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# In-situ oil sands production - benchmarking of $CO_2$ capture solutions

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In-situ oil sands production, SAGD, CO2 capture benchmark

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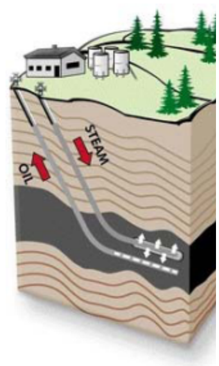
## 1. Introduction




About 80% of the recoverable oil sands deposits in Canada are too deep to be mined and have to be recovered by drilling methods. The main method for in-situ oil sands production is SAGD (Steam Assisted Gravity Drainage). Bitumen production depends on the injection of steam into the reservoir to transfer heat to the resource, thereby reducing the viscosity of the bitumen. Steam is produced by once through steam generators (OTSGs). SAGD may require a steam to oil ratio of 2.5-3.5 and even though natural gas is the main fuel the $CO_2$ emission per produced barrel of heavy oil is still high (60–80 kg/bbl) compared to conventional oil production (10-30 kg/bbl).

Statoil's ambition is a 25% reduction in $CO_2$ intensity over the next ten years and more than 40% reduction by 2025 (for new extra heavy oil developments). $CO_2$ capture solutions might be needed in the longer term (2020+) to achieve large CO2 intensity reductions.

Three concepts for $CO_2$ capture from steam generation used for production of bitumen by the SAGD technology have been benchmarked. The study does not comprise $CO_2$ transport and storage.

## 2. CO2 capture benchmark

A wide range of technologies are suggested for separation and capture of $CO_2$. They are based on different physical and chemical processes including absorption, adsorption, membranes, cryogenics and algae/microbial. Most of these technologies are only paper concepts or have not been tested in a realistic environment, or are not suited for

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application on an OTSG boiler. This work has been concentrated on a few technologies that can be said to be close to commercialisation and are well suited for reducing $CO_2$ emissions from a SAGD installation. The study does not comprise $CO_2$ transport and storage.

The following technologies for capturing $CO_2$ are assessed:

- Amine (MEA) based post combustion $CO_2$ capture
- Oxy-combustion
- Pre-combustion (production of hydrogen fuel)

Traditional post-combustion technology involves the absorption of $CO_2$ from a flue gas by means of an amine (MEA). This is basically a proven technology that has been around for more than 20 years, and is used largely for natural gas sweetening. However, the health and environmental performance of the amine process, if used to capture $CO_2$ from flue gases, is uncertain.

In Oxyfuel combustion, oxygen (95-97%) is used for combustion instead of air, resulting in a flue gas that consists mainly of $CO_2$ and $H_2O$. The $CO_2$ can be captured by condensing the steam by a cooling process. Since unused oxygen, unburned gas and any other gaseous components in the fuel and oxygen feed streams (including most of the NOx) will follow the $CO_2$ stream, additional purification is required. Presently there are not to our knowledge any commercial gas-fired oxy-combustion boiler installations.

Pre-Combustion capture involves reacting a fuel with oxygen and/or steam to give mainly carbon monoxide and hydrogen (known as syngas). The carbon monoxide is further reacted with steam in a catalytic reactor, called a shift converter, to give $CO_2$ and more hydrogen. $CO_2$ is usually separated by a physical adsorption or chemical absorption process, resulting in a hydrogen-rich gas, which can be used as fuel. Hydrogen production technology is commercial at the size needed for a SAGD facility. Hydrogen fired drum boilers are in commercial operations, but no hydrogen fired OTSG's.

The current study is based on a SAGD installation with a production of 60 000 barrels of bitumen per day at a steam to oil ratio of 3.0. Imported natural gas and produced gas are used as fuel. The cooling systems were designed as glycol/water – air cooling systems.

The three different $CO_2$ capture technologies were compared to a reference SAGD facility, without $CO_2$ capture.

Additional energy consumption required for the $CO_2$ capture technologies were estimated. The energy requirement needs to be seen in relation to the $CO_2$ avoided potential for these technologies. $CO_2$ avoided is dependent on assumptions regarding the $CO_2$ emissions from imported electricity. Two scenarios are assumed:

1. <u>Natural gas based electricity:</u> $CO_2$ emissions from natural gas based electricity production included. 50% efficiency assumed.
2. <u>"Green" electricity:</u> No $CO_2$ emissions related to import of electricity (e.g. renewable or $CO_2$ removal included in cost)

Final emissions for the three selected technologies, with natural gas based and green electricity included, was calculated and compared. Finally relative avoided cost of $CO_2$ are compared and translated into an additional processing cost required for the bitumen production.