



# **Hybrid Life Cycle Assessment of Alberta's Oil Sands Industry**

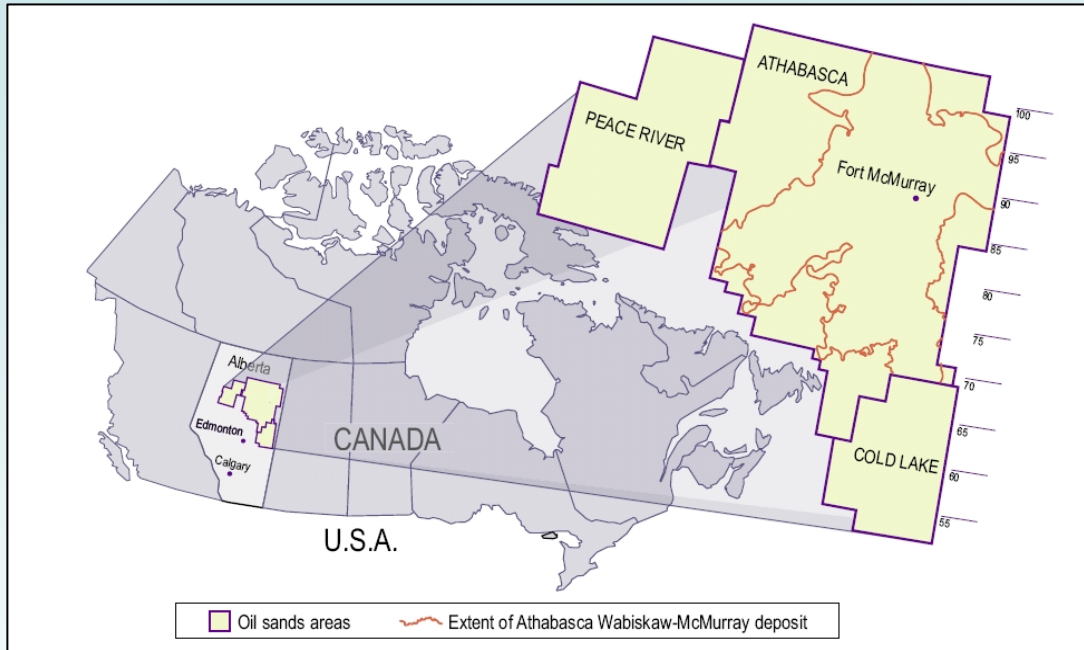
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# Outline

- Oil sands overview
- Hybrid structure definition
- Canadian EIO-LCA model
- Oil sands technologies assessed in the Canadian EIO-LCA model
- Comparison with process-based models
- Conclusions

# Oil sands overview



Reserves :  
179 Billion barrels

**Canada: 2<sup>nd</sup> reserves  
after Saudi Arabia**

Production (Mbpd):

