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

Alternative Silica Removal Technologies

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Our aspiration is to reduce water use and increase water recycling rates at oil sands mining and in situ (in place) operations without environmental burden shifting.

CREATED: March 31, 2014

All projects are evaluated and actioned as they are received.

COSIA has four Environmental Priority Areas (EPAs): Water, Land, Tailings, and Greenhouse Gases (GHGs).

For more information on this COSIA Challenge please visit www.cosia.ca

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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. Challenges are one way we articulate an actionable innovation need, bringing global innovation capacity to bear on global environmental challenges.
WHAT TO SUBMIT TO COSIA

COSIA requires sufficient non-confidential, non-proprietary 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 verification of your proposed technology. 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 and funding the development of the technologies to the point of commercialization, while protecting the Intellectual Property (IP) rights of the owner of the technology.

Successful proposals can receive funding from COSIA members to develop and demonstrate the technology in an oil sands application. Multiple technologies may be funded, at the discretion of the Members.

HOW TO SUBMIT TO COSIA


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.
DETAILED SOLUTION DESCRIPTION

The COSIA Water Environmental Priority Area Steering Committee invites proposals for silica removal technologies to remove silica from Steam Assisted Gravity Drainage (SAGD) produced water, to improve the environmental performance of the oil sands. Proposals based on work that is a proven concept are desired.

The successful technology will:
- Meet the water quality specification below
  - SiO2 <50 mg/L (minimum), <25 mg/L desirable
  - Operate at > 85°C, >135°C desirable
  - Be scalable to 15,000 to 20,000 m3/day

The following characteristic are desirable
- Minimal chemical sludge;
- Minimized reaction times to minimize reactor footprint;
- Removes TOC;
- Low energy;
- Applicable across a broad concentration range
- Modular
- Robust

Process application design basis:
- Volumetric flow rate 15,000 to 30,000 m3/d
- Heavy industrial boiler feed water application (once through steam generators)

BACKGROUND

The most common recovery process employed for producing oil from deep oil sands reservoirs (geological formations), is known as Steam Assisted Gravity Drainage (SAGD). In this process, steam is generated at a Central Processing Facility (CPF), transported to well pads, and injected into a horizontal well bore within the formation. The heat supplied by the steam warms the heavy oil in the reservoir, allowing it to flow via gravity into a second well bore that captures the oil water mixture and produces it to the surface with the hydrocarbon at temperatures of over 180°C, and high levels of impurities, including salts, metals, silica and organic compounds (see water quality data below). Because of the large water requirements recycling and reuse of the produced water recovered is mandatory both to protect the environment and to minimize costs.

The produced oil water is treated to purity where it can be recycled to the steam generators. Produced water treatment includes; oil treatment and de-oiling which separates the bulk of the oil and water, and water treatment which removed silica, hardness, and additional impurities

Current silica removal processes in industrial water treatment rely heavily on:
- Lime-softening style silica precipitation, which has a large footprint, creates large volumes of sludge, is difficult to operate and subject to upsets, and has a high capital cost; and
- Evaporation which is smaller, but more energy intensive with higher operational cost.

Produced water characteristics:
- TDS 500-10,000 mg/L
- pH 6-9
- SiO2 100-350 mg/L, Ca 5-150 mg/L, Mg 5-75 mg/L, TOC 200-600 mg/L, TIC <100 mg/L
APPROACHES NOT OF INTEREST

The following approaches are not of interest:

- Approaches that have not demonstrated proof of concept
- Tube coatings, or tube configurations
- Low quality steam generation
- Configurations that produce steam that is co-mingled with other products (such as the products of combustion from the boiler, or nitrogen)

ADDITIONAL INFORMATION

Supplemental Information – Typical SAGD Material and Energy Balance
High Temperature Membrane Demineralization of Recovered Water

**SOLUTION DESCRIPTION:**

Membrane demineralization technologies operating above 85°C to replace part of or the entire Steam Assisted Gravity Drainage (SAGD) of Cyclical Steam Stimulation (CSS) water treatment train

**CHALLENGE SPONSOR:**

COSIA’s Water EPA is sponsoring this challenge.

The Water EPA is seeking solutions which reduce water use and increase water recycling rates at oil sands mining and in situ (in place) operations without causing negative environmental impacts in other areas.

COSIA has four Environmental Priority Areas (EPAs): Water, Land, Tailings, and Greenhouse Gases (GHGs).

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Some items that will be especially important to present in your submission are:

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DETAILED SOLUTION DESCRIPTION

The Water Environmental Priority Area Steering Committee invites proposals for membrane demineralization technologies operating above 85°C to replace part of or the entire SAGD water treatment train. Two applications, possibly sequential are seen; feed water for once-thru-steam generators (lower quality), and feed water for drum boilers (higher quality).

