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Overview of Emerging Oil Shale Technologies

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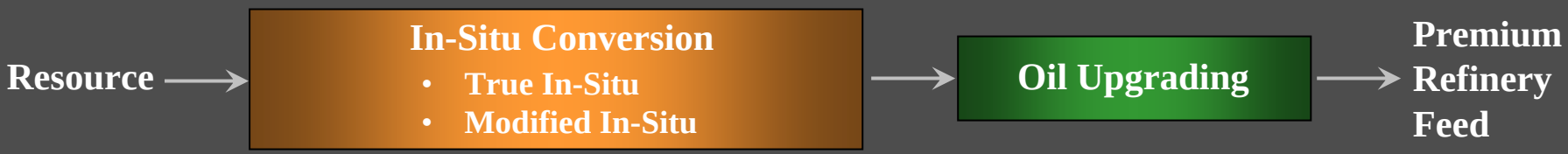
Introduction

- **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

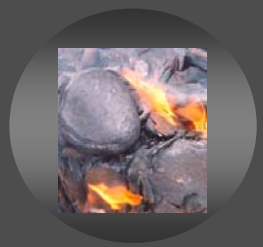
Lessons Learned and New Challenges Drive Technology Development

Technology Challenges	Approaches Considered
Scalability	Smaller units, scaled modularly
Reliability	Redundancy to improve uptime
Efficiency -- Energy Use / Balance -- Resource Recovery	New retort / heater technologies Advanced controls Temperature / residence time Drilling and spacing configurations
Water Use	Low water-use processes Connate water use Capture, clean-up, and re-use
Groundwater Protection	Impermeable barriers Freeze walls
Emissions & Carbon Management	State of the art emissions controls Processes that reduce CO_2 creation CO_2 capture, use, and sequestration strategies

Current Oil Shale Activities

Department of Interior has established an Oil Shale Leasing Program

Department of Energy profiled oil shale companies



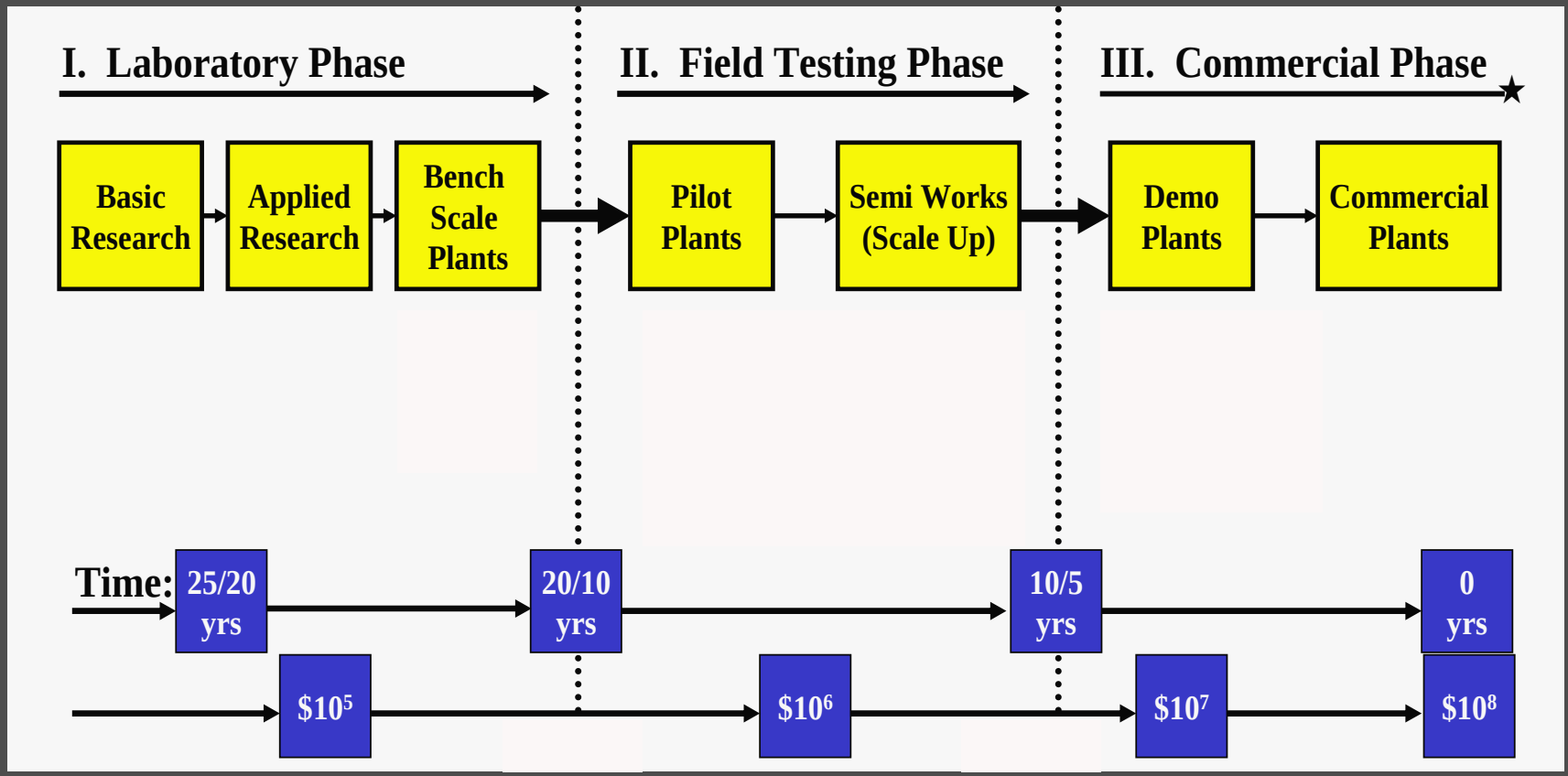
Industry is moving forward with mature and novel technologies on public and private lands

