Carbon Sequestration leadership forum
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# POLICY GROUP

# Supporting Development of 2nd and 3rd Generation Carbon Capture Technologies

Background

At the June 2014 CSLF Policy Group Meeting in London, there was consensus that the Policy Group's overall Action Plan would consist of four main areas of interest. One of these areas is "Supporting Development of 2nd and 3rd Generation CCS Technologies" and to that end the Policy Group established a joint Policy -Technical Working Group that was tasked to develop a draft work plan.

This paper, prepared by the Working Group, provides a description of what specific activities should comprise a work plan in this area. **This document should be considered a work-in-progress.**

Action Requested

The Policy Group is requested to review the following report from the Joint Policy-Technical Working Group.

**SUPPORTING DEVELOPMENT OF 2ND AND 3RD GENERATION CARBON CAPTURE TECHNOLOGIES:**

This is one topic recommended by the Exploratory Committee of the CSLF Policy Group. The Committee states that:

> "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."

To achieve this, the following could be considered for joint work by the CSLF Policy and Technical Groups:

1. Map initiatives and funding mechanisms for 2nd and 3rd generation technologies in CSLF member countries. 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. Provide perspective on how these initiatives parallel with market mechanisms which would drive the adoption of these technologies. The effort should also include:
    - mapping/exploring the criteria that industry around the world may use to adopt technologies, i.e., market pull
    - 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, particularly if government funds are used, as well as the interest in joint funding/international collaboration

    Responsible: Policy Group.

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. Good starting points are technology updates from DOE/NETL Advanced Carbon Dioxide Capture R&D Program, report from UK Advanced Power generation technology Forum, projects and reports from the IEA Greenhouse Gas R&D Program, CLIMIT projects and reports from SINTEF on behalf of CSLF and TCM. Responsible: Technical Group

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. There is knowledge from a limited number of test facilities (e.g. NCCC, CanmetENERGY and TCM) on the possibilities to test 2nd generation technologies in scale 1 - 5 $MW_{th}$. The list of test facilities needs to be expanded. Responsible for liaising with the networks: Technical Group

4. Prepare a Policy document on how to achieve an accelerated implementation of 2nd and 3rd generation $CO_2$ capture technologies. Responsible: Policy Group

Points 1 – 3 can be accomplished by compiling and summarizing information that is already available but spread on a high number of publications.

It may be useful to keep in mind what the CSLF Technical Group has said about 2nd and 3rd generation technologies in the CSLF 2013 Carbon Sequestration Technology Roadmap. The status of 2nd and 3rd generation technologies vs. the targets will help identify where actions are needed to speed up implementation of these technologies.

Definitions of 2nd and 3rd generation capture technologies

- From to the CSLF Technology Roadmap 2013:
    - 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.

There is a slightly different definition used by the CSLF Task Force on CCS Technology Opportunities and Gaps, but we will prefer to use the TRM definition.

The CSLF technology Roadmap 2013 suggests the following targets for 2nd and 3rd generation technologies:

2nd generation:
Towards 2030: Develop 2nd generation $CO_2$ capture technologies with energy penalties and avoidance costs well below that of 1st generation technologies. Possible targets for 2nd generation capture technology for power generation and industrial applications are a 30% reduction of the each of the following the energy penalty, normalized capital cost[1], and normalized operational and maintenance (O&M) costs (fixed and non-fuel variable costs) compared to 1st generation technologies

3rd generation:
Beyond 2030: Possible targets for 3rd generation $CO_2$ capture technology for power generation and industrial applications are a 50% reduction of each of the following: the energy penalty, normalized capital cost, and normalized O&M costs (fixed and non-fuel variable costs) compared to 1st generation technologies.

[1] 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)
E.g. if the energy penalty is 10% in 2013, the penalty should be 7% in 2030.

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Examples of and the challenges facing 2nd and 3rd generations

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