Should Alberta's Oil Sands Bitumen be Upgraded?

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Life Cycle Assessment

- Method to track environmental impact of a product or process
- Examines the product's entire lifecycle – from "cradle" to "grave"
- Quantifies impacts via material & energy balances
- LCA can be used to:
  - Decide which product is more "environmentally friendly"
  - Identify areas of improvement for a product's environmental impact
  - Inform policy decisions (becoming more frequent)

Oil Sands Production Pathways: SCO Option

in situ Extraction

Upgrading

SCO

Pipeline Transport

Refining

Photos 1,2, and 4 courtesy of Suncor Energy

Oil Sands Production Pathways: Dilbit Option

in situ Extraction

Dilution

Dilbit

Pipeline Transport

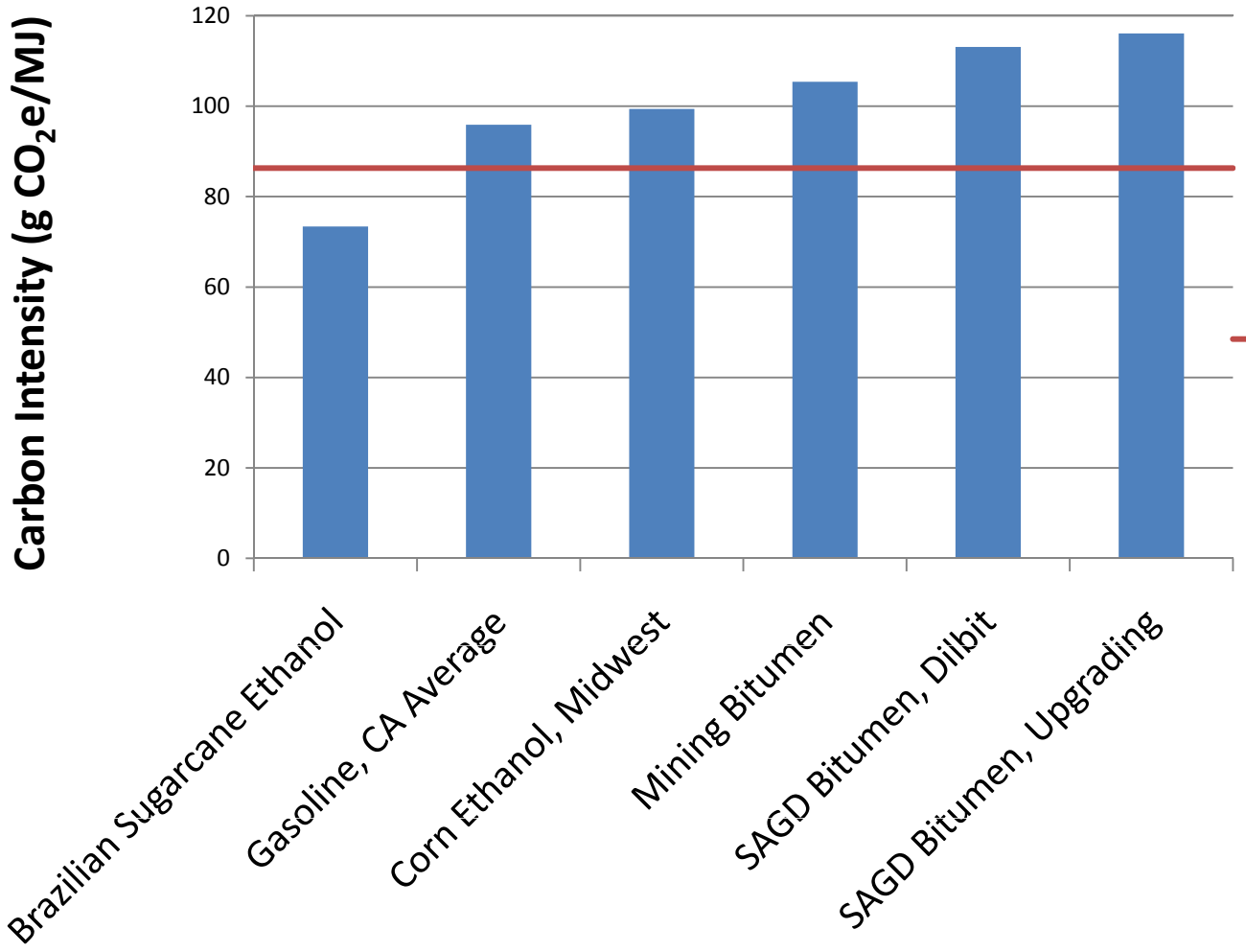
Refining

Photos 1 and 4 courtesy of Suncor Energy

North American Environmental Policies

Policy	**Jurisdiction**	**Impacts…**
Specified Gas Emitters Regulation	Alberta; implemented 2007	Large-emitting energy producers
Low Carbon Fuel Standard (LCFS)	-Implemented in CA, BC, ON -Under consideration by New England states	Fuel producers
Carbon Tariff	Minnesota; takes effect in 2012	Coal-fired electricity producers
American Power Act	Introduced May 2010 in U.S. Senate	Potentially all energy producers