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-Enhaced
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.	Pyrolisis
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

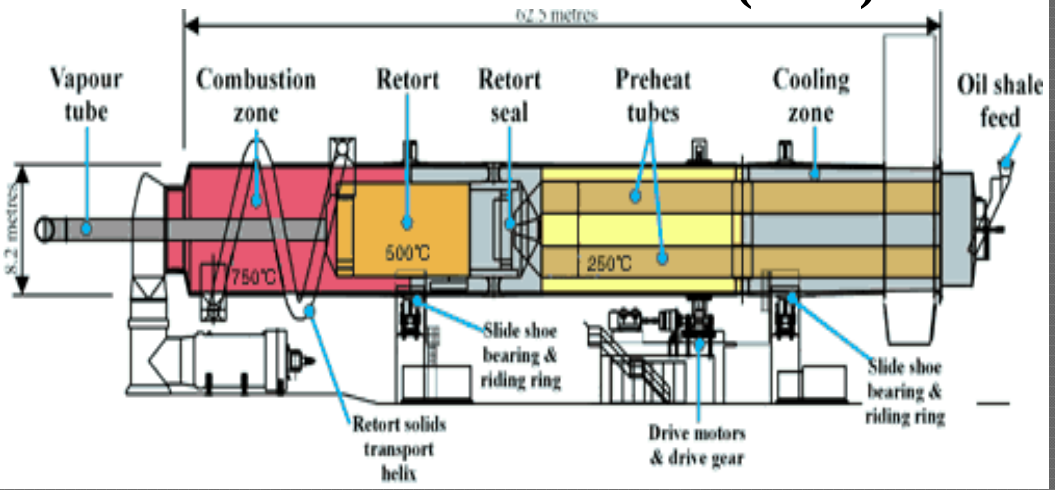
Phases of Oil Shale Technology Maturation



