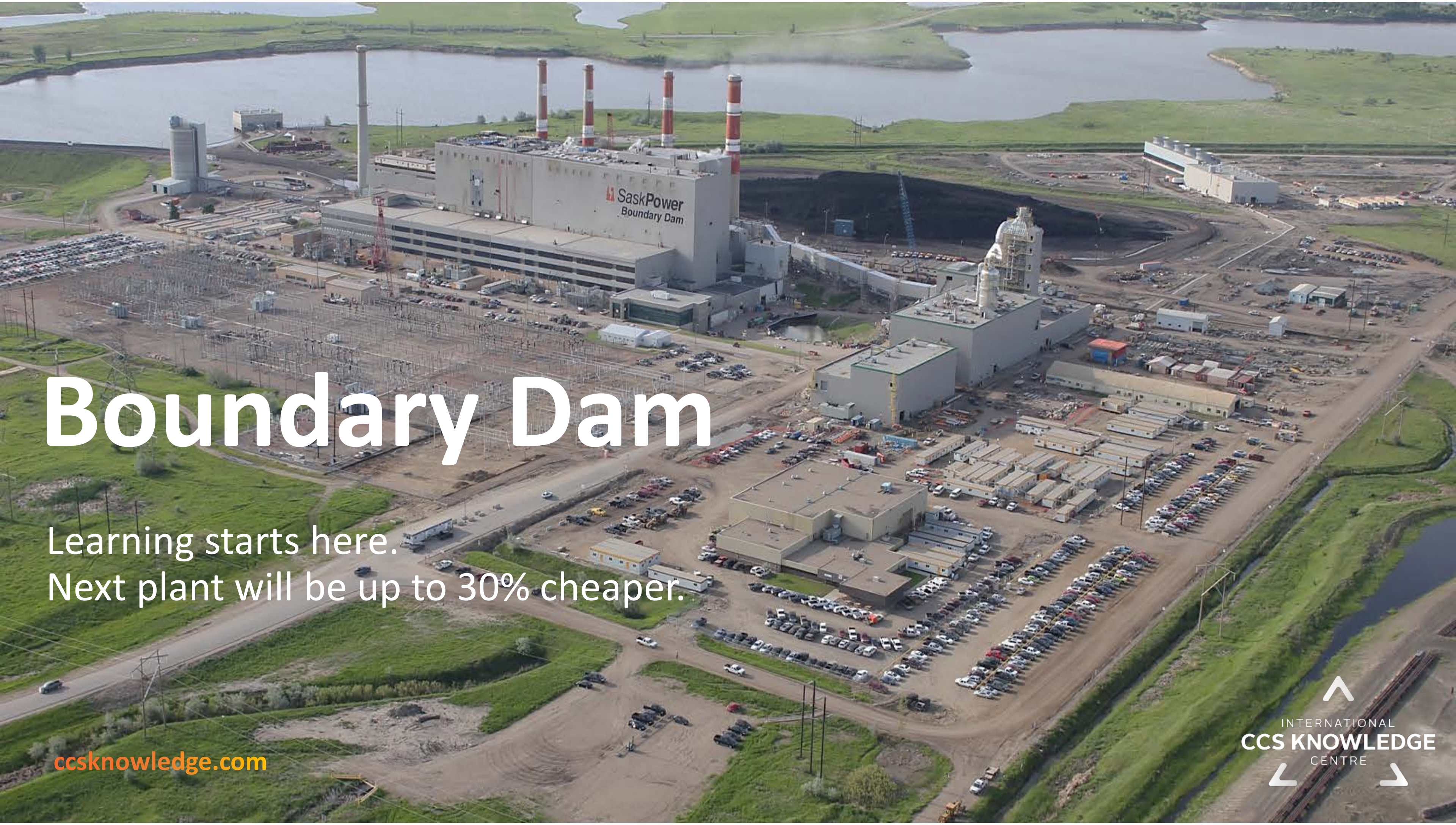
ccsknowledge.com



Boundary Dam

Learning starts here.
Next plant will be up to 30% cheaper.

