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"Greening" the Oil Sands?

Challenging the Myths and Confronting the Realities

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Overview of Presentation

- What are oil sands?
- Where are they located, how much?
- How to recover and process?
- What is the size of the environmental footprint (land, water and air)?
- What research & innovation is underway to improve/reduce impacts?
- Myths and Realities

What are Oil Sands? “Technology Oil”

Oil Sands – combination of

- Bitumen (3 - 18%)
- Water (2 - 10%)
- Sand (50 - 75%)
- Clay (10 - 30%)

From Oil Sands

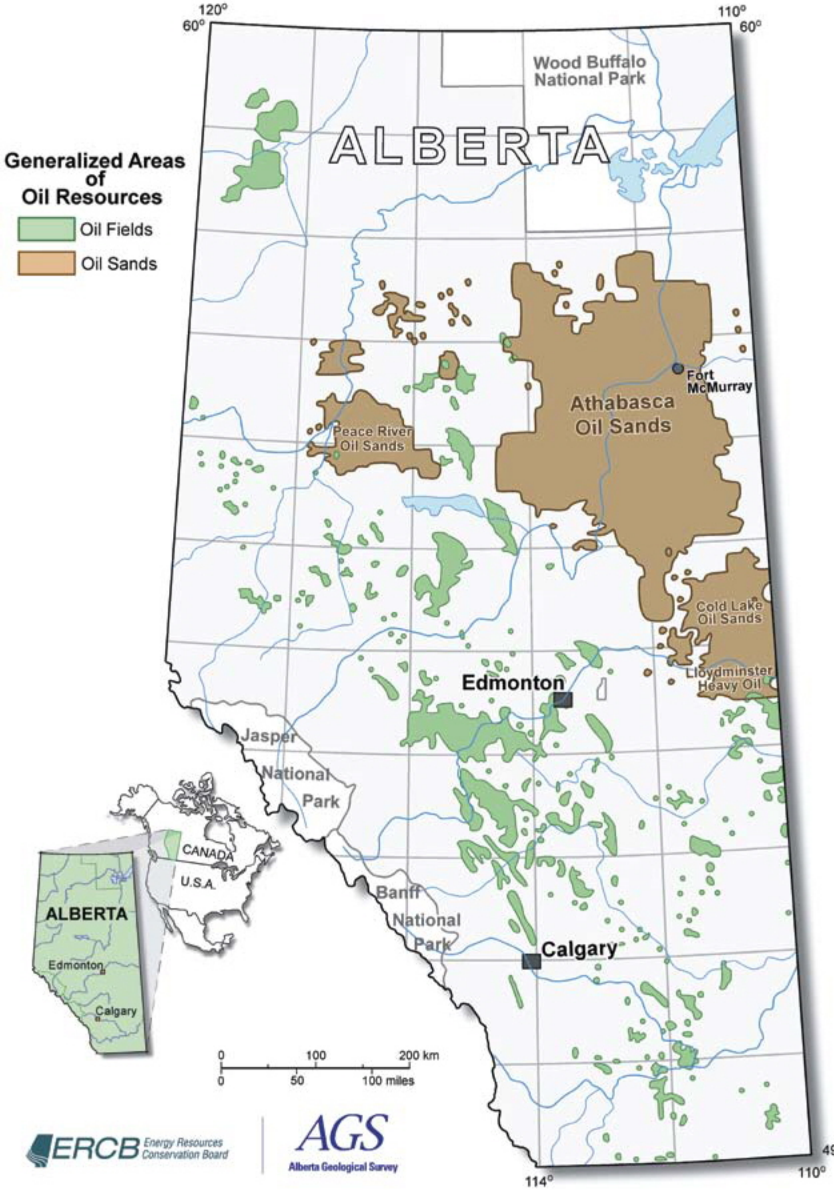
To Bitumen

(high viscosity, 4.5 % Sulfur, contains Vanadium, Nickel, Nitrogen, Oxygen)

To Synthetic Crude Oil

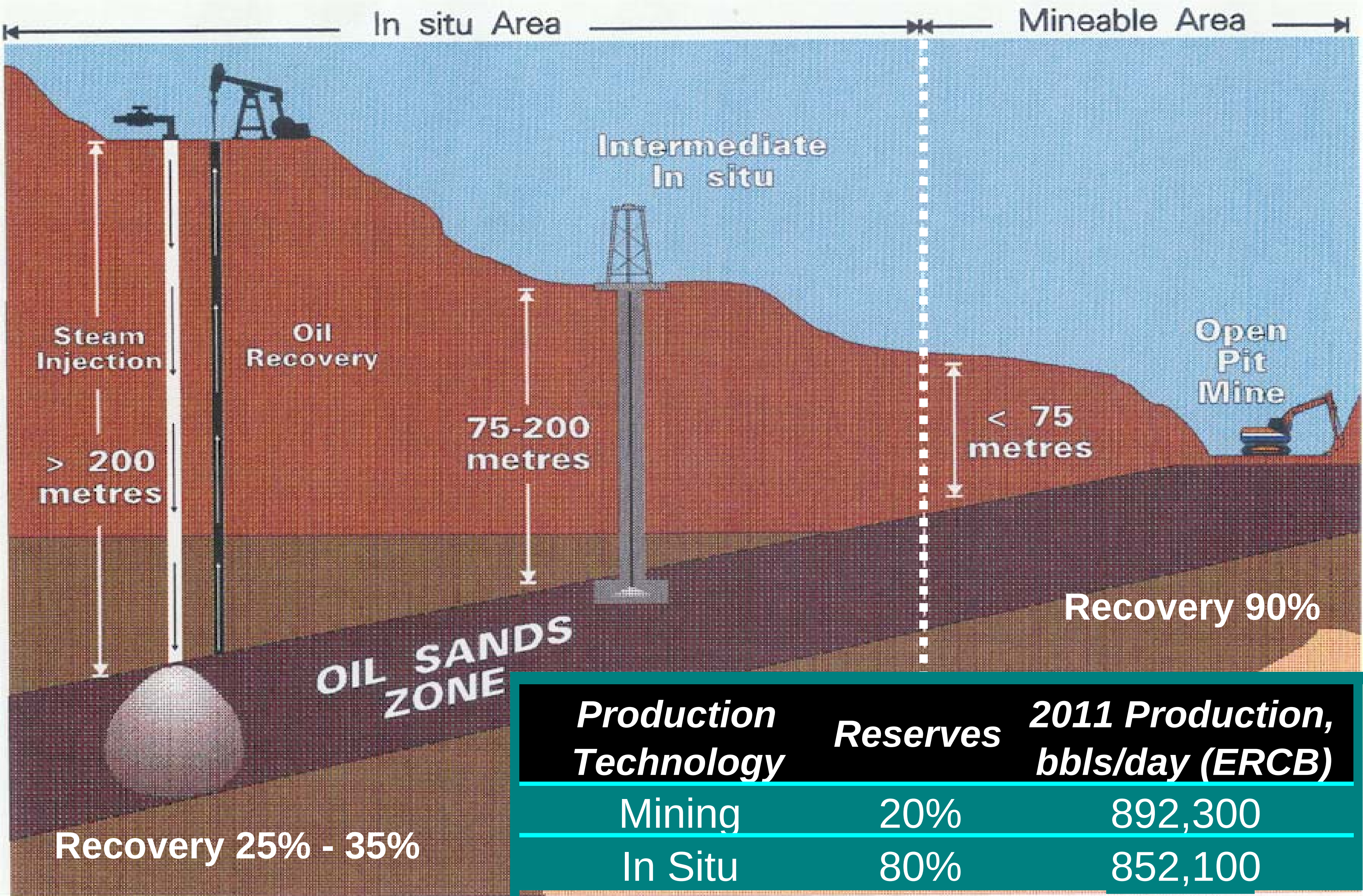
(low viscosity, low Sulfur, low V, Ni, N, O)

