

CATEGORIES: FUTURE OF OIL, OIL PRODUCERS, OIL REFINING, PETROLEUM PRODUCTS, US DEPARTMENT OF ENERGY, US ENERGY POLICY

Unconventional Oil Reserves in and Around the US

The United States has greater oil reserves than Saudi Arabia? Canada with the world's largest reserves? Welcome to the world of unconventional oil. Unconventional or non-conventional oil is oil collected by other means than simply drilling for it. The two greatest potential sources of unconventional oil are from tar sands and oil shale. Oil from these sources that is recoverable using today's technology would double world oil reserves—and if most of the oil bound up in them could ever be tapped, it would triple or quadruple the amount of oil available.

Total vs. Possible vs. Practical

There are three different ways of looking at the size of oil reserves:

- Oil in place is the total amount of oil, without regard to the cost or technology necessary to get at it.
- Technically recoverable oil is oil we can get at—it's within the reach of existing technology—but doesn't take into account whether it is economically worth it.
- Economically recoverable oil is cost effective to extract and process. Of course, "cost effective" is a continuum, not a point: what makes economic sense is very different at crude oil prices of \$40 per barrel, \$80 per barrel, or \$120 per barrel. Also, what is economically recoverable depends on technology as well—as technology improves and becomes more widespread (creating economies of scale), price drops. Cost reductions of 50 – 75% over 20 years are feasible.

Oil in tar sands and oil shale is oil in place: it's there. For the most part, it's technically recoverable: even though there is R&D being done to come up with better ways to unlock it, we know we can do it. The big issue is whether it's economically recoverable oil. In answering that question, you need to look beyond the cost in dollars and cents and consider as well the environmental cost. Unconventional oil is a vast potential resource that is more expensive to produce than conventional oil; releases more greenhouse gases; requires more energy and water to produce; and produces more waste. All these costs must be borne in mind.

Tar Sands: Resources to Our North and South



Tar sand. (image: Suncor Energy Inc. via ostseis.anl.gov)

Tar sand (also known as “oil sand”) is a mixture of sand and a thick, tarry oil called bitumen. Bitumen is petroleum or oil, but it is too thick and viscous to flow or be used for heat and power and must first be processed.

There are tar sands in the United States, primarily in Eastern Utah. It’s estimated that the in-place oil in Utah tar sands amounts to 12 to 19 billion barrels.

However, U.S. tar sand oil reserves are dwarfed by those of Canada and Venezuela. Venezuela’s in-place deposits in the Orinoco Belt are projected to be up to 1,200 billion (that’s 1.2 trillion) barrels, with over 200 billion barrels technically recoverable. Canada’s reserves are believed to be even larger, with in-place Alberta reserves projected at 1,700 – 2,500 billion (1.7 – 2.5 trillion) barrels and recoverable reserves of at least 174 billion barrels. For comparison, in 2008, it was estimated that Saudi Arabia’s total oil reserves were a bit under 270 billion barrels.

Given total world conventional oil reserves of around 1.3 trillion barrels, the recoverable estimates for tar sand oil would increase world reserves by over 25 percent.

Is it practical to produce oil from tar sands? Yes—Canada has been doing so for years. In 2006, it produced over 1.1 million barrels per day, and could produce 3 million barrels a day by 2020.

How are the tar sands mined? Either by underground or open-pit mining, with open-pit mining currently more common. Sand is scooped out of a huge hole in the ground by giant shovels and carried away by dump trucks for processing.



Open pit mining of tar sands in Alberta, Canada. (Suncor Energy Inc. via ostseis.anl.gov)

What happens after tar sands are mined? The sands are trucked to an extraction plant, where hot water is used to separate the bitumen from the sand. Then the bitumen needs to be further refined into usable distillates, such as diesel, gasoline, number 2 home heating oil, etc. Of course, all crude oil has to be refined to be usable—there’s a reason it’s called “crude oil” and not “ready-to-use oil”—but bitumen, being thicker and more sludgy, needs additional refinement compared to conventional crude.