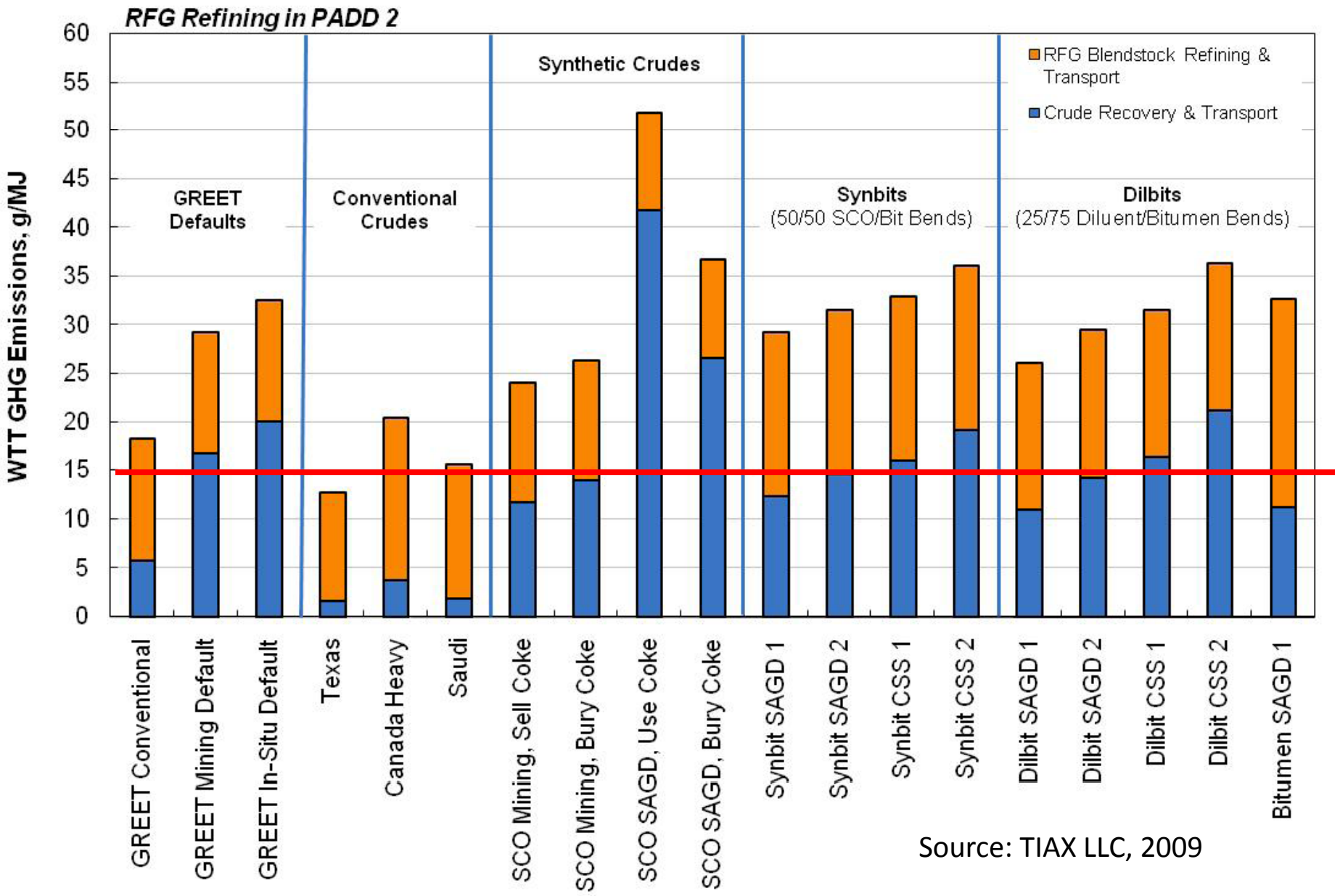
Comparison of Fuel Carbon Intensities



Source: California Air