COSIA INNOVATION OPPORTUNITY

Mobilizing the world's minds and resources to improve environmental performance.

Post Combustion CO2 Capture from Natural Gas Combustion Flue Gas

SOLUTION DESCRIPTION: Looking for new transformative technology to capture CO2 from flue gas streams from natural gas combustion in a once through steam generator (OTSG) or potentially a gas turbine.	**INNOVATION OPPORTUNITY CHAMPION:** COSIA's GHG EPA is championing this Innovation Opportunity. Our aspiration is to produce our oil with lower greenhouse gas emissions than other sources of oil.
CREATED: March 2022 All project proposals are evaluated and actioned as they are received.	
For more information on this COSIA Innovation Opportunity please visit **www.cosia.ca/innovation-opportunities/greenhouse-gases**	

SUBMIT YOUR IDEA HERE

Canada's Oil Sands Innovation Alliance (COSIA) accelerates the pace of environmental performance improvement in Canada's oil sands through collaborative action and innovation. COSIA Members represent more than 90 per cent of oil sands production. We bring together innovators and leading thinkers from industry, government, academia and the wider public to identify and advance new transformative technologies. Innovation Opportunities are one way we articulate an actionable innovation need, bringing global innovation capacity to bear on global environmental challenges.

Canadian Natural · cenovus ENERGY · ConocoPhillips Canada · Imperial · SUNCOR · Teck

POST COMBUSTION CO2 CAPTURE FROM NATURAL GAS COMBUSTION FLUE GAS

WHAT TO SUBMIT TO COSIA

COSIA requires sufficient non-confidential, nonproprietary information to properly evaluate the technology. Some items that will be especially important to present in your submission are:

- Concept and basic unit operations
- Technical justification for the approach (e.g. laboratory batch or continuous experiments; pilot or demo plants; process modeling; literature precedent)
- Describe quantities and qualities of utilities and consumables that are required
- Energy inputs – quantity and type(s)
- Capital and operating cost estimates if available based on described capacity targets
- 3rd party verified comparison of your proposed technology against an MEA baseline. 3rd party verifiers should be reputable, independent engineering companies if possible
- Basis of cost estimation, including estimation scope, contingency, etc.
- IP status of your proposed technology
- What operating environment restrictions might your technology face:
    - Explosive atmospheres
    - Severe weather
    - Power fluctuations

FUNDING, FINANCIALS, AND INTELLECTUAL PROPERTY

COSIA Members are committed to identifying emerging technologies, while protecting the Intellectual Property (IP) rights of the owner of the technology.

HOW TO SUBMIT TO COSIA

Submit a summary of your solution using COSIA's Environmental Technology Assessment Portal (ETAP) Process, available at:

https://cosia.ca/focus-areas/e-tap

Please note: ETAP is a staged submission process. The initial submission requires only a brief description and limited technical information. Upon review by COSIA, additional information may be requested. Instructions for submission are provided on the ETAP site.

All information provided is non-confidential. COSIA will respond to all submissions.

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DETAILED SOLUTION DESCRIPTION

The successful technology will:

- Perform >50% (preferably > 75%) better than benchmark amines (30% monoethanolamine (MEA)) based post-combustion capture technologies on an energy and cost basis i.e. >50% reduction in capital expenses, operating expenses, capture energy requirements and CO2 avoided cost (see CO2 Avoided Cost section). CO2 avoided costs must account for both direct and indirect (see Indirect Emissions section) CO2 reductions.
- Achieve high level of CO2 purity (e.g ~>95vol % CO2), although somewhat lower levels will be acceptable, depending on the end use of the CO2 and if there are significant CAPEX/OPEX savings.
- Capture > 90% of CO2, although lower capture levels will also be considered if there are significant CAPEX/OPEX savings.
- Have a minimal land-based footprint
- Have no adverse environmental or safety impacts (e.g. increased NOx emissions, toxic chemical release)
- Have minimal impact on or beneficial integration opportunities with existing operations.

Technologies at all stages of technical maturity are of interest.

BACKGROUND

Oil sands operations consume large quantities of natural gas to produce steam for in situ bitumen extraction. A typical 33,000 BPD in situ facility would operate six once through steam generators (OTSGs) requiring 1600 GJ/h (LHV) of combined energy input and emitting ~2,200 tonnes CO2 per day. Conventional air supply (containing 21% O2) for combustion of pipeline specification natural gas in OTSGs produces flue gas with a low CO2 content (~7-8% by volume) at atmospheric pressure. OTSG flue gas contains 10 to 15% (volume) water, has a temperature ~185 ^{o}C, and can have 25 – 30ppm SO2 resulting from burning produced gas from the bitumen reservoir. OTSGs are also used for steam generation in oil sands mining and extraction operations.

