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Carbon Capture Technology : Current and Future R&D Focus

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Carbon Dioxide Capture : Primary Processes



- A.) Absorption
- B.) Adsorption
- C.) Membrane
- D.) Others



❖ CO₂ capture experience originates from the gas processing technologies



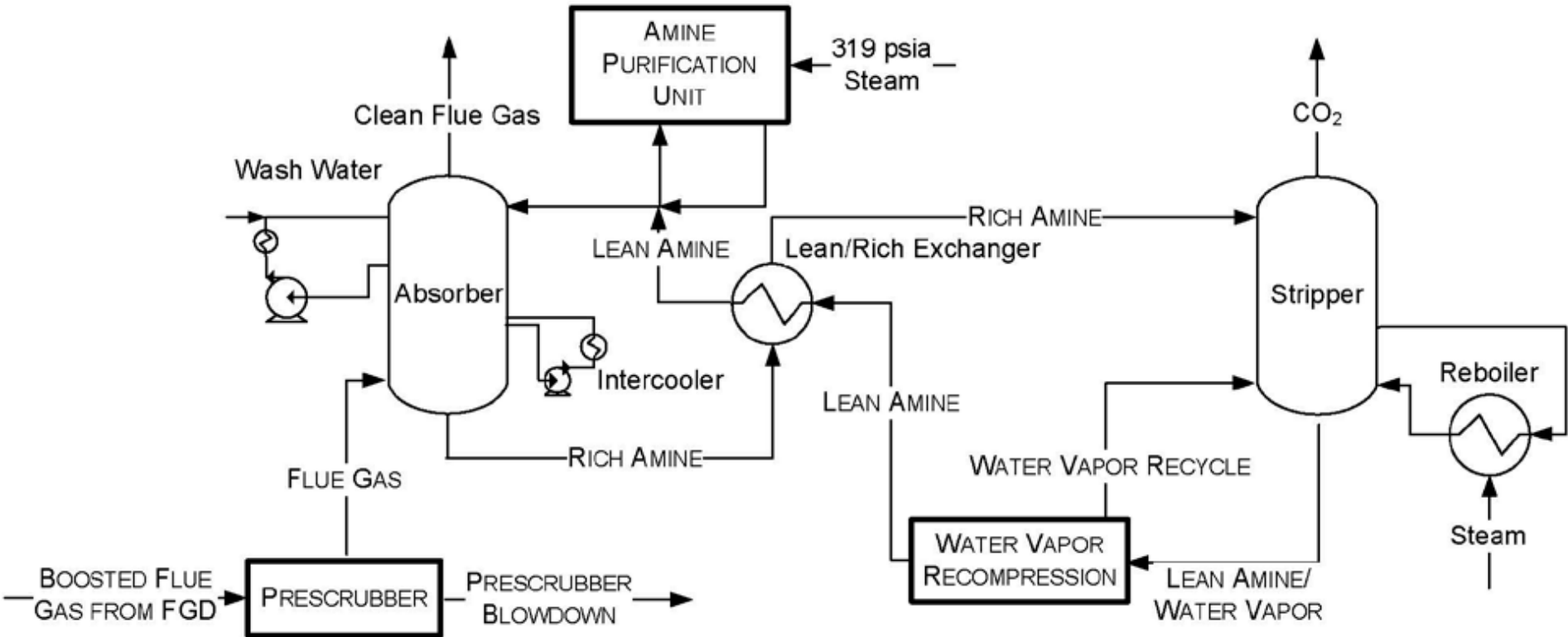
- Absorption : Only class of technology available to the industry for large scale post-combustion capture of CO₂ for a coal fired power plant at present

Commercial Projects



- ❑ Boundary Dam Project : SaskPower, Canada, 110 MW 'equivalent' flue gas is processed
- ❑ Petra Nova : NRG Energy/Nippon Oil & Gas, 240 MW 'equivalent' flue gas is processed
 - ❖ Both projects rely on Enhanced Oil Recovery for revenue (Boundary Dam project have a small saline reservoir storage aspect)

