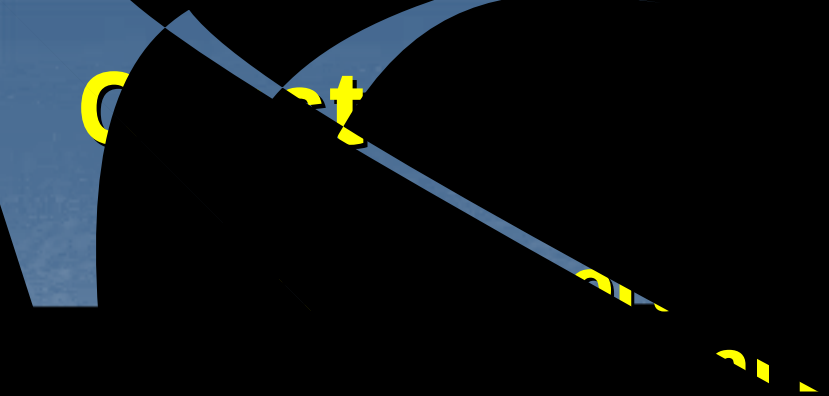
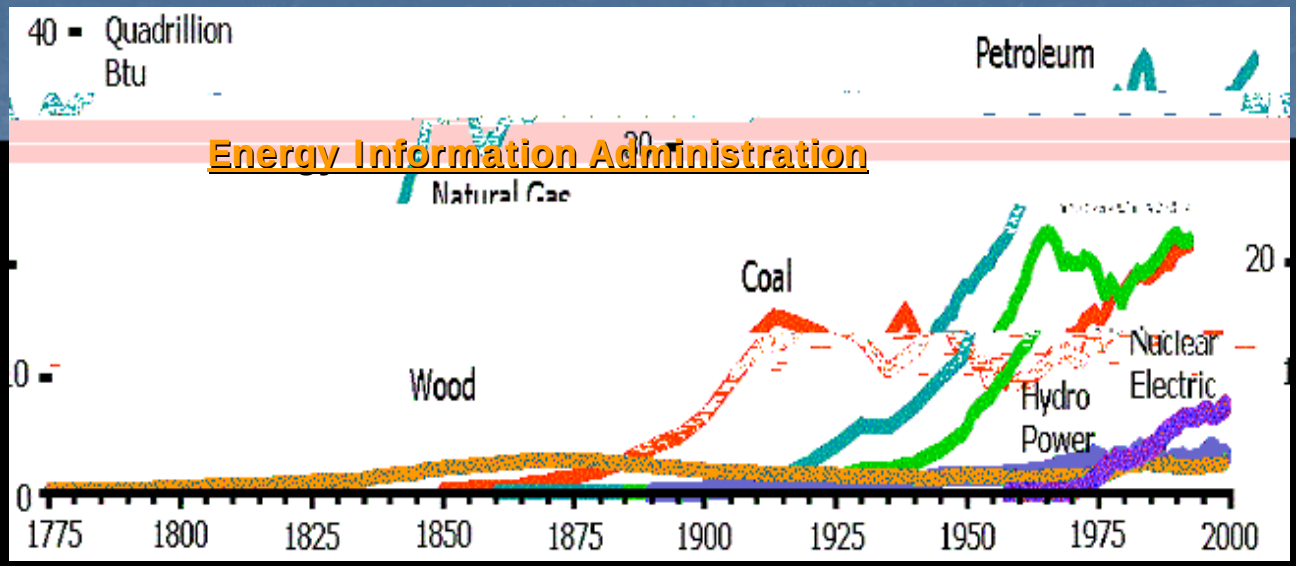


Research Funded By:

* DOE grant of $194,458 to study deep Permian Basin geothermal energy (part of an anticipated 3-year Congressional appropriation) (# DE-FG36-05GO 85023).