ccsknowledge.com

INTERNATIONAL
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Reliable Performance of Capture Island Since 2017 Outage

INTERNATIONAL
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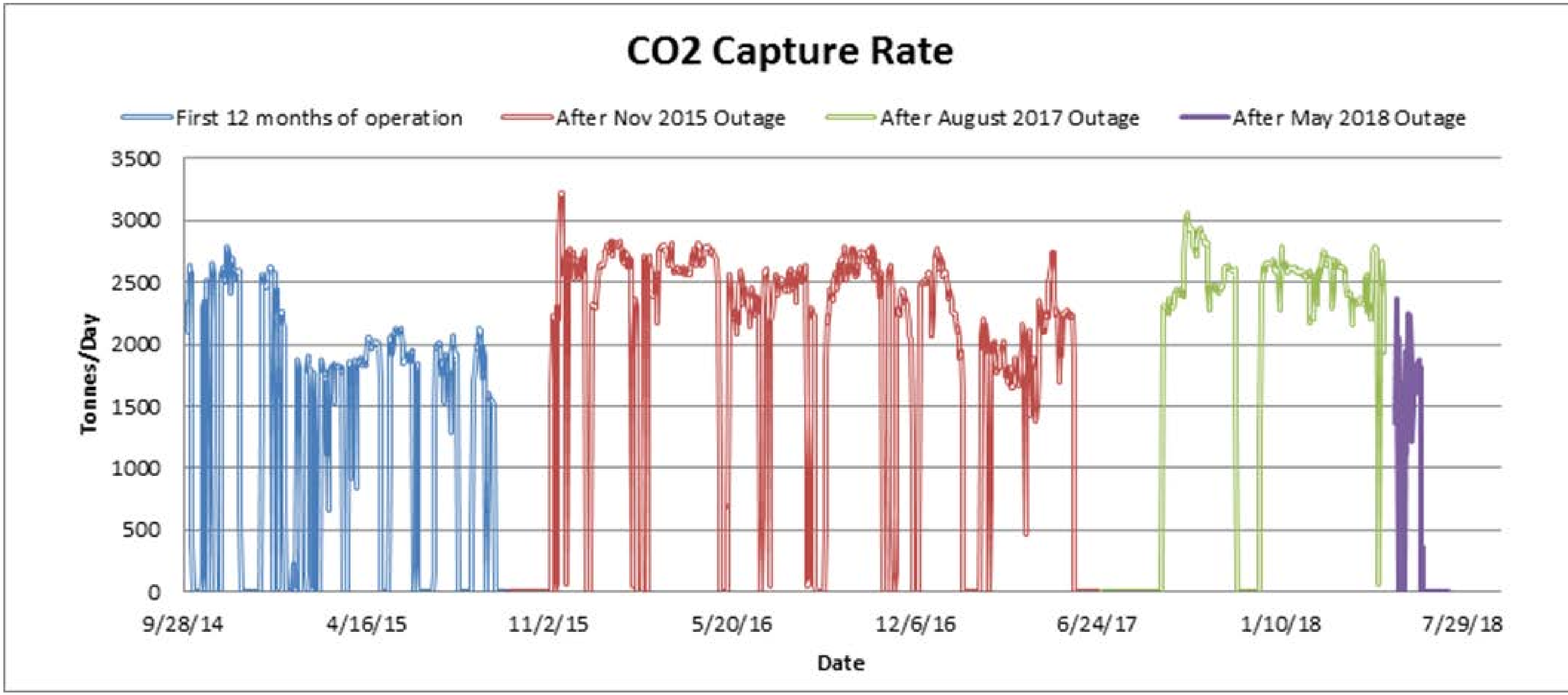


Global Update on CCUS - Policy

- CCUS Initiative launched under Clean Energy Ministerial
  - Ministerial launch in Copenhagen, May 2018

