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LOGISTIQUE ET TRANSPORT DES VRACS

Sous la direction de Yann Alix et Romuald Lacoste

éditions ems MANAGEMENT & SOCIÉTÉ

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CHAPITRE 2

From Insecurity in Oil Supply to Insecurity in Market Access : *Is North America Oil Supply and Demand Entering a New Era?*

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Biographies

Benjamin Israël *graduated from the Environmental Management and Engineering Advanced Master delivered by the prestigious university Mines-ParisTech (Paris) as well as from the French Institute of Geopolitics. He has worked for five years in a think-tank dealing with policy analysis and prospective. In 2012, he published "Industry's Future in Seaports" (Presses des Mines) in which he addresses sustainability issues in the context of globalization and carbon constraint. Explored options include carbon capture and storage (CCS), green logistics, industrial ecology as well as circular economy. Benjamin Israël is currently a research* *coordinator at the Institute for Sustainable Energy, Environment and Economy (ISEEE) at the University of Calgary (Canada). His research focuses on energy systems transformation, especially in the Canadian context.*

David Layzell's *studies energy systems, with a particular focus on understanding and identifying strategies for transforming Canadian energy systems towards sustainability. From 2008 to 2012, he was the Executive Director of the Institute for Sustainable Energy, Environment and Economy (ISEEE), a cross-Faculty, graduate research and training institute at the University of Calgary.*

He began his academic career as a Professor of Biology (cross-appointments in the Schools of Environmental Studies and Public Policy) at Queen's University (Kingston) where he generated over 100 peer reviewed publications, 7 patents and a technology company (Qubit Systems Inc.) before being elected as a 'Fellow of the Royal Society of Canada' (FRSC) in 1998.

Over the past 15 years, he has worked with hundreds of faculty at universities across Canada to build multi-disciplinary research teams in the areas of energy and climate change solutions. In this role, he was instrumental in launching research networks that include the BIOCAP Canada Foundation, Fluxnet Canada, the Green Crop Network, Greenhouse Gas Management Canada Network and Carbon Management Canada.

Throughout his career, David Layzell has been committed to the use of multi- and inter-disciplinary approaches to understand and address complex, real-world problems. By developing novel tools for the analysis and visualization of energy systems, Layzell works to create a forum where various disciplines and industry sectors can work together to find cost-effective solutions to the environmental challenges associated with energy production and use.

Introduction

Since 1945, the per capita global demand for oil has quadrupled to about 4.5 barrels of oil[6] per person per year[7]. When combined with a 2.8 fold increase in the world's population, we see more than a 12 fold increase in world oil consumption over the past 68 years. This energy resource fuels the transportation sector globally, but also requires a massive transportation infrastructure to move the resource from where it is extracted to where it is ultimately used.

The United States (U.S.) remains the world's largest oil consumer. In 1960, it claimed more than one third of world oil consumption and even today the U.S. uses nearly 21% of the world's oil[8]. Once a net exporter of oil, the U.S. oil production peaked in the early 1970's and for the past 40 years, the U.S. has relied on foreign supply chains to provide up to 67% of their oil demand.

Over the past 10 years, Canada has become the largest source of imported oil to the U.S., providing up to 2 400 thousand barrels of oil equivalent per day (kbbl/d) in 2012. This change is but one signpost in a major transformation that seems to be occurring in the supply and demand for oil within North America (NA)[9].

Such transformations in the past have acted as 'bookends' for 30-35 year eras in the North American and global marketplace for oil. This paper begins by looking at the past two eras and then considers the forces that are acting on the North American energy system today. We argue that these forces are transforming the energy system in North America, reshaping the oil supply chain and defining a new era in oil supply and demand: one based on an insecurity in market access.

[6] A barrel of oil has a volume of 159 Liters and an energy content of 6.1 gigajoules (GJ).

[7] Calculation based on United Nations, World Population Prospects: The 2012 Revision, URL: http://esa.un.org/unpd/wpp/Excel-Data/EXCEL_FILES/1_Population/WPP2012_POP_F01_1_TOTAL_POPULATION_BOTH_SEXES.XLS. Retrieved on August 1st 2013; oil demand in 1945 based on Vaclav Smil, May 2010, Energy Transitions: History, Requirements, Prospects. Praeger, ISBN-10: 0313381771; and oil demand in 2012 based on BP, June 2013, BP Statistical Review of World Energy 2013, URL: http://www.bp.com/content/dam/bp/excel/Statistical-Review/statistical_review_of_world_energy_2013_workbook.xlsx. Retrieved August 14th, 2013

[8] International Energy Agency, November 2012, World Energy Outlook 2012, ISBN: 978-92-64-18084-0, URL: http://www.worldenergyoutlook.org/publications/weo-2012/#d.en.26099. Retrieved July 26th, 2013

[9] Although Mexico is often considered as part of North America, in this paper we have used the term to refer only to the United States and Canada.

Past Transformations in North America Oil Supply and Demand

To understand the current forces and the possible transformation to a new era in the global systems for oil supply and demand, it is important to appreciate the two previous eras that have occurred over the past 65 years. Each era has lasted about 30 to 35 years, and were the result of socio-economic, technological and political forces.

An Era of Unbridled Growth: 1945-1974

For much of the first half of the 20th century, the United States produced more than half of the world's crude oil. In the three decades following the Second World War, oil production grew rapidly both within the U.S. and internationally. This production was needed to help rebuild European countries and Japan after the war, and to service the rapidly expanding fleets of personal vehicles, trucks, airlines and ships.

In North America, governments and industry invested in a large number of major transportation and energy infrastructure projects (e.g. Eisenhower Interstate System, Enbridge Mainline, the TransCanada pipeline) that supported both the distribution and use of energy resources for the benefit of jobs and economic growth.

The supply of this growing demand in North America was enabled by the large concentration of wells in Texas and the discovery of oil in Alberta (Canada). By 1970, private companies with head offices in North America or Europe controlled 85% of the global oil reserves[10] and produced most of the world's oil. North America remained self-sufficient for oil until the early 1960's and even though it became a net importer after that, domestic oil production continued to grow until 1970 when it peaked and started to decline.

As a result the U.S. started to import more of its oil from overseas and in 1973, the Organization of Arab Petroleum Exporting Countries launched an oil embargo that resulted in a quadrupling of oil prices. These events marked and an end to the unbridled growth in oil production and demand, and the beginning of a new era.

An Era of Insecurity in Energy Supply: 1975-2010

The sharp increase in oil prices empowered many of the oil exporting nations of the world to take control of their own resources. By the end of the 20th century, National Oil Companies (NOCs) controlled 90% of the global oil reserves and

[10] Wikipedia, Seven Sisters (oil companies). URL: http://en.wikipedia.org/wiki/Seven_Sisters_%28oil_companies%29. Retrieved August 1st, 2013

produced 75% of the oil consumed around the world[11], effectively reducing the power and control formerly held by the independent oil companies. Per capita global demand for oil halted its exponential rise and stabilized at about 28 GJ (equivalent to about 4.6 bbl) per person per year for the next 30 years[12]. Of course, the rising global population meant that the total demand for oil continued to rise from 60 Mbbl/d in 1975 to 87 Mbbl/d in 2011.

A key milestone included the 1979 Iranian revolution that resulted in another oil price shock on international markets. In response to such events, the U.S. launched an energy security policy that aimed at reducing or at least stabilizing domestic oil consumption, including the construction of nuclear power plants for electricity generation and the movement to more fuel-efficient cars. Many of the oil producing countries in the Middle East were considered hostile to U.S. interests and U.S. military investments to protect access to Persian Gulf Coast oil rose sharply from ~$180B per year in the 1990's to ~$490B per year in the 2000's[13]. New shipping routes were developed, seaports were modified to handle more energy commodities, and large oil supertankers were built to increase the efficiency and reduce the cost of transporting oil in a global marketplace.

