Supporting Development of 2nd and 3rd Generation CCS Technologies

Trygve Riis, Norway
at
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From the Exploratory Committee of the Policy Group

- ”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 is 2nd and 3rd generation capture technologies?

From the CSLF Technology Roadmap 2013 (other definitions exist):

- 2nd generation technologies are systems generally based on 1st generation concepts and equipment with modifications to reduce the energy penalty and CCS costs (e.g. better capture solvents, higher efficiency boilers, better integration) – this may also involve some step-changes to the 'technology blocks'.
- 3rd generation technologies are novel technologies and process options that are distinct from 1st generation technology options and are currently far from commercialisation yet may offer substantial gains when developed.

Targets for 2nd and 3rd generation capture technologies (from CSLF TRM 2013)

- For energy penalty, normalized capital cost, and normalized operational and maintenance (O&M) costs (fixed and non-fuel variable costs) compared to 1st generation technologies for power generation and industrial applications:
  - 2nd generation:
    - Towards 2030: 30% reduction
  - 3rd generation:
    - Beyond 2030: 50% reduction

Energy penalty = [Power output (state-of-the-art plant w/o CCS) - Power output(state-of-the-art plant w/CCS)) / Energy input (state-of-the-art plant w/o CCS]

Normalized cost = [Cost (state-of-the-art plant w/CCS) – cost (state-of-the-art plant w/o CCS)) / Cost (state-of-the-art plant w/o CCS]

Suggested actions

Action	Description	Suggested responsible
1	Map initiatives and funding mechanisms for 2nd and 3rd generation technologies in CSLF member countries, including: • mapping/exploring the criteria that industry around the world may use to adopt technologies • identifying, the specific financial challenges associated with scale-up and deployment of 2nd and 3rd generation capture technologies • exploring the understanding of what those challenges might be, particularly if government funds are used, as well as the interest in joint funding/international collaboration	Policy Group Lead: Canada ??
2	Map/Identify 2nd and 3rd generation technologies under consideration in CSLF member countries, and identify technologies that may mature in the 2020 –2030 timeframe, their development plans to scale from current readiness levels to prepare for demonstration, and the major challenges facing technology development.	Technical Group Lead: Norway
3	Use existing networks, e.g. the established International CCS Test Centre Network and ECCSEL, to map potential for testing 2nd and 3rd generation technologies at existing test facilities.	Technical Group: Lead: Norway
4	Prepare a Policy document on how to achieve an accelerated implementation of 2nd and 3rd generation CO_2 capture technologies.	Policy Group Lead: ?

Notes

Action	Note
1	US DOE/NETL Advanced Carbon Dioxide Capture R&D Program, Norwegian CLIMIT and UK Innovation Fund for Carbon Capture Projects are examples that should be summarized for the benefit of CSLF members. There must be others. Food for Policy Group delegates
2	Good staring points are Technology update from DOE/NETL Advanced Carbon Dioxide Capture R&D Program, report from UK Advanced Power generation Technology Forum, a forthcoming report from the IEA Greenhouse Gas R&D Program as well as other of their reports, CLIMIT projects and reports from SINTEF on behalf of CSLF and TCM. Possibly many others. Food for Technical Group delegates
3	Presently, the information is readily available for a limited number of test facilities (e.g. NCCC, CanmetENERGY and TCM). There be be other facilities capable of testing pilot scale (1 - 5 MW_{th}) 2^{nd} generation technologies. CCS Test Centre Network is willing to contribute by mapping potential at member facilities and in associated networks

Examples of and the challenges facing 2nd and 3rd generation capture technologies

	Possible 2nd and 3rd generation technology options	Implementation challenges
IGCC with pre-combustion decarbonisation	• Membrane separation of oxygen and syngas • Turbines for hydrogen-rich gas with low NO_x	• Degree of integration of large IGCC plants versus flexibility • Operational availability with coal in base load • Lack of commercial guarantees
Oxy-combustion	• New and more efficient air separation, e.g. membranes • Optimized boiler systems • Oxy-combustion turbines • Chemical looping combustion (CLC) - reactor systems and oxygen carriers • High pressure combustion – reactor systems to enhance efficiency.	• Unit size and capacity combined with energy demand for ASU • Peak temperatures versus flue-gas re-circulation • NO_x formation • Optimisation of overall compressor work (ASU and CO_2 purification unit (CPU) require compression work) • Lack of commercial guarantees
Post-combustion capture	• New solvents (e.g. amino acids, enzyme-accelerated carbonates) • 2nd & 3rd generation amines requiring less energy for regeneration • 2nd & 3rd generation process designs and equipment for new and conventional solvents • Solid sorbent technologies • Membrane technologies • Hydrates • Cryogenic technologies	• Scale and integration of complete systems for flue gas cleaning • Slippage of solvent to the surrounding air (possible health, safety & environmental (HS&E) issues) • Carry-over of solvent into the CO_2 stream • Flue gas contaminants • Energy penalty • Water balance (make-up water)

Status Technical Group work

- Suggested a template for report describing 2nd and 3rd generation capture technologies:
  - **Executive Summary**
  - **Recommendations for Follow-Up**
  - **Background and Objectives**
  - **Scope and Approach**
  - **What are 2nd and 3rd generation capture technologies?**
  - **Summary of Identified Technologies - Post-combustion**
  - **Summary of Identified Technologies - Pre-combustion**
  - **Summary of Identified Technologies - Oxy-combustion**
  - **Test facilities and their capabilities**

Suggested description of emerging technologies

- Suggesdt to group the technologies, e.g. for post-combustion
  - Precipitating solvents
  - Multi-liquid phase solvents
  - Enzymes
  - Ionic liquids
  - etc

In main report, short description, e.g.

