

# ENERGY RICH

NON-RENEWABLES ACCOUNT FOR 90 PER CENT OF CANADA'S PRIMARY ENERGY PRODUCTION. A LOOK AT SOME OF THE NATION'S MOST IMPORTANT ENERGY RESOURCE SITES.

BY KARAN SMITH AND MICHELA ROSANO

In the chilly North Atlantic, massive ocean rigs draw oil from under the seabed. Along the shores of the mighty St. Lawrence River, untapped deposits of natural gas that could be worth billions lie in shale. In the farmland of Alberta, coal is hauled out of the Earth. In the boreal forest of northern Saskatchewan, remote-controlled machinery extracts the world's highest-grade uranium. Canada boasts great diversity above ground, but there are also rich resources beneath it. While the use of renewable energy sources, such as wind turbines and solar panels, continues to increase every year, non-renewable energy forms still largely fuel industry and our lives. In the past three decades, Canadian energy production has almost doubled, and the nation continues to be among the top per capita consumers of energy in the world. In the pages that follow, *Canadian Geographic* examines what's driving the country's energy sector and explores the journey of that oil, gas, ore and uranium, from field and mine to refinery and power plant.





The West Aquarius exploration drill rig, off the Newfoundland coast.

## Alberta and Atlantic oil

**IT WOULD BE THE** elephant in the room. You can't discuss energy in Canada without talking about northeastern Alberta's oilsands. And the size of that deposit is massive — 168 billion barrels worth, or 97 per cent of the country's crude oil reserves, giving Canada the world's third largest supply. You also can't talk about energy without touching on our use of crude oil. Petroleum products — consumed largely as fuel in transportation — account for almost 45 per cent of energy consumption in Canada.

But in the rough waters of the Atlantic Ocean, Canada's offshore oil industry is also making headlines. This summer, the Norwegian energy company Statoil plans to start exploration drilling at its prospect site, known as Bay du Nord, in the Flemish Pass Basin, 500 kilometres east of Newfoundland. The site is considered the largest find in the area in 30 years. Meanwhile, the White Rose project, some 350 kilometres east of St. John's, started production in 2010 from its North

Amethyst field, and is expanding into new nearby fields in the Jeanne d'Arc Basin.

The three producing Newfoundland offshore oil projects — Hibernia, Terra Nova and White Rose — produce a substantial volume: 1.14 billion barrels have been extracted since 1997. There remains an estimated 2.9 billion barrels in reserves off the coasts of Newfoundland and Labrador.

The Hebron oilfield, discovered in 1980 and also located in the Jeanne d'Arc Basin, is the latest project. Work is now underway on what's called a gravity-based structure — essentially, a massive concrete pedestal that sits on the ocean floor and is designed to withstand icebergs and rough sea conditions — that will house drilling rigs, production facilities and

**Environmental challenges** Canada's oil and gas sector — production, transmission, processing, refining and distribution — accounts for nearly a quarter of the country's greenhouse gas emissions. Natural Resources Canada estimates that more than seven per cent of Canada's total greenhouse gases are from the oilsands.

crew quarters, and subsea wells will extend to tap oil beyond the structure. It's estimated that there are more than 700 million barrels of recoverable reserves in the Hebron oilfield, most of it heavy oil. The first crude is expected to fill tankers by the end of 2017.

Such ships will then carry the crude to Canadian, American and international refineries, and eventually on to market, where it will make its way into gas pumps, jet fuel, heating oil and other petroleum-based products that power our lives.



### BY THE NUMBERS HEBRON OIL

**Location** About 350 kilometres south-east of St. John's.

**Size of deposit** About 700 million barrels.

**Annual production** About 54.75 million barrels, based on an estimated production rate of 150,000 barrels per day.

**Number of employees** Roughly 230 positions, or 460 people on rotation work. Tanker crew and onshore work will also be required.

**Energy produced** It's estimated that 700 million barrels is enough oil to meet Canada's consumption at current rates (1.6 million barrels a day) for more than a year.