2005 1.1

2015 3

2030 5

2005 World Production

85 Mbpd

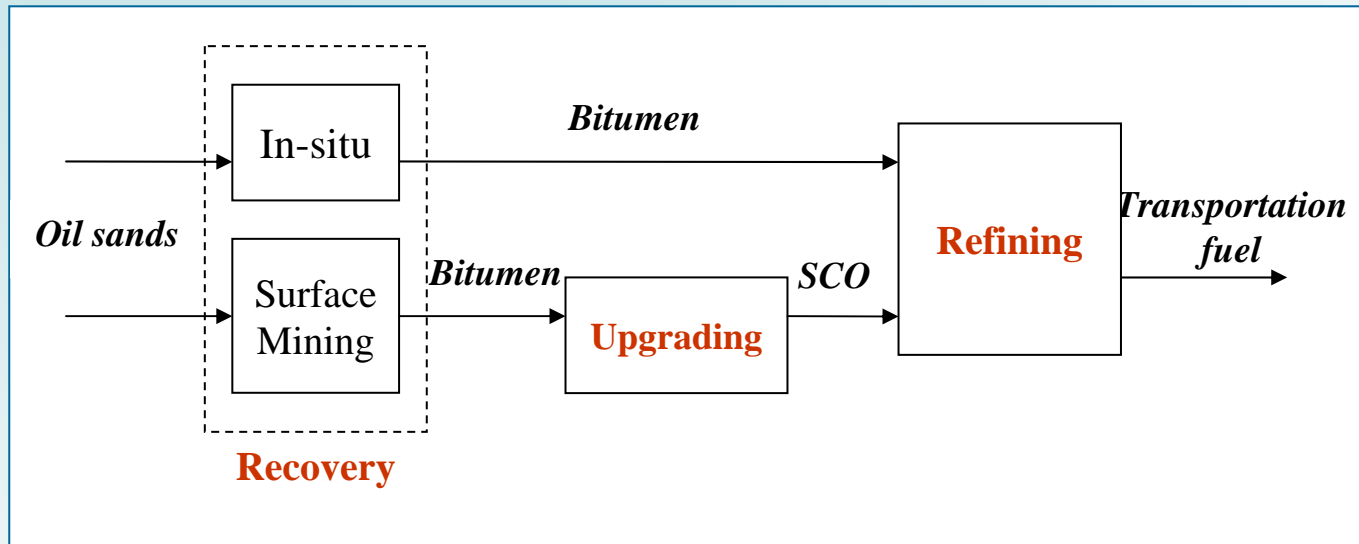
## Motivation of research

Estimate the energy use and GHG emissions associated with oil sands development

Make informed decisions to minimize impacts

# Oil sands overview

## Oil sands-based fuel production (Well-To-Pump processes)



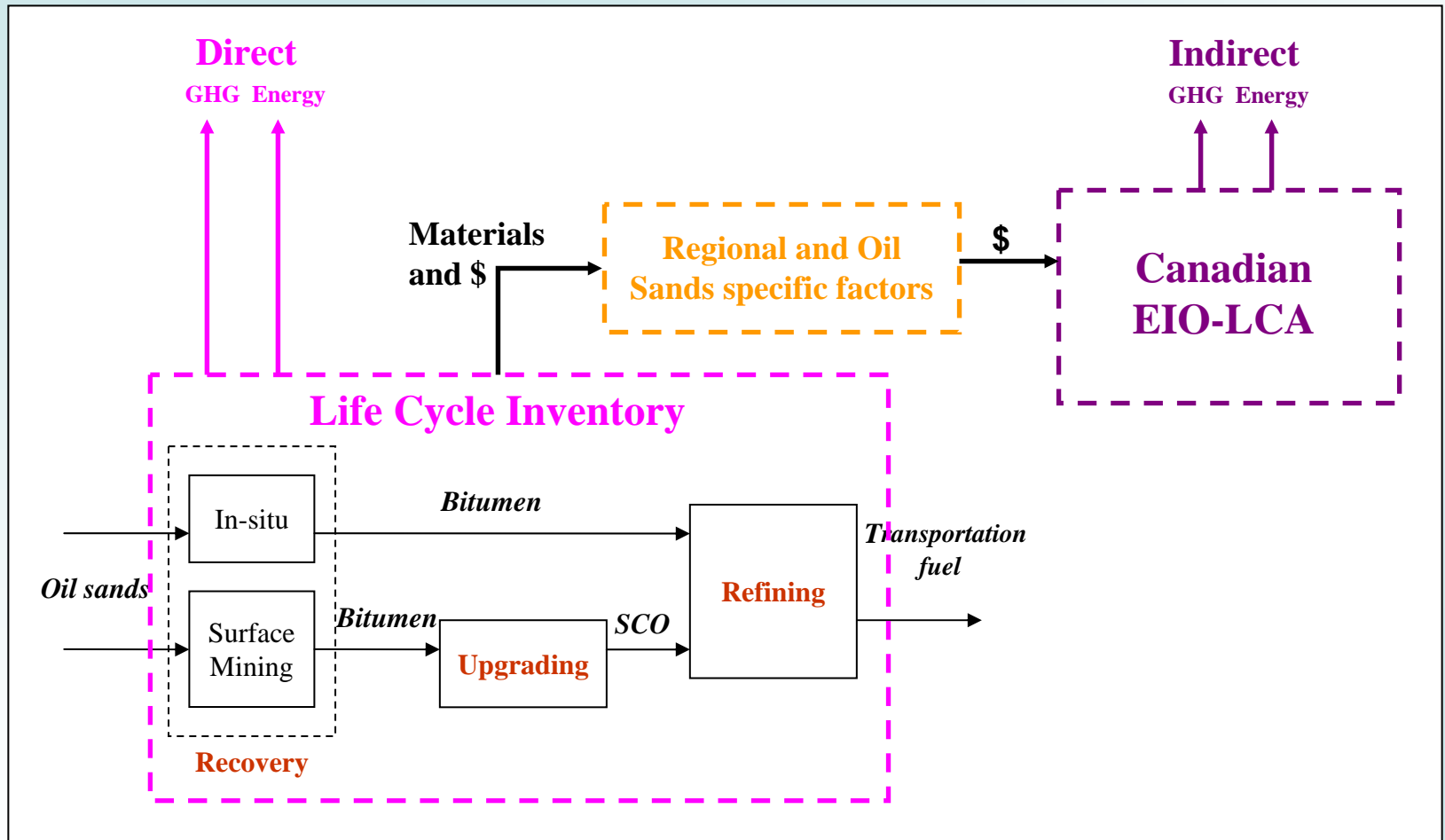
### Environmental issues :

