OIL SHALE'S QUESTIONABLE ENERGY RETURN

HUGE ENERGY CONSUMPTION FOR LIMITED ENERGY PRODUCTION

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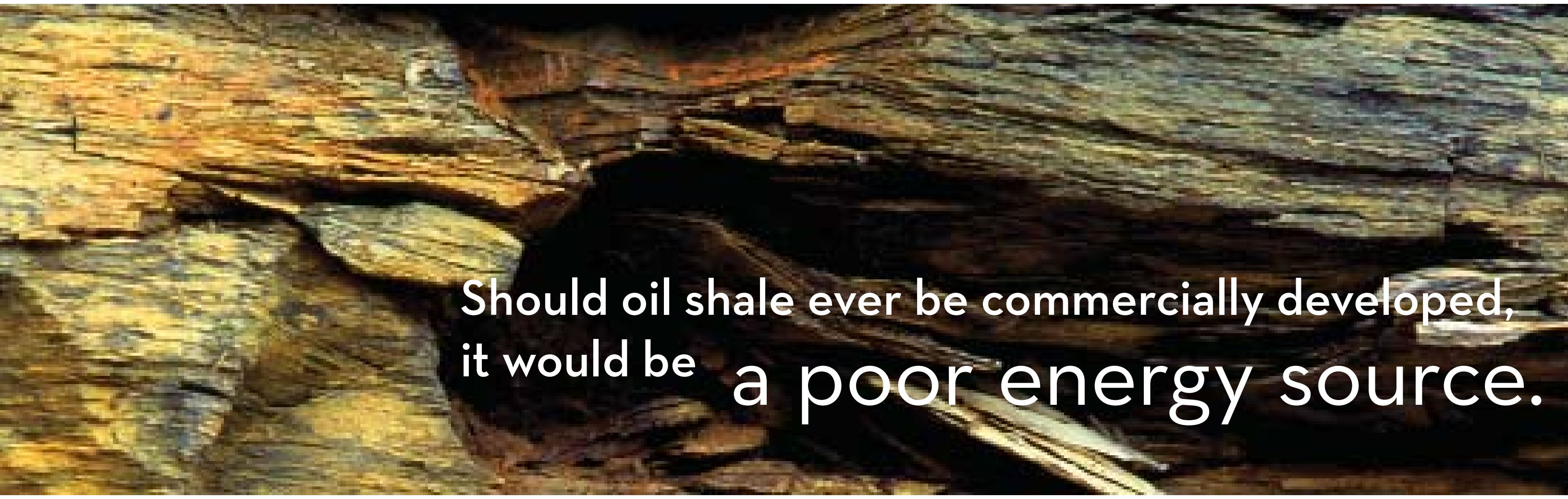
Executive Summary of
"An Assessment of the Energy Return on Investment (EROI) of Oil Shale"
By Cutler J. Cleveland and Peter O'Connor

EROI, or Energy Return on Investment, underpins any analysis of the value of energy produced. In simple terms, EROI is a comparison of the amount of energy that goes into a production process versus the amount of energy delivered by the process. An EROI of 1:1 means there is no energy "profit" from the investment of energy.



Why is EROI Important to Oil Shale?

The oil shale resources in Colorado, Utah, and Wyoming are being promoted as a fuel source of the future. What the low EROI for oil shale shows is that should oil shale ever be commercially developed, it would be a poor energy source.

There is no oil in oil shale. Instead, there is kerogen, a combination of chemical compounds that can be converted through heating into synthetic petroleum in one of two primary processes: (1) surface retorting ("conventional"), where the shale is mined, crushed, and then heated to a high temperature to extract the kerogen, and (2) in situ extraction, where energy is used to heat the shale while it is still underground, converting kerogen into liquid form so it can be pumped out, and refined into petroleum products.

Developing oil shale requires a considerable amount of direct energy inputs, as well as water, capital, and material inputs. Understanding the energy value is central to evaluating whether as a country we should pursue this energy source. This data point – the EROI of oil shale – is yet another reason to strongly question the value and wisdom of pursuing this resource as a potential fuel source.

