Freshwater: The Role and Contribution of Natural Resources Canada

Energy

Water Issues and Energy

Water and energy have numerous commonalities: both are essential to human well-being, limited in supply, and subject to a growing demand. As world population grows and living standards rise in developing nations, there will be increased pressure on these resources. Water and energy issues are also interconnected; for example, the delivery of water depends on energy for pumping, and many forms of energy production require a dependable water supply. A combined approach to water and energy issues makes sense, for both developed and developing nations.[22]

In Canada, oil and gas development and the generation of hydroelectricity require significant water supplies. In fact, the energy industry withdrew 63 percent of all surface water used in Canada in 1996, making it the single largest user of water. At least 40 percent of this water is recirculated, and 98 percent is discharged.[23] The three main water users within the energy sector are the oil and gas industries, thermal electric generators, and hydroelectric power plants.

Significant potential exists in Canada for conflict between competing users of water. This conflict is already emerging in the western provinces where increasing and competing demands for water by both existing agricultural operations and oil and gas development have escalated into a significant and sometimes heated public-policy issue.

Public Concern

In addition to water-quality issues, some of the public concerns raised in Alberta have included:

- The volume of water being used for enhanced oil recovery;
- Opportunity costs of using surface water for enhanced oil recovery instead of irrigation;
- The risk of wells drying up due to the energy industry's use of groundwater; and
- Perceived limits on agricultural expansion resulting from the energy sector's water use.

Oil and gas industry

The petroleum sector is a large user of water, although a much smaller user than irrigation, commercial cooling and municipal users. This sector, including water injection for oil recovery purposes, was allocated slightly over 4.6 per cent (2.7 billion barrels) (Fig. 3-4) of the total 60 billion barrels of water that were allocated in Alberta in 2002.[24]

The quantity and use of water in Alberta has become a high-profile issue due to many factors. The consecutive years of drought, dwindling water supplies and the rapid growth and expansion of industries and population in Alberta have all played a role in increasing the demand on

Alberta's water supply, thereby raising stakeholder concern about the supply of water for the future.[25] As part of its Water for Life – Alberta's Strategy for Sustainability, the Alberta government is currently assessing water demands and at the watershed level.[26] The Senate Committee on Environment and Natural Resources expressed particular interested in these issues during a recent hearing with the Honourable John Efford, Minister of Natural Resources Canada.

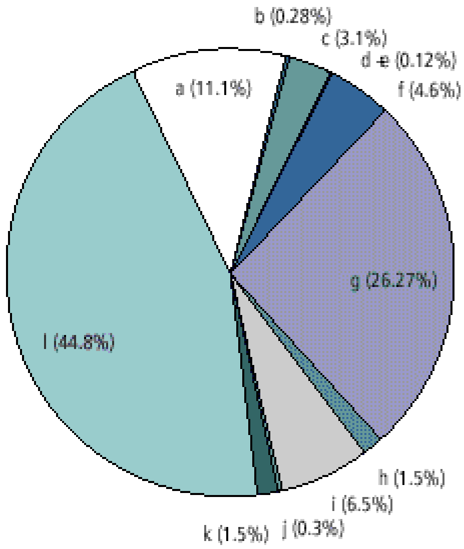
Water use in conventional oil recovery

In conventional recovery, oil is extracted using a well that either allows the oil to flow naturally to the surface or pumps the oil to the surface using artificial lift. Once primary production is complete, secondary or tertiary oil recovery techniques can be used to recover more of the oil resource. In secondary recovery, water or gas is injected into the reservoir to maintain pressure, and water flooding is used to drive the oil through the reservoir to the producing wells.

Tertiary recovery techniques include thermal, gas, solvent and chemical recovery processes. A large amount of water is recycled during the water-flooding process. However, water ultimately replaces the oil that is removed from the reservoir and cannot be recovered, and is therefore removed from the hydrological cycle. It is this loss of water from the cycle that is the greatest concern among stakeholders, especially when freshwater is used.[27]

Figure 3-4:
Water allocation in Alberta by specified purpose

(surface plus groundwater, based on existing licences as of 2001)



- **a** Municipal
- **b** Recreation
- **c** Water Management
- **d** Other Purpose Specified by the Director
- **e** Wildlife Management
- **f** Oil & gas
- **g** Commercial (Cooling)
- **h** Agricultural
- **i** Commercial
- **j** Fish Management
- **k** Habitat Enhancement
- **l** Irrigation

Total Licensed Volumes =9,443,795,000 m^3
(9,259,492,000 m^3 surface water;
184,303,000 m^3 groundwater)

Source: *Water and ©An overview of the use of water for enhanced oil recovery in Alberta.* Government of Alberta, March 2004.