Gas turbines, with heat recovery steam generators, are also applied in some oil sands in situ or mining operations in place of one or more OTSGs. While gas turbine flue gas is a candidate for CO2 capture, CO2 concentration in the flue gas is much lower (4% by volume).

COSIA is ideally seeking transformative CO2 capture technologies that significantly outperform today's state-of-the art advanced amines. The ultimate fate of the CO2 could be geological storage or conversion to useful products, for which purity, contaminants, and required delivery pressure may vary. Innovative combinations of post-combustion capture technologies will also be considered (e.g. "hybrid" approach of using a membrane for initial concentration of CO2 prior to capture). Modularization and offsite fabrication is preferable given the remote location of Canada's Athabasca oil sands.

Material and energy flow diagrams for a standard 33,000 BPD Steam Assisted Gravity Drainage (SAGD) facility are provided below.

APPROACHES NOT OF INTEREST

The following approaches are not of interest for this specific Innovation Opportunity, although may still be of interest (see other posted Innovation Opportunities):

- Incremental improvements to advanced (next generation) amine based capture systems – targeting significantly better performance as detailed in the "Request for Proposal Description" section;
- Pre-combustion technologies;
- CO2 conversion technologies; and
- Fuel cell technologies.

ADDITIONAL INFORMATION

CO_2 AVOIDED COST

The CO2 Avoided Cost is the overall cost measure most commonly reported in CCS studies. It compares a plant *with* CO2 Capture (CC) to a "reference plant" *without* CC, and quantifies the average cost of avoiding a unit (typically in tonnes) of atmospheric CO2 emissions while still producing the same quantity of useful product. The CO2 avoidance cost can be directly compared with market carbon price or regulatory carbon compliance cost. The Cost of CO2 Avoided ($/tonnes CO2) is calculated as follows.

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$$Cost\ of\ CO_2\ Avoided = \frac{Cost\ of\ Plant\ with\ CC - Cost\ of\ Reference\ Plant\ (no\ capture)}{CO_2\ emissions\ from\ Reference\ Plant - CO_2\ emissions\ from\ Plant\ with\ CC}$$

Capturing carbon dioxide requires energy which is generally produced by the combustion of a fuel. Therefore, CO2 is created to facilitate the capture process. This additional CO2 produced is not included in the avoided cost calculation because it is additional emissions to the reference case with no CO2 capture. The Avoided CO2 emissions from Plant with CC is the difference between the amount of CO2 captured and the CO2 emitted by the operation of the CO2 Capture Plant (including both direct and indirect** CO2 emissions).

The avoided cost of your technology must be compared to a reference case of post combustion CO2 capture at a SAGD facility using 30% MEA. As COSIA members must compare capture costs on an equal and consistent basis, use the avoided cost calculations found in the Alberta Innovates – Energy and Environment Solutions report ”ECM Evaluation Study “ (Case 1B). This report can also inform your key assumptions and avoided cost calculation methodology.

Case 1B provides you the cost build up and avoided cost calculation methodology for the 30% MEA case as applied to OTSG flue gas CO2 capture. To evaluate your technology on a comparable basis, please provide the following in your submission:

Base Case: Your estimate for the avoided cost for the base 30% MEA capture case (Case 1B). If your assessment of the Base Case is different from Case 1B above, please provide supporting documentation to support your claims.

New Capture Technology Case: provide an assessment of your proposed capture technology using the same methodology as used to assess the Base Case. A comparison of the avoided cost and operating performance against the Base Case will be required. The CO2 will be delivered at the facility battery limits at the same operating and purity specifications as Case 1B.

Ensure to provide COSIA with a breakdown of the cost calculations and assumptions for your technology. Submissions that do not include an assessment of both the Base Case and New Capture Technology Case using the referenced methodology described above will be rejected.

INDIRECT EMISSIONS

For any power consumption within the capture process, an electricity grid GHG intensity factor of 0.64 t CO2e/MWh can be assumed, as per the Alberta Government's "Carbon Offset Emission Factors Handbook, 2019, version 2.0"

COSIA has several tools you can use, including sample Reference Facilities. These tools will help you analyze and quantify the benefits of your technologies prior to submitting them to our Environmental Technology Assessment Portal (ETAP). You can find these tools on the Green House Gases Innovation Opportunity page at **Greenhouse Gases Innovation Opportunities | Canada's Oil Sands Innovation Alliance - COSIA.**

For this specific Innovation Opportunity, please review the tools noted below:

SAGD Reference Facility

- Base Case, mechanical lift, Warm Lime Softening CPF **pg 43/60**
- Base Case WLS/OTSG Energy Flow **pg 45/60**