Simplified process flow for absorption based CO₂ capture technology



Ref. : Cost and Performance Baseline for Fossil Energy Plants Volume 1a: Bituminous Coal (PC) and Natural Gas to Electricity Revision 3 July 6, 2015 DOE/NETL-2015/1723

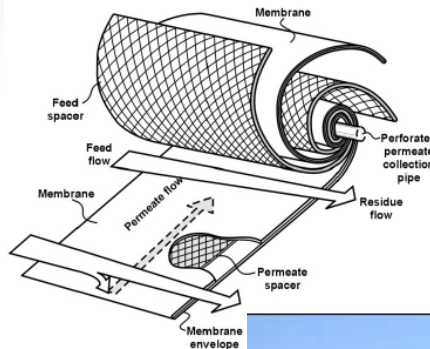
Next generation technologies :



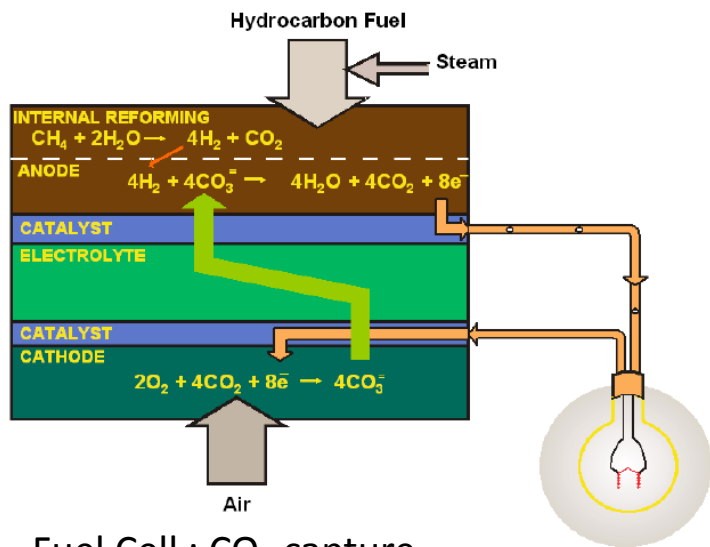
❑ Advanced solvents

❑ Membranes

❑ Fuel Cell



Typically, 500-1000 m²/m³



Fuel Cell : CO₂ capture





❑ Size analogy for a commercial scale plant for CO₂ capture by membrane from a fossil fired generation unit

Ashkelon desalination plant

- 40,000 spiral-wound RO membrane modules (Dow Filmtec®)
- 1.5 million m² membrane area

- Depending on membrane technology type and capture percentage requirement (if 90%) the total membrane surface area for a membrane CCS process could be 1.5 to 2.0 million m².
- The footprint of just the membrane skid will much smaller than that of a RO membrane system.



Next generation technologies : Example

- ❑ Cryogenic separation
- ❑ Technology being developed by Sustainable Energy Solutions



Pilot scale test unit



Bubbling Desublimating Heat Exchanger

CO₂ Capture at fossil fired plant, post combustion : Issues



- High capital cost/auxiliary load.
- Lack of regulatory mechanism for cost recovery.
- Scale issues: Based on current technologies, for 90% CO₂ capture from a 550MW unit, there needs to be at least two capture units !
- Slow decline of capacity factors for baseload coal units.