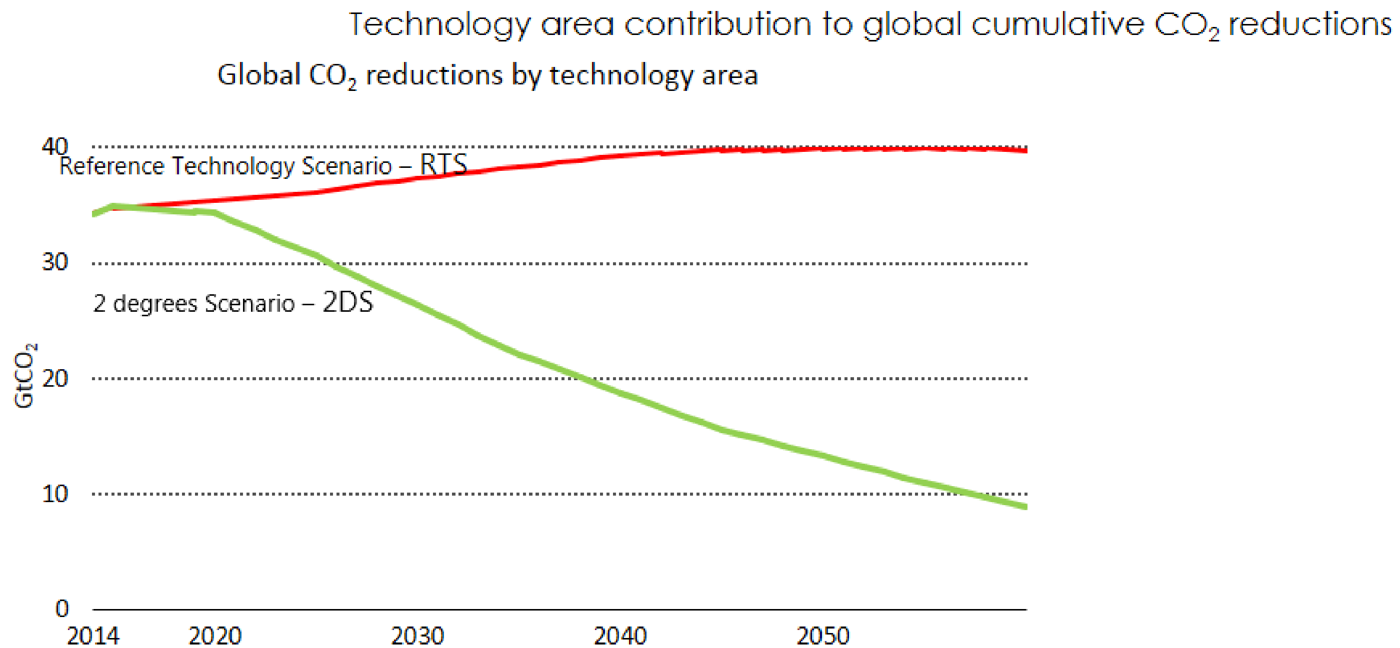
- Mission Innovation's Carbon Capture Challenge report issued
  - 30 Priority Research Directions for advancing the performance and reducing the costs of CCUS, focussing on low technology readiness levels (TRL)
  - Ministerial launch in Malmo, May 2018

- Country developments
  - USA enhanced 45Q
  - Norway – FEED on industrial CCS for cement and WtE
  - UK CCUS Cost Challenge Task Force report
  - Japan/Australia/Norway/UK – Hydrogen value chains with CCS

