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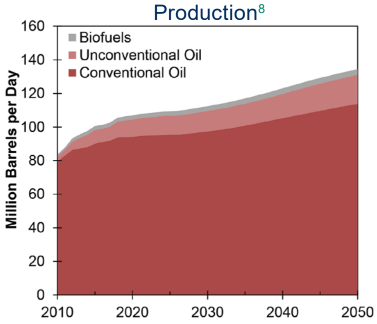
factsheets
Energy

Unconventional Fossil Fuels

Patterns of Use

Globally, fossil fuels supply 81% of primary energy.[1] In 2022, 79% of U.S. primary energy consumption came from fossil fuels.[2] Conventional and unconventional fossil fuels differ in their geologic locations and accessibility; conventional fuels are often found in discrete, easily accessible reservoirs, while unconventional fuels are found in pore spaces throughout a wide geologic formation, requiring advanced extraction techniques.[3] If unconventional oil resources (oil shale, tar sands, extra heavy oil, and natural bitumen) are accounted for, global oil reserves are quadruple current conventional reserves.[4] The price of crude oil peaked in 2008 at $145.31 per barrel, making unconventional fossil fuels more cost-competitive.[5] The price of crude oil temporarily fell below zero in 2020.[5] Partially as a result of sustained low oil prices, over 270 oil and gas producers have filed for bankruptcy since 2015.[6] The Energy Policy Act of 2005 includes provisions to promote U.S. oil sands, oil shale, and unconventional natural gas development.[7]

Global Projected Liquid Fuel Production[8]

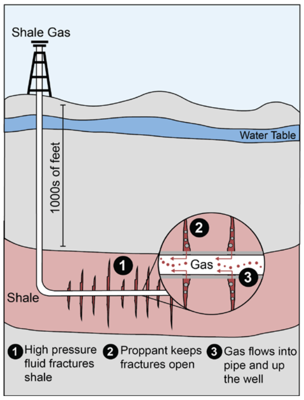


Major Unconventional Sources

Unconventional Natural Gas

- Unconventional natural gas (UG) comes primarily from three sources: shale gas in low-permeability shale formations; tight gas in low-permeability sandstone and carbonate reservoirs; and coalbed methane (CBM) in coal seams.[9]
- Although several countries have begun producing UG, many global resources have yet to be assessed. According to current estimates, China has the largest technically recoverable shale gas resource with 1,115 trillion cubic feet (Tcf), followed by Argentina (802 Tcf) and Algeria (707 Tcf).[10] Global tight gas resources are estimated at 2,684 Tcf, with the largest in Asia/Pacific and Latin America.[9] Resources of CBM are estimated at 1,660 Tcf, with more than 75% in Eastern Europe/Eurasia and Asia/Pacific.[9]
- Recoverable U.S. resources are estimated at 1,778 Tcf from shale and tight gas and 76 Tcf from CBM.[11]
- UG, particularly shale and tight gas, is most commonly extracted through hydraulic fracturing, or "fracking." A mixture of fluid (usually water) and sand is pumped underground at extreme pressures to create cracks in the geologic formation, allowing gas to flow out. When the pressure is released, a portion of the fluid returns as "flowback," and the sand remains as a "proppant," keeping the fractures open.[9]
- UG accounted for 89% of total U.S. natural gas production in 2022 and is expected to account for 93% of production by 2050.[12]

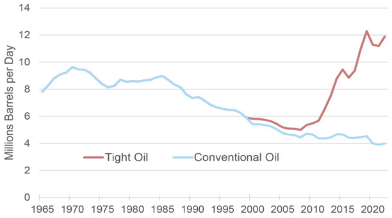
Hydraulic Fracturing Horizontal Well[9]



Tight Oil

- Tight oil, or shale oil, is found in impermeable rocks such as shale or limestone and is extracted through fracking, often concurrently with natural gas.[13]
- Over the past decade, tight oil production has expanded significantly. In 2022, 66% (7.8 million barrels per day) of crude oil production in the U.S. came from tight oil.[14] In 2021 the top tight oil producing states were Texas, New Mexico, North Dakota, Alaska, and Colorado.[15]
- It is estimated that the U.S. has 191 billion barrels of technically recoverable tight oil.[11]
- Negative health effects in newborns from *in utero* exposure to fracking sites have been found.[18]

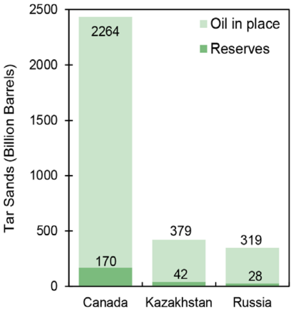
Annual U.S. Crude Oil Production[16,17]



Tar Sands

- Tar sands, i.e., "oil sands" or "natural bitumen," are a combination of sand (83%), bitumen (10%), water (4%), and clay (3%). Bitumen is a semisolid, tar-like mixture of hydrocarbons.[19]
- Known tar sands deposits exist in 23 countries. Canada has 73% of global estimated tar sands, approximately 2.4 trillion barrels (bbls) of oil.[20] The U.S. has 1.6% of global tar sands resources; however, 60% of U.S. crude oil imports came from Canada in 2022, and 66% of Canadian production comes from tar sands.[20,20,22]
- Deposits less than 250 feet below the surface are mined and processed to separate the bitumen.[23] Deeper deposits employ *in situ* (underground) methods, including steam or solvent injection to liquify the bitumen so that it can be extracted from the ground. Bitumen must be upgraded to synthetic crude oil (SCO) before it is refined into petroleum products.[19]
- Around two U.S. short tons (tons) of tar sands produce one barrel of SCO.[19]