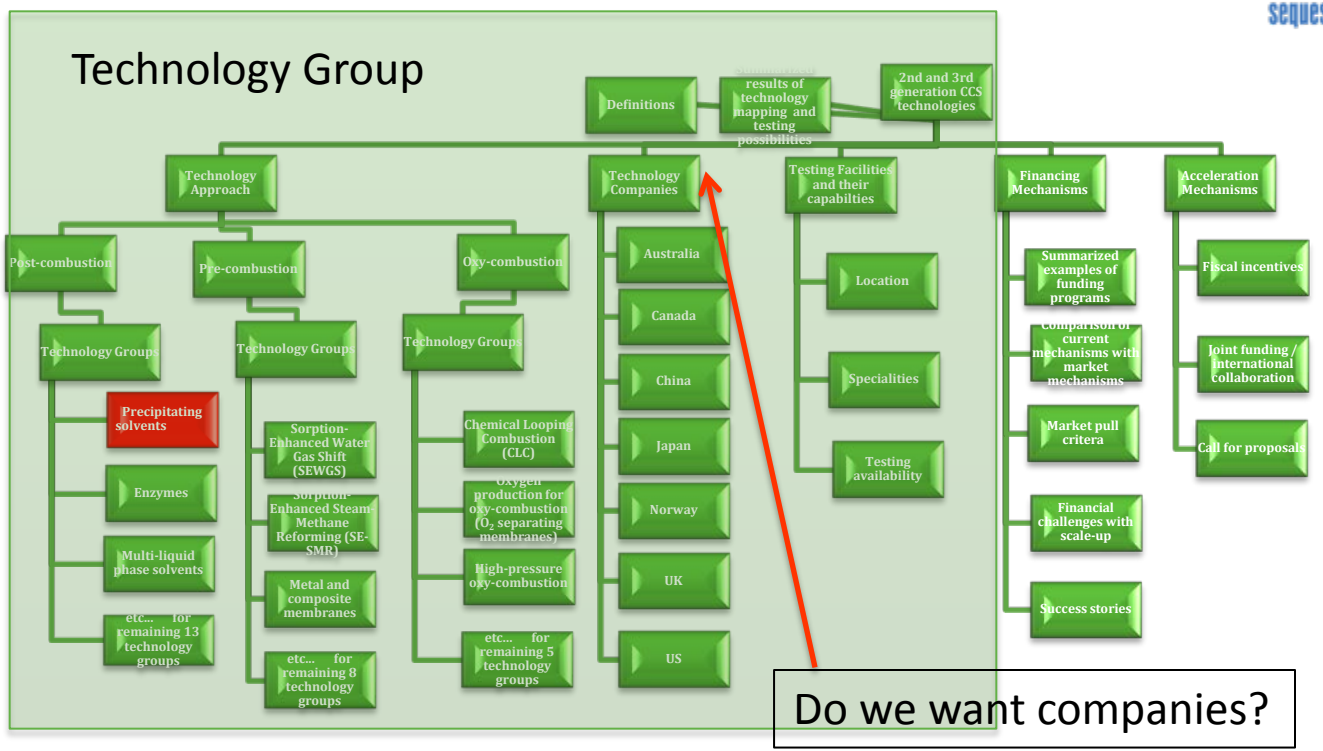
- **Precipitating solvents**
  - Description: When absorbing CO_2 certain solvent systems form a precipitate. Amino acid salts or carbonate solvent systems are among the examples, in which precipitation of neutral amino acid or bicarbonate salts occur. The use of precipitating solvents has potentially several advantages over traditional solvents. As the equilibrium CO2pressure remains constant when the CO2 loading continues to increase the absorption can be maintained, potentially leading to improved absorber performance such as increased stability and absorption capacity, increased kinetics, higher cyclic loading and reduced energy consumption during regeneration compared to amine systems.
  - Maturity: Lab scale testing
  - Key Challenges: Further lab tests needed to determine the impact of SO2 and Nox
  - Some players: Shell Global Solutions, Alstom, CSIRO, SINTEF/NTNU, TNO, University of Melbourne

In Appendix, more extensive description (1- 1.5 page)

- General description
- Possible application
- Potential
- Who is involved?
- Maturity, challenges and status
- Possible pathways for technology qualification
- Infrastructure required and available testing facilities
- Environmental impact
- Generation and expected time to commercialization

Overall plan suggested by Canada

Site Map for 2nd and 3rd generation CCS technologies - Proposed website section of CSLF website



Comments?

Thank you!