CLEANER AND VIABLE OIL SAND PROJECT IS A REALITY

MECH 4810 – Energy Conversion Systems

Project #1a

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OUTLINE

- Introduction
- Motivation
- Current Practices
- Alternatives
- Nuclear Power
- Economic Feasibility
- Environmental Impact
- Other Issues
- Conclusion

2

INTRODUCTION

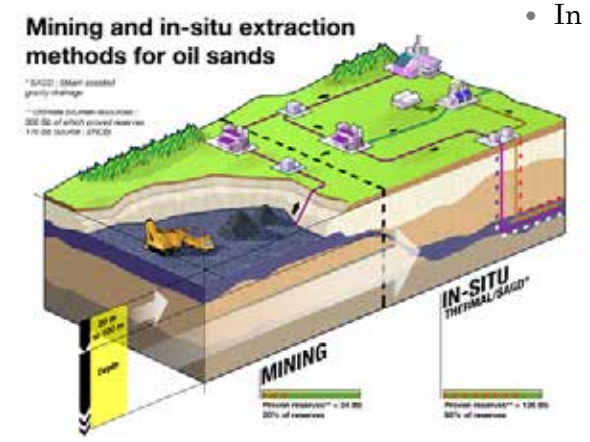
- Our focus:
  - Alberta

3

Image source: http://upload.wikimedia.org/wikipedia/commons/7/7a/Athabasca_Oil_Sands_map.png

INTRODUCTION

- 2 types of oil sand production:
  - Open pit mining
  - In situ



4

Image source: http://www.total.com/en/special-reports/oil-sands/canada-s-oil-sands/production-techniques-200931.html

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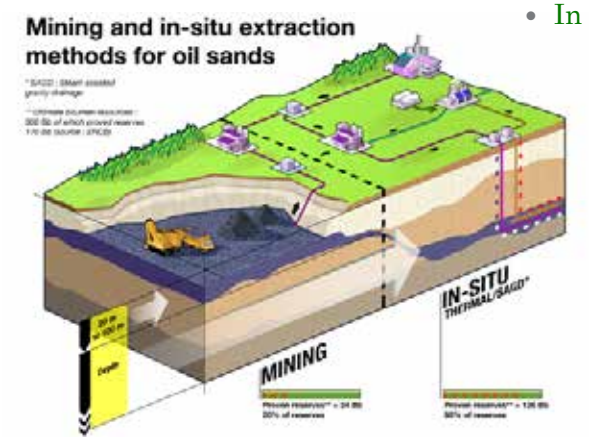

5

Image source: http://www.total.com/en/special-reports/oil-sands/canada-s-oil-sands/production-techniques-200931.html

INTRODUCTION

- Many methods for improving the environmental impact
  - Increasing efficiency of extraction
  - Cleaner power supplies of extraction
  - Reducing water consumption
  - Reducing emissions and other pollutants
- Our focus:
  - Reducing C02 emissions
  - Switching to nuclear power

6

MOTIVATION: WHY DO WE NEED THE OIL SANDS?

- Energy
- Transportation
- Plastics

- In Canada and out
- Exporting = $$

- Alberta oil sands: 3rd largest in the world
- Projected production increase:
  - 1.31 million barrels per day (2008)
  - 3 million barrels per day (2018)

7

MOTIVATION: WHAT ARE THE ISSUES?

- Limited supply
- Negative environmental impact:
  - C02 emissions:
  - Toxic emissions to atmosphere
  - Water requirements
  - Pollution of land and water

8

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9

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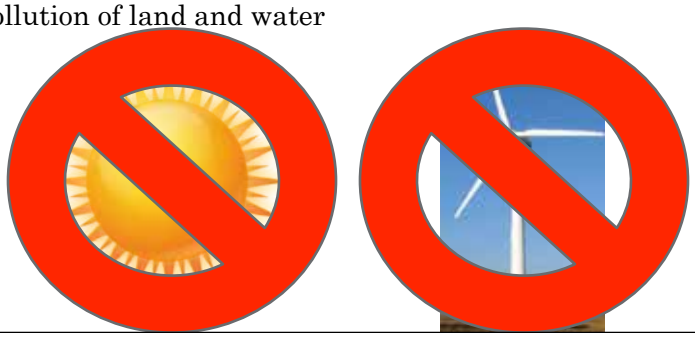


10

Current Practices Overview

- Requires a lot of energy
  - Steam!
- Natural gas for power generation
- CSS
- SAGD

11

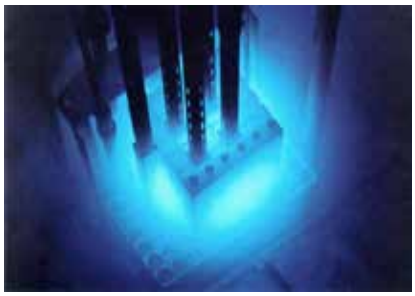
Technical Details and Alternatives

- Commercial processes:
  - Cyclic steam stimulation (CSS)
  - Steam assisted gravity drainage (SAGD)
  - Toe to heel air injection (THAI)
- Emerging technologies:
  - Enhanced solvent extraction incorporating electromagnetic heating (ESEIEH)
  - Vapour extraction process (VAPEX)
  - Liquid addition to steam for enhanced recovery (LASER)

12

NUCLEAR POWER

- Conventional oil sand processing uses natural gas as a power source.
- Nuclear reactors can be used to generate the heat, electricity, and hydrogen gas needed for oil sands processing.

