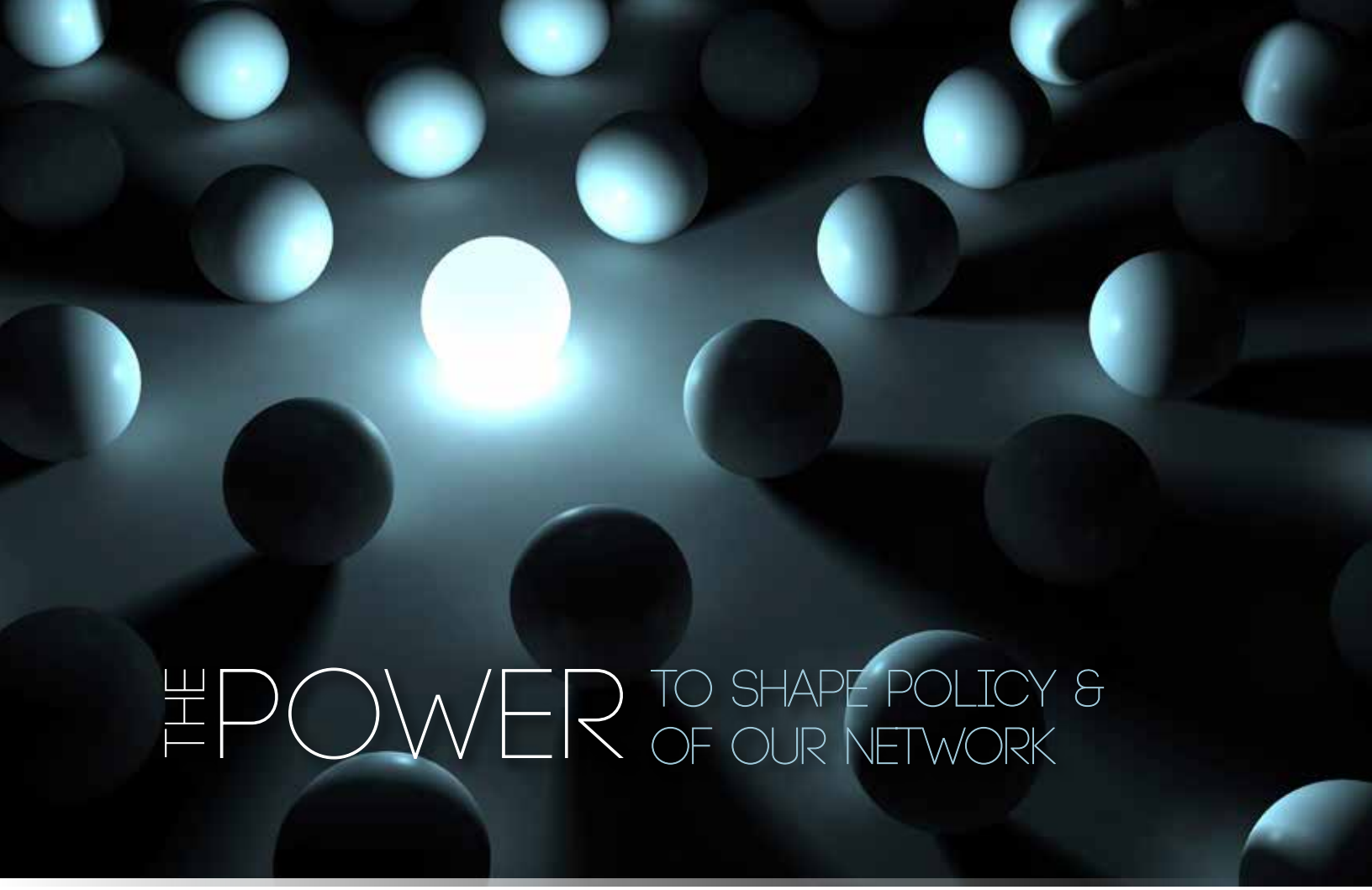
THE CANADIAN CHAMBER OF COMMERCE
LA CHAMBRE DE COMMERCE DU CANADA

The Voice of Canadian Business ™
connect! branché!
Le porte-parole des entreprises canadiennes MD

The Measures that Matter:

How Canada's Natural Resource Sector Is Working to Protect the Environment

December 2014



Get plugged in.

As Canada's largest and most influential business association, we are the primary and vital connection between business and the federal government. With our network of over 450 chambers of commerce and boards of trade, representing 200,000 businesses of all sizes, in all sectors of the economy and in all regions, we help shape public policy and decision-making to the benefit of businesses, communities and families across Canada.

Be heard.

The Voice of Canadian Business™

connect!

TABLE OF CONTENTS

1. Introduction 1

2. Forestry and Logging 3

3. Mining 10

4. Oil and Gas 22

    4.1 Oil Sands Mining 22

    4.2 Oil Sands In Situ 35

    4.3 Conventional and Hydraulic Fracturing 42

5. How Does Canada Compare? 53

6. Conclusion 61

1. Introduction

Natural resources are essential to our quality of life. Forest products are used to build houses and to produce an increasingly sophisticated range of products, such as biochemicals and bioenergy. The mining sector provides the materials to build everything from smartphones to crop fertilizers to ships and airplanes. Crude oil will power our trucks, ships and planes for the foreseeable future, and natural gas is an increasingly popular choice for both transportation and electricity generation.

Trends like urbanization and a growing middle class will continue to drive demand for natural resources. In China alone, the government is planning on moving the equivalent of three New York Cities from the country to its cities every year.[1] The growing middle class in other nations will want the same kinds of consumer goods and convenience we take for granted here in Canada, such as washing machines and the family car.

While natural resource production is needed to support growing global prosperity, it is also clear that there are implications for the environment. Natural resource industries are the front lines of environmentalism: the place where humanity's need for materials and energy directly confront the biological systems that support life on earth. There is ample evidence that several areas of human activity could lead to devastating impacts on local ecologies and the global environment.

Bringing the needs of a more prosperous world in line with the limits of the earth is one of the greatest challenges of our time. The environmental impacts of natural resource production are an increasingly important issue to communities across Canada, which demand a balance between economic development and environmental protection. Reducing consumption and developing lower impact goods and services are part of the solution, but so is finding ways to continually reduce the impact of extracting and harvesting essential natural resources. These are the "measures that matter."

Developing the regulations, practices and technologies to produce natural resources in an environmentally sustainable manner is a field in which Canada plays an important role in a global context. Canada is a world leader in the production of several types of natural resources.

- Canada is one of the largest exporters of several forest products, including softwood lumber and newsprint.[2]
- Canada is in the top five in the global production of potash, uranium, aluminum, cobalt, titanium, tungsten, cadmium, diamonds, platinum, sulphur and nickel.[3]
- Canada is the fifth largest producer of oil and the fourth largest exporter of natural gas.

In this report, the Canadian Chamber of Commerce examines the ways in which Canadian industry and governments are addressing the environmental challenges of resource production. The goal is to provide an overview of the approaches, technologies and tools being developed or put into practice to mitigate impacts on air, land and water.

The report focuses on the extractive or harvesting part of three natural resource industries: forestry and logging, metal and mineral mining, and oil and gas production. Transportation, such as pipelines, or manufacturing processes, like pulp and paper production, is beyond the scope of this report.

---

1 Ian Johnson. China's Great Uprooting: Moving 250 Million Into Cities. The New York Times. June 15, 2013. www.nytimes.com/2013/06/16/world/asia/chinas-great-uprooting-moving-250-million-into-cities.html?pagewanted=all

2 Natural Resources Canada. *Forest products*. September 2014. www.nrcan.gc.ca/forests/industry/13317 Accessed November 20, 2014

3 Mining Association of Canada. *Mining Facts*. http://mining.ca/resources/mining-facts Accessed November 20, 2014

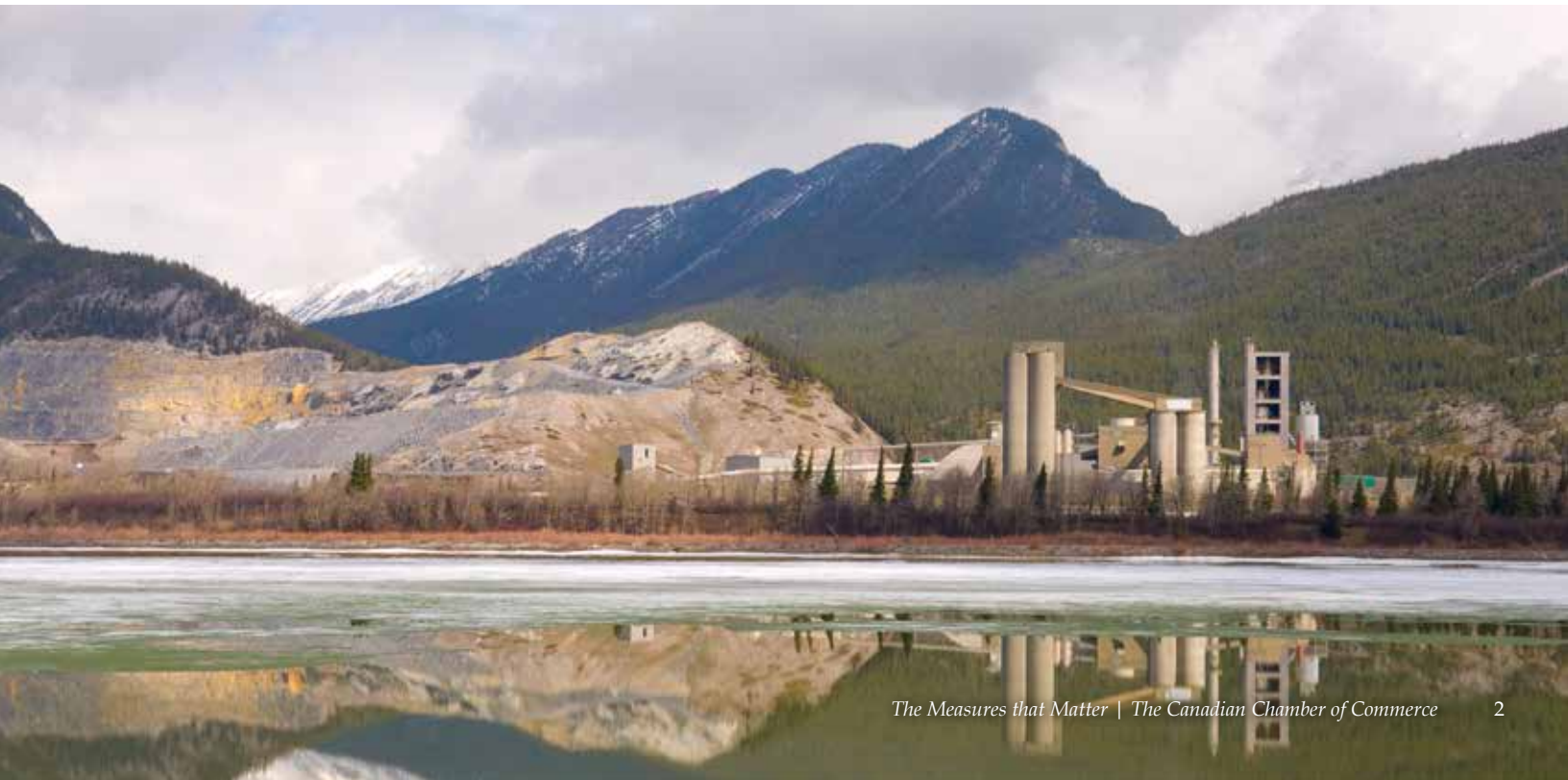
Three principal types of impacts are examined: impacts on land (land use as well as the effect on biodiversity), greenhouse gas emissions and impacts on water (water use and water quality). These are by no means the only impacts the resource sector has on the environment, but they are often the ones that are of top concern to communities potentially affected by these developments.

For each type of resource, this report provides a brief summary of the harvesting/extraction process and outlines the main environmental challenges posed by each stage of the process. It then describes some of the key strategies industry is using to address that particular environmental impact. For each strategy, the report attempts to answer three questions:

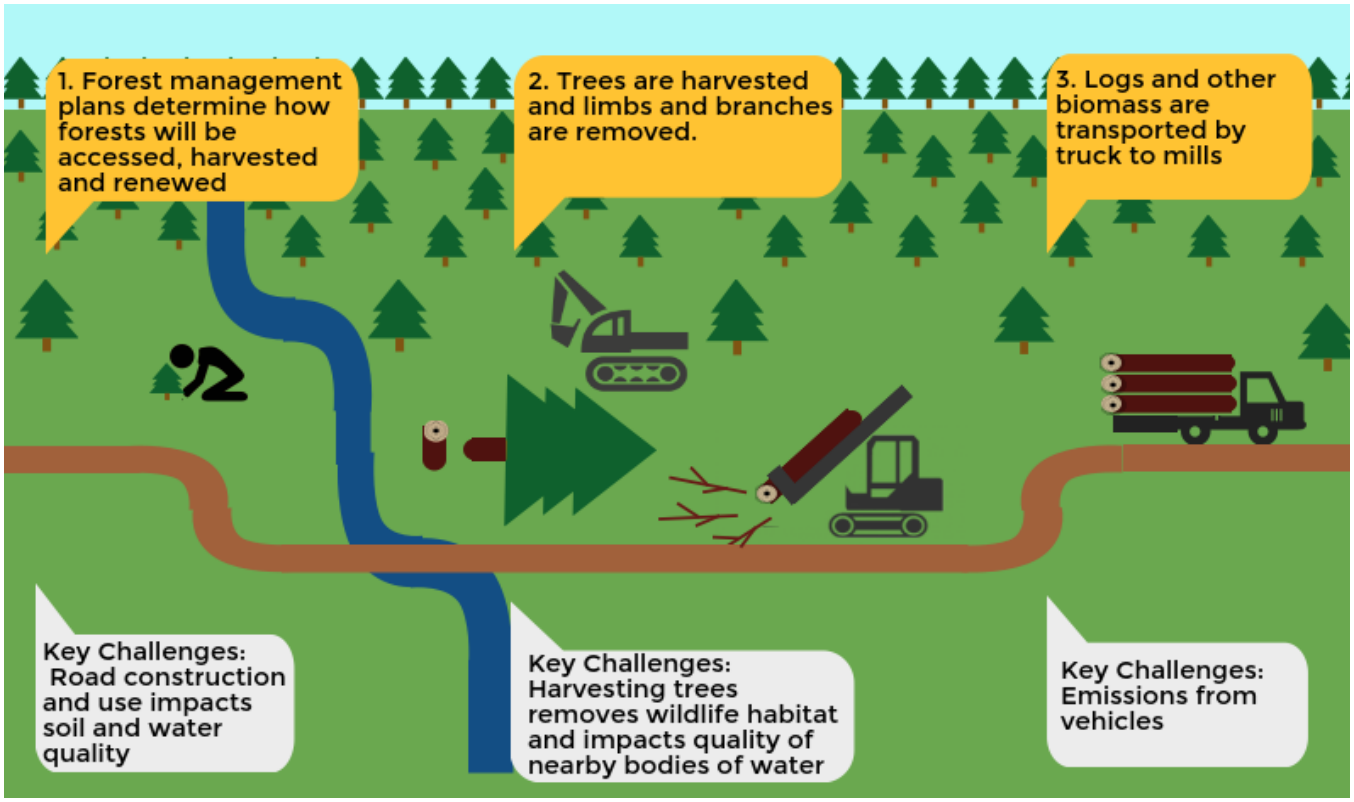
- *How is industry doing?* A look at indicators of industry's performance on addressing a particular impact. Where data on performance is not available, the report draws on information about the industry's efforts to address the issue or highlights some of the technological solutions being put forward. In some cases, the report includes a few examples of specific programs or technologies being applied to improve performance.
- *What is on the horizon?* In the course of our research, we discovered dozens of noteworthy examples of innovations that are now reducing environmental impacts or that show promise for the near future. The processes or technologies in this section are neither the industry norm nor revolutionary solutions, but represent encouraging examples of the potential of environmental innovations in every one of the natural resource sectors.
- *What is government's role?* A brief summary of some of the relevant government regulation or programs meant to address each environmental challenge.

The last chapter, *How Canada Compares*, brings some international context to Canada's performance. A comprehensive assessment of the environmental performance or regulation of Canada's resource sector is beyond the scope of this report. Instead, this chapter will draw on existing materials, where available, to describe how Canada's resource sectors stack up to their peers.

The struggle to strike a balance between economic development fuelled by natural resource production and protecting our environment is one of the most critical challenges of our time. This report examines some steps Canadians are taking to achieve this.



2. Forestry and Logging



CHALLENGE: IMPACTS ON LAND

Forests cover 40% of Canada's land surface, representing 10% of the world's forest cover.[4] Canada's forests provide a variety of important environmental services, such as purifying water, stabilizing soils, providing wildlife habitat and sequestering carbon dioxide emissions. Consequently, maintaining the health of Canada's forests is essential to any measure of environmental sustainability.

Human activities like harvesting trees or adapting forests lands to other uses are only a few of the disruptions forests face. Forests fires and insect damage affect a large area of Canada's forests each year. Forests naturally follow a cycle of disruption and recovery and, within limits, can recover from disturbances. Maintaining forest health requires practices to ensure human-caused disruptions are within the limits of the forests' ability to regenerate.

This section will look at the forests sector's performance at sustainably harvesting forest resources.

4 Natural Resources Canada. Forests in Canada: Key Facts. February 12, 2014. http://www.nrcan.gc.ca/forests/canada/13169. Accessed November 27, 2014.

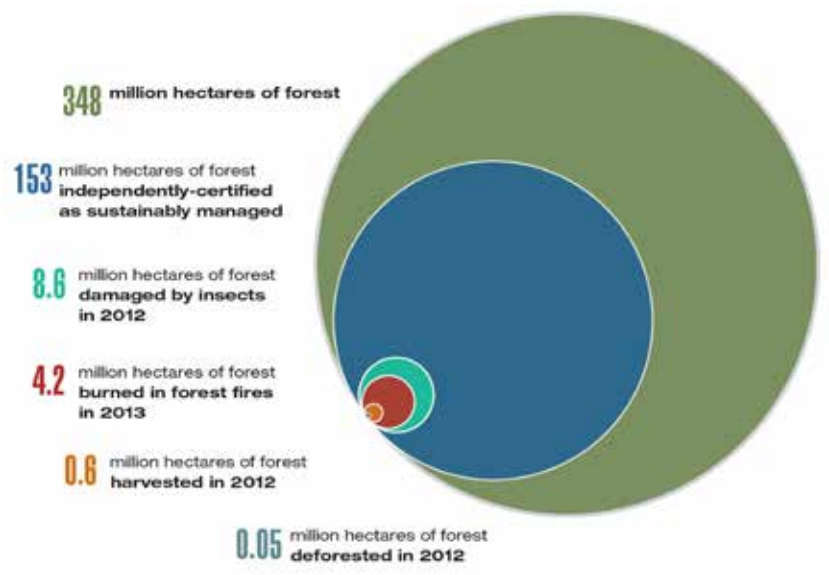


Figure 2.1: Area of forest land disrupted in Canada, 2012. Source: Natural Resources Canada, State of the Forests Report 2014.

Strategy: Sustainable Harvest

How Is Industry Doing?[5]

There are several ways to measure whether Canada's forest resources are being sustainably managed. One way is to look at whether wood harvesting levels are within a sustainable range. The level of wood supply that can sustainably be harvested has remained fairly constant over the past few decades, amounting to 227 million cubic metres in 2012.[6] The amount of wood harvested has remained well within this level, and in 2012, the harvest was 35% below the maximum sustainable level.[7]

Another measure of sustainable forest management practices is the use of sustainable forest management (SFM) certification. These are voluntary programs that ensure forests are being managed to standards recognized by non-governmental organizations. There are several certification systems, but third-party audits of plans and performance and public disclosure of findings are standard practices for all of them. Canada is a world leader in the use of third-party verified SFM certification, with 40% of the world's certified forests located in this country.[8]

Over the last two decades, the rate of deforestation in Canada has been decreasing and in 2010, it was less than 0.02%.[9] Because the forestry and logging industry replants the trees it harvests through natural regeneration or tree planting, the industry accounted for only 8% of deforestation, mostly due to the construction of forestry access roads. Agriculture (41%) and oil and gas (24%) were the two largest contributors to deforestation.[10]

---

5 Source for Figure 2.2: Environment Canada. *Environmental Indicators: Sustainability of Timber Harvest*. June 11, 2014. http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=A132BB91-1 Accessed December 2, 2014. Source for Figure 2.3: Canadian Council of Forest Ministers. *Sustainable Forest Management in Canada: Canada: Embracing Third-Party Certification*. 2014. http://www.sfmcanada.org/en/sustainable-forest-management/embracing-third-party-certification. Accessed December 2, 2014.

6 Natural Resources Canada. *The State of Canada's Forests: Annual Report 2014*. http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/35713.pdf

7 Natural Resources Canada. *The State of Canada's Forests: Annual Report 2014*.

8 Source for Figure 2.3: Canadian Council of Forest Ministers. *Sustainable Forest Management in Canada: Canada: Embracing Third-Party Certification*.

9 Natural Resources Canada. *Deforestation in Canada: The facts*. September 3, 2014. http://www.nrcan.gc.ca/forests/inventory/13419. Accessed December 2, 2014.

10 Natural Resources Canada. *The State of Canada's Forests: Annual Report 2014*.

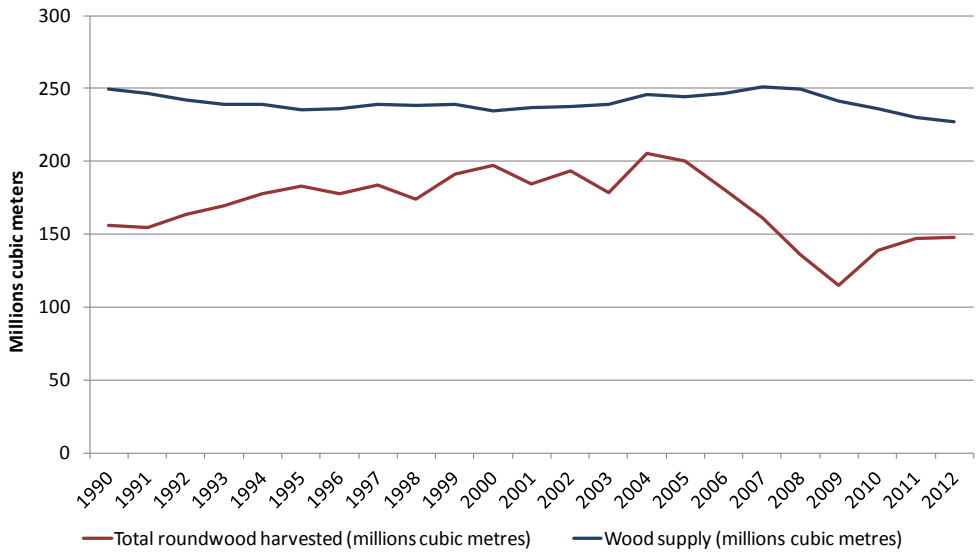


Figure 2.2: Canada's Sustainable Wood Supply and Industrial Roundwood Harvest, 1990 to 2011. Source: Environment Canada.

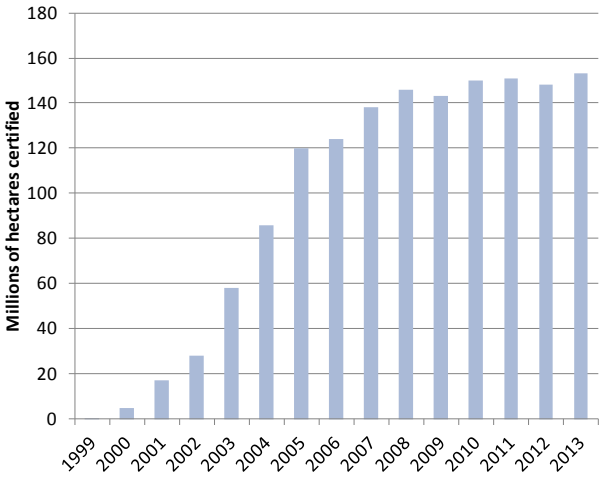


Figure 2.3: Area of Canada's Forests certified third-party Sustainable Forest Management programs, 1999 to 2013. Source: Canadian Council of Forest Ministers.

What Is on the Horizon?[11]

Using Lasers in Forest Inventories

Light detection and ranging (LiDAR) technologies measure distance by illuminating a target with a laser and analyzing the reflected light. LiDAR can be used to gain detailed information on the terrain in a forest block. Better knowledge of the terrain can help minimize the need for access roads, which have significant environmental impacts.

What Is Government's Role?

About 90% of Canada's forests are publically owned, meaning the provinces and territories play the central role in forest management. The provinces and territories use a range of tenure arrangements to grant rights and responsibilities to companies operating in public forests. Prior to removing any trees, governments must approve forest management plans and authorize the proposed harvesting.[12] Provinces typically set an annual allowable cut—a yearly level of harvest allowed on a particular area of

11 Source for Using Lasers in Forests Inventories textbox: Guy K.M. Smith and Steve D'Eon. "Precision forest inventory pays-off in woodlands and sawmills". *Logging and Sawmilling Journal*. December/January 2012. http://www.forestnet.com/LSJissues/Jan_12/the_edge.php

12 Natural Resources Canada. *Forests: Legality and Sustainability*. October 14, 2014. http://www.nrcan.gc.ca/forests/canada/sustainable-forest-management/13303#section-2 Accessed December 2, 2014.

Crown land over a specified number of years.[13] All the provinces require that forests harvested on public lands be successfully regenerated, either through the natural re-growth of trees or through artificial means like replanting tree seedlings.[14]

CHALLENGE: GREENHOUSE GAS EMISSIONS

The forestry and logging industry itself contributes less than 1% of Canada's greenhouse gas (GHG) emissions, mostly through diesel powered vehicles and machinery. Direct emissions from the sector have remained relatively stable since 2009 (the earliest year available in this data time series). However, looking at direct emissions alone fails to capture the full impact forestry has on GHG emissions.

Forests play a significant role in mitigating climate change: over the last 40 years, forests have absorbed about a quarter of humanity's carbon emissions.[15] Changes in forest cover contributed 4.5% of Canada's GHG emissions in 2012.[16] Many of the factors driving the ability of forests to absorb carbon are beyond industry's control, particularly forest fires. Forest products and wastes are increasingly used as a low-carbon source of energy. Switching to forest biomass from higher carbon sources of energy can provide GHG savings.