Over this period, U.S. domestic oil production continued to decline and a higher and higher proportion of U.S. oil demand was provided by imports. Canada had developed innovative new technologies to extract bitumen from its vast oil sands deposits and started to bring these technologies on line in order to meet the rising U.S. demand. By 2008, 66% of U.S. crude oil was imported, with Canada as the largest supplier (20%) followed by Mexico (12%).

In 2008, dwindling supplies of conventional oil combined with a strong and rising demand for oil in Asia contributed to a new energy crisis, driving the oil price to $147 per barrel, before triggering a global financial meltdown and a subsequent collapse in oil prices.

Throughout this 35 year era, insecurity in energy supply was a common theme. However, the sharp rise in oil price, new technological innovations, environmental

[11] Silvana Tordo, Brandon S. Tracy, and Noora Arfaa, March 2011, National Oil Companies and Value Creation, Volume I, World Bank, World Bank Working Paper Series #18, p ix, URL: http://siteresources.worldbank.org/INTOGMC/Resources/336099-1300396479288/noc_volume_I.pdf. Retrieved August 1st 2013

[12] Calculation based on United Nations, World Population Prospects: The 2012 Revision, URL: http://esa.un.org/unpd/wpp/Excel-Data/EXCEL_FILES/1_Population/WPP2012_POP_F01_1_TOTAL_POPULATION_BOTH_SEXES.XLS. Retrieved on August 1st, 2013; and BP, June 2013, BP Statistical Review of World Energy 2013, URL: http://www.bp.com/content/dam/bp/excel/Statistical-Review/statistical_review_of_world_energy_2013_workbook.xlsx. Retrieved August 14th, 2013

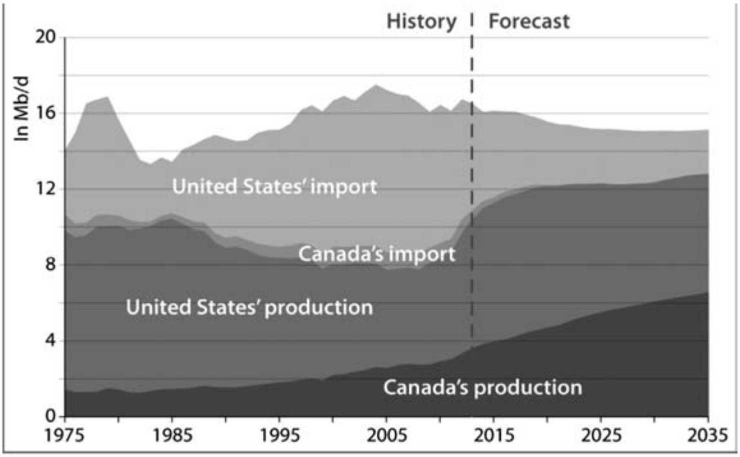
[13] Values in 2008$US, from Stern, R.J., United States cost of military force projection in the Persian Gulf, 1976–2007. Energy Policy (2010), doi:10.1016/j.enpol.2010.01.013, URL: http://www.princeton.edu/oeme/articles/US-miiltary-cost-of-Persian-Gulf-force-projection.pdf. Retrieved August 12th, 2013

concerns and demographic changes over the past decade point to a transformation to a possible new, multi-decade era for the industry. While it may be too early to predict with accuracy the precise nature of this new era, there are telling signposts that will be considered in the next four sections.

North American Oil Production Rises

After decades of declining NA oil production, it stabilized over the past 10 years and showed a sharp rise in the past 5 years (Figure 1). Between 2008 and 2012, oil production in NA increased by 25% and is expected to reach 12.1 Mbbl/d in 2020, compared with only 7.8 Mbbl/d in 2008 (a 57% increase). Both the U.S. and Canada have contributed to this phenomenon. However the nature of their contributions differ significantly.

Figure 1 : History and forecast of the North American crude oil supply[14] [15] [16] [17]



[14] U.S. historical data from Energy Information Agency, Crude Oil Production, URL: http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbblpd_a.htm. Retrieved August 9th, 2013; and Energy Information Agency, U.S. Net Imports by Country. URL: http://www.eia.gov/dnav/pet/pet_move_neti_a_ep00_IMN_mbblpd_a.htm. Retrieved August 9th, 2013

[15] Canadian historical data from Statistics Canada, Supply and disposition of crude oil and equivalent, Cansim table 126-0001. URL: http://www5.statcan.gc.ca/cansim/pick-choisir?lang=eng&p2=33&id=1260001. Retrieved August 9th, 2013; and Statistics Canada, Crude oil and equivalent supply and disposition, Cansim table 126-0002. URL: http://www5.statcan.gc.ca/cansim/pick-choisir?lang=eng&p2=33&id=1260002. Retrieved August 9th, 2013

[16] U.S. forecast data based on the reference case scenario from U.S. Energy Information Agency, April 2013, Annual Energy Outlook 2013 (AEO2013). URL: http://www.eia.gov/forecasts/aeo/pdf/0383(2013).pdf. Data accessible at http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2013&subject=0-AEO2013&table=14-AEO2013&region=0-0&cases=ref2013-d102312a. Retrieved August 8th, 2013

[17] Canadian forecast data based on the reference case scenario from National Energy Board, June 2012, Energy Futures Backgrounder: Addendum to Canada's Energy Future. URL: http://www.neb-one.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/nrgyftr/2012/nrgftrddndm2012-eng.pdf. Retrieved August 8th, 2013

In United States: the Shale Oil Revolution

Over the past 10 years, innovative companies working with U.S. federal investments[18] brought together two technologies: horizontal drilling and hydraulic fracturing (also called "fracking"). The result was unprecedented access to previously inaccessible oil and gas reserves distributed in very-low-permeability reservoirs. They made it possible to develop new plays for conventional light oil trapped in unconventional reservoirs, such as shale, sandstone or carbonate formations. In this paper, we refer to all forms as 'shale oil'.
Three main shale oil plays (the 'Big Three'[19]) have been identified and are currently exploited:

- **The Bakken-Three Forks formation** is the largest producing shale oil play and is located in the states of North Dakota and Montana in the U.S. as well as in the provinces of Saskatchewan and Manitoba in Canada. The shale revolution began in this formation: from a few thousand barrels in 2007, production reached 550 kbbl/d in 2011 and 770 kbbl/d in December 2012. The Bakken-Three Forks formation could trap up to 45 billion barrels of recoverable oil.[19]

- In the Gulf Coast, **the Eagle Ford formation** (south of Texas) experienced a similar boom: starting from zero in 2009, it averaged 190 kbbl/d in 2011 and increased to 560 kbbl/d in 2012. Its reserve of recoverable oil could be as high as 15 billion barrels.[19]

- **The Permian Basin** (Texas and New Mexico) has a long history of oil and gas production from 1920's and peaked in the early 1970's. While the basin has already produced over 29 billion barrels of oil, industry estimates that new technologies could recover at least the same amount of oil.[19]

There are more than twenty other large shale formations that have been identified in North America, but only two have the theoretical potential to enter the league of the "Big Three" in terms of size and production capacity: the Utica shale play located on U.S. and Canada's East Coast and the Monterey shale play in California.
One feature of shale oil is the rapid rate of decline in production. Shale oil wells exhibit their peak production rates during the first weeks of operation. The wells then decline by 40 to 50% by the end of the first year and a further decline of 30 to 40% by the end of the second year[19]. These dramatic declines account for the

[18] Alex Trembath, Jesse Jenkins, Ted Nordhaus, and Michael Shellenberger, May 2012, Where the Shale Gas Revolution Came From. Government's Role in the Development of Hydraulic Fracturing in Shale, Breakthrough Institute. URL: http://thebreakthrough.org/blog/Where_the_Shale_Gas_Revolution_Came_From.pdf. Retrieved August 12th 2013.