Source: Lukens, 2004

Surface Retort Technology Today

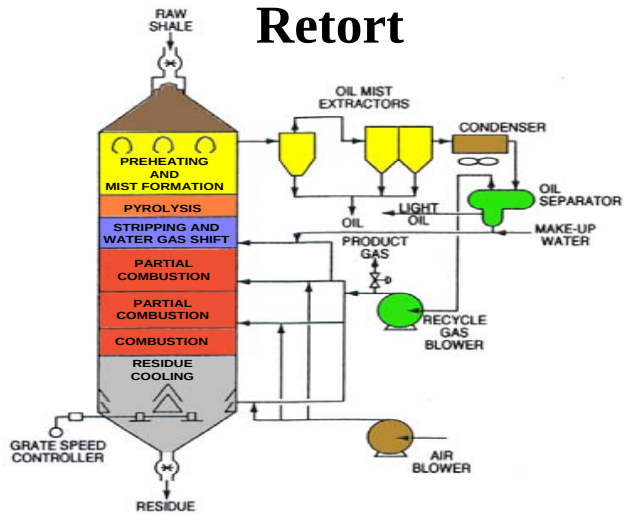
Alberta Taciuk Processor (ATP)



- 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

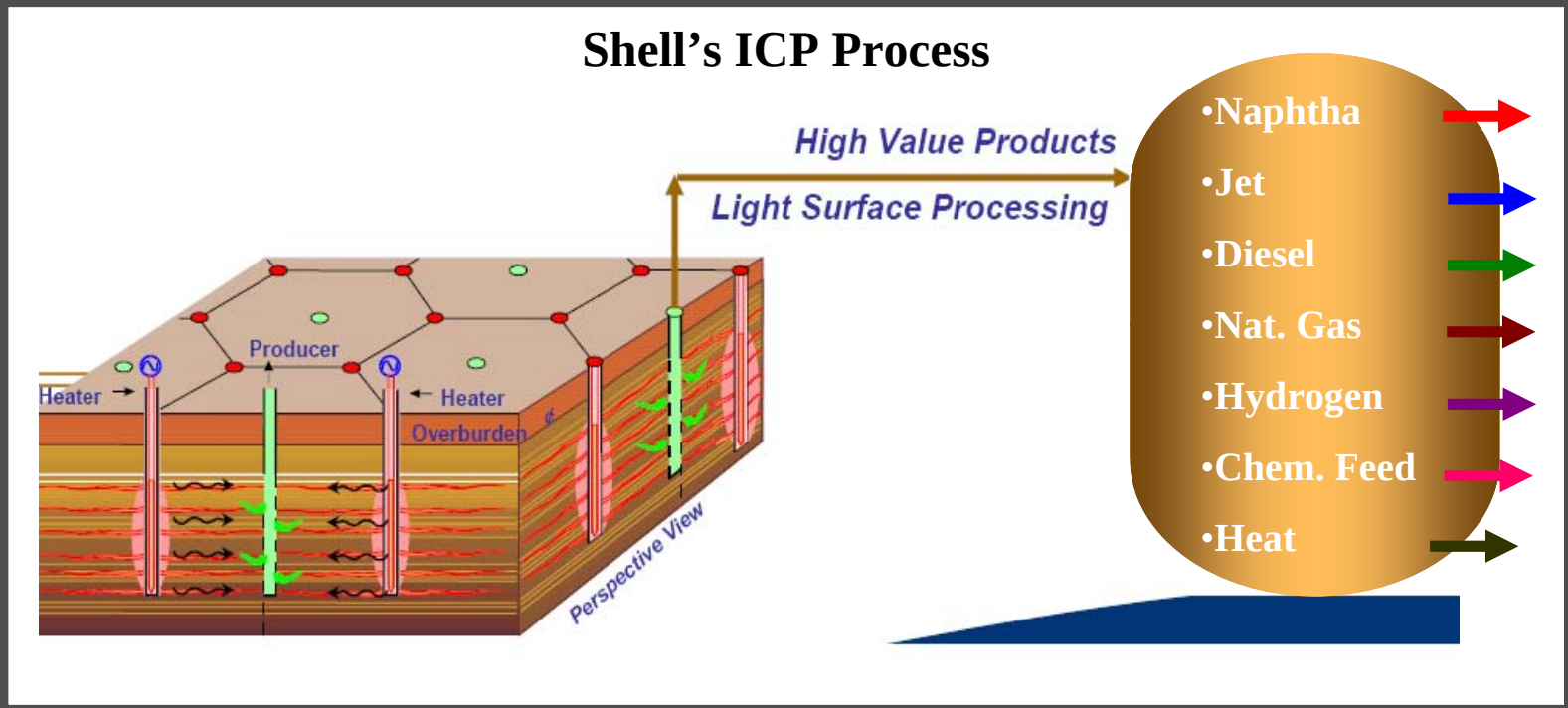
- Originally developed by
  - Cameron Engineering
  - Bureau of Mines
- Most successful
  - High thermal efficiency
  - High retort efficiency
- Variations of GCR
  - Petrosix operating in Brazil
  - Paraho Process / Pilot in CO
  - Variations being tested considered for other projects