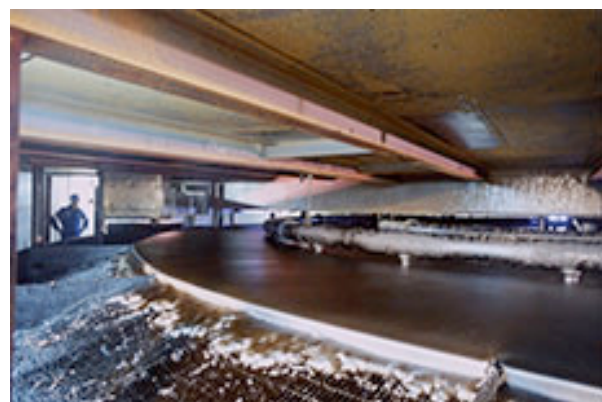
What are the costs of extracting oil from tar sands? Compared to conventional crude, producing oil from tar sands is dollar, energy, and water intensive. To begin with, mining the sand requires giant

machinery. Trucking it to the extraction plant requires huge trucks (some can carry up 320 tons—that’s equal to two 1,600 sq. ft homes!).

Massive quantities of water are used in separating the bitumen from the sand—several barrels of water are required for each barrel of oil. The water has to be heated for the extraction process, and the additional refinement that bitumen requires needs more energy still. Overall, it takes the equivalent of 1 barrel of oil to create 5 – 6 barrels from tar sands. This is roughly double the energy used to produce a barrel of crude by conventional means.

As a result of the additional steps in the process, the extra fuel, water, and machinery required, it costs around \$25 to produce a barrel of oil from tar sand, as opposed to around \$5 from conventional drilling or \$15 from deep water drilling.)

What Pollution or Waste Is Given Off? There is solid waste—for example, sand sans bitumen—which is the least troublesome waste. It can be trucked back to the mine and



Separating tar sands--one step in the extraction process. (image: Suncor Energy Inc. via ostseis.anl.gov)

used to fill it in when done.

More serious are the greenhouse gases (primarily carbon dioxide) given off, since they are implicated in global warming. Producing oil from tar sands releases around 1.5 times as much greenhouse gas as producing it from conventional crude oil.

Also, remember all that water used in the process? Well, large amounts of water contaminated with naphthenic acid are produced—entire lakes worth. Right now, there is no means to permanently clean up this liquid waste.

Oil Shale: America's Trapped Oil

Location of the Green River Formation Oil Shale and Its Main Basins



SOURCE: Adapted from Smith, 1966.
RAND M0414(2)

Location of US oil shale reserves. (image: Rand Corporation via ostseis.anl.gov)

Oil shale is a sedimentary rock that contains a solid oil “precursor” called kerogen. Oil was produced by the action of heat and pressure over millions of years. In the case of oil shale, the heat and pressure weren’t quite enough to make liquid oil.

If it’s not oil, what good is it? Basically, the kerogen can be “cooked” into oil.

Where is oil shale found—and how much is there? The world's largest oil shale reserves right here in the United States—mostly in the Green river formation, which covers portions of Colorado, Utah, and Wyoming.

This is same area that U.S. tar sands occupy, but the amount of U.S. oil shale is vastly larger. The Department of the Interior estimates that there may be 800 billion recoverable barrels (out of perhaps 1.5 trillion barrels total). That's three times the amount of recoverable Saudi oil, and 80 times what is believed to be under Alaska's Arctic National Wildlife Refuge.

How is kerogen extracted from shale and turned into oil? There are two very different methods for producing oil from oil shale. The older method is called *ex situ*, which means the processing is done "off site"—first the rock is mined, then the kerogen is extracted and processed elsewhere. The newer method, *in situ*, looks to free the kerogen from the rock and convert it to oil "in place"—while it's still underground. The resulting oil would then be pumped to the surface similar to how conventional crude is pumped.