This section looks at two strategies the industry is pursuing to lower emissions:

- Using less energy
- Using lower carbon forms of energy

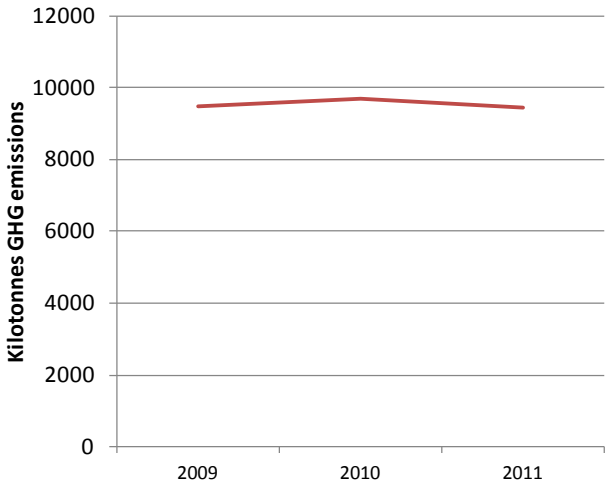


Figure 2.4: Emissions from forestry and logging, 2009 to 2011. Source: Statistics Canada CANSIM Table 153-0114

Strategy 1: Using Less Energy

How Is Industry Doing?

Over the past few decades, energy use in forestry and logging has not followed a clear trend, appearing to rise and fall in response to production.[17] Since 2009, there appears to be some

13 Conference Board of Canada. "Environment: Forest Cover Change". *How Canada Performs*. January 2013. http://www.conferenceboard.ca/hcp/details/environment/forest-cover-change.aspx Accessed December 2, 2014.

14 Natural Resources Canada. *Forests in Canada: Key Facts*. February 12, 2014.

15 Natural Resources Canada. *Forests: Climate change: Forest Carbon*. March 3, 2014. http://www.nrcan.gc.ca/forests/climate-change/13085 Accessed December 2, 2014.

16 Statistics Canada. *Table 153-0114 - Physical flow account for greenhouse gas emissions, annual (kilotonnes)* CANSIM (database). Accessed December 2, 2014.

17 Statistics Canada. *Table 153-0114 - Physical flow account for greenhouse gas emissions, annual (kilotonnes)*

improvement in the energy intensity of the sector. Despite a 28% increase in round wood production between 2009 and 2011, energy use in the sector rose by only 8%.[18]

Energy use in the broader forest product industry, which includes wood manufacturing and pulp and paper facilities, has also been falling in the recent past. From 2005 to 2011, energy use fell by 32% in the forest products sector.[19]

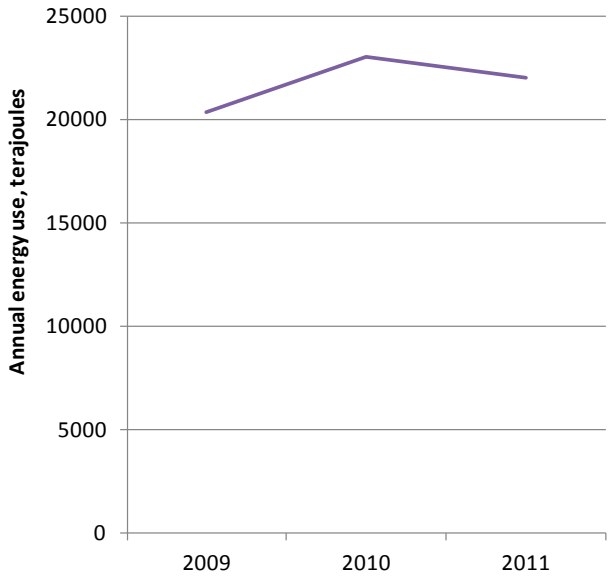


Figure 2.5: Energy use in the forestry and logging industry, 2009 to 2011. Source: Statistics Canada CANSIM Table 153-0113

What Is on the Horizon?[20]

More Aerodynamic Trucks

Sometimes small changes can have big impacts. For example, on logging trucks, stakes are used to hold logs in place but they cause unnecessary drag when the truck is unloaded. Simply folding down these stakes when not in use can reduce fuel usage by almost 15%, leading to emissions reductions of eight tonnes per vehicle per year. FPI Innovations, a forest products research centre, is working with trailer manufacturers to develop vehicles with foldable stakes.

Strategy 2: Using Lower Carbon Forms of Energy

How Is Industry Doing?

This report focuses on the harvesting/extraction end of the natural resource sectors. Unfortunately, data on fuel usage for the forestry and logging sector alone was not available from either Statistics Canada or the Canadian Industrial Energy End-Use Data and Analysis Centre, the two sources used in this report.

Looking at the forest product sector as a whole by including wood product and pulp and paper manufacturers, it appears as though some progress has been made. Members of the Forest Products Association of Canada have pledged that the industry as a whole will become carbon-neutral by 2015 without the purchase of carbon offset credits.[21]

Between 2007 and 2011, the forest products sector reduced its greenhouse gas intensity by 21%, although absolute emissions have risen by a substantial amount over the last few years. Much of the reduction in GHG intensity was due to switching from fossil fuels to biomass or hydroelectricity. In 2012, forestry wastes or by-products from milling and pulp and paper production accounted for 57% of the sector's fuel use, up from 46% in 1990. The sector has eliminated its use of coal and reduced its use of fuel oil by over 90%.[22] Some forest product facilities are now net suppliers of electricity to provincial grids.

18 Statistics Canada. *Table 153-0113 - Physical flow account for energy use, annual (terajoules)*, CANSIM (database). Accessed December 2, 2014.

19 International Council of Forest and Paper Associations. *2013 ICFPA Sustainability Progress Report*. www.icfpa.org/uploads/Modules/Publications/icfpa-2013-progress.pdf

20 Mithun Shetty. "Aerodynamic modelling reduces forestry truck fuel consumption". Logging and Sawmill Journal. May 2014. www.forestnet.com/LSJissues/2014_may/the_edge.php Accessed December 2, 2014.

21 Forest Products Association of Canada. *Vision2020 Report Card: 2010 to 2012*. June 2014. www.fpac.ca/images/uploads/Vision2020_ReportCard_2014.pdf

22 International Council of Forest and Paper Associations. *2013 ICFPA Sustainability Progress Report*.

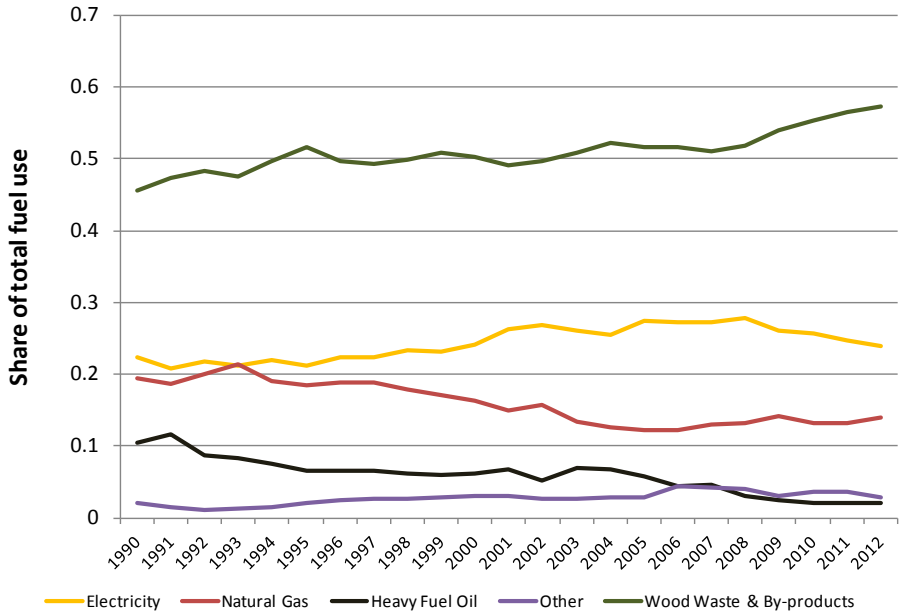


Figure 2.6: Share of various energy sources in total fuel use for the wood products and pulp and paper sectors, 1990 to 2012. Source: Canadian Industrial Energy End-Use Data and Analysis Centre

What Is on the Horizon?[23]

Natural Gas-powered Trucks

Natural gas can be used to replace diesel in transportation trucks, leading to potential greenhouse gas savings of up to 25%. British Columbia has been supporting the use of natural gas vehicles for forestry and other applications by providing grants for natural gas trucks and building refuelling facilities throughout the province.

New Products from Forest Wastes

Alterna Energy Inc. is developing a process that uses forestry wastes, like bark and pine-beetle infested wood, and transforms it into biocarbon. The process carbonizes and pelletizes almost any form of biomass with virtually no external energy inputs. Since the physical and chemical properties of biocarbon are similar to coal, the product can be used as a low-carbon substitute in existing coal-powered electricity plants.

What Is Government's Role?

Greenhouse gas regulations are both a federal and provincial responsibility. The federal government has released regulations on coal-powered electricity generation and transportation, but has not put into place any regulations specifically targeting the forest products sector. British Columbia has put into place a carbon tax of $30 per tonne of carbon dioxide equivalent emissions on all purchases of fuel in the province. Quebec has joined with California in a cap and trade system that applies to businesses that emit 25,000 metric tonnes or more of carbon dioxide equivalent a year. Governments have also been supporting greenhouse gas reductions in the sector through funding programs like the Pulp and Paper Green Transformation Program, which is discussed in greater detail on page 9.

23 Source of Nautral Gas Powered Trucks textbox: FPInnovations. *Natural Gas Trucks: Greenhouse Gas Reductions*. https://fpinnovations.ca/ResearchProgram/natural-gas-trucks/Pages/fortisbc-ngt-incentive-program.aspx#.VIYRWjHF9hw Accessed December 2, 2014. Source for New Products from Forest Wastes Textbox: Sustainable Development Technology Canada. *SDTC Portfolio Projects*. www.sdtc.ca/uploads/Portfolio_English.html Accessed December 2, 2014.

CHALLENGE: WATER USE AND QUALITY

Forestry and logging can have a variety of impacts on water quality. When timber harvesting occurs near streams, wetlands or lakes, it can result in increased water temperatures or a greater volume of sediment entering waterways. The construction and use of forestry roads can also cause sediment to contaminate water bodies, affecting plant and wildlife. Discharges from pulp and paper mills, in particular, can have an impact on water quality.

Strategy: Reducing Water Effluent

How Is Industry Doing?

As was the case with fuel use, measures of water quality were not available for the forestry and logging sector alone, therefore this data includes the wood products and pulp and paper manufacturing sectors.

One way to measure water quality is to assess the amount of oxygen in the water. Organic materials from mills or other parts of the forest industry use up oxygen as they decompose, taking it away from aquatic life. Biochemical oxygen demand is a measure of the quantity of oxygen used by microorganisms in the oxidation of organic matter. Reducing this measure allows for more oxygen in the body of water for other aquatic life. Between 2005 and 2011, industry reduced its impact on biological oxygen demand by 34%.[24]

Total suspended solids measures the amount of solids present in a quantity of water. From 2005 to 2011, industry reduced total suspended solids by 72%. Most of these solids are now used for energy generation, composting or other applications.[25] In more recent years, this measure has been trending upwards. Industry and government must continue to implement new measures in order to continue to progress in this area.

What Is Government's Role?

Discharges of waste water from industrial facilities like pulp and paper mills are regulated by the federal and provincial governments. The federal regulations limit the maximum biological oxygen demand and suspended solids for paper mills and require monitoring and emergency response programs to be established.[26]

From 2009 to 2012, Natural Resources Canada ran the Pulp and Paper Green Transformation Program to help industry make capital investments that could both improve the environmental performance of Canada's pulp and paper mills and increase the competitiveness of the sector. The program helped industry put into place new processes and equipment that helped industry reduce its impacts on water quality.

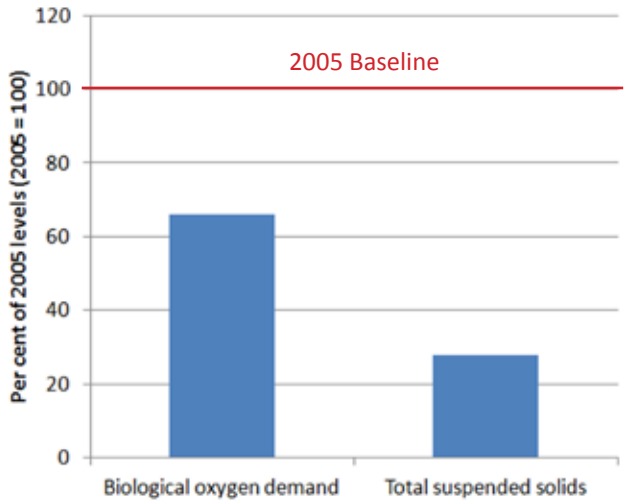


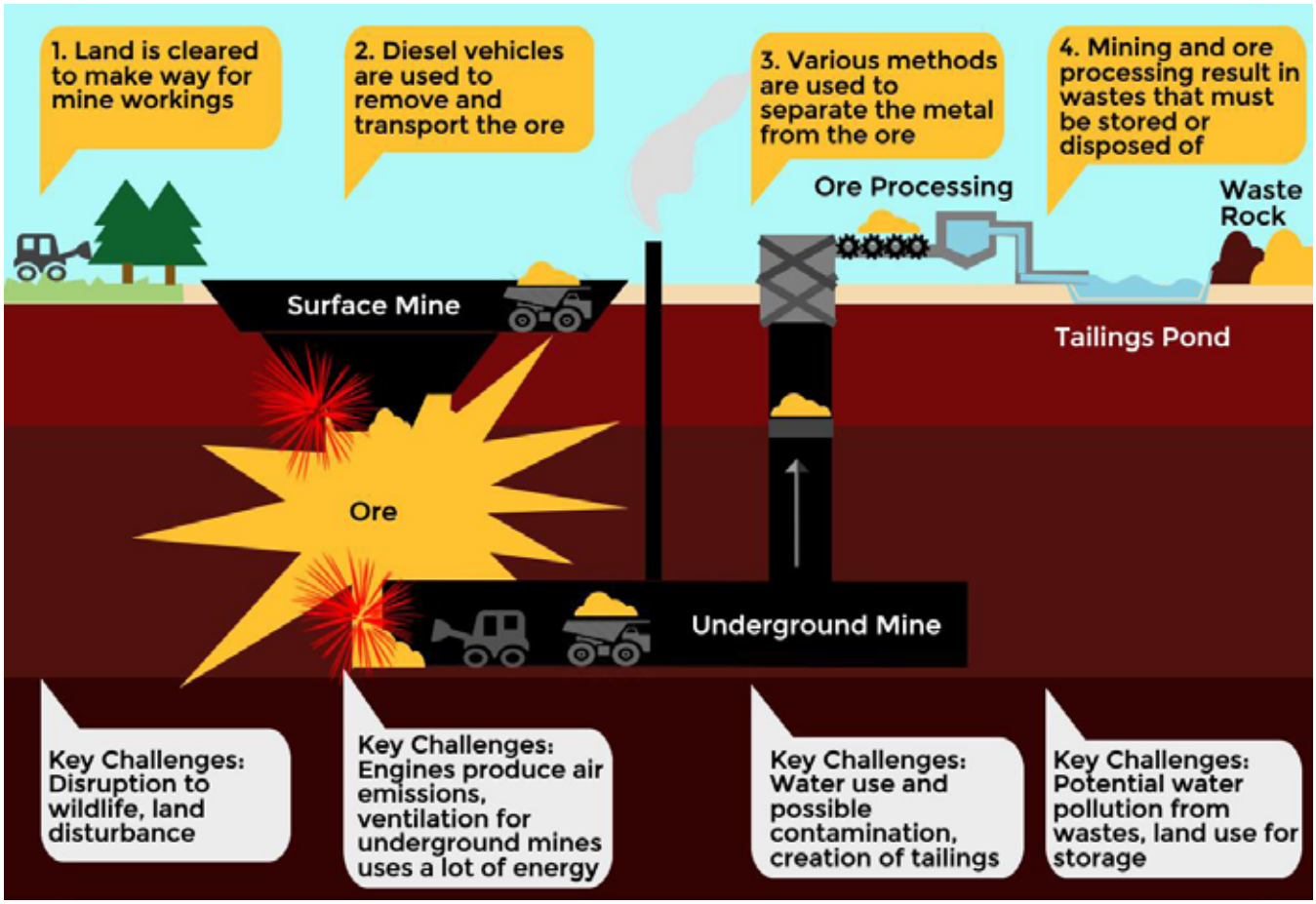
Figure 2.7: 2011 levels of Biological Oxygen Demand and Total Suspended Solids as a per cent of their 2005 levels. Source: Forest Products Association of Canada.

24 International Council of Forest and Paper Associations. *2013 ICFPA Sustainability Progress Report.*

25 Forest Products Association of Canada. *Vision2020 Report Card: 2010 to 2012.*

26 Government of Canada. Pulp and Paper Effluent Regulations. http://laws-lois.justice.gc.ca/eng/regulations/SOR-92-269/page-7.html#h-14 Accessed December 2, 2014.

3. Mining



Most of the indicators for this report were drawn from two sources. The first is a 2013 report by Natural Resources Canada entitled *Mining Sector Performance Report: 1998-2012.* The second is the Mining Association of Canada's Towards Sustainable Mining (TSM) initiative, which set out a series of reporting protocols, best practices and other tools to improve the sector's sustainability. Participation in the TSM—which is mandatory for members of the Mining Association of Canada—requires that individual mining facilities report on the measures they are taking to improve performance in a number of areas, particularly greenhouse gas emissions, biodiversity conservation and tailings management.

CHALLENGE: IMPACTS ON LAND

Over the past 100 years less than 0.01% of Canada's land area has been used for the production of minerals and metals. Land is needed for every stage of the mine cycle, including exploration, construction, operation, closure and post-closure. Roads, buildings, power lines, pits and tunnels, and waste storage facilities all require vegetation to be cleared and land to be disrupted, potentially leading to habitat loss and deforestation.[27]

There are a number of strategies for reducing the land-use impacts of mining. This section will focus on the following two:

- Conserving biodiversity
- Rehabilitating mine sites

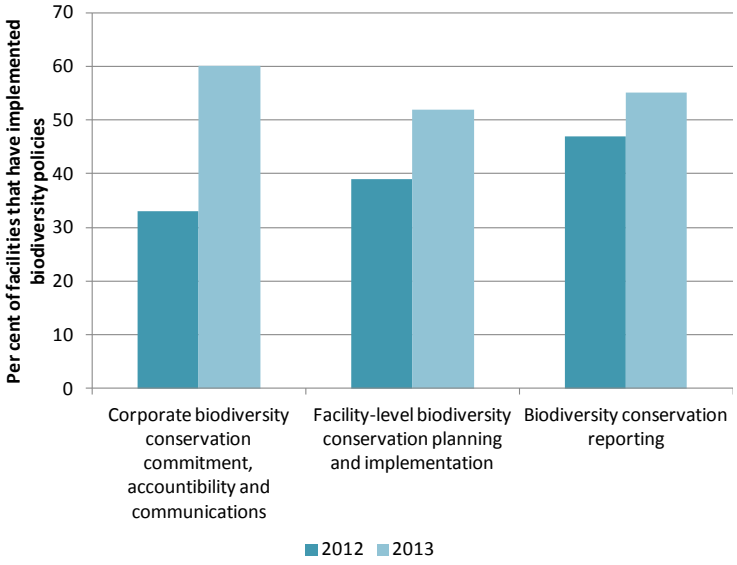


Figure 3.1: Percent of mining facilities that have implemented biodiversity policies as part of the Towards Sustainable Mining Initiative, 2012 and 2013. Source: Mining Association of Canada.

Strategy 1: Conserving Biodiversity

How Is Industry Doing?[28]

Biodiversity in a particular region is affected by a range of human activities, such as industry, agriculture and urbanization. The Towards Sustainability Mining project recently began measuring the actions mining companies are taking to protect biodiversity through three indicators. Under the first indicator—corporate biodiversity conservation commitment, accountability and communications—companies had to demonstrate a commitment to conservation, including defined roles and responsibilities for its implementation. The second indicator—facility-level biodiversity conservation planning and implementation—measures whether a facility has put a biodiversity conservation plan in place, including processes for setting targets, monitoring, consulting with communities and training employees. The last indicator—biodiversity conservation reporting—measures whether the mining facility has put into place systems to report on performance, both internally and to the public.

Since reporting on these indicators began in 2012, there has been an increase in the number of facilities that have implemented these practices.

27 Fraser Institute. *How Can Mining Become More Sustainable?* Miningfacts.org. http://www.miningfacts.org/Environment/How-can-mining-become-more-environmentally-sustainable/ Accessed November 18, 2014.

28 Source of *Land Conservation* textbox: *Teck Resources. Sustainability at Teck: Conserving Land in the East* Kootenays. June 25, 2014. http://www.tecksustainability.com/sites/base/pages/story-detail/conserving-land-in-the-east-kootenays-109930 Accessed November 18, 2014. Sources of *Up to Something Fishy* textbox: Vale. Biodiversity: Fish Rearing. http://www.vale.com/canada/en/aboutvale/communities/health-safety-environment/our-environment/reclamation-and-decommissioning/reclamation-and-decommisioning-sudbury/pages/biodiversity.aspx. Accessed November 18, 2014. Lisa Wright. Bees help restore Sudbury mining site. *The Toronto Star*. October 13, 2014. http://www.thestar.com/business/2014/10/13/bees_help_restore_sudbury_mining_site.html. Accessed October 18, 2014.

What Is on the Horizon?

Land Conservation

To promote biodiversity in British Columbia, Teck Resource purchased over 7,000 hectares of private land to set aside as a protected area. With an area the size of 17 Stanley Parks, it is the largest private purchase of land for conservation in the province's history. The land will provide critical habitat for Grizzly bears, wolverines, elks, trout and other species and holds significant cultural importance for local communities and First Nations. Teck consulted with First Nations and environmental groups to determine which lands to purchase.

Up to Something Fishy

Vale, a global mining company with operations in Sudbury, has been working to boost fish populations and biodiversity in waterways that have historically been affected by their mining operations. In 2011, the company began raising fish at a surface greenhouse and, since that time, has released 5,000 rainbow trout and 1,000 walleye into a local river. Vale has also been raising fish at its underground greenhouse, which also serves as a tree nursery. The wastes from the fish are used as fertilizer for the trees, replacing chemical fertilizers.

What Is Government's Role?

As the primary custodians of natural resources in their jurisdiction, the provinces have authority over many important components of biodiversity. Ontario, British Columbia, Manitoba and Alberta have all released their own biodiversity strategies.[29]

Land-use planning—the process of evaluating and regulating land use in order to balance competing land use—is an important tool to ensure human activity is compatible with maintaining important environmental functions. A 2013 evaluation of trends in mining sector performance noted that the absence of up-to-date land-use plans over large stretches of Canada is becoming an issue as pressure to conserve or develop land intensifies. The report noted some provincial government leadership in this area—for example, 85% of British Columbia is covered by land-use plans—but ultimately could not do a complete assessment on whether performance was improving in this area.[30]

The federal government has jurisdiction over fisheries, species at risk, migratory birds and navigable waters.

Under the *Fisheries Act*, any fish habitat that is destroyed must be replaced. Recent bitumen mines have been required to provide double the amount of habitat that is affected by their operations.[31]

The federal *Species at Risk Act* makes it illegal to kill or harm a species at risk or destroy its critical habitat. There are over 500 species listed as being at risk under the Act, and various federal agencies are responsible for creating recovery strategies that set out the measures needed to stop or reverse the decline of a species. In 2013, a report by the Commissioner of the Environment found that the federal government had not met its legal requirements to establish these recovery strategies, having only seven of the 97 required action plans in place.[32]

Both levels of government have measures in place to protect certain at risk species, such as caribou. For example, the Federal Recovery Strategy for

---

29 Environment Canada. *Canada's 5th National Report to the Convention on Biological Diversity*. March 2014. http://www.cbd.int/doc/world/ca/ca-nr-05-en.pdf Accessed November 18, 2014.

30 Natural Resources Canada. *Mining Sector Performance Report: 1998-2012*. August 2013.

31 University of Alberta. Fish Habitat Compensation Lakes. July 30, 2012. http://www.osrin.ualberta.ca/en/Resources/DidYouKnow/2012/July/FishHabitatCompensationLakes.aspx. Accessed October 29, 2014.

32 Office of the Auditor General. "Chapter 6 – Recovery Plans for Species at Risk". *2013 Fall Report of the Commissioner of the Environment and Sustainable Development*. November 2013.

Woodland Caribou sets a minimum target that 65% of critical habitat for caribou should remain undisturbed.[33] Provinces have created their own protection plans as well. For example, Alberta requires construction activities happening in caribou zones to submit Caribou Protection Plans that outline how the company will work to minimize disruptions to caribou habitat.[34]

Aside from its regulatory responsibilities, the federal government announced the $252-million National Conservation plan in 2014 to restore and conserve land and waterways over the next five years. Canada has also developed goals and targets for biodiversity that were informed by the Aichi Targets set out by the UN Convention on Biological Diversity.[35]

Strategy 2: Rehabilitating Mine Sites

How Is Industry Doing?[36]

Mine closure is the process of winding down a mine on a temporary or permanent basis. In Canada, mining companies are required to present regulators with plans on how they will close and reclaim a mine long before operations begin. These plans outline how the mine will be rehabilitated throughout its life cycle, how it will be decommissioned and how much financial security will be posted to ensure the funds to carry out these activities will be available. Modern mines are "designed for closure," meaning that consideration of how the land will be used by future generations starts right in the design phase and continues throughout the life of the mine. No national data on the success of mining sector reclamation activities could be identified for this report.

Before current regulatory measures were put into place, inadequate regulation or bad management resulted in 10,000 mine sites whose liabilities have been left to government and that require various degrees of rehabilitation. These orphaned or abandoned mines pose economic, environmental and safety problems to local communities. The National Orphaned/Abandoned Mines Initiative has successfully closed or decommissioned a number of mines and is currently developing an inventory that will provide a Canada-wide perspective on the number and status of these mine sites.

What Is on the Horizon?[37]

Improving Tree Survival

Mikro-Tek Inc. is developing a technology that enables grasslands and forests that have been damaged by industrial development to be reclaimed. To promote growth on these lands, Mikro-Tek has harnessed a naturally occurring soil fungi called mycorrhizae and has developed a method to inoculate seedlings and plant roots. The increased growth rates enable these plants to capture harmful climate change gases and mining companies to cost-effectively reduce their environmental and social impact.