Future areas of R&D for fossil fired generation

- Next generation power cycles
- Advanced turbines/advanced materials for higher temperature
- Predictive data analytics

Global CO2 capture projects



Facility name (click on link to view)	Lifecycle stage	Country	State / district	CO ₂ capture capacity (Mtpa)	Operation date	Industry	Capture type	Transport type	Transport length (km)	Primary storage type
Terrell Natural Gas Processing Plant (formerly Val Verde Natural Gas Plants)	Operating	UNITED STATES	Texas	0.4-0.5	1972	Natural gas processing	Industrial separation	Pipeline	316	Enhanced oil recovery
Enid Fertilizer	Operating	UNITED STATES	Oklahoma	0.7	1982	Fertiliser production	Industrial separation	Pipeline	225	Enhanced oil recovery
Shute Creek Gas Processing Plant	Operating	UNITED STATES	Wyoming	7.0	1986	Natural gas processing	Industrial separation	Pipeline	Multiple, maximum of 460 km	Enhanced oil recovery
Sleipner CO₂ Storage	Operating	NORWAY	North Sea	1	1996	Natural gas processing	Industrial separation	No transport required (direct injection)	Not applicable	Dedicated geological storage - offshore deep saline formations
Great Plains Synfuel Plant and Weyburn-Midale	Operating	CANADA	Saskatchewan	3.0	2000	Synthetic natural gas	Industrial separation	Pipeline	329	Enhanced oil recovery
Snøhvit CO₂ Storage	Operating	NORWAY	Barents Sea	0.7	2008	Natural gas processing	Industrial separation	Pipeline	153	Dedicated geological storage - offshore deep saline formations
Century Plant	Operating	UNITED STATES	Texas	8.4	2010	Natural gas processing	Industrial separation	Pipeline	64 to 240	Enhanced oil recovery
Air Products Steam Methane Reformer	Operating	UNITED STATES	Texas	1.0	2013	Hydrogen production	Industrial separation	Pipeline	158	Enhanced oil recovery
Coffeyville Gasification Plant	Operating	UNITED STATES	Kansas	1.0	2013	Fertiliser production	Industrial separation	Pipeline	112	Enhanced oil recovery
Lost Cabin Gas Plant	Operating	UNITED STATES	Wyoming	0.9	2013	Natural gas processing	Industrial separation	Pipeline	374	Enhanced oil recovery
Petrobras Santos Basin Pre-Salt Oil Field CCS	Operating	BRAZIL	Santos Basin (off the coast of Rio de Janeiro)	Approx. 1.0	2013	Natural gas processing	Industrial separation	No transport required (direct injection)	Not applicable	Enhanced oil recovery
Boundary Dam Carbon Capture and Storage	Operating	CANADA	Saskatchewan	1.0	2014	Power generation	Post-combustion capture	Pipeline	66	Enhanced oil recovery
Uthmaniyah CO₂-EOR Demonstration	Operating	SAUDI ARABIA	Eastern Province	0.8	2015	Natural gas processing	Industrial separation	Pipeline	85	Enhanced oil recovery
Quest	Operating	CANADA	Alberta	Approx. 1.0	2015	Hydrogen production	Industrial separation	Pipeline	64	Dedicated geological storage - onshore deep saline formations
Abu Dhabi CCS Project (Phase 1 being Emirates Steel Industries)	Operating	UNITED ARAB EMIRATES	Abu Dhabi	0.8	2016	Iron and steel production	Industrial separation	Pipeline	43	Enhanced oil recovery
Petra Nova Carbon Capture	Operating	UNITED STATES	Texas	1.4	2017	Power generation	Post-combustion capture	Pipeline	132	Enhanced oil recovery
Illinois Industrial Carbon Capture and Storage	Operating	UNITED STATES	Illinois	1.0	2017	Ethanol production	Industrial separation	Pipeline	1.6	Dedicated geological storage - onshore deep saline formations
Gorgon Carbon Dioxide Injection	In construction	AUSTRALIA	Western Australia	3.4-4.0	2018	Natural gas processing	Industrial separation	Pipeline	7	Dedicated geological storage - onshore deep saline formations

