Renewable Energy Applications for Oil Shale Drilling

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Introduction:

Extracting oil shale requires a large amount of energy for heating and pyrolyzing the rock. Using renewable energy sources is a good opportunity to reduce the overall carbon footprint.

This poster details thermal solar as an energetic solution and compares different renewable energy sources, as well as their consumption water, greenhouse gas emissions and embodied energies. All the calculations are based on energy calculations to extract 100,000 barrels of oil shale per day of rich (30 gal/ton) and medium (20 gal/ton) oil shale provided by Alan Burnham of American Shale Oil (AMSO).

Figure 1: world refection's in oil

Background: *What is oil shale?*

Oil shale is a sedimentary rock rich in solid organic material called kerogen, which is the source of all petroleum. However, the kerogen in oil shale has never been buried deeply enough to generate oil. Oil shale is formed from organic material which may have several different origins : terrestrial, lacustrine, and marine.

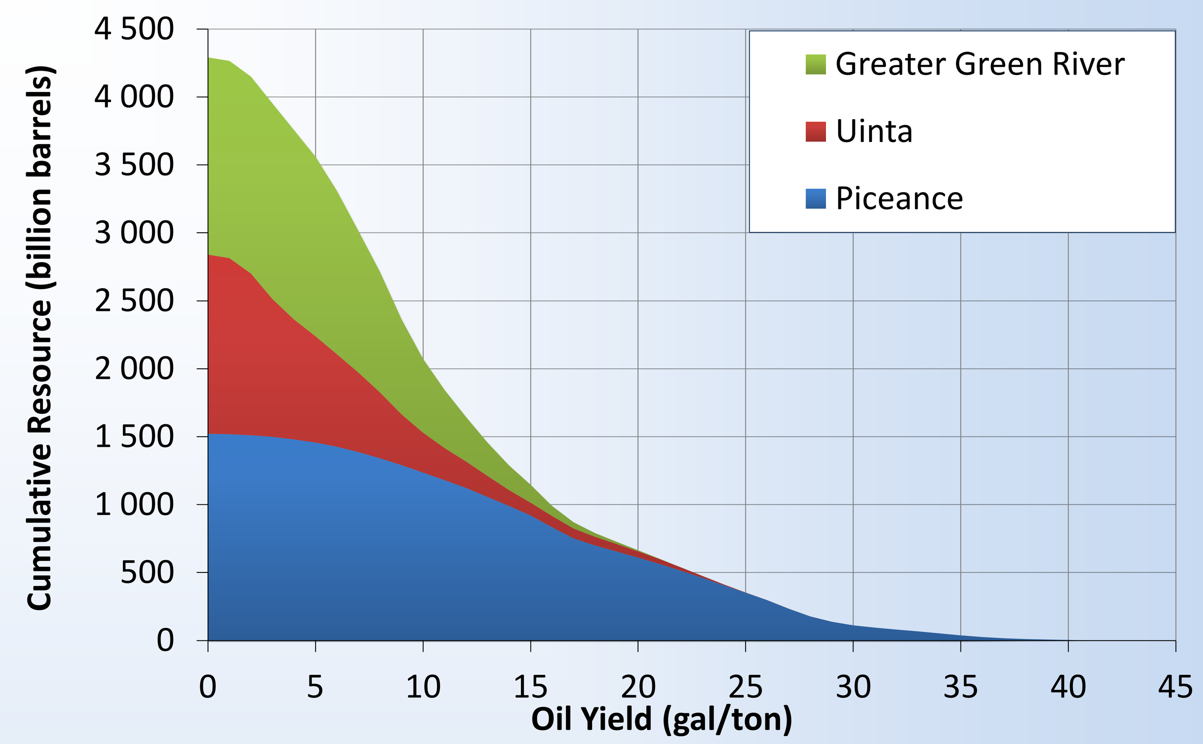
Retorting technology converts kerogen from shale ore into hydrocarbon liquids and gases. Pyrolysis produces hydrocarbon gases and vapors that when condensed would become liquid shale oil. The richness or grade of oil shale, which is determined by the percentage of organic carbon in the ore, varies considerably.

