Land Rig System
Mud Circulation

Photo courtesy the Energy Institute
Mud System

Mud with traces of oil and gas

Rock cuttings with oil shows

Oil and gas zone
Basics of Well Cementing
Well Cementing Animation
Perforating Animation
Acidizing

Before Treatment

After Formation Damage and Debris
Fracturing Treatment

Filter Cake
Proppant Suspended in Fluid
Fracture Extension - Proppant Placement
Polymers Concentrated within Proppant-Pack
Proppant Placed - Pumping Halted - Fracture Closure
Fracturing Demonstration
Hydraulic Fracturing: Surface Use Concerns
Fracturing in Horizontal Wells

- Ground Water Aquifers
- Conductor Casing
- Surface Casing
- Intermediate Casing
- Production Casing

Horizontal Well

Vertical Well

500 ft Radius

Vertical Fractures in Vertical Wells

Producing Formation

Vertical Fractures in Horizontal Well
Fracturing in Horizontal Wells
Multi-Stage Fracturing in Horizontal Wells
Separator Units and Storage Units
Resource Triangle

- High-Medium Quality
- Low Perm Oil
- Gas Shales
- Heavy Oil
- Tight Gas Sands
- Coalbed Methane
- Oil Shale
- Gas Hydrates
North America Gas Shale Basins

Lower 48 states shale plays

Source: U.S. Energy Information Administration based on data from various published studies.
Updated: June 2016

* Mixed shale & chalk play
** Mixed shale & limestone play
*** Mixed shale & dolostone-siltstone-sandstone play
**** Mixed shale & limestone-siltstone-sandstone play

Legend:
- Current play - oldest stacked play
- Current play - intermediate depth/age stacked play
- Current play - shallowest/youngest stacked play
- Prospective play
- Basin
Source of Energy

Figure 18. Primary energy consumption by fuel in the Reference case, 1980-2040 (quadrillion Btu)

Source: EIA Annual Energy Outlook 2015
Natural Gas Market Outlook

Most natural gas production growth is expected from shale gas and tight oil plays.

With rising domestic production, the United States become a net exporter of natural gas.

[Graph showing U.S. natural gas production by source, 1990-2040, with projections for 2035 showing a net export of 5% and domestic production exceeding consumption.]
“Energy imports and exports come into balance around 2028 (although liquid fuel imports continue)”

Figure 20. Total energy production and consumption in the Reference case, 1980-2040 (quadrillion Btu)
Major Texas Oil and Gas Fields
Permian: Conventional and Shale

Economides Petroleum Technology, Inc.
Map of the Permian Basin in southeast New Mexico and west Texas showing the multiple stacked producing zones in cross-section. Even after 100 years of production, the Permian Basin is producing more oil and gas than ever, thanks to new technologies and strategies.
East Texas Field
PLANT & ANIMAL LIFE FROM RIVER

PLANKTON MINUTE PLANT & ANIMAL LIFE

PLANT & ANIMAL GROWTH ON SEA BOTTOM
Reservoir Dynamics

1. Dissolved Gas Drive
2. Gas Cap Drive
3. Water Drive

Public Policy is best promoted when:

1. Production is maintained at a controlled rate
2. Proper location of wells
Gas Cap / Water Drive
Figure 6-7. Very large but non-artesian associated aquifer-edge water drive reservoir.
Permeability

• Ability of a rock to transmit fluid
  – Units are in length squared (sq. feet, sq. meters, etc.)
  – Since those units will result in small numbers, millidarcies (md) are the standard unit for permeability
Permeability
Permeability
1. Injection of gas or water is used to drive oil away from injection well and towards the producing stripper well

2. Enhanced Oil Recovery involves either thermal processes; carbon dioxide flooding; or chemical flooding.
Secondary Recovery: Thermal Recovery

Thermal Recovery is accomplished either by hot fluid injection (hot water or steam) or in situ combustion (burning a part of the crude oil in place). Variations of these methods improve production of crudes by heating them, thereby improving their mobility and ease of recovery by fluid injection.