- Energy and water consumption
- GHG emissions
- Waste Management
- Land use

...

# Hybrid structure definition

## Schematic definition of the hybrid model



# Canadian EIO-LCA model

## *Economic component :*

- Industry x industry model
- 117 sectors (L-level in Canada)

Data from Statistics Canada, Industry Accounts Division,  
System of National Accounts

## *Environmental component :*

- Energy use: Total + detail for 10 energy sources
- GHG emissions: Total + disaggregation CO<sub>2</sub>, CH<sub>4</sub> & N<sub>2</sub>O

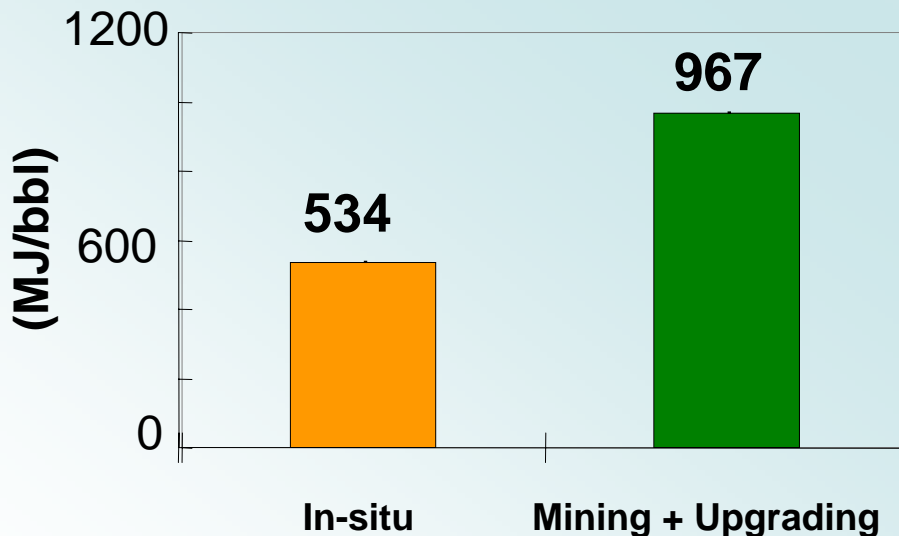
Data from Statistics Canada, Environment Account and  
Statistics Division

# Oil sands in EIO-LCA model

Input : Supply cost (1997 C\$)

in sector “Oil and Gas extraction” (2111 in NAICS)

Total Energy Use for oil sand extraction



Results misleading  
based on \$ input into one sector

→ Need disaggregation  
energy sectors

→ Need new data (1997)

# Oil sands in EIO-LCA model

Use EIO-LCA model for yearly estimates :

## Energy Use

2005	336,000 TJ/yr	→ mostly natural gas
2015	846,000 TJ/yr	→ what sources?

## Greenhouse gas emissions

2005	36 MT CO <sub>2</sub> eq./yr	(5% Total Canada)
2015	91 MT CO <sub>2</sub> eq./yr	

→ Global warming? “Kyoto” engagement?