Oil Sands (Bitumen) Deposits in Alberta



- Alberta land area: 661,185 sq. km
- Boreal forest area: 381,000 sq.km
- Oil Sands deposits area: 142,200 sq. km (Florida has 149,000 sq.km)
- Mineable oil sands area: 4,800 sq. km (approximately 0.7% of Alberta land area located mainly north of Fort McMurray); PEI is 5,660 sq.km
- Active oil sands mining area: 715 sq. km (with 63 sq. km reclaimed or under active reclamation) including 170 sq. km of tailings ponds (0.03% of Alberta land area)

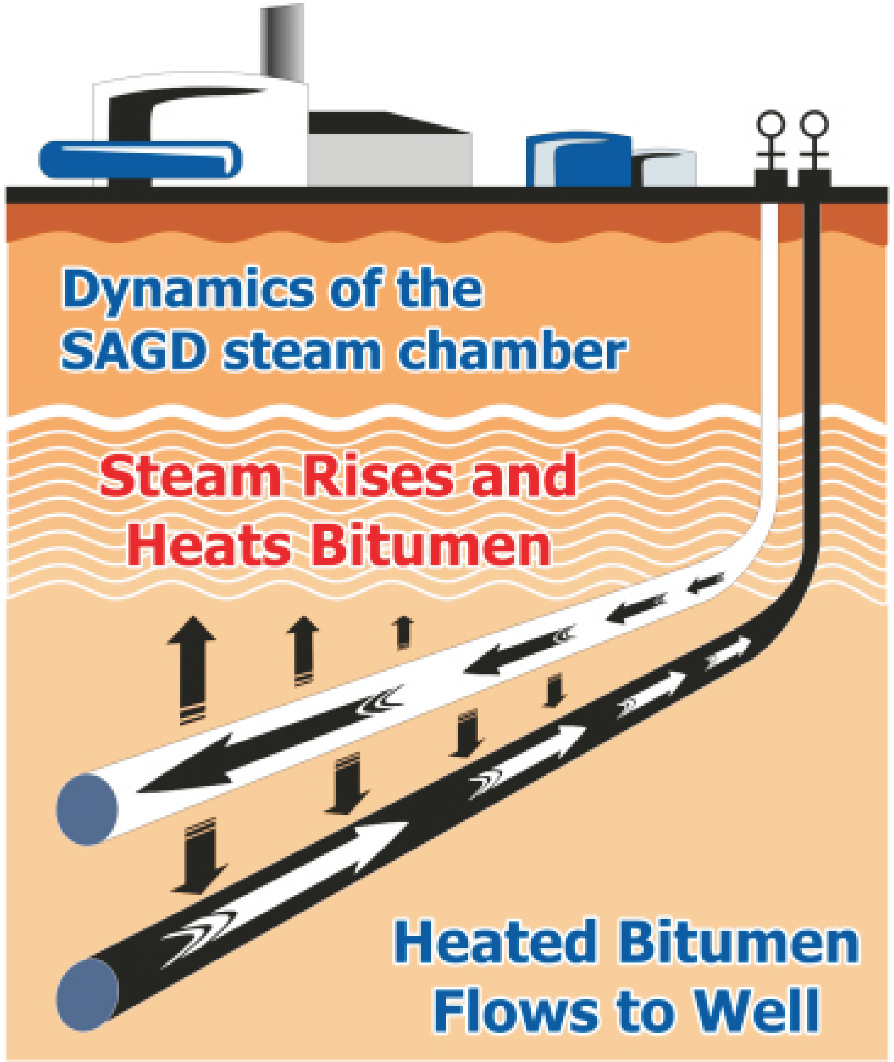
The Nature of the Oil Sands Resource



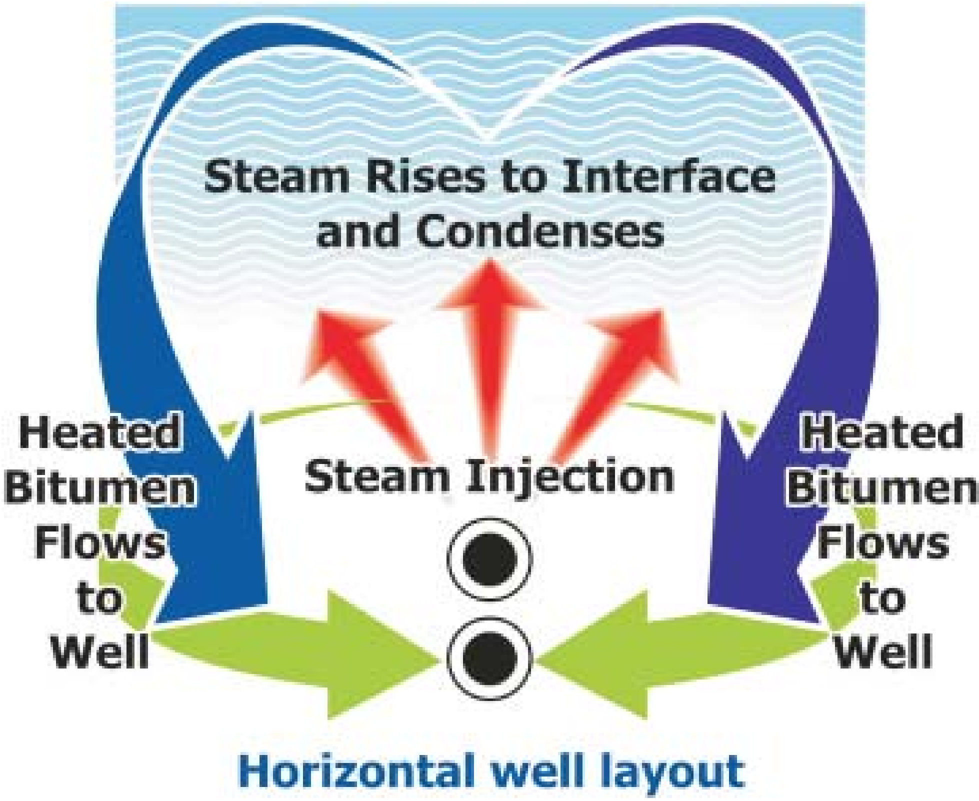
Production Technology	Reserves	2011 Production, bbls/day (ERCB)
Mining	20%	892,300
In Situ	80%	852,100

Steam Assisted Gravity Drainage (SAGD)

