CARBON CAPTURE AND STORAGE

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CCS: an option to reduce CO_2 emissions

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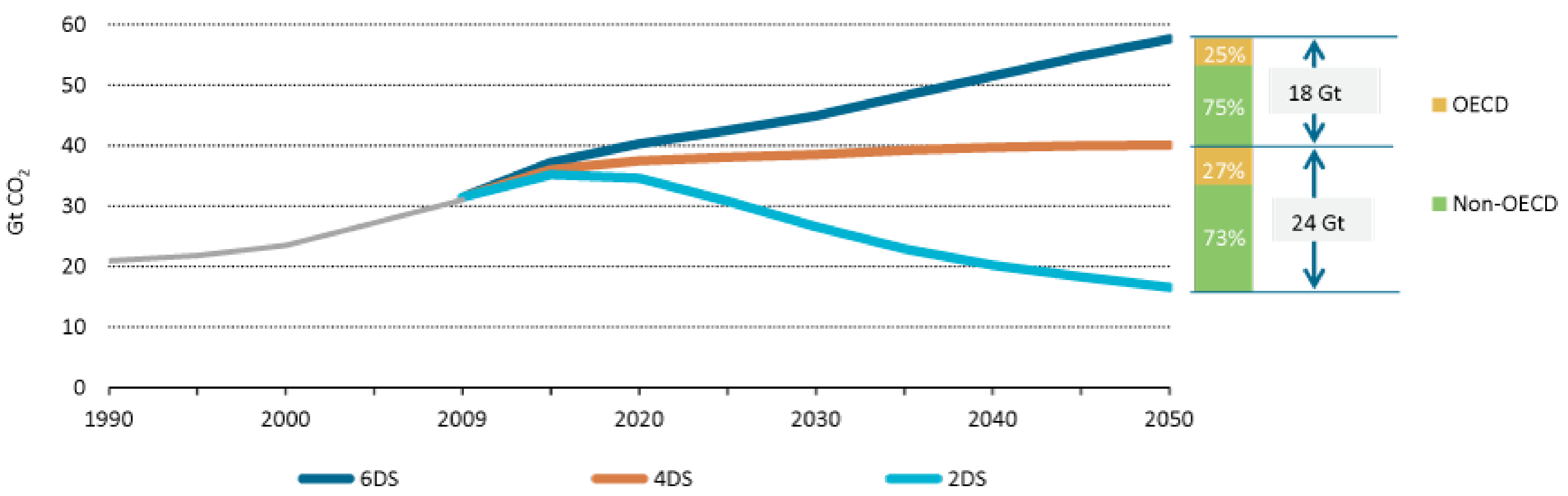
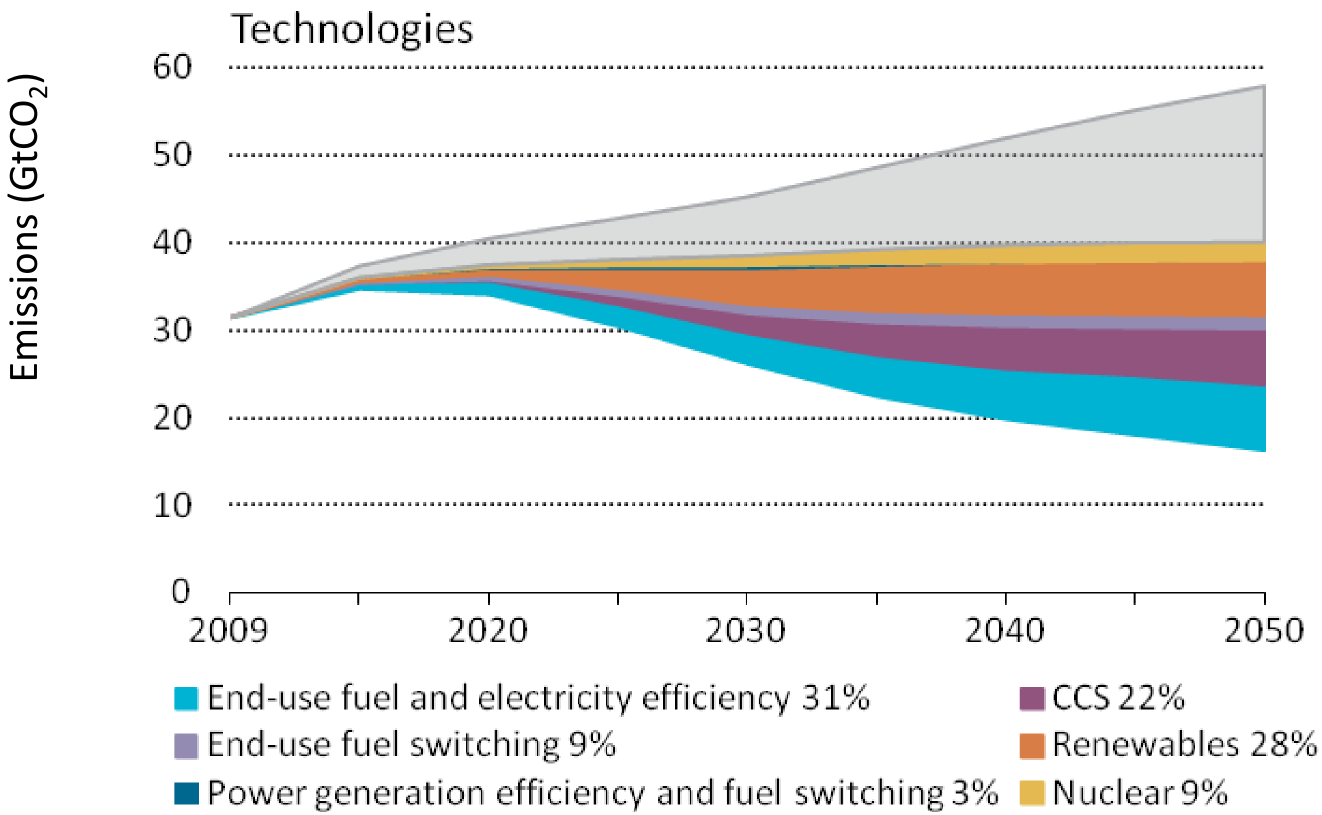
Bioenergy, CCS and BECCS: Options for Indonesia, Jakarta, 21-23 September 2012