Using Forestry Waste in Mine Remediation

Goldcorp and Abitibi-Bowater have experimented in using pulp and paper waste to rehabilitate the Porcupine Gold Mine in Timmins. The forest product waste was normally disposed of in specially constructed landfills, where it released greenhouse gases, such as methane, as it decomposed. The waste is similar to compost and provided an environmentally sound solution to more traditional chemical fertilizers. Porcupine first began using biosolids on a tailings dam to reduce dust and, in less than two years, not only were dust emissions nearly

33 Environment Canada. "Recovery Strategy for the Woodland Caribou (Rangifer tarandus caribou), Boreal population, in Canada." *Species at Risk Recovery Strategy Series*. 2012

34 Government of Alberta. Caribou Protection Plans. July 22, 2014 http://esrd.alberta.ca/fish-wildlife/wildlife-management/caribou-management/caribou-protection-plans/default.aspx. Accessed October 29, 2014.

35 Biodivcanada.ca. *Draft 2020 Biodiversity Goals and Targets for Canada.* Accessed November 18, 2014. http://www.biodivcanada.ca/default.asp?lang=En&n=00248250-1

36 Source of Rehabilitating Coal Creek North Pit 7 textbox: Canadian Land Reclamation Association. Reclamation Stories. http://www.clra.ca/default.aspx?page=29 Accessed November 20, 2014.

37 Source for *Improving Tree Survival* Textbox. Sustainable Development Technology Canada. *SDTC Portfolio*. http://www.sdtc.ca/uploads/Portfolio_English.html Accessed November 20, 2014. Source for *Using Forestry Waste in Mine Remediation* textbox. Goldcrop. Environmental Case Studies: Biosolids as soil cover. http://www.goldcorp.com/files/annual_reports/Report2010/6_environmental.htm. Source for Using Mine Tailings as agricultural land textbox: Natural Resources Canada. *Mining Sector Performance Report: 1998-2012.*

eliminated, but a vegetative cover was established that, over the years, has attracted a variety of small mammals, birds of prey, migrating birds and black bears. The same process is now being used at other parts of the mine.

Using Mine Tailings as Agricultural Land

Natural Resources Canada has been working with industry on research into combining mine site rehabilitation with biofuel production. To date, the Green Mines Green Energy initiative has worked with three mines in Northern Ontario to use biosolids as cover for six hectares of tailings. The land is used to grow canola, sunflower, switchgrass and hybrid willow. With more than 41,000 hectares of mine tailings in Canada, turning mine tailings into agricultural land could have significant benefits in reducing dust and eliminating exposure of tailings to water and oxygen as well as providing new sources of renewable fuels that do not compete with food production.

What Is Government's Role?

In Canada, the provincial governments and the government of Yukon regulate the mining industry and have all developed and enacted legislation and regulations for the administration of mining activities and mine closure. Provincial governments across Canada require mines to provide closure and remediation plans before permits are issued. All the provincial, territorial and federal governments have legislation in place to provide financial insurance for reclamation in the event the mine operation is unable to do so. New Brunswick and Ontario require financial assurance covering the complete cost of mine cleanup, while Quebec requires funds covering 70%.[38]

CHALLENGE: GREENHOUSE GAS EMISSIONS

Metal and non-metal mines accounted for less than 1% of Canada's greenhouse gas (GHG) emissions in 2012.[39] Almost all (95%) of the mining sector's GHG emissions comes from energy use, mostly in the form of diesel-powered electricity generation and vehicles.[40] Moderate progress has been made on the sector's GHG emissions. In 2012, the mining industry produced 12% less emissions for each tonne of milled ore than it did in 1990, although emission intensity for the non-metal mining has been rising in recent years.[41] Although more mining firms are implementing plans to reduce GHG emissions, the majority of firms still do not have plans in place. In

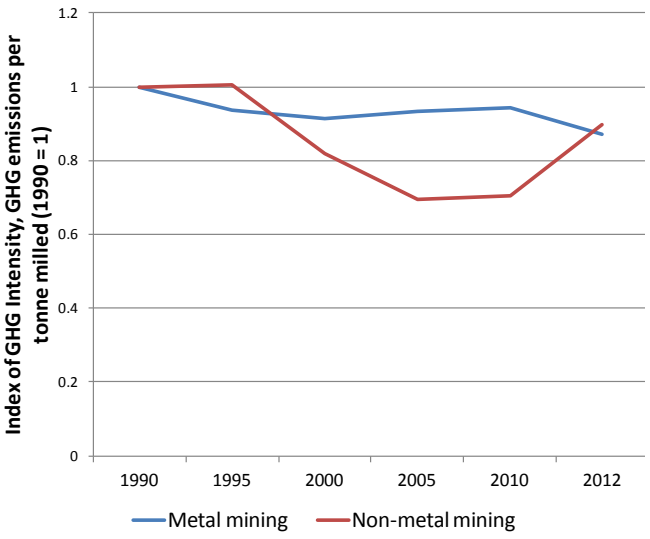


Figure 3.2: Greenhouse gas emission intensity (kt CO_2 per Mt mine output) in the mining sector, 1990 to 2012 (excluding oil, gas and coal) Source: Canadian Industrial Energy End-Use Data and Analysis Center, Simon Fraser University

38 Miningfacts.org. *What happens to mine sites after a mine is closed?* http://www.miningfacts.org/environment/what-happens-to-mine-sites-after-a-mine-is-closed/ Accessed November 20, 2014.

39 Canadian Industrial Energy End-Use Data and Analysis Center. Industry Specific Reports. 2122 - Metal Ore Mining and 2123 Non-Metal Min. Mining and Quarrying.

40 The Mining Association of Canada. *Energy and GHG Emissions Management Guidance Document*. July 2009. http://mining.ca/sites/default/files/documents/EnergyandGHGEmissionsManagementGuidanceDocumentJuly2009.pdf

41 John Nyboer and Michelle Bennett. *Energy Use and Related Data: Canadian Mining and Metal Smelting and Refining Industries, 1990 to 2012.*

2006, only 23% of mining facilities participating in the TSM initiative had GHG targets in place; by 2012, that number had risen to 43%. Over half of TSM firms now have GHG management and reporting systems in place.[42]

Energy is a significant cost for the sector, with electricity alone accounting for up to 10% of the production costs for a typical mine.[43] Energy costs have been rising, more than doubling over the 2000s, giving industry a strong economic incentive to reduce both energy use and emissions.[44] Industry is using a number of strategies to reduce its GHG emissions. This section will focus on the following two strategies:

- Using energy more efficiently
- Using lower carbon sources of energy

Strategy 1: Using Energy More Efficiently

How Is Industry Ding?

Changes in energy intensity can be influenced by factors beyond an individual miner's control. As easily accessible deposits get used up, miners must dig deeper or go through harder rock to access ore. In many cases, ore deposits are becoming less rich, meaning more and more ore has to be dug up in order to recover a certain amount of metal or mineral. Different types of mines might have different energy needs so changes in the types of metals or minerals being produced—such as the introduction of diamond mining to Canada in the late 1990s—can impact the industry's overall energy usage.[45]

An analysis by the Simon Fraser University found that the energy intensity of mining—the amount of energy needed to produce a tonne of milled ore—fell by 12% from 1990 to 2012. Metal mines improved their energy efficiency by almost 10% between 1990 and 2012, while non-metal mines improved by 19% over the same time period; although since 2010, energy intensity has been trending upwards.[46]

Another measure of industry's efforts in energy efficiency is the steps companies are taking to reduce energy use. In 2006, about a quarter of mining facilities participating in the TSM initiative had implemented energy intensity performance targets. By 2012, 52% of facilities had implemented targets. More facilities are also implementing energy use management and reporting systems in their facilities, helping to identify issues and implement solutions.[47] While these figures show improvement, more facilities should be implementing tools to improve their performance on energy use.

---

42 Mining Association of Canada. *Towards Sustainable Mining Progress Report 2014*.

43 Natural Resources Canada. Green Mining Initiative Energy Efficiency. http://www.nrcan.gc.ca/mining-materials/green-mining/8218. Accessed November 19, 2014.

44 Mining Association of Canada. *Facts & Figures of the Canadian Mining Industry 2013*. http://mining.ca/sites/default/files/documents/FactsandFigures2013.pdf

45 John Nyboer and Michelle Bennett. *Energy Use and Related Data: Canadian Mining and Metal Smelting and Refining Industries, 1990 to 2012. March 2014*. Canadian Industrial Energy End-use Data and Analysis Centre prepared for the Mining Association of Canada.

46 John Nyboer and Michelle Bennett. *Energy Use and Related Data: Canadian Mining and Metal Smelting and Refining Industries, 1990 to 2012*.

47 Mining Association of Canada. *Towards Sustainable Mining Progress Report 2014*. http://mining.ca/sites/default/files/documents/TSM_Progress_Report_2014.pdf

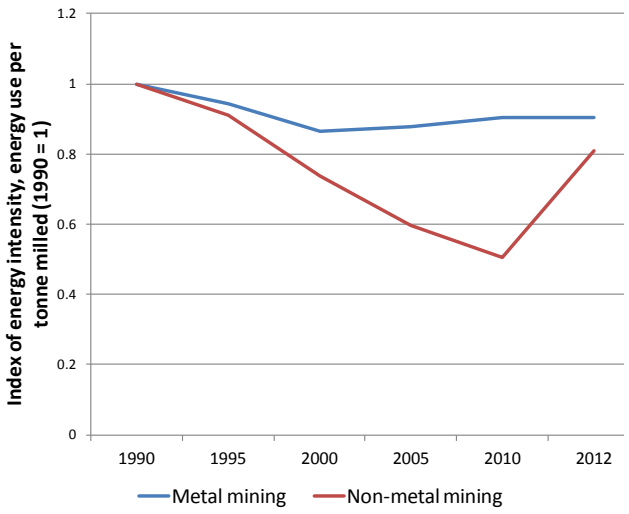


Figure 3.3 Energy intensity (energy composite per tonne milled) for metal and non-metal mines, 1990 to 2012. Source: Canadian Industrial Energy End-Use Data and Analysis Center, Simon Fraser University

What Is on the Horizon?[48]

Ventilation on Demand

In underground mining, ventilation systems are needed to make sure the air is safe for mine workers. Ventilation is a huge energy consumer, using between 40 to 60% of an underground mine's total energy consumption. Ontario's BESTECH has developed a system that will allow mine operators to only use ventilation where and when it is needed, rather than running the system all the time. By targeting ventilation only where it is needed, the system will reduce energy use by 12 to 20%, reducing GHG emissions in the process.

Bump and Grinding Circus

After it is removed from the earth, ore needs to be broken into small pieces in order to start the process of removing the valuable metal or mineral from the surrounding rock. The process of crushing and grinding is very energy intensive, and for some surface mines, can represent up to 60% of their energy use and 35% of their greenhouse gas emissions. As much as 3% of global electricity use goes towards this one part of the mining process. Barrick Gold has been experimenting with various measures to improve this process. The measures have resulted in a 20% bump to energy efficiency of the grinding processes, saving the equivalent of annual emissions of over 9,000 passenger cars

Hybrid Mining Vehicles

The vehicles that dig and transport the ore in an underground mine are usually powered by diesel, creating emissions that must be removed with power-intensive ventilation systems. Natural Resources Canada has been working with a Canadian company to develop the world's first hybrid diesel-electric scoop tram, a type of mining vehicle. By decreasing noxious gases and particles released into the air, hybrid vehicles could reduce the amount of energy used for ventilation by 20 to 40%.

Strategy 2: Using Lower Carbon Sources of Energy

How Is Industry Doing?

Progress on this strategy has been somewhat mixed. Since 1990, the mining industry has been using less heavy fuel oil and more diesel and propane. Shifting from fuel oil to diesel has little impact on GHG emissions, as both releases a similar amount of GHG per gallon (11.8 kg CO_2 / gallon for heavy fuel oil compared to 10.2 kg CO_2 / gallon for diesel). On the other hand, propane releases less than half the emissions of heavy oil and its increasing use would lower emissions for the industry.

48 Source for *Ventilation on Demand* textbox: Cheryl L. Allen and Trang T. Tran. *Ventilation-On-Demand Control System's Impact on Energy Savings and Air Quality*. April 2011. http://www.bestech.com/Downloads/Whitepapers/VOD%20Impact%20CIM_Montreal-CHERYL%20ALLEN-2011-04-21.pdf Accessed November 18, 2014. Source for *Bump and Griding Circuits* textbox: Lloyd Buckingham et al. *Improving Energy Efficiency in Barrick Grinding Circuits*. Fifth international conference on autogenous and SEMIAUTOGENOUS GRINDING TECHNOLOGY (SAG 2011). http://www.ceecthefuture.org/wp-content/uploads/2013/01/Improving-Energy-Efficiency-in-Barrick-Grinding-Circuits3.pdf?dl=1 Accessed November 18, 2014. Source for *Hybrid Mining Vehicles* textbox. Emmanuelle Brière. *Clean Energy-Powered Mining Vehicles*. Science @ NRCan. May 2012. http://www.nrcan.gc.ca/science/story/1367 Accessed November 20, 2014.

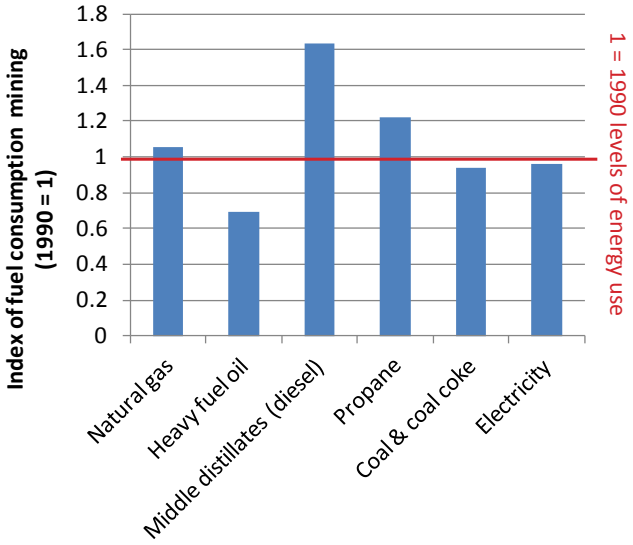


Figure 3.4: Index of fuel consumption in the mining sector in 2012, compared to 1990 levels. Source: Canadian Industrial Energy End-Use Data and Analysis Center, Simon Fraser University

What Is on the Horizon?[49]

Harnessing the Wind

Rio Tinto has developed a wind-diesel facility to power its Diavik Diamond mine in the Northwest Territories. The nine-megawatt plant is the most northern large-scale facility of its type in the world and its innovative turbines are designed to withstand -40°C temperatures. In 2013, the facility provided 10% of the mine's power needs, preventing the equivalent of the emissions from 2,500 cars from entering the atmosphere and reducing the winter fuel haul by 100 loads.

Floating Solar Energy

Located in Ontario, the Mining Innovation Rehabilitation and Applied Research Corporation, or MIRARCO, is the largest not-for-profit applied research firm in North America. MIRARCO is conducting research on generating electricity from a flexible system photovoltaic that floats directly above the water surface like tailing ponds. A demonstration project is currently underway in Malta. The array of panels, measuring about 20 metres by 20 metres, is expected to have a peak output of eight kilowatts, enough power for two typical three-bedroom homes.

49 Source for *Harnessing the Wind* textbox. Dominion Diamond Corporation. *Wind Farm*. http://www.diavik.ca/ENG/ouroperations/565_wind_farm.asp# accessed November 19, 2014. Source for *Switching to Natural Gas* textbox: Mining Association of Canada. *Facts & Figures of the Canadian Mining Industry 2013*.

Switching to Natural Gas

As an energy source, natural gas offers many of the same advantages as diesel but with fewer GHG, air and particle emissions. Shell and Caterpillar are developing a new mining haul truck that runs on liquefied natural gas, potentially reducing GHG emissions by 25% compared to a diesel-powered vehicle. Stornoway Diamond Corporation recently ran a feasibility study on switching power generation for its Renard Diamond Project from diesel to natural gas, a change that would reduce GHG emissions by 43%.

What Is Government's Role?

Four provinces account for three-fourths of the value of Canada's mineral production: Ontario, Quebec, Saskatchewan and British Columbia. These provinces have been taking action on greenhouse gas emissions. Ontario eliminated coal-powered electricity generation in 2014 and has been promoting renewable energy through subsidies. Quebec has joined with California in a cap and trade system that applies to businesses that emit 25,000 metric tonnes or more of carbon dioxide equivalent a year. British Columbia has put into place a carbon tax of $30 per tonne of carbon dioxide equivalent emissions on all purchases of fuel in the province. Saskatchewan is currently developing a regulatory regime similar to Alberta's system, where facilities emitting more than 100,000 tonnes must reduce their emissions, buy offsets or pay a $15 a tonne levy.

The federal government has released regulations on coal-powered electricity generation and transportation but has not put into place any regulations specifically targeting the mining sector.

CHALLENGE: IMPACTS ON WATER QUALITY

Water is used at the mine sites for a wide range of purposes, such as cooling drill bits, separating ore from the mined rock, washing extracted ore or removing unwanted materials. Despite this range of uses, the mining sector is a very small water user, accounting for just 1% of the national water intake in 2005.[50]

Once ore-bearing rock has been taken from the ground, the valuable metal or mineral must be separated from wastes before it can be sent for processing. Rock that has been removed from the ground to get access to ore is called waste rock. The left over substances from the milling process are called tailings. Tailings are usually mixed with water and impounded in large structures called tailings ponds.

One of the most serious environmental challenges faced by the mining industry is acid rock drainage. The problem arises when commonly supplied materials—particularly iron sulfide or fool's gold—are exposed to oxygen. This leads to the formation of acids that can dissolve heavy metals, which, if they make their way to surface water, could have a harmful impact on aquatic life.[51] Acid rock drainage can arise from natural causes wherever sulfide materials are exposed to the atmosphere, but human activities, such as tailings ponds and waste rock piles, have the potential to accelerate the process.

This section looks at three strategies for reducing the industry's impact on water quality:

- Using less water
- Protecting the quality of surrounding bodies of water
- Better waste management

50 Statistics Canada. Water use parameters in mineral extraction and thermal-electric power generation industries. CANSIM Table 153-0079.

51 Fraiser Institute. What is acid rock drainage? Mining.org. http://www.miningfacts.org/Environment/What-is-acid-rock-drainage/ Accessed November 20, 2014.

Strategy 1: Using Less Water

How Is Industry Doing?

The mining sector has been steadily reducing its water use over the past decades. Between 1981 and 2009, water use dropped by a third.[52] In recent years, the downwards trend has continued, falling another 6% between 2005 and 2011. The mining sector typically returns more water to the environment than it extracts due to the discharge of water that accumulates on the mine site, which is often due to the interception of groundwater or runoff from precipitation.[53] Water that is discharged from mine facilities to the environment is subject to strict environmental controls for the quality of the water to be discharged.

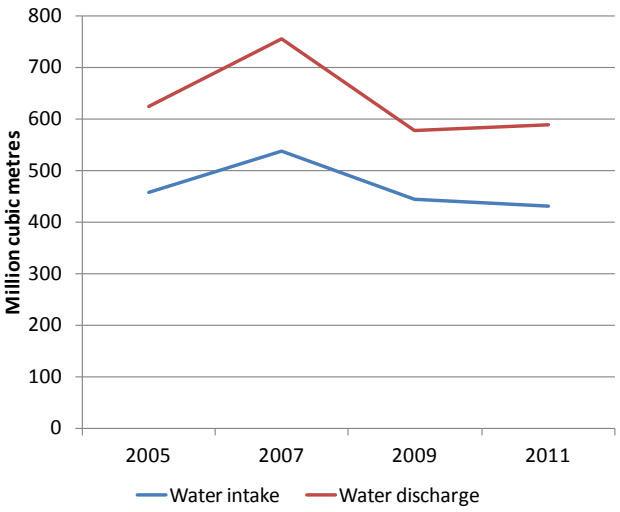


Figure 3.5: Index of the value of mining output, water intake and water use intensity, 2005 to 2011. Source: Statistics Canada CANSIM Table 153-0079

What Is Government's Role?

The outline of water regulation in Canada is given on page 20.

Strategy 2: Protecting the Quality of Surrounding Bodies of Water

How Is Industry Doing?[54]

The federal government's Metal Mining Effluent Regulations (MMER) sets out standards of quality for discharges from mines into waterways. Natural Resources Canada has used compliance with MMER as a measure of how well industry is doing at protecting water quality.[55] Although the number of mines subject to the MMER has been increasing, there has been a downwards trend in the number of

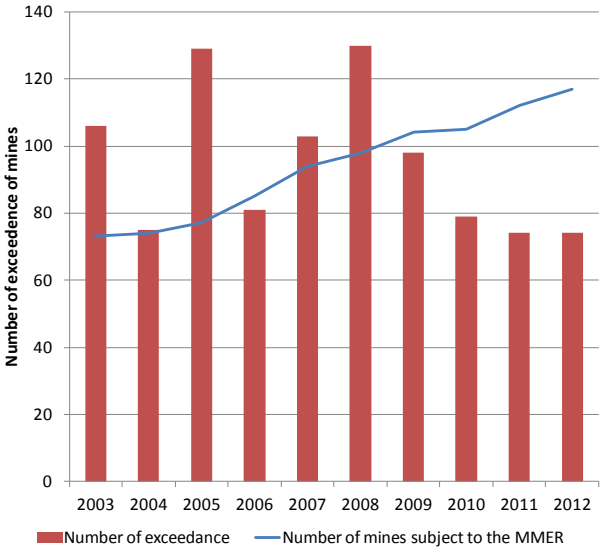


Figure 3.6: Number of mines subject to the Metal Mining Effluent Regulations and number of cases where the limits on effluent discharge were exceeded. Source: Environment Canada Summary Review of Performance of Metal Mines.

52 National Roundtable on Energy and the Environment. *Charting a Course: Sustainable Water Use by Canada's Natural Resource Sectors*. November 2011. http://nrt-trn.ca/charting-a-course-sustainable-water-use-by-canadas-natural-resource-sectors#sthash.Am1RvO2C.dpuf Accessed November 20, 2014.

53 National Roundtable on Energy and the Environment. *Charting a Course: Sustainable Water Use by Canada's Natural Resource Sectors*.

54 Source for *Test and test some more* textbox: Cameco. "Clean Environment". *Sustainable Development Report 2014*. file:///C:/Users/kmarsh/Downloads/Cameco-Sustainable_Development_Report_2014.pdf Accessed November 18, 2014. Source for Real Time Water Quality Monitoring textbox: Mining Association of Canada. TSM Excellence Awards 2014. http://mining.ca/tsm-excellence-awards-2014 Accessed November 18, 2014.

55 Natural Resources Canada. *Mining Sector Performance Report:1998-2012.*

56 Environment Canada *Summary Review of Performance of Metal Mines subject to the Metal Mining Effluent Regulations in 2012*. January 2014.

times facilities exceeded their proscribed limits. Since 2003, there has been a 30% decrease in the number of times facilities exceeded their limit, dropping to 74 from 106 the decade before.[56]

Test and Test Some More

At Cameco's Key Lake operation, the mill does not discharge directly to the environment. Instead, the mill pumps treated water to a series of holding ponds prior to release. If the samples taken from a particular holding pond do not meet specifications, that water is returned to the mill for further treatment. Treated pond water is only released into the receiving environment when it meets specifications through sampling and laboratory testing. A number of samples are also taken from different locations in the downstream receiving environment.

Adapted from Cameco's 2014 Sustainability Report

Real Time Water Quality Monitoring

Vale put into place a Real Time Water Quality Monitoring Partnership in 2003. The program provides various data about the water quality of streams near Vale's Voisey Bay mine and mill in Labrador that can be read by the public within four hours. Community members use the information to enhance traditional knowledge and to help predict the migration patterns of Arctic Char.

What Is on the Horizon?[57]

Using Wetlands as a Biofilter

Wetlands have a natural capacity to remove sediment and pollutants, like heavy metal, from water. Mining companies and researchers have been developing engineered wetlands to serve as water treatment systems. One pilot system at the Keno silver mines in Yukon achieved 99% metal removal in a climate where -45°C temperatures are not unheard of.

What Is Government's Role?

In Canada, water outflows from metal mines must be monitored to ensure they meet authorized limits for dissolved materials. The federal *Fisheries Act* Metal Mining Effluent Regulations, mentioned above, set limits for substances, such as arsenic, copper, lead, nickel, zinc, cyanide, radium-226, and total suspended solids. In addition, most provinces regulate the mines on a case-by-case basis, using the federal regulations as a guide. Mining water is treated to remove metals and other contaminants and sampled to ensure it meets environmental regulations right before it is discharged into the environment, which at most metal and mineral mines, is the tailings pond.[58]

Strategy 3: Better Waste Management

How Is Industry Doing?

While the amount of waste rock and tailings remained fairly consistent between 2006 and 2008, there has been a marked increase in tailings since 2009. Although the overall totals are increasing, the data does not capture information on the composition of the tailings. Decreases in the release of certain substances, like mercury, would lessen the environmental impact of tailings even if the total amount was increasing.[59]

The Mining Association of Canada's Towards Sustainable Mining initiative has five indicators related to tailings. Industry has improved its performance on all five indicators since 2006 but has not yet reached complete coverage. While only 39% of facilities had implemented a tailings management system in 2006, by 2013 80% of facilities had a system in place.[60]

57 Herb Mathisen. "Pollutant-hungry wetlands: Patience key to future of passive water treatment". *CMI Magazine*. February 2013.

58 Fraser Institute. *How are the effects of mining on water quality monitored?* Miningfacts.org http://www.miningfacts.org/Environment/How-are-the-effects-of-mining-on-water-quality-monitored-/ Accessed November 18, 2014.

59 Natural Resources Canada. *Mining Sector Performance Report: 1998-2012.*

60 Mining Association of Canada. *Towards Sustainable Mining Progress Report 2014.*

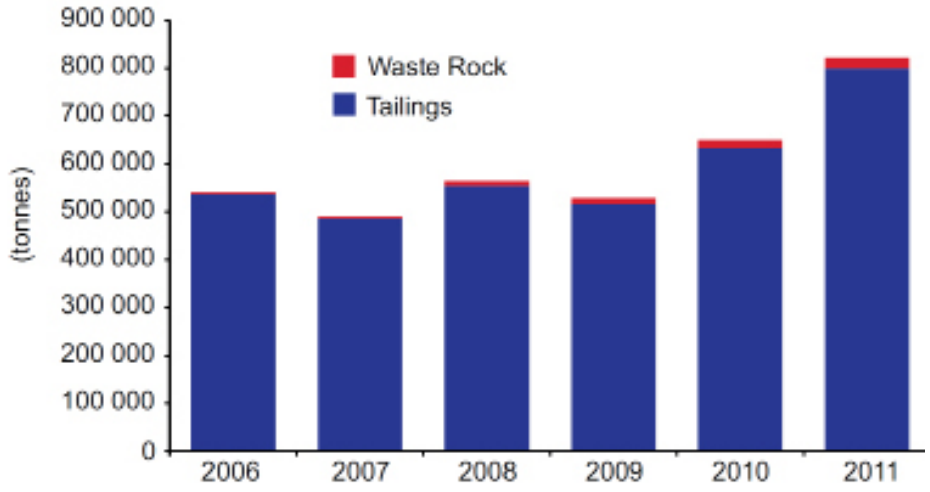


Figure 3.7: Tonnes of tailings produced by the Canadian Mining industry, 2006 to 2012. Source: Natural Resource Canada

What Is on the Horizon?[61]

Dry Tailings

Instead of storing tailings in large bodies of water, industry has developed processes to dry them out. Large scale vacuum and pressure filter technology removes most of the water from the tailings, which are then transported by conveyor or truck. The tailings are then spread and compacted to form a dry tailings stack that does not require a dam for retention. Filtering and dry stacking the tailings not only recovers water, it also makes the rehabilitation process easier as plants can be grown on top of dry stacked tailings.