Figure 2: Burning oil shale

The largest and most concentrated deposit of oil shale in the world is located in the western U.S in the states of Colorado, Wyoming, and Utah. Total U.S resource is estimated to approach 6 trillion barrels[2] of shale oil.

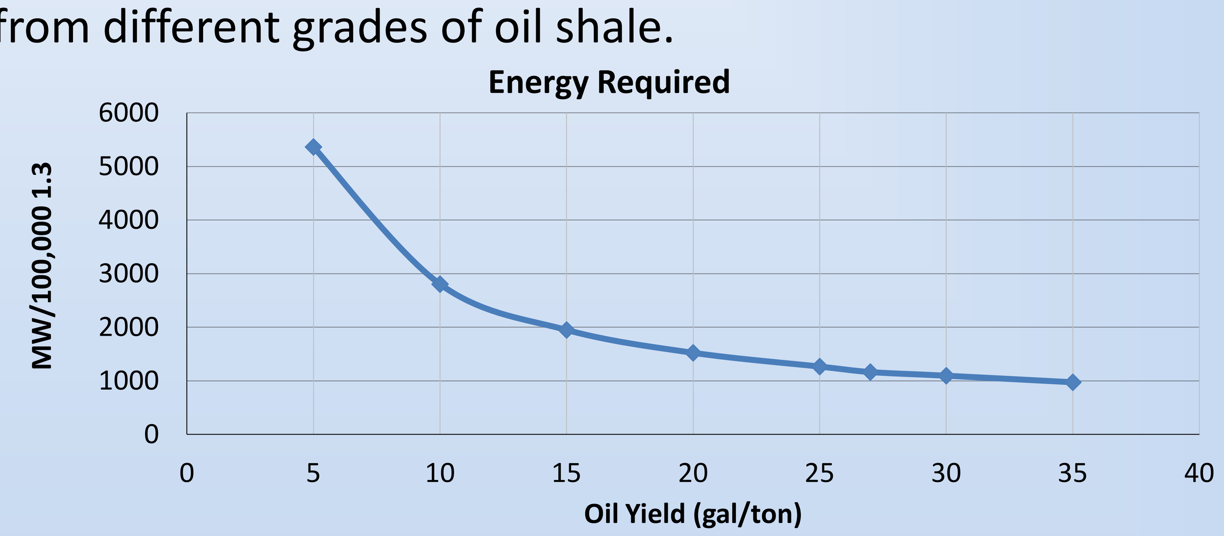
Some environmental issues might appear during the production of oil shale, as CO_2 emissions or water consumption.

Western U.S oil shale resource:



Heat Requirements for Retorting:

Alan Burnham calculated the heat needed to extract shale oil from different grades of oil shale.



These results are the basis for the next calculations. The energy required has to be recalculated to account for losses (10%) in transportation or efficiency of a power plant.

Thermal Solar:

Thermal solar is also known as Concentrating Solar Power (CSP). This technology concentrates the sunlight with mirrors or reflectors to heat a fluid and produce steam which drives a turbine and is then converted to electricity by a generator.

Three different methods for CSP:

- Power Tower system
- Parabolic dish
- Parabolic trough

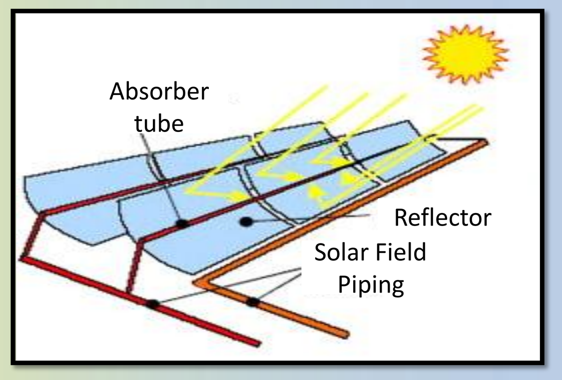


Figure 3: Parabolic trough

The parabolic trough is currently the most mature and commercially available CSP technology[3]. So this poster focuses on parabolic trough.