- **Ex situ method:** Depending on depth, oil shale is mined underground or by surface open-pit mines. The shale is then brought to a facility where it is placed in a large vessel or container known as a retort. Since kerogen is oil that did not finish "cooking," large amounts of heat (up to more than 900 degrees Fahrenheit) is applied to separate the kerogen from the rock and finish its conversion into oil. However, just because it's oil now, doesn't mean that it is ready for the gas tank or your home heating oil tank: it still needs to be refined, like any other crude.
- **In situ method:** Heat is "injected" underground, into the oil shale, through a variety of methods, including circulating hot liquids or gases, using electricity, or using radio or microwaves. Less heat is applied than in *ex situ* methods, but it is applied for far longer—two, three, or more years, rather than a matter of hours for surface retorting. Once the kerogen has been freed from the rock and converted to oil, it is pumped out—though it still needs to be refined.
- **Advantages of ex situ over in situ:** The *ex situ* methods are better understood and proven—they could be applied more quickly. They also work much faster. The combination means that *ex situ* methods could produce oil years faster than *in situ*.
- **Advantages of in situ over ex situ:** *In situ* methods promise to be more efficient at extracting kerogen, and should be able to produce oil from rock formations that *ex situ* methods can't reach. If done properly, *in situ* methods may use fewer resources and trap waste underground—in *in situ* methods are potentially less "costly," in every sense of the word, than *ex situ*.

However, the problem is that these advantages are theoretical at this point. There have been studies and “demonstration” projects, but no one has produced oil on a commercial basis using in situ technology.

Since in situ technology is as-yet unproven, the discussion to follow will be based on ex situ methods, for which there is some experience, though far less than for producing oil from tar sand.

Has oil been commercially produced from oil shale? Yes, though not in large quantities. Estonia has the longest history of processing oil shale—they’ve been doing it since the 1920s. Most of its oil shale has been used in ways other than converting it to oil (for example, pulverizing it and burning it directly), but they have begun producing small amounts of oil (around 2,500 barrels/day).

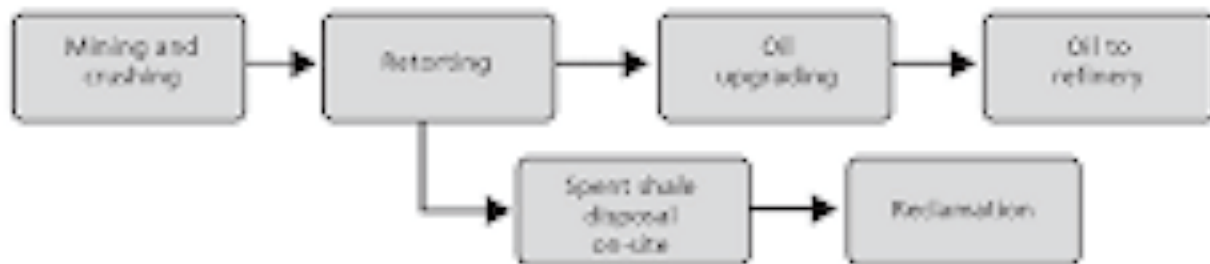
China has several active oil shale projects and more under development. At present, it produces 18,000 tons, or around 112,000 barrels, per day.

Brazil has produced around 20 million barrels to date from a large scale retort that has been in operation for years.http://www.ogj.com/articles/save_screen.cfm?ARTICLE_ID=344197

What are the costs of producing Oil from shale? First, there is the actual monetary cost: at present, it costs more than \$60 per barrel to produce oil from oil shale. This is over twice the cost of producing oil from tar sand, four times the cost of deep-water drilling, and a dozen times the cost from a conventional dry-land well. The chief factors driving this cost are:

- The need to first mine, then retort, then refine; it is a multi-stage process:

Major Process Steps in Mining and Surface Retorting



EAHD-10019-01

(image: ostseis.anl.gov)