ETP2012: need to cut CO_2 by 50% by 2050

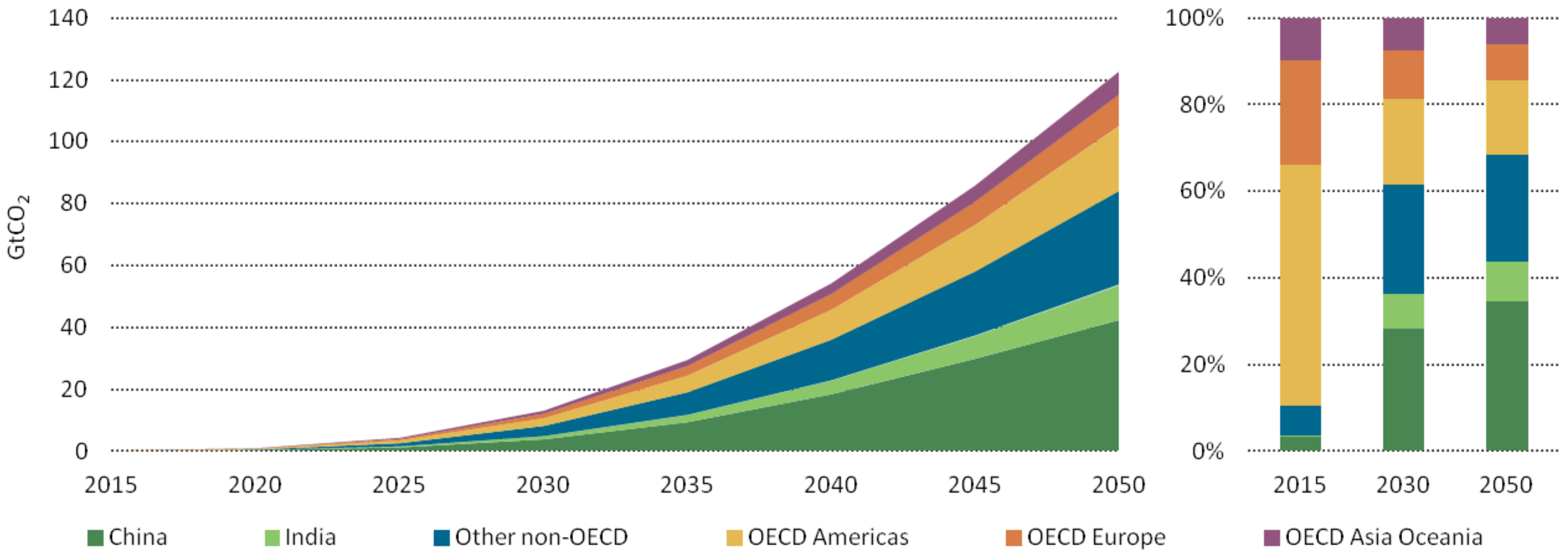


The technology portfolio includes CCS



Carbon capture and storage (CCS) contributes one-fifth of total emissions reductions through 2050

CCS must be deployed globally



- 2015-2050: almost 123 $GtCO_2$ captured and stored
- Non-OECD countries will dominate by 2030

Table 4.1 Investment requirements by sector in the 6DS and 2DS

	6DS (in USD trillions)			2DS (in USD trillions)		
Sector	2010 to 2020	2020 to 2030	2030 to 2050	2010 to 2020	2020 to 2030	2030 to 2050
Power	5.9	6.5	15.9	6.5	8.7	20.7
Buildings	3.2	3.9	9.1	6.2	6.9	14.7
Industry	2.8	2.3	4.4	3.1	2.7	5.4
Transport	(33.0) 7.0	(44.8) 9.9	(137.3) 32.5	(33.7) 8.1	(47.3) 12.5	(149.9) 44.4
Total investment	19.0	22.7	61.9	23.9	30.9	85.2

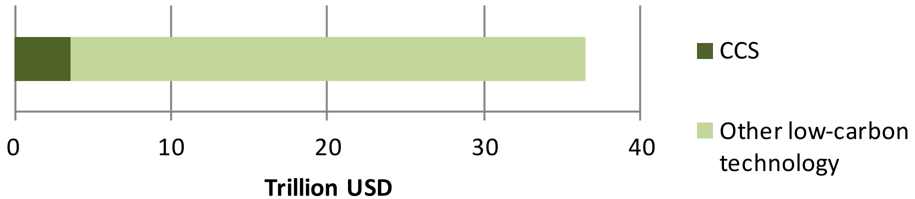
Notes: Industry includes iron and steel, chemicals, cement, pulp and paper, and aluminium. Transport includes the cost of the powertrain only; full vehicle costs are shown in parentheses.
Source: Unless otherwise noted, all tables and figures in the chapter derive from IEA data and analysis.