[19] Leonardo Maugeri, June 2013, The Shale Oil Boom: a U.S. Phenomenon, Harvard Kennedy School. URL: http://belfercenter.ksg.harvard.edu/files/The%20US%20Shale%20Oil%20Boom%20Web.pdf. Retrieved September 2nd, 2013

need to drill many new wells to maintain a consistent flow of oil. As an example, in the largest shale oil play in the United States (located in North Dakota), about 90 new producing wells were needed per month to maintain its oil production level in 2012 (770 kbbl/d)[19].

According to EIA's Energy Outlook reference case[20], approximately 25.3 billion barrels could be produced cumulatively from 2012 through 2040, mainly from the Big Three shale plays. This is equivalent to about 2 500 kbbl/ day for 28 years. However, the yield structure of shale oil means that after a period of rapid growth from 2010, U.S. oil production is expected to peak at about 7 535 kbbl/d in 2019 and then slowly decline over the next decade to 6 302 kbbl/d in 2030 (Figure 1).

In Canada: Oil Sands Development

In contrast to the rapid, shorter-term nature of shale oil wells, the dominant oil production systems in Canada require long term planning, multi-decade investments and typically return relatively stable and predictable product yields. The oil sands facilities are capital intensive to establish and energy intensive to operate. The shallow bitumen deposits are mined while the deeper deposits use an *in situ* recovery technology such as steam-assisted gravity drainage (SAGD).

Canada's oil sands deposits are the third largest proven oil reserve on earth[21] and are located in Northern Alberta, a land-locked province that is far away from the demand centres in North America, or from tidewaters that could provide access to global markets. Once extracted, the bitumen typically requires an additional treatment to bring it to market, primarily by pipeline. It is either upgraded by 'cracking' to form shorter chain, less viscous molecules (a synthetic crude oil), or diluted with condensate or other natural gas liquids to allow the bitumen to be pipelined (dilbit).

Oil sands production is expected to grow steadily in the coming decades from 1.8 Mbbl/d in 2012 to 5.2 Mbbl/d in 2030 (78% of Canada's production)[22]. This unconventional oil production is in addition to approximately 1 Mbbl/day of conventional oil produced in Canada (Figure 1). The National Energy Board (NEB) and the Energy Information Agency (EIA) have predicted that Canada's crude oil production will account for over 50% of North American domestic production in 2035.

[20] U.S. Energy Information Agency, April 2013, Annual Energy Outlook 2013 (AEO2013), p 82. URL: http://www.eia.gov/forecasts/aeo/pdf/0383(2013).pdf. Retrieved August 8th, 2013

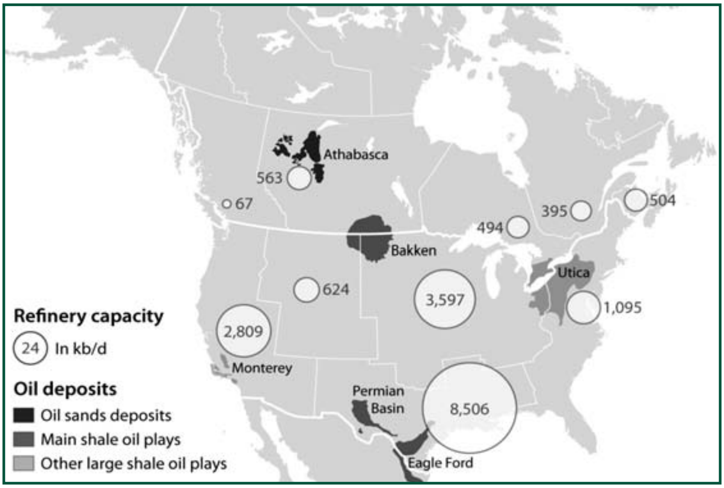
[21] International Energy Agency, November 2012, World Energy Outlook 2012, p 98, ISBN: 978-92-64-18084-0

[22] Canadian Association of Petroleum Producers, June 2013, Crude Oil: Forecast, Markets & Transportation. URL: http://www.capp.ca/getdoc.aspx?DocId=227308&DT=NTV. Retrieved August 8th 2013

As a result of the forecasts for new shale oil and oil sands production, North America's reliance on international markets is predicted to decline precipitously, from about 42% in 2012 to 15% (2 300 kbbl/d) by 2035. In 2012, the *World Energy Outlook* suggested that the United States could become the largest global oil producer by 2020, be a net oil exporter by 2030 and reach energy self-sufficiency by 2035[23]. This represents a major transformative change in the supply of oil within North America.

Connecting the New Supply to Demand

Figure 2 : Location of major unconventional oil deposits and regional refinery capacity (circles)[24]



Much of the new oil supply in North America arises from regions that have not traditionally been involved in oil extraction, certainly at the current and projected levels of production. For example, many new oil plays are located in the north-central U.S. and Canada, with no access to tidewater and long distances from the refinery capacity that exists across the continent (Figure 2). The pipeline network, typically built many decades ago, lacks capacity to move oil from Western Canada and the U.S. Midwest to refineries on the Gulf, West or East coasts. As a result, North America faces a transportation challenge to connect its new supplies to the demand centres for the product.

[23] International Energy Agency, November 2012, World Energy Outlook 2012, ISBN: 978-92-64-18084-0

[24] Energy Information Administration, 2012, Refinery Utilization and Capacity, URL: http://www.eia.gov/dnav/pet/pet_pnp_unc_a_%28na%29_yro_mbblpd_a.htm. Retrieved August 26th, 2013 ; and data from the Canadian Association of Petroleum Producers published in Parliament of Canada, House of Commons, Standing Committee on Natural Resources (RNNR), April 2012, Report 3: The Current And Future State Of Oil And Gas Pipelines And Refining Capacity In Canada, URL: http://www.parl.gc.ca/HousePublications/Publication.aspx?DocId=5499677&Language=E&Mode=1&Parl=41&Ses=1&File=30. Retrieved August 8th, 2013

Figure 3 : Forecast of the supply of oil from Western Canada plus U.S. Bakken fields and the takeaway capacity associated with existing and proposed infrastructure (* pipelines not yet approved)[25]

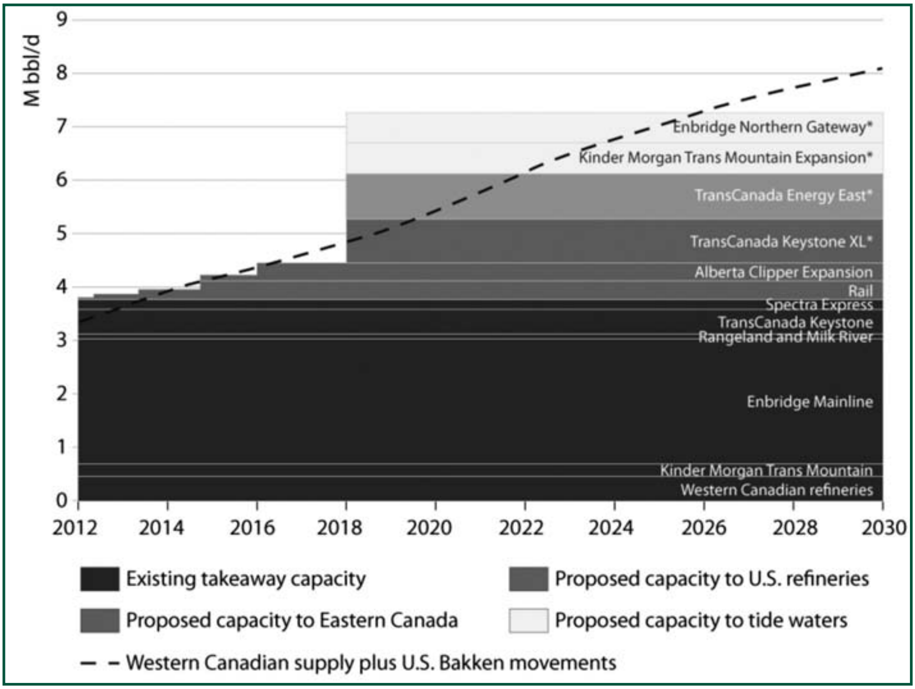


Figure 3 shows the projected rise in oil production from Western Canada and the U.S. Bakken fields and the ongoing efforts to put takeaway capacity in place. To address the challenge, there are a number of major efforts that are underway to connect the new oil supply to markets. Together these initiatives represent another transformative change that may signal a new era in oil supply and demand.