**Serious issues which need critical assessment**

# LCA model comparison

Process-based LCA models that include oil sands:

- GREET 1.7 – Argonne National Laboratory
- GHGenius 3.2 – Natural Resources Canada

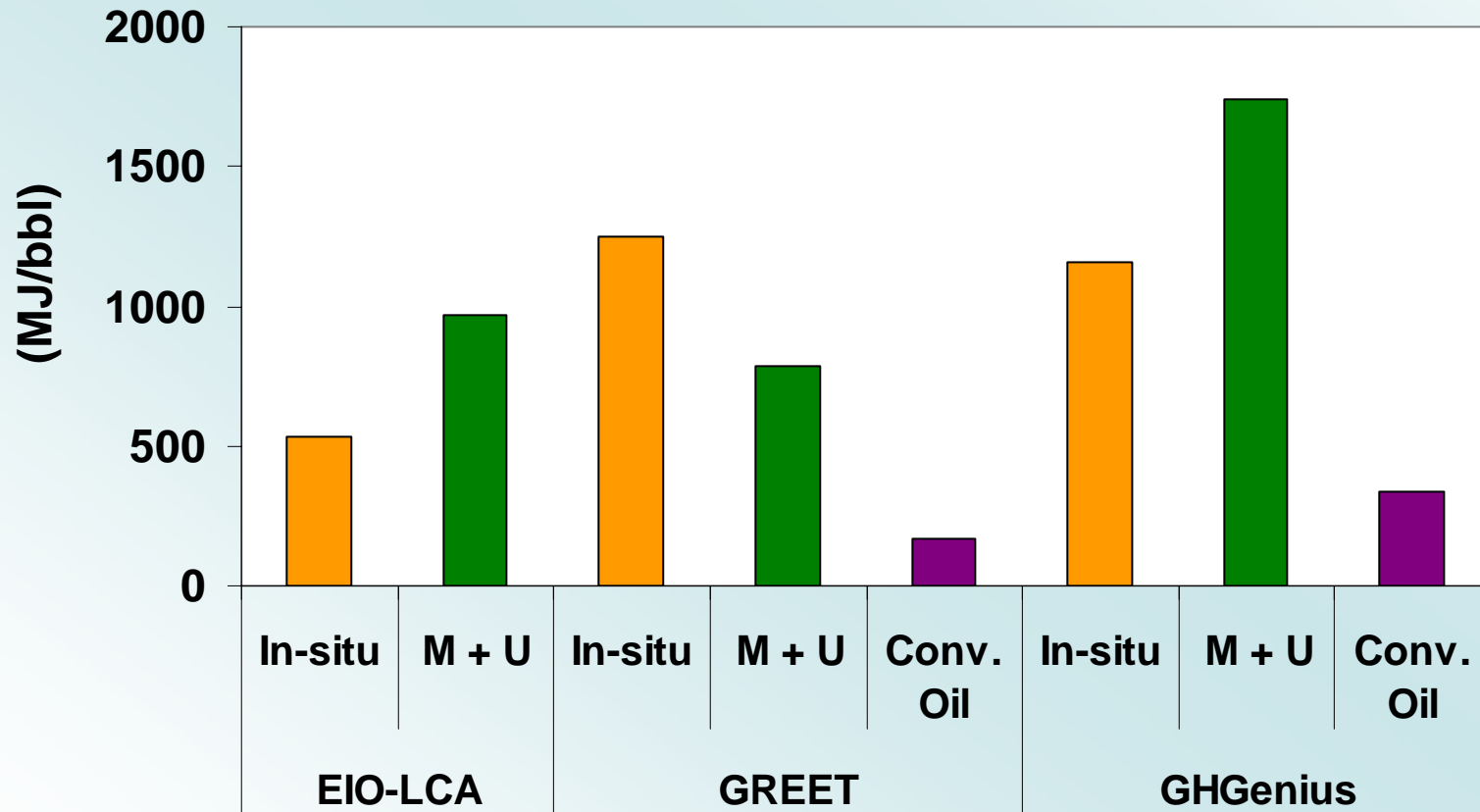
Well-To-Tank and Well-To-Wheel models for assessing the energy use and environmental impacts of alternative transportation fuels

Both propose a selection of crude oils:

- Conventional crude oil
- Bitumen from in-situ projects
- Synthetic crude oil (SCO) from upgraded surface-mined bitumen