Mining Tailings for Metals

Tailings often contain small amounts of valuable metals. BioteQ, a Vancouver-based company, has developed a process to recover copper, iron, lead, aluminum and other metals from tailings streams. The firm has built 16 water treatment plants, including one with Jiangxi Copper Company, the largest copper mining company in China. This facility recovers 930,000 pounds of copper concentrate per year, improving water quality and generating between $2.4 and $2.8 million a year in additional revenue for the mine.

What Is Government's Role?

Regulation of dams in Canada, including tailings ponds, is a provincial/territorial responsibility. British Columbia, Alberta, Saskatchewan, Ontario and Quebec all have laws in place to manage the construction, operation, maintenance and surveillance of tailings ponds.[62]

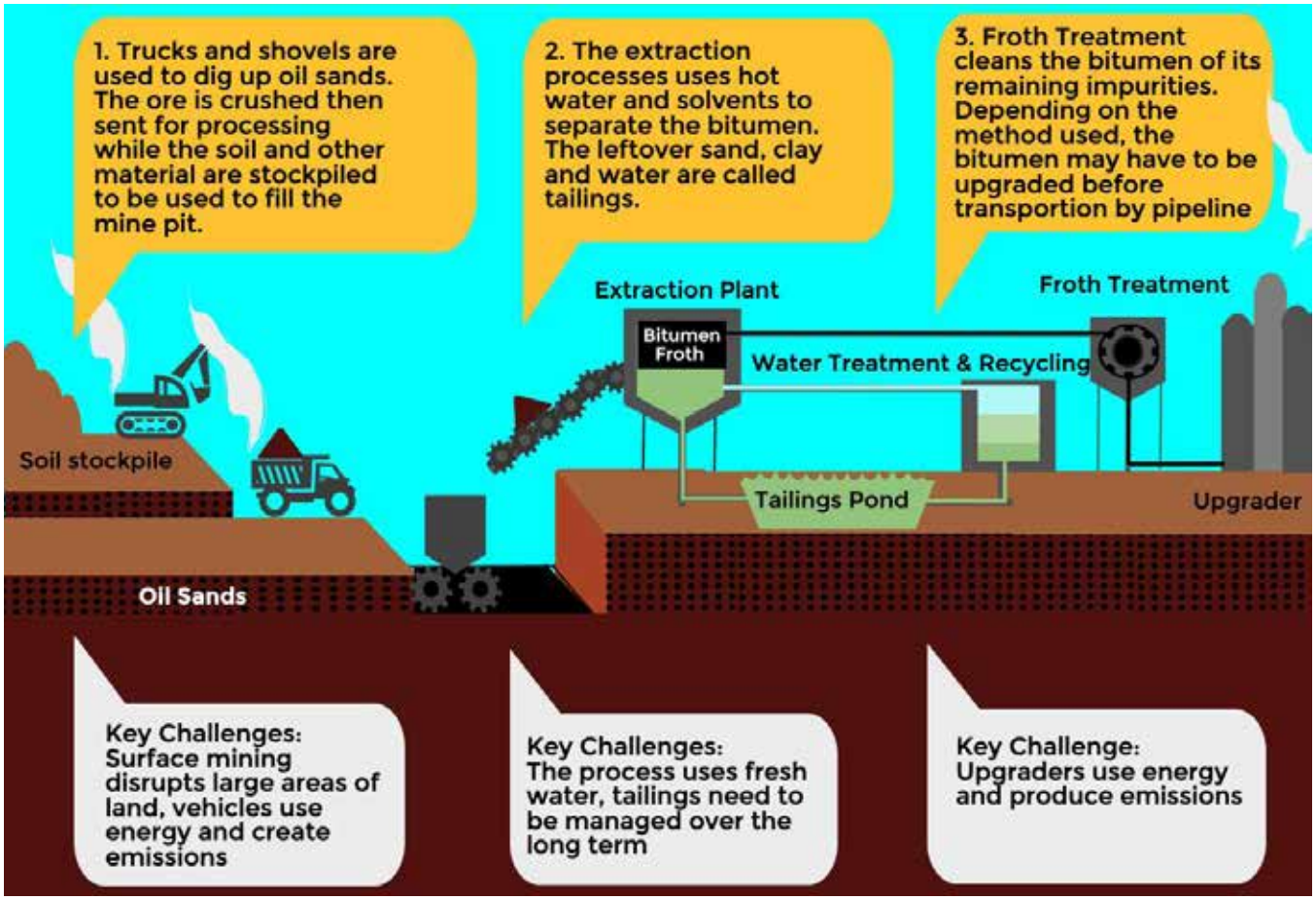
The Metal Mining Effluent Regulations, mentioned on page 20, set limits on substances that can be released into the water from tailings ponds. Alberta also has special regulations for oil sands tailings ponds, which are described on page 33.

61 Source for Dry Tailings textbox: Michael P. Davies and Stephen Rice. *An alternative to conventional tailing management – "dry stack" filtered tailings*. AMEC Earth & Environmental. 2004. Source for Mining Tailings for Metals textbox: *BioteQ Environmental Technologies. BioteQ and Jiangxi Copper Sign Agreement to Build Third ChemSulphide® Water Treatment Plant*. August 1, 2013. http://bioteq.ca/2013/08/bioteq-and-jiangxi-copper-sign-agreement-to-build-third-chemsulphide-water-treatment-plant/ Accessed November 20, 2014.

62 Canadian Dam Association. *Regulation of Dams and Tailings Dams in Canada*. Presented at the CDA 2010 Annual Conference, October 2010.

4. Oil and Gas

4.1. Oil Sands Mining



CHALLENGE: IMPACTS ON LAND

Bitumen mining operations are exactly that: surface mines. As with any type of surface mine, the disturbance of the land, animals and plants is a significant environmental challenge. Canada's bitumen is located in the boreal forest, a sensitive ecological area. Bitumen mining affects a relatively small area of Canada's boreal forest (0.2%), but still disrupts plant and wildlife habitat.

This report examines three strategies for mitigating land disturbance caused by bitumen mines:

- Reclaiming the land
- Reducing the land use of mining operations
- Conserving plants and wildlife

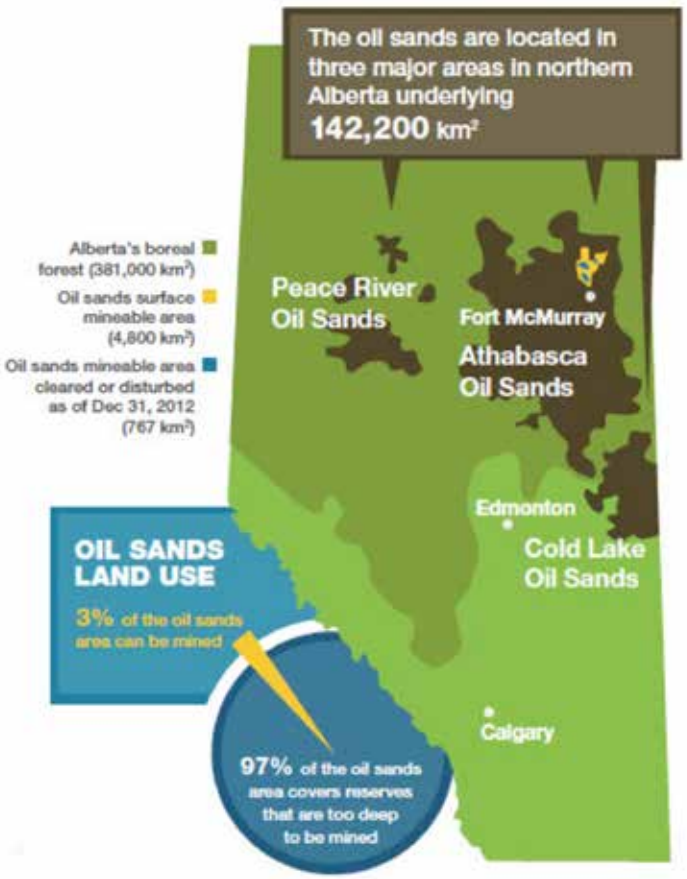


Figure 4.1: Map of Alberta's Oil Sands. Source Alberta Ministry of Energy.

Strategy 1: Reclaiming the Land

Reclamation is the decades-long process of restoring land to a natural state. It starts right at the beginning of the planning process and continues through returning soil and replanting local flora to years of monitoring.

How Is Industry Doing?[63]

Since mining operations began in 1967, bitumen mining has affected 844 square kilometres.[64] Two-thirds of this area is still under active production. Another quarter has been cleared vegetation for roads or structures, leaving the soil otherwise undisturbed. This leaves about a tenth of the area in some part of the reclamation process.[65] As more bitumen projects mature, an increasing portion of the bitumen mining footprint has been reclaimed.[66]

After the initial reclamation work is done, a company must conduct 15 years of monitoring before it can apply for a government certificate, the last step in the reclamation process. A 104-hectare area called Gateway Hill is the only site to have undergone the entire decades-long year certification process.[67] Another 65 square kilometres have been reclaimed by industry but have not been certified, which may be the case if the land is near an active mine site, and are being used for other purposes or are being monitored to ensure a viable ecosystem has been re-established.[68]

63 Sources for the Gateway Hill Text Box: Bridget Mintz Testa. "Reclaiming Alberta's oil sands mines" *Earth Magazine*. February 22, 2010. http://www.earthmagazine.org/article/reclaiming-albertas-oil-sands-mines. Accessed October 29, 2014. Source for the South Bison Hills textbox: Jim Carter. Bringing the Buffalo Home. Bison Producers of Alberta. August 2000. http://www.bisoncentre.com/index.php/producers-2/resource-library/ibc2000-proceedings/primary-sessions/bringing-the-buffalo-home. Accessed October 29, 2014.

64 Alberta Government. *Alberta's Oil Sands: Reclamation*. http://www.oilsands.alberta.ca/reclamation.html. Accessed October 29, 2014.

65 Alberta Government. "Land Response Indicators: Oil Sands Mining Development and Reclamation." Environment and Sustainable Resource Development. http://esrd.alberta.ca/focus/state-of-the-environment/land/response-indicators/oil-sands-mining-development-and-reclamation/default.aspx. Accessed October 29, 2014.

66 Alberta Government. "Land Response Indicators: Oil Sands Mining Development and Reclamation."

67 Bridget Mintz Testa. "Reclaiming Alberta's oil sands mines" *Earth Magazine*.

68 *Alberta's Oil Sands: Reclamation*.

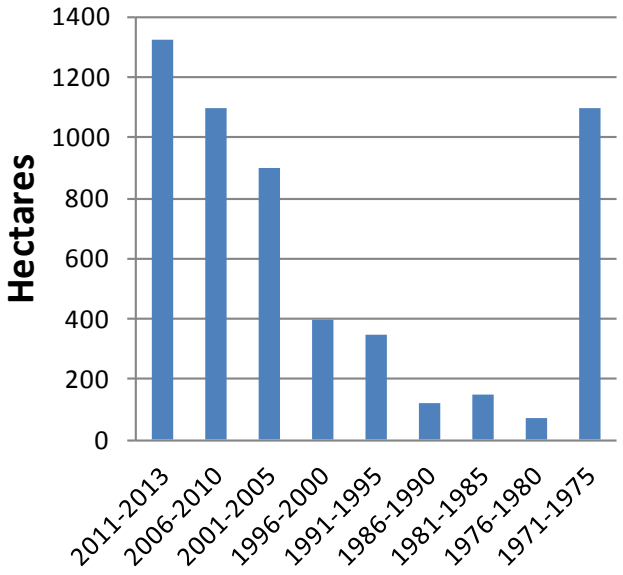


Figure 4.2: Years in which permanent reclamation activities were completed for oil sands mines, 1971-2013. Source: Government of Alberta.

Syncrude was one of Canada's first bitumen miners, starting operations in 1978. To date, it has reclaimed about 20% of the land affected by its mines. Gateway Hill was used for the storage of soil and other materials removed in the mining process. The site was first reclaimed in the 1980s and has advanced several reclamation processes. Today, Alberta's first certified site is home to a number of animal species.

In partnership with the Fort McKay First Nation, Syncrude co-manages a herd of 300 bison on land that was formally part of a mining operation. The heard has won a number of livestock awards and has contributed to a genetic preservation program led by the universities of Calgary and Saskatchewan and the provincial governments.

What Is on the Horizon?[69]

Speeding up Topsoil Reconstruction

A key part of reclamation for any industrial development is replacing topsoil. Since left to the course of nature, subsoil can take hundreds of years to transform into topsoil; most mining sites stockpile soil from the mining operations for later use. However, this soil can degrade over decades, losing nutrients and microbial life. Imperial Oil has been working for the past 10 years on a process to transform subsoil into topsoil in just five years. The process will be particularly useful at older sites where salvaging topsoil was not a requirement at the time and could be applied at mine sites in other areas of the country.

Replanting Shrubs and Forests

Faster Forests is a collaboration lead by COSIA that aims to speed up the reclamation of sites disturbed by exploration activities. To date, through the program, 2.3 million trees have been planted over 700 hectares. Other COSIA projects, such as the Oil Sands Vegetation Cooperative, look to find and bank seeds from a wide variety of species in order to support reclamation efforts that will happen several decades in the future.

Learning to Re-grow Peat Land

The Suncor Nikanotee Fen project is working to reconstruct a fen, a type of peat land. The project places 'donor' peat and fen plants at the site. A constructed aquifer fed by tailings materials from the mine site will provide the water. After 10 years, the project's team expects to have established a working ecosystem. Syncrude is also working to construct a fen using a different technique.

69 Source for Speeding up top soil reconstruction textbox: Canadian Oil Sands Research Alliance (COSIA). *Topsoil Reconstruction*. http://www.cosia.ca/topsoil-reconstruction. Accessed October 29, 2014. Source for Replanting Shrubs and Forests textbox: COSIA. *Faster Forests*. http://www.cosia.ca/initiatives/land/faster-forests and *Oil Sands Vegetation Cooperative*. http://www.cosia.ca/initiatives/land/oil-sands-vegetation-cooperative Accessed October 29, 2014. Source for learning to re-grow peat land textbox: University of Waterloo Wetlands Hydrology Research Group. Nikanotee Fen Project. http://env-blogs.uwaterloo.ca/pilotfenproject/ Accessed October 29, 2014.

What Is Government's Role?

Before any development takes place, bitumen producers must prepare and get approval from the provincial government for its reclamation plans. Bitumen mine operators are legally required to return all of the land to a working ecosystem that can provide the same capabilities as the pre-mining site, such as providing wildlife habitat, acting as a watershed and supporting Aboriginal culture.[70] Replacing peat lands—a water-logged soil layer found in fens and other wetlands—is a particular challenge and has yet to be accomplished in Alberta, although projects are underway.

When their operations are complete, mines must apply for a reclamation certificate, which is issued only after 15 years of monitoring to ensure a functioning ecosystem has taken root.[71] Industry must also provide a security as a guarantee that reclamation work will take place. Currently, the government holds over $1 billion in reclamation securities.[72]

Strategy 2: Reducing the Land Use of Mining Operations

How Is Industry Doing?

The amount of land needed to produce a barrel of bitumen has remained relatively constant, meaning that growth in land use has been keeping in pace with growth in production.[73]

What Is on the Horizon?

Only 3% of Alberta's oil sands area can be mined. The rest must be extracted using one of several drilling or in situ technologies, which use almost six times less land per barrel of bitumen than mining.[74] As the industry increasingly shifts to in situ technology, the intensity of land use per barrel of bitumen will decrease.

Tailings ponds make up a substantial amount of the land used by a bitumen mine. The technologies and practices to reduce tailings mines outlined later in this chapter will also have a significant impact on land use.

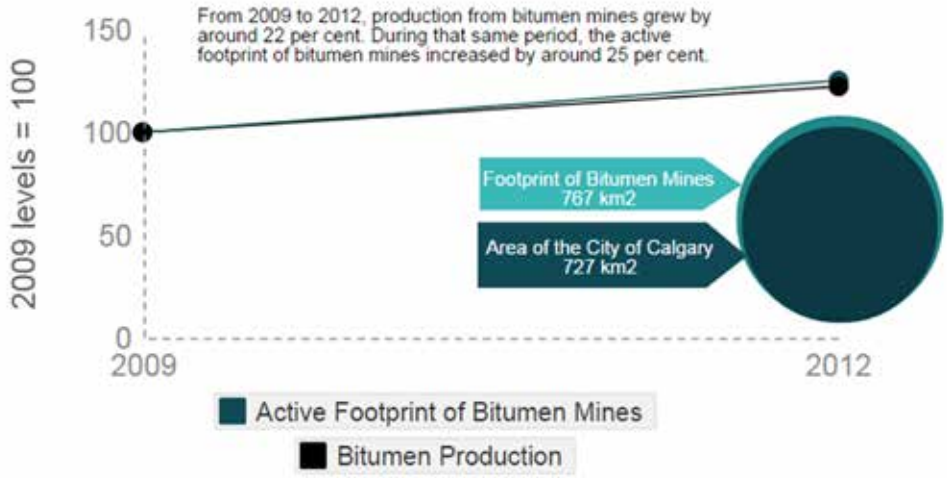


Figure 4.3: Land use in oil sands mines, 2009 to 2012. Source: Canadian Association of Petroleum Producers Responsible Canadian Energy Data Table.

70 Government of Alberta. Public Lands Operational Handbook. Alberta Sustainable Resource Development, Public Lands and Forest Division. December 2004.

71 Alberta Government. *Alberta's Oil Sands: Reclamation*.

72 Alberta Government. *Alberta's Oil Sands: Reclamation*.

73 Canadian Association of Petroleum Producers. Responsible Canadian Energy 2012 Data Tables. http://www.capp.ca/rce/downloads/ Accessed October 29, 2014.

74 Jennifer Grant, Eli Angen and Simon Dyer. *Forecasting the impacts of oil sands expansion*. Pembina Institute. June 2013.

What Is Government's Role?

The government of Alberta employs a regulatory regime that is intended to balance economic, social and environmental priorities through the development of regional plans for land use. The Lower Athabasca Regional Plan was the first regional plan to be put into place and outlines a vision for the region over the next 50 years. The plan includes a number of strategies to ensure the land, biodiversity and water impacts of all industries in the area are properly managed.[75]

Strategy 3: Conserving Plants and Wildlife

How Is Industry Doing?

A 2013 report by the Alberta Biodiversity Monitoring Institute measured the state of biodiversity in the Athabasca Oil Sands region using a measure called biodiversity intactness. An untouched wilderness area would have an intactness value of 100%, while a parking lot surrounded by big box stores would have a value of 0%. The overall biodiversity intactness score for the minable region was 86%, which means that there were on average 14% fewer animals in bitumen mining areas than you would expect to see in an untouched wilderness. The average intactness score for the Athabasca region was 94%.[76]

Some species of mammal, such as deer and coyotes, are able to adapt well to industrial developments. For other animals, such as the woodland caribou, mining is another stress on a population dealing with the impacts of other industries, climate change and increased predation.

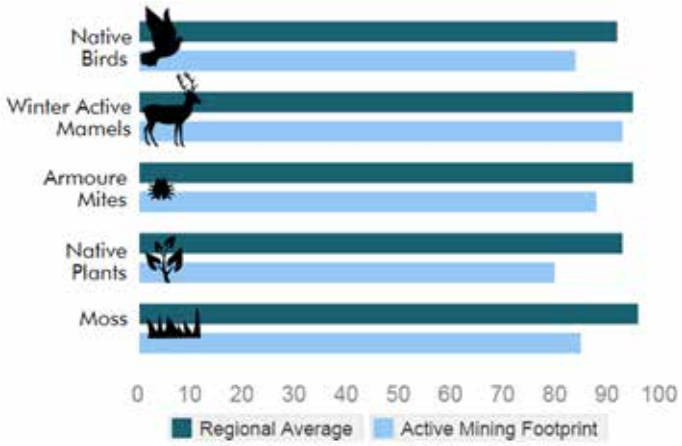


Figure 4.4: Biodiversity intactness index for the Athabasca region, regional average and active mining footprint 2013. Source: Alberta Biodiversity Monitoring Institute

75 Government of Alberta. Land-Use Framework Regional Plans: Progress Report. July 2014.

76 Alberta Biodiversity Monitoring Institute. *The Status of Biodiversity in the Athabasca Oil Sands Area*. 2013.

What Is on the Horizon?[77]

Biodiversity Offsets

Several companies have constructed lakes to replace fish habitat disturbed by oil mine operations. An example is Imperial Oil's Kearl Mine project, which is building three new lakes that will provide twice the amount of fish habitat as the original watershed. Local Aboriginal groups were consulted on the design, which recreates natural features like gravel substrates and sunken wooden debris structures.

Caribou Habitat

Protecting habitat is essential to protecting caribou. Through COSIA, industry is working to reclaim liner developments like roads and pipelines that have fragmented caribou habitat. By replanting trees and encouraging plant growth through a number of techniques, land that has been disturbed for upwards of 40 years is being reclaimed as wildlife habitat.

What Is Government's Role?

Jurisdiction over conservation efforts is held by both the federal and provincial governments. The federal government has jurisdiction over species at risk, migratory birds, fisheries and navigable waters. Under the *Fisheries Act*, any fish habitat that is destroyed must be replaced. Recent bitumen mines have been required to provide double the amount of habitat that is affected by their operations.[78] The federal *Species at Risk Act* makes it illegal to kill or harm a species at risk or destroy its critical habitat.

Both levels of government have measures in place to protect certain at risk species, such as caribou. For example, the Federal Recovery Strategy for Woodland Caribou Sets a minimum target that 65% of critical habitat for caribou should remain undisturbed.[79] Alberta requires construction activities happening in caribou zones to submit Caribou Protection Plans that outline how the company will work to minimize disruptions to caribou habitat.[80]

CHALLENGE: GREENHOUSE GAS EMISSIONS

Oil sands mines use various types of energy—diesel to power trucks and shovels, natural gas and fuel gas to generate hot water or electricity and waste heat from up-graders or power plants—that generate greenhouse gas (GHG) emissions. Producing gasoline from crude oil or bitumen production and getting it to gas stations account for only 20 to 30% of life cycle emissions. Most of the emissions—70 to 80%—arise when gasoline is used to power cars or trucks.[81]

This report looks at two strategies for reducing air emissions from oil sands operations:

- Reducing energy use and GHG emissions
- Capturing GHG emissions for storage or use

77 Source of Biodiversity Offsets textbox: Imperial Oil. Compensation Lake and Stakeholder Compensation. http://www.imperialoil.ca/Canada-English/operations_sands_kearlvidecl.aspx. Accessed October 29, 2014. Source of Caribou Habitat Reforestation textbox: COSIA. Caribou Habitat Restoration. http://www.cosia.ca/caribou-habitat-restoration. Accessed October 29, 2014.

78 University of Alberta. Fish Habitat Compensation Lakes. July 30, 2012. http://www.osrin.ualberta.ca/en/Resources/DidYouKnow/2012/July/FishHabitatCompensationLakes.aspx. Accessed October 29, 2014.

79 Environment Canada. "Recovery Strategy for the Woodland Caribou (Rangifer tarandus caribou), Boreal population, in Canada." *Species at Risk Recovery Strategy Series*. 2012

80 Government of Alberta. Caribou Protection Plans. July 22, 2014 http://esrd.alberta.ca/fish-wildlife/wildlife-management/caribou-management/caribou-protection-plans/default.aspx. Accessed October 29, 2014.

81 Government of Canada. Oil Sands: A strategic resource for Canada, North America and the global market. May 2013. http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/eneene/pubpub/pdf/12-0607-OS-GHG_Emissions_us-eng.pdf Accessed October 29, 2014.

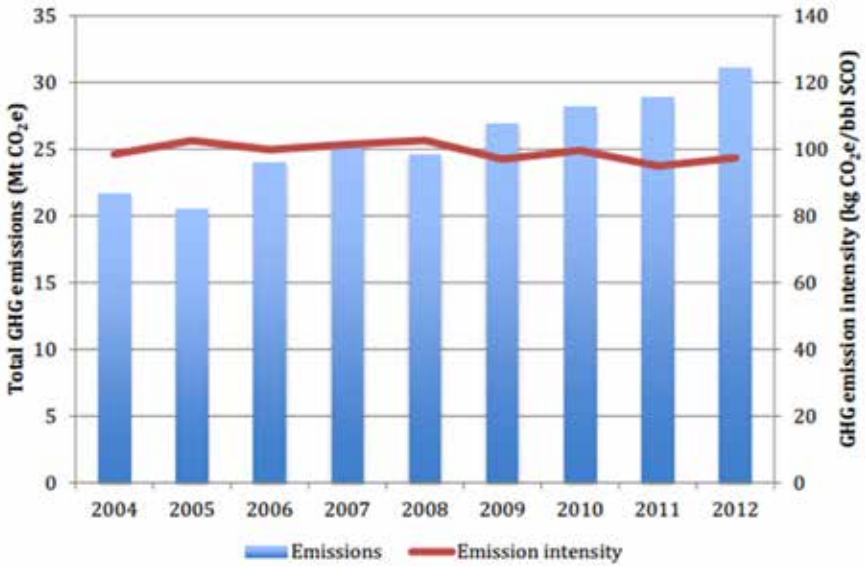


Figure 4.3: Land use in oil sands mines, 2009 to 2012. Source: Canadian Association of Petroleum Producers Responsible Canadian Energy Data Table.

Strategy 1: Reducing Energy Use and GHG Emissions

How is Industry Doing?

