

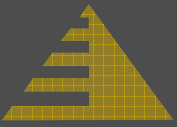


# Overview of Emerging Oil Shale Technologies

**October 17, 2007**

**Peter M. Crawford  
INTEK, INC.**

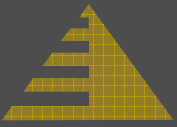
**27<sup>th</sup> Oil Shale Symposium  
The Colorado Energy Research Institute & The Colorado School of Mines  
October 15 – 17, 2007**



# Introduction

- **Key Oil Shale Processes**
- **History of Oil Shale Technologies**
- **Lessons Learned and New Challenges**
- **Current Technologies, and Industry RD&D Activities**



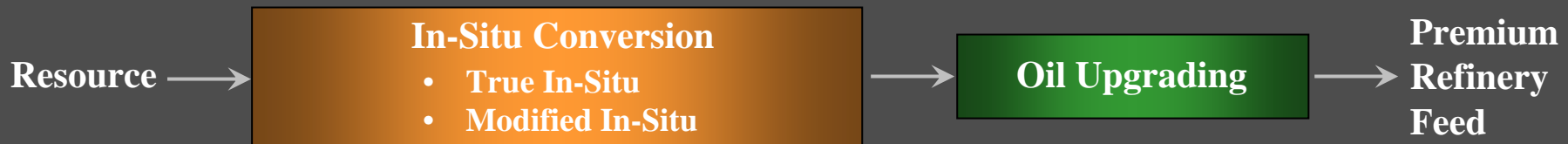


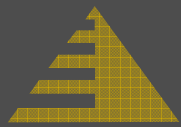
# Key Oil Shale Processes

## Surface Process



## In-Situ Process





# History of Oil Shale Technologies



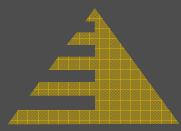
**Abandoned Oil Shale Retort  
Utah, circa 1900**



**UNOCAL's Demonstration Plant  
Parachute Creek, circa 1990**

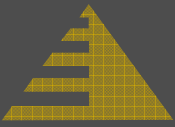


**Millennium Synfuels  
Vernal Utah, circa 2006**



# Lessons Learned and New Challenges Drive Technology Development

<b>Technology Challenges</b>	<b>Approaches Considered</b>
<b>Scalability</b>	<b>Smaller units, scaled modularly</b>
<b>Reliability</b>	<b>Redundancy to improve uptime</b>
<b>Efficiency</b> -- Energy Use / Balance -- Resource Recovery	<b>New retort / heater technologies</b> <b>Advanced controls</b> <b>Temperature / residence time</b> <b>Drilling and spacing configurations</b>
<b>Water Use</b>	<b>Low water-use processes</b> <b>Connate water use</b> <b>Capture, clean-up, and re-use</b>
<b>Groundwater Protection</b>	<b>Impermeable barriers</b> <b>Freeze walls</b>
<b>Emissions &amp; Carbon Management</b>	<b>State of the art emissions controls</b> <b>Processes that reduce CO<sub>2</sub> creation</b> <b>CO<sub>2</sub> capture, use, and sequestration strategies</b>



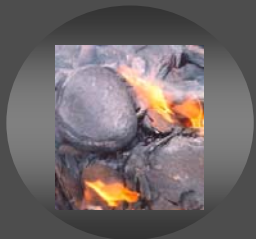
# Current Oil Shale Activities



**Department of Interior has established an Oil Shale Leasing Program**



**Department of Energy profiled oil shale companies**



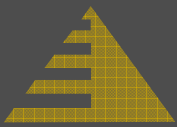
**Industry is moving forward with mature and novel technologies on public and private lands**