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

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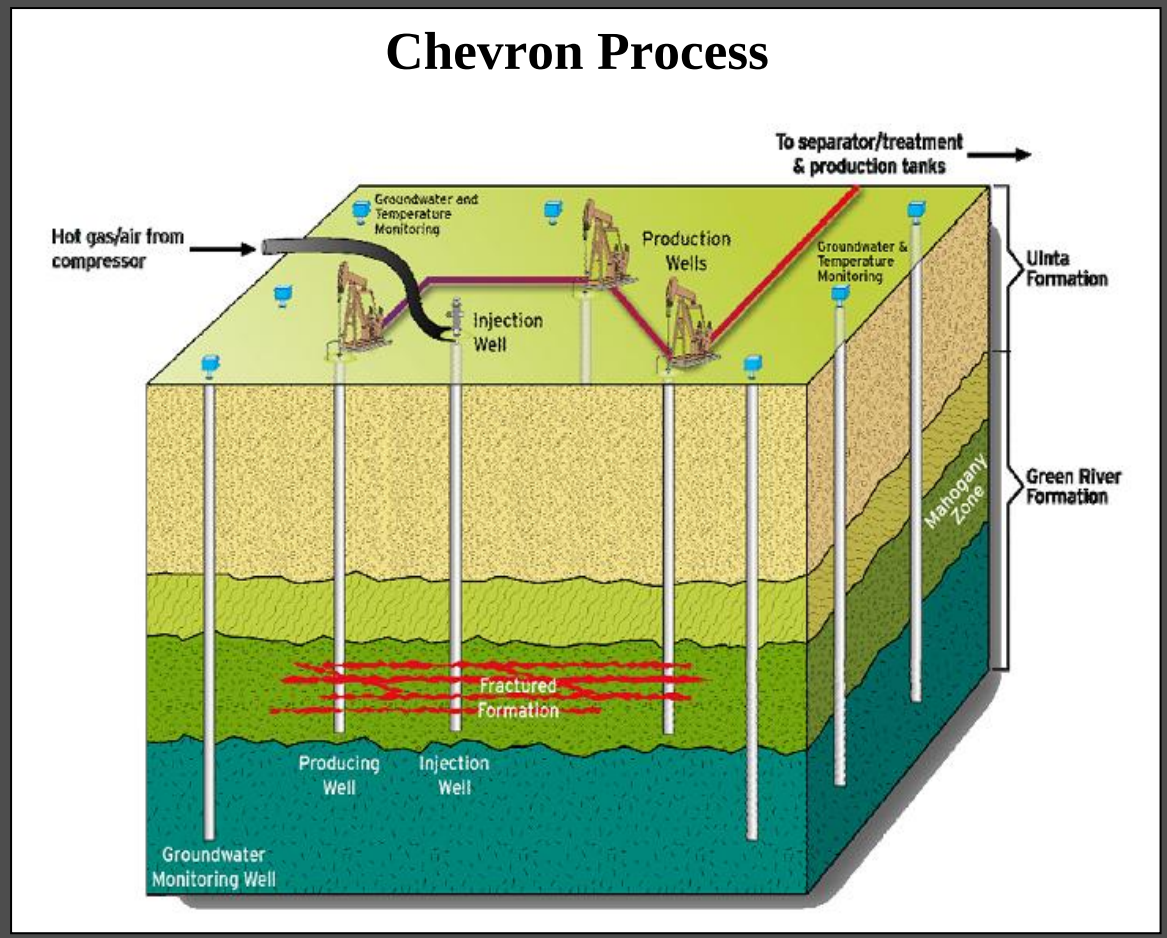