103.6

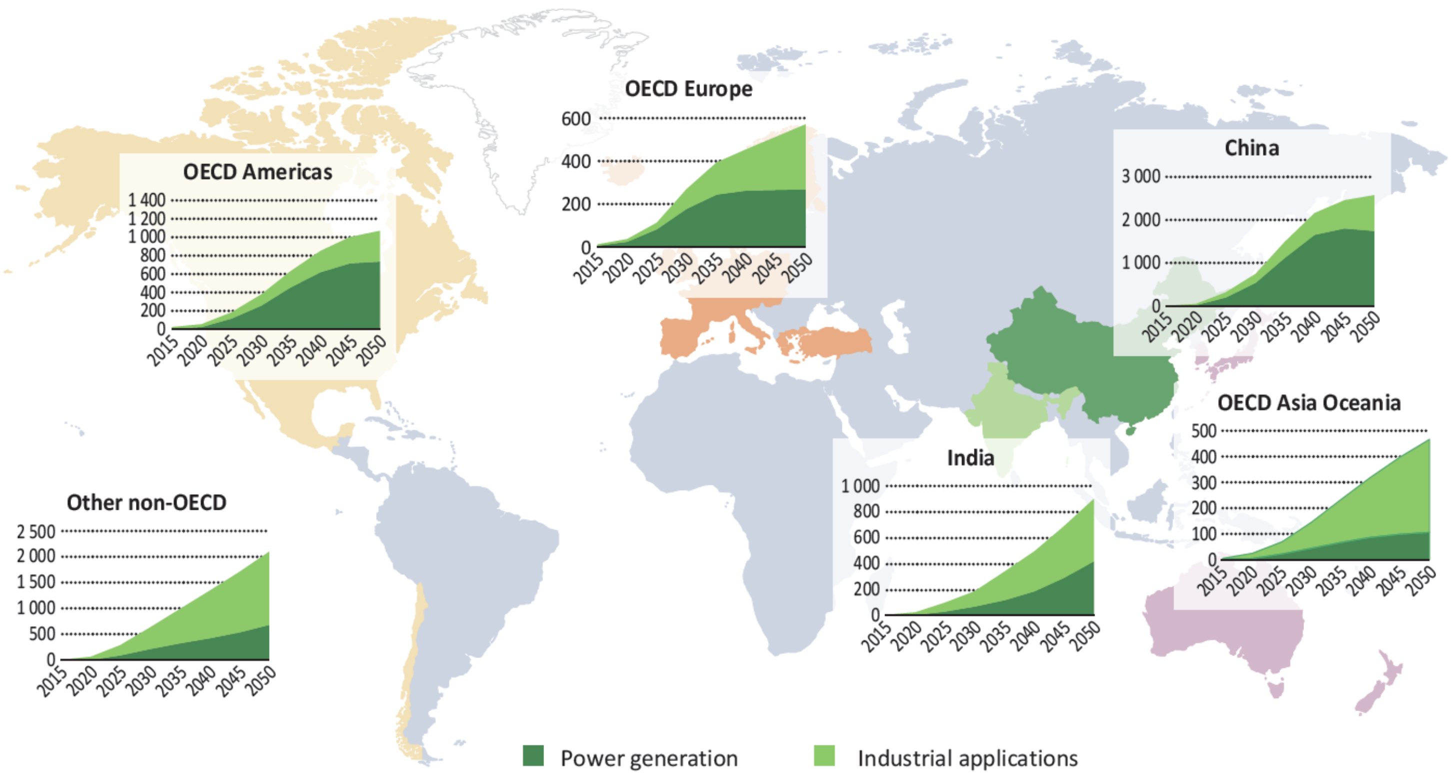
140

- **Investment requirements without particular clean energy goals are 103.6 trillion USD until 2050**
- **Investment requirements to reach 2DS scenario are 140 trillion USD until 2050**
- **Additional investment thus 36,4 trillion USD until 2050**

CCS accounts for roughly 10% of the required additional investment:



CCS is applied in power *and* industry



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Note: Capture rates shown in $MtCO_2$/year

The majority of CO_2 is captured from power generation globally, but in some regions CO_2 captured from industrial applications dominates

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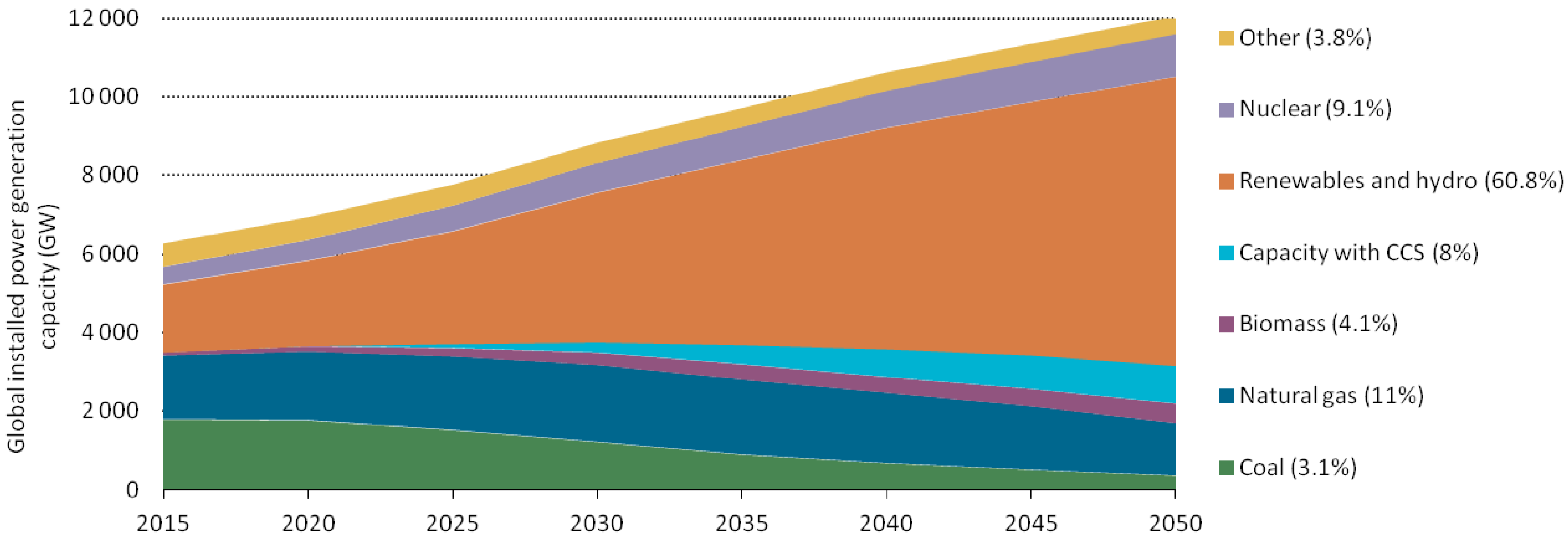
Three CO_2 capture routes in power