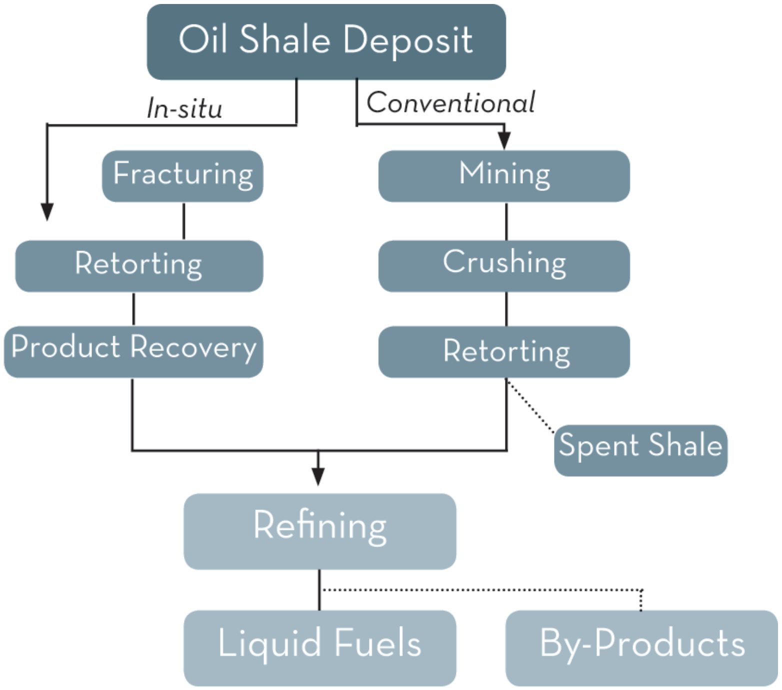


Figure 3. Oil shale conversion processes. Source: U.S. Dept. of Energy

What is the EROI of Oil Shale?

In October 2009, Western Resource Advocates hired Dr. Cutler Cleveland, a Professor of Geography and Environment at Boston University and an expert on EROI, to evaluate the studies conducted to date on the EROI of oil shale. What Cleveland and his graduate student, Peter O'Connor, learned was that most reliable studies (Adam Brandt 2008 , 2009) suggest that the EROI for oil shale falls between 1:1 and 2:1 when internal energy is counted as a cost. (Internal energy includes the energy released by the oil shale during production that is then used to power that operation – e.g., natural gas co-produced during extraction that is used as part of processing.)

How does the EROI of oil shale compare to conventional oil?

The EROI for oil shale is considerably less than the EROI of conventional crude oil, both at the wellhead and at the refined fuel stages of processing. Even under marginal conditions, such as smaller and deeper well fields, loss of artesian pressure, etc., conventional crude oil still generates a significantly larger energy surplus than oil shale – approximately 20:1.

Notably, in the United States in the 1930s, the EROI for oil was at least 100 barrels returned for each barrel invested (i.e. EROI = >100:1). That number declined to approximately 30:1 in the 1970s, and is even lower today as oil resources are harder to find.

Why Does Oil Shale Have a Low EROI?

The low EROI for oil shale is not surprising. The kerogen in oil shale is solid organic material that has not been subject to the temperature, pressure, and other geologic conditions required to convert it to liquid form. In effect, humans must supply the additional energy required to "upgrade" the oil shale resource to the functional equivalent of conventional crude oil. This extra effort carries a large energy penalty, producing a much lower EROI for oil shale.

Is Oil Shale's EROI Greater Than 1:1?