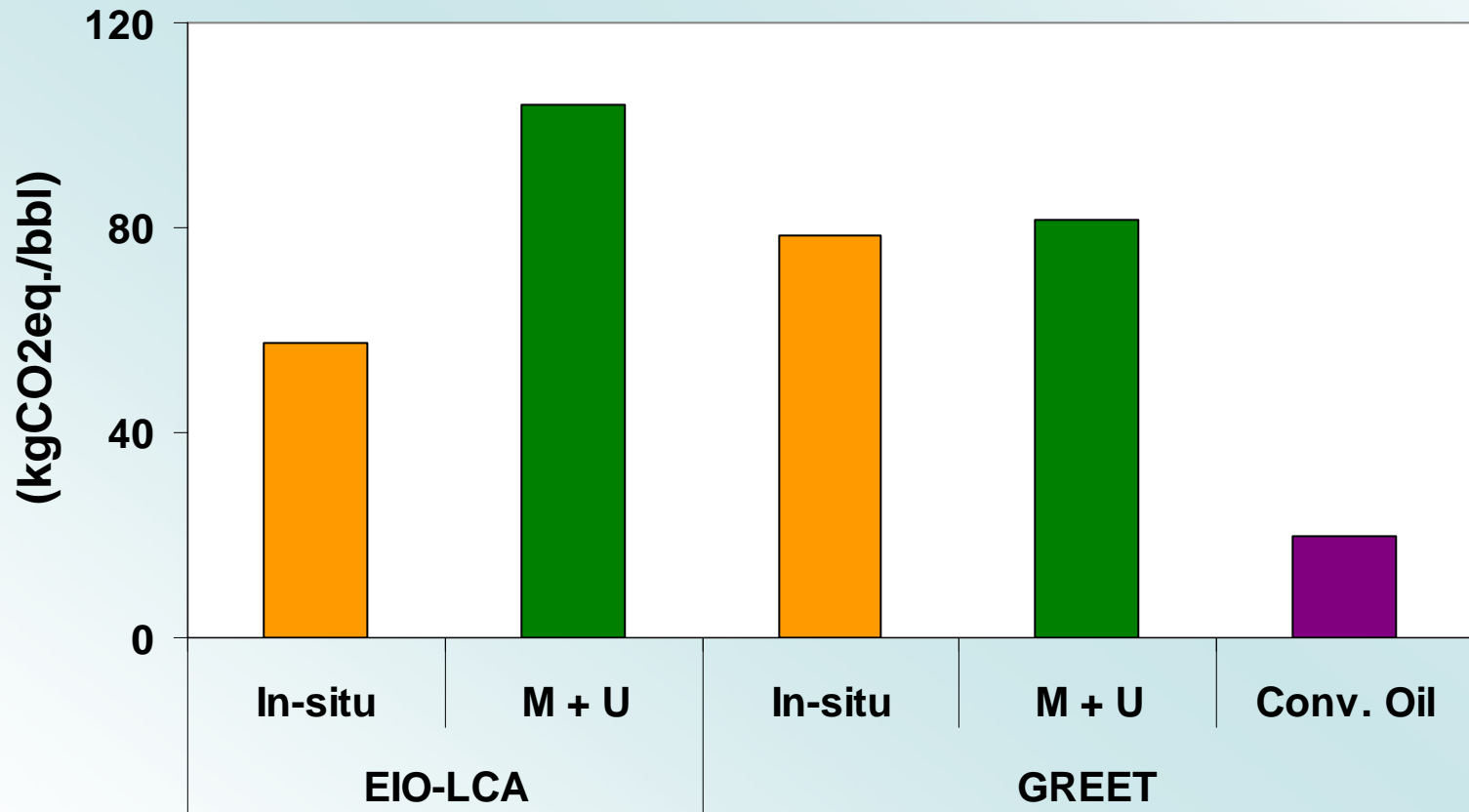
# LCA model comparison (Energy)

## Comparison of bitumen/SCO energy use



# LCA model comparison (GHG)

## Comparison of bitumen/SCO GHG emissions



# LCA model comparison

Significant differences between models :

- between EIO-LCA and process-based models  
e.g. in-situ energy use
- between GREET and GHGenius  
e.g. mining & upgrading energy use

Among the issues :

- EIO-LCA: - aggregation in “oil and gas extraction”  
- 1997 data when less oil sands influence
- Process-based LCA : - different boundary definitions  
- data inventory