Resources Board

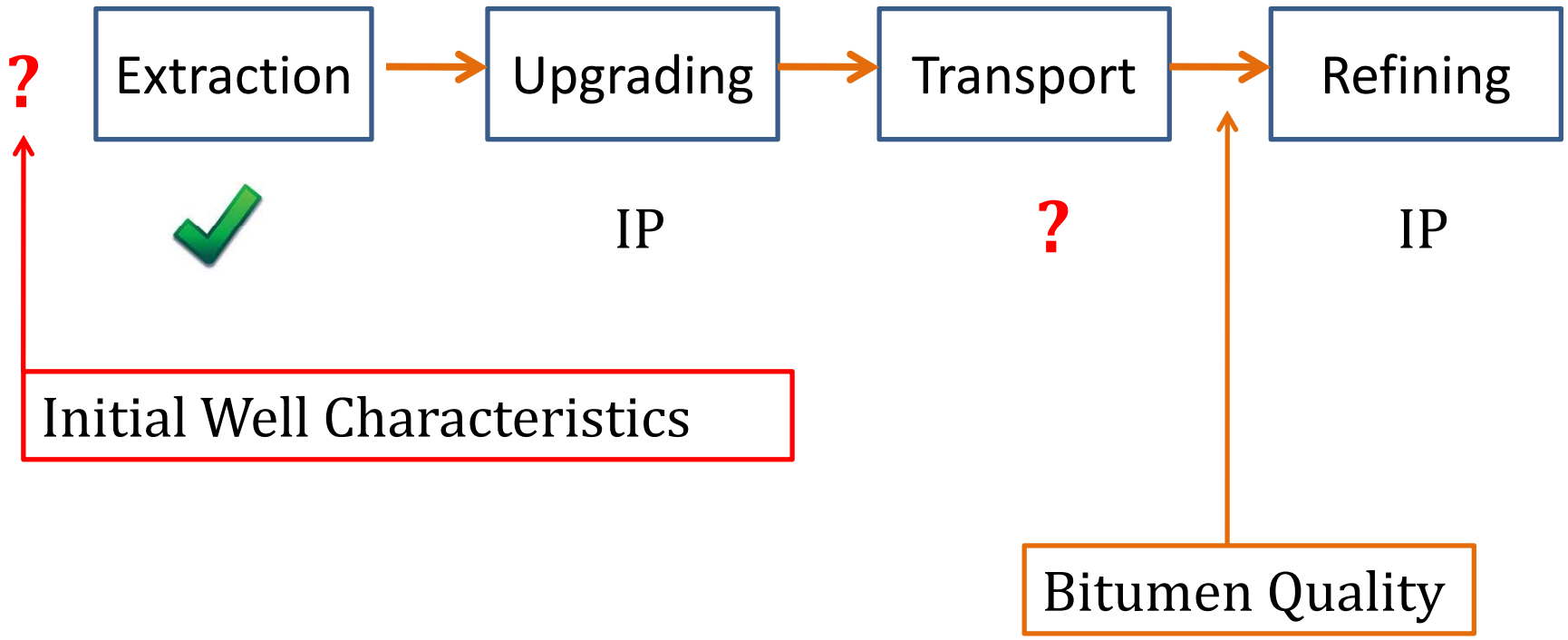
Threshold to be assigned baseline crude CI:

Extraction to Transportation Emissions < 15 g/MJ



Source: TIAX LLC, 2009

Gaps in Oil Sands LCA Research



Canadian Oil Pipelines

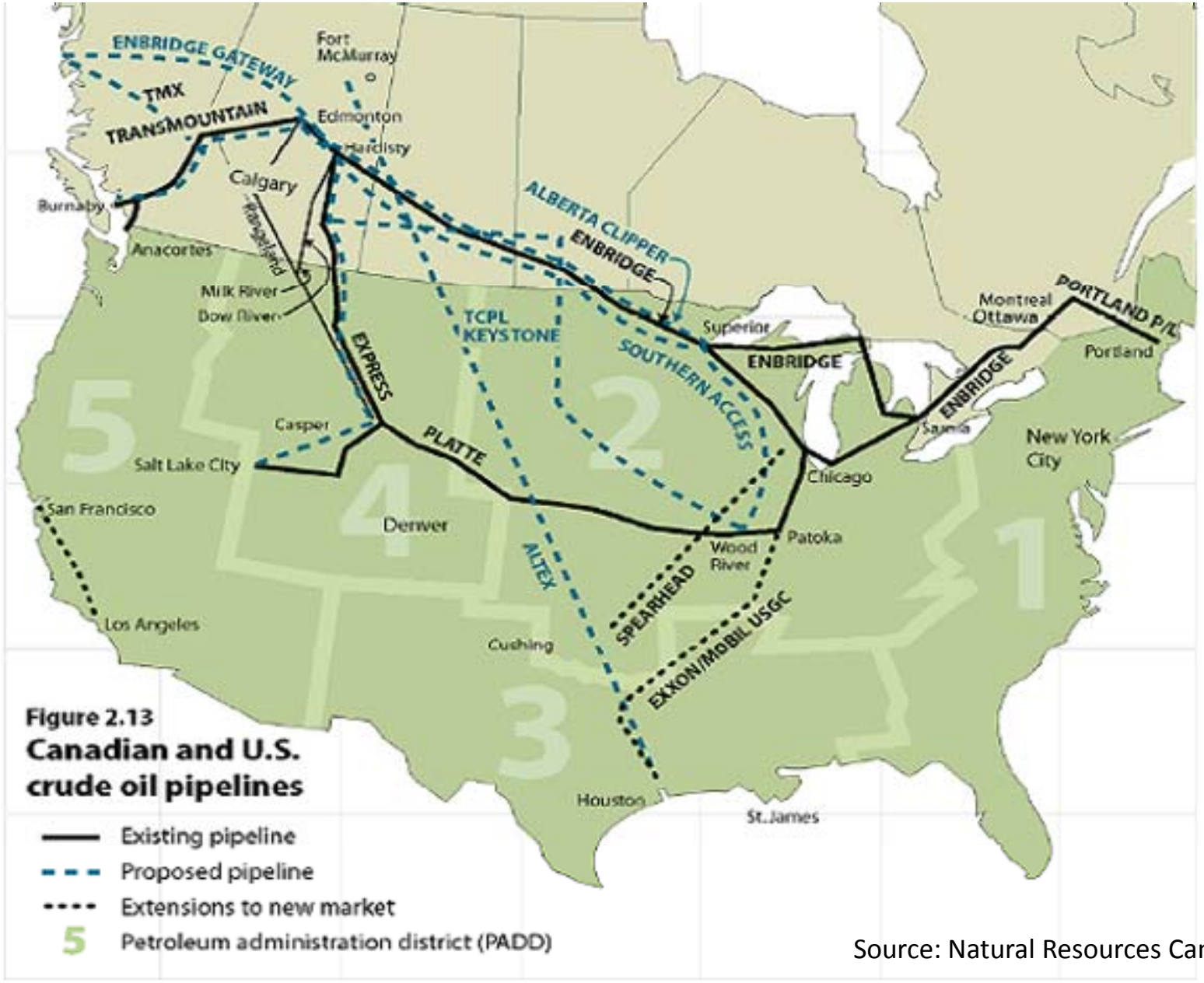
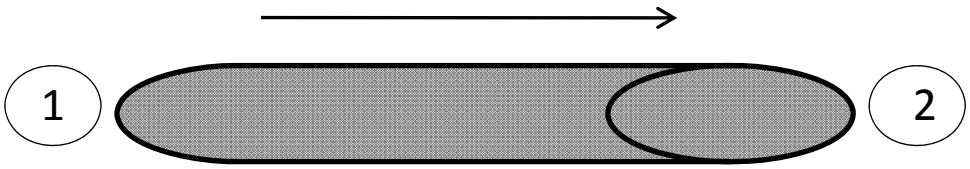


Figure 2.13
Canadian and U.S. crude oil pipelines

- Existing pipeline
- Proposed pipeline
- Extensions to new market
- 5 Petroleum administration district (PADD)