Post-combustion CO_2 capture	• Fossil fuel or biomass is burnt normally and CO_2 is separated from the exhaust gas
Pre-combustion CO_2 capture	• Fossil fuel or biomass is converted to a mixture of hydrogen and CO_2, from which the CO_2 is separated and hydrogen used for fuel
Oxy-combustion CO_2 capture	• Oxygen is separated from air, and fossil fuels or biomass are then burnt in an atmosphere of oxygen producing only CO_2 and water

At the present time, none of the options is superior; each has particular characteristics making it suitable in different power generation applications

CCS is applied to coal, gas and biomass



In 2050, 63% of coal-fired electricity generation (630 GW) is CCS equipped, 18% of gas (280 GW) and 9% of biomass (50 GW)

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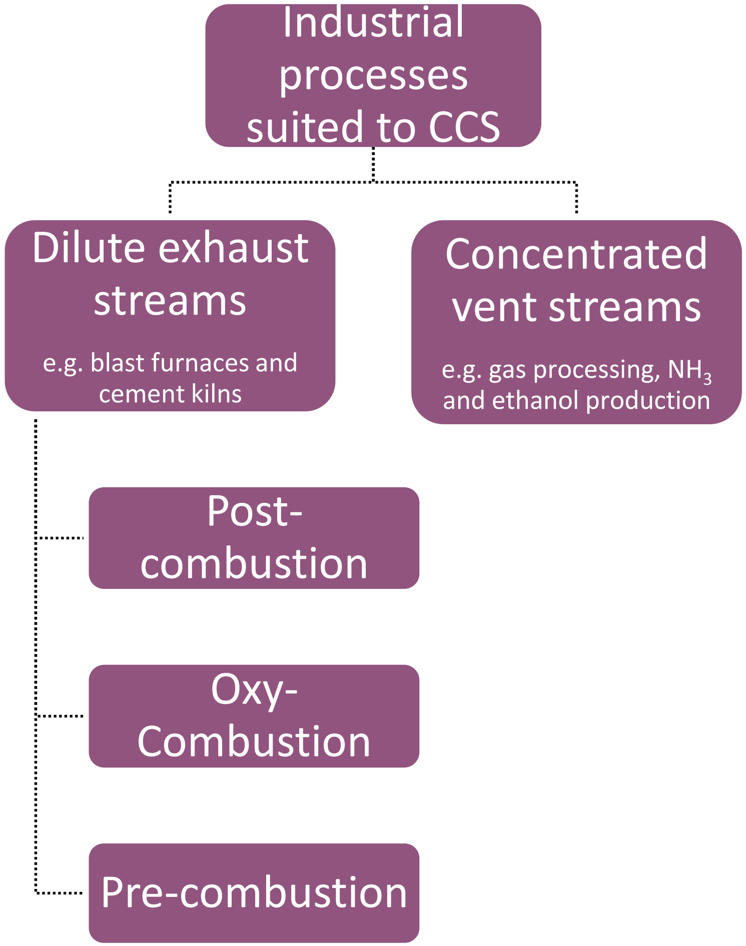
Considering CCS in Industry