Over the past decade, the emissions needed to produce a barrel of synthetic crude oil from a mine have remained relatively constant. As a result, increasing production has meant increasing emissions.[82] In 2012, emissions from oil sands mining was around 31 megatonnes of carbon dioxide equivalent, comparable to some of the larger coal power plants in Europe, like Germany's Neurath plant (33 megatonnes of carbon dioxide equivalent).[83]

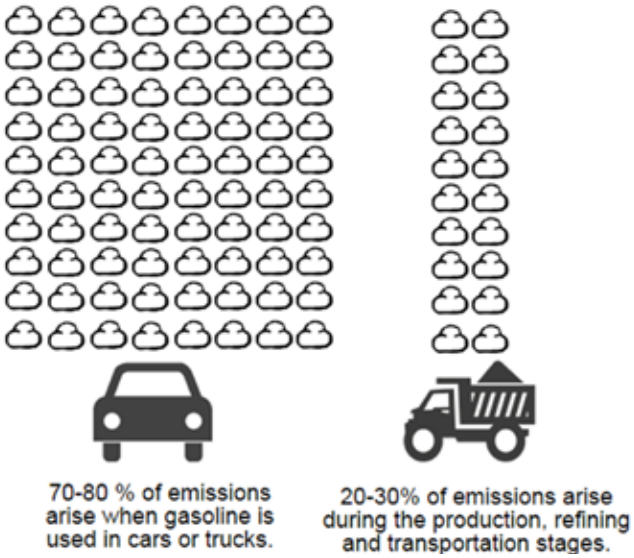


Figure 4.6: Absolute emissions and emissions per barrel of synthetic crude, 2004 to 2012. Source: Canadian Energy Research Institute

Co-generation

When natural gas is burned to create electricity, it generates large amounts of waste heat. In a normal power plant, this heat is just wasted, but many oil

82 Canadian Energy Research Institute. *Oil Sands Environmental Impact*. Study no 143, July 2014.

83 Kathrin Gutmann et al. *Europe's Dirty 30: How the EU's Coal-Fired Power Plants are Undermining its Climate Efforts*. July 2014.

sands operations capture the heat and use it in other parts of the process, which can save significant amounts of energy. For example, Imperial Oil's co-generation system at its Kearl mine will reduce emissions by 500,000 megatonnes of carbon dioxide equivalent, the equivalent of emissions from 100,000 cars.

What Is on the Horizon?[84]

New Treatment Processes

In an oil sands mine, after the bitumen is separated from the sand, it needs to be treated to remove remaining impurities before it can be transported by pipeline to refineries. Older methods of treatment did not remove enough of these impurities, meaning the bitumen had to be upgraded on site, an energy intensive process. A new process called Paraffinic Froth Treatment does a much better job of removing impurities, allowing bitumen miners, in certain cases, to skip the upgrading step and save 8 to 10% of the GHG emissions from mining.

What Is Government's Role?

Alberta—home to 78% of Canada's oil production—was the first jurisdiction in North America to legislate GHG emissions reductions for large industrial facilities.[85] Facilities that generate more than 100,000 tonnes of GHG emissions a year must reduce their emissions by 12%. Companies have three ways to meet this target: they can reduce their emissions at their own facilities, buy offsets from other projects that are reducing carbon dioxide, or pay a levy of $15 per tonne of carbon dioxide.[86]

Strategy 2: Capturing GHG Emissions for Storage or Use

Storing natural gas in underground geological formations has been happening in Canada since 1915, and injecting emissions underground to increase production from mature oil fields has been taking place since 1972.[87] Canada has 132 billion tonnes of storage available for carbon capture and storage (CCS), more than 150 times greater than Canada's current GHG emissions.[88] Captured emissions are also being put to use to make product like biofuels or in industrial processes.

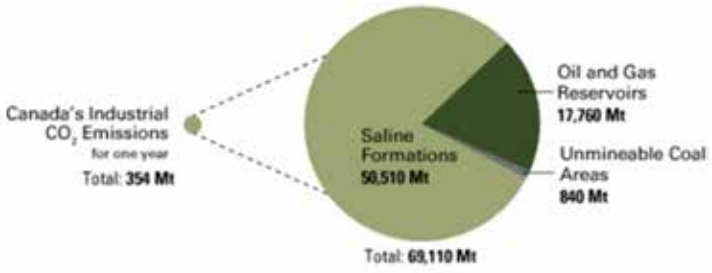


Figure 4.7: Canada's Carbon Storage Capacity. Source: ICO2N

84 Source of Co-Generation textbox: Imperial Oil. *Canada's Oil Sands: Responsible Development, Innovation and Opportunity*. http://corporate.exxonmobil.com/~/media/Brochures/2012/iol_oilsands_brochure.pdf Accessed October 29, 2014. Source of New Treatment Processes textbox: Natural Resources Canada. Froth Treatment. http://www.nrcan.gc.ca/energy/oil-sands/5873 Accessed October 29, 2014.

85 Energy Information Administration. Canada. September 30, 2014. http://www.eia.gov/countries/cab.cfm?fips=ca

86 Alberta Government. Alberta and Climate Change. October 24, 2014. http://esrd.alberta.ca/focus/alberta-and-climate-change/default.aspx Accessed October 29, 2014.

87 Shell Canada. CCS Technologies show long, safe history. http://www.shell.ca/en/aboutshell/our-business-tpkg/upstream/oil-sands/quest/technology.html

88 Natural Resources Canada. "Carbon Capture and Storage". *Oil Sands: A Strategic Resource for Canada, North America and the Global Market*. February 2013. Accessed October 29, 2014. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/eneene/pubpub/pdf/OS_CC-storage_us-eng.pdf

How Is Industry Doing?[89]

CCS works with large, stationary sources of GHG emissions. Two projects are currently underway to apply CCS to oil sands upgraders.

A Quest to Reduce Emissions

Starting in 2015, Shell's Quest project will capture 35% of the emissions from its Scotsford upgrader. The project will permanently store the emissions two kilometres underground.

A Pipeline for Carbon

The Alberta Carbon Trunk line (ACTL) is the largest CCS project in the world. The line will take carbon emissions from the North West Redwater upgrader and transport them to be injected underground in more mature oil fields to help with oil recovery. The ACTL will also help form the backbone of a growing carbon transportation and storage infrastructure. Initially, the project will capture 1.8 million tonnes of carbon dioxide, the same as 378,000 cars, and could scale up to capture the equivalent of emissions from over three million cars.

What Is on the Horizon?[90]

An Oil Sands Bio-refinery

Canadian Natural has constructed a pilot bio-refinery at its Primerose in situ operation and, pending the results, a full commercial facility will be built at its Horizon oil sands mine. The bio-refinery will use the carbon dioxide released at the oil sands facility to grow algae. This algae will be harvested and the pressed to create a bio-oil that can be used for jet fuel or added into crude oil. The project could reduce emissions at Primerose by 30%, and the GHG savings from Canadian Natural's bio-refineries could be equivalent of taking 300,000 cars off the road.

Treating Tailings Ponds with Carbon

Tailings—the mix of sand, water and clay leftover after the bitumen has been removed—is one of the oil sand's greatest environmental challenges. Canadian Natural Resources is using waste carbon dioxide to create a chemical reaction that allows the solids in the tailings pond to settle more quickly, not only speeding up the water recycling process but sequestering carbon dioxide emissions as well. While the carbon dioxide is currently being purchased offset, in 2017 Canadian Natural Resources will be using carbon dioxide captured from the onsite upgrader.

What Is Government's Role?

Both the federal and the Alberta governments are encouraging CCS research through financial support. To date, Canadian governments have provided $1.8 billion in funding for CCS projects.[91] The Alberta government alone claims to have contributed 10% of the all the money invested worldwide into large scale carbon capture and storage.[92]

89 Source for A Quest to reduce emissions Textbox: Shell Canada. CCS Technologies show long, safe history. Source for A Pipeline for Carbon textbox: Enhance Energy Inc. The ACTL Project. http://www.enhanceenergy.com/

90 Source for An Oil sands bio-refinery textbox: COSIA. The Algea Project. http://www.cosia.ca/the-algae-project Accessed October 29, 2014. Source for Treating Tailings Ponds with Carbon textbox: COSIA. Carbon Dioxide Amended Tailings. http://www.cosia.ca/initiatives/tailings/carbon-dioxide-amended-tailings. Accessed October 29, 2014.

91 Natural Resources Canada. *Carbon Capture and Storage: Canada's Technology Demonstration Leadership*. http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/files/pdf/11-1416_eng_acc.pdf

92 Geoffrey Morgan. Jim Prentice says to wind down carbon capture fund in Alberta, new projects 'on hold'. Financial Post. October 6, 2014.

CHALLENGE: WATER USAGE & TAILINGS PONDS

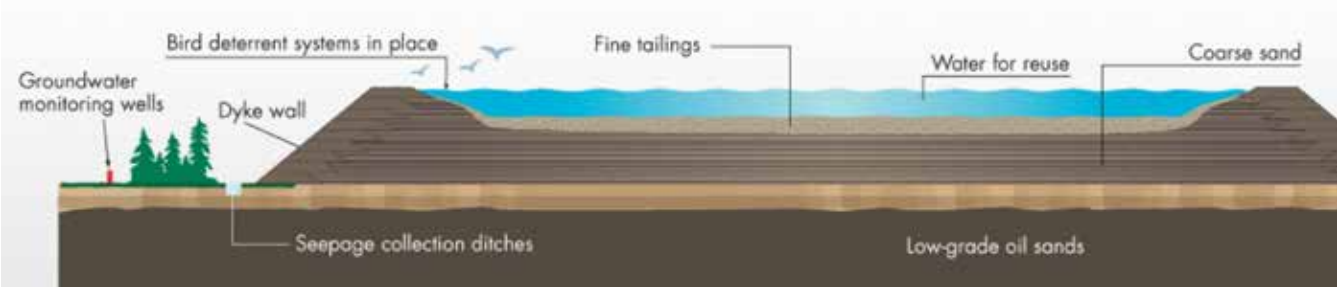


Figure 4.8: Tailings Pond. Source: Oil Sands Today

Most of the water used in an oil sands mine is consumed when the bitumen is separated from the sand and other materials. The leftover mix of water, sand and clay is called tailings. Tailings are stored in ponds to allow for the water to separate from the sand and clay. Think of a muddy puddle after someone has jumped in it. While the dirt makes the puddle murky at first, after a while, the water becomes clear as the sediment settles to the bottom. In an oil sands mine, the water from a tailings pond is re-used while the dried-out sand and clay are covered by soil to begin the reclamation process.

The problem is, without the use of technology to speed up the process, the fine particles of clay can take decades to settle. As a result, more land is needed to store liquid tailings. Increasing the rate of recycling from tailing ponds can displace the use of fresh water. Because the water in a tailings pond has come into contact with oil, it is toxic to fish, while the residual oil floating on top of ponds poses a threat to water fowl. There is also the potential for tailings ponds to leak and contaminate groundwater.

Tailings management is the greatest environmental challenges facing oil sands mines. This report looks at four strategies for addressing this issue:

- Using less fresh water
- Reducing tailings
- Disposing of tailings below lakes
- Eliminating the need for tailings ponds

Strategy 1: Using Less Fresh Water

How is Industry Doing?

Up to 90% of the water for an oil sands mines is recycled from tailings ponds.[93] The rest of the water needed is drawn from fresh water sources like rivers. Between 2003 and 2012, the amount of water per barrel of production at oil sands mines decreased by 28%.[94] As a result, total water use has remained relatively constant despite increasing production.

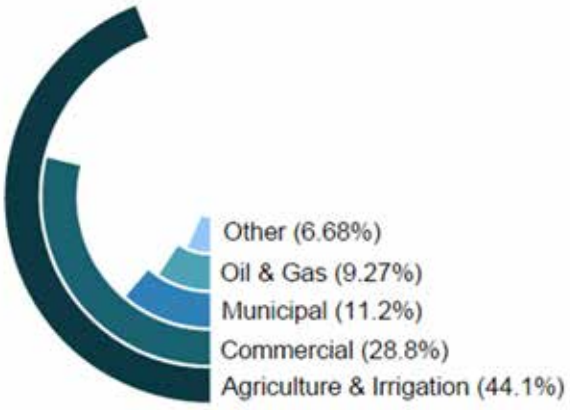


Figure 4.9: Oil sands mine fresh water use and water use per barrel of bitumen, 2005 to 2013. Canadian Energy Research Institute.

93 Alberta Government. Tailings. http://oilsands.alberta.ca/tailings.html Accessed October 29, 2014.

94 Canadian Association of Petroleum Producers. *Responsible Canadian Energy: Water* http://www.capp.ca/rce/report-overview/water/ Accessed October 29, 2014.

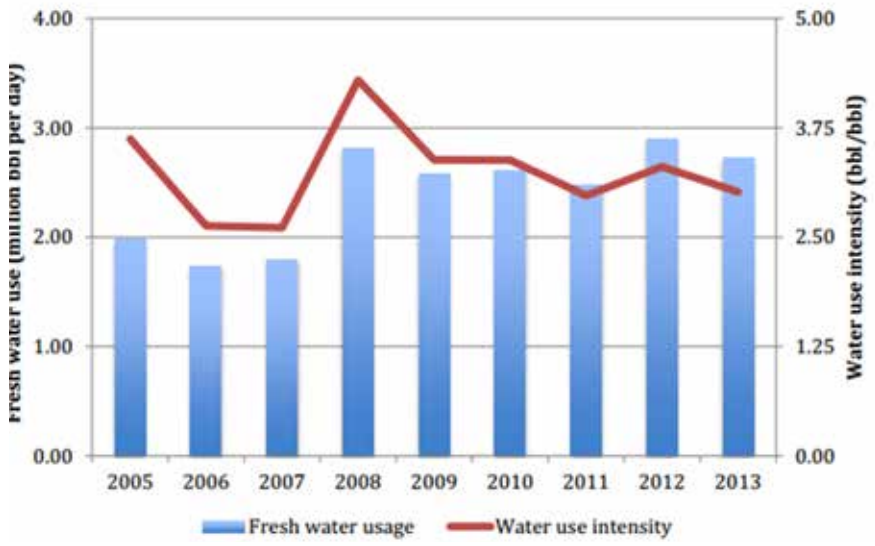


Figure 4.10: Share of total water allocations by industry, 2010. Source: Alberta Government

What Is on the Horizon?

Because water becomes trapped in tailings ponds, industry's ability to increase the amount of water it recycles depends on the success of its new tailings management outlined below.

What Is Government's Role?

The government of Alberta manages withdrawals of both fresh and groundwater through a licensing system. Throughout the province, the largest allocation of water goes to the agricultural, commercial and municipal sectors. These allocations represent the maximum amount of water that can be withdrawn by each sector every year. For the municipal and commercial sectors, much of the water used is eventually returned to the system. However, the oil and gas and agricultural sectors consume much of the water they withdraw. For the province as a whole, oil and gas received 9% of water allocations, compared to 44% for agriculture.[95]

Water use by industry varies throughout the province. In the Athabasca River region, the oil and gas industry used 75% of the total allocation basin in 2010. However, despite the recent growth in water use, the Athabasca water shed is one of the lesser-used basins, with only 4% of average natural supply allocated in 2010.[96]

Strategy 2: Reducing Tailings

How Is Industry Doing?

Capturing more of the fine tailings would help to speed up the drying process, leading to greater water recycling and the need for fewer tailings ponds. Starting in 2009, the Alberta government has required oil sands mines to capture an increasing amount of their fine tailings before they are released to a tailings pond. In a 2013 report, the Alberta Energy Regulator found that, despite the commitment of significant resources and material progress towards fine tailings capture technologies, industry did not meet its targets in the first two years.[97]

95 Alberta Government. Sectoral Water Allocations. April 2, 2014. http://esrd.alberta.ca/focus/state-of-the-environment/water/surface-water/pressure-indicators/sectoral-water-allocations/default.aspx

96 Alberta Government. Sectoral Water Allocations: Athabasca River Basin. February 5, 2014. http://esrd.alberta.ca/focus/state-of-the-environment/water/surface-water/pressure-indicators/sectoral-water-allocations/athabasca-river-basin.aspx Accessed October 29, 2014.

97 Energy Resources Conservation Board. *2012 Tailings Management Assessment Report*. June 2013.

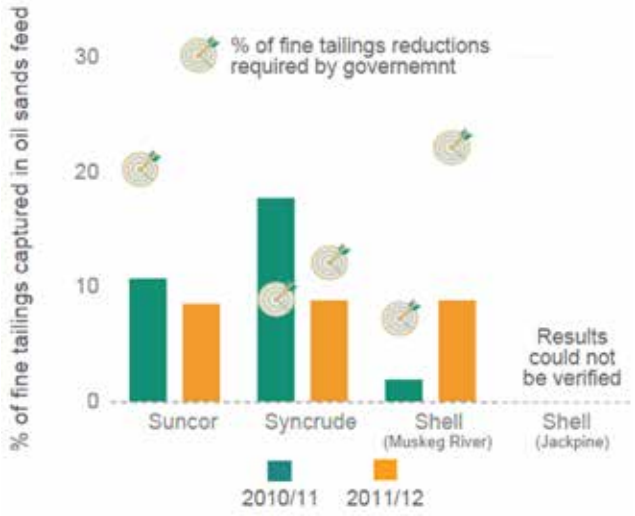


Figure 4.11: Per cent of fine tailings captured in oil sands feed compared to government targets. Source: Government of Alberta.

What Is on the Horizon?[98]

Speeding up the Drying Process

Suncor has a process to speed the process of drying out tailings. It uses a chemical used to treat municipal water to thicken the liquid tailings. The tailings are then laid out on slopes to let the water separate from the clay, where it is recycled. Suncor's process has sped up the drying process by 20 years, allowing the firm to cancel plans for five tailings ponds. Over the next few years, Suncor expects to reduce the land needed for its existing tailings ponds by 80%.

Turning Tailings into Titanium

Titanium Corporation, a Calgary-based clean tech firm, has developed a technology to remove bitumen, the solvent used to dilute the bitumen, water and heavy minerals, like titanium and zircon, from oil sands tailings before they reach the tailings pond. Both these minerals are in high demand—titanium as an additive for paint and zircon for use in the manufacturing of ceramics. By 'mining' tailings for valuable products, Titanium Corp. will not only create a new profit stream for oil sands firms, but will prevent 80% of the volatile organic compound emissions, reduce fresh water use by a quarter and increase high-quality bitumen recoveries by 2%.

Oil Sands Spin Cycle

Syncrude is developing a process that takes liquid tailings from a pond, adds a thickener often used in municipal water processing and runs the mixture through a centrifuge. Just like the spin cycle on a washing machine, the centrifuge removes much of the water from the tailings. This water is recycled, while the remaining clay is topped with sand and soil for the reclamation process. The first centrifuge will be used in a mine in 2014.

What Is Government's Role?

In 2009, the Alberta government started setting limits for oil sands firms to reduce the amount of fine tailings released into tailings ponds. Starting in June 2012, oil sands mines were expected to capture half of the fine tailings released into tailings ponds. As mentioned above, these targets have not been met and government is considering the use of enforcement measures.[99]

Strategy 3: Disposing of Tailings Below Lakes

How Is Industry Doing?

End pit lakes are old mine pits that have been filled with tailings then covered with water. These lakes become permanent features of the landscape, providing a sustainable aquatic ecosystem while supplying permanent storage and remediation for oil sands tailings. Natural sedimentation processes isolate the tailings, while bacteria digest many of the hydrocarbons, salts and other substances of concern.[100]

98 Source for Speeding up the drying process textbox: Cosia: Tailings Reduction Technology. http://www.cosia.ca/initiatives/tailings/tailings-reduction-technology. Source for Turning Tailings into Titanium textbox: Titanium Corporation. Creating Value from Waste. http://www.titaniumcorporation.com/s/Home.asp. Source for Oil Sands Spin Cycle textbox: COSIA. Tailings Centrifuge http://www.cosia.ca/tailings-centrifuge

99 Alberta Energy Regulator. Tailings Management Assessment Report: Oil Sands Mining Industry Report. June 2013.

100 Cumulative Environmental Management Association. End Pit Lake Guidance Document 2012.

The technology has been used successfully to reclaim old mines sites in the iron, copper and coal industries. For example, TransAlta's East Pit Lake, a former coal mining site near Edmonton, now supports rainbow trout and recreational fisheries.[101] However, there are also cases where the technology has not worked and it will take decades to assess its impact as a tailings pond reclamation technique.[102] Continued monitoring and research are needed to understand the long-term impact of this disposal method for oil sands tailings.

What Is on the Horizon?[103]

Base Mine Lake

Syncrude has been working on end pit lakes as a strategy to dispose of tailings for over 20 years. The company has tested the approach through 11 test ponds that now support plant life. Naturally occurring bacteria in these ponds have been shown to eat leftover hydrocarbons, speeding the remediation process. The challenge is now to test the approach in larger ponds. In 2012, Syncrude opened a full-scale demonstration project, the 2,000-acre Base Mine Lake. Over the next decade, the firm will measure progress on the technology's ability to reduce the toxicity of tailings, clean the water on top and establish aquatic life.

What Is Government's Role?

Before any development takes place, bitumen producers must prepare and get approval from the provincial government for its reclamation plans. The use of end pit mines would therefore need to be approved by regulators. Regulators have approved a number of end pit lakes, subject to demonstration that it is a suitable, and permanent sites for toxic tailings waste. Currently, industry has plans for 30 end pit lakes, about half of which will be used to dispose of tailings.[104]

Strategy 4: Eliminating the Need for Tailings Ponds

How Is Industry Doing?

In situ oil sands production methods do not result in tailings, eliminating the need for tailings ponds. Instead, the main use for water in an in situ process is to generate steam. Brackish groundwater can be used in place of fresh water for steam production. As a result, as oil sands production increasingly shifts to in situ methods, it will impact the intensity of fresh water use.

What Is on the Horizon?[105]

Mining without Tailings

U.S. Oil Sands, a Canadian company, has developed a completely new oil sands extraction process. A solvent is added that prevents the clay, water and bitumen from binding together into fine tailings. The solvent is an extract from orange peels called d-limonen, which is used as an environmentally friendly industrial cleaner and food additive. Almost all of the solvent will be recycled. If the technology works as planned, it will have tremendous environmental benefits compared to a conventional oil sands mine. The site will have no need for tailings ponds, which will reduce its footprint, and will achieve recycling rates of 95% from water drawn from an underground aquifer.

101 Melanie Collison. "The science and evolving practice of applying the end-pit lake to the oil sands". *Air Water Land: Energy's New Environment*. October 2008. http://www.airwaterland.ca/print-article.asp?id=7358

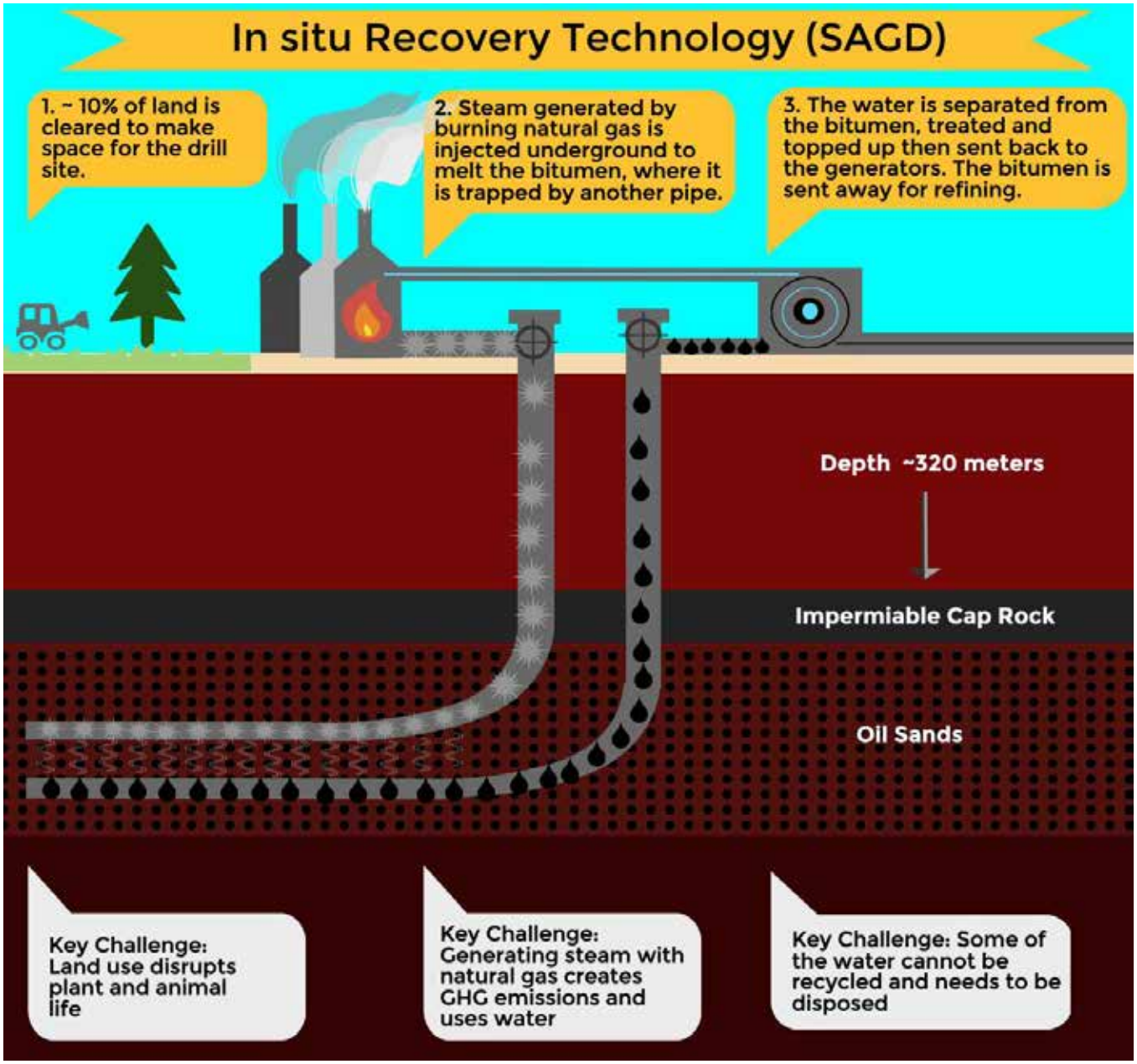
102 Christopher H. Gammons el al. Creating lakes from open pit mines: processes and considerations, with emphasis on northern environments. 2009 http://www.dfo-mpo.gc.ca/Library/337077.pdf Accessed October 29, 2014.

103 Source for the Base Mine Lake textbox: COSIA Pit Lake Research: http://www.cosia.ca/pit-lake-research

104 Edmonton Journal. Oil Sands pit lakes a big gamble. October 10, 2012.

105 Source for Mining without tailings textbox: US Oil Sands. http://www.usoilsandsinc.com

4.2. Oil Sands In Situ



SAGD stands for Steam Assisted Gravity Drainage, the most commonly used in situ process to extract bitumen.