As Cleveland and O'Connor note, there remains considerable uncertainty surrounding the commercial development technologies and

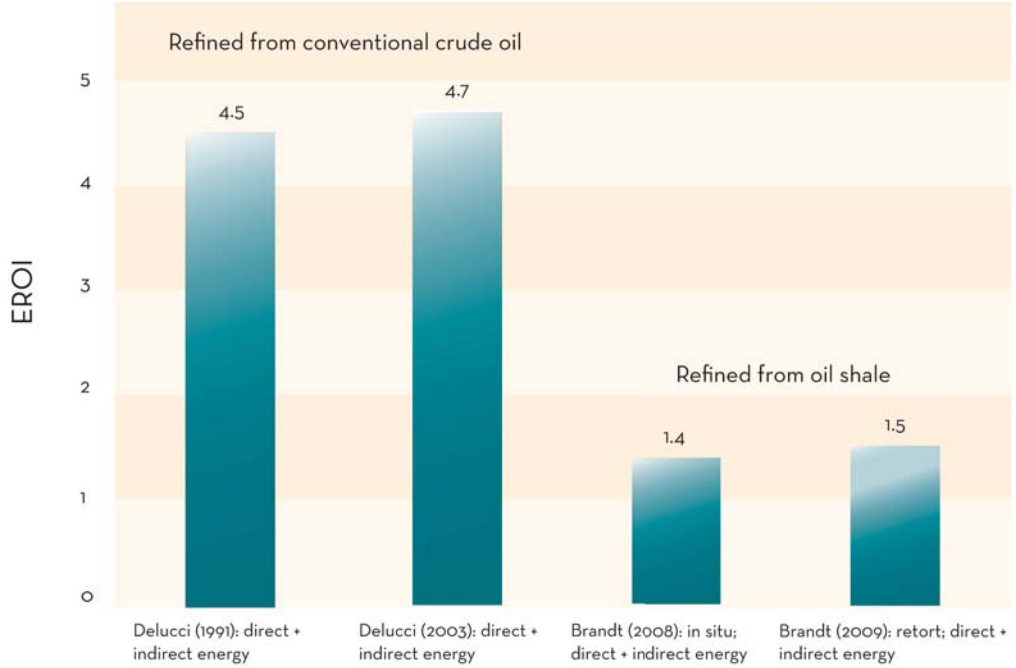


Figure 1. A comparison of estimates of the energy return on investment (EROI) at the wellhead for conventional crude oil, or for crude product prior to refining for oil shale.

the resource. Even the most thorough analyses (Brandt, 2008, 2009) exclude some energy costs. These two observations lead Cleveland and O'Connor to conclude that oil shale "cannot yet be 'certified' as a clear net energy producer."

Put another way, we cannot yet say with certainty that the EROI for oil shale is unequivocally greater than 1.