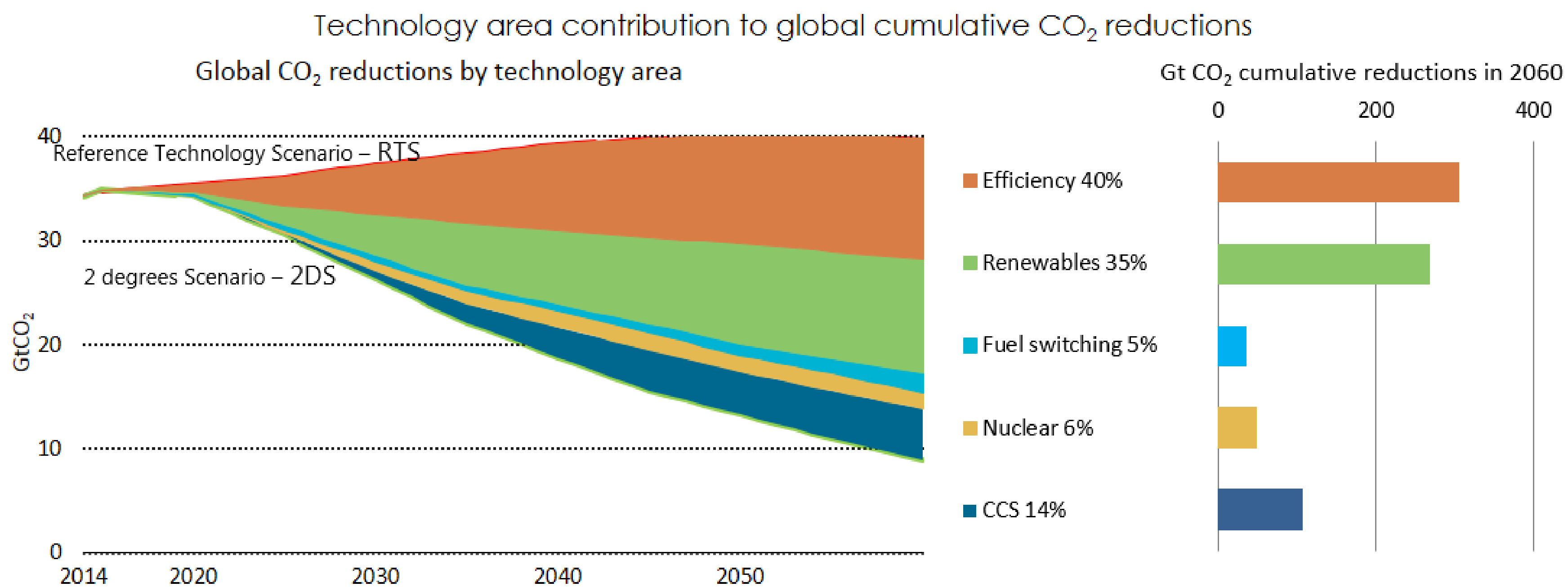
ETP 2017
The role of CCS

IEA

CCS plays a leading role in the energy transformation



CCS plays a leading role in the