A Strategy to Reduce the CO₂ Footprint of SAGD Oil Sands Recovery

David B. Layzell, Manfred Klein, Song Sit Madhav Narendran & Bastiaan Straatman

CESAR Initiative, University of Calgary

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Steam Assisted Gravity Drainage (SAGD) is GHG Intense

Cost-effective technologies are needed to reduce the \( \text{CO}_2 \) footprint of SAGD oil sands recovery;

- Oil sands development
- Pipelines needed for market access

Differential has undermined public support for:

- Oil sands development
- Pipelines needed for market access

Recovery GHG Emissions

<table>
<thead>
<tr>
<th>GHG Intensity (kg CO(_2)e/bbl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>40</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>60</td>
</tr>
<tr>
<td>70</td>
</tr>
<tr>
<td>80</td>
</tr>
<tr>
<td>90</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

Target zone for GHG emission Intensity

- COSIA SAGD Std\(^{1,2}\)
- Oil Sands Mining\(^2\)
- Avg Cdn OS (2012)\(^2\)
- Avg US crude prod\(^n\)\(^2\)
- Avg oil refined in US\(^2\)
- Lowest C footprint\(^2\)

1 COSIA Challenges 2014
2 IHS Energy. 2014. Comparing GHG intensity of the oil sands and the average US crude oil
Proposal: SAGD ‘Greens’ the Alberta Grid (& Itself), Gaining Economic & Environmental Benefits

- In most jurisdictions, no industries could use the waste heat from power gen.;
- Considered to be the ‘cost’ of thermal power generation

Not in Alberta:
- SAGD heat demand:
  - 227 PJ/yr in 2013
  - 469 PJ/yr in 2020
- Plus heat demand for CSS, OS mining / upgrading

- SAGD could help & benefit -

The Time to Act is Now
- Carbon Price increases;
- ‘Off-Coal’ Policy (by 2030);
- 30% Renewable target (by 2030);
- Policies will be set within 6 months.
Cogeneration

- Already important in many OS facilities;
- Potential to dramatically increase deployment, especially on SAGD facilities:
- For a ‘typical’ 33,000 b/d facility:

<table>
<thead>
<tr>
<th># GE Frame 7 Gas Turbines</th>
<th>Duct Burning?</th>
<th>SAGD (33,000 bpd)</th>
<th>Contribution to ‘Public’ Grid</th>
<th>GHGs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>% Power</td>
<td>% Heat</td>
<td>GWh / yr</td>
</tr>
<tr>
<td>One</td>
<td>Yes</td>
<td>100%</td>
<td>~50%</td>
<td>Up to 590</td>
</tr>
<tr>
<td>Two</td>
<td>Yes</td>
<td>100%</td>
<td>100%</td>
<td>Up to 1300</td>
</tr>
</tbody>
</table>

- There is also potential to modulate SAGD heat & power output to provide low-cost backup for renewables while maintaining SAGD production.
Two Ways to Produce 33 kbbl SAGD/d + 550 GWhₑ/yr to Grid

**COSIA Standard:**
OTSG + Grid Power

- **Bitumen Production:** (33,000 b/d, 12 Mb/yr)
  - Steam for 33,000 b/d (12.9 PJ/yr)

- **TOTAL LOSSES:**
  - (5.5 PJ/yr; 26% of energy input)

**Cogen:** 85 MWₑ GT with 30% Duct Firing + OTSG

- **Steam for:**
  - 17,918 b/d (7.0 PJ/yr)
  - 15,082 b/d (5.9 PJ/yr)

- **Total Energy Input:** 18.6 PJ/yr

- **TOTAL LOSSES:**
  - (3.2 PJ/yr; 17% of energy input)

**Fuel mix**
- 6.9 PJ/yr
- Grid: 0.42
- OTSG: 0.80

**TOTAL ENERGY INPUT:** 20.9 PJ/yr

**Tidal and Wave Energy**
Exploring the Potential in Alberta

Preliminary Scenario Models (2015-2030):

Assumptions:
- High Oil Sands Growth Future
- Cogen: One 85 MW Gas Turbine / 33kbd SAGD with duct firing
- No major growth in renewables

Five Scenarios:
1. Status Quo (continue with Coal)  
2. NG-CC to meet off-coal regulations  
3. SAGD-Cogen to meet off-coal regulations  
4. SAGD-Cogen exceeds off-coal regulations by 5 yrs  
5. SAGD-Cogen exceeds off-coal regulations by ~10 yrs
The Next 15 Years in Alberta...