Use of water in oil sands development

Water is an integral part of the oil sands industry for both surface mining and in situ projects. Mining occurs where bitumen deposits are located near the surface and can be recovered by open-pit mining techniques. In situ projects, in which the bitumen is extracted in-place, occur where bitumen deposits are buried too deeply (more than about 75 metres) for mining to be practical. Water from rivers and/or groundwater is used in oil sands projects. Projects located close to a river, as is the case for the existing surface-mining operations, will draw some river water. In situ projects typically use fresh or saline groundwater as their source. In either case, it should be noted that recycling of water to reduce overall requirements is common and that brackish or saline groundwater is used wherever possible.

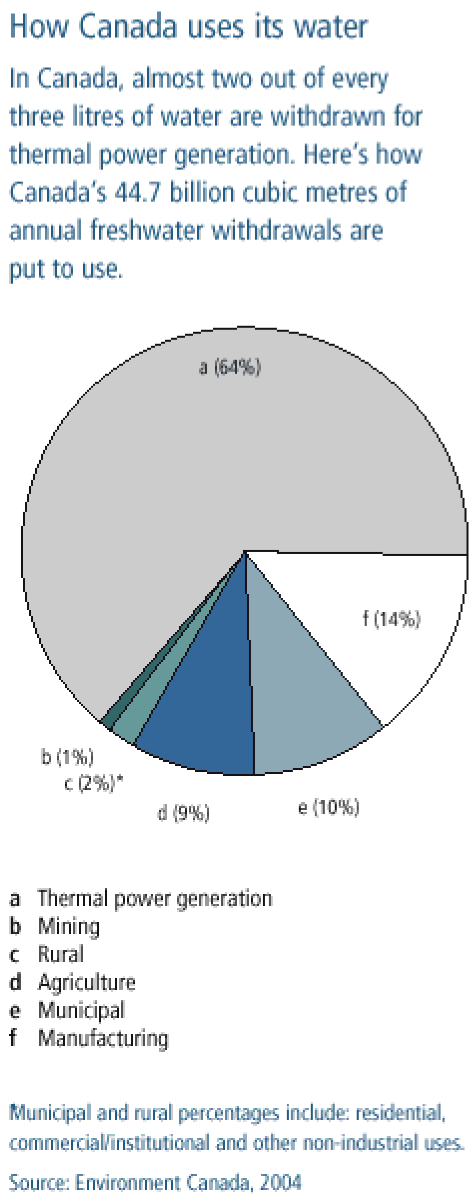
In mining projects, water is used create a slurry of the oil sand ore that is then transported by pipeline to the extraction plant where more water is added and the bitumen is separated the from the sand. Water is also used in integrated operations to upgrade the bitumen to synthetic crude oil. About 70 percent of water is recycled, leaving a balance of two to three barrels of water being used to produce one barrel of synthetic crude oil.[28]

In addition to the above noted uses of water, mining operations affect the natural water flows in the area. To keep the mine area from flooding, water flow from nearby aquifers is diverted, overburden and adjacent formation is dewatered, and muskeg is drained. Overburden, the layer of material (muskeg, shale) between the surface and the underlying bitumen ore, is stripped before the oil sands can be mined. Mining projects route tailings to the tailings-management area where clay and sand separate out of the water. Sand separates rapidly leaving suspended clay and fine sand particles in the tailing pond. As the tailings solids settle, all water released is recycled back to the plant. The long-term objective is to return lands to their pre-mining condition (or as close as possible) within a 10- to 50-year timeframe. This involves topography and watershed reconstruction, as well as vegetation and wildlife repopulation.

