CSLF Joint Task Force on Supporting Development of 2nd and 3rd Generation CO_2 Capture Technologies

A status report from the Technical Group

Supporting development of 2nd and 3rd generation CCS technologies

”Efforts should be taken to better understand the role of 2nd and 3rd generation technologies for CCS deployment, and policies and approaches identified among individual CSLF member countries that can stimulate 2nd and 3rd generation CCS project proposals to improve the outlook for successful Large Scale Integrated Project deployment in the 2020 to 2030 timeframe. Development of these technologies will benefit from the CCS Pilot Scale Testing Network, which is in the process of being stood up. ”

What we do

- Policy Group
  - Map initiatives and funding mechanisms for 2nd and 3rd generation technologies in CSLF member countries.
  - Prepare a Policy document on how to achieve an accelerated implementation of 2nd and 3rd generation CO_2 capture technologies
- Technical Group
  - Map/Identify 2nd and 3rd generation
    - mature in the 2020 –2030 timeframe,
    - development plans to scale from current readiness
    - major challenges facing technology development.
  - Use existing networks to map potential for testing 2nd and 3rd generation technologies at existing test facilities
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Approach of Technical Group to identify technologies

- ***Summarised several review papers, NOT an original work***
  - ***SINTEF (2013)***
  - ***DOE/NETL (2013)***
  - ***IEAGHG (2015)***
  - ***ZEP (2013)***
  - ***CSLF (2013a)***
  - ***GCCSI (2014)***
  - ***Supplementary information***

Organization of report

- Post-combustion
  - Solvents
  - Sorbents
  - Menbranes
  - Other (Cryogenic, hydrates, CO_2 enrichment, algae, supersonic pressurized)
- Pre-combustion
  - Solvents
  - Sorbents
  - Membranes
  - Other (cryogenic, fuel cell concepts, not requiring capture facilities)

Organization of report

- Oxy-combustion
  - Chemical Looping Combustion (CLC)
  - Oxygen Transporting Membranes (OTM)
  - Other (incl. air separation, turbines and boilers, high pressure, CO_2 processing and clean-up
- Other new emergig technologies with limited info today
- Test facilities and capabilities
  - CCS Test Centre Network
  - ECCSEL
  - Other (China, Japan, Korea, Europe, etc)

Example of technology summary

Enzymes

The enzyme carbonic anhydrase (CA) is known to accelerate the hydration of neutral aqueous CO_2 molecules to ionic bicarbonate species. CA is amongst the most well-known enzymes, since it operates in most living organisms, including human beings. By adding a soluble enzyme to an energy efficient solvent one may be able to achieve a lower cost process for carbon capture and mimicking nature's own process. Increasing the kinetic rates of the hydration of CO_2 and dehydration, as CA does, results in enhanced absorption and desorption of CO_2 into and out of a CO_2 solvent and/or in various membrane processes with immobilized CA. Novozymes applies ultrasonic energy to increase the overall driving force of the solvent re-generation reaction.

Maturity: 3rd generation; TRL 1 - 2 (Bench scale testing with real flue gas)
Challenges: Understanding the level of enzyme activation; increasing the chemical and physical stability of the enzymes (mainly thermal stability); advancing the limited cyclic capacity (for carbonates)
Some players: CO_2 Solutions, Novozymes, Carbozymes, Akermin
Pathway to technology qualification: Further basic research to understand the level of enzyme activation and to increase the chemical and physical stability of the enzymes (mainly thermal stability). In addition, the limited cyclic capacity (for carbonates) needs further advancements. Scale-up to lab and small pilot.
Infrastructure required: The concept can utilize the existing infrastructure for post-combustion as found at many larger test facilities, such as access to real flue gas, water, electricity and other utilities. Some modifications may be required, depending on the need for recycling enzymes to avoid high temperature exposure.
Environmental impact: Potentially low impact. If inorganic carbonates are use as main component and there are no other activators than the enzyme, there should be no emissions.
Applications: Power industry, cement industry, steel industry

TCN member facilities and capacities

Facility	Owner(s)	Country	Technology approach (post-, pre- or oxy-combustion) that may be tested	Flue gas	Capacity		Available infrastructure	Comment
				Type, amount	Carbon dioxide, t CO_2/y	Power (real or equivalent)		
National Carbon Capture Center	DOE, operated by Southern Company	USA	Post and pre	Coal power:14 % CO_2; Post: Slip stream ~ 17 000 kg/hr. Possibiity to dilute with air to 3% Pre: Syngas 750 kg/hr		Post: 0.5 – 4.3 MW_e Pre:	Real flue gas, water, electricity	
CO2 Test Center Mongstad	Gassnova, Statoil, Shell and Sasol	Norway	Post	Refinery FCC: 12 – 14%, 22 – 50 000 Sm^3/hr CHP gas turbines: 3.5-9%; 28 – 56 000 Sm^3/hr	FCC : 80 000 CHP: 25 000	Coal: 10 - 12 MW Gas: ~ 7.5 MW	Real flue gas, water, electricity	
Shand	SaskPower	Canada	Post, may evolve into other types after 1 – 2 years	Coal power	45 000	5 – 6 MW	Real flue gas, water, electricity	Presently operated by Mitsubishi-Hitachi, may be open to others from 2017
PACT	UKCCSRC	UK	Post, pre and oxy	Coal, gas, biomass From stand-alone units (not from plant)	1	Two 330kW Gas Turbines; 1,5 MW_{th} gas turbine burner rig One 250kW air/oxyfuel combustion plant	Flue gas from stand-alone burner or turbine; water, electricity; gas mixing facility with trace gas injection capability	

Next steps TG

- Quality check of 2nd and 3rd generation report
- Complete information gathering on test facilities

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