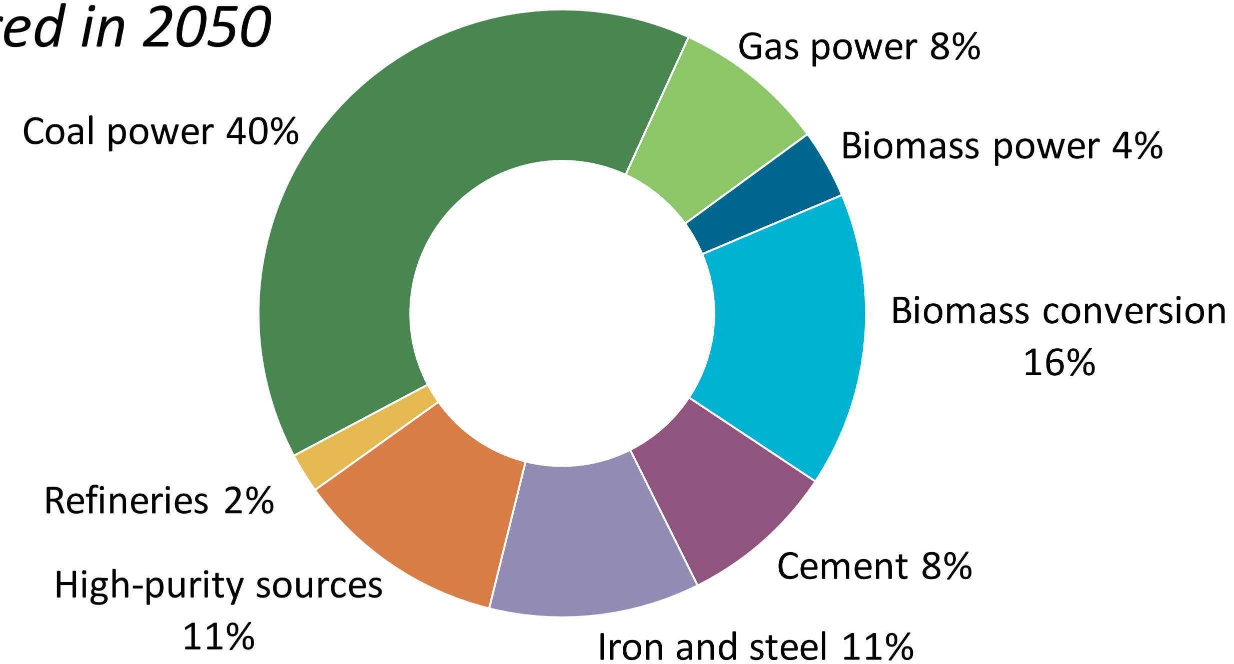
Industrial applications of CCS

- Some industrial processes produce highly concentrated CO_2 vent streams; capture from these "high-purity" sources is relatively straightforward
- Other industrial applications require additional CO_2 separation technologies to concentrate dilute streams of CO_2
- The same CO_2 separation technologies applied in power generation can be applied to industrial sources



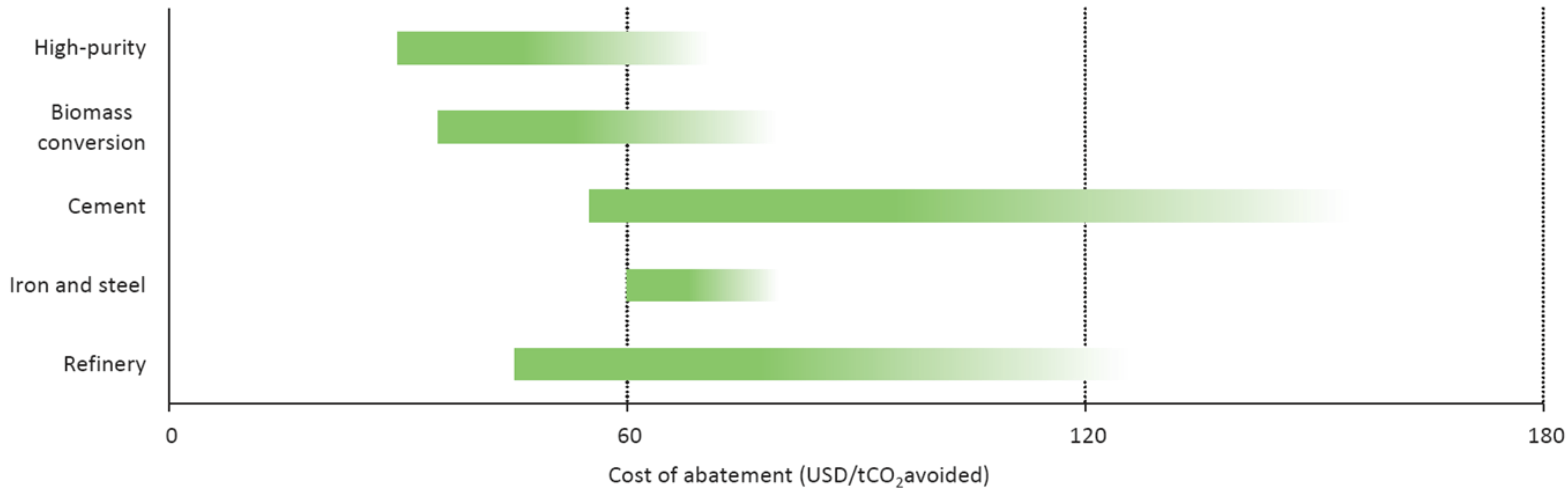
CCS by sector: BECCS Options

7.9 Gt captured in 2050



Around 1.5Gt of CO_2 are captured at BECCS plants in 2050 in the 2DS.