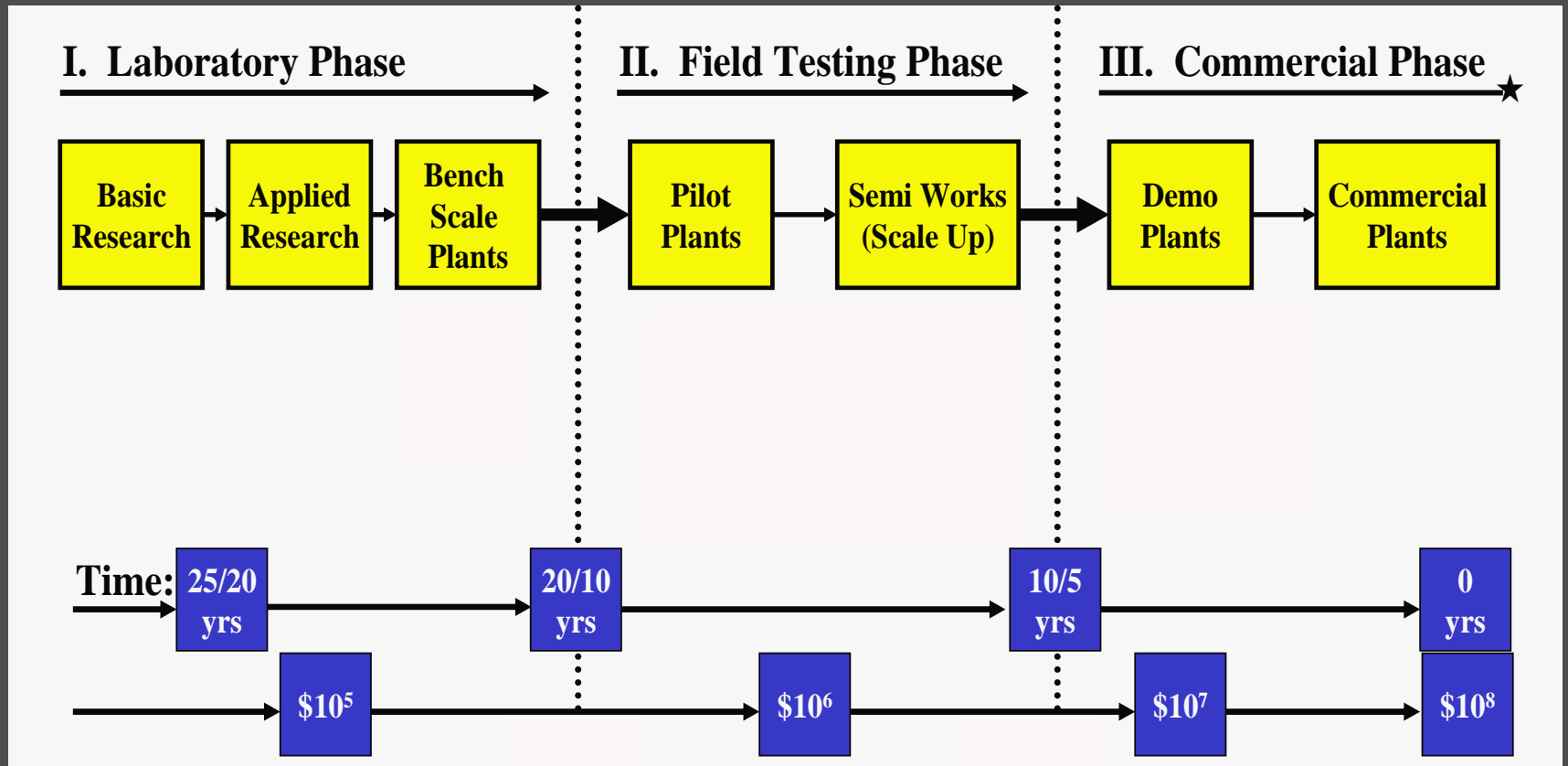
# Companies and Current Technologies

In-Situ	
Chevron USA	CRUSH
E.G.L. Resources	Closed Loop In-Situ
Earth Search Sciences / Petro-Probe, Inc.	Superheated Air
Electro-Petroleum	Electrically-Enhanced
ExxonMobil Corporation	Electro-Frac
Independent Energy Partners	Geothermic Fuel Cell
James A. Maguire, Inc.	Fracturing System
Mountain West Energy Company	Gas Extraction
Phoenix-Wyoming, Inc.	Borehole Microwave
Raytheon Corporation	RF/Critical Fluid
Shell Frontier Oil and Gas, Inc.	In-Situ Conversion
Red Leaf Resources	In-Capsule