Moving oil by Rail

In North America, the vast majority of oil transport is via pipeline. However, the recent rapid rise in domestic oil production has filled the existing pipeline capacity so the industry has commissioned the rail system to deliver oil while new pipeline projects are being developed, approved and built.

Moving oil by rail can be three times more expensive per barrel than pipeline transport[26], however advantages of rail transport include the immediate access

[25] Adapted from Canadian Association of Petroleum Producers, June 2013, Crude Oil: Forecast, Markets & Transportation. URL: http://www.capp.ca/getdoc.aspx?DocId=227308&DT=NTV. Retrieved August 8th 2013

[26] Dinara Millington, Carlos A. Murillo, May 2013, Canadian Oil Sands Supply Costs and Development Projects (2012-2046), Canadian Energy Research Institute, Study No. 133. ISBN 1-927037-12-6. URL: http://www.ceri.ca/images/stories/2013-06-10_CERI_Study_133_-_Oil_Sands_Update_2012-2046.pdf. Retrieved July 22nd, 2013

to markets with negligible upfront costs (most of the infrastructure is already in place), and the lack of a need for regulatory approval. Also, the ability to transport bitumen without dilution, the scalability of rail transport and the flexibility to access virtually any refinery or marine terminal can account for the 2.6 fold increase in oil transport by rail in Canada in the past 2 years[27].

Current rail reliance for oil transport from Western Canada is 150 kbbl/d, and this could increase to 360 kbbl/d[28] by the end of 2014 to meet demand until new pipeline capacity has been built. The surge in rail for oil transport is being seen across North America, so that the total rail capacity is expected to double from 2012 to the end of 2013, to over 1.4 Mbbl/d. This oil is delivered to refineries on the Eastern Seaboard (~600 kbbl/d), Gulf Coast (~750 kbbl/d) and West Coast (~110 kbbl/d)[21].

While moving oil by rail may relieve pressure points in the oil transportation system, it is not competitive with pipelines in the longer term.

Pipelines to Bring New Oil to Existing U.S. Refineries

With rising oil production in Canada and northern U.S., there is a need to bring the oil to existing refineries, especially those on the Gulf Coast that currently import oil from overseas. Consequently, numerous pipeline projects have recently been completed or are currently in development, especially connecting North Central America to the U.S. Midwest (Figures 3 and 4). These include:

- **The Enbridge Alberta Clipper Expansions** are being built to reinforce the Enbridge Mainline from Hardisty, Alberta to Superior, Wisconsin thanks to two new pipelines: a first line will add 120 kbbl/d by the end of 2014; an additional 230 kbbl/d line should be built by the beginning of 2016. These two improvements should bring the Alberta Clipper line to an 800 kbbl/d capacity.

- The northern section of **TransCanada Keystone XL** is proposed to connect Hardisty, Alberta to Steele City, Nebraska, providing a 830 kbbl/d capacity to move Albertan bitumen to the U.S. Midwest. This pipeline is highly controversial and its approval rests with President Obama. If it goes ahead, the 2015 in-service target is expected to be delayed.

[27] Between March 2011 and March 2013, from Statistics Canada, Cansim table 404-0002, Railway carloadings statistics, by commodity. URL: http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=4040002&paSer=&pattern=&stByVal=1&p1=1&p2=31&tabMode=dataTable. Retrieved on July 28th, 2013

[28] Jackie Forrest and Aaron Brady, August 2013, Keystone XL Pipeline: No material impact on US GHG emissions, IHS CERA, p 3. URL: http://www.ihs.com/products/cera/energy-industry/oil-sands-dialogue.aspx?ocid=cera-osd:energy:print:0001. Retrieved September 2nd, 2013

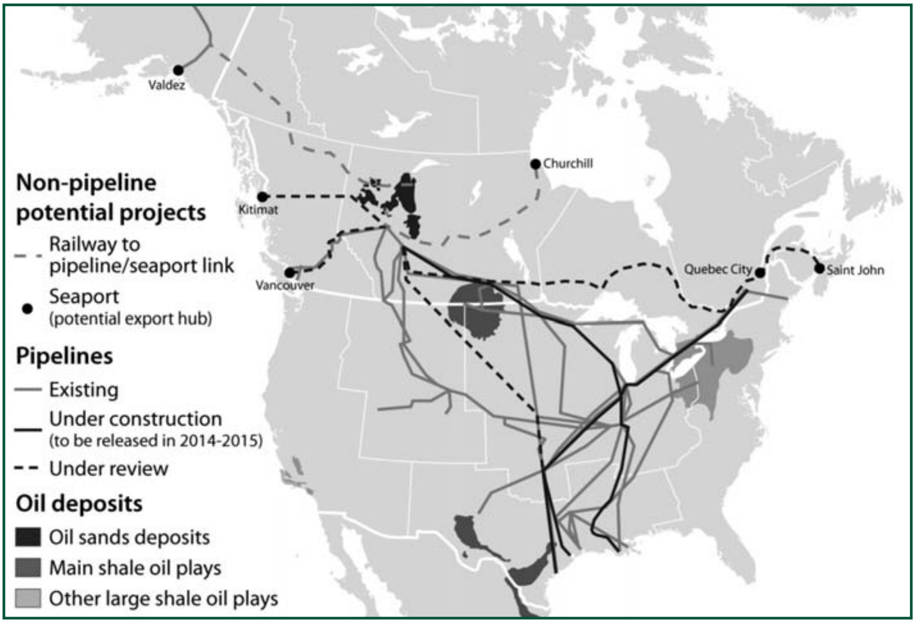
A set of pipelines are proposed to provide the Bakken-Three Forks shale play with a better access to existing pipeline system, such as the Enbridge Sandpiper Expansion (375 kbbl/d to be added in January 2016) or the Bakken Marketlink project (a leg from Bakken to TransCanada Keystone XL pipeline with a 100 kbbl/d capacity).

In the U.S. Midwest, pipelines are also proposed to handle the rising oil supply coming from the West and move it to the South. These include the Enbridge Southern Access Pipeline (to add 330 kbbl/d to the Enbridge Mainline by 2015) or the improvements on the Enbridge Spearhead Pipelines (to add a combined 675 kbbl/d capacity by 2015). Most of these pipelines converge in Cushing, Oklahoma, which is considered the gateway to U.S. Gulf coast refineries. Cushing is also the place where the oil price is set.

Access to the Gulf Coast will also be enhanced by three major projects (total of 1 810 kbbl/d capacity) that should be completed by 2015. These include the southern section of TransCanada Keystone XL (currently being built), the Enbridge/Energy Transfer Eastern Gulf Crude Access and the twinning of Seaway Pipeline. While the Gulf coast hosts most of the U.S. refinery capacity, its refineries are suited to receive Canada's oil sands product since they have been processing heavy crude oil from Mexico and Venezuela[29].
Most of the pipelines set to come on line by 2015 have received regulatory approval and are currently under construction. However, many of the more recently proposed pipelines face strong opposition, including these designed to bring oil from Western Canada.