energy transformation



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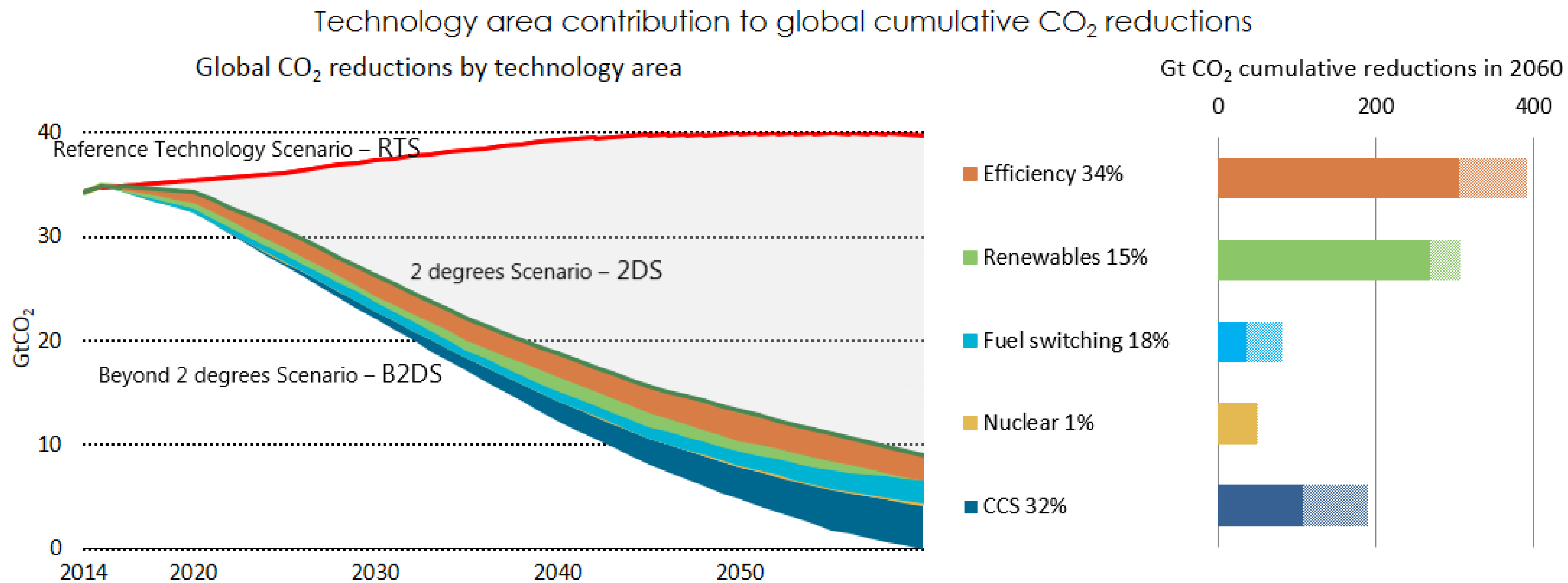
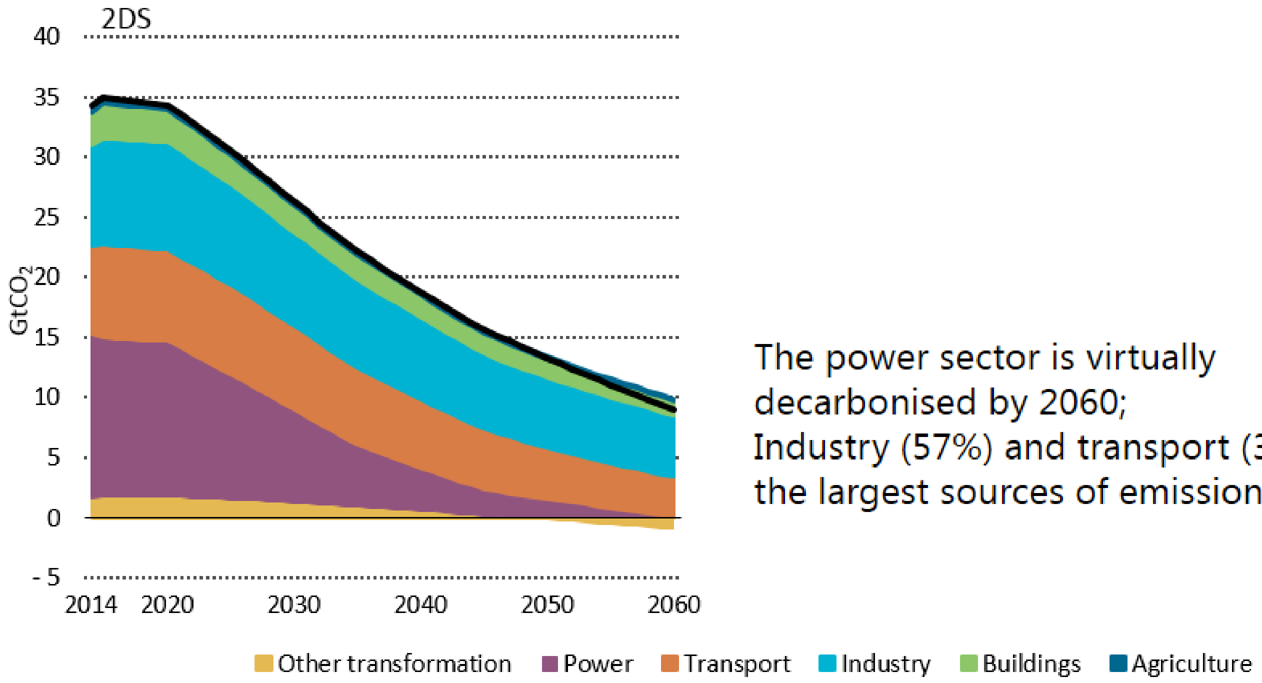