Global CO2 capture projects

Alberta Carbon Trunk Line ("ACTL") with Agrium CO2 Stream	In construction	CANADA	Alberta	0.3-0.6	2018	Fertiliser production	Industrial separation	Pipeline	240	Enhanced oil recovery
Alberta Carbon Trunk Line ("ACTL") with North West Sturgeon Refinery CO2 Stream	In construction	CANADA	Alberta	1.2-1.4	2018	Oil refining	Industrial separation	Pipeline	240	Enhanced oil recovery
Yanchang Integrated Carbon Capture and Storage Demonstration	In construction	CHINA	Shaanxi Province	0.41	2018-19	Chemical Production	Industrial separation	Pipeline	150	Enhanced oil recovery
Sinopec Qilu Petrochemical CCS	Advanced development	CHINA	Shandong Province	0.5	2021	Chemical Production	Industrial separation	Pipeline	75	Enhanced oil recovery
Lake Charles Methanol	Advanced development	UNITED STATES	Louisiana	4.2	2022 (Institute estimate)	Chemical production	Industrial separation	Pipeline	244	Enhanced oil recovery
Texas Clean Energy Project	Advanced development	UNITED STATES	Texas	1.5-2.0	2022 (Institute estimate)	Chemical production	Industrial separation	Pipeline	Not specified	Enhanced oil recovery
Norway Full Chain CCS	Advanced development	NORWAY	Southern Norway	1.2	2022	Various	Various	Combination of shipping and pipeline	Under evaluation	Dedicated geological storage - offshore deep saline formations
CarbonNet	Advanced development	AUSTRALIA	Victoria	1.0-5.0	2020's	Under evaluation	Under Evaluation	Pipeline	130	Dedicated geological storage - offshore deep saline formations
Sinopec Eastern China CCS	Early development	CHINA	Jiangsu Province	0.5	2020-2021	Fertiliser production	Industrial separation	Pipeline	200	Enhanced oil recovery
Sinopec Shengli Power Plant CCS	Early development	CHINA	Shandong Province	1.0	2020's	Power generation	Post-combustion capture	Pipeline	80	Enhanced oil recovery
China Resources Power (Haifeng) Integrated Carbon Capture and Sequestration Demonstration	Early development	CHINA	Guangdong Province	1.0	2020's	Power generation	Post-combustion capture	Pipeline	150	Dedicated geological storage - offshore deep saline formations
Huaneng GreenGen IGCC Project (Phase 3)	Early development	CHINA	Tianjin	2.0	2020's	Power generation	Pre-combustion capture (gasification)	Pipeline	50-100	Enhanced oil recovery important, dedicated geological storage options under review
Korea-CCS 1	Early development	SOUTH KOREA	Either Gangwon province or Chungnam Province	1.0	2020's	Power generation	Post-combustion capture	Shipping	Under evaluation	Dedicated geological storage - offshore deep saline formations
Korea-CCS 2	Early development	SOUTH KOREA	Not Decided	1.0	2020's	Power generation	Pre-combustion or oxy-combustion	Shipping	Under evaluation	Dedicated geological storage - offshore deep saline formations
Teesside Collective	Early development	UNITED KINGDOM	Tees Valley	0.8	2020's	Various	Various	Pipeline	Under evaluation	Dedicated geological storage - offshore deep saline formations
Caledonia Clean Energy	Early development	UNITED KINGDOM	Scotland	3	2024	Power generation	Post-combustion capture	Pipeline	382	Dedicated geological storage, offshore deep saline formations with potential for enhanced oil recovery
South West Hub	Early development	AUSTRALIA	Western Australia	2.5	2025	Fertiliser production and power generation	Industrial separation	Pipeline	80-110	Dedicated geological storage - onshore deep saline formations
Shanxi International Energy Group CCUS	Early development	CHINA	Shanxi Province	2.0	2020's	Power generation	Oxy-fuel combustion capture	Pipeline	Not specified	Under evaluation
Shenhua Ningxia CTL	Early development	CHINA	Ningxia Hui Autonomous Region	2.0	2020's	Coal-to-liquids (CTL)	Industrial separation	Pipeline	200-250	Under evaluation





Questions???



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