The table below shows how large a solar farm would have to be to provide enough energy to extract 100,000 barrels per day :

	Power needed (Mw/day)	Mirror Area (km²)
medium grade & 1.3 % water	1522,09	6.98
medium grade & 5 % water	1607,33	7.37
high grade & 1.3 % water	1094,65	5.02
high grade & water 5 % water	1155,95	5.30

Data from Skyfuel[4], a Solar Thermal Energy Company located in Arvada, were used to make this calculations.

This technology is more efficient than PV but uses a lot of water.

Water consumption, Green house Gas Emissions and Energy Embodied:

The next table compares water consumption, GHG and energy embodied to extract 100,000 barrels of oil shale according different energies.

Renewable energies		Energy embodied		Green House Emission		Water consumption		Sources
		Baseline data	For our case (MWh)	Baseline data	For our case (kg CO_2)	Baseline data	For our case (m^3/day)	
CSP	Wet Cooling	0,4 Mjeq/kWh	1,52E+06 / 1,10E+06	26 g CO2eq/kWh	3,56E+08 / 2,56E+08	4,7 L/kWh	176499 / 126934	NREL, LCA of a parabolic trough
	Dry Cooling	0,43 Mjeq/kWh	1,64E+06 / 1,18E+06	28 g CO2eq/kWh	3,84E+08 / 2,76E+08	1,1 L/kWh	41308 / 29708	
	Wet Cooling					3,420 L/kWh	128436 / 92368	Skyfuel, Parabolic Trough
	Dry Cooling					0,203 L/kWh	7605 / 5469	
	Wet Cooling					3 L/kWh	113723 / 81787	CSP commercial Application Study
	Dry Cooling					0,3 L/kWh	11372 / 8179	
	Hybrid Cooling					1,28 L/kWh	48048 / 34555	
Wind turbine		84237 GJ/Turbine	3,51E+07 / 2,57E+07	60 kg/GJ	2,96E+09 / 2,13E+09			Science Direct
				8-30 gCO2eq/kWhe	2,60E+08 / 1,87E+08			LC GHG
		4304221 kWh/Turbine	6,46E+06 / 4,73E+06					LCA Onshore Turbine
PV				43-73 gCO2eq/kWhe	7,95E+08 / 5,72E+08			LC GHG
		768,1 kWh/Pannel	8,86E+06 / 6,42E+06	145,5 kg CO2/Pannel	7,63E+08 / 5,49E+08			Carbon footprint

Medium oil shale
Rich oil shale

Conclusion and perspectives:

Oil shale production requires a large amount of energy to extract 100,000 barrels of oil per day. But oil shale sites could reduce their carbon footprint by using renewable energies sources available in Colorado or Wyoming. CSP technology seems to be a good solution to provide this energy but should use hybrid or dry cooling.

A continuation of the project would consider the economic aspect. It would also be interesting to consider the shale gas extracted with shale oil that could provide energy too.

References:

[2] Olayinka I. Ogunsola, Arthur M. Hartstein, Olubunmi Ogunsola, ***Oil shale: A solution to the Liquid Fuel Dilemma***, 2010, 325p

[3] *Sargent & Lundy LLC Consulting Group (S&L)*, ***Assessment of Parabolic Trough and Power Tower Solar Technology Cost and Performance Forecasts***, Energy Efficiency and Renewable Energy (EERE) , 2003, 47p

[4] http://www.skyfuel.com/downloads/brochure/SkyTroughFactsheet.pdf

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