**Estimated life of reserves** Including construction and operations, Hebron is estimated to have a 30-year lifespan.

PREVIOUS PAGES: ANDREW PENNER/GETTY IMAGES; THIS PAGE: GREG LOCKE

## Quebec's Utica shale gas

**SHALE GAS IS** a game-changer. It has caused a massive energy resource boom in North America reminiscent of the Gold Rush, and at current consumption rates could provide Canada and the United States with natural gas for about 100 years.

Thanks to advances in the 1990s and early 2000s, such as horizontal drilling, 3D seismic imaging and multistage hydraulic fracturing ("fracking"), resource developers are able to access pockets of natural gas trapped in shale deposits deep underground. Since the United States started developing the Marcellus Shale deposit in Pennsylvania and the Barnett Shale deposit in Texas, it has become the world's largest producer of natural gas (1.87 billion cubic metres per day).

While there are no large-scale shale gas developments in Canada, the country is still the world's fifth largest producer of natural gas, generating about two trillion cubic metres every year. In addition, there's an estimated 16 trillion cubic metres, or about \$2 trillion at current rates, of shale and tight gas (the latter a form of natural gas trapped in low-porosity silt or sand) resources in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick and Nova Scotia.

One such deposit, the Utica Shale, is in the St. Lawrence Lowlands region of Quebec, beneath the land between Montreal and Quebec City. The presence of natural gas here has been known for decades, and exploration wells have been drilled in the area since 2007. The deposit is estimated to contain between 510 billion and 1.1 trillion cubic metres of natural gas (\$70 billion to \$140 billion

RENE BOURQUE



Natural gas deposits lie buried in shale in areas such as Quebec's Anticosti Island.

today). The results of multiple environmental assessment hearings and the position of the former provincial government, however, led to a five-year moratorium on shale gas development in Quebec in 2013.

On February 3, 2014, former premier Pauline Marois announced prior to the provincial election campaign that her government would spend \$115 million to help finance two exploratory shale gas operations on Anticosti Island, part of the Maritimes Shale deposit next to the Utica Shale — work that would have triggered an end to the moratorium and the beginning of Quebec's first major oil and gas deal. On April 7, 2014, however, Marois's Parti Québécois lost the election. While the winners, the Liberals, have been critical of the shale gas moratorium in the past for its

**Environmental challenges** Shale gas is extracted using hydraulic fracturing, a process by which a combination of water, sand and other fluids are injected at high pressure into wells, breaking up rock and releasing trapped natural gas. This method of extraction uses large amounts of water, and some methane escapes from the well and into the atmosphere. There is also a risk of groundwater contamination.

impact on investment in the province, it remains to be seen how the party will approach this resource in the future. One thing's for certain: the Utica Shale, and shale gas in general, are sure to keep garnering attention.



### BY THE NUMBERS UTICA SHALE GAS

**Location** South shore of the St. Lawrence River, from Quebec to upstate New York.  
**Size of deposit** Estimated at between 510 billion and 1.1 trillion cubic metres of natural gas.