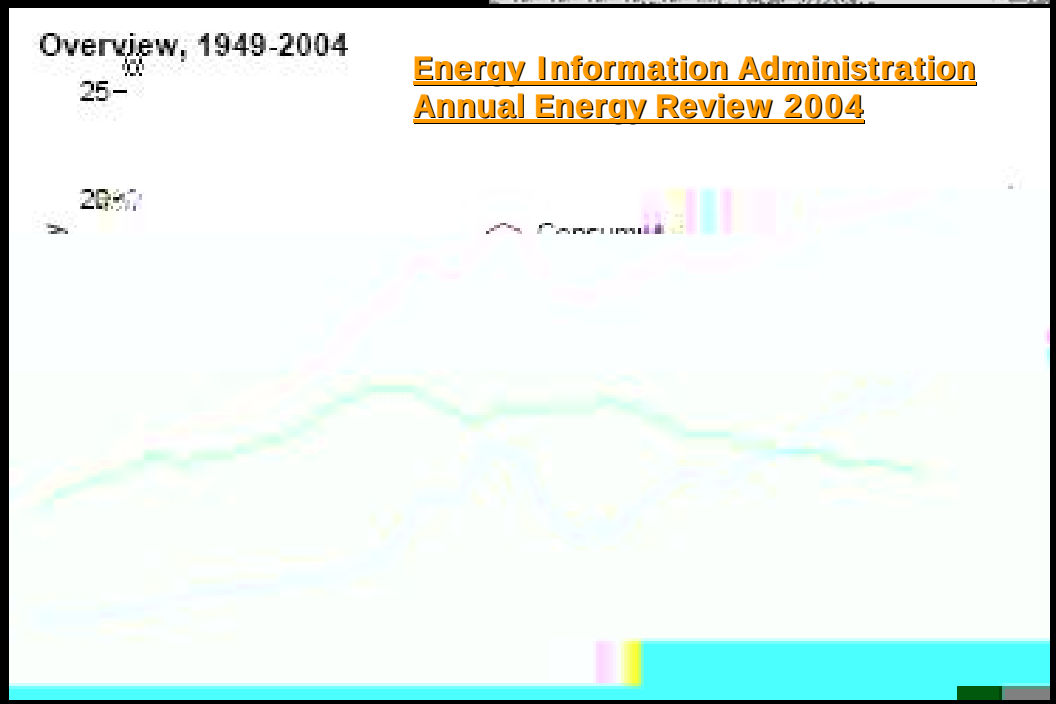
* State Energy Conservation Office grant of $40,000 to help study deep Permian Basin geothermal energy and to develop a state-wide geothermal program (# CM540).

U.S. Energy Usage – Up…and UP!



Automotives – 9 million Bbl/day

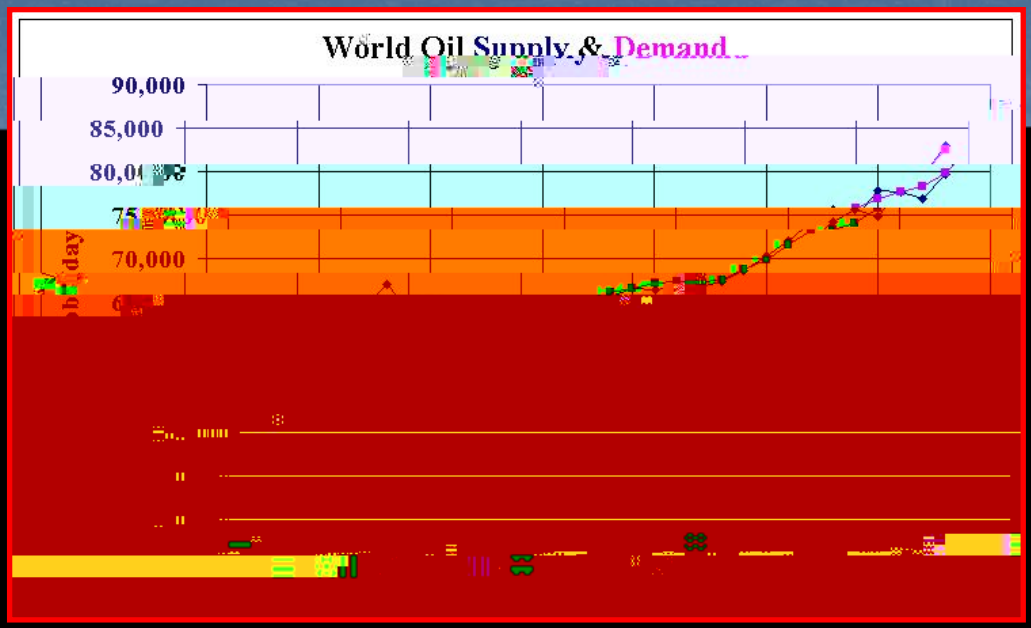
Trucks, Heavy Machinery, Power Plants – 11 million Bbl/day