[29] In 2012, U.S. Gulf Coast refineries processed over 2.2 Mbbl/d of heavy oil, including 100 kbbl/d coming from Western Canada. Source: Canadian Association of Petroleum Producers, June 2013, Crude Oil: Forecast, Markets & Transportation, p iii. URL: http://www.capp.ca/getdoc.aspx?DocId=227308&DT=NTV. Retrieved August 8th 2013.

Figure 4 : Map of existing, under construction and proposed oil pipelines in North America and their relationship to the major new unconventional oil deposits being developed[30]



Reversing a natural gas pipeline across Canada to bring Western Canadian oil to Eastern Canada

Approximately 39% of Canadians live in the province of Ontario, and a leg from the Enbridge system that travels through the U.S. but connects Western Canada to South-Western Ontario provides much of their oil supply. However, the refineries in Québec and provinces further east rely on international markets and currently import about 86% of their oil supply (~700 kbbl/d in 2012)[25].

Consequently, the oil prices in Eastern Canada are defined by European Brent Crude prices that, until recently, have been considerably higher than North American prices. For example, in 2010 U.S. crude oil price calculated at Cushing, Oklahoma (i.e. Western Texas Intermediate or WTI), became disconnected from Brent crude oil prices and WTI oil traded as much as $29 per barrel lower than Brent Crude in September 2011[31]. The price differential narrowed to less than $10 per barrel in April 2013.

[30] Adapted from Canadian Association of Petroleum Producers, June 2013, Crude Oil: Forecast, Markets & Transportation, p iii. URL: http://www.capp.ca/getdoc.aspx?DocId=227308&DT=NTV. Retrieved August 8th 2013.

[31] U.S. Energy Information Agency, Spot Prices. URL: http://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm. Retrieved September 1st, 2013

In addition, the Western Canadian Select (WCS, calculated at Hardisty, Alberta) price for oil traded at lower price than WTI by as much as $31 per barrel in April 2012. This "bitumen bubble" was attributed to the low quality of WCS oil (a heavier, sourer crude oil that delivers a lower yield of high-value products) as well as competition from new U.S. shale oil production. As of July 2013, the price differential was nearly $20 per barrel.

As a result, meeting the Eastern Canadian market demand for oil could further enhance North American security in energy supply, while reducing feedstock costs. To achieve this objective, two major pipeline projects are under development to add 825 to 1 150 kbbl/d capacity by 2018.

- **Enbridge plans to reverse its pipeline '9'** that runs from Montreal, Québec to Sarnia, Ontario. This reversal will allow 300 kbbl/d of crude oil coming into Canada from the U.S. at Sarnia to be delivered to Québec in late 2014[32].

- **TransCanada Energy East**. TransCanada has developing a proposal to convert to oil, a natural gas pipeline that runs from Hardisty, Alberta to Québec City, Québec and Saint John, New Brunswick. The proposed pipeline would have a capacity ranging from 525 to 850 kbbl/d and could be operational in early 2018. If built, it would be the first oil pipeline connecting Western and Eastern Canada without going through the U.S.

If these projects are implemented, Canada could become self-sufficient for oil supply. Of course, the refineries in Eastern Canada would need to be modified to process heavy oil, but the lower cost and reliable supply of this oil should provide a strong incentive to make such a change.

Moving Oil to Tidewaters and World Markets

Since the 1970's, U.S. law has banned the export of crude oil: all oil must first be refined to petroleum products before the products can be shipped to other countries.[33] There are exemptions for oil produced in Alaska and for oil exported to Canada, but the law does restrict the shipping of oil from continental U.S. In addition, the Jones Act (1920)[34] mandates that any intra-U.S. shipping by water be done using vessels under U.S. flag, built in the U.S., and manned primarily by U.S. crews. This requirement further restricts the shipping of oil, even between U.S. ports.

[32] This reversal is actually a re-reversal since the pipeline was already reversed in 1999 when North America needed massive imports to supply its demand.

[33] Blake Clayton, July 2013, The Case for Allowing U.S. Crude Oil Exports, Council on Foreign Relations, Renewing America, Policy Innovation Memorandum No. 34. URL: http://i.cfr.org/content/publications/attachments/Policy_Innovation_Memo34_Clayton.pdf. Retrieved August 8th, 2013

[34] John F. Frittelli, Resources, Science, and Industry Division, July 2003, The Jones Act: An Overview, Congressional Research Service, Report RS21566.

The same rules do not apply to Canada. Nevertheless, the U.S. remains the market for 97% or more of Canada's oil, despite the fact that Canadian producers (and governments taking royalties) have been hurt by the 'Bitumen bubble', where Canadian bitumen sells at a significant discount to other oil in U.S. markets.
As a result, there could be major benefits to Canadian oil producers if they were able to access the global marketplace. According to the Energy Information Administration, the combined oil imports of China and India are forecast to increase by 15.5 Mbbl/d by 2040[35]. Until recently, Canada has not had sufficient oil production capacity to be concerned about accessing markets other than the U.S. This is now changing.

Nevertheless, there are still barriers to gaining access to tidewater and shipping ports for Canadian oil. Alberta, the province with most of the oil reserves, is landlocked and must send its products across other provinces. In the Canadian confederation, energy is a provincial, not a federal responsibility, so cooperation of the relevant provinces is both a necessity and a source of inter-provincial tension.
With these barriers in mind, multiple alternatives are being explored.

- **Across British Columbia.** The closest route to tidewater from the Canadian oil sands is across the province of British Columbia. Two pipeline routes have been proposed:
  - **The twinning of Kinder Morgan Trans Mountain pipeline** could enhance the export capacity from 280 to 820 kbbl/d by 2017. This existing pipeline is the only one that carries crude from Alberta to Burnaby, British Columbia. This new line would mainly carry heavy crude oil while the former line would transport refined petroleum products as well as light oil.
  - **The Enbridge Northern Gateway Pipeline** has been proposed to bring 525 kbbl/d from Bruderheim, Alberta to a marine terminal in Kitimat, British Columbia and be operational by 2017.[36]
- **Through Alaska.** The G Seven Generations project (also known as the G7G project) is a First Nations[37] led initiative that proposes a rail link between Alberta's oil patch and the under-utilized TransAlaska Pipeline that could transport up to 4 Mbbl/d. Crude oil would be then shipped on tankers in the existing marine terminal of Valdez, Alaska (United States).[38] Oil could then be exported to Asian markets or the U.S. Pacific Coast.

[35] U.S. Energy Information Agency, July 2013, International Energy Outlook 2013 (IEO2013), p 27. URL: http://www.eia.gov/forecasts/ieo/pdf/0484(2013).pdf. Retrieved August 18th, 2013

[36] The main pipeline is associated with another pipeline from Kitimat to Edmonton to ship diluents that is used to lower the viscosity of heavy oil and to allow it to be transported by pipeline.

[37] The First Nations are the Aboriginal peoples in Canada.

[38] G7G Railway Corporation, November 2012, First Nations and Alaskan Tribes show support for Alberta-Alaska rail link. URL: http://unfnrailco.com/ESW/Files/G7G_Release_Nov-14-2012-EN.pdf. Retrieved August 2nd, 2013

- **To Churchill, Manitoba, on Hudson Bay.** This project would transform the under utilized Port of Churchill into a key export hub for Western Canadian oil. Bitumen would be transported by rail from Alberta to Churchill, Manitoba, located on the West Coast of the Hudson Bay. Crude oil would be then loaded on Panamax-class tankers and exported to U.S. North-East Coast, U.S. Coast as well as European market. A significant challenge with this plan is that Hudson Bay is only ice-free from July to mid-October, restricting the use of the port to only a portion of the year.