- The enormous amounts of water required. Retorting takes up to five barrels of water per barrel of oil produced. Until in situ methods are proven, cost estimates need to be based on

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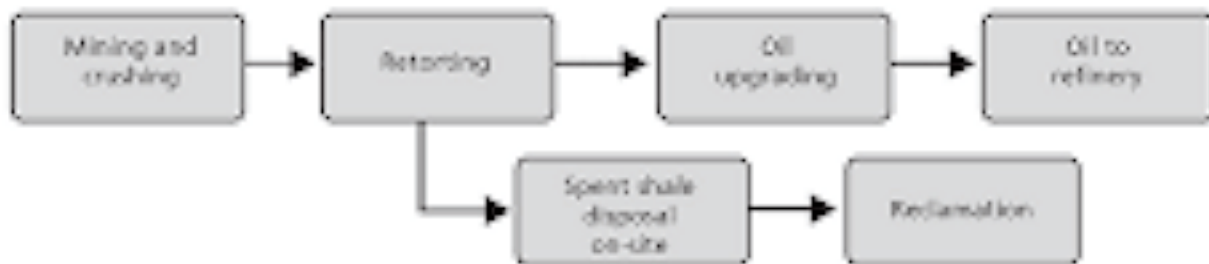
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process, and the environmental impact, Ken Salazar, Obama's Secretary of the Interior, withdrew the Bush leases. Salazar says that new leases will be offered, but he did not say when; he's also soliciting public comment on the terms of any new leases. Oil shale production has not been ruled out, but a more cautious approach has been adopted, one that emphasizes additional research, development, and demonstration before proceeding to commercial scale leases and applications.

Should We or Shouldn't We Exploit Unconventional Resources?

That's the real question—not can we do it, but should we do it? And whether we should depends on the balance of cost vs. benefit. The monetary cost is the least of it. Figuring out when it makes economic sense to produce oil from unconventional sources is a straightforward job for the green-eyeshade boys and girls in the accounting department. Plot cost per barrel vs. sale price per barrel (current and projected), factor in any tax benefits vs. the time cost of money invested, crunch the numbers, and you have an answer.

More to the point, if the only issues were monetary, there'd be no reason to worry about the question—the free enterprise system will provide the answer for us. When it makes sense economically to produce oil from unconventional sources—when someone can make a profit doing it—someone will.

The environmental issues complicate matters. These are costs that, no matter how hard economists might try, cannot be fully captured or reflected by reducing them to dollars and cents. Weighing them in the balance is tricky

What about jobs? Building and servicing a new domestic energy industry will add jobs—lots of them. Alberta, Canada, added around 26,000 jobs over just a two-year period through developing oil sand resources. And the potential size of a U.S. oil shale industry is three or four times that of Canada's oil sands.

National security? What would it do to U.S. safety, peace of mind, and foreign policy options to command its own oil reserves that dwarf those of Saudi Arabia?

Impact of technology? We know that production will become more cost effective over time—it always does. For example, Alberta's tar sand oil production costs declined up to 80 percent over the course of one generation (1980 to 2003). Some of the in situ technologies in development for oil shale may reduce costs and pollution by half or more. However, exactly when and how much these improvements will flow through, that's something nobody knows.

Perhaps the best place to leave the question of whether to exploit unconventional resources is with two observations:

- 1) There is a point at which almost everyone would agree to tap unconventional resources. Extra greenhouse gasses and \$60 a barrel to produce? Cheap at twice the price if that's what it took to stave off a Road Warrior-style post-apocalyptic future of feral biker gangs scavenging in the wasteland for a few stray gallons of gasoline. On the other hand, few people would agree to mining the Green River basin and increasing pollution just to have enough gasoline that we can all drive Hummers to the corner grocery. Somewhere in between those two wild extremes, most of us would find a place where the balance of cost and benefit makes sense.
- 2) It is much better to have unconventional resources that we can argue about than to not have them available as an option.

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