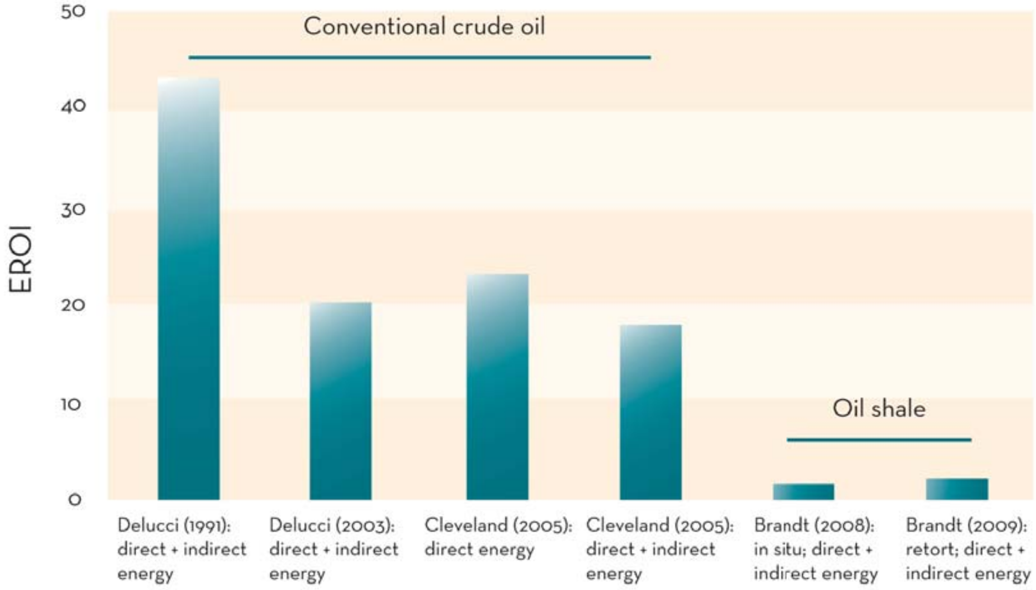


Figure 2. A comparison of estimates of the energy return on investment (EROI) for refined fuel produced from conventional crude oil and from oil shale.

EROI and Greenhouse Gasses – A Double Whammy for Oil Shale

As Cleveland and O'Connor note, Adam Brandt with Stanford University has determined that oil shale's low EROI is closely connected to a significant release of greenhouse gases. The large quantities of energy needed to process oil shale, combined with the thermochemistry of the retorting process, produce disproportionally high levels of carbon dioxide and other greenhouse gas emissions. As shown in Figure 3, oil shale produced via the Alberta Taciuk Processor (ATP) retort method emits 20% to 75% more greenhouse gases than conventional liquid fuels from crude oil feedstocks. The low EROI and high GHG are costs to society.

Gaps in Existing EROI Analyses

As Cleveland and O'Connor conclude, "The discussion surrounding the net energy balance of oil shale is characterized by data and conclusions that lack rigorous analysis and review." While many studies, say Cleveland and O'Connor, "apply some type of formal analysis, most focus on the assessment of a portion of direct energy use [i.e., fuel or electricity used directly in the extraction or generation of a unit of energy], ignoring other direct energy use and indirect energy use [i.e., the energy used elsewhere in the economy to produce the goods and services used to extract or generate energy]." This approach is flawed, as all direct and indirect uses must be taken into account in EROI analyses.