In the case of in situ projects, water is used to produce the steam that is injected into the reservoirs to heat up the bitumen and reduce its viscosity in order to bring it to the surface. Because water for steam generation is largely recovered with bitumen produced, and is continuously treated and recycled, net water consumption for in situ production is considerably smaller than for the mining operations. The industry has increased the amount of water that is recycled, typically more than 90 percent, for a net loss of less than 0.2 to 0.3 units per unit volume of bitumen.[29]

The recent oil sands expansion announcements have led to concerns regarding water availability for these new and expanded commercial operations. Questions have been raised regarding the ability of some watersheds to meet the projected demand for water by oil sands developments. Although groundwater is used in most oil sands projects rather than river or lake water, the choice is dependant on where the project is located with respect to water supplies. A project with no river or lake water source close by has no choice but to use groundwater as its source.[30]

With knowledge gaps concerning the actual supply of freshwater and a forecasted increase in oil sands development, it is anticipated that this issue will continue to be a priority among concerned stakeholders. More data collection and research is required to create a sound knowledge base to support decision making on the oil sands industry's use of freshwater sources in its extraction processes.



Thermal and nuclear power plants

Thermal and nuclear power plants generate electricity by converting water into high-pressure steam, which then drives turbines. Water is also used as a coolant to condense the steam back into water. The main issues arising from thermal and nuclear generating plants' water use include the impacts of withdrawing large volumes from aquatic ecosystems, the effects of temperature change caused by thermal plant water discharge, and the potential release of impurities into the environment.[31]

Hydroelectric power generation

The amount of electricity a hydro power installation can produce depends on the quantity of water passing through a turbine (the volume of water flow) and on the height from which the water falls (the amount of head). The greater the flow and the head, the more electricity produced. There are different types and sizes of hydro power installations in Canada, ranging from micro hydro plants that provide electricity to only a few homes to mega-installations, such as Churchill Falls in Labrador which produces enough power to light three cities the size of Montreal. Hydro power provides an opportunity to meet Canada's increasing energy needs, provide recreational uses, steady sources of water for drinking, forestry operations, and irrigation without substantially increasing greenhouse gas emissions, or increasing air emissions, smog or acid precipitation. However, there are impacts of building dams that must be considered.

Responding to Stakeholder Challenges

For the past decade hydroelectric companies have been facing challenges from many stakeholders, including Aboriginal communities, fisheries agencies, environmental groups, and recreational users, about the allocation of water resources. Companies have been developing water planning processes involving extensive stakeholder consultations to ensure their continued ‘licence to operate' while balancing stakeholder needs and other resource values.

World Water Council

First International Summit

on Sustainable Use of Water

for Energy

In Canada, there are over 600 large dams, and 54 inter-basin diversions created mainly for the purpose of hydroelectric power generation.[32] An inter-basin diversion is the withdrawal of water from its basin of origin for use in another drainage basin. Dams can alter the natural habitat of fish, and result in changes in plant life and nutrient levels which can impact the food chain.[33] Other potential impacts of reservoirs and inter-basin diversions include effects on water quality in terms of temperature, nutrient loading, mobilization of mercury from soils, and changes to sediments and the amount of silt in the water. Reservoirs can also alter the timing and distribution of streamflow, which in turn, disrupts ecosystems upstream as well as downstream.[34]

Today, more emphasis is being placed on small hydroelectric developments and run-of-river facilities. A recently completed inventory of Canadian small hydro sites generating between 20 and 25 megawatts (MW) identified over 5,500 sites with a technically feasible potential of about 11,000 MW.[35] Small hydro stations particularly in New Brunswick, Nova Scotia, Ontario, and Alberta produce about 2,000 MW. This capacity is only a small contribution to the total Canadian installed hydroelectric capacity of 70,000 MW.[36]

Water-Related NRCan Energy Sector Activities

NRCan's Energy Technology and Programs Sector enhances the economic and environmental well-being of Canada by fostering the sustainable development and use of the nation's energy resources through technology innovation, development and demonstration. Activities include: the enhancement of water management in the energy industry, reduction of contaminated water discharge from the recovery and processing of oil sand bitumen and heavy oil, supporting the development of CO_2 sequestration

technologies using depleted oil reservoirs and aquifers, improved oil sands processing technologies for greater water recycling, and improved hydrocarbon-water separation technologies that reduce the discharge of oily water from various hydrocarbon processes and sites. These projects contribute to reducing the demand for freshwater and also decrease the negative environmental impacts of energy development.

Water use in oil and gas production

NRCan is involved in issues related to the cumulative effects of development, particularly as it relates to the oil sands, and has a number of science and technology initiatives dealing with water use in oil and gas production.