Pushing energy technology to achieve carbon neutrality by 2060 could meet the mid-point of the range of ambitions expressed in Paris

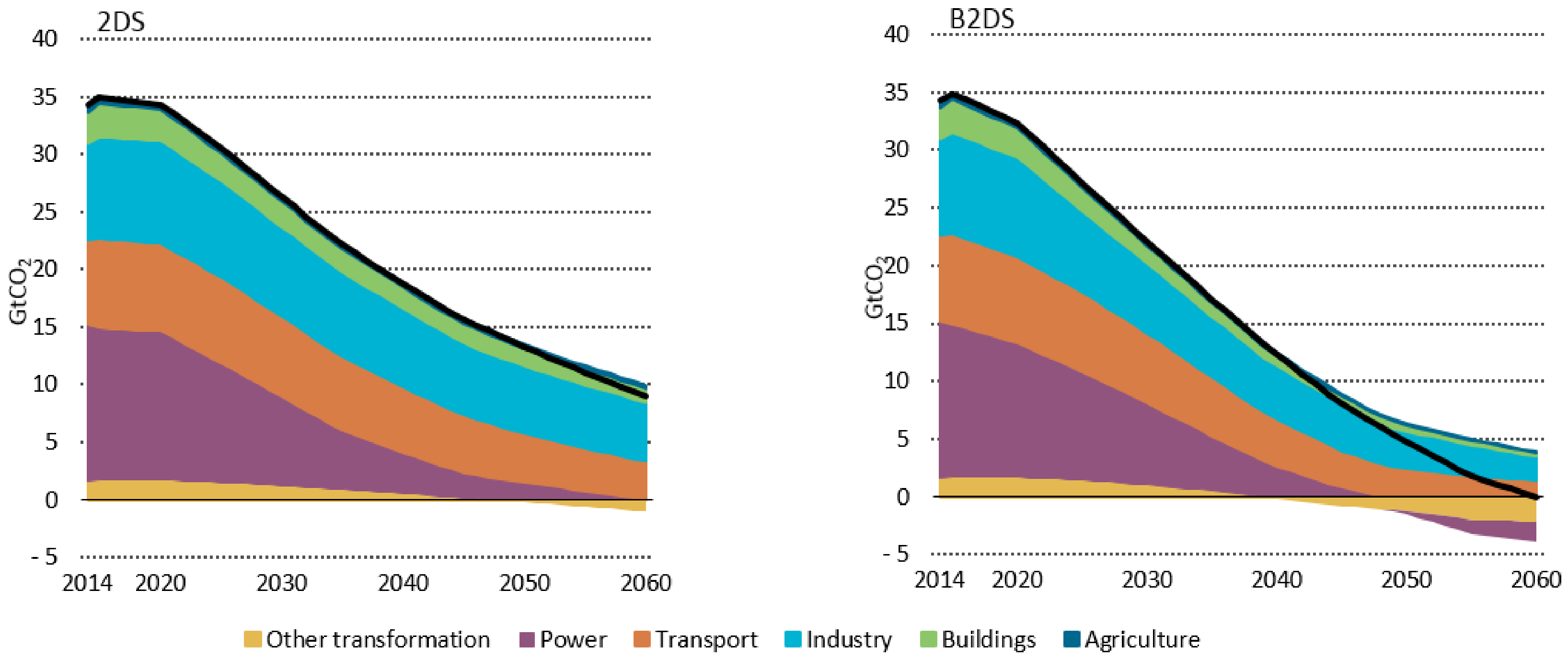
Remaining CO_2 emissions in the 2DS and B2DS