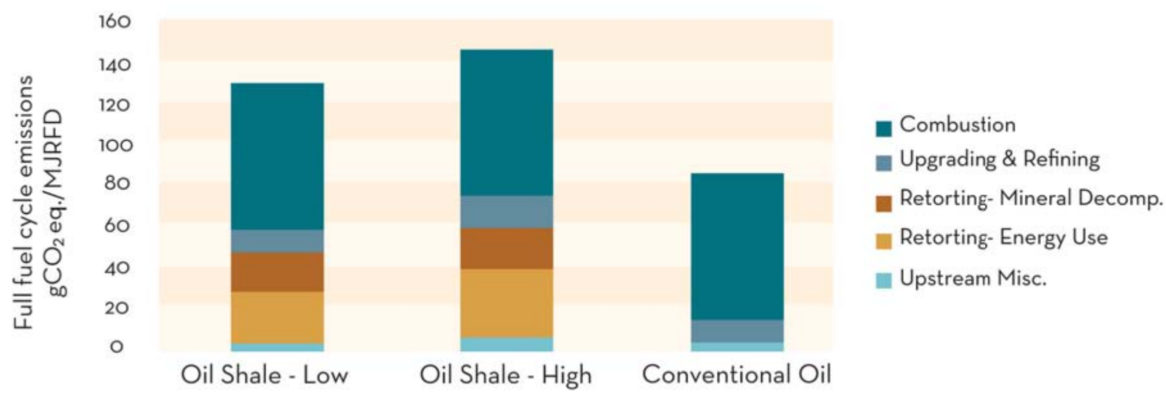
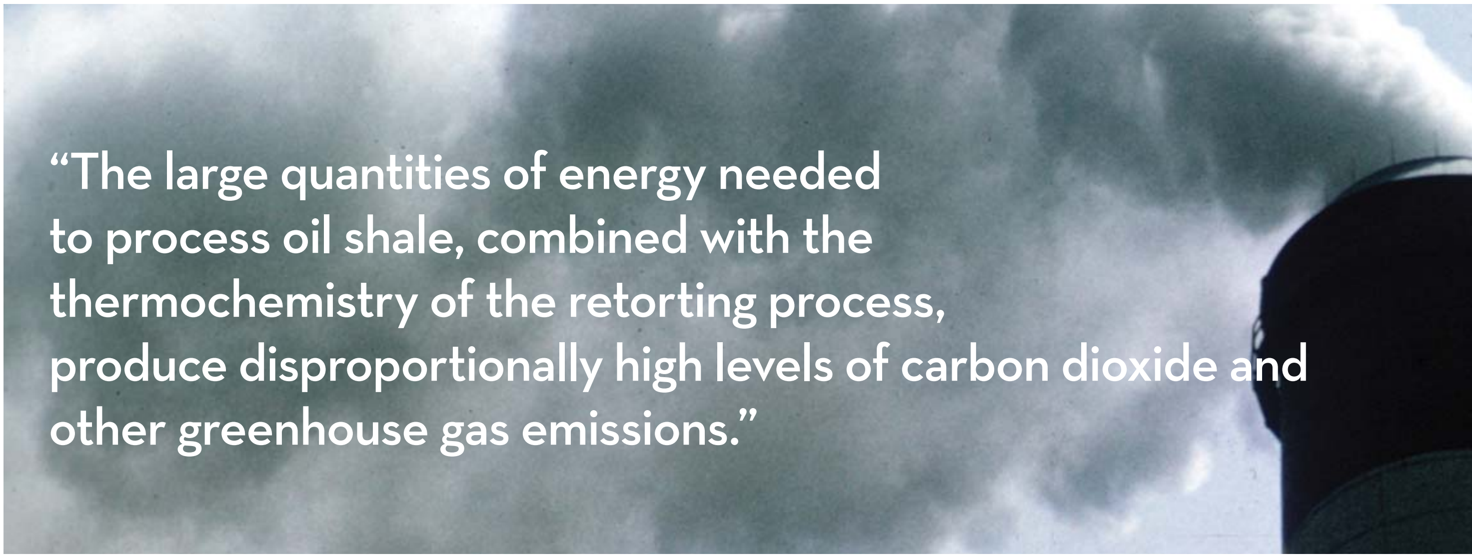


Figure 3 – GHG produced via oil shale using ATP processor versus conventional oil. Source: Brandt, Adam R., Converting Oil Shale to Liquid Fuels with the Alberta Taciuk Processor: Energy Inputs and Greenhouse Gas Emissions, "Energy Fuels" 2009, 23 (12), pp 6253–6258 http://pubs.acs.org/doi/abs/10.1021/ef900678d



> "The large quantities of energy needed to process oil shale, combined with the thermochemistry of the retorting process, produce disproportionally high levels of carbon dioxide and other greenhouse gas emissions."

Additionally, internal energy – the energy released by the oil shale process that is then used to power that operation – should also be used in an EROI analysis. For example, Shell Oil's in situ process produces significant quantities of hydrocarbon (HC) gas, which is burned to generate electricity; that electricity is then used as part of the production process. Similarly, the ATP, an above-ground oil shale retort processor, produces HC gases and a solid char substance. Both the HC and char are burned to help power production. Not all studies include internal energy as part of the EROI analysis, but they should.

Conclusion

This nation must clearly understand the trade-offs it will be making if public lands and resources are signed over to private companies in the hopes of making oil shale a significant transportation fuel source. In exchange for a fuel that may not produce more energy that it consumes, the public may be forced to bear the costs of consumed water, impaired water and air quality, negative climate impacts, and destruction of public lands.

Before expending public or private dollars to support any future commercial development projects, we must further evaluate, among other considerations, the EROI for oil shale. Cleveland's analysis, as we see it today, raises serious concerns.

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For more information on EROI for oil shale, or to read the full report by Cleveland & O'Connor, visit www.westernresourceadvocates.org