CANMET Energy Technology Centre tailings research

NRCan scientists at CANMET Energy Technology Centre (CETC – Devon, Alberta), have developed a comprehensive understanding of the implications of water chemistry on surface mined bitumen extraction performance and tailings behaviour. These researchers have also built a water chemistry model capable of simulating process water chemistry changes associated with recycled water use decades into the future.

NRCan researchers were directly involved in the development of composite or consolidated tailing (CT), and paste tailing technologies for oil sands tailings. These technologies result in rapid water release from tailings and reduce make-up water demand by providing more recycle water for the process. Paste has the added advantage of recovering heat from the waste water. The tailings activity at CETC–Devon also includes research and development and/or evaluation of more aggressive tailings treatments that can return even more water to the extraction process than CT or past technologies.

The Oil Sands Tailings Research Facility (OSTRF) was opened in 2004 at the Devon Research Centre to develop long-term technology options for oil sands tailings management. The OSTRF is a joint partnership between CETC-Devon, University of Alberta, Alberta Research Council and the oil sands industry with start-up funds provided by Canada Foundation for Innovation.

Science and technology development

NRCan researchers are evaluating and researching new extraction technologies that would use less water per barrel of bitumen extracted at both mining-based and in situ oil sands operations, and/or tolerate the use of poorer-quality water streams rather than draw from the Athabasca River.

Through the Petroleum Technology Research Centre (PTRC) in Regina, Saskatchewan, NRCan is financially supporting research on 21st-century water flooding. That work is expected to help improve our understanding of water injection on reservoir processes and reduce the need for potable water use in water flooding (i.e. increased saline groundwater and recycle fractions).

Managing Cumulative Effects

NRCan is an associate member in the Cumulative Environmental Management Association (CEMA), a multi-stakeholder group that has been set-up to look at issues related to the cumulative environmental effects of Athabasca oil sands development—including water management—especially in the Wood Buffalo Area.

NRCan was a major sponsor of the four-year International Energy Agency Greenhouse Gas Weyburn CO_2 Monitoring and Storage Project, led by PTRC. Funding was provided during 2000-2004 towards the study of CO_2 sequestration through tertiary recovery at the EnCana Weyburn CO_2 -EOR (enhanced oil recovery) operation in southeastern Saskatchewan, which was previously operated solely as a water-flood oil recovery field. More than one-quarter of the oil production at Weyburn is now attributed to CO_2 -EOR. A further phase of the project is expected to begin in April 2005 to further improve the understanding and operation of CO_2 sequestration in partially depleted oil reservoirs.

Small hydroelectric power technology

There is considerable scope for the development and optimization of this renewable, non-polluting energy source. Small-scale hydroelectric facilities have a valuable role to play in meeting Canada's energy requirements, particularly those of rural regions, in a sustainable and environmentally friendly manner. Natural Resources Canada supports the development of small hydroelectric facilities in Canada through the programs described below. More information is available on the program web sites referenced in the notes.

Renewable Energy Technologies R&D Program[37]

The Small Hydro Technology Development Program is part of NRCan's Renewable Energy Technologies (RET) Program. Its objective is to promote the development of appropriate technology to make it more economical to develop a greater range of small-scale and low-head hydroelectric resources. This Program responds to the needs of the Canadian small hydroelectric industry, and brings together the expertise in industry, universities and other relevant government programs. The Program is now concentrating on tools and techniques for reducing equipment and construction costs.

Renewable Energy Policy and Market Development[38]

NRCan's Renewable and Electrical Energy Division promotes the development of a sustainable renewable energy industry in Canada, including small hydro. The Division promotes investments in renewable energy systems for heating and cooling and provides information on renewable energy technologies. It also provides analysis and advice to the Minister on electricity issues in Canada. By strengthening markets for the renewable energy industry, the Division's programs will contribute to the reduction of greenhouse gas emissions and reduce traditional water needs in the energy sector, as well as fostering job creation and export sales.

The Canadian Renewable Energy Network[39]

The Canadian Renewable Energy Network (CanREN) was created to increase understanding of renewable energy to accelerate the development and commercialization of renewable energy technologies. CanREN promotes what NRCan and its partners are doing to advance the role of renewable energy, including small hydro, in Canadian society. It offers general information on renewable energy sources, highlights the technologies and applications being developed to harness these sources, and presents Canadians with the knowledge and support they need to make renewable energy part of their everyday lives.