The power sector is virtually decarbonised by 2060;
Industry (57%) and transport (36%) are the largest sources of emissions in 2060

The remaining CO_2 emissions in industry and power must be targeted for the B2DS

Remaining CO_2 emissions in the 2DS and B2DS



The remaining CO_2 emissions in industry and power must be targeted for the B2DS
Negative emissions are necessary to achieve net-zero emissions in 2060

IPCC 1.5 Special Report

- Impacts and pathways to achieving 1.5C by 2100, in context of increasing global response, sustainable development and poverty
- To agree and publish SR1.5 in September 2018
- Expert reviews: August-September 2017; January-February 2018
- https://www.ipcc.ch/report/sr15/

IPCC SR 1.5

Chapters

1. Framing and Context
2. Mitigation pathways compatible with 1.5C in context of sustainable development
3. Impacts of 1.5C on natural and human systems
4. Strengthening and implementing the global response
5. Sustainable development

Integrated Assessment Models used to inform IPCC, IEA and others. These typically assume Capture rate of 90%—this is a limiting factor for CCS deployment in IAMs later this century.

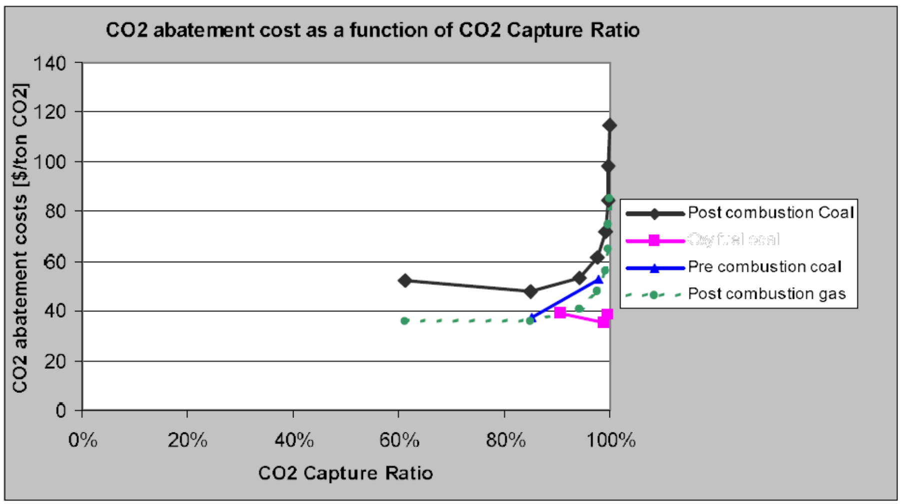
IEAGHG Study - Towards Zero Emissions CCS

- CSIRO appointed as contractor (6 July 2017)
- Initial results presented to IEAGHG members May 2018
- Draft report received, peer reviewed, awaiting final version