In-Situ Conversion Technology Today

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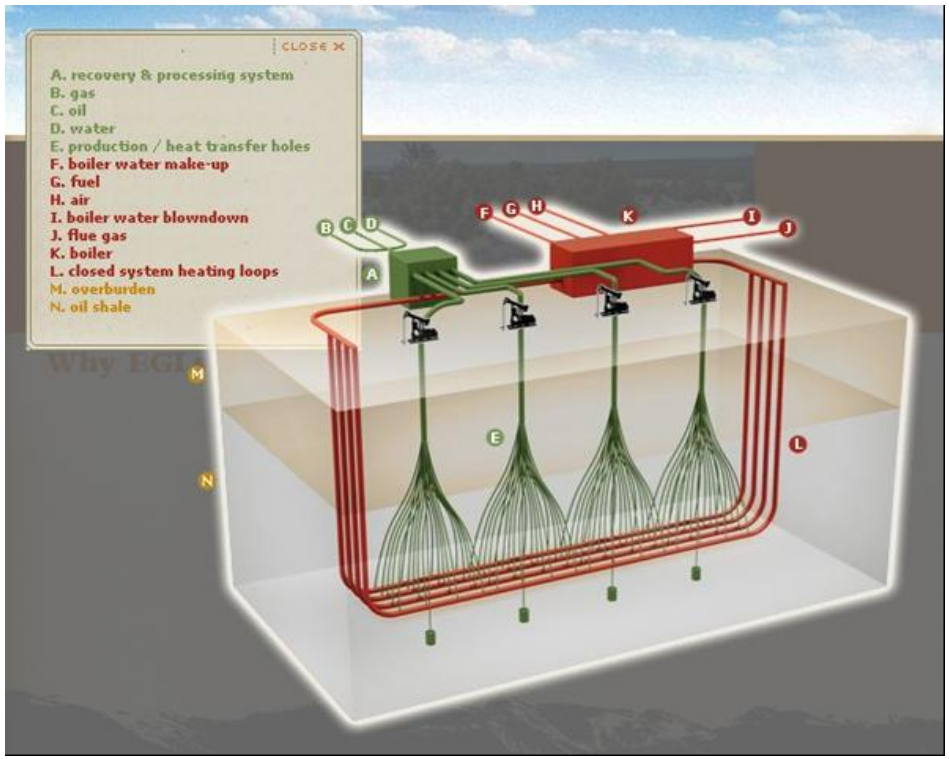
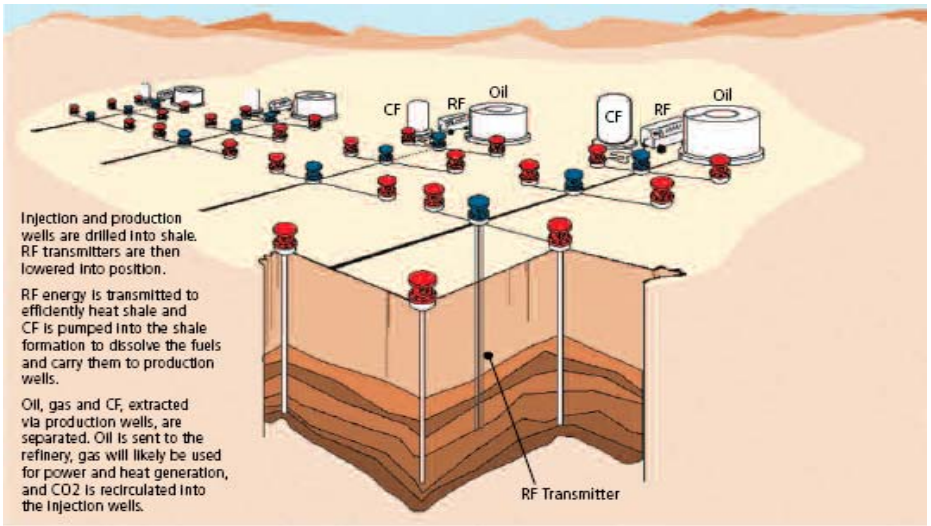
EGL Resources Process



Novel Technologies Cont.