- **To the Atlantic Ocean.** Should the TransCanada Energy East pipeline be implemented, its capacity would exceed demand in the region and could allow for the export of up to 300 kbbl/d of oil. Ports at Québec City, Québec, and Saint John, New Brunswick, are along the pipeline route and could handle export to foreign markets or to U.S. East and Gulf Coasts (figure 4). This project could also enable the reversal of the Portland-Montreal pipeline that is currently used to import crude oil from overseas markets and bring Canadian oil to tidewater.

Barriers to producing and transporting oil

Over the past 20 years, there has been a rising level of concern over the environmental impacts of the world's energy systems, particularly its impacts on climate, water use and soil/water contamination. In North America, the recovery and transport of unconventional oil and gas has become the battleground for the environmental movement, and the public's support for this industry has been decreasing. A brief overview of some of the key issues are provided here:

Climate change

The combustion of fossil fuels releases carbon dioxide (CO_2) to the atmosphere, a gas that adsorbs radiant heat energy produced when the sun strikes the earth's surface. In the past 150 years, the atmospheric CO_2 level has increased by about 35%, and it continues to rise[39]. Recent climatic changes (global warming, severe weather events), have been attributed to this alteration in the heat balance of the planet, and climate scientist predict that the impacts on human population and biodiversity will be more severe as the polar ice caps continue to melt and sea levels rise[34].

Unconventional sources of oil, such as that from oil sands or shale oil, tend to have higher CO_2 equivalent (CO_2e) emissions associated with their recovery than conventional sources. This is particularly a problem with the recovery of bitumen

[39] Intergovernmental Panel on Climate Change (IPCC), 2007, Climate Change 2007, Fourth Assessment Report (AR4) of the United Nations Intergovernmental Panel on Climate Change (IPCC)

from oil sands since the generation of the heat needed to separate the bitumen from the sand involves the combustion of large amounts of natural gas[40]. In the case of shale oil, the fracking process is also energy intensive, but the CO_2 and methane (CH_4, a gas with ~23 times the global warming potential of CO_2) emissions from venting and flaring off-gases can make an even greater contribution to the life cycle greenhouse gas (GHG) emissions[41].

The majority (70% or more) of the GHG emissions from oil are associated with the combustion of the resulting refined petroleum products (e.g. gasoline, diesel). Since these products are similar for conventional and unconventional oils, the 'well to wheels' GHG emissions of unconventional oil is approximately 15% more than conventional oil, but varies widely depending on what conventional and what unconventional oil is being compared[42].

A more fundamental issue for many environmentalists is the question as to whether the unconventional energy resources should be developed at all. A case has been made that the release of these additional large carbon stores to the atmosphere will perpetuate our reliance on fossil fuels[43] and may trigger 'run-away' climate change.

Water

Water is another environmental pressure point that surrounds the recovery and use of unconventional oil. The large tailings ponds associated with the mining of oil sands (about 2 volumes of water per volume of bitumen produced) has attracted international attention[44] as has the use of large volumes of water needed to fracture rock in shale oil operations.

There are also concerns about contamination of surface and ground water resources, with particular focus on surface water contamination from oil sands ope-

[40] Alex Charpentier, Oyeshola Kofoworola, Joule Bergerson, and Heather MacLean, September 2011, Life Cycle Greenhouse Gas Emissions of Current Oil Sands Technologies: GHOST Model Development and SAGD Application. Environmental Science and Technology. 2011. Vol. 45. pp. 9393-9404.

[41] European Parliament, Directorate General For Internal Policies, Environment, Public Health and Food Safety, 2011, Impacts of Shale Gas and Shale Oil Extraction on the Environment and on Human Health. URL: http://www.europarl.europa.eu/document/activities/cont/201107/20110715ATT24183/20110715ATT24183EN.pdf. Retrieved on September 6th, 2013

[42] Jacobs Consultancy prepared for Alberta Energy Research Institute, July 2009, Life Cycle Assessment Comparison of North American and Imported Crudes. URL: http://www.eipa.alberta.ca/media/39640/life%20cycle%20analysis%20jacobs%20final%20report.pdf. Retrieved July 18th, 2013

[43] Neil C. Swart, and Andrew J. Weaver, 2012, The Alberta oil sands and climate, Nature Climate Change 2, 134–136 (2012) doi:10.1038/nclimate1421. Published online 19 February 2012. URL : http://www.nature.com/nclimate/journal/v2/n3/full/nclimate1421.html. Retrieved August 28th, 2013

[44] Robert Kunzig , March 2009, The Canadian Oil Boom, National Geographic. http://ngm.nationalgeographic.com/2009/03/canadian-oil-sands/kunzig-text. Retrieved August 20th 2013.

rations[45] and drinking water contamination associated with hydraulic fracturing operations such as those used in shale oil development[46].

Finally, disposal of wastewater from oil and gas operations has been implicated in triggering seismic events[47] that has led to more resistance against unconventional oil development.

Spills

Spills of oil from pipelines, trains, ships and offshore oil production systems are frequently in the news[48] and have contributed to the public's concern about developing and transporting oil. While most oil will float on water making it possible to clean up, bitumen's high density means that it could sink in water and be more challenging to remediate.

Aboriginal relations

Another potential barrier to the public license to develop and transport oil resources is the necessity to engage and gain support from Aboriginal groups, especially in Canada. Many of these groups have land claims or treaties that have not been settled or they are working within provincial or with federal governments that have not upheld their part of long-standing agreements. Understandably, the desire to develop and deploy resource development and pipeline projects on the Aboriginal lands of such groups is seen by them as a opportunity to address ongoing conflicts that may extend beyond the particular energy / environment issue under consideration.

These issues are but four of the barriers to securing the public license to develop and deploy the new oil resources within North America. While they all differ in their particular characteristics, the battleground seems to be converging around the deployment of transportation infrastructure, in particular the approvals for new pipeline capacity.

[45] Dr. Steve Hrudey, Pierre Gosselin, M. Anne Naeth, André Plourde, René Therrien, Glen Van Der Kraak, and Zhenghe Xu, December 2010, Environmental and Health Impacts of Canada's Oil Sands Industry, The Royal Society of Canada. URL: http://rsc-src.ca/sites/default/files/pdf/RSC_ExP_ExecutiveSummary_ENG_Dec14_10_FINAL_v5.pdf. Retrieved August 26th, 2013

[46] European Parliament, Directorate General For Internal Policies, Environment, Public Health and Food Safety, 2011, Impacts of Shale Gas and Shale Oil Extraction on the Environment and on Human Health. URL: http://www.europarl.europa.eu/document/activities/cont/201107/20110715ATT24183/20110715ATT24183EN.pdf. Retrieved on September 6th, 2013

[47] Nicholas J. van der Elst1, Heather M. Savage, Katie M. Keranen, and Geoffrey A. Abers, July 2013, Enhanced Remote Earthquake Triggering at Fluid-Injection Sites in the Midwestern United States, Science 12 July 2013: Vol. 341 no. 6142 pp. 164-167, DOI: 10.1126/science.1238948

[48] In 2013, North America experienced several significant spills from pipelines and train derailments including the train that derailed on July 6th, 2013, in the town of Lac-Mégantic, Quebec, killing 47 people and destroying the town center.

Future Demand for Oil in North America

Oil demand in North America has declined about 1.6% since 2001, even though the population has increased by 10.3% over the same period[49]. According to NEB and EIA predictions (Figure 1), the decline is expected to continue and then stabilize at approximately 15 Mbbl/d by 2025. Is this prediction reasonable?