Results from earlier studies

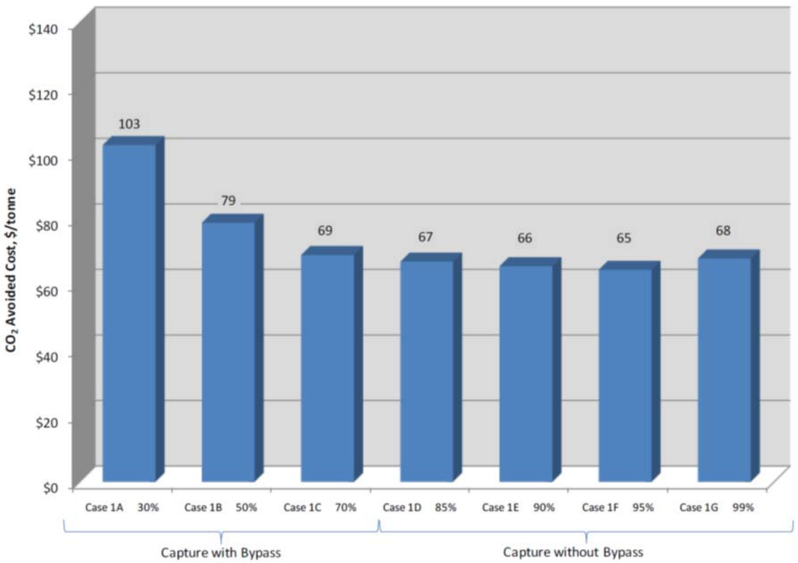
Previous dedicated studies give diverging techno-economic results—but capture rates mostly 85-90%

IEA GHG 2006



Significant cost increases when going from 90% to 99% CO_2 capture

DOE NETL 2011



Minor cost increases when going from 90% to 99% CO_2 capture

Reducing the CO_2 slip

Capture route	Capture rate determinant	Opportunity to lower CO_2-slip
Oxyfuel	- O_2 purity - Ambient air leakage - CO_2 processing unit	- CO_2 recovery from vent gases - Avoidance of inerts in CO_2 product - Trade-off with CO_2 purity
Pre-combustion	- Carbon conversion process - CO_2 capture process - O_2 purity (gasification)	- Water gas shift reaction conditions - Avoidance of inerts in syngas - Residual CO recovery from syngas - CO_2 separation from syngas - CO_2 separation from flue gas
Post-combustion	- CO_2 capture process	- CO_2 separation from flue gas

Overview of capture technologies

Capture technology	90% CO_2-capture	99% CO_2-capture	Comments
Chemical absorption	+	+	Increased costs Higher energy
Physical absorption	+	+	Pressurised gas streams Deeper regeneration
Solid sorbent - chemical	+	+	Process design optimisation Steam stripping; vacuum
Solid sorbents - physical	+	+/-	Trade off with CO_2-purity Process design optimisation
Chemical looping	+	+	Selective process Avoidance of leakage between reactors
Polymeric membranes	+	-	Bulk separation works best with pressurised gas streams Trade of with CO_2-purity High compression/low vacuum needed
Metal membranes (H_2)	+	+	Used with pressurised gas streams High selectivity
Ion transport membranes (O_2)	+	+	High selectivity
Ceramic membranes	+	+	Used with pressurised gas streams
Refrigeration	+	+/-	Higher capture rates achievable with CO_2-solid formation; purity issues with liquid formation

Conclusions

- Ubiquitous 90% CO_2 capture puts an artificial limit on CCS deployment
- All three CO_2 capture routes are adaptable to increase in capture rates
- Most CO_2-capture technologies allow for higher CO_2 capture rates than 90%
- Indirect emissions are dominant at high (99%) CO_2 capture rates
- Biomass co-combustion with 90% CO_2 capture provides zero emissions
- Techno-economic assessments for amine-based PCC indicate only minor cost increases

Report will be presented at GHGT-14

ghgt-14

Greenhouse Gas Control Technologies 14th International Conference on

1077 Abstracts from 43 countries!

Technical Programme available early May 2018

355 Oral Presentations, 500+ Poster presentations.

Authors notified early May 2018

Registration open. Early bird rate ends 13 June 2018

anlecr&d

CO2CRC BUILDING A LOW EMISSIONS FUTURE

CSIRO

State Government Victoria AUSTRALIA

ieaghg Evaluating technology options to mitigate greenhouse gas emissions

www.ghgt.info

MELBOURNE, AUSTRALIA, OCTOBER 21-26, 2018

Post Combustion Capture Conference

- PCCC5
- 17-19 September 2019
- Hosted by RITE in Kyoto, Japan
- Site visits 20 September
- Call for abstracts Dec 2018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AND
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ON
Have YOU seen the

Thank you

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