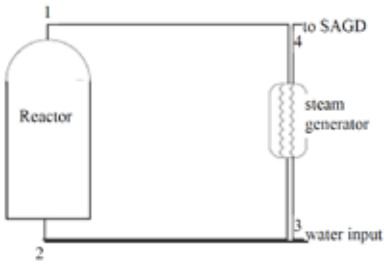


13

NUCLEAR POWERED BITUMEN PRODUCTION

- Nuclear reactor is used for steam generation to drive SAGD process.

Type of Oil Field	2 Mpa	6 Mpa
Low Performance	1,230 MWth	1,264 MWth
High Performance	820 MWth	843 MWth

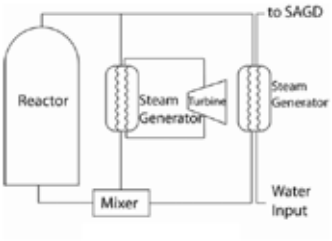


14

Bitumen and Electricity Production

- Reactor generates steam and electricity to run supporting equipment.

Area	Connected Load (MWe)	Average Demand (MWe)
Mine	27	20
Bitumen Extraction and Cleaning	200	150
Utilities and Off-sides	44	33
Infrastructure	1	1
Total	**272**	**204**

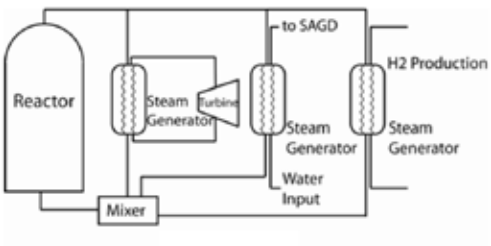


15

Bitumen, Syncrude and Electricity Production

- Reactor generates steam, electricity, and hydrogen for upgrading process

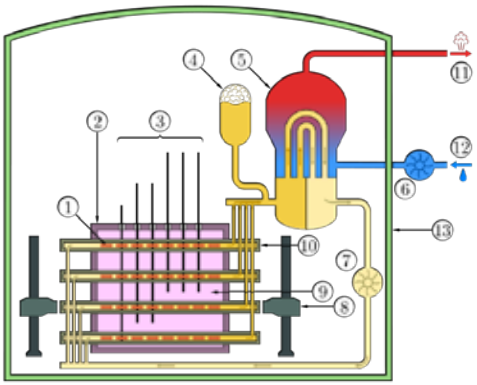
Area	Connected Load (MWe)	Average Demand (MWe)
Mine	27	20
Bitumen Extraction and Cleaning	200	150
Upgrader	115	86
Utilities and Off-sides	44	33
Infrastructure	1	1
Total	**387**	**290**



16

NUCLEAR REACTOR OPTIONS

Scenario	ACR-700	AP600	PBMR
Bitumen Only	1	1	4
Bitumen and Electricity	1	2	5
Bitumen, Electricity, and Hydrogen	2	2	8



17

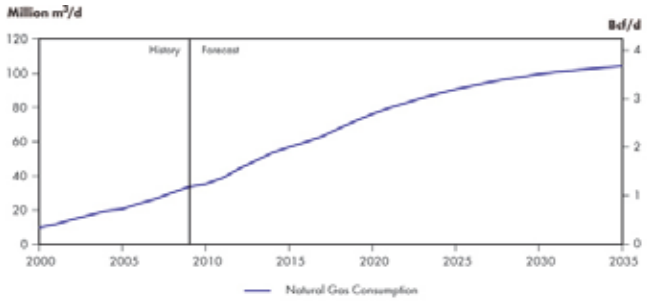
ECONOMIC FEASIBILITY

- Compare Nuclear Power to Natural Gas
  - Fuel Reserves
  - Life Cycle Costs
    - Capital Cost
    - Operating & Maintenance
    - Fuel
    - Decommissioning

18

Economic Feasibility: Fuel Reserves

- Currently 424 trillion cubic feet of natural gas in Canada
- Alberta oil sands demand of natural gas is projected to increase

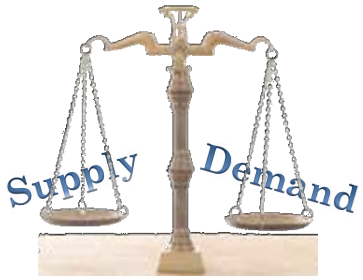


(National Energy Board, 2012)

19

Economic Feasibility: Fuel Reserves

- Natural gas reserve would only last another 106 years
- Natural gas is not just used for oil sands
- As the reserve diminishes, the price increases



http://www.seriousinvestmentreturns.com

20

Economic Feasibility: Fuel Reserves

- Estimated 170.8 billion barrels of oil remaining
- 80% (136 billion) of the reserve will be mined using in-situ methods