Courtesy Husky Energy



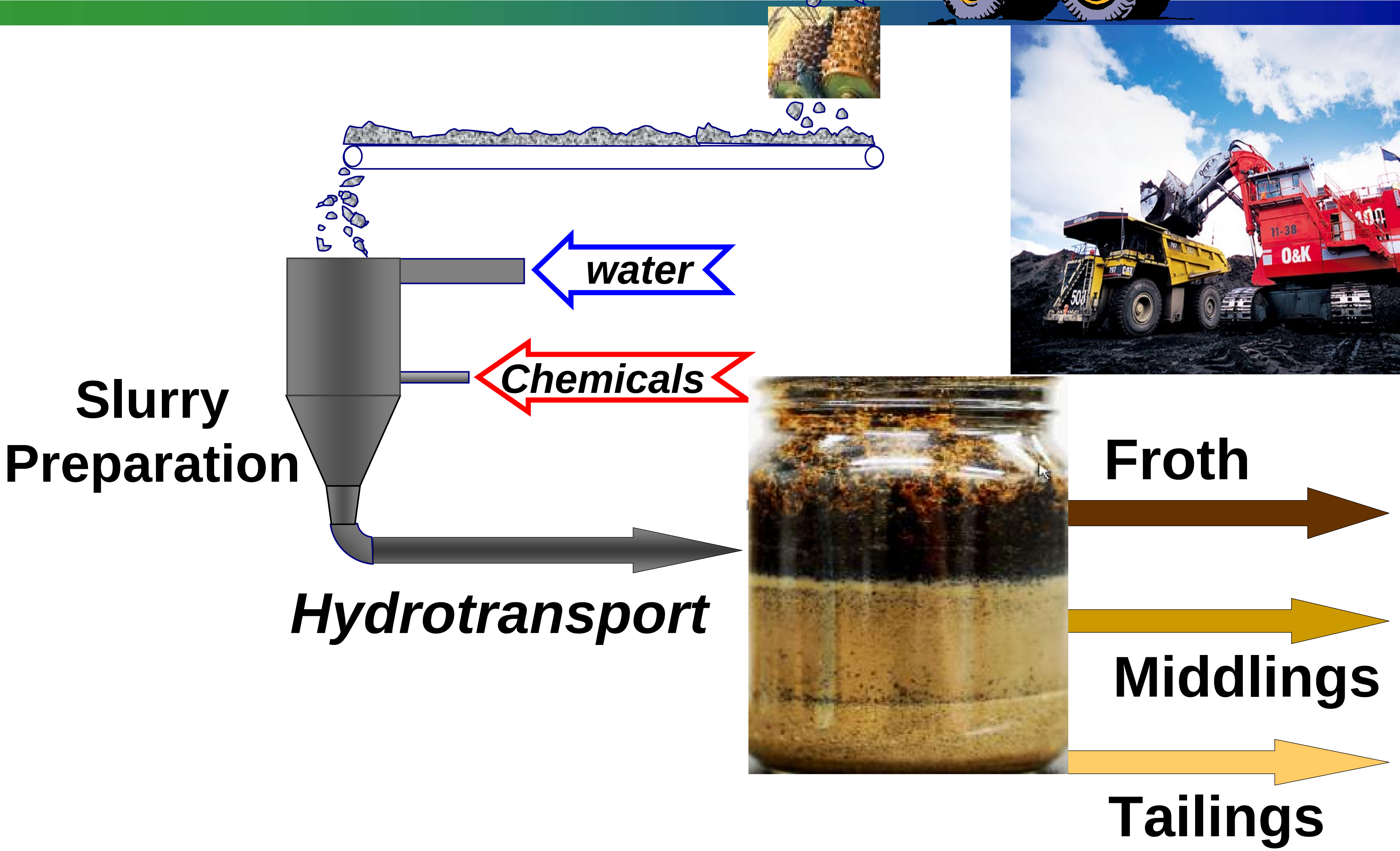
Recovery 30% to 60%



In Situ Recovery of Bitumen

Land disturbance footprint for in situ bitumen recovery is significant when multiplied by thousands, eventually tens of thousands, of such facilities – for example, over 10,000 in situ bitumen and 100,000 conventional wells producing in AB

Mining and Extraction



Courtesy of Michael MacKinnon, Syncrude Canada


Suncor
Syncrude Tailings Ponds
And Mines

Oil Sands Impact on the Land

- Mineable oil sands will disturb a maximum of 4,800 sq.km. (but not all at one time due to progressive reclamation occurring) – this is **<u>not</u>** the size of Florida (149,000 sq.km.), or New York State (128,000 sq.km.), or England (130,000 sq.km.)
- In situ oil sands recovery will disturb more land (perhaps 15,000 sq.km.) than mineable recovery but it will be spread over a much larger area of land
- Oil sands development will **<u>not</u>** cut down Alberta's boreal forest (381,000 sq.km. out of Canada's 3.2 million sq.km. of boreal forest)
- All oil sands areas disturbed by mining or in situ recovery must <u>eventually</u> be reclaimed (how long?)

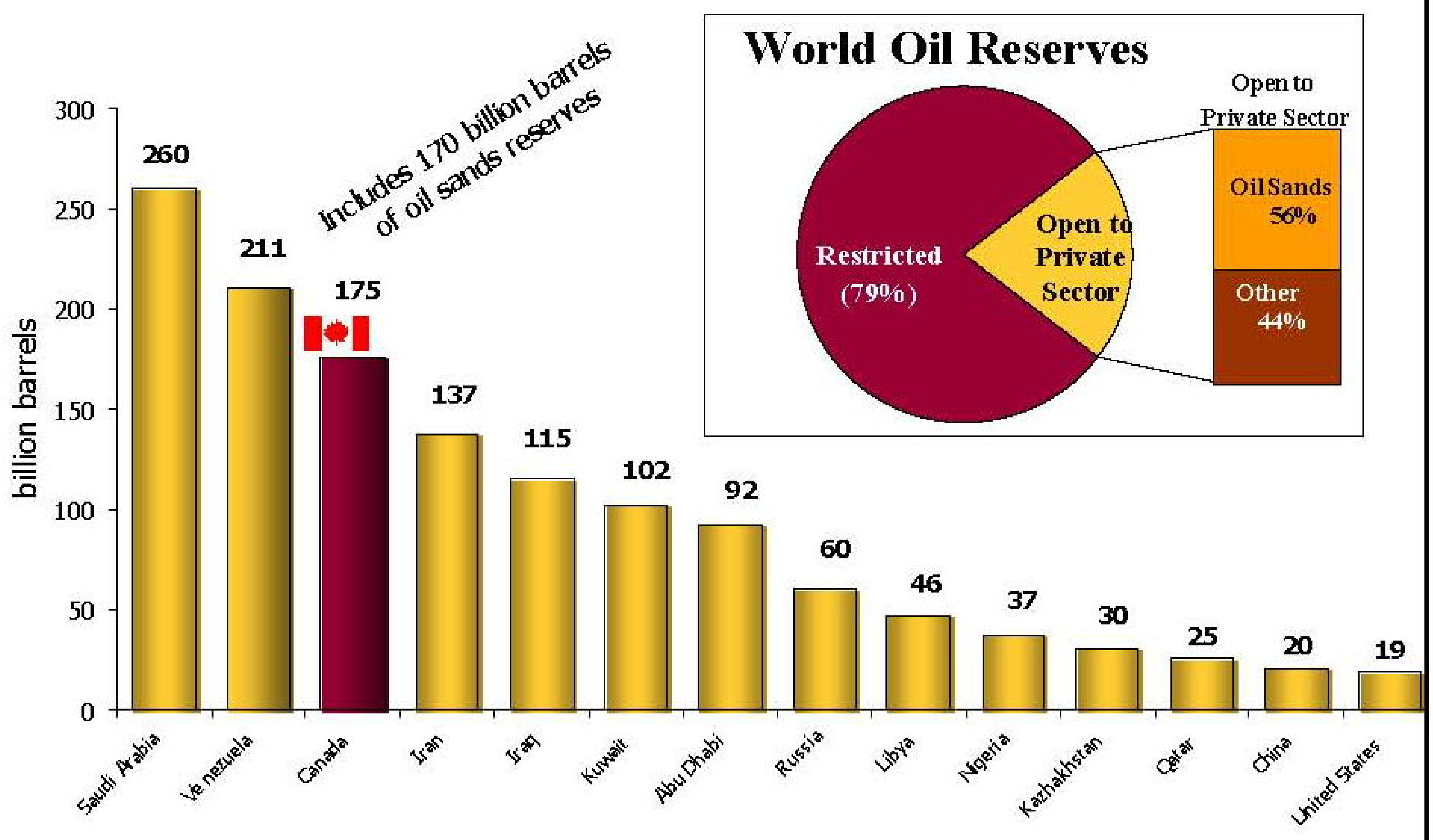
Size &Types of Oil Sands Deposits

- 1,840 billion barrels of bitumen resource
- 169 billion barrels recoverable with existing technology, 20% mining, 80% in situ
- 315 billion barrels ultimately recoverable