Source: Natural Resources Canada

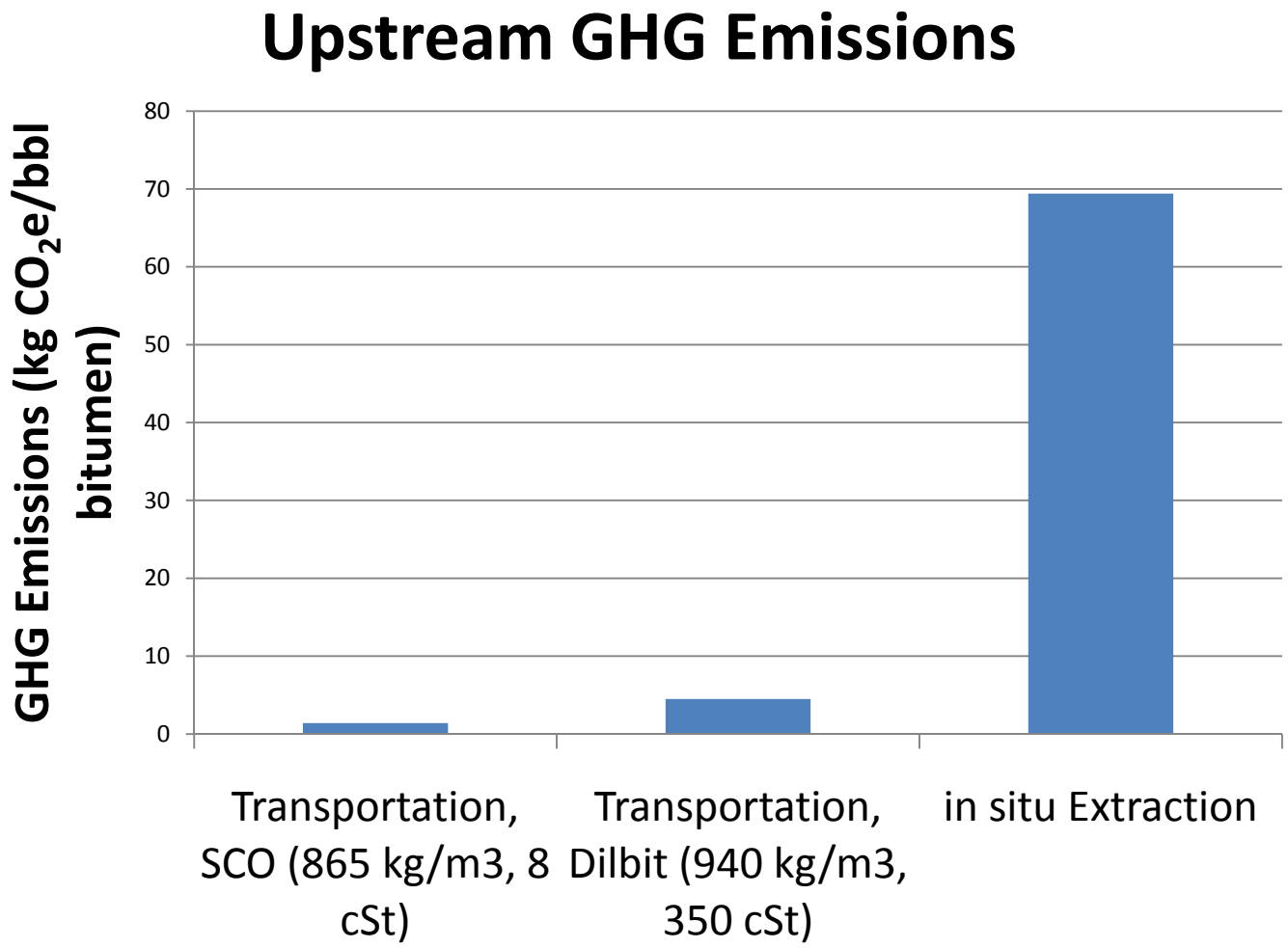
Transportation Modelling: Bernoulli's Equation