CHALLENGE: IMPACTS ON LAND

In situ technologies have a very different impact on land use than surface mining. In situ technologies do not create tailings and, as a result, do not require tailings ponds. Multiple wells are drilled from a single pad, minimizing land impacts. The result is that in situ production methods, like SAGD, use almost six times less land per barrel of bitumen than mining.[106] As the industry increasingly shifts to in situ technology, the intensity of land use per barrel of bitumen will decrease.

This section examines two strategies industry is pursuing to lower its impact:

- Reclaiming land faster
- Minimizing impacts on wildlife (see Conserve Plant and Wildlife page 26)

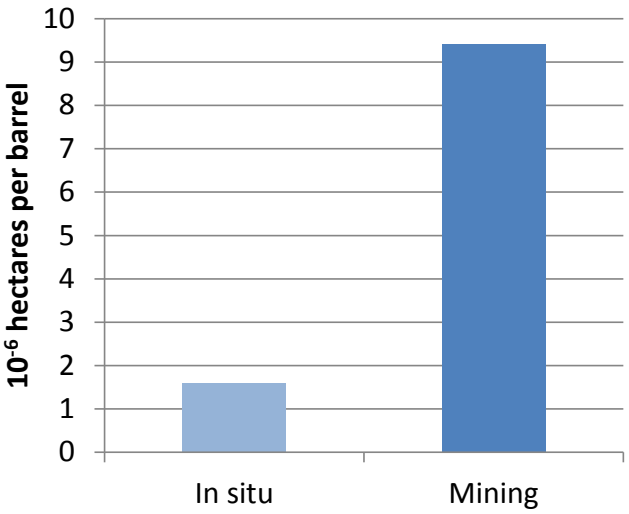


Figure 4.12: Land use intensities for oil sands mining and in situ production, 2012. Source: Pembina Institute

Strategy 1: Reclaiming Land Faster

How Is Industry Doing?[107]

Abandonment is the process of removing equipment from and safely retiring an oil well that is no longer producing. It is the first step in reclaiming the site to a state similar to before production began and serves as a key indicator for how fast industry is reclaiming land.

The first commercial SAGD oil sands project went online in 1996. An in situ operation runs, on average, for more than 30 years. Due to less land disturbance, the reclamation process itself can begin immediately, taking an average of five to seven years. Given that in situ extraction is a relatively new technology, the reclamation of oil sands wells is in an early stage.[108]

The number of abandoned oil sand wells has grown, rising from 49 in 2008 to 751 in 2012.[109] In 2012, 77% of abandoned oil sands wells were in some part of the reclamation process.[110] That year, industry received 321 reclamation certificates—the last step in the reclamation process that allows the firm to release the land back to the government—up from three in 2008.[111]

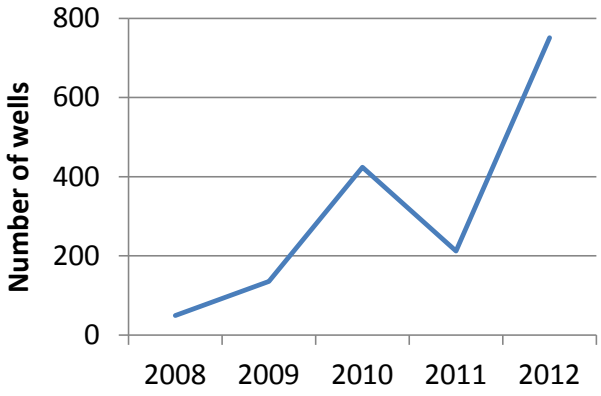


Figure 4.13: Number of annual well abandonments, 2008 to 2012. Source: Canadian Association of Petroleum Producers

106 Jennifer Grant, Eli Angen and Simon Dyer. *Forecasting the impacts of oil sands expansion*. Pembina Institute. June 2013.

107 Source for Replanting Shurbs and Forests textbox: COSIA. *Faster Forests*. http://www.cosia.ca/initiatives/land/faster-forests and *Oil Sands Vegetation Cooperative*. http://www.cosia.ca/initiatives/land/oil-sands-vegetation-cooperative Accessed October 29, 2014.

108 Canadian Association of Petroleum Producers. *Responsible Canadian Energy: Land*.

109 Canadian Association of Petroleum Producers. *Responsible Canadian Energy 2012 Data Tables*. http://www.capp.ca/rce/downloads/ Accessed October 29, 2014.

110 Canadian Association of Petroleum Producers. *Responsible Canadian Energy: Land*.

111 Canadian Association of Petroleum Producers. *Responsible Canadian Energy 2012 Data Tables*.

While industry is increasing the pace at which it is abandoning and reclaiming land, the number of inactive wells—wells that are not producing but have not yet been abandoned—grew by 31% from 2008 to 2012.[112] Well abandonment and reclamation must accelerate in order to keep pace with the growth in production.

Replanting Shrubs and Forests

Faster Forests is a collaboration lead by Conoco Phillips, MEG Energy and several other oil sands firms through COSIA that aims to speed up reclamation of sites disturbed by exploration activities. To date, the program has planted almost three million trees over 1,000 hectares. Other COSIA projects, such as the Oil Sands Vegetation Cooperative, looks to find and bank seeds from a wide variety of species in order to support reclamation efforts that will happen several decades in the future.

What Is Government's Role?

The government of Alberta requires oil and gas companies to abandon wells that are no longer producing and return the land to its original state. Industry must pay $15 million a year into an Orphan Well Fund to cover the costs of reclaiming wells whose owners have gone out of business.[113] In addition, Alberta requires companies to post a security if their environmental liabilities exceed their assets in order to provide greater certainty that the funds will be available to reclaim these sites.[114]

CHALLENGE: GREENHOUSE GAS EMISSIONS

Steam generation represents 90% of the energy used in a typical in situ facility.[115] When the steam is generated using natural gas or other fossil fuels, it becomes a significant source of GHG emissions. About half of the costs of an in situ operation are tied to steam generation and water treatment, giving firms a strong incentive to improve performance.

This report looks at two strategies for reducing the greenhouse gas emissions from in situ operations:

- Reducing emissions from steam generation
- Eliminating the need for steam altogether

112 Canadian Association of Petroleum Producers. *Responsible Canadian Energy 2012 Data Tables.*

113 Alberta Energy Regulator. 2014 Orphan Fund Levy. January 6, 2014. http://www.aer.ca/rules-and-regulations/bulletins/aer-bulletin-2014-02. Accessed October 29, 2014.

114 Canadian Association of Petroleum Producers. *Responsible Canadian Energy: Land.*

115 Jacobs Consultancy. *A Greenhouse Gas Reduction Roadmap for Oil Sands*. Prepared for the Climate Change and Emissions Management Corporations. May 2012. http://ccemc.ca/wp-content/uploads/2013/01/C101221-CCEMC-GHG-Reduction-Roadmap-Final-Report.pdf Accessed October 30, 2014.

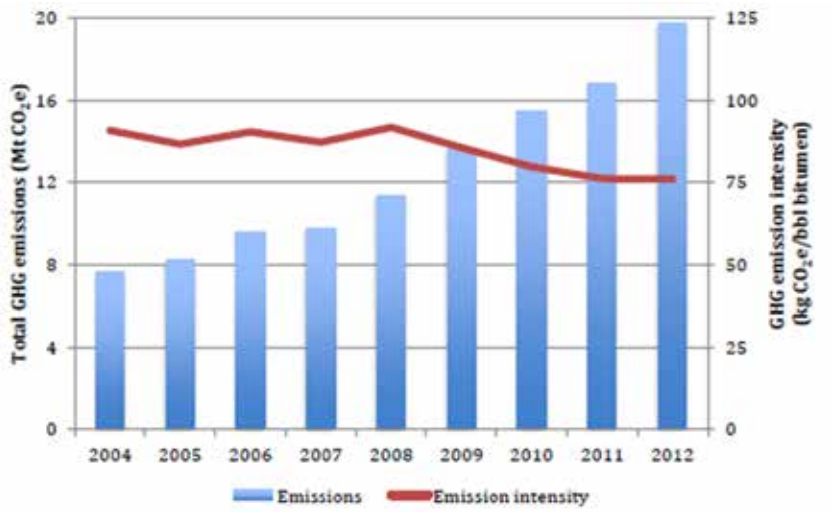


Figure 4.14: Total GHG emissions and GHG emissions per barrel of oil produced, 2004 to 2012. Source: Canadian Energy Research Initiative

Strategy 1: Reducing Emissions from Steam Generation

How Is Industry Doing?[116]

The amount of GHG emissions created to produce a barrel of oil has been falling steadily over the past decade at a rate of about 2% per year.[117] However, as in situ production continues to grow, the industry's absolute levels of GHG has continued to rise. Over the next five years, in situ operations will be one of the fastest growing contributors to greenhouse gas emissions in Canada. Using technologies to improve the energy efficiency of steam generations, particularly co-generating heat and electricity, has the potential to reduce emissions from in situ operations by 12%.[118]

Two Types of Energy for the Price of One

When clean-burning natural gas is burned to create electricity, it generates large amounts of waste heat. Co-generation captures both the heat and the power from a natural gas generator, reaching efficiency levels of up to 95%, twice as high as conventional facilities. MEG Energy uses co-generation at its Christina Lake project, selling much of the electricity it generates back to the provincial electricity grid. When co-generated electricity replaces coal-powered electricity from Alberta's provincial grid, it helps reduce the province's over all GHG emissions. With co-generation, in situ oil sands producers can produce a barrel that is in the range or below common oil imports to the United States.

116 Source for Two types of energy for the price of one textbox: Meg Energy. Cogeneration. http://www.megenergy.com/operations/cogeneration. Accessed October 30, 2014.

117 Canadian Energy Research Institute. *Oil Sands Environmental Impact*. Study no 143, July 2014.

118 Jacobs Consultancy. *A Greenhouse Gas Reduction Roadmap for Oil Sands*.

What Is on the Horizon?[119]

Solar Thermal Generation

Solar thermal technologies use mirrors to collect the heat of the sun. Solar thermal systems could be used to replace at least part of the natural gas used to generate steam for in situ production, leading to fewer GHG emissions. Currently, a demonstration project is underway in California to use solar power to generate steam for enhanced oil recovery.

Mini Nuclear Plants

Japan's Toshiba Corporation has been developing a 'mini' nuclear power station that would produce only 5% of the electricity generated by a typical facility and would only need to be refuelled once every 30 years. A 2013 report indicated that the company is working on applying the technology to the oil sands. For a project producing 100,000 barrels a day, nuclear technology could save 100 megatonnes of carbon dioxide a year.

What Is Government's Role?

The government of Alberta was the first to regulate greenhouse gases in North America. The government mandates emissions reductions with those not in compliance paying $15 per tonne or purchasing Alberta-based offsets. The money collected from industry, now nearly $500 million, is being invested in technology development and in projects to reduce emissions at the source.Government regulation to regulate GHG emissions from in situ projects are the same as the ones outlined in the mining section on page 18.

Strategy 2: Eliminating the Need for Steam Altogether

How Is Industry Doing?[120]

There are several technologies in the development or demonstration stage to reduce or even eliminate the need for steam, leading to significant savings in energy use, greenhouse gas emissions and water use.

Solvents with Steam

Laricina Energy is running a demonstration project that uses solvents along with steam. The solvents are propane (used to fuel BBQs and hot air balloons) and butane (used in lighters). These hydrocarbons make the bitumen easier to extract from the surrounding sand and clay, and as a result, the amount of steam needed is reduced by a quarter. Production from the project is set to ramp up in 2014.

Solvents Instead of Steam

Imperial Oil has a pilot project underway to replace steam with solvents, mostly propane. The solvent mixes with the bitumen to create liquids that are pumped to the surface and then processed, where the solvent will be recovered. The process has the potential to reduce GHG emissions from in situ production by more than 90%.

119 Source for Solar Thermal Generation text box: Meagan Wohlberg. Solar heat holds potential for steam-assisted oilsands: engineer. Northern Journal. June 9, 2014. http://norj.ca/2014/06/solar-heat-holds-potential-for-steam-assisted-oilsands-engineer/ Accessed October 30, 2014. Source for Mini nuclear plants: Alberta Oil. "Mini-Nuclear Reactors: Distributed, small scale nuclear reactors is ready to go prime time". *Alberta Oil Magazine*. May 1, 2014. http://www.albertaoilmagazine.com/2014/05/mini-nuclear-reactors/

120 Source for Solvents with steam textbox: Laricina Energy. Germain. http://www.laricinaenergy.com/operations/germain.html Accessed October 30, 2014.

What Is on the Horizon?[121]

Microwaving the Oil Sands

A new process being developed by a group of companies uses microwaves to heat the oil sands. Just like food in a microwave oven gets hot while the container stays cool, the process heats up the moist oil sands without wasting heat on the surrounding rock. A solvent is used to make the bitumen flow more readily. The result is a process that uses no steam, leading to large savings in GHG emissions and water use.

Electrifying the Oil Sands

E-T Energy is developing a process that uses electrical currents to heat the water already present in oil sands reservoirs. The heated water melts the bitumen, which is brought to the surface relatively free of sand and other impurities. The process uses no steam and little water and natural gas and can be used to extract oil sands that are too deep for extraction using SAGD.

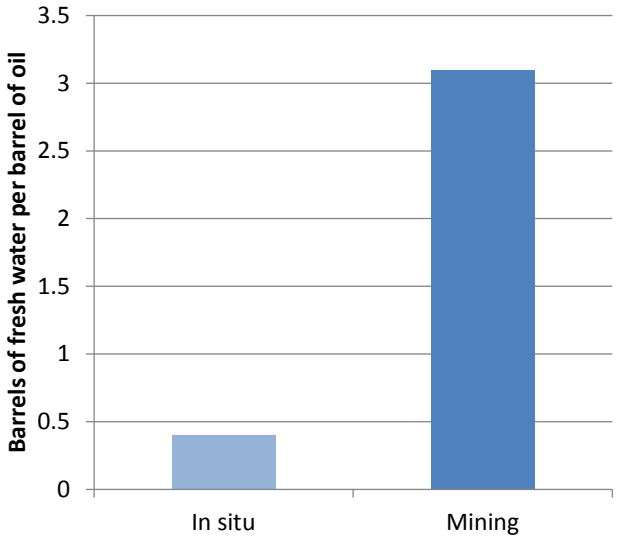


Figure 4.15: Fresh water use intensity for mining and in situ oil sands production. Source: Canadian Association of Petroleum Producers.

CHALLENGE: WATER USE

Just as with land use, in situ technologies have a different impact on water use. In situ technologies do not create tailings and thus do not require tailings ponds. Instead, water is mostly used to generate steam. Recycling rates over 90% and the use of deep, undrinkable water sources means that in situ producers use a much smaller proportion of fresh (not surface) water to produce a barrel of bitumen than mining.[122]

When recycled water is used to make steam in a boiler, the natural salts and silica end up becoming concentrated over time to the point where the water can no longer be used. This water must be disposed of in underground wells or in treatment facilities, far below the water table.

This section examines how industry is working to reduce the amount of fresh water used in in situ oil sands production.

Strategy: Using Less Fresh Water

How Is Industry Doing?

On average, in situ oil sand projects recycle about 93% of the water they use. The remaining water must be 'made up' by drawing on new sources. In situ operators are regulated to use non-potable water supplies. In 2002, almost all this make-up water came from fresh water sources, but industry has increasingly been turning to brackish water—undrinkable groundwater— which now makes up half of in situ water use. The amount of fresh water per barrel of oil has dropped by more than 70% over the past decade. As a result, despite a 450% increase in production since 2002, fresh water use has only risen by 10%.

121 Source for Solvents instead of steam: Nathan Vanderklippe. "Imperial to spend $100-million to test new oil sands technology". *Globe and Mail*. October 3, 2012. Source for Microwaving the oil sands: Carrie Tait. "Oil sands firms test alternative way to tap bitumen". Globe and Mail. June 12 2012 Source for Electrify the oil sands: Canadian Energy Research Institute. *Oil Sands Environmental Impact*.

122 Canadian Energy Research Institute. *Oil Sands Environmental Impact*.

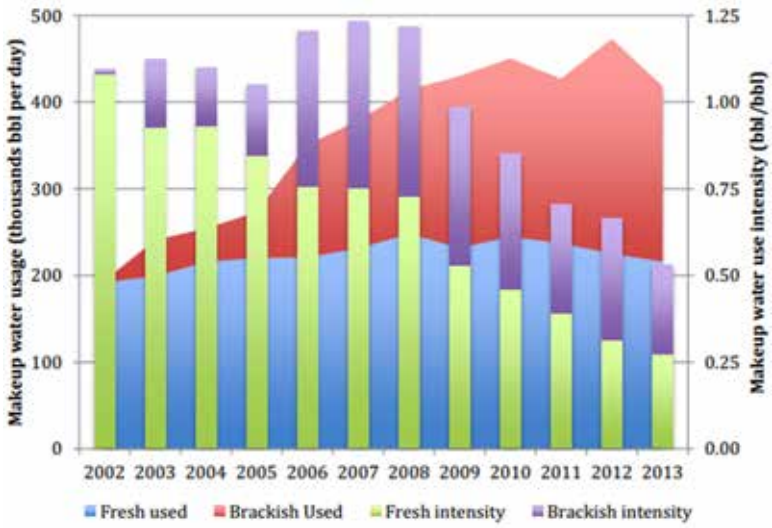


Figure 4.14: Total GHG emissions and GHG emissions per barrel of oil produced, 2004 to 2012. Source: Canadian Energy Research Initiative

What Is on the Horizon?[124]

Recycling Waste Water

Suncor has been using new sources of water for steam generation. In spring 2014, the company began using water from its nearby tailings pond to generate steam for its Firebag in situ operation. It expects the recycling project to reduce fresh water use by 65% compared to 2007.

Better Boilers

Boilers are used to produce the steam for in situ oil sands projects. About 20% of the water used by the boiler becomes thickened with the salts and silica naturally found in the water. This water is usually disposed of either underground or in treatment facilities. BP and Imperial Oil are experimenting with a process that would use the waste water from one boiler as the input to another, increasing the efficiency of the boilers and cutting the waste water by half.

What Is Government's Role?

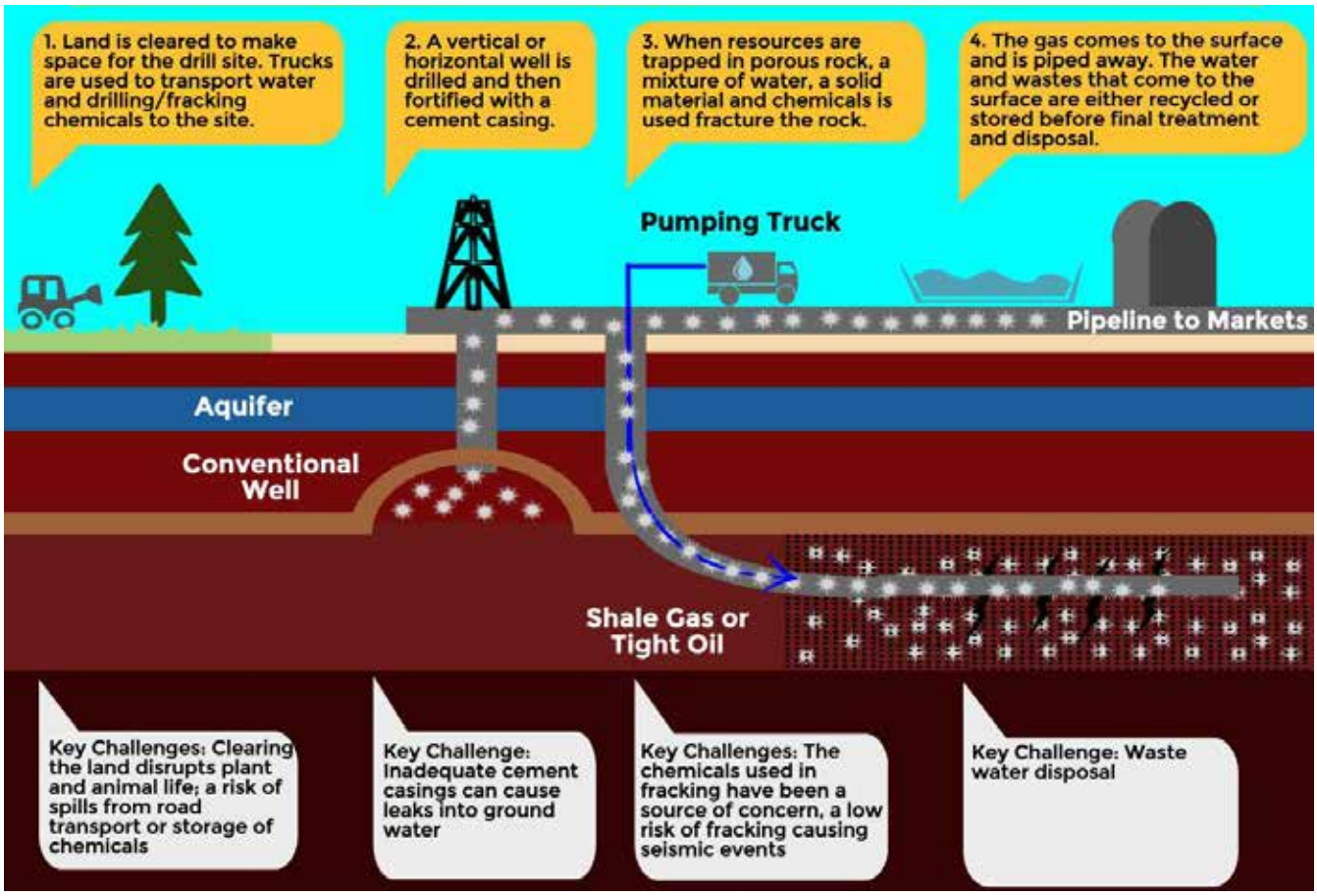
The Alberta government's system for managing withdrawals of fresh water is outlined in greater detail on page 32.

In addition, the government limits the amount of waste water in situ oil sands operators can dispose of in order to promote water recycling and ensure all water sources are effectively used. As an upper limit, in situ operators are only allowed to dispose of 3% of fresh water, 10% of produced water (water that is released during the drilling process) and 35% of brackish water.[125]

124 Source for Recycling waste water textbox: Philippe de Montigny. "Suncor Energy recycles toxic oil-sands runoff in industry first — but will other firms follow?" *National Post*. June 5, 2014. http://business.financialpost.com/2014/06/05/suncor-energy-inc-tailing-ponds/?__lsa=eb2a-deb0 . Accessed October 30, 2014. Source for Better Boilers textbox: COSIA. Boiler Blowdown Reduction Technologies. http://www.cosia.ca/boiler-blowdown-reduction-technologies Accessed October 30, 2014.

125 Alberta Energy Regulator. Directive 81: Water Disposal Limits and Reporting Requirements for Thermal In Situ Oil Sands Schemes. http://www.aer.ca/rules-and-regulations/directives/directive-081 Accessed October 30, 2014.

4.3. Conventional and Hydraulic Fracturing



Conventional oil and gas drilling has been taking place in Canada for over 150 years but has been declining as easy to access gas and oil resources have become exhausted. As a result, the use of techniques to stimulate declining reserves or tap into unconventional sources has become increasingly common. One of these techniques is hydraulic fracturing—the use of high pressure water and chemicals to create fractures in rock—which dates back to the 1950s. Since that time, 175,000 wells have been hydraulically fractured in Western Canada.[126]

In the 2000s, industry combined hydraulic fracturing with a technique that had been used since the 1970s to drill wells horizontally rather than vertically. The combination of these two technologies made resources trapped in porous rock—such as shale gas or tight oil—economical to extract.[127]

This section looks at the environmental challenges of both conventional and unconventional oil and gas production outside of the oil sands.

126 Canadian Association of Petroleum Producers. Governments regulate shale gas, industry promotes operating practices. June 11, 2012. http://www.capp.ca/aboutUs/mediaCentre/NewsReleases/Pages/governments-regulate-shale-gas.aspx

127 Zhongmin Wang and Alan Krupnick. "A Retrospective Review of Shale Gas Development in the United States: What Led to the Boom?" Resources for the Future Discussion Paper. http://www.rff.org/RFF/documents/RFF-DP-13-12.pdf

CHALLENGE: IMPACTS ON LAND[128]

Similar to any kind of industrial development, oil and gas production require land to be cleared of trees and other vegetation to make way for roads, pipelines, wells and facilities. These clearings can adversely impact wildlife habitat and lead to problems like erosion.

Compared to conventional gas production, shale gas requires more wells to be drilled. On the other hand, horizontal drilling allows for several wells to be produced from a single drill site, greatly reducing the footprint of the site.[129] Overall, the National Energy Board does not expect the land footprint of shale gas production to be much more than conventional gas.[130]

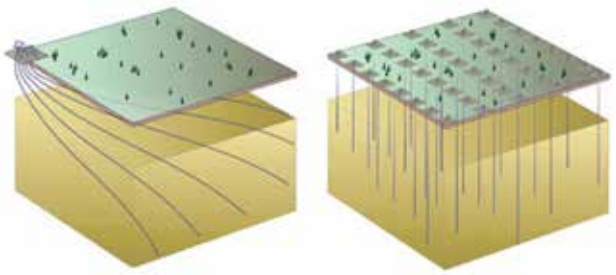


Figure 4.17: A 20-well horizontal drilling pad disturbs about 5% of the land of an equal number of vertical drilling pads. Source: Canadanaturalgas.ca

Of great concern for many members of the public is the potential for hydraulic fracturing to cause earthquakes. Activities that inject gas or liquids underground, such as carbon dioxide disposal, geothermal energy, mining, waste water disposal or hydraulic fracturing, have long been known to have a risk of triggering small earthquakes. According to the Council of Canadian Academies—a panel of independent scientists that provides science advice to the federal government—most experts believe the risk of triggering earthquakes as part of hydraulic fracturing or waste water disposal to be low.[131]

Earthquakes triggered by hydraulic fracturing or waste water injection are rare and these quakes are typically not strong enough to felt by humans or do damage to property. For example, an investigation in British Columbia's Horn River Basin determined that between 2009 and 2011, injection of waste water from shale gas production caused 38 small earthquakes. In comparison, Horn River has had 8,000 hydraulic fractured wells without any associated earthquakes. The risks of inducing a small earthquake during oil and gas production can be minimized by monitoring and proper site section.