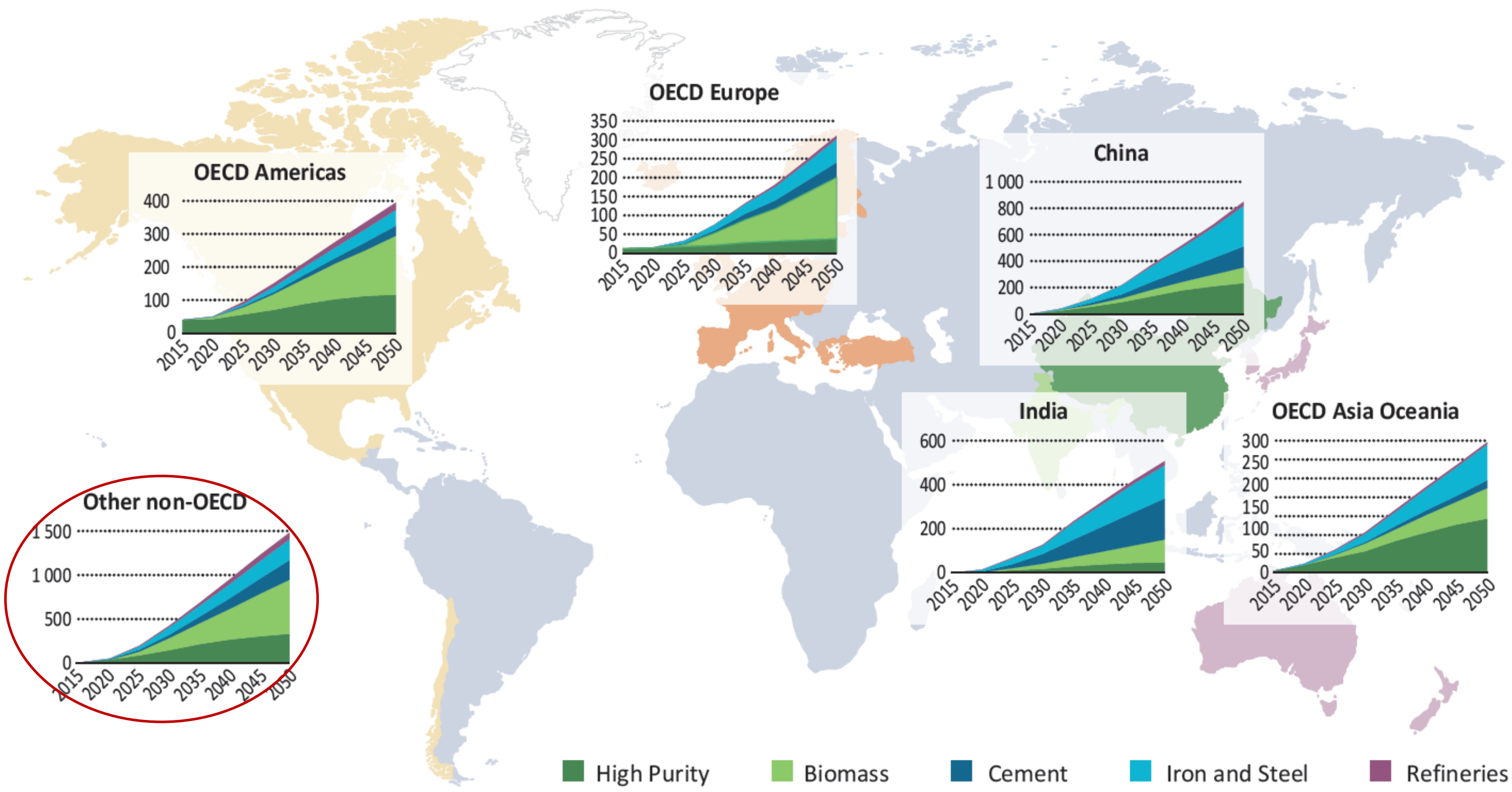
Cost of CCS in industry varies widely



Notes: The range of costs shown here reflect the regional average cost of applying CCS in each sector, and, therefore, the overall cost of abatement in a sector will be affected by the assumed level of CCS uptake in each sector (IEA, 2009 and IEA and UNIDO, 2011). These costs include the cost of capture, transport, and storage, but do not assume that storage generates revenues – *i.e.* CO_2 storage through enhanced oil recovery (EOR) is not considered as a storage option.

A wide range of abatement costs through CCS exists in industrial applications

Industrial applications vary by region



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The predominant industrial application of CCS will vary by region and over time

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Considering CO_2-EOR

Considering CO2-EOR linked to CCS

- CO2-EOR could reduce costs of CCS by supporting early opportunities for demonstration
- Under some circumstances, and accounting may lead to negative emissions in some cases
- There is limited potential for storage relative to power plant emissions .
- Must be considered in context of competing EOR technologies
- Only driver for CCS in absence of carbon price incentive

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Barriers to private investment in CO_2-EOR

BAU CO2-EOR	CO_2-EOR for Climate Change Mitigation
• Low valued investment option in IOC portfolios • Lack of low cost CO_2 for injection in many places • Competition with other EOR processes • Mismatch in business cases for capture versus injection	• Those for BAU CO_2-EOR, PLUS: • No return on additional cost for storage • Cost for monitoring, measurement, and verification • Cost for ensuring long-term containment

From issues to actions at the IEA: possible next steps

Engage with investors to **better understand barriers to investment**

Quantitative **understanding of oil market response to additional; CO_2-EOR production**

Engage with **developing economies to develop value propositions for storage via CO_2-EOR**

Clarify **treatment of CO_2-EOR under IPCC Greenhouse Gas Inventory Guidelines**

Background document summarizing these issues with **global examples**

Recommendations on the means by which policy makers can align **increased oil production** and **emissions reductions**

Considering BECCS

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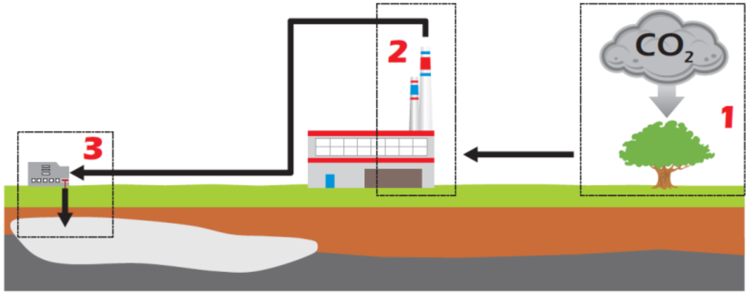
Negative emissions from BECCS By linking the Chain

