Oil and Gas Basics
Worldwide commercial energy production.

- Oil: 40%
- Coal: 28%
- Gas: 23%
- Nuclear: 7%
- Hydro: 2%
- Geothermal and wind: 1%
Today’s oil is yesterday’s plankton

- Small marine and lake organisms live in surface waters
- They die, fall to the bottom and get buried into an organic rich sedimentary layer
- If geologic processes heat and squeeze these rocks sufficiently, they will create crude oil and natural gas (hydrocarbons) from the fossils
- Crude oil and natural gas will migrate toward the surface
- Geologic traps must exist to create an oil field
Origin of Hydrocarbons

- Accumulation of organic matter (kerogen) and sediments to form a “source rock”
- Generation - Burial of source rock to temperature and pressure regime sufficient to convert organic matter (kerogen) into hydrocarbons
- Migration - Movement of hydrocarbons out of the source rock into a trap
- Accumulation - Hydrocarbons migrate into a trap faster than the trap leaks, forming a reservoir
- Preservation - Hydrocarbons remain in the reservoir and are not destroyed by biodegradation or overheating
- The next slides will present these steps
Accumulation and burial of organic matter
Hydrocarbon Generation

Burial to Greater and Hotter Depths
Generation and Maturation

- There is an increase in temperature with depth in the Earth’s crust. As organic matter is buried it is heated and progressively transformed into kerogen, oil and gas.
- The most oil is produced between the temperatures of 60 and 120 C, a temperature range known as the “oil window”.
- The place where oil and gas are cooked out of the rocks is called “kitchen”
Migration

- After hydrocarbon has formed it must migrate out of the source rock and into a reservoir where it can be stored.
- Some hydrocarbons form close to the reservoir but in most cases they migrate many kilometers before coming to rest in the reservoir.
- Petroleum migrates as a mixture of oil, gas and water. In the reservoir these phases separate according to density with the most dense, water on the bottom, least dense gas on top and oil between the two.
Migration

- Entrapment
- Accumulation
- Migration
- Generation
- Source Rock
- Oil
- Water
- Gas Cap
- Seal Rock

Temperature Levels:
- 120° F
- 350° F
Migration Anticlinal Theory

Petroleum Accumulates in Structural Closure
Prudhoe Bay Oil Field, Alaska

- Largest North American field
- More than 8 billion barrels recoverable
Requirements for a Reservoir Rock

Reservoir Rock - A rock in which oil and gas accumulates, it must have:

• Porosity - space between rock grains in which oil accumulates.

• Permeability - passage-ways between pores through which oil and gas moves.
Reservoir Sandstone

Porosity is the amount of void spaces in a rock.

Permeability is how easy fluids move through a rock.
Requirements for Traps

Traps are porous rocks covered by impermeable rocks, that isolates the fluid from the surface. Main types of traps are:

- **Anticlinal** - Rock layers folded into a dome
- **Stratigraphic** - Rock layers changing from a good reservoir to non-reservoir due to change in rock type.
- **Fault** - Offset of rocks such that oil and gas accumulates in reservoir rock
Trap types

The pinchout and lithologic variation reservoirs are examples of stratigraphic traps.
Hydrocarbon Trap Types

- Salt Dome
- Fault
- Unconformity
- Pinchout
- Anticline
Production: to produce hydrocarbons, we have to find and drill into the reservoir.
Petroleum Products

A Barrel of Crude Oil (Light Texas Crude)
Provides:

- Gasoline - 19.5 gallons
- Fuel Oil - 9.2 gallons
- Jet Fuel - 4.1 gallons
- Asphalt - 2.3 gallons
- Kerosene - 0.2 gallons
- Lubricants - 0.5 gallons
- Petrochemicals, other products - 6.2 gallons

One Barrel = 42 gallons

American Petroleum Institute, 1999
Drilling Rig

American Petroleum Institute, 1999
Drilling

Rock Bit

Cuttings

Core (Diamond) Bit

Core

American Petroleum Institute, 1999
Production: Two different environments for production rigs

Offshore

- Daily Rig Cost
  - 1999: $148,672 (Drillships: Dynamically Positioned)

Onshore

- Daily Rig Cost
  - 1999: $30,000 (Single year contract)

American Petroleum Institute, 1999.
Offshore Drilling

Drilling derrick

Crew quarters

Ocean

Seabed

Platform legs imbedded in seabed

Directionally drilled wells

Impermeable cap rock

Oil and gas reservoir

Reservoir rock

Impermeable cap rock

Oil and gas reservoir

Reservoir rock
Recovery process for petroleum.
Demographics of Energy Use

- The 20 richest countries consume
  - 80% of natural gas
  - 65% of oil
  - 50% of coal
- U.S. and Canada have 5% of world population, use 25% of available energy
Per capita energy use and GNP.
HOW LONG WILL OIL AND GAS LAST?
World Oil Supply Today

World Total Oil Production, 2000

- Saudi Arabia: 12%
- United States: 12%
- Russia: 9%
- Iran: 5%
- Mexico: 5%
- Norway: 4%
- United Kingdom: 4%
- Venezuela: 4%
- China: 4%
- Rest of World: 37%

Source: EIA
World Oil Supply Tomorrow

Proved oil reserves at end 2002
Thousand million barrels

Middle East
685.6

Africa
77.4

Europe & Eurasia
97.5

S. & Cent. America
98.6

North America
49.9

Asia Pacific
38.7

BP statistical review of world energy 2003
Crude oil prices since 1861
US dollars per barrel

World events

Pennsylvania oil boom
Russian oil exports begin
Sumatra production begins
Discovery of Spindletop, Texas
Fears of shortage in USA

Growth of Venezuelan production

East Texas field discovered
Post-war reconstruction

Loss of Iranian supplies
Suez crisis
Yom Kippur war

Netback pricing introduced
Iranian revolution

Iraq invaded Kuwait

1861-1944 US average.
1945-1985 Arabian Light posted at Ras Tanura.
1986-2002 Brent spot.

$ money of the day  $ 2002
The End of Cheap Oil

Campbell and Laherrere
Scientific American, 1998
What oil companies would have you believe

- 1,020 billion barrels of oil in reserve that will be just as cheap as it is today
- Production can continue at today’s levels for many decades to come

What Campbell and Laherrere would have you believe

- Amount of oil in reserve has been distorted
- Production will not remain constant for very long
- The last bucket of oil is not as easy to remove as the first
Hubbert Curve

- Flow of oil starts to fall when \( \sim 1/2 \) of crude oil is gone
- In 1956, M. King Hubbert of Shell Oil used this curve to successfully predict US peak in production in 1970

C & L, p. 80
Global discovery peaked in 1960

Industry has found 90% of oil that exists
How long will it last?

Perhaps more importantly, when will it become expensive?
Major conclusions of Campbell and Laherrere

- US oil production peaked in 1970
- World production will peak this decade!
- By 2002, Mid-East will have control over major part of supply
- What about Latin America?
Oil will get expensive!

- 1,000 billion barrels left
- At 20 billion barrels/year, will last about 50 years
- Will start to decline in production within 15 years
- Oil shale and tar sands may help ease pain, but will have environmental consequences
- Check this http://www.oilcrisis.com/