Tar Sands Resources, Top 3 Countries[20]

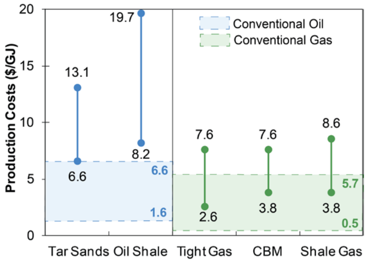


Oil Shale

- Oil shale is a sedimentary rock with deposits of organic compounds called kerogen, which has not undergone enough geologic pressure, heat, and time to become conventional oil. Oil shale can be heated to generate petroleum-like liquids.[24]
- Oil shale deposits exist in 33 countries.[4] The U.S. has the largest oil shale resource in the world, approximately 6 trillion bbls of oil in place, though oil shale is far from commercial development.[4,25]

Life Cycle Impacts

Greenhouse Gases


Production Cost Ranges, Conventional and Unconventional Fossil Fuels[19]

- Fossil fuel combustion accounted for 73% of U.S. greenhouse gas (GHG) emissions in 2021.[26]
- Equivalent amounts of GHGs are released by conventional and unconventional fuels at the point of use. Life cycle emissions for unconventional oil are higher than conventional oil on average, though some studies suggest they are similar.[27] Studies have found life cycle emissions for tar sands are 17% higher than average refined U.S. crude, and oil shale emissions are 21% to 47% higher than conventional oil.[28,29] Studies of life cycle emissions for UG have resulted in estimates from 6% lower to 43% higher than conventional natural gas sources.[30,31]
- Natural gas generates fewer GHG emissions when combusted than other fossil fuels.[32] Natural gas is primarily methane (CH_4) and CH_4 leakage can significantly decrease any emissions benefit of natural gas over other fossil fuels.[30] CH_4 leakage from the U.S. oil and natural gas supply chain is estimated to be 13 million metric tons (MMT) per year, equivalent to 2.3% of U.S. annual gross natural gas production and nearly 42% of U.S. anthropogenic CH_4 emissions. With a global warming potential of almost 30, this leakage is equivalent to 387 MMT of CO2, or 6.1% of total U.S. GHG emissions in 2021.[26,33,34]

Water

- Producing one barrel of oil from oil shale uses 1 to 12 barrels of water for *in situ* production and 2 to 4 barrels of water for mining production; one barrel of oil from tar sands uses 0.4 to 3.1 barrels of water.[35,36] Producing one barrel of oil in Saudi Arabia requires 1.4 barrels of water.[37]
- A horizontal gas well can require 2 to 4 million gallons of water to drill and fracture.[38] One study found shale gas production uses up to four times more water than producing conventional natural gas.[32]
- CBM production requires groundwater extraction; U.S. CBM basins withdraw 32 million to 15 billion gallons of water from aquifers per year.[39]
- Wastewater, produced water, and flowback water from oil and gas extraction can contain excess salts, high levels of trace elements, and naturally-occurring radioactive materials.[40] Groundwater can be polluted through above- and below-ground activities, including construction, drilling, chemical spills, leaks, and discharge of wastewater.[41]

Land Impacts and Waste

- More than 75% of U.S. oil shale is on federal land, of which 678,700 acres has been designated for development.[42,43] A 20,000 bbl/day tar sands facility requires 2,950 acres of land and creates 52,000 tons/day of waste sand; a 25,000-30,000 bbl/day oil shale facility requires 300-1,200 acres and creates 17 to 23 million tons/year of waste. An oil shale facility often remains active for several years.[44]
- One gas well requires one to two hectares of land, in addition to road networks.[45] Drilling fluid, or "mud," is used to cool the drill bit, regulate pressure, and remove rock fragments. One well may require hundreds of tons of mud and produce 110 to 550 tons of rock cuttings.[9]
- Small to moderate magnitude (<M6) seismic activity has been linked to underground injection of wastewater produced in oil and gas operations.[46] Fracking has been associated with microearthquakes (<M2), but no association has been found with larger magnitude events.[47]
- The human toxicity impact (HTI) of electricity produced from shale gas is estimated to be 1-2 orders of magnitude less than that from coal. Particulate matter is the dominant factor for both systems.[48]

Solutions and Sustainable Alternatives

- Chemicals used in hydraulic fracturing fluid are often considered proprietary.[45] Requiring companies to disclose these chemicals will lead to better understanding of the risk to public health from their use.[38] Twenty eight U.S. states required disclosure as of 2016.[49]
- Careful siting and monitoring of injection wells can reduce the potential for seismic events.[9]
- Water consumption in oil and gas extraction can be significantly reduced through efficiency improvements and the recycling of wastewater.
- Support policies that increase energy efficiency and renewable energy use. Although natural gas has been considered preferable to other fossil fuels because it is less expensive and burns more cleanly, it ultimately remains a nonrenewable fuel and a source of GHG emissions.

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