Not yet commercial:

- 5% of the resource is too deep to mine, but too shallow for current in situ methods
- 25% of the resource is in thin layers
- 27% of the resource is in carbonates

Country Ranking by Size of Oil Reserves



Source: Oil & Gas Journal Dec. 2010

Courtesy Canadian Association of Petroleum Producers

Oil Sands Production Capacity

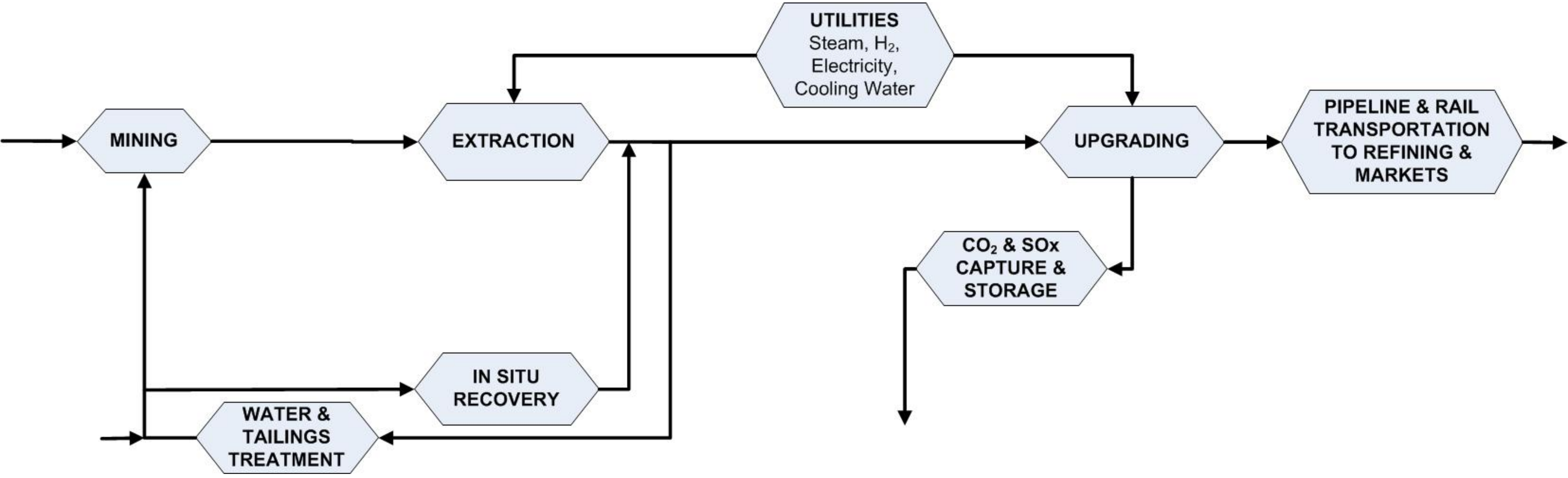
Current and projected oil sands projects (bbl/day)

Status	Mining	In-situ	Total
Operating (2013)	1,127,000	1,055,000	2,182,000
2014-21 (ERCB)	526,000	988,000	1,514,000
Sub-Total (2021)	**1,653,000**	**2,043,000**	**3,696,000**
2021-40 Potential	1,647,000	3,157,000	4,804,000
Total (bbls/day)	**3,300,000**	**5,200,000**	**8,500,000**

8.5 million bbls/day could be produced for > 50 yrs (but not all of these projects will necessarily be developed)

Summary of Project Production Capacities from Oil Sands Developers Group and ERCB

Oil Sands Process Flow Diagram



Oil Sands Mining Tailings Ponds

- Approximately 1 to 1.5 barrels of Mature Fine Tailings (MFT) are produced for each barrel of oil
- MFT – 15% solids (mainly fine clay) by volume, or 30% by mass – not weight bearing, holds water, settles only very slowly, if at all
- Volume of MFT has been increasing with production (time)
- 170 sq. km tailings ponds (storing MFT)
- 80% to 95% of tailings pond water is reused (recycled), but MFT accumulates

Adding Polymer to Fine Tailings

(such as polyacrylamide that is used in water treatment)

No polymer:

Slow solids settling

Clear water

With polymer:

Fast solids settling

Compact sediment

Courtesy: Jacob Masliyah

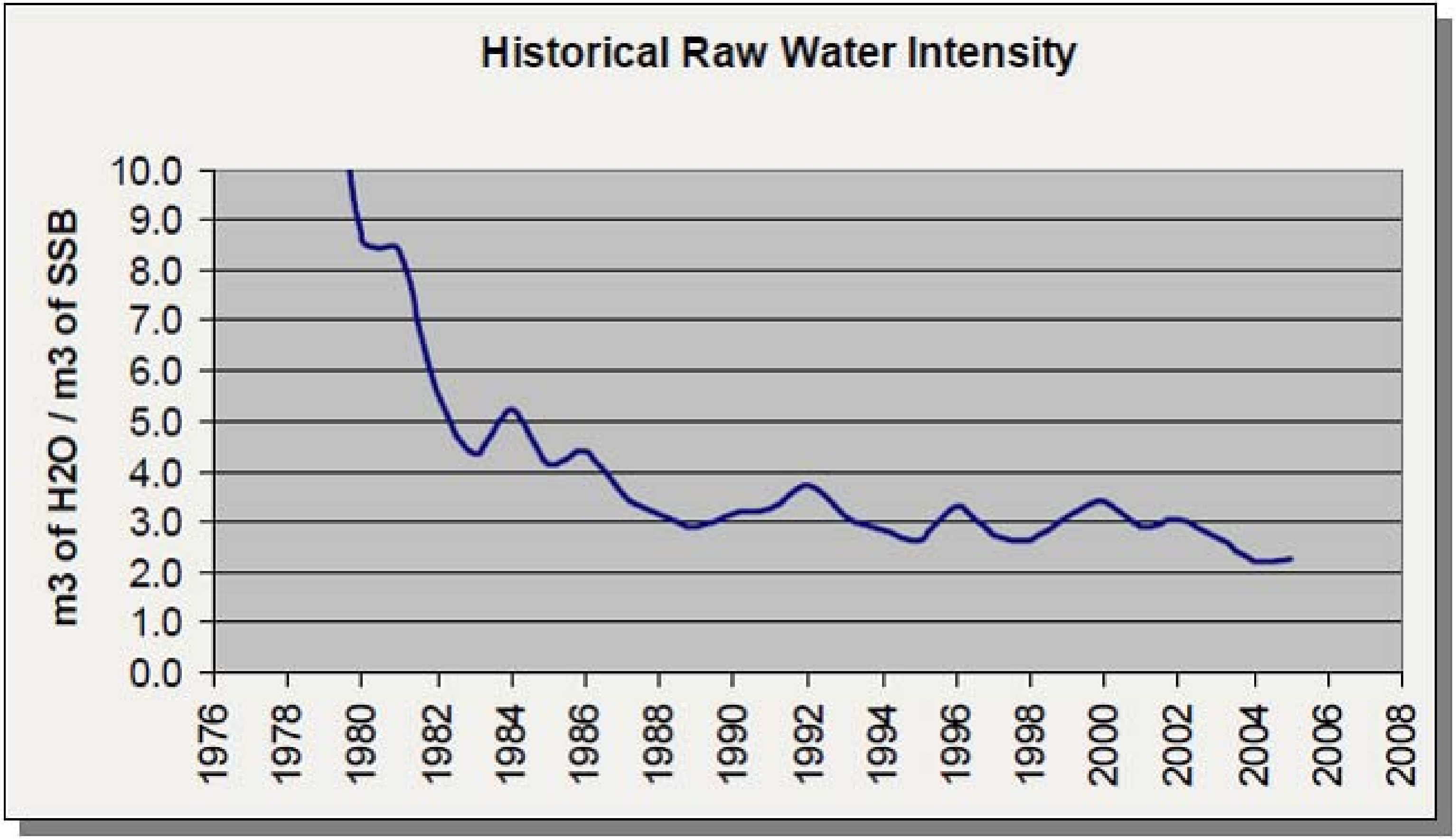
Stabilizing/Reducing Tailings Ponds

- Paste and "beach" (Suncor TRO, Shell) technologies (flocculants/polymers added to bind to clay)
- Consolidated tailings technologies: mix MFT with coarse sand and gypsum, or add CO_2 to tailings
- Centrifugation (also with polymer addition)
- Water capping over MFT in end-pit lakes
- Freeze-thaw evaporative drying
- Significant progress, drawbacks for all technologies
- Energy Resources Conservation Board (ERCB) Directive 74 – stabilizes the amount of fluid tailings by 2013 – existing tailings ponds will stop growing in size by 2016, but some new ponds for new projects

Stabilizing/Reducing Tailings Ponds

- **Myth**: No, or little, oil sands area has been reclaimed
- 73 sq. km of 715 sq. km of mineable oil sands disturbed area has been reclaimed or is undergoing active reclamation – mainly mined areas, but reclamation certificate issued for only 1.0 sq.km.
- Obtaining the reclamation certificate means that control/use of land is returned to the public – no access by company – this is a problem if reclaimed area is in the middle of an active development area
- First tailings pond at Suncor has been reclaimed in 2010 (but the MFT was moved to another pond awaiting dewatering/consolidation treatment)
- All surface mines (not just oil sands) usually have a tailings pond which enables water re-use to occur and reduces the need for use of fresh water

Mining Oil Sands Water Use

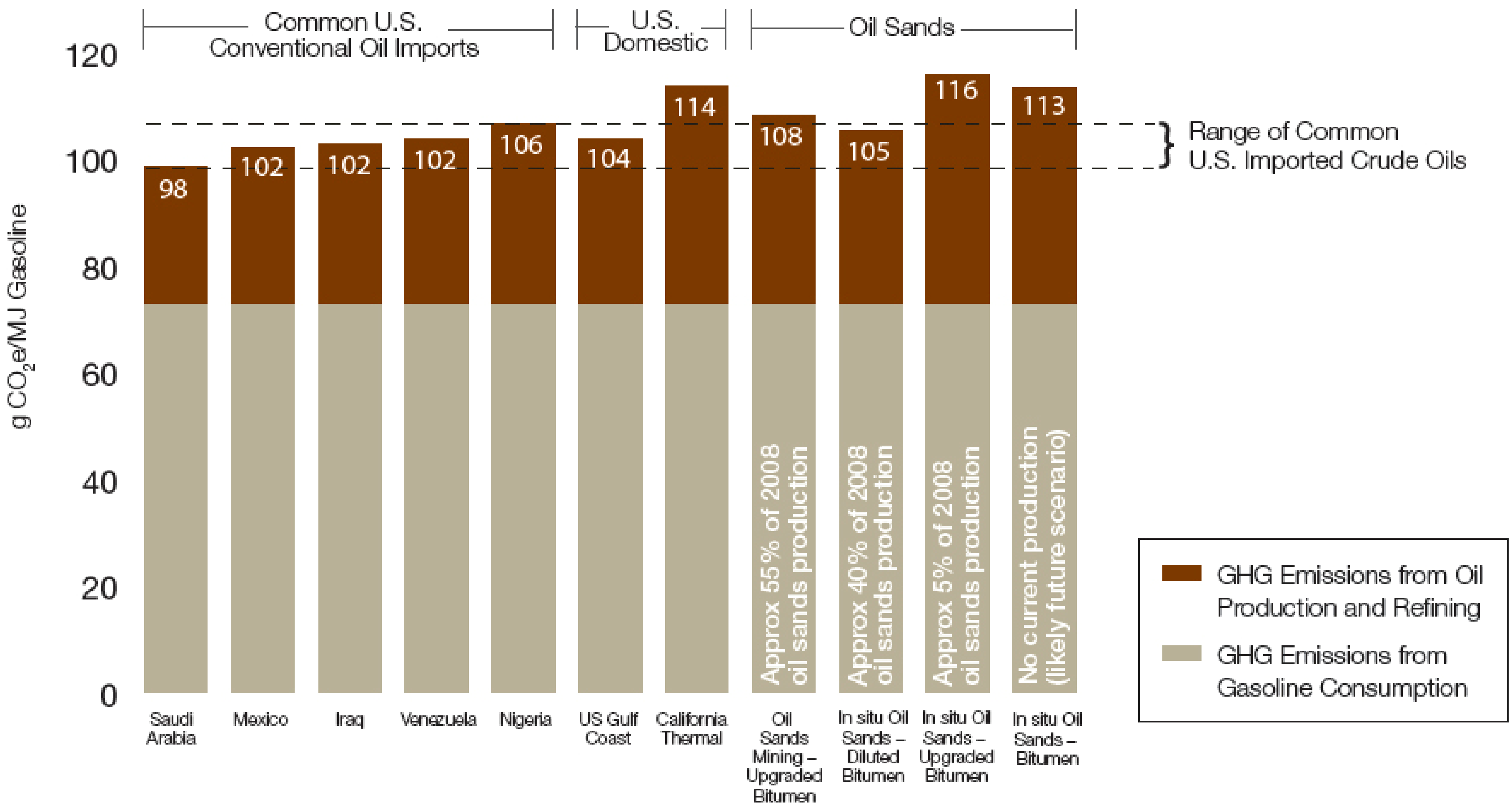


Compiled from Sustainability and Annual Reports data for Syncrude Sweet Blend Production