The diagram illustrates the process of thermal recovery, including:
- Stack Gas Scrubber
- Steam Generator
- Injection Well
- Chemical Pump
- Production Well

The process illustrated here is Steamflooding with Chemical Additives to reduce channeling.
Secondary Recovery: CO$_2$ Injection

MISCIBLE RECOVERY

Recovery methods in this category include both hydrocarbon and non-hydrocarbon miscible flooding. These methods involve the injection of gases (carbon dioxide, nitrogen, flue gases, etc.) that either are or become miscible (mixable) with oil under reservoir conditions. This reaction lowers the resistance of oil to flow through a reservoir, making it more easily produced, either by water drive or injected gas pressure.

This drawing illustrates the alternate CO$_2$ and water injection (WAG) method of oil recovery.
Secondary Recovery: Water Flush
The Mineral Estate “Bundle” consists of the following *Attributes or Incidents*:

1. Right to use the surface
   - Surface Easement: defined by common law accommodation doctrine, or express language in deed and some statutes
   - Mineral Estate is dominate

2. Right to develop
   - Mineral Estate is a cost-bearing interest
   - Incur the cost of self-developing

3. Right to alienate or convey (lease)
   - The Executive Right: the right to execute an oil and gas lease
   - The right comes with duties to non-executives

4. Right to share in lease benefits
   - Bonus
   - Delay Rentals
   - Shut-in Royalties
   - Land-owner’s Royalty (fractional amount of production or proceeds from sale of production)
Example: Jill conveys an undivided $\frac{1}{2}$ mineral interest to Jack but reserves all executive rights in Blackacre to herself.

Blackacre Title: Jill owns the surface and an undivided $\frac{1}{2}$ mineral interest and all of the executive rights. Jack owns an undivided $\frac{1}{2}$ non-executive mineral interest that is called a non-participating mineral interest. Jack cannot lease or develop Blackacre, but Jack is entitled to $\frac{1}{2}$ of the mineral estate attributes from leasing of the mineral estate.
Non-Participating Royalty Interest

1. Cost free interest
2. No mineral estate attributes (e.g., cannot lease and cannot receive lease benefits)
3. NPRI owner entitled to share of production or proceeds from sale of production
4. NPRI is a vested real property interest in Texas, so there is no Rule of Perpetuities issue with creating this interest.

Example (1): Jill conveys to Jack a 1/16th royalty interest in Blackacre.

Blackacre Title: Jill owns the surface and all of the minerals. Jack owns a 1/16th NPRI. Jill’s mineral estate is burdened by the NPRI. Consequently, when the minerals are leased or otherwise developed, Jack is entitled to 1/16th of the oil and gas or proceeds from the sale of the oil and gas free of cost (or “off the top”).

Example (2): Jill conveys to Jack “1/2 of the royalty reserved in any lease on Blackacre.”

Blackacre Title: Jill owns the surface and all of the minerals. Jill’s mineral estate is burdened by the NPRI. However, this time, when Jill executes an oil and gas lease, Jack is entitled to 1/2 of the royalty reserved in the oil and gas lease. Thus, if Jill executed a lease that reserved for the landowner a 1/8th royalty, then Jack is entitled to ½ of that 1/8th royalty or in other words is entitled to 1/16th of all royalties (i.e., ½ * 1/8th royalty).
**Landowner Royalty:** This royalty is created in an oil and gas lease. The benefits are reserved to the lessor. It has the same attributes as the general royalty interest in that it represents a cost free percentage of production or proceeds from the sale of production (i.e., it is paid “off the top”).

**Example (1):** Jill executes an oil and gas lease with Humble Oil Company and reserves a 1/8th landowner’s royalty interest in Blackacre.

**Blackacre Title:**
- Humble Oil Company: Owns a **Fee Simple Determinable** in the mineral estate. The FSD is a possessory estate in all of the minerals covered by the lease. Humble Oil Company’s estate lasts “so long as oil and gas are produced in paying quantities.” The leasehold interest held by the lessee (Humble Oil Company) is also referred to as the **working interest** because the lessee is the person that generally takes the executive right to work or operate the property.
- Jill: Jill owns a landowner’s royalty that entitles her to 1/8th percentage of production or proceeds from the sale of production free of all cost (“off the top”). Jill also owns a Possibility of Reverter. A Possibility of Reverter is a **vested** non-possessory estate in all of the minerals conveyed by the lease that entitles Jill to all of the mineral estate when the lease ends (i.e., when the FSD expires). Because the possibility of reverter is a **vested** property right, it does not create a Rules Against Perpetuity issue.
Conveyance of Lessee’s Interest in Mineral Estates

**Assignment:** Total or partial transfer of lease. In this situation, the lessee generally reserves an Overriding Royalty Interest. An overriding royalty interest is a royalty that is carved out of the oil and gas lease. This royalty allows the royalty holder to a percentage of production or of the proceeds from the sale of production free of cost (“off the top”).