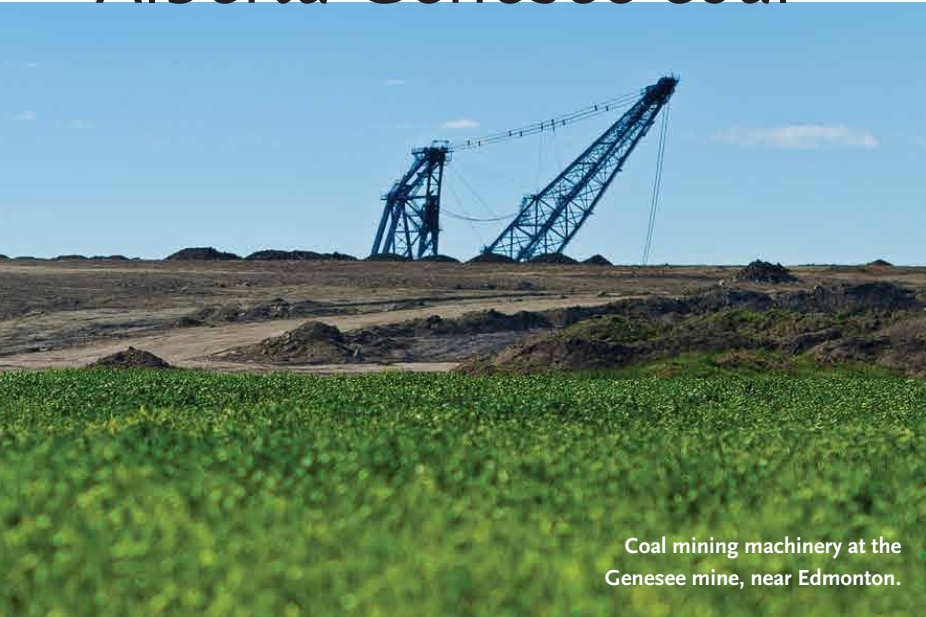
**Annual production** Not applicable

**Number of employees** Not applicable  
**Energy produced** It's estimated that the Utica Shale could produce enough to meet all of Canada's natural gas needs for six to 13 years or more.

**Estimated life of deposit** Unknown



# Alberta Genesee coal




Coal mining machinery at the Genesee mine, near Edmonton.

**IF YOU COULD TRACE** electricity as it travels from the coal-fired plants around Edmonton through transformers and transmission lines and into household electrical outlets, you could see the journey from turbine to toaster. But you can't. All the energy — be it sourced from coal, hydro or wind — intermingles on the grid. But behind that journey are these facts: Alberta is home to 70 per cent of Canada's total coal reserves and more than half of its electricity is generated from the black substance. (Roughly 60 per cent of electricity generated in both Nova Scotia and Saskatchewan also comes from coal.)

In recent years, growth in coal mining in Canada has shifted to metallurgical or “coking” coal, which is used in steel production. Almost all of this coal is exported. Thermal coal, on the other hand, is used for power generation.

There were 21 operating thermal coal mines in Canada in 2012, mostly in British Columbia and Alberta. And while the Highvale mine, about 70 kilometres west of Edmonton, is Canada's largest surface-strip coal mine, the Genesee mine, about 50 kilometres southwest of the city, is particularly interesting. It annually produces enough coal to meet Edmonton's electricity demands for a year.

The Genesee deposit is the country's third largest thermal coal mine. When mining started at this site in 1988, the deposit contained an estimated 400 million tonnes of reserves. For the past 26 years, loaders, shovels, dozers and draglines have worked to remove the black rock. The coal is then trucked to the nearby Genesee generating station, which has three units. (The newest of these, Genesee 3, uses advanced



## BY THE NUMBERS GENESE COAL

**Location** About 50 kilometres southwest of Edmonton.

**Size of deposit** An estimated 305 million tonnes of mineable coal. Sixty million mineable tonnes remain within the existing 7,250-hectare permit area. The mine has applied to increase its operations to add 3,820 hectares.

**Annual production** About 5.1 million to 5.3 million tonnes per year. Around 95 million tonnes of coal have been mined since the mine opened in 1988.

**Number of employees** About 160 people work at the Genesee mine, with another 225 people at the Genesee generating station.

**Energy produced** In 2013, the three units at Genesee generated more than 8,000 gigawatt hours of electricity (roughly equal to the energy used by 800,000 homes in one year).

**Estimated life of reserves** Under the existing permit, a few more years; with the new permit, another 42 years.

technology to reduce its carbon dioxide emissions — 18 per cent lower per megawatt than the conventional coal-fired plants.) The coal is crushed and pulverized into a flour-like powder and burned in huge furnaces where temperatures may reach 1,300 C, creating steam to turn a turbine and produce electricity. The power produced accounts for about 8.5 per cent of Alberta's minimum demand. In 2013, 8,001 gigawatt hours of electricity were supplied — roughly equivalent to the energy used by 800,000 homes — some of which surely made its way into kitchens and bedrooms in Edmonton and beyond.

