

# Heavy Oil

Abundant but hard to work with, heavy oil has some specific environmental impacts

## Introduction

Naturally occurring crude oil comes in many forms. The most familiar to many people is light crude oil, which is less dense than water and flows easily at room temperature. Heavy oil and bitumen are forms of crude oil that are more viscous (thicker) and dense. The largest crude oil deposits in the world are heavy oil, extra-heavy oil, and bitumen oil sands (also called tar sands) in Venezuela and Canada. The U.S. also has heavy oil and oil sands, mostly in California, Alaska, and Utah. Globally, almost 1.1 trillion barrels of heavy oil, extra-heavy oil, and natural bitumen may be technically recoverable, compared to 950 billion barrels of light crude oil.<sup>1</sup>

Vast heavy oil resources pose an environmental conundrum: they are major energy resources and important to their host countries' economies, but they require more energy and water to produce and refine than lighter oils. They also contain sulfur and a range of polluting or toxic contaminants, including heavy metals, which must be removed and disposed of, further increasing costs and environmental impacts.<sup>1,2</sup>

## Production Techniques

Because heavy oils are very viscous, they are difficult to extract from rocks. Different techniques are used depending on the type of oil and the properties and depth of the rocks:

Oil sand from Athabasca, Canada. The oil in these sands is so thick (viscous) that special processing is required to separate it from the sand. Image credit: Wikimedia Commons user Int23.<sup>3</sup>



- **Open-pit mining** – used for oil sands that are very close to the Earth's surface (typically less than 250 feet deep). The oil sands are mined in bulk, crushed, and transported to processing facilities that separate the oil from the sand using hot water and/or solvents. The ultra-thick oil (bitumen) is then refined or diluted with light oil for pipeline transport.<sup>4</sup> Open-pit mining is used for about 20% of Canadian oil sand production.<sup>4</sup> The Uinta basin in Utah also contains large, shallow oil sand deposits, but many efforts to produce oil from these sands have failed commercially.<sup>5</sup>
- **Injection of water, steam, and/or solvents** – used where heavy oil is deep below the surface, or where surface mining is not viable for environmental or commercial reasons.
  - **Waterflooding** – the injection of water through one well to push oil towards another well where it is extracted – has been used to produce over 100 million barrels of heavy oil in Alaska since the early 1990s.<sup>5</sup>
  - **Steam flooding** works in the same way, but the steam's heat softens the oil, allowing the process to be used for more viscous oils than waterflooding. This method is used in central California<sup>6</sup> and parts of Alberta. A special steam injection method called **steam-assisted gravity drainage (SAGD)** is used for 80% of Canadian oil sand production. SAGD involves the injection of steam into a horizontal well at the top of the oil sands. The heated and thinned oil then drains down into another horizontal well at the base of the oil sands, which then pumps the oil to the surface.<sup>4</sup> Any of these processes may be enhanced by adding solvents to the water.
- **Cold heavy oil production with sand (CHOPS)**<sup>7</sup> – used for mushy heavy and extra-heavy oil sands that can be extracted in their entirety through a well using intensive pumping. The oil, water, and sand are then separated at the surface. This technique has been tested in oilfields in Alaska's North Slope but not yet commercially developed due to low oil prices.<sup>5</sup>

### Environmental Impacts Specific to Heavy Oil

**Energy** – heavy oils require much more energy to produce and refine than light crude oil. This leads to higher overall greenhouse gas emissions per barrel of oil produced, especially due to gas-fired steam generators and the energy-intensive processing required to lighten or break down heavy oil into forms that can be transported and used. Total “lifecycle emissions” from production, refining, transportation, and use for light vs. various heavy oils are:<sup>8</sup>

- Typical light West Texas oil - 480 kg CO<sub>2</sub> per barrel
- Canadian oil sands bitumen produced by SAGD, and Venezuelan extra-heavy oil, both diluted with lighter oil for ease of transport – 600 kg CO<sub>2</sub> per barrel
- Heavy oil produced by steam injection in California’s Midway Sunset field - 725 kg CO<sub>2</sub> per barrel
- Canadian oil sands produced by open-pit mining and upgraded to a light synthetic crude oil (“syncrude”) before transporting – 729 to 736 kg CO<sub>2</sub> per barrel

**Open pits** – open-pit mining of oil sands poses some specific environmental challenges that are less common elsewhere in the oil industry:

- Large volumes of tailings (residual clay, bitumen, and other chemicals) are stored in open surface ponds, presenting a potential risk to wildlife<sup>9</sup> and groundwater.<sup>10,11</sup>
- Tailings ponds, piles, and exposed heavy oil in the open mine, along with the heavy industrial activity common to all mining operations, are a major source of air pollution,<sup>12</sup> and dust from the mines can contaminate nearby surface waterbodies.<sup>9</sup>
- Open-pit mining of oil sands disturbs more of the land surface than oil wells. This impact is temporary if the mine land is fully reclaimed after the oil sands are extracted (as is currently required by the Government of Alberta, Canada), but has the effect of fragmenting or destroying habitats.<sup>13</sup>

### Consistency of Heavy Oils

Heavy oil - like molasses  
Extra-heavy oil – like peanut butter  
Oil in oil sand – like window-sealing caulk or putty



Open-pit mining of oil sands in Alberta, Canada. The ponds in the photo are “tailings ponds”, containing a mixture of water, fine sand, clay, and residual oil components after the sands have been processed to remove most of the oil. Image Credit: Dru Oja Jay, Dominion.<sup>14</sup>

### U.S. Imports of Heavy Oil

The United States is the largest consumer of Canadian and Venezuelan heavy oil, extra-heavy oil, and bitumen. In 2017, the United States imported 2.7 million barrels of heavy oil per day from Canada<sup>15</sup> and 618,000 barrels per day from Venezuela.<sup>16</sup> Heavy oil imports from these two countries represented over 40% of U.S. crude oil imports in 2016.<sup>16</sup>

### References & More Resources

For a complete listing of references, see the “References” section of the full publication, *Petroleum and the Environment*, or visit the online version at: [www.americangeosciences.org/critical-issues/petroleum-environment](http://www.americangeosciences.org/critical-issues/petroleum-environment)

Gosselin, P. et al. (2010). Environmental and Health Impacts of Canada’s Oil Sands Industry. The Royal Society of Canada Expert Health Panel, December 2010. <https://rsc-src.ca/en/expert-panels/rsc-reports/environmental-and-health-impacts-canadas-oil-sands-industry>

Natural Resources Canada – Environmental Challenges. <https://www.nrcan.gc.ca/energy/oil-sands/5855>

Carnegie Endowment for International Peace – Oil-Climates Index: Profiling Emissions in the Supply Chain. <http://oci.carnegieendowment.org/#supply-chain>