Water Use by Oil Sands

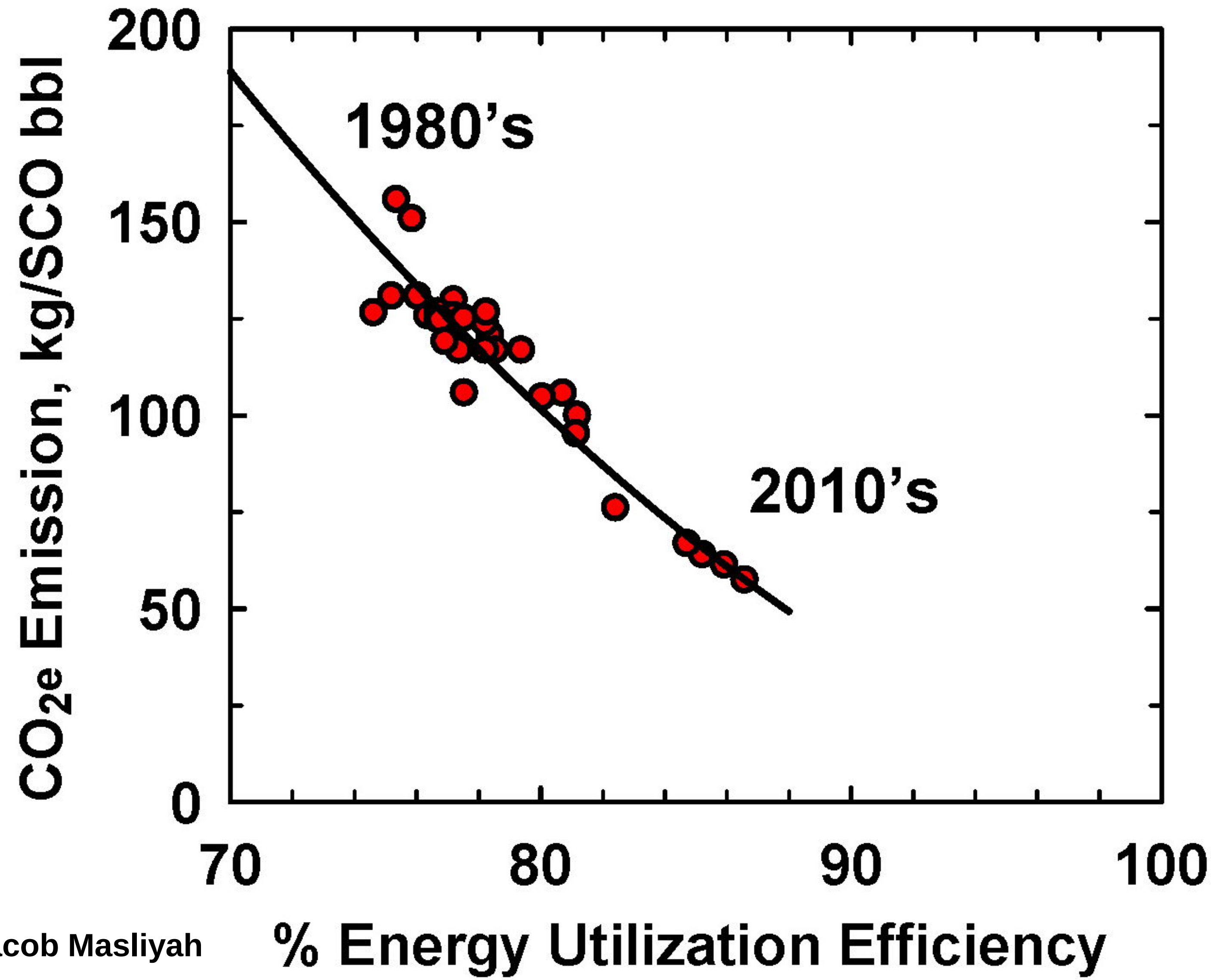
- Alberta surface and ground water allocations (2010):
  - 7% oil sands (Athabasca River for 5 mining ops., 122 distributed locations for in situ recovery (2013))
  - 2.5% balance of energy industry
  - 44% agriculture
  - 29% commercial
  - 16.5% municipal and other uses
  - note only 35% of all allocations are actually used
- In winter during low flow conditions, Athabasca River water use for mineable oil sands is capped at 5% of low flow (some other rivers are 100% allocated, but full allocations are not actually used)

Life Cycle (Well to Wheels) GHG Emissions ("Dirty Oil" vs. Role of Consumers?)



Source: Jacobs Consultancy, Life Cycle Assessment Comparison for North American and Imported Crudes, June 2009

GHG Emissions (Mining & Upgrading)



Courtesy: Jacob Masliyah

Oil Sands GHG Emissions

- Mineable oil sands GHG production per barrel has decreased by approximately 40% to 50% (or more) since the 1980s, but it may now be increasing on a per barrel basis due to in situ.
- Oil sands total GHG production has tripled but with a six-fold production increase since 1980s
- On a full life cycle basis, oil sands result in 5% to 15% higher GHG emissions relative to typical crude oils

GHG (CO_2 equiv.) Emissions 1990-2010

GHG (CO_2 equiv.) Emissions, Megatonnes/yr

Year	Canada	Electricity	Alberta	Oil Sands	kgGHG/BBL
2010	692	99	233	48	82
2009	690	98	232	45	83
2008	731	116	244	37.2	78
2007	751	122	247	37	77
2006	726	115	235	32.5	71
2005	740	123	231	29.5	76
2004	751	123	234	31.5	79
1990	589	92	166	17	114

Major effect on GHG in 2009 due to recession. Large rapid GHG reduction without effect on economy is likely difficult.

Mineable Oil Sands Industry Collaborations

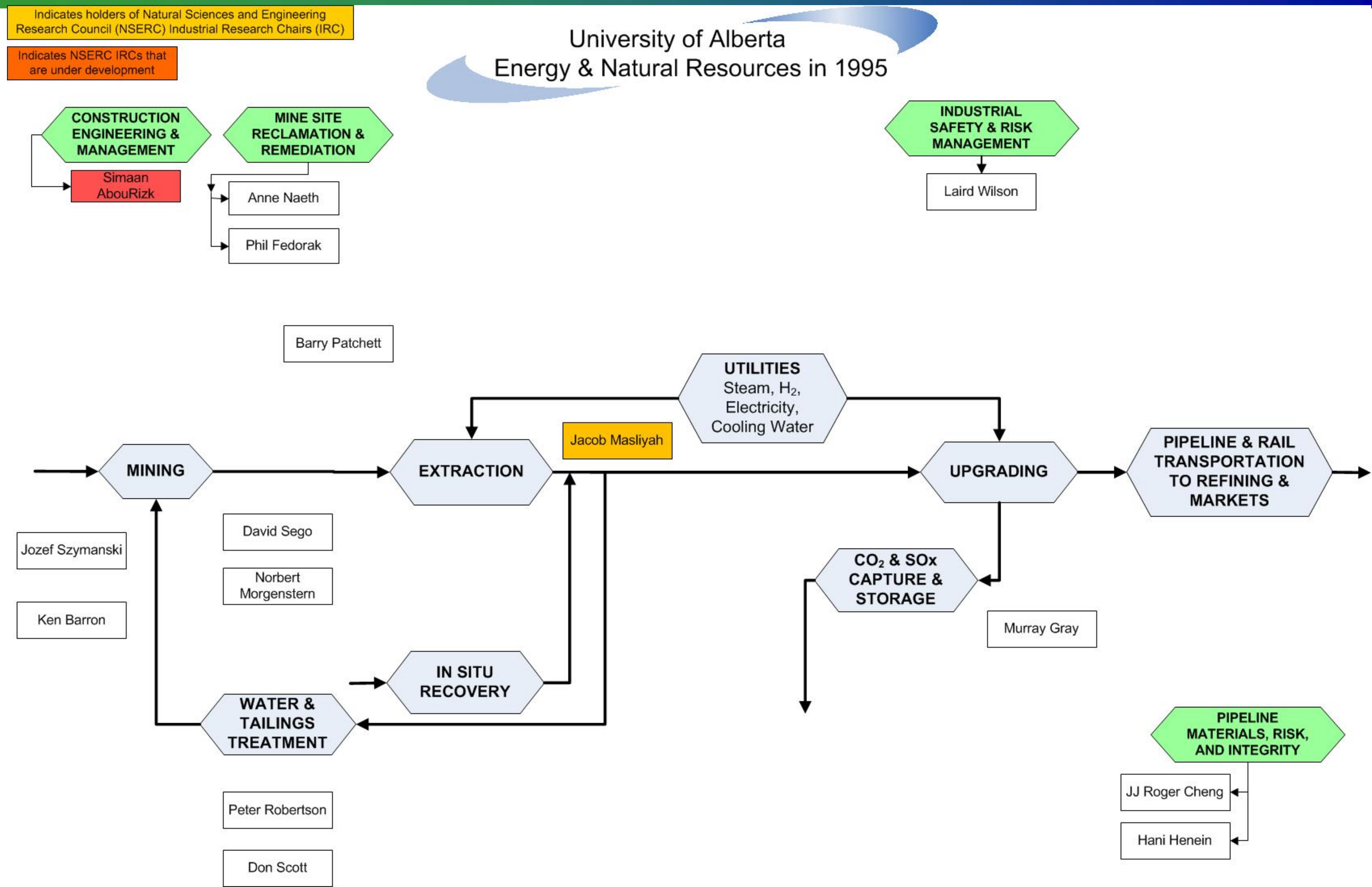
In response to needs expressed by industry, over the past 18 years the University of Alberta has hired faculty and strategically established University-Industry-Government oil sands collaborations focused on:

