Alternative Silica Removal Technologies

**SOLUTION DESCRIPTION:**
Silica removal technologies for Steam Assisted Gravity Drainage (SAGD) produced water

**CREATED:** March 31, 2014

All projects are evaluated and actioned as they are received.

**CHALLENGE SPONSOR:**
COSIA’s Water EPA is sponsoring this challenge.

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

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](http://www.cosia.ca)

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.
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**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 characteristics 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
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**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
### ENERGY FLOW DIAGRAM
Base Case: WLS - OTSG

#### Input Energy
- **HP Steam** GJ/h
- **Natural Gas** 1538 GJ/hr (LHV)

#### Outputs Energy
- **Produced Gas** 51.1 °C 40 °C 63 GJ/h (LHV)
- **Total** 1655 GJ/hr

#### Electrical Loads
- **Power** kW
- **Equivalent Heat** GJ/h

#### Miscellaneous Users
- **Heat Input (LHV)**

#### Heat Exchangers Legend
- **Process to Process**
- **Emulsion**
- **BFW**
- **Sales Oil Coolers**

#### Radiation Losses
- **30.1 GJ/hr (LHV basis)**
- **(relative to ambient)**

#### Stack Losses
- **187.8 GJ/hr**
- **(relative to ambient)**

#### Water Heat to Earth
- 80 °C 9.16 GJ/h

#### Make-up Water
- 69 °C 40 °C 5 °C

#### Produced Gas Air Cooler
- 3.5 GJ/h

#### Air Glycol Preheater
- 219 °C
- **(based on 5°C Ground Temp)**
- 79.3 GJ/h

#### Forced Draft Fan
- 24.0 GJ/hr

#### Utilities
- **Gas Tracing & Utility**
- **Natural Gas**
- **Utility Coolers**

#### Electrical Power
- 117.3 GJ/hr

#### Production Water
- **Coolers**
- **Emulsion / BFW**
- **85 °C 90.3 °C 85 GJ/h**
- **Direct Contact/Quench**
- **97.2 °C 106 °C**

#### Produced Water
- **Coolers**
- **Emulsion / BFW**
- **5 °C**
- **13.4 GJ/h**

#### Produced Gas Cooler
- **128 °C 55 °C**

#### Produced Gas Air Cooler
- **125 GJ/h**

#### Glycol System
- **0.4 GJ/h**

#### Make-up Water Glycol Heater
- 21.8 GJ/h

#### Blowdown Cooler
- **79.3 GJ/h**

#### Blowing Water Heater
- **85 °C 90.3 °C 85 GJ/h**

#### OTSG Air Glycol Heaters (two services)
- 22.7 GJ/h

#### BFW Preheaters
- **86.7 GJ/hr**

#### Stack Losses
- **100.9 GJ/hr**

#### Electric Loads
- **Power** kW
- **Equivalent Heat** GJ/h

#### Stack Emissions
- **CO2 Emissions** MT/day
- **Direct Emissions from Combustion only**
- **Indirect CO2 Generation**
- **Total CO2 Emissions** MT/day

#### Direct CO2 Generation
- **MT/day** 417.6 kg/m³ Bitumen

#### Indirect CO2 Generation
- **MT/day** 62.5 kg/m³ Bitumen

#### Power Equivalent Heat
- **HP Steam** GJ/h
- **MW**

#### Miscellaneous Users
- **kg/h**

#### VRU Compressors
- **2.1**
- **13.7**

#### Building Heat Coolers
- **GJ/h**

#### Forced Draft Fans
- **Utilities**

#### Radiation Losses
- **Pad Auxiliaries**
- **1.3**
- **8.5**

#### Water Heat Exchangers
- **WLS/Evaporator**
- **BFW Preheaters**
- **0.5**
- **3.1**

#### Total Radiation Losses
- **22.9**
- **117.3**

#### Total 17.9 117.3 GJ/hr

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### Temperature Values
- **128 °C**
- **55 °C**
- **118 °C**
- **113 °C**
- **119 °C**
- **121 °C**
- **124 °C**
- **125 °C**
- **129 °C**
- **131 °C**
- **128.2 °C**
- **5 °C**
- **1538**
- **328**
- **2191**
- **480.1**
- **2519**
- **35.0**

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1. [Energy Flow Diagram](#)
2. [Base Case: WLS - OTSG](#)
3. [Input Energy](#)
4. [Outputs Energy](#)
5. [Electrical Loads](#)
6. [Miscellaneous Users](#)
7. [Heat Exchangers](#)
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