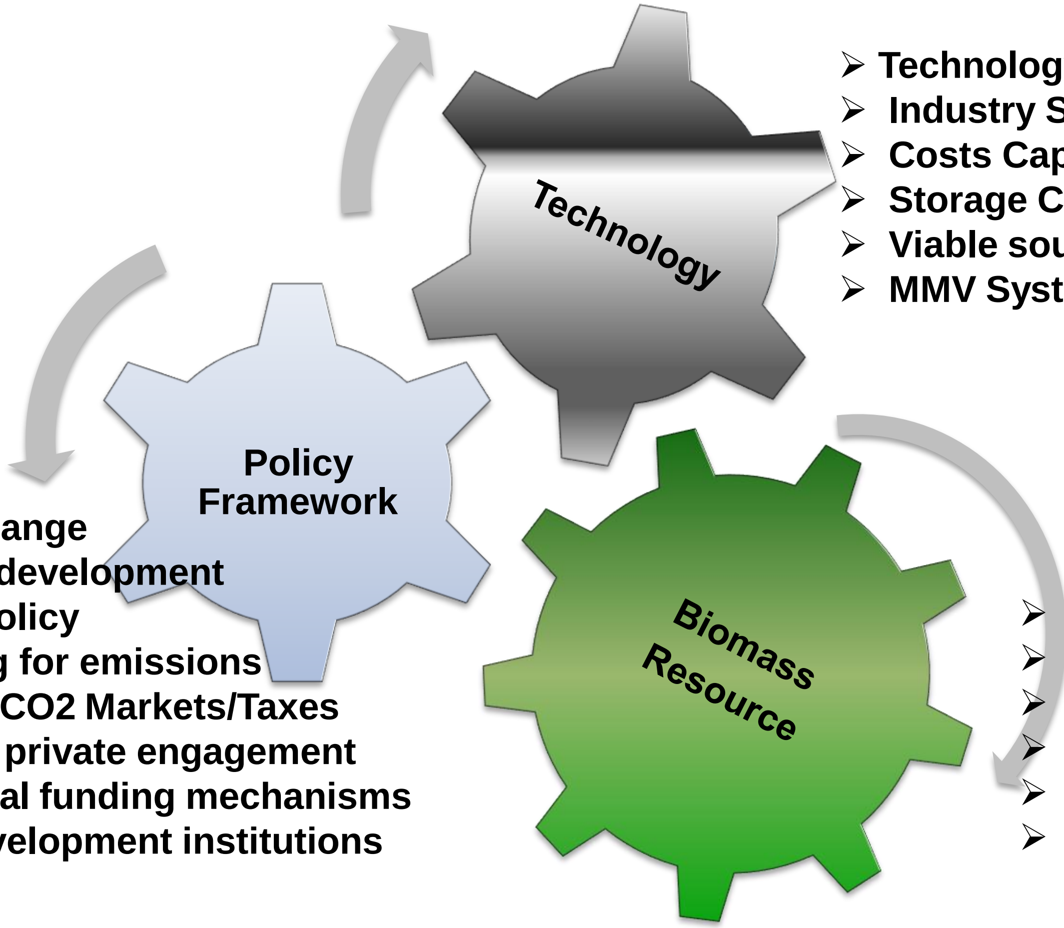
1. Biomass 2. Capture 3. Storage



- Bio-energy with carbon capture and storage (BECCS) can result in permanent net removal of CO_2 from the atmosphere, i.e. “negative CO_2 emissions”
- In BECCS, energy is provided by biomass, which removed atmospheric carbon while it was growing, and the CO_2 emissions from its use are captured and stored through CCS
- BECCS can be applied to a wide range of biomass conversion processes and may be attractive cost-effective in many cases

Biomass must be grown and harvested sustainably, as this significantly impacts the level of emissions reductions that can be achieved

BECCS – A Complex technology, resource and policy chain



- Technology R&D policy (Biomass/CCS)
- Industry Sectors
- Costs Capture, Transport, Storage
- Storage Capacity potential
- Viable source and sinks (Clustering)
- MMV Systems

- Climate Change
- Economic development
- Biomass policy
- Accounting for emissions
- Incentives/CO_2 Markets/Taxes
- Public and private engagement
- International funding mechanisms
- Role of development institutions

- Resource availability
- Transport/supply
- Lifecycle Costs
- Sustainability/LULUCF
- Scale
- Markets and Trade

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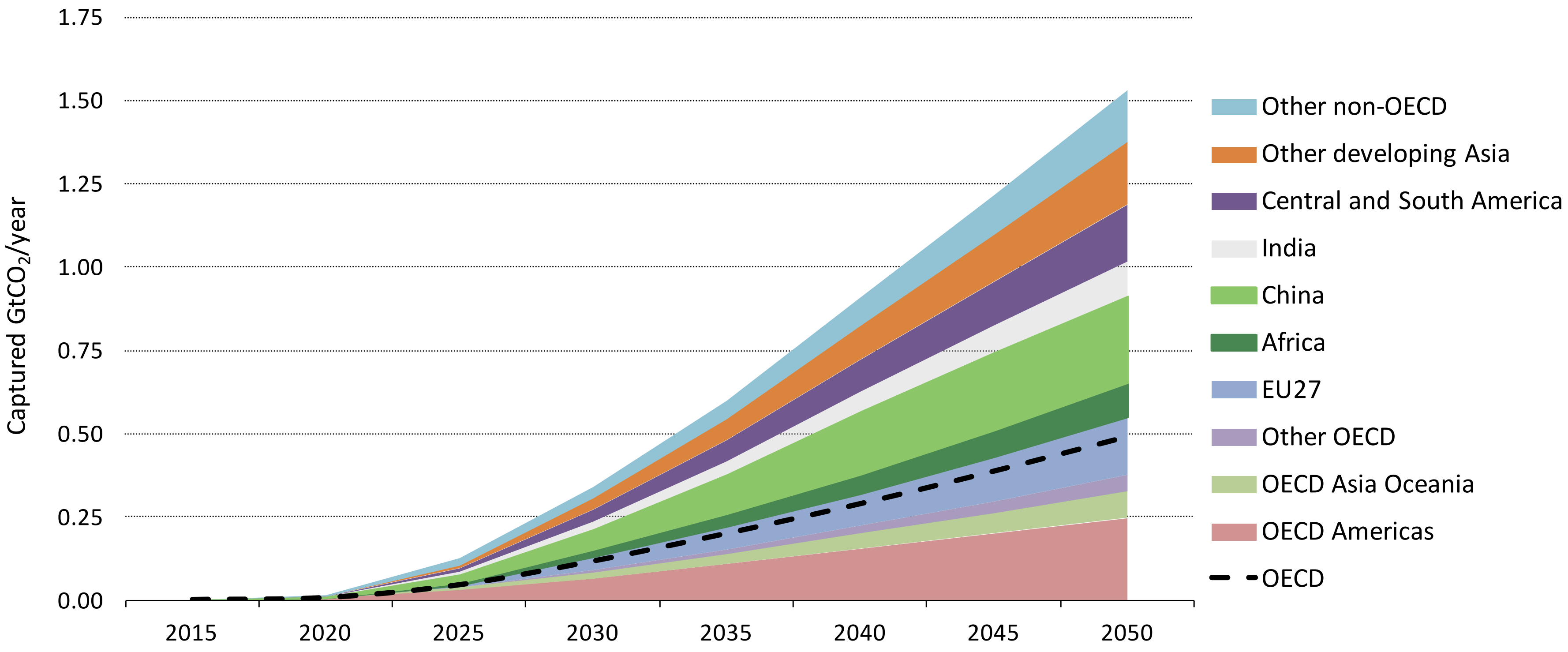
Considering Incentives for BECCS