**Example:** Humble Oil Company assigns to grantee (geologist, oil service company, etc.) the right to 1/16th of all of the oil, gas, and other minerals produced in the lease.

**Blackacre Title:** Humble Oil Company has a fee simple determinable interest in all of the minerals. The landowner has a possibility of reverter and also may be entitled to a landowner’s royalty. The Humble Oil Company’s fee simple determinable interest is burdened by the landowner’s royalty and also is burdened by the overriding royalty.

**Farmout:** An agreement in which lessee agrees to assign the lessee’s interest to the farmee upon farmee’s completion of a “drill and earn” provision.
Example: Jack owns an undivided ½ interest in minerals under Blackacre and Jill owns the other undivided ½. Jack has ½ of bonus and Jill is entitled to ½ of bonus payments. Jill can lease her undivided ½ interest in Blackacre and Jack can lease his undivided ½ interest in Blackacre.

Question: Can Jill lease without joinder of Jack? Yes, one co-tenant can lease without joinder of other cotenants, but Jill or her lessee then has a duty to account to Jack for ½ of the net profits (producer can deduct reasonable cost before accounting proportionately to the non-joined co-tenant).
Royalty

Working Interest

Bonus

Delay Rentals

Term of Lease (primary term)

Royalties to be paid (historically 1/8th but not as much as 1/4th)

Delay Rentals (paid up?) for privilege of deferring drilling
Rule of Capture: Barnard v. Monogahala Natural Gas

1. Facts

2. Discuss Policy Implications
Rule of Capture:

“the owner of a tract of land acquires title to the oil or gas which he produces from wells on his land, though part of the oil or gas may have migrated from adjoining lands. He may thus appropriate the oil and gas that have flowed from adjacent lands without the consent of the owner of those lands and without incurring liability to him for drainage.” This rule is followed in all producing states, whether they have adopted an “ownership in place” theory such as Texas has or have adopted a “non-ownership” approach such as Louisiana and California. The defense to the rule of capture is: the rule of capture. Thus there is a great incentive to drill wells to prevent another party from draining your property and to produce from such wells as rapidly as possible.

- Kramer & Martin, Pooling and Unitization, 1 §2[1]
In the tale, *The Little Red Hen* finds a grain of wheat, and asks for help from the other farmyard animals to plant it. However, no animal will volunteer to help her. At each further stage (harvest, threshing, milling the wheat into flour, and baking the flour into bread), the hen again asks for help from the other animals, but again she gets no assistance.

Finally, the hen has completed her task, and asks who will help her eat the bread. This time, all the previous non-participants eagerly volunteer. However, she declines their help, stating that no one aided her in the preparation work, and eats it with her chicks, leaving none for anyone else.

The moral of this story is that those who show no willingness to contribute to an end product do not deserve to enjoy the end product: "if a man does not work, let him not eat."
Rule of Capture:
Reservoir Dynamics

1. Dissolved Gas Drive
2. Gas Cap Drive
3. Water Drive

Public Policy is best promoted when:

1. Production is maintained at a controlled rate
2. Proper location of wells
Rule of Capture:
Should Drilling Be Done Into the Gas Cap?
Limits on the Rule of Capture:
Lone Stare Gas Co. v. Murchison

1. Facts

2. Discuss Lower Court Holding

3. Discuss Reasoning of the Appellate Court.

Bacon Field
Weekly Natural Gas Storage Report

Working Natural Gas in Storage

EIA Natural Gas Storage Data

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1. Facts

Diamond Jim West sells Blackacre to Exxon, reserving a 1/16 royalty on oil and gas produced from Blackacre. As the natural gas in the reservoir underlying Blackacre nears depletion, Exxon injects gas transported from a distant gas field into the reservoir. Some native gas remains in the reservoir. When Exxon withdraws the gas from the reservoir, West demands a 1/16 royalty on this gas. Does Exxon owe West this 1/16 royalty?