Surface	
Brent Fryer, Sc.D.	Pyrolysis
Chattanooga Corporation	Fluidized Bed Reactor
J.W. Bunger and Associates, Inc.	Value-Enhancement
Millennium Synthetic Fuels, Inc.	Vertical Retort
Oil Shale Exploration Corporation (OSEC)	Alberta Taciuk Process
Syntec, Inc.	Gasification/Rotary Kiln
Western Energy Partners	Gasification
Upgrading	
Imperial Petroleum Recovery Corp.	Microwave Separation
Global Resource Corporation	Gasification/Purification



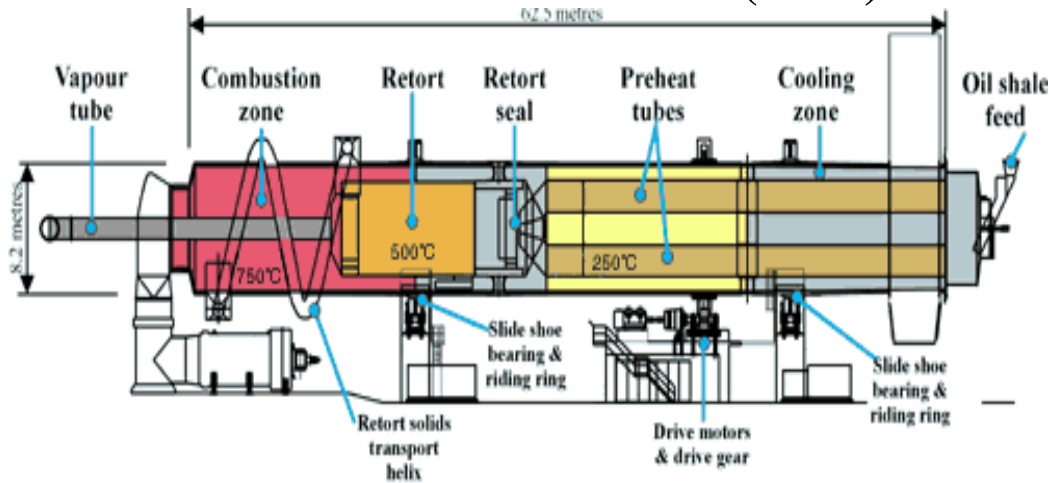
# Phases of Oil Shale Technology Maturation



Source: Lukens, 2004

# Surface Retort Technology Today

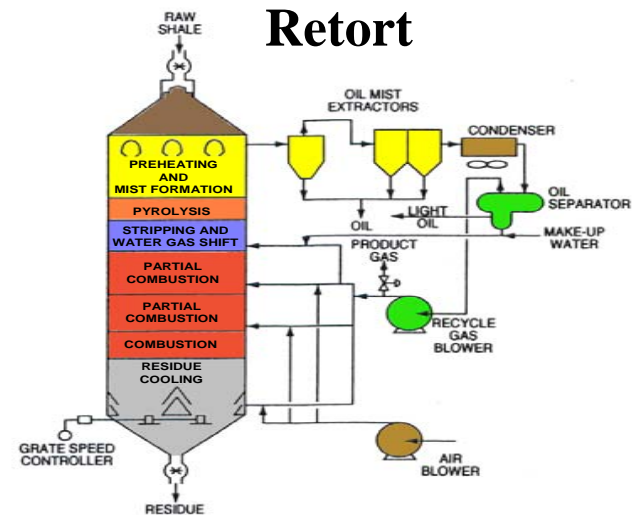
## Alberta Taciuk Processor (ATP)