COURTESY CAPITAL POWER/JIMMY JEONG

**Environmental challenges** It's estimated that one 150-megawatt coal-fired power plant can produce more than a million tonnes of greenhouse gas emissions annually, or the same emissions as 200,000 cars. Coal also releases mercury emissions and other pollutants, including sulphur dioxide.



### CANADIAN GEOGRAPHIC EDUCATION

For a plethora of lesson plans and other education resource materials related to this feature story and the energy resources and reserves poster map that accompanies this issue, visit [cgeducation.ca](http://cgeducation.ca) or [energyiq.canadiangeographic.ca](http://energyiq.canadiangeographic.ca).

A worker inspects part of the McArthur River mine.



For a story examining the nation's renewable energy resource potential and a look at Canada's unique nuclear reactor technology, visit [mag.cangeo.ca/jun14/energy](http://mag.cangeo.ca/jun14/energy).

## Saskatchewan's

# McArthur Uranium

**CANADA IS KNOWN** for many things — hockey, health care, Tim Hortons — but it is also remarkable for something else: rich deposits of uranium.

Canada is tied with Russia for the world's third largest reserve of the heavy metal, and is second only to Kazakhstan in global production and exports of the valuable resource.

This country's uranium mining is centred more than 600 kilometres north of Saskatoon, Sask., at a place called McArthur River, site of the world's biggest uranium mine (based on annual production). There, deep beneath the ground, remote-controlled machinery extracts the mineral, which is processed underground and pumped to the surface before being trucked an hour away to be milled. More than nine million kilograms of uranium concentrate (ore that's been mined and milled) was excavated at the site in 2013, equivalent to the amount required to meet Ontario's total electricity demand for more than 2½ years. And it isn't only size that makes the mine stand out. The ore it produces is of the highest-grade quality — estimated to be 100 times the world average — which means less McArthur uranium is needed to produce the same amount of energy as uranium from other mines.

The McArthur River deposit — which encompasses about two square kilometres amid the spruce and moraines — has been mined since 1999. Between 2000 and 2013, more than 100 million

kilograms of uranium concentrate was removed. Milling takes place in Key Lake, 80 kilometres away.

From there, the uranium concentrate, also known as yellowcake, is packaged in steel drums and shipped to a refinery in Blind River, Ont., for further processing. It's then converted and manufactured into the fuel pellets for Canada's nuclear reactors at a facility in Port Hope, Ont. Some of the uranium is also converted into another form used in nuclear plants in the United States and Europe. The energy, once released, heats water into steam to power generators and create electricity.

All of Canada's uranium production is used to produce electricity, here and abroad. Half of Ontario's electrical energy comes from nuclear reactors, making it the third largest source of electricity

**Environmental challenges** Nuclear power plants create energy without generating carbon dioxide or greenhouse gases. But as was made clear when the earthquake and tsunami damaged Japan's Fukushima plant in 2011, significant risks include radioactive contamination and evacuation zones. As well, nuclear reactors use significant amounts of water — 205 litres for each kilowatt-hour provided — and there are challenges with the long-term management of radioactive nuclear fuel waste. At the mine site, radiation issues also have to be monitored.

generation in Canada. And uranium mining continues to grow. Cigar Lake, in northern Saskatchewan, began operations in March 2014, and lays claim to the title of world's second-largest high-grade uranium deposit, after McArthur River.



## BY THE NUMBERS

### McARTHUR RIVER URANIUM

**Location** About 620 kilometres north of Saskatoon.

**Size of deposit** Proven and probable reserves of 114 million kilograms of uranium concentrate.

**Annual production** 9.1 million kilograms of uranium concentrate.

**Number of employees** About 810 people: 480 Cameco staff and almost 330 long-

term contractor employees.

**Energy produced** The 9.1 million kilograms of uranium concentrate taken from the McArthur River mine in 2013 produces about 350,000 megawatt hours of electricity, enough to meet Ontario's total electricity demand for more than 2½ years.

**Estimated life of mine** Until 2034