→ **Build a hybrid model**

# Hybrid model requirements

## EIO-LCA component :

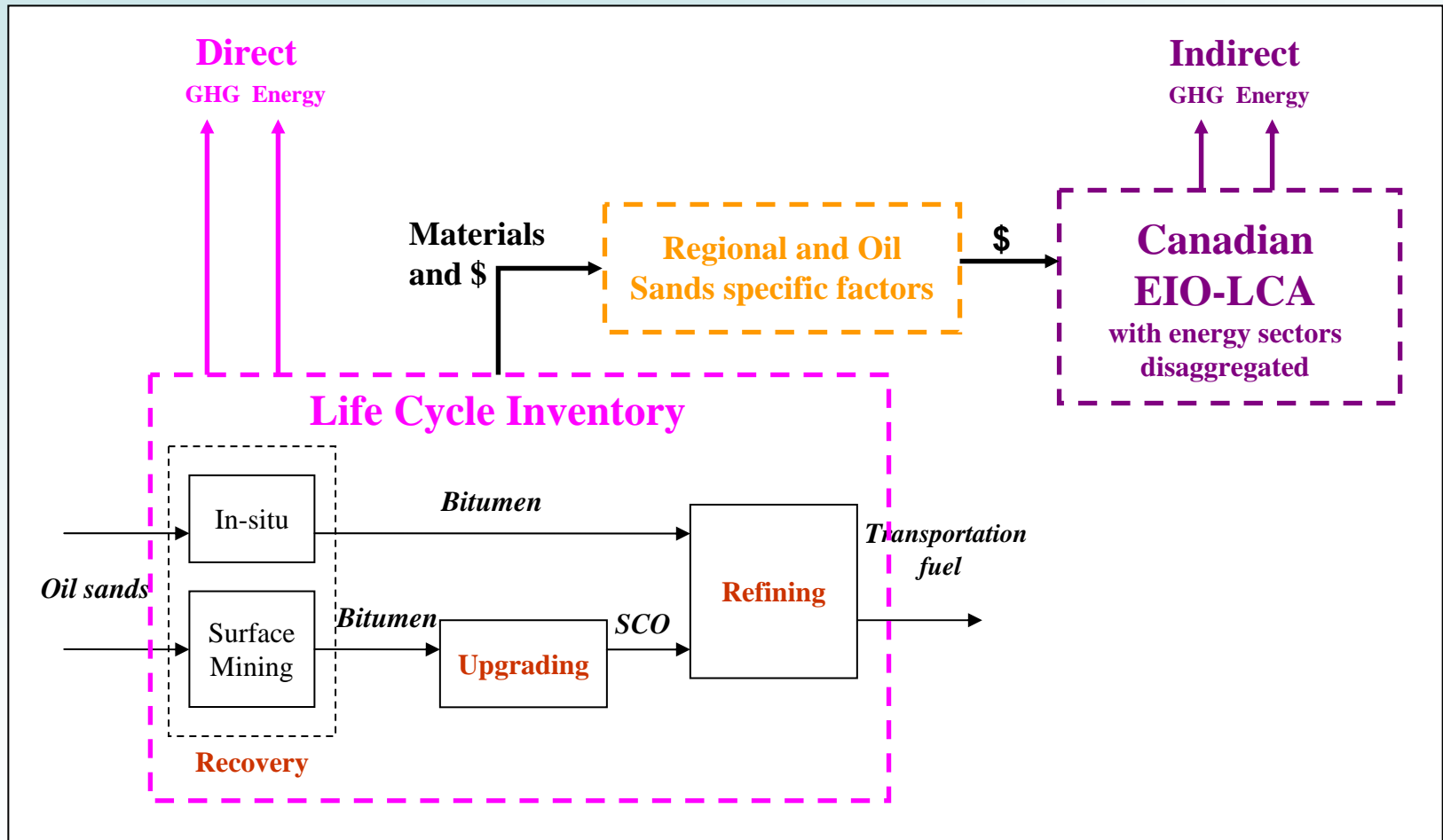
- To disaggregate the energy sectors, especially “oil and gas extraction”
- To complete the Canadian model with regional aspects specific to the province of Alberta
- To integrate factors specific to oil sands processing

## Life Cycle Inventory :

- To collect data from industrial partners
- To define boundaries compatible with the EIO-LCA extension

# Hybrid structure definition

## Schematic definition of the hybrid model



# Conclusions

- **Need to make informed decisions on oil sands development to estimate and minimize energy use and greenhouse gas emissions**
- **Current EIO-LCA and process-based models give order of magnitude estimates**
- **Hybrid LCA will provide more precision, especially in comparing current and developing oil sands technologies**
- **Other key environmental impacts such as water consumption, land use, and air pollutants emission could be added into the model**
- **Industry and government collaboration needed for model improvements**

# Acknowledgements

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# Questions ?