2. Answer?
1. Facts

2. Discuss Hammons Holding

For the same ‘sound and logical reason, especially in light of advanced knowledge and scientific achievement in the oil and gas industry . . . ‘ this Court is of the opinion that it is time to limit *Hammond* and to now hold that natural gas once converted to personal property by extraction remains personal property notwithstanding its subsequent storage in underground reservoirs with confinement integrity.

3. Discuss Holding.
Elliff v. Texon Drilling Co., 210 S.W. 2d at 582:

1. Facts

2. Plaintiff’s theory

3. Court reasoning

- $13.096 \text{ BCF}$
- $57.625 \text{ BCF}$

- $(W 1500 \text{ E 1554.49})$
- $466’$

- $1/8^{th}$
- $1/16^{th}$

- Driscoll-Servier No. 2
- Eliff No. 1
Limits on the Rule of Capture: Correlative Rights and Negligence

Elliff v. Texon Drilling Co., 210 S.W. 2d at 582:

[N]otwithstanding the fact that oil and gas beneath the surface are subject both to capture and administrative regulation, the fundamental rule of absolute ownership of the minerals in place is not affected in our state. In recognition of such ownership, our courts, in decisions involving well-spacing regulations of our Railroad Commission, have frequently announced the sound view that each landowner should be afforded the opportunity to produce his fair share of the recoverable oil and gas beneath his land, which is but another way of recognizing the existence of correlative rights between the various landowners over a common reservoir of oil or gas. It must be conceded that under the law of capture there is no liability for reasonable and legitimate drainage from the common pool. The landowner is privileged to sink as many wells as he desires upon his tract of land and extract therefrom and appropriate all the oil and gas that he may produce, so long as he operates within the spirit and purpose of conservation statutes and orders of the Railroad Commission. These laws and regulations are designed to afford each owner a reasonable opportunity to produce his proportionate part of the oil and gas from the entire pool and to prevent operating practices injurious to the common reservoir. In this manner, if all operators exercise the same degree of skill and diligence, each owner will recover in most instances his fair share of the oil and gas. This reasonable opportunity to produce his fair share of the oil and gas is the landowner’s common law right under our theory of absolute ownership of the minerals in place. But from the very nature of this theory the right of each landholder is qualified, and is limited to legitimate operations. Each owner whose land overlies the basin has a like interest, and each must of necessity exercise his right with some regard to the rights of others. No owner should be permitted to carry on his operations in reckless or lawless irresponsibility, but must submit to such limitations as are necessary to enable each to get his own.
Limits on the Rule of Capture: Correlative Rights and Nusuanace

*People’s Gas Co. v. Tyner*, 310 N.E. 59:

1. Facts
2. Court reasoning
Limits on the Rule of Capture: Correlative Rights and Waste

*United Carbon Co. v. Campbellsville Gas Co.*, 118 S.W. 2d 1110:

1. Facts
2. Court reasoning
Phillips Petroleum Co. v. American Trading and Production Corp., 361 S.W. 2d 942:

1. Facts

2. Court reasoning


**Limits on the Rule of Capture: Correlative Rights and Illegal Production**

*Wronski v. Sun Oil Co.*, 279 N. W. 2d 564:

1. Facts

2. Court reasoning
**Browning Oil v. Luecke.**, 38 S.W. 3d 625:

1. **Facts**

2. Court reasoning: The better remedy is to allow the offended lessors to recover royalties as specified in the lease, compelling a determination of what portion can be attributed to their tracts with reasonable probability. The Lueckes are entitled to the royalties for which they contracted, no more and no less.
Unanswered Question: How Do we calculate production from a particular tract?

Horizontal Well Diagram #1
(Overview of a Horizontal Well)

A

Kick-Off Point

B

Deviated Drilling
Penetration Point

C

Horizontal Drilling
Terminus

Correlative Interval

“Take-Points” (Perforations)

Horizontal Drainhole Displacement