- There are 572,000 tons of uranium ore in Canada
- This ore could produce 55.5 billion barrels

21

Economic Feasibility: Life Cycle Analysis

- Steam Assisted Gravity Drainage (SAGD)
- Use to generate steam & electricity
- 30 Year Life

Estimated life cycle cost comparison

	Natural Gas	PBMR	ACR-700	AP600
Capital	$120.00M	$717.90M	$1,190.50M	$1,012.30M
Operating and Maintenance	$75.40M	$169.70M	$461.00M	$445.90M
Fuel	$3,959.40M	$285.60M	$114.10M	$184.80M
Decommissioning	$0.50M	$12.40M	$5.90M	$20.30M
Total Cost	$4,155.30M	$1,185.60M	$1,771.50M	$1,663.30M

http://web.mit.edu/pebble-bed/papers1_files/OilSands.pdf

22

ECONOMIC FEASIBILITY: FUEL COST

- One uranium pellet (7 *grams*) produces as much energy as 17,000 ft^3 of natural gas
- Cost to purchase uranium ore & refine it into 1 kg of U_3O_8 is \$2770
- 1 ft^3 of natural gas can produce 0.001025 MMBtu

$$Cost = \$2770/1\ kg\ uranium \times 0.007\ kg\ uranium/17000\ ft^3\ natural\ gas \times 1\ ft^3\ natural\ gas/0.001025\ MMBtu$$

$$Cost = \$1.11/MMBtu$$

23

ECONOMIC FEASIBILITY: FUEL COST

- Efficiency of nuclear power plant: 33%
- Efficiency of steam generating natural gas plants: 33%

$$Cost_u = \$1.11/1\ MMBtu \times 1/\eta_{nuclear} = \$1.11/1\ MMBtu \times 1/0.33 = \$3.36/1\ MMBtu$$

$$Cost_{ng} = \$4.50/1\ MMBtu \times 1/\eta_{natural\ gas} = \$4.50/1\ MMBtu \times 1/0.33 = \$13.64/1\ MMBtu$$

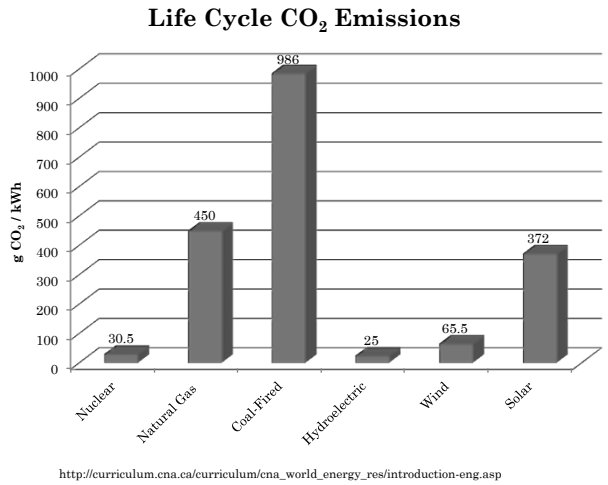
24

ENVIRONMENTAL IMPACT

- Key issues:
  - CO_2 emissions
  - Water use
  - Waste
- Each SAGD facility that produces 100,000 barrels per day of bitumen could reduce CO_2 emissions by up to 3.1 million metric tons per year

25

ENVIRONMENTAL IMPACT - CO_2



http://curriculum.cna.ca/curriculum/cna_world_energy_res/introduction-eng.asp

26

Environmental Impact - Water

- Conventional oil production:
  - 0.39 barrels of water/ barrel of bitumen for SAGD
  - 0.52 barrels of water/ barrel of bitumen for CSS
- Nuclear energy for oil production:
  - [Finish calculation to show how many barrels of water are required to collect one barrel of bitumen]

27

Environmental Impact - Waste

- About 27 tonnes of used fuel is taken each year from the core of a 1000 MWe nuclear reactor
- First, stored in cooling ponds for at least 5 years
- Then, in dry concrete structures at the reactor site for 40-50 years
- Ultimately, buried in stable geological formations approx. 500 m deep

http://www.energy-net.org/01NUKE/NUKE-14.HTM

28

Social Issues

- Concern about nuclear production after Three Mile Island, Chernobyl, and Fukushima
- Canadian Nuclear Attitude Survey:
  - Nuclear is opposed at a general level by 56% of Canadians
  - Building new nuclear plants is opposed by 61% of Canadians
  - 39% of respondents strongly oppose nuclear power (11% strongly support)
  - 6% of respondents strongly oppose natural gas (28% strongly support)

29

Conclusion

- Lots of room for improvement
- Nuclear energy for power requirements
  - Takes time to get going
  - Costly up front
  - Eventually yields a return
  - Less environmental impact

Nuclear energy for power requirements and other technologies can and should be implemented to reduce carbon emissions

30

WE'RE ALL IN THIS TOGETHER

31

Image retrieved from: http://www3.delta.edu/broadcasting/news/012012-redgreen.html

QUESTIONS?

32