- Initially designed for extracting bitumen from tar sands
- Applied for oil shale conversion in Australia (SPP)
- OSEC evaluating ATP for its RD&D efforts in Utah

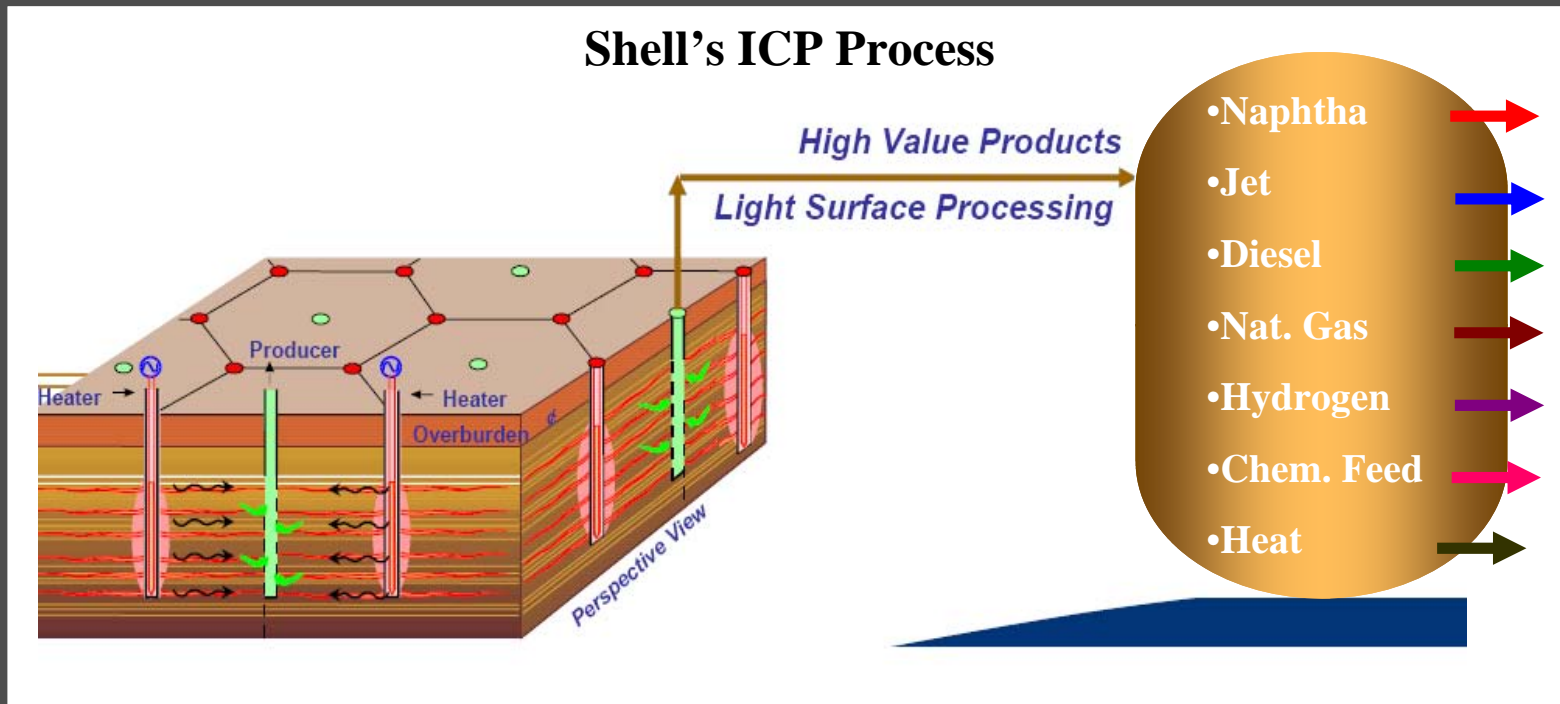
- Originally developed by
  - Cameron Engineering
  - Bureau of Mines
- Most successful
  - High thermal efficiency
  - High retort efficiency
- Variations of GCR
  - Petrosix operating in Brazil
  - Paraho Process / Pilot in CO
  - Variations being tested considered for other projects