A. In-situ OS Energy Demand

- Power
- Heat

B. Coal Phase-out Options

- Expected Demand Growth
- Regulated Coal retirement
- ~10 year early retirement
- ~5 year early retirement

GHG Emissions*

- $9.9\text{ kg CO}_2/bbl$
- @grid av 763 $\text{ kg CO}_2/\text{MWe}$
- 66.4
- 76.3

*from COSIA Challenges 2014

GHG Savings (Mt CO$_2$e)

- For Grid
- For SAGD
- 133
- 53
- 0
- +87
- 0
- +87
- 133
- 227

New off-coal target (not modeled here)

Replace regulated coal retirements + new demand & get GHG benefits for both the AB Grid + SAGD.

Go beyond regulation and claim the additional GHG benefits for SAGD.
Source of Heat for SAGD Steam

S1: Status Quo

S2: NG-CC for regulated coal retirement

S3: Cogen for regulated coal retirement

S4: Cogen for 5 yr early coal retirement

S5: Cogen for 10 yr early coal retirement
**GHG Emissions from Grid + SAGD**

**Note:** the lower GHGs in S3 than S2 is due to the better efficiency of Cogen than NG-CC.
Overview of GHG Scenarios (2016 to 2030):

<table>
<thead>
<tr>
<th>Scenario Change</th>
<th>Cumulative GHG Benefit (Mt CO$_2$e)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TOTAL</td>
</tr>
<tr>
<td>Coal Dom. Grid to <strong>NGCC</strong> to meet regulations, no change in SAGD (S1 → S2)</td>
<td>141</td>
</tr>
<tr>
<td>Coal Dom. Grid + SAGD (COSIA) to <strong>Cogen</strong> to meet regulations (S1 → S3)</td>
<td>186</td>
</tr>
<tr>
<td>More SAGD Cogen to retire coal plants ~5 yrs early (S3 → S4)</td>
<td>87</td>
</tr>
<tr>
<td>More SAGD Cogen to retire coal plants ~10 yrs early (S4 → S5)</td>
<td>87</td>
</tr>
<tr>
<td><strong>TOTAL BENEFIT of Cogen Alternatives (S1 → S3 → S4 → S5)</strong></td>
<td>359</td>
</tr>
</tbody>
</table>

* Assumes that GHG benefits of initiatives which go beyond regulations (e.g. early coal retirement) can be assigned by proponents to areas of their choice (i.e. SAGD)
GHG Intensity for SAGD Bitumen from Cogen Heat

NOTE

- COSIA Std SAGD [76]
- S1 (Status Quo), S2 (NGCC) & S3 (Cogen A) [49]
- S4 (Cogen B) [wtd avg. 33]
- S5 (Cogen C) [wtd avg. 22]

Target zone for GHG Emission Intensity

GHG Intensity (kg CO$_2$e/bbl)
Conclusions

By deploying cogeneration (with duct burning) at SAGD facilities between 2017 and 2030, Alberta could simultaneously:

- Reduce reliance on coal-fired power, with associated air quality / health benefits;
- Consume less natural gas (reduce price risk);
- Eliminate 359 Mt GHG emissions (133 Mt from Power generation; 227 Mt from SAGD operations);
- Produce SAGD bitumen with a GHG footprint equivalent to / better than conventional crudes;
- Create a second source of income from SAGD facilities;
- ...with little or no increase in either the cost of power or bitumen recovery.
Next Steps

- **New Context:**
  - Low Oil Sands Growth Future
  - Complete decommission of coal power by 2030
  - Up to 30% Renewable Power by 2030
  - Assume Retrofit of SAGD with 1 or 2 GT per 33,000 bpd facility

- **Compare Cogen energy efficiency and GHG intensities during ‘normal’ operation & when ‘modulated’ to provide backup for renewables**
  - Compare various water treatment and power generation technologies to optimize SAGD production, grid power supply and backup capacity for renewables

- **Looking for an industry partner to develop site specific CAPEX & OPEX estimates to evaluate project economics and CO₂ avoidance costs.**