$$P_1 - P_2 = \rho g(z_2 - z_1) + \frac{\rho}{2}(v_2^2 - v_1^2) + h_f$$

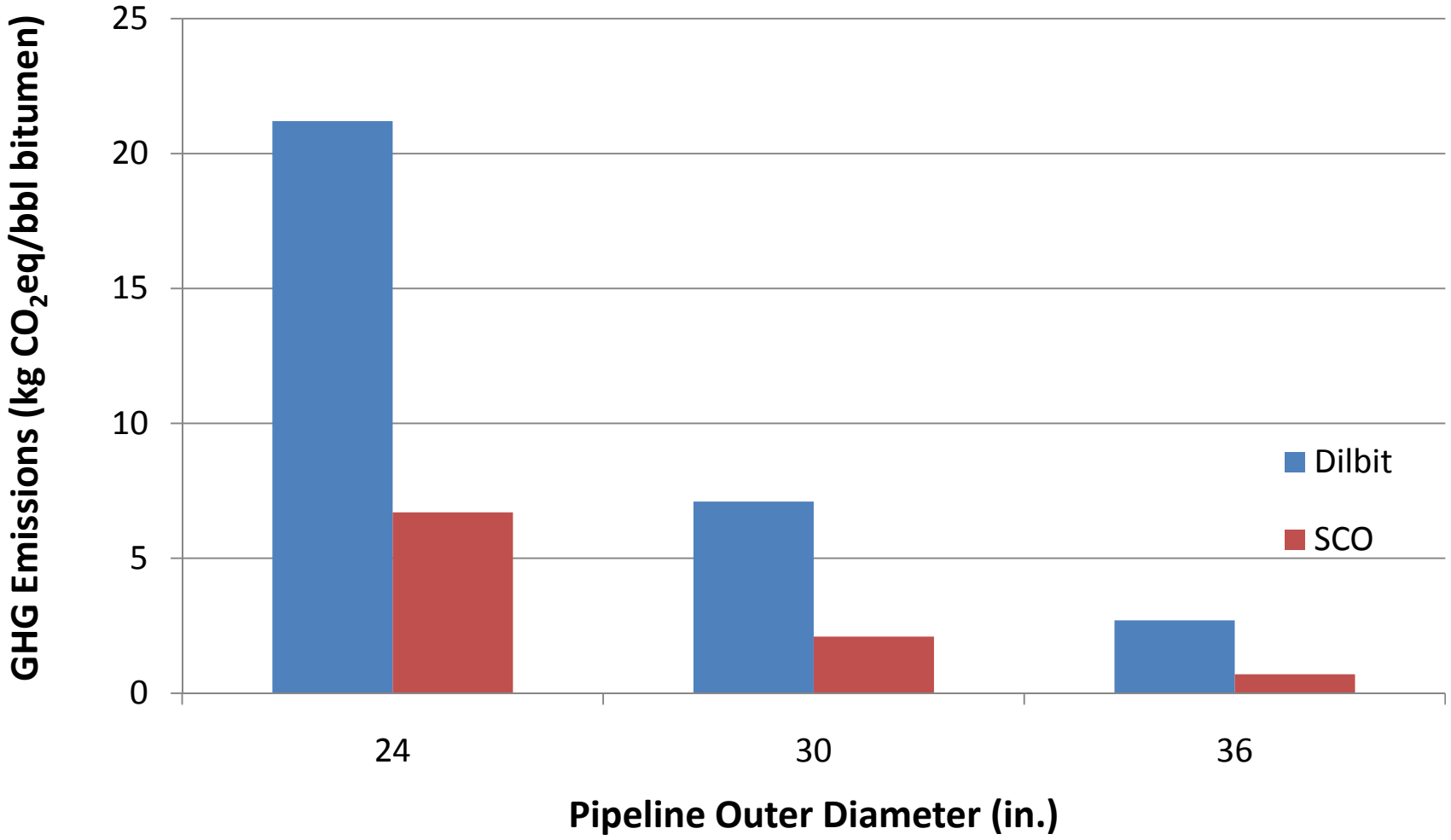
P: Fluid Pressure
ρ: Fluid density
g: Acceleration of gravity
z: Elevation
v: Velocity
h_f: Head loss due to friction

Transportation Stage – Preliminary Results



Note: Reflects transport from Hardisty, AB to Patoka, IL (2950 km)

Estimated GHG Emissions by Pipeline Size



Note: For Schedule 30 pipe; flow rate = 12,700 gallons/minute

Policy Ramifications

- LCFS Conclusions:
  - Deciding not to upgrade may lead to higher emissions in downstream lifecycle stages
  - Transportation stage emissions could partially offset GHG benefit of not upgrading, depending on which pipeline is used
- LCA and Policy Conclusions:
  - Need for oil sands LCA studies that track bitumen quality
  - Policies that target specific stages of life cycle e.g. the LCFS may lead to "re-shuffling" of emissions
  - LCFS could conflict with a U.S. carbon tax on refinery emissions and lead to policy confusion

Future Work

- Model different pipelines
- Track bitumen characteristics that may affect refinery emissions
- Use well characteristics to predict extraction input data
- Incorporate multiple vehicle use options (e.g. hybrids)
- Gather economic data
  - Upgrading capital and operating expenses
  - Forecasted tight diluent markets

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