## Gas Combustion Retort

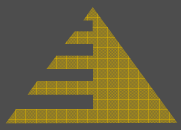


# In-Situ Conversion Technology Today

Pilot tests under development in Colorado

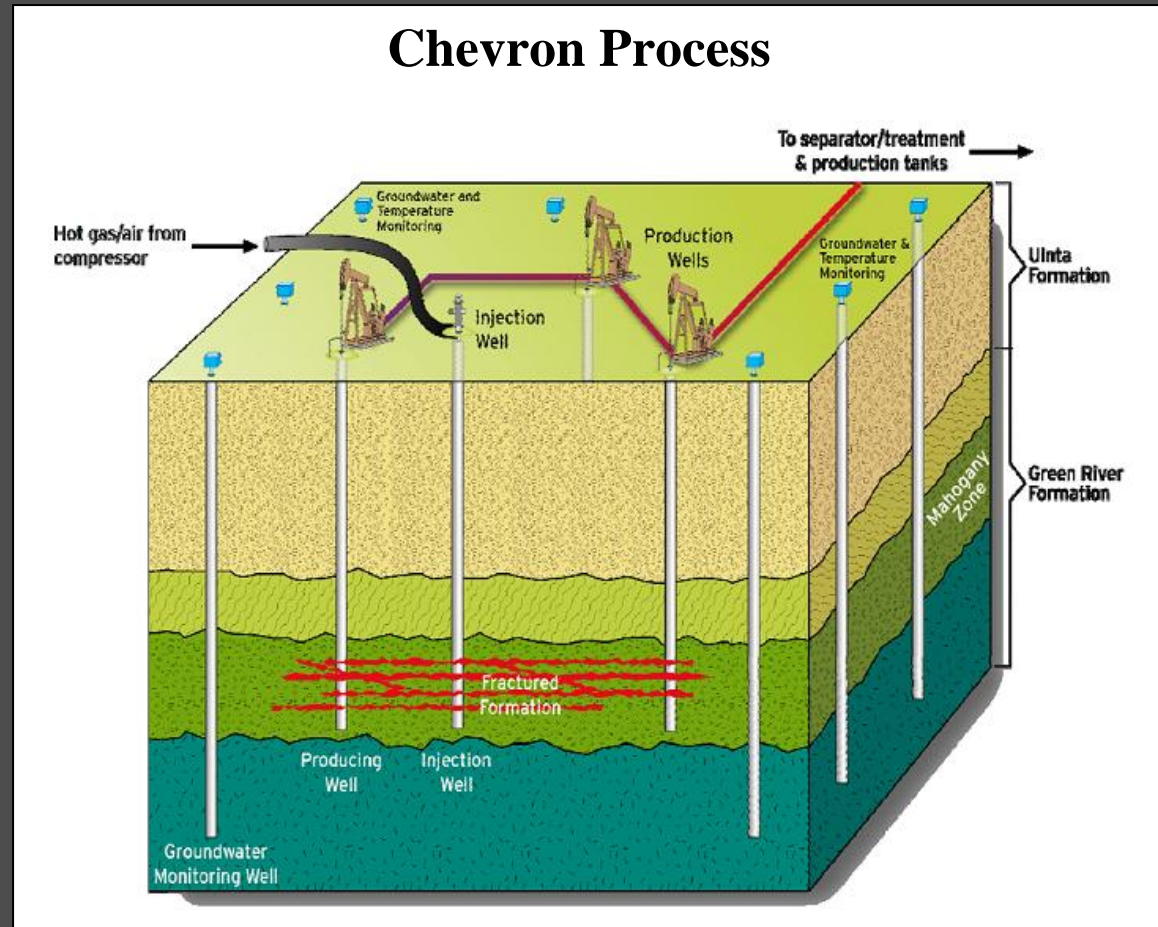


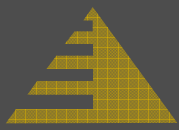
- Developed by Shell Frontier Oil & Gas Inc.
- Currently in “pilot” phase in north-western Colorado
- Shell to apply technology at three other sites in Colorado