[1] Petroleum products supplied is used as an approximation for consumption.

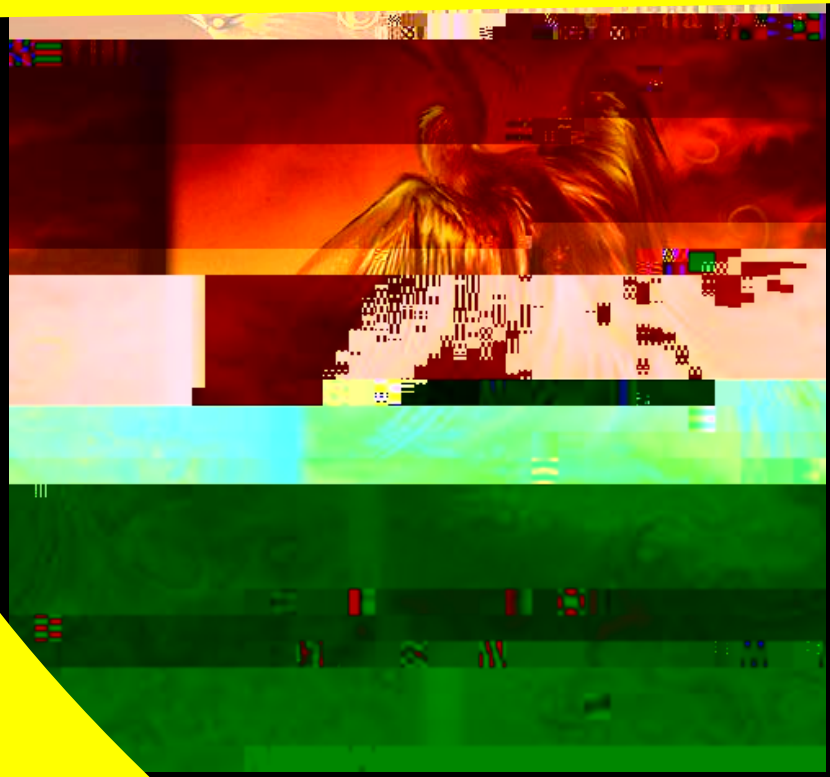
[2] Crude oil and natural gas plant liquids production

World Oil Supply & Demand Are Close



“Yes, Virginia, there is a . . .”

. reason to



Geothermal Energy Industry Constraints

Only Three Variables Control All Constraints

CONSTRAINTS TO GEOTHERMAL DEVELOPMENT			
Natural (Geological / Geographical)		Technical	Human
Surface	Subsurface		
Landforms/Geography/ Geology	Heat Resource Available	Drilling (techniques- horizontal, radial patterns)	Economics (cost vs. profit; drilling costs)
	Reservoir Characteristics	Heat Acquisition Methodologies	Perception
	Water as Transfer/Storage Agent	Environmental Concerns (toxic & nontoxic minerals)	Transmission
		Data acquisition	Information/Technology Transfer
			Politics (gov., people [advocacy groups])
			Ownership
			Resource Management
			Research

Constraining The Constraints

Many of these constraints do not exist in the

Natural Variable

- √ Surface – a non-issue; land very accessible.

