

## Modelling the costs of non-conventional oil: A case study of Canadian bitumen

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There are growing concerns about whether a petroleum-based economy can be sustained in the coming decades. High crude oil prices, uncertainties about the consequences of climate change and the eventual depletion of conventional oil resources raise the issue of alternative fuels, such as non-conventional oil and biofuels. In particular, bitumen can be extracted and upgraded into synthetic crude oil, a substitute to conventional oil. This paper describes a simple probabilistic model for projecting the cost of producing bitumen, and sketches how this model can be expanded and generalised to project the costs of other alternatives.

The paper aims to express our uncertainty about the future costs of supplying alternative liquid fuels. A model is introduced that draws on the user's degree of belief about a series of parameters as an input: learning, depletion, resources and production parameters are introduced. Learning drives costs down, and depletion drives costs up, as the resources become more difficult to extract.

The model reveals the kind of uncertainties that need to be dealt with when designing policies. The results show large uncertainties on future supply costs of bitumen, with costs falling in the range of \$7 to \$15 per barrel in 2050 (2005 US\$). Learning dominates in the lower percentile curve until 2050, as costs continue to decrease: supply costs fall by around 50% over a 45 year time period. Mean supply costs decrease by 30% over the same period. However, the higher percentile curve shows increasing costs in the second half of the time period due to the depletion effect overtaking the learning effect.

The influence of each parameter on the supply costs is examined. The minimum cost of supplying the resources is the most influential parameter over the whole time period. However, as costs start to increase due to depletion, this parameter becomes less of a constraint on the evolution of the costs of supplying bitumen. Over time, the influence of the learning rate on the supply costs decreases, while the influence of the depletion parameter

increases. The learning effect is gradually overtaken by the depletion effect.

This research ultimately aims to reveal the effects of investments, learning, depletion and production constraints on the costs of supplying alternative fuels. The supply of biofuels and carbon intensive fuels will also be considered in the wider context of the world crude oil market. It is expected that the study will inform decision makers on the type of policy and the scale and timing of investments that will be needed to meet the growing demand for liquid fuels while satisfying CO<sub>2</sub> constraints, and the first model described here is a step in this direction.

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