# In-Situ Conversion Technology Today

Pilot tests under development in Colorado

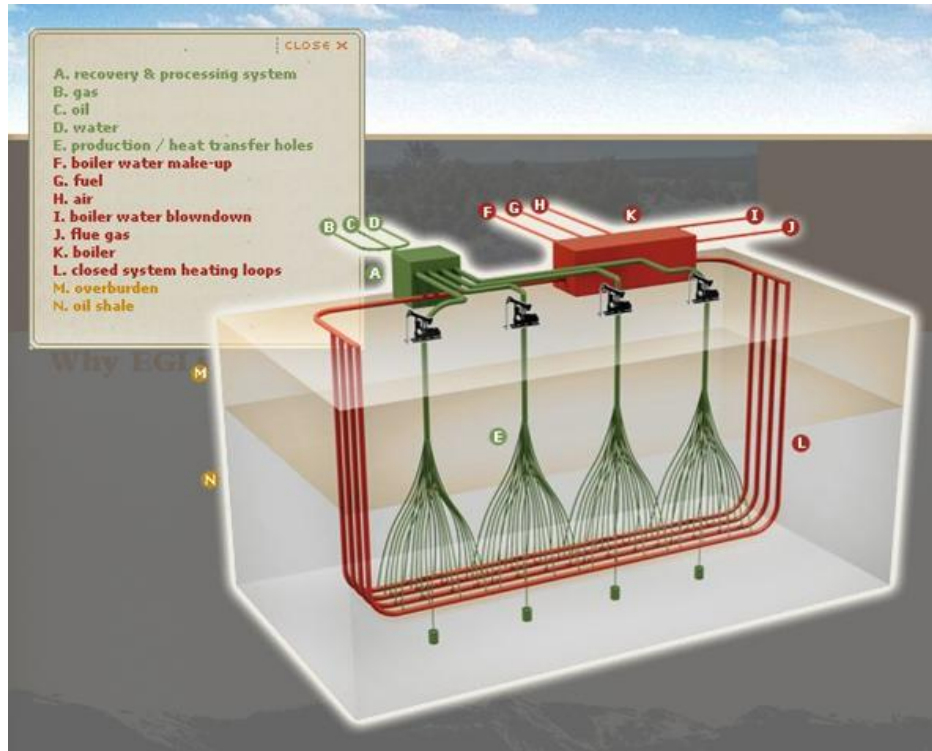


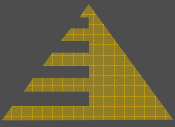


# In-Situ Conversion Technology Today

Pilot tests under development in Colorado

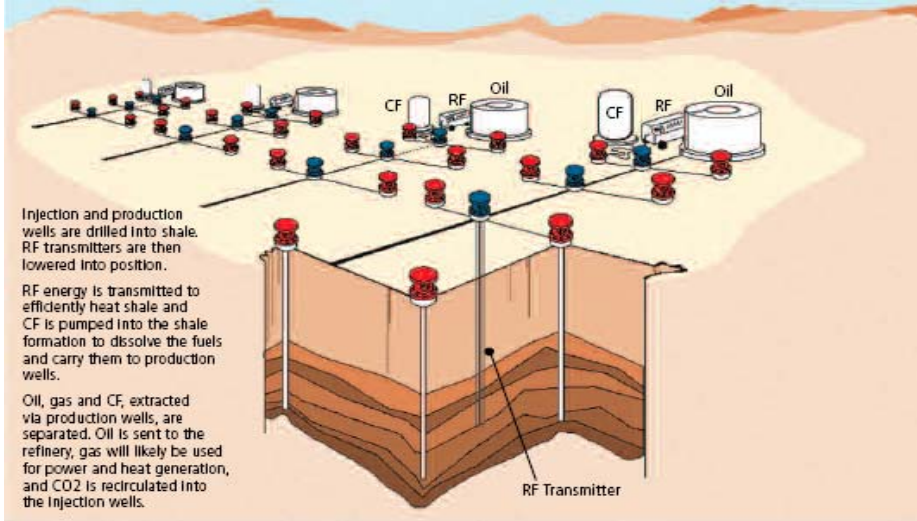
## EGL Resources Process





# Novel Technologies Cont.

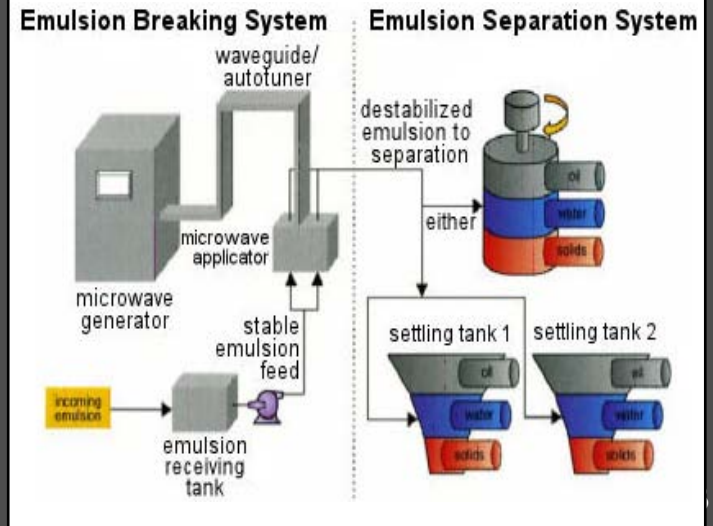
## Radio Frequency/Critical Fluid Oil Extraction Technology

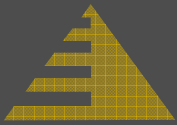


- Raytheon & CF Technology's patent-pending extraction methodology
- Radio frequency energy is used to heat the shale
- Super critical carbon dioxide is pumped in to extract oil

- Imperial Petroleum Recovery Corporation's patented Microwave Separation Technology
- Add on system to separate emulsions into usable products
- Improves the processing of shale oil

## "Microwave Separation Technology" Process Schematic





# DOE's Report on Oil Shale Companies



## **Secure Fuels from Domestic Resources**

**The Continuing Evolution of America's Oil Shale and Tar Sands Industries**

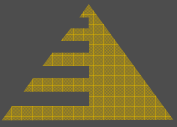
**Profiles of Companies Engaged in Domestic Oil Shale and Tar Sands Resource and Technology Development**

U.S. Department of Energy  
Office of Petroleum Reserves  
Office of Naval Petroleum and Oil Shale Reserves  
June 2007



- Department of Energy's Naval Petroleum and Oil Shale Reserves Produced a Profile of 27 Companies
- Report is available for download on website at:

[http://www.fossil.energy.gov/programs/reserves/npr/NPR\\_Oil\\_Shale\\_Program.html](http://www.fossil.energy.gov/programs/reserves/npr/NPR_Oil_Shale_Program.html)



# Conclusions

- **Oil Shale technologies continue to advance**
- **RD&D is addressing lessons learned and new challenges**
- **BLM lease program facilitates development and demonstration**
- **Numerous other technologies offer significant promise and potential**
- **The development timeline requires investment now to meet energy supply, security, and environmental challenges**