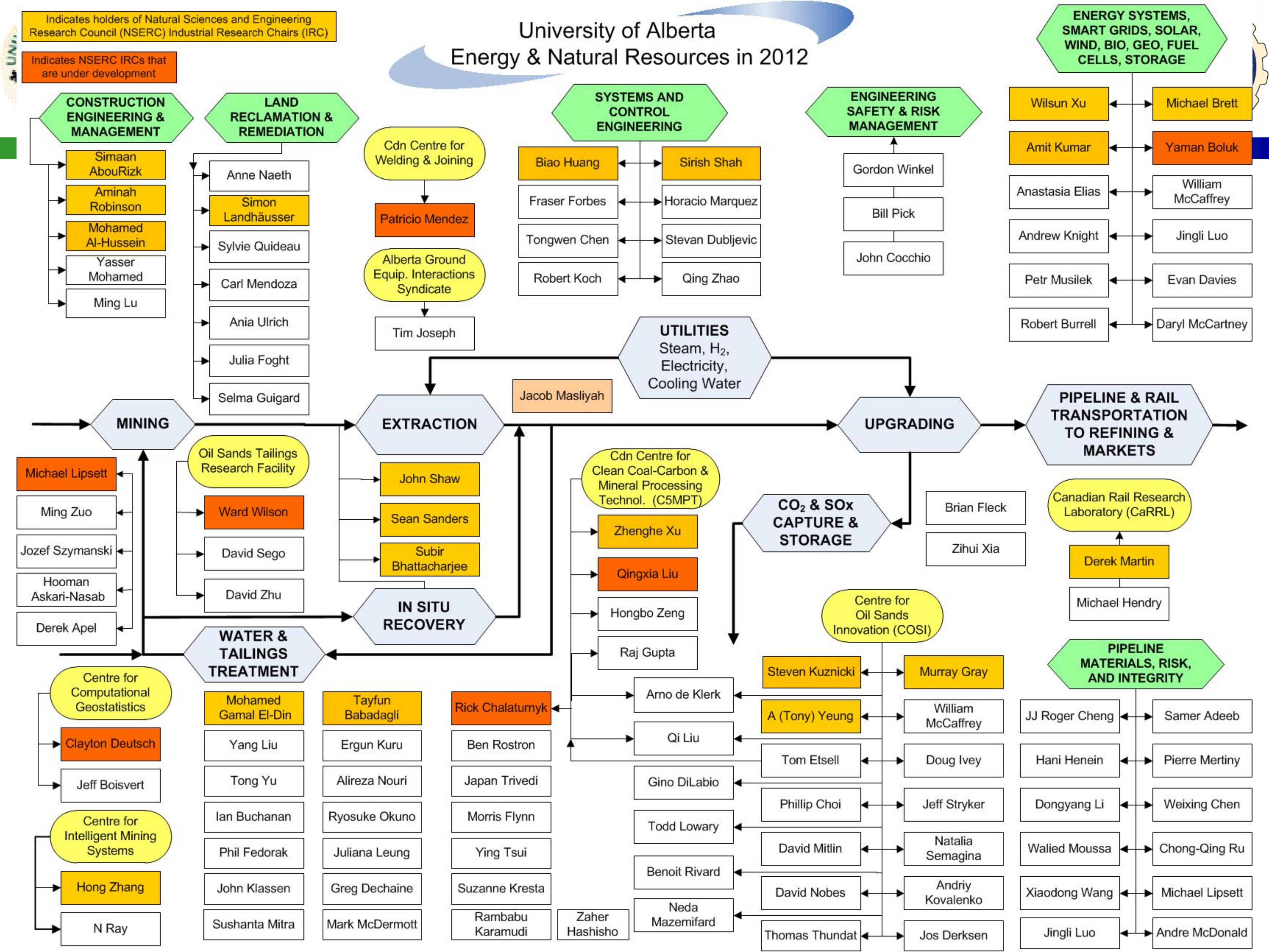
- environmental footprint (efficiency (GHG reduction), air, water, land, CCS, non-aqueous extraction, remediation/reclamation, hydrotransport, etc.)
- extraction/mineral processing
- upgrading processes
- control of operations/processes
- safety and risk management
- construction engineering and management
- welding and joining, and many more topics

In Situ Oil Sands Industry Collaborations

- Focus on major reductions in use of water, increasing recycle of water, use of brackish/ saline water, goal of zero liquid discharge
- Water purification and treatment technologies
- Use of mining tailings pond water for SAGD
- Combined use of solvents and steam
- Caprock integrity issues/risk for high pressure underground steam chamber explosive release
- In situ combustion approaches
- Electrical heating of bitumen deposits (both for deposits in sand and in carbonates)

Oilsands Research at U. Alberta in 1995





University of Alberta
Energy & Natural Resources in 2012
Indicates holders of Natural Sciences and Engineering Research Council (NSERC) Industrial Research Chairs (IRC)
Indicates NSERC IRCs that are under development
CONSTRUCTION ENGINEERING & MANAGEMENT
Simaan AbouRizk
Aminah Robinson
Mohamed Al-Hussein
Yasser Mohamed
Ming Lu
LAND RECLAMATION & REMEDIATION
Anne Naeth
Simon Landhäusser
Sylvie Quideau
Carl Mendoza
Ania Ulrich
Julia Foght
Selma Guigard
Cdn Centre for Welding & Joining
Patricio Mendez
Alberta Ground Equip. Interactions Syndicate
Tim Joseph
SYSTEMS AND CONTROL ENGINEERING
Biao Huang
Sirish Shah
Fraser Forbes
Horacio Marquez
Tongwen Chen
Stevan Dubljevic
Robert Koch
Qing Zhao
ENGINEERING SAFETY & RISK MANAGEMENT
Gordon Winkel
Bill Pick
John Cocchio
ENERGY SYSTEMS, SMART GRIDS, SOLAR, WIND, BIO, GEO, FUEL CELLS, STORAGE
Wilsun Xu
Michael Brett
Amit Kumar
Yaman Boluk
Anastasia Elias
William McCaffrey
Andrew Knight
Jingli Luo
Petr Musilek
Evan Davies
Robert Burrell
Daryl McCartney
UTILITIES
Steam, H_2, Electricity, Cooling Water
Jacob Masliyah
MINING
EXTRACTION
UPGRADING
PIPELINE & RAIL TRANSPORTATION TO REFINING & MARKETS
Michael Lipsett
Ming Zuo
Jozef Szymanski
Hooman Askari-Nasab
Derek Apel
Oil Sands Tailings Research Facility
Ward Wilson
David Sego
David Zhu
John Shaw
Sean Sanders
Subir Bhattacharjee
IN SITU RECOVERY
WATER & TAILINGS TREATMENT
Cdn Centre for Clean Coal-Carbon & Mineral Processing Technol. (C5MPT)
Zhenghe Xu
Qingxia Liu
Hongbo Zeng
Raj Gupta
CO_2 & SOx CAPTURE & STORAGE
Brian Fleck
Zihui Xia
Canadian Rail Research Laboratory (CaRRL)
Derek Martin
Michael Hendry
Centre for Oil Sands Innovation (COSI)
Steven Kuznicki
Murray Gray
Arno de Klerk
A (Tony) Yeung
William McCaffrey
Qi Liu
Tom Etsell
Doug Ivey
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Phillip Choi
Jeff Stryker
Todd Lowary
David Mitlin
Natalia Semagina
Benoit Rivard
David Nobes
Andriy Kovalenko
Neda Mazemifard
Thomas Thundat
Jos Derksen
PIPELINE MATERIALS, RISK, AND INTEGRITY
JJ Roger Cheng
Samer Adeeb
Hani Henein
Pierre Mertiny
Dongyang Li
Weixing Chen
Walied Moussa
Chong-Qing Ru
Xiaodong Wang
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Ryosuke Okuno
Juliana Leung
Greg Dechaine
Mark McDermott
Rick Chalaturnyk
Ben Rostron
Japan Trivedi
Morris Flynn
Ying Tsui
Suzanne Kresta
Rambabu Karamudi
Zaher Hashisho