The successful technology will:

Meet one or both applications for water quality specifications below:

- **Application 1 – OTSG Feed**
  - TDS 500-8,000 mg/L, SiO2 < 50 mg/L (minimum, < 25 mg/L desired), Ca/Mg <0.5mg/L, >25 mg/L TOC
  
  Or

- **Application 2 – Drum Boiler Feed**
  - TDS < 20 mg/L, SiO2 < 10 mg/L, Ca/Mg <0.1mg/L, TOC <10 mg/L
  - Recover >80% of feed water
  - Use less than 5 kWh/m³
  - Scale to 15,000-30,000 m³/day

BACKGROUND

The most common recovery processes employed for producing oil from deep oil sands reservoirs (geological formations), are SAGD and CSS. In these processes, steam is generated at a Central Processing Facility (CPF), transported to well pads, and injected into a horizontal well bore within the formation. The heat supplied by the steam warms the heavy oil in the reservoir, allowing it to flow via gravity into a second well (SAGD), or the injecting well bore (CSS) which captures the oil water mixture and produces it to the surface with the hydrocarbon at temperatures of over 180°C, and high levels of impurities, including salts, metals, silica and organic compounds, and needs to be treated before being fed to the steam generators.

If most of the hardness and silica can be removed the produced water can be fed to a Once Through Steam Generator (OTSG) (Application 1), or if almost all the dissolved solids can be removed it can be fed to a high quality drum boiler, recycling more of the water (Application 2). OTSGs tolerate lower quality water because 15-25% of the water is discharged to waste, while the yield of steam from a drum boiler is near 100%, but the drum boiler requires near pure water to avoid rapid fouling.

Currently produced water treatment is done using lime softening or evaporation. Oil sands companies believe that there are opportunities to improve environmental and economic produced water recycle performance using emerging membrane technologies, and are interested in a high flux, low energy process to remove impurities from heavy industrial process water, either membranes which:

- Can produce drum boiler quality (Application 1) water in
  - a single step (silica & hardness)
  - two steps (replacing the WLS, which removes silica, and the WAC polishers, which remove hardness in separate steps)
- Can produce OTSG quality (Application 2) water in a single step

Produced (inlet) Water Characteristics

- Water temperatures of 85°C (minimum) to 165°C
- TDS 500-10,000 mg/L
- pH 6-11
- SiO2 100-350 mg/L, Ca 5-150 mg/L, Mg 5-75 mg/L, TOC 200-600 mg/L, TIC <100 mg/L
- Free and emulsified oil <10 mg/L
COSIA CHALLENGE

#0003: High Temperature Membrane Demineralization of Recovered Water

APPROACHES WHICH HAVE BEEN OF INTEREST
The following approaches have/are being investigated by COSIA members:
• New and novel ceramic, polymer, hybrid and graphene membranes
• Membrane treatments which improve performance including fouling resistance

APPROACHES NOT OF INTEREST
The following approaches are not of interest:
• Solutions which are currently commercial, COSIA members have investigated these existing solutions thoroughly
• Approaches requiring the use of chemical pretreatment
• Approaches not operating above 85 °C
• Packed bed systems
• Solutions which add complexity to the overall operation for a slight increase in boiler feed water quality

ADDITIONAL INFORMATION
Supplemental Information – Typical SAGD Energy and Material Balance
COSIA SAGD TEMPLATE

Base Case
- Mechanical Lift - 2200 psig
- Warm Line Softening - OTSG

Water Balance
- Make-up Water
  - 13 BPSD
  - 7.727 MMSCFD
  - 0.71 GJ/hr
  - 573 kg/h
  - 515 kg/h
  - 32,894 kg/h
  - 103 kg/h
  - 83.6 kg/h
- Produced Gas
  - 63,435 kg/h
  - 91.1 GJ/hr
  - 9,763 MW
  - 7,817 MW
  - 37.33 MMSCFD
  - 28,472 kg/h
  - 1,523 kg/h
  - 2,193 kg/h
  - 462 kg/h
- Flue Gas (includes Glycol Heater)
  - 63,435 kg/h
  - 3,321 kg/h
  - 3.7 MW

Base Off Produced Gas
- Composition (Dry Basis)
  - H2S 0.13 Mol%
  - CO2 4.31 Mol%
  - CH4 91.3 Mol%
  - N2 4.21 Mol%
  - CO 0.06 Mol%
  - NOx 0.38 metric t/d
  - NOx 0.38 metric t/d

Emissions Summary
- NOx 0.38 metric t/d
- SO2 0.06 metric t/d
- CO2 4.31 Mol%
- CH4 91.3 Mol%
- CO 0.06 Mol%
- N2 4.21 Mol%
- NOx 0.38 metric t/d
- NOx 0.38 metric t/d

Steam Generation
- 63,435 kg/h
- 7,172 kg/h
- 589,560 kg/h
- 591,682 kg/h
- 655,220 kg/h
- 14,234 kg/h
- 851,624 kg/h
- 589,710 kg/h
- 855,905 kg/h

Utilities
- Air Blower
  - 482 kg/h
  - 123 MW
  - 100 % Quality
  - 456 kg/h
  - 456 kg/h
  - 456 kg/h
  - 456 kg/h
  - 456 kg/h
  - 456 kg/h

Well Pad Facilities
- Air Cooler
  - 149,027 kg/h
  - 3.7 MW
  - 32,894 kg/h
  - 103 kg/h
  - 83.6 kg/h
- Produced Gas
  - 63,435 kg/h
  - 2,193 kg/h
  - 462 kg/h
- Produced Gas
  - 63,435 kg/h
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Make-up Water
- 13 BPSD
- 7.727 MMSCFD
- 0.71 GJ/hr
- 573 kg/h
- 515 kg/h
- 32,894 kg/h
- 103 kg/h
- 83.6 kg/h

Method 1 Water Recycle
- 0.8 %