Subsurface –

- √ Heat resource – known from O&G data.
- √ Reservoir characteristics – known from O&G data.
- √ Water availability – known from O&G data; total amount unknown as industry does not perforate

Technical Variable

- **Drilling – involved with pioneering oil/gas drilling techniques; nothing new needed for geothermal.**

Pinnate drainage pattern horizontal drilling system pioneered by CDX Gas LLC for coal-bed methane extraction.

Joint venture between the DOE, NovaTek Engineering, and Grant Prideco. Decreases deep drilling time & cost through real time data transfer. Provide pipe and links. Twice cost of normal pipe. Size: 5”, 5 $^{7}/_{8}$”.

Technical Variable

Heat acquisition – O&G industry knows how to move water, but will need to learn to generate electricity

Ormat

Binary Cycle

Combined Cycle

And if Kinder Morgan can generate electricity at the Sac Rock field, so can other companies.

UTC Power

PureCycle™ 200
200 kW net range

AND…..

Technical Variable

It Has Already Been Proven Once!

Sept 1989- May 1990: Brazoria County, Texas

Three heat exchangers at Pleasant Bayou

Minimum rating 1.191

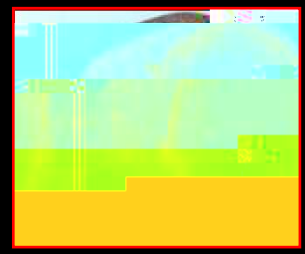
Binary Cycle Turbine 541 kW
Gas Engine 650 kW
Parasitic Load -209 kW
Capacity factor 80.2%
(3-day plant outage & 4-wk

Compare with Ormat heat exchangers, Imperial Valley Geothermal

Technical Variable

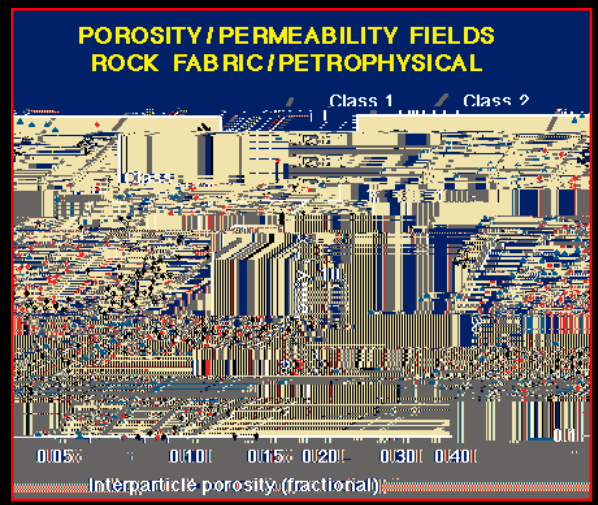
- Environmental – O&G biggest problems have been solved through chemical inhibitors; highly toxic mineralization not of concern.

$CaCO_3$



Silica
Sulfides

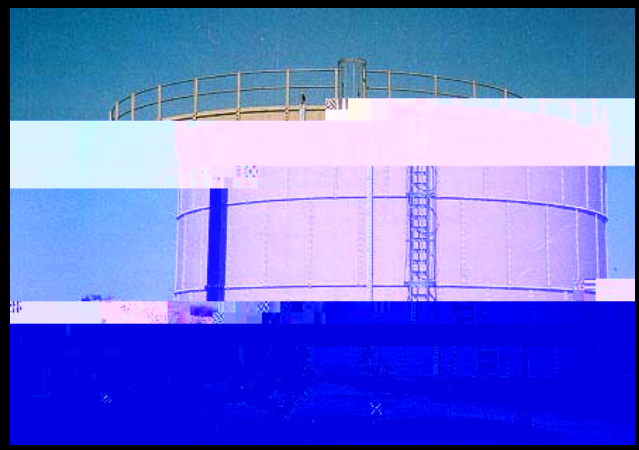
- Data – huge amounts of subsurface data regarding temperature, seismic, porosity, permeability, reservoir imaging, etc. are all important for heat extraction.