To further reduce their land footprint, oil and gas operators are pursuing two strategies:

- Reducing the impact of land use
- Reclaiming the land after use

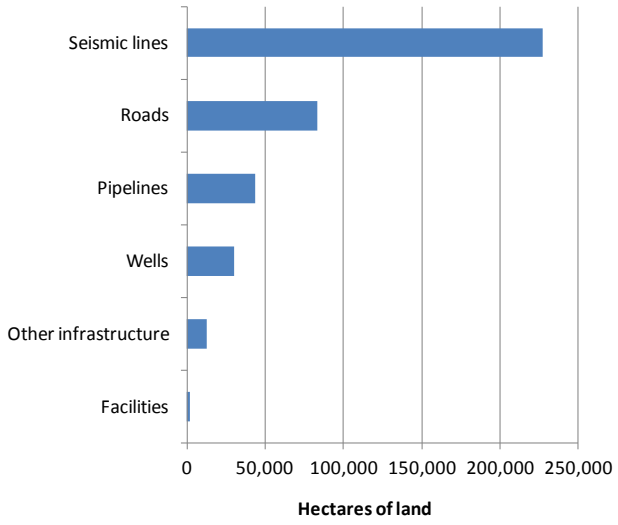


Figure 4.18: Surface Area used by oil and gas activities in British Columbia, 2013. Source: BC Oil and Gas Commission.

128 Source for Does fracking cause earthquakes? Textbox: Council of Canadian Academies. *Environmental Impacts of Shale Gas Extraction in Canada*. Ottawa (ON): The Expert Panel on Harnessing Science and Technology to Understand the Environmental Impacts of Shale Gas Extraction, Council of Canadian Academies. 2014.

129 Canadian Society for Unconventional Resources. *Understanding Well Construction and Surface Footprint*. http://www.csur.com/sites/default/files/Understanding_Well_Construction_final.pdf

130 National Energy Board. *A Primer for Understanding Canadian Shale Gas*. Energy Briefing Note. November 2009. http://www.neb-one.gc.ca/clf-nsi/archives/rnrgynfmtn/nrgyrprt/ntrlgs/prmrndrstndngshlgs2009/prmrndrstndngshlgs2009-eng.pdf

131 Council of Canadian Academies. *Environmental Impacts of Shale Gas Extraction in Canada.*

Strategy: Reducing the Impact of Land Use

How Is Industry Doing?[132]

Most of the land use associated with conventional, shale or tight oil and gas production comes from long, linear clearings. For example, as much as 60% of the land used by industry in British Columbia is for seismic lines used to locate an oil or gas resource and understand its characteristics.[133] Conventional methods of building seismic lines have resulted in straight paths as large as eight metres wide where vegetation was cut and soil disturbed, fragmenting wildlife habitat and causing problems like erosion and runoff into streams.[134]

Newer low-impact methods have reduced both the footprint of seismic lines, roads and pipelines and the impact these linear developments have on the environment. Low-impact seismic lines are anywhere between 1.75 and 5.5 metres wide. Where possible, these lines are built to preserve vegetation and avoid the use of heavy equipment.[135]

Mulch Roads

Instead of building access roads to its shale gas sites, Devon Energy lays down wood mulch created from waste wood or unsold timber harvested at the work site. The use of mulch reduces the size of the right-of-way by as much as half and preserves roots, plants and wildlife habitat, speeding the reclamation process. Once the project is completed, the mulch is collected and reused for another road.

Hand-cut Lines

Conventional seismic lines often used bulldozers to clear seismic lines, leading to long-term impacts. An alternative is to use crews of four to hand-cut seismic lines following a path that avoids ecologically important trees and other features. These types of lines can be as narrow as 1.5 metres wide, about the same as a low-use hiking trail. Because stumps are not removed, the risk of erosion is minimal.

What Is on the Horizon?[136]

Exploration by Helicopters

In certain cases, helicopters can replace vehicles to move equipment and personnel along seismic lines. This allows for narrow seismic lines and eliminates the need for access roads. Cenovus is developing a seismic rig that can be transported by helicopter, reducing the footprint of its test well program by half.

Strategy: Reclaiming the Land Faster

How Is Industry Doing?

Abandonment is the process of removing equipment from and cementing off formally productive oil and gas wells. It is the first step in restoring the site to a state similar to before production began.

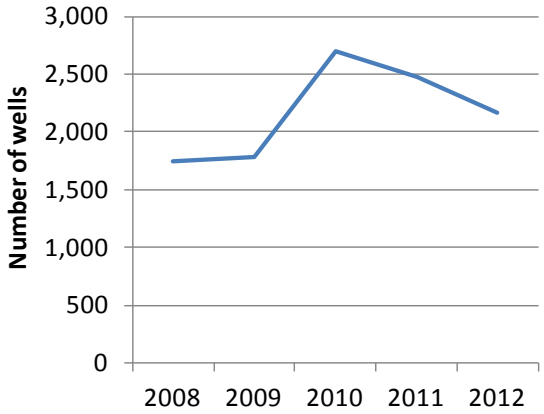


Figure 4.19: Annual Well abandonments in Western Canada, 2008 to 2012. Source: Canadian Association of Petroleum Producers.

132 Source for Mulch Roads textbox: Devon. Canadian Sustainability Part 3: Making Roads that Disappear. http://www.devonenergy.com/featured-stories/canadian-sustainability-part-3-making-roads-that-disappear. Accessed October 30, 2014. Source for Hand-cut lines textbox. Canadian Association of Petroleum Producers. *Geophysical Exploration Processes*.

133 BC Oil and Gas Commission. Oil and Gas Land Use in Northeastern British Columbia. August 2013. http://www.bcogc.ca/node/11039/download

134 Canadian Association of Petroleum Producers. *Geophysical Exploration Processes*. http://www.capp.ca/getdoc.aspx?DocId=81307&DT=NTV

135 Canadian Association of Petroleum Producers. *Geophysical Exploration Processes*.

136 Source for Exploration by Helicopters textbox. COSIA. Flying Drill Rig. http://www.cosia.ca/flying-drilling-rig. Accessed October 30, 2014.

The number of abandoned conventional, shale and tight oil and gas wells in Western Canada rose by about a quarter between 2008 and 2012. In 2012, 71% of abandoned oil sands wells were in some part of the reclamation process.[137] However, the number of inactive wells—wells that are not producing but have not yet been abandoned—grew by 32% from 2008 to 2012.[138] Well abandonment and reclamation must accelerate in order to keep pace with growth in production. The pace at which sites are being reclaimed is not keeping pace with well drilling activity.

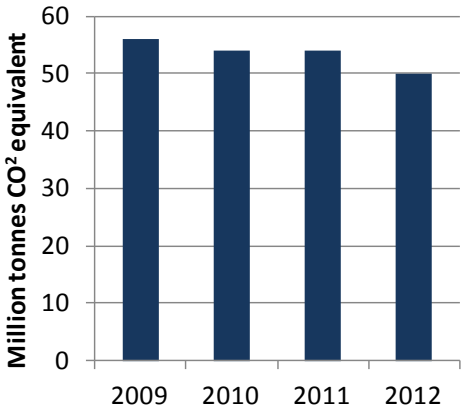


Figure 4.20: GHG Emissions from Western Oil and Gas production. Source: Canadian Association of Petroleum Producers.

What Is Government's Role?

Alberta's regulation of land use for oil and gas wells is outlined on page 37. British Columbia and Saskatchewan have similar orphan well regulations.

CHALLENGE: GREENHOUSE GAS EMISSIONS

Emissions from western oil and gas production have remained constant over the past five years. A slight increase in greenhouse gas (GHG) emissions is anticipated as production from shale gas and tight oil rises.[139]

A number of U.S. studies have found that there is little difference in GHG emissions from conventional natural gas production and shale gas production.[140] One 2011 study by Natural Resources Canada found that life cycle emissions from Canadian shale gas were on average less than 4% higher than conventional gas.[141]

Much of the discussion around the climate impacts of shale gas has focused on its use as a replacement for coal in electricity generation. When burned to produce electricity, natural gas (methane) emits around half the emissions of coal-fired power plants. However, if methane is released directly into the atmosphere, it is has an impact on climate that is 25 times greater than carbon dioxide over the course of a century. Accordingly, the benefit to the climate of replacing coal with natural gas depends on how much methane is accidentally or intentionally released.

Accidental leakages or intentional releases of natural gas are significant sources of GHG emissions during conventional, shale, and tight oil and gas production, accounting for 30% of GHG emissions on average.[142] Natural gas might be intentionally burned (flared) or released without burning (vented) for safety reasons or because it is not economical to capture the gas.

A widely-reported 2011 study from Cornell University argued that because of leaks during shale gas production, emissions from electricity generated from natural gas was 20% higher than coal. This result has been refuted by a number of studies, including

137 Canadian Association of Petroleum Producers. *Responsible Canadian Energy 2012 Data Tables*.

138 Canadian Association of Petroleum Producers. *Responsible Canadian Energy 2012 Data Tables*.

139 Canadian Association of Petroleum Producers. "Greenhouse Gas Emissions: Western Canada". *Responsible Canadian Energy*. http://www.capp.ca/rce/western-canada/air/greenhouse-gases/ Accessed October 30, 2014.

140 ICF Consulting Canada. "A literature review of key studies comparing emissions from natural gas and coal". Prepared for the Canadian Natural Gas Initiative. December 2012. http://www.capp.ca/getdoc.aspx?DocId=215278

141 (S&T)2 Consultants. *Shale Gas Update for GHGenius*. Prepared for Natural Resources Canada. August 31, 2011. http://www.ghgenius.ca/reports/ShaleGasUpdateFinalReport.pdf

142 (S&T)2 Consultants. *Shale Gas Update for GHGenius*.

ones runs by the University of Maryland, the Massachusetts Institute of Technology, the Carnegie Mellon University, the U.S. Environmental Protection Agency and the Worldwatch Institute. The studies found that emissions from natural gas generation were 36 to 44% lower than coal.[143]

It has even been refuted by recent history: energy-related GHG emissions fell 10% between 2005 and 2013, a drop possible in part by plants switching from coal to natural gas generation.[144]

The two strategies to reduce GHG emissions from oil and gas production discussed in this report are:

- Reducing flaring and venting
- Reducing leaks

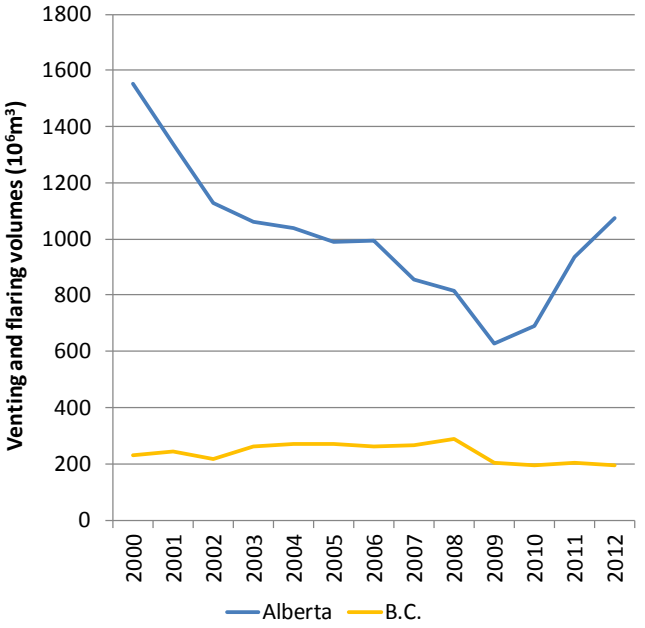


Figure 4.21: Venting and flaring volumes from the B.C. and Alberta Oil and Gas industry, 2000 to 2012. Source: BC Oil and Gas Commission and Alberta Energy Regulator.

Strategy 1: Reducing Flaring and Venting

How is Industry Doing?[145]

Flaring and venting natural gas is done by the oil and gas industry for both safety and economic reasons. Driven by new regulations and industry practices, flaring and venting from crude oil and gas operations fell by 56% in Alberta between 2000 and 2010. However, low natural gas prices, which discourage capture, and increased production have reversed that trend over the last few years.[146] In British Columbia, flaring and venting fell 15% between 2000 and 2012.[147]

An issue particular to hydraulic fracturing is methane emissions associated with well completions. Once a well has been drilled, some of the fracking fluid returns to the surface, bringing natural gas along with it. Historically, that natural gas was vented into the atmosphere, but new "green completion" technologies capture up to 90% of these emissions.[148] In B.C., the majority of natural gas operations use green completions or flare the natural gas.[149]

143 ICF Consulting Canada. "A literature review of key studies comparing emissions from natural gas and coal". Prepared for the Canadian Natural Gas Initiative. December 2012. http://www.capp.ca/getdoc.aspx?DocId=215278

144 U.S. Energy Information Administration. *U.S. Energy-Related Carbon Dioxide Emissions, 2013*. October 21, 2014. http://www.eia.gov/environment/emissions/carbon/

145 Source for Green Completions textbox: Adam Goehner and Matt Horne. *Wellhead to Waterline: Opportunities to limit greenhouse gas emissions from B.C.'s proposed LNG industry*. Pembina Institute. February 2014. http://www.pembina.org/reports/pi-wellhead-to-waterline-goehnerhorne-022014.pdf

146 Alberta Energy Regulator. *Upstream Petroleum Industry Flaring and Venting Report*. October 2013. http://www.aer.ca/documents/sts/ST60B-2013.pdf

147 BC Oil and Gas Commission. *Flaring Summary 2012*. July 2013 http://www.bcogc.ca/node/11030/download

148 Council of Canadian Academies. *Environmental Impacts of Shale Gas Extraction in Canada*.

149 Adam Goehner and Matt Horne. *Wellhead to Waterline: Opportunities to limit greenhouse gas emissions from B.C.'s proposed LNG industry*. Pembina Institute. February 2014. http://www.pembina.org/reports/pi-wellhead-to-waterline-goehnerhorne-022014.pdf

Green Completions

Reduced emissions or "green" completions use portable equipment to capture the mixture of fluid and natural gas that rises up after a well has been drilled. It then separates the natural gas and sends it down a pipeline for sale. A 2013 study run by the University of Texas-Austin and the Environmental Defense Fund measured the emissions from 190 wells. It found that new facilities were capturing 99% of the emissions from well completions. As a result, methane emissions from these facilities were in fact 97% lower than a previous U.S. government estimae.

What Is Government's Role

Both Alberta and British Columbia prohibit venting, except in limited circumstances. Both provinces have also set targets to reduce or eliminate the use of flaring.[150]

Strategy 2: Reducing Leaks

How Is Industry Doing?

Methane can leak from pipes and equipment during processing or transportation or from abandoned wells where the cement is failing.[151] The Canadian Association of Petroleum Producers (CAPP) estimates leakages at 0.4% of total gas production, lower than the U.S. estimate of 1.5%.[152] A CAPP survey of 120 facilities in Alberta and British Columbia found that equipment leakages have fallen 75% since 2005, when industry began implementing inspection and maintenance programs.[153]

There is limited data on leakages from abandoned wells, which can vary widely by region. In B.C., an estimated 10% of both active and suspended oil and gas wells leak, while in Saskatchewan, 20% of wells leaked. In Quebec, 18 of 28 active wells had minor leaks, while the figure from New Brunswick was two of 29.[154] Generally, a few poorly constructed wells are responsible for the majority of emissions. This underscores the importance of ongoing monitoring as well as developing new technologies to ensure the long-term integrity of wells.[155]

What Is on the Horizon?[156]

Space-age Inspection Technology

Most of Canada's pipelines are inspected by human operators. Synodon, a Canadian firm, has developed a sensor that uses technology currently used on NASA's Terra satellite. The sensor is mounted on a helicopter, allowing 10 times more pipeline to be inspected every hour than is possible with conventional methods. The firm expects the widespread use of the technology could reduce pipeline losses by 20%.

What Is Government's Role

Provincial regulators generally require testing for leaks shortly after construction of the well and again when it is abandoned. Severe leaks must be reclaimed immediately and all leaks, both severe and minor, must be repaired when the well is abandoned.

---

150 Council of Canadian Academies. *Environmental Impacts of Shale Gas Extraction in Canada.*

151 Council of Canadian Academies. *Environmental Impacts of Shale Gas Extraction in Canada.*

152 Council of Canadian Academies. *Environmental Impacts of Shale Gas Extraction in Canada.*

153 Canadian Association of Petroleum Producers. *An Update of Fugitive Equipment Leak Factors. Report 2014-0023*. 2014 www.capp.ca/getdoc.aspx?DocId=238773&DT=NTV

154 Maurice B. Dusseault, Richard E. Jackson, Daniel Macdonald. *Towards a Road Map for Mitigating the Rates and Occurrences of Long-Term Wellbore Leakage*. Department of Earth and Environmental Sciences, University of Waterloo. May 22, 2014. http://www.geofirma.com/Links/Wellbore_Leakage_Study%20compressed.pdf

155 Maurice B. Dusseault, Richard E. Jackson, Daniel Macdonald. *Towards a Road Map for Mitigating the Rates and Occurrences of Long-Term Wellbore Leakage*.

156 Source for Space-Age inspection technology textbox: Sustainable Development Technology Canada. *Canadian Innovation Improves Pipeline Safety*. http://www.sdtc.ca/uploads/documents/en/successstories/SDTC_Synodon_WEB_V2_280110.pdf

CHALLENGE: WATER USE & QUALITY

Water is used for a number of purposes in oil and gas production. In conventional oil and gas drilling, small amounts of water are used to lubricate the drill and support the well shaft. During hydraulic fracturing, water mixed with sand and a small proportion of chemicals are sent down the well at high pressure to create the small fractures that release oil or gas from the surrounding rock. Water contamination has been a particular concern with regards to hydraulic fracturing since small amounts of toxic chemicals are added to the fracturing mixture.

The strategies industry has been using to reduce its impact on water include:

- Using less fresh water
- Preventing groundwater contamination
- Developing green fracking chemicals

Strategy 1: Using Less Fresh Water

How Is Industry Doing?[158]

Given that conventional natural gas and oil operations use very little water, concerns over water use tend to focus on wells that use hydraulic fracturing. Overall, the oil and gas industry uses little water compared to total water resources.[159] For example, water allocated to the oil and gas industry in British Columbia, through approvals or licences, accounted for 0.015% of the runoff from B.C.'s river basins.[160]

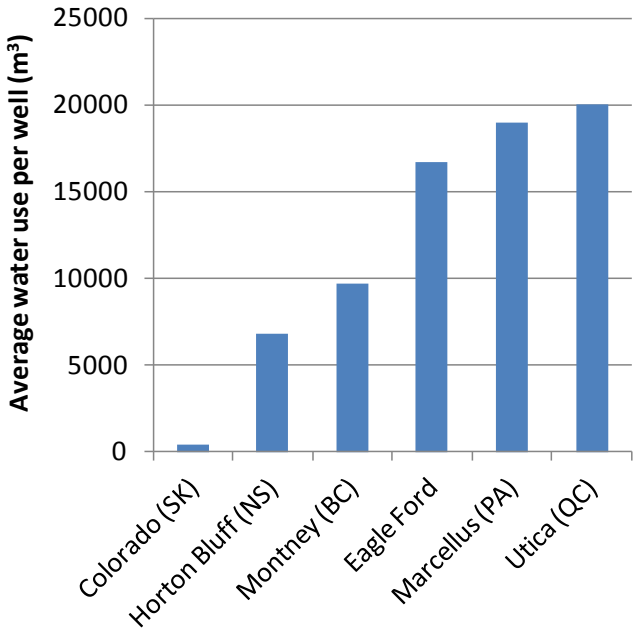


Figure 4.22: Average water use per well for hydraulic fracturing by region. Source: Council of Canadian Academies

Shale gas and tight oil fracking needs anywhere from 5,000 to 100,000 cubic metres of water per well depending on the geological features of the resources such as the thickness of the rock.[161] As a comparison, 19,000 cubic metres of water could grow three hectares of corn in a season or water a golf course for 25 days.[162] Even with hydraulic fracturing, natural gas is one of the least water intensive fuels, consuming less water than coal, uranium, oil and cellulose or corn-based ethanol.[163]

Industry is developing a number of alternatives to fresh water. In B.C., about 15% of the water used in hydraulic fracturing comes from water that has been recycled from other wells. Other sources include waste water from drilling or mining, sewage from local municipalities or undrinkable underground reservoirs.

158 Source for Dawson Creek Reclaimed Water Project textbox. Shell Canada. Shell and Dawson creek to conserve water in British Columbia. September 7, 2012. http://www.shell.ca/en/aboutshell/media-centre/news-and-media-releases/2012/0907dawson-creek.html

159 Council of Canadian Academies. *Environmental Impacts of Shale Gas Extraction in Canada.*

160 B.C. Oil and Gas Commission. Water Use for Oil & Gas Activities: 2013 Annual Report. http://www.bcogc.ca/node/11262/download

161 Canadian Association of Petroleum Producers. "The Facts on Natural Gas". *Upstream Dialogue*. December 2012.

162 Council of Canadian Academies. *Environmental Impacts of Shale Gas Extraction in Canada.*

163 Erik Mielke, Laura Diaz Anadon, and Venkatesh Narayanamurti. *Water Consumption of Energy Resource Extraction, Processing, and Conversion*. Energy Technology Innovation Policy Research Group. Harvard Kennedy School Belfer Center for Science and International Affairs. October 2010. http://belfercenter.ksg.harvard.edu/files/ETIP-DP-2010-15-final-4.pdf

Waterless Fracking

A Canadian company has developed a way to eliminate the use of water in hydraulic fracturing. The Gasfrac system uses a gelled form of propane, a gas used in BBQs across Canada, in place of water. Most of the propane can be recovered within a few days and recycled for future use. This not only saves fresh water but also reduces the need to store water waste and to transport water to the well.

Using Underground Salt Water

The Debolt water aquifer is an underground, non-potable water reserve in British Columbia that is unfit for most uses. Apache and Encana have developed a first-of-its-kind system to use this salty, sulfur-heavy water for at least 80% of the water needed for hydraulic fracturing.

What Is on the Horizon?[164]

Recycling Water

After a well is fracked, some of the water returns to the surface. This flowback water can be treated and recycled in new wells. A system to treat and reuse flowback water developed by Haliburton was used in New Mexico to save 30 million litres of fresh water. Recycling water also eliminated 1,400 truck loads to the site, saving GHG emission from transport. The technology saved the operator between $500,000 and $700,000.

Dawson Creek Reclaimed Water Project

In 2012, Shell and the City of Dawson Creek partnered to build a sewage treatment plant with a capacity of 4,000 cubic metres a day, enough water for over 12,000 households. Previously, this sewage was released directly into a local waterway, but now the treated water is used both by Shell for natural gas production and by the city for municipal uses like watering plants. Shell has virtually eliminated the need for fresh water at its Groundbirch shale gas project.

What Is Government's Role?

The governments of Alberta and British Columbia manage withdrawals of both fresh and groundwater through a licensing system. As in Alberta, the oil and gas industry in B.C. accounts for a relatively small amount of total water allocation.

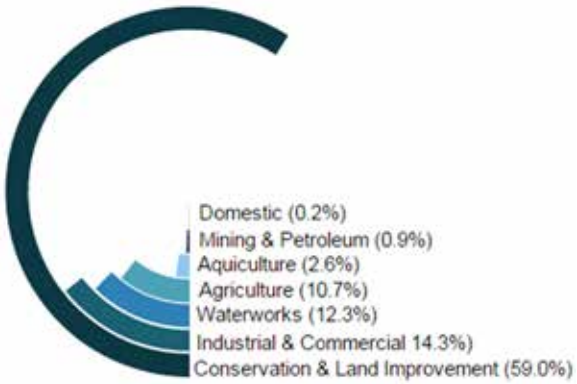


Figure 4.23: Surface Water Allocated by sector, British Columbia, 2006. Source: Government of British Columbia. For water allocations in Alberta, please Figure 4.10 on page 32.

164 Source for recycling water: Halliburton. *Case Study: Effective Fracturing with Recycled Water*. 2013. http://www.halliburton.com/public/pe/contents/Case_Histories/web/A_through_R/H09855-Permian-Basin-Case-History.pdf. Accessed November 3, 2014. Source for Dawson Creek Water Reclamation Project textbox: Council of Canadian Academies. *Environmental Impacts of Shale Gas Extraction in Canada*. Source for Waterless fracking textbox: Gasfrac Energy Services. Proven Innovation Technology. http://www.gasfrac.com/ Accessed November 3, 2014. Source for Using underground salt water textbox: Encana. Debolt facility provides alternative to surface water sources. http://www.encana.com/news-stories/our-stories/environment-debolt-facility.html Accessed November 3, 2014

Strategy 2: Preventing Groundwater Contamination

How Is Industry Doing?

The potential for oil and gas developments, particularly those that use hydraulic fracturing, to contaminate surface or ground water is a major public concern. There are two main ways oil and gas operations could contaminate water.

- Accidental spills from trucks or storage facilities that hold chemicals or waste water into lakes or rivers. The risks from spills can be minimized by proper management practices.[165]
- Leaks of methane from drilling operations into groundwater. The water used in or produced by hydraulic fracturing is generally too heavy to migrate to the surface under normal circumstance.[166] In fact, with an estimated 2.5 million fracs conducted worldwide, there is no known case of hydraulic fracking fluids migrating through rock to contaminate groundwater.[167] Accordingly, concerns about groundwater contamination focuses on natural gas contamination.

While most of the attention around groundwater contamination has focused on hydraulic fracturing, it is a relatively low-risk part of the oil and gas extraction process.[168] A 2011 study in Ohio and Texas looked at decades' worth of state investigations into groundwater pollution from oil and gas production. Of the 396 incidents uncovered, none were related to hydraulic fracturing. Instead, contamination was most often caused by accidental leaks from waste storage facilities into surface water, particularly legacy issues from an outlawed form of disposal pit, or problems with the cement casing used to stabilize the well.[169] The fact that most fracking happens thousands of kilometres below groundwater sources, coupled with the geological feature that kept oil and gas trapped for millions of years, means that groundwater contamination from fracking is unlikely.[170]

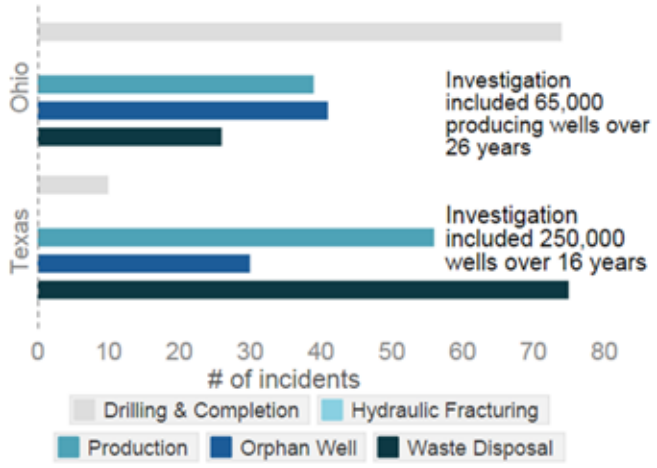


Figure 4.24: Number of groundwater pollution incidents. Source: Society of Petroleum Engineers

165 Council of Canadian Academies. *Environmental Impacts of Shale Gas Extraction in Canada.*

166 George E. King. *Hydraulic Fracturing 101: What Every Representative, Environmentalist, Regulator, Reporter, Investor, University Researcher, Neighbor and Engineer Should Know About Estimating Frac Risk and Improving Frac Performance in Unconventional Gas and Oil Wells*. Society of Petroleum Engineers. February 2012.