The price of a barrel of oil has increased sharply over the past 8 years and now seems to have stabilized at about $100 per barrel, a level hard to imagine only 10 years ago. Since 70% of oil use is coupled to transportation fuels in the United States[50], many now see a very large market opportunity to provide an alternative to oil in fuelling transportation needs. Indeed, ongoing trends and new technological innovations could lead to a more precipitous decline in oil demand in North America than that shown in Figure 1. These include:

The Biofuel Revolution

Ethanol is the fast growing transportation fuel in the U.S. It rose from 2.8% of gasoline supply in 2005 to 9.9% in 2012[51]. With 49.2 billion liters produced in 2012, the U.S. leads the world in ethanol production. Made mainly from corn, ethanol is a biofuel additive that increases the octane level of gasoline, reduces dependence on oil imports (from 60% in 2005 to 42% in 2012[45]) and stimulates the rural economy by providing new markets for agricultural production.

The growth of this market has largely been driven by regulation and policy, including the U.S. Open Fuel Standard Act (OFS, May 2011) which requires 95% of cars built in 2017 to operate on non-petroleum-based fuels, including ethanol and biodiesel, the latter of which is made from plant oils or waste animal fats.

Controversy exists around the costs and benefits of biofuels, including life cycle greenhouse gas emissions[52], land use/ biodiversity[53], food prices and about their

[49] Calculation based on United Nations, World Population Prospects: The 2012 Revision, URL: http://esa.un.org/unpd/wpp/Excel-Data/EXCEL_FILES/1_Population/WPP2012_POP_F01_1_TOTAL_POPULATION_BOTH_SEXES.XLS. Retrieved on August 1st 2013; and BP, June 2013, BP Statistical Review of World Energy 2013, URL: http://www.bp.com/content/dam/bp/excel/Statistical-Review/statistical_review_of_world_energy_2013_workbook.xlsx. Retrieved August 14th, 2013

[50] U.S. Energy Information Agency, September 2012, Annual Energy Review 2011, p 117. URL: http://www.eia.gov/totalenergy/data/annual/pdf/aer.pdf. Retrieved August 21st, 2013

[51] Renewable Fuels Association, 2013 Ethanol Industry Outlook, URL : http://ethanolrfa.org/page/-/PDFs/RFA%202013%20Ethanol%20Industry%20Outlook.pdf?nocdn=1

[52] Michael Wang, 2005, Updated Energy and Greenhouse Gas Emission Results of Fuel Ethanol, Center for Transportation Research, Argonne National Laboratory, URL: http://www.transportation.anl.gov/pdfs/TA/354.pdf. URL: retrieved on September 5th, 2013

[53] Timothy Searchinger et al., February 2008, Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change, Science 319 (5867): 1238–1240, doi:10.1126/science.1151861, PMID 18258860

performance as a fuel compared to 'straight' gasoline or diesel fuels[54]. However, a new generation of biofuel ethanol made from lignocellulosic feedstocks (wood, straw) is now coming into commercial scale production that should be able to address concerns about GHG benefits, land use and food production systems.
According to EIA, advanced renewable fuels (i.e those with a 50%+ reduction in GHGs) are expected to continue to grow quickly in the coming decades, from 90 kbbl/d in 2013 to ~550 kbbl/d in 2040[55].

Natural gas as a transportation fuel

Over much of the past 25 years, the price of natural gas has tended to track the price of crude oil in North America. On an energy content basis ($/GJ), natural gas prices have averaged 77% of the oil price between 1989 and 2005[56].
The situation changed dramatically in the past eight years when the price of natural gas in North America decoupled from the world's oil price and dropped to only 15% of the price of oil on an energy basis[50].This seven fold spread in the price of similar energy commodities can be attributed to the same horizontal drilling and fracturing technologies that enabled the shale oil revolution in the United States. When applied to formations containing methane, the technologies have contributed to a dramatic rise in shale gas production, from 56 billion cubic meters (6.2% of NA production) in 2007 to 241 billion cubic meters (24.2% of NA production) in 2011[57].
The divergence in NG to oil price has stimulated interest in using compressed (CNG) or liquefied (LNG) natural gas to power vehicles in markets segments where there is no need to first build an extensive network of distributed fueling infrastructure. These market segments include:

- Municipal transit, refuse and maintenance vehicles;
- Supply chains vehicles such as those from companies such as UPS, Fedex, Walmart and Shell;

[54] The energy content of ethanol is about 33% less than «pure» gasoline. Source: U.S. Energy Information Agency, How much ethanol is in gasoline and how does it affect fuel economy? URL: http://www.eia.gov/tools/faqs/faq.cfm?id=27&t=4. Retrieved September 2nd, 2013

[55] U.S. Energy Information Agency, April 2013, Annual Energy Outlook 2013 (AEO2013), p 84. URL: http://www.eia.gov/forecasts/aeo/pdf/0383(2013).pdf. Retrieved August 8th, 2013

[56] BP, June 2013, BP Statistical Review of World Energy 2013, URL: http://www.bp.com/content/dam/bp/excel/Statistical-Review/statistical_review_of_world_energy_2013_workbook.xlsx. Retrieved August 14th, 2013

[57] Numbers refer to NA natural gas gross production and Canada is assumed not having a significant shale gas production over the period. Sources: U.S. Energy Information Administration, U.S. Natural Gas Gross Withdrawals and Production. URL: http://www.eia.gov/dnav/ng/ng_prod_sum_dcu_NUS_a.htm. Retrieved August 18th, 2013; and Statistics Canada, Supply and disposition of natural gas, Cansim table 131-0001. URL: http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=1310001&paSer=&pattern=&stByVal=1&p1=1&p2=31&tabMode=dataTable. Retrieved August 18th, 2013

- Trains, including pilot tests by Canadian National Railway[58] and BNSF Railway[59];
- Ships, including BC Ferries on the Pacific coast or Staten Island Ferry in New York[60,61];
- Heavy duty trucking. This will require a greater penetration of LNG refuelling infrastructure along the main North American transportation corridors; and
- Airline transport, including a concept study by Boeing for an airliner powered by LNG[54]

In 2012, the EIA projected that sales of heavy-duty natural gas vehicles could increase to 275 000 in 2035, equivalent to 34% of new heavy-duty vehicles sales[62].

Natural gas could also compete with oil directly in the diesel and gasoline market by first being converted to those fuels through Fischer-Tropsch synthesis or other gas to liquid (GTL) technologies. Recently Qatar airways completed its first commercial flight running on a mixture of conventional and GTL jet fuels[63].
Besides affordability, switching from diesel to a CNG or LNG fuel will decrease particulate emissions and direct greenhouse gas emissions per km travelled. A study by MIT has estimated that CO_2 emissions reductions of up to 25% could be achieved[64].

Electrification of transportation

The rising cost of oil coupled with climate change concerns have renewed interest in electric vehicles over the past 5 years, especially for personal transportation. Over this period, more than 116 000 plug-in electric vehicles were sold in

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[58] Guy Dixon, and Kelly Cryderman, May 14th, 2013, CN tries out liquefied natural gas to power locomotives, The Globe and Mail. URL: http://www.theglobeandmail.com/report-on-business/industry-news/energy-and-resources/cn-tries-out-liquefied-natural-gas-to-power-locomotives/article11901916/. Retrieved September 2nd, 2013

[59] BNSF Railway, March 2013, BNSF to test liquefied natural gas in road locomotives. URL: http://www.bnsf.com/employees/communications/bnsf-news/2013/march/2013-03-06-a.html. Retrieved September 2nd, 2013

[60] Seth Kleinman et al., March 2013, Global Oil Demand Growth – The End Is Nigh, Citigroup. URL: http://xa.yimg.com/kq/groups/17389986/160616929/name/CITI+Global+Oil+Demand+Growth.pdf. Retrieved September 2nd, 2013

[61] Sunny Dhillon, July 23rd, 2013, New BC Ferries ships will be fuelled by liquefied natural gas, The Globe and Mail. URL: http://www.theglobeandmail.com/news/british-columbia/new-bc-ferries-ships-will-be-fuelled-by-liquefied-natural-gas/article13383262. Retrieved September 2nd, 2013