Invention, Innovation, Industry Cycle

- Long time lines for industrial implementation
- Mineable oil sands
  - 1920 hiring of Dr. Karl Clark by University of Alberta
  - 1921 creation of the Alberta Research Council at UofA
  - 1920s to 1950s Clark Hot Water Process development
  - 1967 first major commercial facility (GCOS/Suncor)
  - 1978 (Syncrude), 2003 (Shell/Albian), 2009 (CNRL), 2013 (Imperial Oil/Exxon)
- In situ SAGD technology
  - 1969 Imperial Oil (Dr. Roger Butler)
  - 1974 to mid-1990s AOSTRA Underground test facility
  - 2001 SAGD commercially applied (now Cenovus)

Oil Sands R&D and Innovation

- Reduce the impact on land, air and water by mineable and in situ oil sands production
- Reduce impact on people, flora, and fauna such as caribou
- Improve efficiency of existing processes
- Develop new breakthrough technologies (e.g., non-aqueous extraction)
- Over 1,000 researchers at the University of Alberta, mainly in the Faculty of Engineering, are working on oil sands issues, most in collaboration with industry and government

Related and/or New/Other Issues

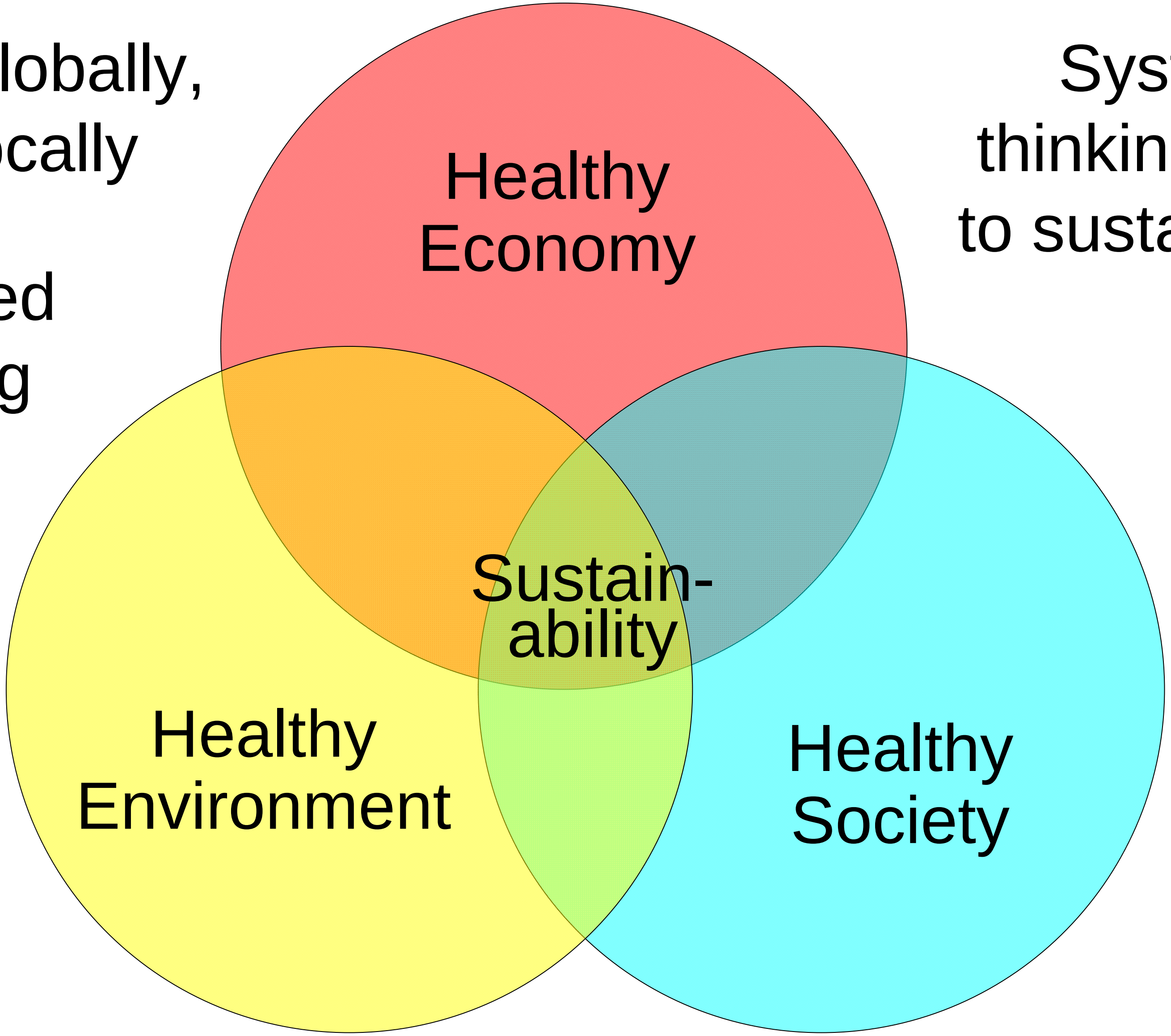
- Impact of SAGD operations on caribou
- Access to markets: pipelines and/or rail
  - Keystone XL to Texas – TransCanada
  - Northern Gateway to Kitimat, BC – Enbridge
  - TransMountain Vancouver/Kitimat – Kinder Morgan
  - Line 9 reversal (Sarnia to Montreal) – Enbridge
  - TransCanada Mainline Gas to Oil Conversion
  - Norman Wells to Whitehorse Pipeline
- Nuclear energy for oil sands? Geothermal?
- Shale gas, shale oil, horizontal wells with hydraulic fracturing, and water issues

Sustainability

Think globally,
act locally

Integrated
planning

Systems
thinking is key
to sustainability



Acknowledgements

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  - Government of Alberta
  - Drs. Murray Gray, Eddy Isaacs, Jacob Masliyah
  - Canadian Association of Petroleum Producers
  - Energy Resources Conservation Board
  - Natural Resources Canada