- At point of combustion/fuel transformation, the same benefit is realised - prevention of CO_2 emission - and so whatever applies to CCS should also apply to BECCS
- An additional incentive should also be provided
  - Could be achieved through providing credits for biological sequestration of CO_2
- Cultivating, harvesting, transporting and processing of biomass all result in emissions that may reduce the emissions reduction potential of BECCS
  - Emissions from indirect land-use change as result of cultivating biomass need to be monitored
- These need to be accounted for to provide correct strength of incentives for BECCS

Regional breakdown of BECCS



Non-OECD regions account for two thirds of the CO_2 captured at BECCS plants in 2050.

Many policy & finance challenges

- Many industry sectors, no one-size-fits-all policy
- Government and industry awareness of CCS as a mitigation option needs a boost
- How can international finance mechanisms help CCS/BECCS
- Trade issues: need solutions that cover specific sectors globally, not just in one country
- Importance of cluster approach
- R&D for industrial applications
- Storage capacity assessment and investigation

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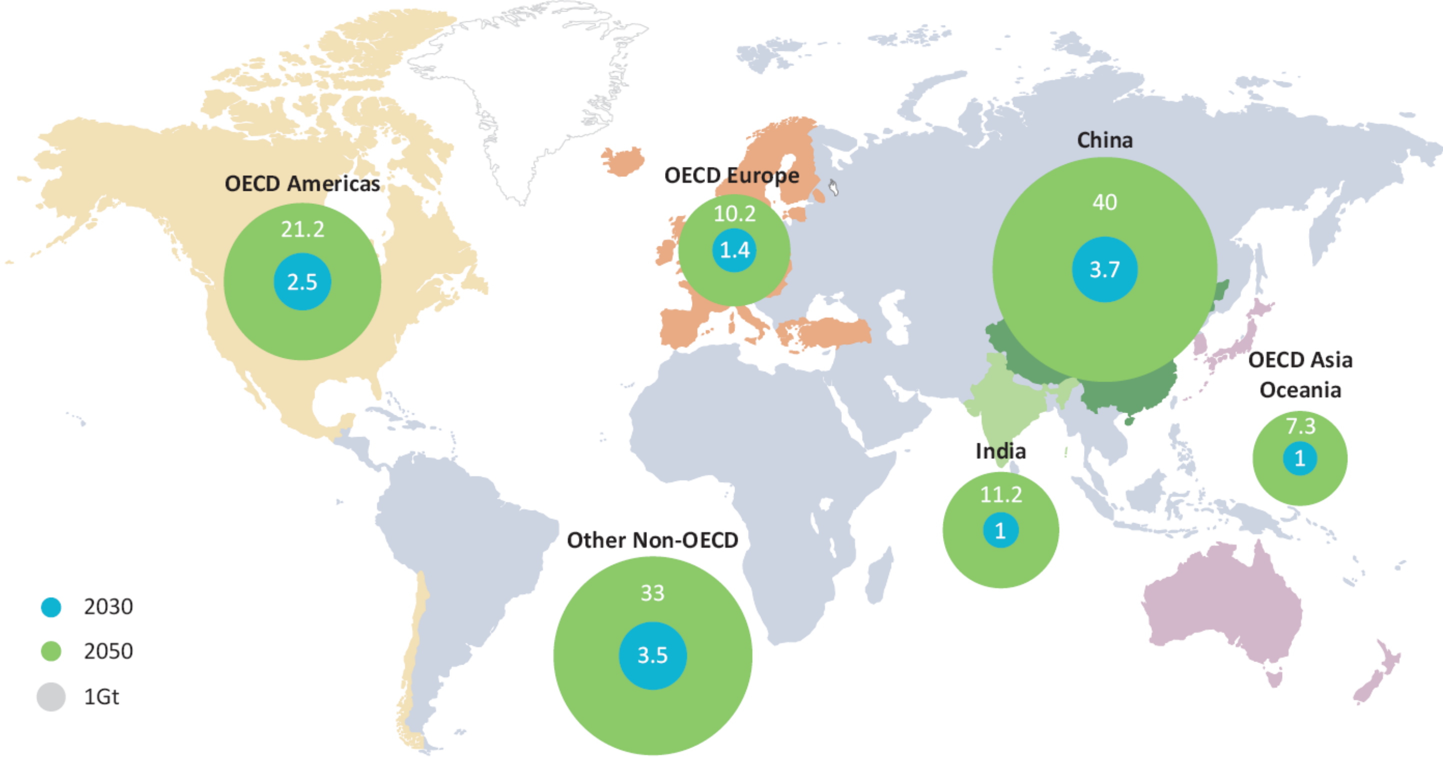
CCS in ETP: Where is CO_2 storage needed?



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Note: Mass captured shown in $GtCO_2$

Between 2015 and 2050, 123 Gt of CO_2 are captured that need to be transported to suitable sites and stored safely and effectively. Storage sites will need to be developed all around the world.

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Thank You!

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