[62] U.S. Energy Information Agency, June 2012, Annual Energy Outlook 2012 (AEO2012), p 40. URL: http://www.eia.gov/forecasts/aeo/pdf/0383(2012).pdf. Retrieved August 15th, 2013

[63] Pilita Clarck, October 13th, 2009, Airline flies on natural gas, Financial Times. URL: http://www.ft.com/intl/cms/s/0/b15c685e-b78e-11de-9812-00144feab49a.html. Retrieved September 1st, 2013

[64] On a life cycle basis this advantage is reduced due to GHG emissions associated in production and distribution greater for natural gas than for oil. Source: Massachusetts Institute of Technology, June 2011, The Future of Natural Gas. URL: http://mitei.mit.edu/publications/reports-studies/future-natural-gas. Retrieved September 1st, 2013

the United States, helped by federal tax credits and state incentives. As a result, new electric vehicle companies are being created and traditional auto companies are bringing new models to the market. The U.S. government also supports the development of the next generation batteries[65] as well as the charging infrastructure in 21 different metropolitan areas across the country[66].

A new generation of all-electric and fast charging technologies are being introduced and gaining widespread interest, if not market share. In early 2013, a U.S. Department of Energy study noted that the success of the electric vehicle industry will depends on significant reductions in the cost of the electric drive system (by 75%), the weight of the vehicle (by 30%) and the cost of the batteries (by 75%)[67].

Whether a movement to electric vehicles will contribute to effective climate change solutions will depend on reducing the carbon intensity of the electrical grid in many parts of North America, especially those where there is a reliance of coal fired power generation.

Societal and behavioural change

In the past two to three decades, the rapid development of information and communications technologies have impacted the way people live, interact and do business. Teleworking, videoconferencing, internet marketing as well as cell phone and file sharing technologies have changed the importance of face to face meetings, how retailers and shoppers interact, the nature of socialization and ultimately the role of transportation in society.

This transformation has shaped a new generation, the Y generation, who clearly place personal mobility lower on their priority list than previous generations. Many have suggested that North America has already reached 'Peak Car' even though the population continues to rise[68].

As this new generation matures and the mobility needs of the 'baby boom' generation decline when they move into retirement, there are likely to be major impacts on urban design, with increasing densification and a lower dependence on per-

[65] U.S. Department of Energy, March 2009, Recovery Act Announcement: President Obama Announces $2.4 Billion for Electric Vehicles, URL: http://apps1.eere.energy.gov/news/progress_alerts.cfm/pa_id=152. Retrieved July 29th, 2013

[66] The EV Project, URL: http://www.theevproject.com. Retrieved September 6th, 2013

[67] U.S. Department of Energy, January 2013, EV Everywhere Grand Challenge Blueprint. URL: http://www1.eere.energy.gov/vehiclesandfuels/electric_vehicles/pdfs/eveverywhere_blueprint.pdf. Retrieved August 21st, 2013

[68] Elisabeth Rosenthal, June 29th, 2013, The End of Car Culture, The New York Times. URL: http://www.nytimes.com/2013/06/30/sunday-review/the-end-of-car-culture.html. Retrieved September 1st, 2013

sonal vehicle transportation that has dominated North American culture for the past 65 years.

Public transit and car sharing are likely to increase in importance, but a transformational change in our transportation needs (and the resulting demand for oil) will likely require the implementation of one or more of the new technologies currently in development. For example, self-driving vehicles[69] could provide a low-cost, on-demand, internet-connected taxi service that will be more cost effective and convenient to use than personal car ownership. In addition, it could free up some of the 30%+ of the land area in cities that is now dedicated to vehicle parking.

Conclusion: The Dawn of an Era of Insecurity in Market Access

After approximately 35 years of insecurity in oil supply in North America (1975 to 2010), a transformation seems to be occurring to a new, multi-decade era in oil supply and demand.

Concerns about security of supply combined with the recent rise in global oil prices have stimulated the technological innovations that reversed the steady decline in North American oil production (pages 86-93), making it possible to reduce, and potentially eliminate dependence on imported oil. However, to achieve this objective, massive investments must be made to connect the new domestic sources of oil to existing refinery capacity (pages 89-96). If achieved, the resulting oil self-sufficiency in North America may have major implications on global geopolitics, including U.S. military investments in the Middle East and around the world.

However, there are major environmental and sociological barriers that are working to restrict both the development of these oil resources within North America and the movement of oil to existing refineries either within North America, or overseas (pages 96-98). In addition, other changes in market conditions, from new sources of liquid and gaseous fuels to technology changes are working to reduce overall demand for crude oil in North America (pages 98-102). These factors are creating a new insecurity in market access for oil, and this insecurity is likely to intensify in the foreseeable future.

Most experts predict an increase in global oil demand in future decades, driven largely by economic development in China and India[70]. Therefore, on a global

[69] Navneet Alang, July 29th, 2013, Self-driving cars will set off an economic and cultural earthquake, The Globe and Mail. URL: http://www.theglobeandmail.com/technology/digital-culture/self-driving-cars-will-set-off-an-economic-and-cultural-earthquake/article13456267/. Retrieved September 3th, 2013

[70] U.S. Energy Information Agency, July 2013, International Energy Outlook 2013 (IEO2013), p 10.

scale the trends in North America seem to be an anomaly, due in part to the voracious demand for oil in the past (it was difficult to envisage how North American oil demand could increase further), and the technological, environmental and societal forces now at play.

From the perspective of the global transportation industry, ships that used to bring oil to North America will start to carry it elsewhere, and may even be involved in carrying North American oil to global markets.

In past eras, industry and governments in North America have adapted to oil's supply and demand forces, and it is important that they do so again as we enter this new era of insecurity in market access. Today, more than ever, there is a need for a coordinated North American energy strategy that will balance the needs to greatly reduce the climate change / environmental footprint associated with energy use in North America, and to generate the economic benefits associated with developing the continent's energy resources.

The per capita use of oil in North America (~25 bbl/yr) is 2.5 times higher than that in Europe (~10 bbl /yr) and up to 25 times higher than that in the developing economies (e.g. ~1 bbl/yr in Africa)[71]. To address environmental and climate change priorities, North American oil demand must either decline dramatically or be offset by massive investments in carbon capture and storage.

Taking a global leadership role in transforming the North America's transportation systems into systems that are innately more sustainable is a strategy that will stimulate the economy and create new jobs. It should also help to develop the public license to produce and export domestic sources of oil, (as well as new transportation technologies) to the developing world. As oil demand declines in North America, these new, international markets will be more important.

If Canada and the United States do not develop the capacity to export oil to international market, the North American market could become disconnected from the international market similar to the one which has occurred with natural gas. Such a disconnection could lead to lower oil prices, a weaker economy, and less of an incentive to address climate change concerns. By coupling the economic benefits of oil production and export to the transformation of the North American transportation systems towards sustainability, the U.S. and Canada have an opportunity to adapt to this new era of insecurity in market access.

URL: http://www.eia.gov/forecasts/ieo/pdf/0484(2013).pdf. Retrieved August 18th, 2013

[71] Average number from 2000 to 2010. Calculation based on United Nations, World Population Prospects: The 2012 Revision, URL: http://esa.un.org/unpd/wpp/Excel-Data/EXCEL_FILES/1_Population/WPP2012_POP_F01_1_TOTAL_POPULATION_BOTH_SEXES.XLS. Retrieved on August 1st, 2013; and BP, June 2013, BP Statistical Review of World Energy 2013, URL: http://www.bp.com/content/dam/bp/excel/Statistical-Review/statistical_review_of_world_energy_2013_workbook.xlsx. Retrieved August 14th, 2013