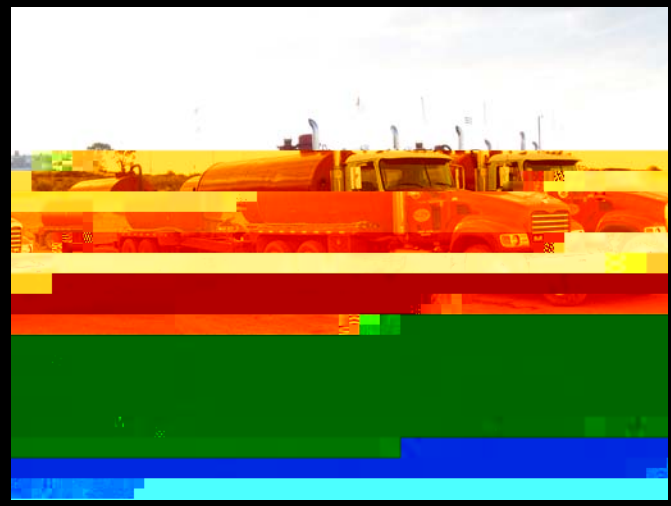
Human Variable

Perception – O&G industry must think of hot water as an energy asset, not as a production liability; biggest hurdle to overcome.

Waste water storage.



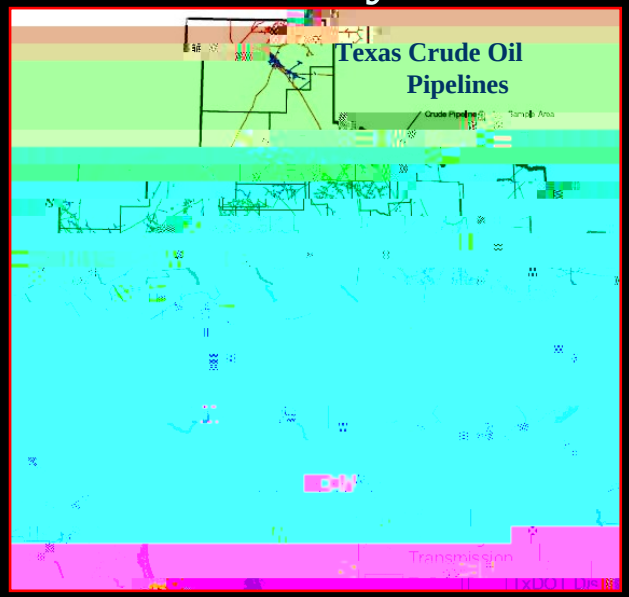
Pit liner for produced water.



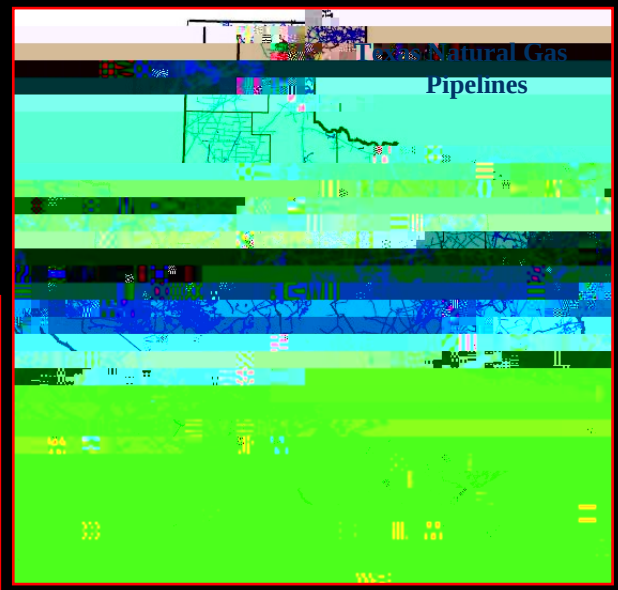
Oil field water hauling.

Human Variable

- Transmission – a huge infrastructure for transmission already exists.



Transmission right of ways are important to maintain. Many existing right-of-ways may eventually double as electrical right-of-ways.



Electrical right-of-ways within existing oil fields can send electricity out.