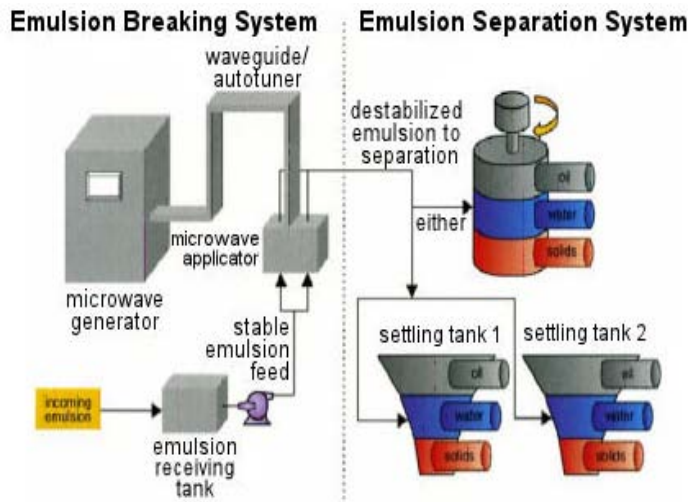
Radio Frequency/Critical Fluid Oil Extraction Technology



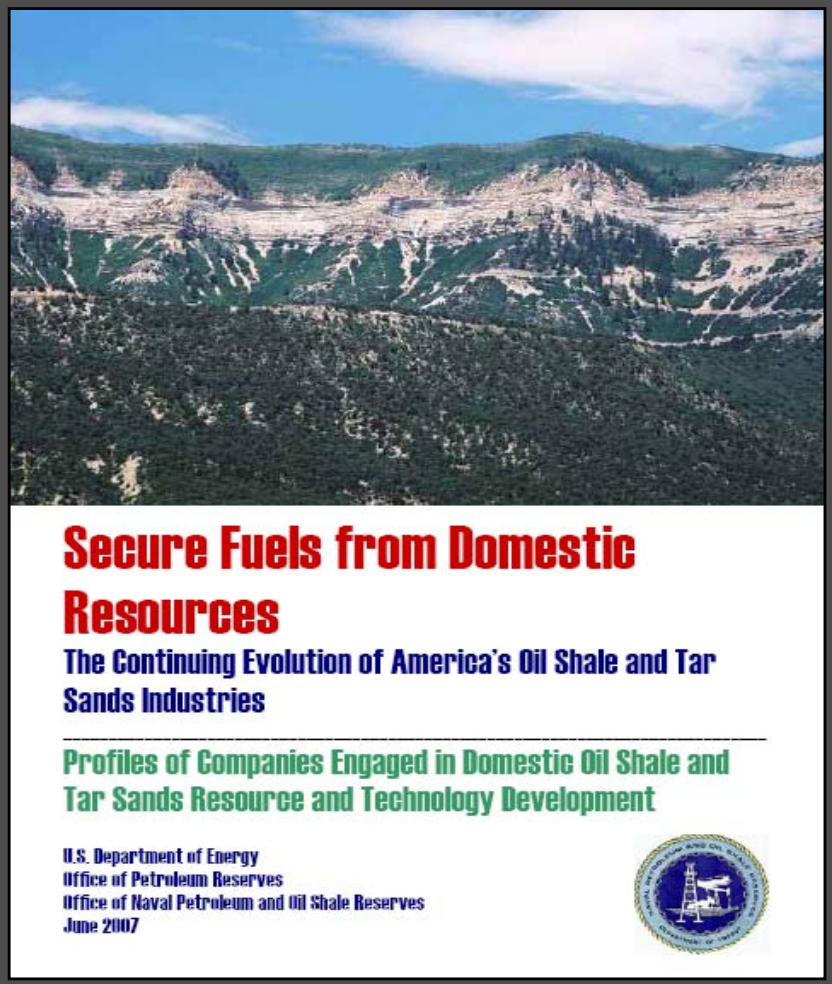
- Raytheon & CF Technology's patent-pending extraction methodology
- Radio frequency energy is used to heat the shale
- Super critical carbon dioxide is pumped in to extract oil

- 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



- **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

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**