167 George E. King. *Hydraulic Fracturing 101.*

168 George E. King. *Hydraulic Fracturing 101.*

169 George E. King. *Hydraulic Fracturing 101.*

170 George E. King. *Hydraulic Fracturing 101.*

For both conventional wells and those that use hydraulic fracturing, leaks from wells is the more common concern. An independent panel in Nova Scotia found that, while complete success is impossible, modern techniques have lead to excellent wellbore integrity and leaks do not seem to be a large problem in British Columbia or Alberta where most production takes place. While natural gas leaks are a concern for climate change, natural gas is a non-toxic substance and large leaks are rare and, as a result, do not pose a large risk to human health.[171]

What Is Government's Role

The Alberta and British Columbia governments regulate several aspects of oil and gas production to ensure the safety of water resources, such as requiring specific types of well casings, requiring monitoring and testing and determining minimum setbacks between water wells and drilling operations. Releasing water used in shale gas production is prohibited in British Columbia.[172]

Strategy 3: Developing Green Fracking Chemicals

How Is Industry Doing?

Fracking fluid is injected underground as part of hydraulic fracturing process. Some of that water stays underground where it is trapped by the same clay or impermeable rocks that have kept the oil and gas in place for millennia. With an estimated 2.5 million fracs conducted worldwide, there is no known case of hydraulic fracking fluids migrating through rock to contaminate groundwater.[173] Some of the fluid returns to the surface where it must be reused and stored. The possibility of spills or leaks from fracking fluids that have returned to the surface has led to concerns over the use of chemicals in hydraulic fracturing.

Fracking fluid is almost all (~ 95%) water, with some additional sand or another hard material to help prop open the fractures and release the gas or oil. The rest—0.1 to 2%—of the fracking fluid is chemical

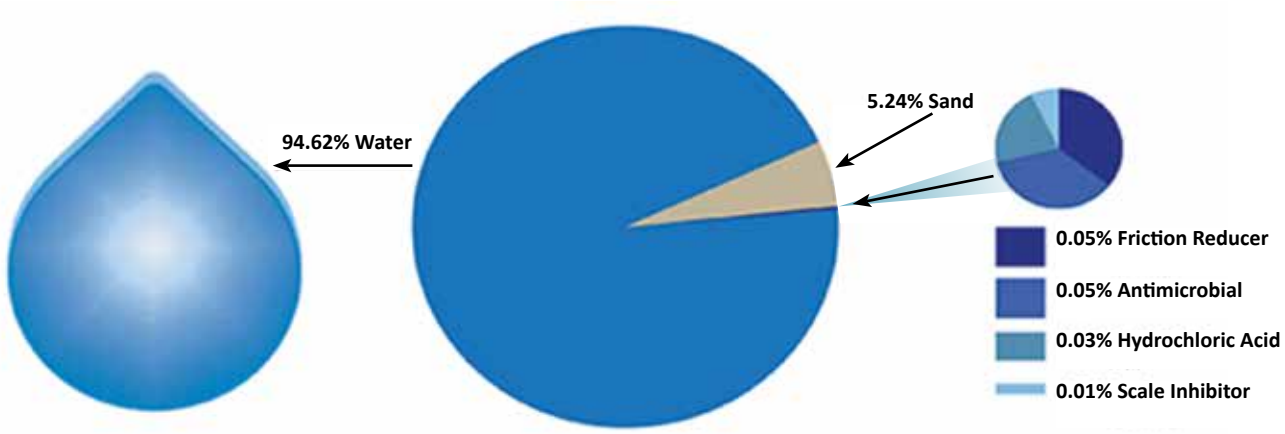


Figure 4.25: Composition of fracking fluid. Source: BC Oil & Gas Commission

171 Dr. Maurice Dusseault. Energy Well Integrity. Nova Scotia Hydraulic Fracturing Independent Review and Public Engagement Process. Cape Breton University. http://www.cbu.ca/sites/cbu.ca/files/docs/hfstudy/Discussion%20Paper%20-%20Energy%20Well%20Integrity.pdf Accessed November 4, 2014.

172 Dr. Graham Gagnon. *What are the interactions between unconventional gas resources and water resources? Input quality and quantity requirements and water treatment needs and impacts*. Nova Scotia Hydraulic Fracturing Independent Review and Public Engagement Process. http://www.cbu.ca/sites/cbu.ca/files/docs/hfstudy/Discussion%20Paper%20-%20Water.pdf Accessed November 4, 2014.

173 George E. King. *Hydraulic Fracturing 101*

additives, which vary depending on the particular characteristics of the geological formation. A typical fracturing fluid will have from three to 12 chemicals serving one of the following roles[174]:

- *Friction reducers* minimize the friction and pressure on the pipes, allowing the fluid to carry more sand into the fractures. A common friction reducer is polyacrylamide, a non-toxic polymer used in the treatment of municipal water and disposable baby diapers.
- *Biocides* are added to kill down-hole bacteria that can corrode pipes. Some biocides like glutaraldehyde, a medical disinfectant, are toxic. However, non-toxic alternatives like ultraviolet light and ozone are increasingly being used.[175]
- *Scale inhibitors* are compounds that keep scales from forming in pipes. The formation of scales can slow oil and gas flow. An example is phosphonate, a common ingredient in detergents.
- *Surfactants* are detergents that help wash out contaminants down-hole so the well can yield more oil and gas. Lauryl sulphate is a surfactant that is a common additive that is also used in dish soaps and shampoos.

What Is on the Horizon?

A Drinkable Fracking Fluid

Haliburton's CleanSim fracturing service uses a fracking fluid made from ingredients sourced from the food industry. While it does not taste very good, the fluid is completely non-toxic.

What Is Government's Role?

Both Alberta and British Columbia require companies to disclose the chemicals used in their fracking fluids. In both jurisdictions, this information is disclosed to the public on Fracfocus.ca. Other Canadian jurisdictions do not mandate disclosure.

174 BC Oil and Gas Commission. "What Chemicals are Used". FracFocus: Chemical Disclosure Registry. http://fracfocus.ca/chemical-use/what-chemicals-are-used Accessed November 4, 2014.

175 George E. King. *Hydraulic Fracturing 101*

5. HOW DOES CANADA COMPARE?

This report focuses on the environmental performance of resource industries. An important question is how well Canada's resource sector is doing in protecting land, air and water resources compared to other jurisdictions around the world. Claims that Canada is a world leader in sustainable natural resource production seems at odds with reports and rankings of Canada's overall environmental performance, which do not often place Canada in a leadership position:

- The Environmental Performance index compiled by Yale University and Columbia University ranks Canada' 24th out of 178 countries.[176]
- The World Energy Council ranks Canada 56th out of 129 in terms of the environmental sustainability of our energy system.[177]
- Conference Board of Canada ranks Canada 15th out of 17 peer countries in terms of environmental performance.[178]

However, Canada's overall environmental performance does not necessarily reflect the progress being made by individual industries. Assessing an industry's performance requires an examination of specific regulations, indicators and sector practices that are not captured by national-level data.

Comparing the environmental performance of natural resource industries in different countries is a difficult task. Geological or topological features often dictate the choice of extraction or harvesting techniques, which can make direct comparisons hard to make. For instance, Norway's oil and gas resources are produced by off-shore drilling, a technique that has very different environmental impacts than oil sands mining in Alberta. Regulations that might make sense in some environments may not be applicable in others. An example is Brazilian regulations that apply forestry buffer zones to Amazon Rivers wider than 600 metres, which are not comparable to the many areas of the world where rivers are generally narrower.[179]

There are other complicating factors as well. Regulations of environmental impacts and natural resource production are often set by states and provinces, so there can be wide variation between the approaches and stringency of environmental regulation within countries. Finding comparable data is not always possible.

These challenges make a comprehensive comparison of the environmental performance of Canada's resource industries very difficult. Instead, this last section reviews some of the pre-existing reports on the performance of the forestry and oil and gas sectors. No recent international comparison report was identified for the mining sector. Given the central place climate change has in discussions over environmental protection, a separate section examines the economy-wide policies for regulating greenhouse gas emissions.

176 Yale Center for Environmental Law & Policy and the Center for International Earth Science Information Network. 2014 Environmental Performance Index. http://epi.yale.edu/epi. Accessed December 10, 2014.

177 World Energy Council. 2014 Energy Trillema Index. www.worldenergy.org/data/trilemma-index/. Accessed December 10, 2014.

178 Conference Board of Canada. How Canada Performs 2012: Environment. www.conferenceboard.ca/hcp/details/environment.aspx. Accessed December 10, 2014.

179 Forest Products Association of Canada. *How Canada Compares: International Review of Forest Policy and Regulation*. July 2004. http://en.calameo.com/read/00012681467065a7e157c

FOREST PRODUCTS[180]

Perhaps the most comprehensive assessment of international forest regulation was a 2004 report conducted by Ben Cashore of Yale University's Center for Forestry. His work examined the forestry regulatory regimes of 38 different jurisdictions around the world, including four Canadian provinces (British Columbia, Alberta, Ontario and Quebec) and 14 U.S. states. The study looked at a number of different regulations in order to assess their stringency, defined as regulations that they were mandatory rather than voluntary and included a substantive amount of detail.[181]

For all of the types of regulation examined in the report, Canada had put into place stringent policies and regulations. While there were areas that could be improved, the study concluded that Canada had one of the world's most advanced regulatory regimes.

Equally important, Canadian provinces, particularly Ontario and British Columbia, had the most thorough processes to monitor compliance of all of the jurisdictions examined. This was a key finding, given that jurisdictions with the most stringent regulations generally had the lowest compliance rates. Problems of political stability, corruption or insufficient budget can make the enforcement of these regulations difficult, resulting in a very different reality from what the regulations envision.[182]

Key Areas of Forestry Sustainability Regulation

Some of the key findings of the Cashore report:

Regulation of areas around waterways
Canada had put into place mandatory and detailed rules regarding forestry buffer zones around waterways, generally considered a fundamental element of sustainable forestry.

Mandatory limits on the size of clear cuts
All four Canadian provinces included in the study had established mandatory limits on the size of clear cuts, which were not common on plantation forests in the U.S. and Latin America.

Roads
Canada and the U.S. had similar rules in place regarding road decommissioning but were the only jurisdictions besides Indonesia to have taken this approach.

Annual allowable cuts
Canada has put into place limits on the amount of trees that can be harvested. Generally, countries with plantation forests do not specify allowable cuts.

Reforestation
Similar to many European jurisdictions, Canada had stringent time limits on forest regeneration.

180 Source for textbox: Forest Products Association of Canada. *How Canada Compares: International Review of Forest Policy and Regulation*.

181 Forest Products Association of Canada. *How Canada Compares: International Review of Forest Policy and Regulation*.

182 Forest Products Association of Canada. *How Canada Compares: International Review of Forest Policy and Regulation*.

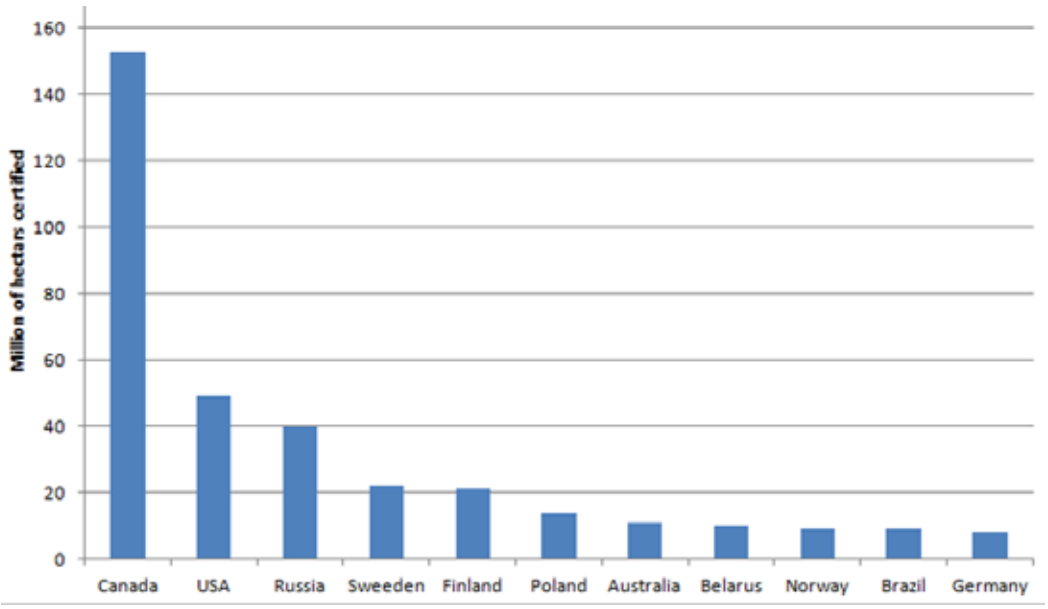


Figure 5.1: Area of third-party certified forests for selected countries, 2013. Source: Canadian Council of Forests Ministers.

An increasingly important tool for managing the sustainably of forests is third-party certification standards. To become certified under one of these standards, forest companies must have plans, procedures and systems that meet certain requirements. Performance is monitored and audited by outside companies and is assessed against predetermined criteria. These audit reports must be disclosed to the public.[183] Canada currently leads the world in the use of third-party certification, with 40% of the world's certified lands.[184]

Although it ranks Canada's environmental performance poorly overall, the Conference Board of Canada ranks Canada second out of 17 peer countries for the intensity of use of forest resources, defined as the actual harvest as a per cent of annual growth. In recent years, Canada's actual harvest has been 44% of annual growth, while the OECD average has been 56%.[185] Canada ranked much lower in terms of change in forest cover, placing 15 out of 17 nations. This result is largely due to the fact that, after centuries of deforestation, European countries are actively working to increase their forest cover, while Canada's forest cover has remained fairly consistent over the last few decades.[186]

Boreal Forest Agreement

In 2010, 21 major Canadian forest products companies and nine leading environmental non-government organizations signed the Canadian Boreal Forest Agreement (CBFA). The CBFA is an ambitious multi-year collaborative agreement that sets six strategic goals to address both environmental and economic sustainability. Covering an area three times the size of the U.K., the CBFA is the largest conservation agreement ever signed. It is also notable for bringing industry and environmental groups together to work towards common goals. After four years, the agreement has had setbacks, in particular the slow progress at setting up a network of protected areas and recovering species at risk. Nevertheless, it represents an important experiment in a new paradigm for resource management to reconcile environmental and economic concerns.

183 Canadian Council of Forest Ministers. *Sustainable Forest Management in Canada: Canada: Embracing Third-Party Certification*. 2014. www.sfmcanada.org/en/sustainable-forest-management/embracing-third-party-certification. Accessed December 2, 2014.

184 Canadian Council of Forest Ministers. *Sustainable Forest Management in Canada: Canada: Embracing Third-Party Certification*.

185 Conference Board of Canada. *How Canada Performs 2012: Use of Forests Resources*. www.conferenceboard.ca/hcp/details/environment/use-of-forest-resources.aspx Accessed December 12, 2014.

186 Conference Board of Canada. *How Canada Performs 2012: Use of Forests Resources*.

OIL AND GAS

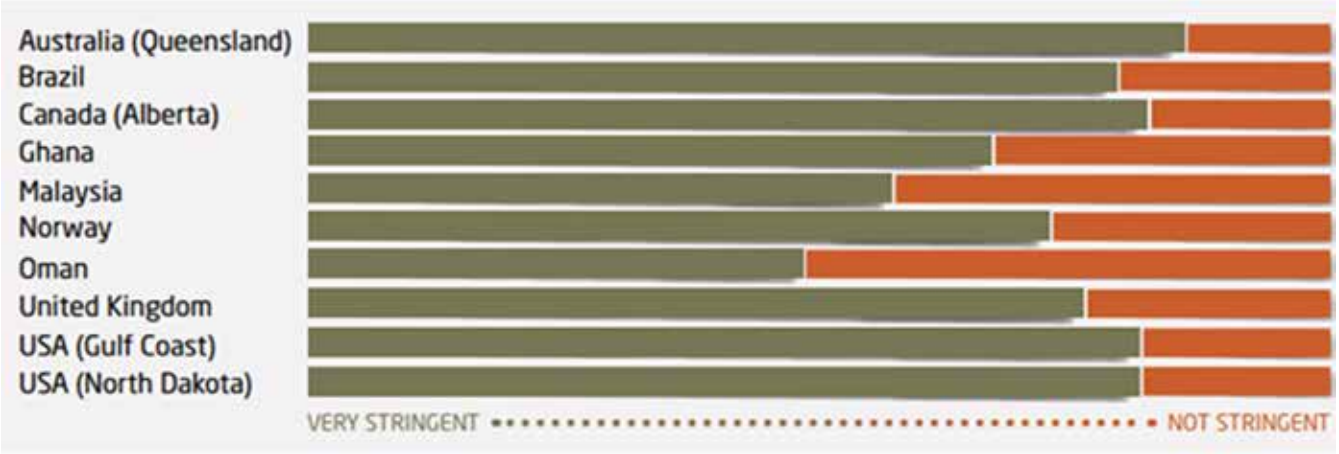


Figure 5.2: Stringency of environmental laws in various oil producing regions: Source Worley Parsons

In 2014, Worley Parsons was commissioned by the Canadian Association of Petroleum Producers to compare the regulatory regime of Alberta's oil and gas system to various oil-producing jurisdictions around the world. The examination focused on the stringency of environmental laws, the transparency of the system and the rules around compliance of 10 jurisdictions chosen for their similarity to Alberta—based on activity levels, governance and maturity.[187]
The report found that the regulatory regime in Alberta was among the most stringent among the 10 jurisdictions. Included in this assessment were factors like:

- Requirements for project approvals
- Time and cost to obtain an approval
- Number of regulators reviewing applications
- Opportunities for the public to review and comment
- Requirements for monitoring
- Facility licence renewals
- Consideration of cumulative effects
- Closure planning
- Decommissioning requirements
- Government security requirements

187 Worley Parsons. *An International Comparison of Leading Oil and Gas Producing Regions: Environmental Regulation*. 2014.

	AUS (QLD)	BRA	CAN (AB)	GHA	MYS	NOR	OMN	GBR	USA (North Dakota)	USA (Gulf)
Legend ■ Yes □ No										
Does the government require Environmental Impact Assessments for specified development projects?	■	■	■	■	■	■	■	■	■	■
Are there opportunities for stakeholders to review and provide input on regulatory applications?	■	■	■	■	■	■	□	■	■	■
Is environmental monitoring and reporting required during operations?	■	■	■	■	■	■	■	■	■	■
Is an Operations Environmental Management Plan required to be approved by the regulatory authority?	■	■	■	■	■	■	■	■	■	■
Are cumulative effects monitored?	■	■	■	■	■	■	■	■	□	■
Are there requirements for continuous monitoring?	■	■	■	■	■	■	■	■	■	■
Is there regulatory mandated remediation and reclamation at facility end-of-life?	■	■	■	■	□	■	□	■	■	■
Are reclamation certificates issued by the government?	■	□	■	■	□	■	□	■	□	■
Are there bond or financial security requirements against end-of-life facility liability?	■	□	■	■	□	■	□	□	■	■
Are there government-run programs to remediate and reclaim orphaned facilities and oil wells if a company defaults?	■	□	■	□	□	□	□	□	■	□

The table above shows some of the questions that were used to make the assessment as well as which jurisdictions had put into place each of the environmental sustainability resolutions. The stringency of Alberta's environmental regulation compared favourably to other developed nations like Australia and Norway. Alberta's rules on compliance and transparency were deemed to be the strongest among the countries, provinces and states included in the report.[188]

GREENHOUSE GAS EMISSIONS

Greenhouse gas (GHG) regulation is often used as an important measure of a country, province or state's commitment to environmental regulation. Canada's withdrawal from the Kyoto protocol, a key international agreement on climate change regulation, and the federal government's failure to regulate GHG emissions beyond the electricity and transportation sectors have affected Canada's reputation as an environmental leader. However, in a federation where natural resource development is primarily a provincial concern, looking at the federal government level is not enough to get a true view of Canada's progress in this area. Some of Canada's largest resource-producing provinces have emerged as North American leaders in GHG regulations.

The following table lists the climate change policies of selected Canadian provinces and American states as well as the policies of Australia, Norway and Russia, chosen for being large producers of a range of natural resource commodities.

188 Worley Parsons. *An International Comparison of Leading Oil and Gas Producing Regions: Environmental Regulation*. 2014.

JURISDICTION	PRINCIPAL NATURAL RESOURCES PRODUCED IN THE PROVINCE[189]	ARE THERE ECONOMY-WIDE REGULATIONS FOR GREENHOUSE GASES?
CANADA (Federal)	World's first exporter of forest products, one of the largest mining nations in the world producing more than 60 minerals and metals, a globally important producer of oil and gas	NO – The federal government has put in place GHG regulations for light and heavy on-road vehicles and coal-powered electricity generation but has not implemented regulations that directly impact the oil and gas sector or other resource sectors
British Columbia	Canada's largest producer of roundwood, second largest natural gas producer, fourth largest mineral producer	YES – A carbon tax of $30 per tonne of CO_2 equivalent emissions on all purchases of fuel in the province, including those by mining, forest products or natural gas producers
Alberta	Accounts for 80% of Canada's oil and gas production, Canada's third largest producer of roundwood	YES – GHG reductions are mandated for facilities emitting more than 100K tonnes of carbon a year, with the option of paying a $15 levy per tonne of CO_2 above the limit
Saskatchewan	Canada's third largest mineral producer, second largest oil producer	NO – Saskatchewan is currently developing a GHG policy similar to Alberta's
Ontario	Fourth largest producer of roundwood, largest mineral producer in Canada	NO – Ontario is studying a cap and trade system and has closed all coal-powered electricity generation in the province
Quebec	Canada's second largest mineral producer and producer of roundwood	YES – A cap and trade system that applies to businesses that emit 25,000 metric tonnes or more of CO_2 equivalent a year that allows permits to be traded with California
UNITED STATES (Federal)	World's leading producer of industrial roundwood, largest natural gas producer, third largest oil producer, a significant producer of several minerals	NO – The federal government is putting into place regulations for coal-powered electricity generation, but has not implemented regulations that directly impact the oil and gas sector or other resource sectors
Arizona	The U.S.'s second largest mineral producer	NO

189 Sources for information on resources: U.S. Energy Information Administration, Canadian Association of Petroleum Producers, U.S. Geological Survey, United Nations Food and Agriculture Organization.

California	The U.S.'s third largest crude oil producer, a significant producer of minerals	YES – California has a cap and trade system that applies to businesses that emit 25,000 metric tonnes or more of CO_2 equivalent a year that is linked to the system in California
Nevada	The U.S.'s largest mineral producer	NO
North Dakota	The U.S.'s second largest crude oil producer	NO
Texas	The largest oil and gas producer in the U.S., accounting for 34% of oil production	NO
AUSTRALIA	A leading producer of several important minerals including coal, iron and bauxite, world's third largest liquefied natural gas (LNG) exporter in 2013	NO – An economy-wide carbon tax was repealed in 2014
NORWAY	World's third largest natural gas producer, 12th largest exporter of crude oil	YES – Norway has a carbon tax on fuel use in the Petroleum production and natural gas extraction of around $US 70 per tonne of CO_2
RUSSIA	World's largest exporter of industrial roundwood, second largest producer of natural gas, third largest producer of crude oil	NO

6. CONCLUSION

Canada is a world leader in the production of an incredible range of natural resource commodities. One of the greatest contributions Canada can make to global environmental sustainability is to provide these essential materials in a way that minimizes their impact on land, water and air. This report looked at the forestry, mining and oil and gas sectors in detail, examining indicators that showed how industry is doing today and featuring some of the solutions that could drive performance in the future.

There are some areas where performance has not been improving fast enough, such as managing tailings from oil sands or mining industries. But there are also areas where clear progress has been made and where technological progress offers the chance for even more improvements in the future. What emerges from this report is a clear sense that industry and governments have been taking these problems seriously, putting into place new technologies, practices and regulations that are at least equal to, and in some cases better than, other natural resource-producing nations.

Many Canadians will feel that when it comes to environmental protection, best in the world is simply not enough. The Canadian Chamber of Commerce has a number of recommendations for action by the federal government to help support the continuous improvement in the environmental performance of Canada's resource sectors:

- Implement an economy-wide, market-based approach to climate mitigation that includes all greenhouse gas emitters and sinks.

- Among the broad issues which will need to be faced in the coming years, Canada should focus attention on water management issues by introducing a national water strategy developed in concert with relevant stakeholders.

- Technological development and innovation are crucial to addressing industry's environmental impacts. Support for research and development and commercialization of novel approaches should remain a government priority.

For more information, please contact:
Katrina Marsh | Director, Natural Resources & Environmental Policy | 613.238.4000 (223) | kmarsh@chamber.ca

This report was made possible by the generous support of our sponsors

Diamond

ASSOCIATION OF CONSULTING ENGINEERING COMPANIES | CANADA
ASSOCIATION DES FIRMES D'INGÉNIEURS-CONSEILS | CANADA

Cameco

resolute Forest Products

Platinum

HALLIBURTON

Syncrude

YAMANAGOLD

Gold

ConocoPhillips Canada
EDI – Environmental Dynamics Inc.
PotashCorp
Progress Energy Canada Ltd.
TimberWest Forest Corp.
TransCanada Corporation
Valero Energy Inc.

Ottawa
420-360 Albert Street
Ottawa, ON
K1R 7X7
613.238.4000
613.238.7643

Toronto
901-55 University Avenue
Toronto, ON
M5J 2H7
416.868.6415
416.868.0189

Montreal
560-999 de Maisonneuve
Boulevard West
Montreal, QC
H3A 3L4
514.866.4334
514.866.7296

Calgary
PO Box 38057
Calgary, AB
T3K 5G9
403.271.0595
403.226.6930

THE CANADIAN CHAMBER OF COMMERCE
LA CHAMBRE DE COMMERCE DU CANADA

Chamber.ca