BOLD MOVES
BIG FUTURE

Chesapeake ENERGY

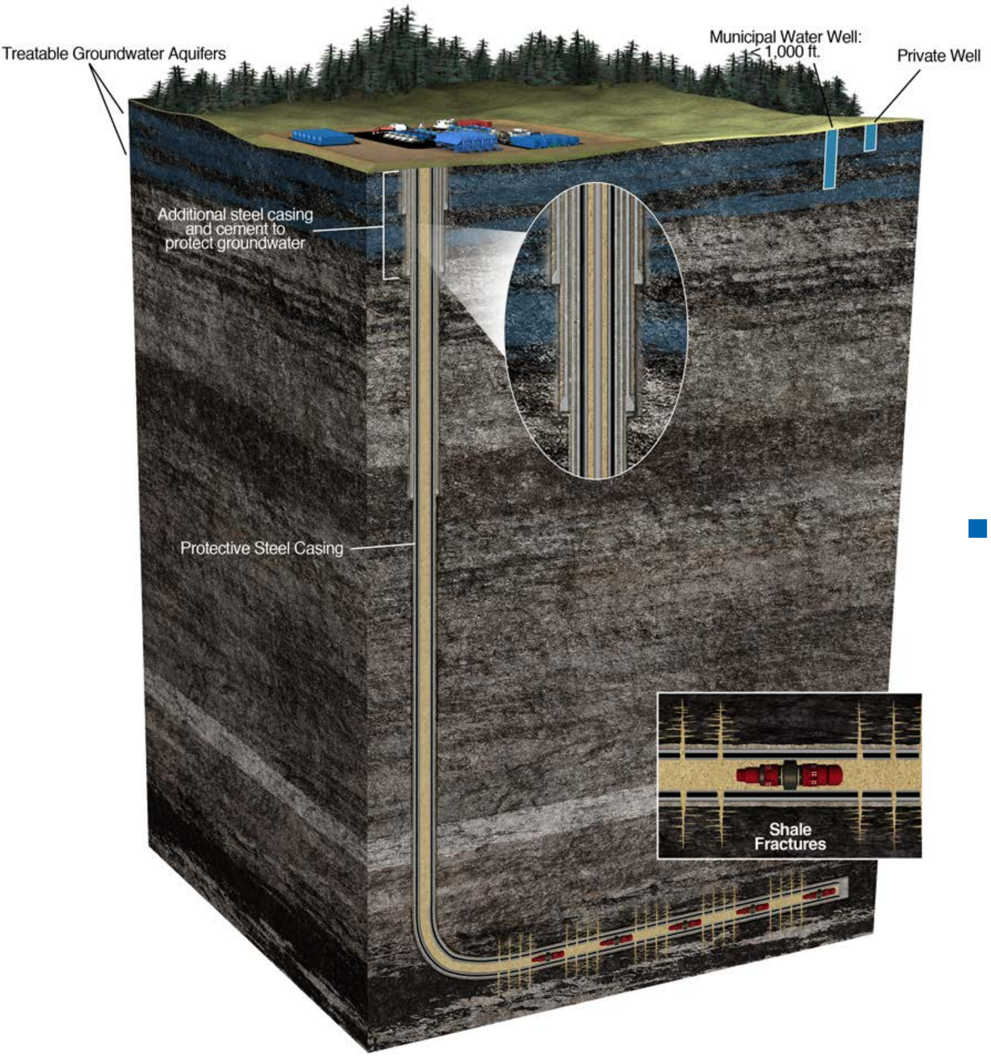
HYDRAULIC FRACTURING OPERATIONS AND TECHNOLOGY

LSU CES – GULF STATES ENERGY RETREAT
JUNE 20, 2012

BRIEF HISTORY OF FRAC'ING

- **Predecessor technologies**
  - Nitroglycerin treatments (1860s)
  - High pressure acidizing (1930s)
- **Introduction of proppant – 1947**
  - Hydraulic propped fracture process patented (1949)
- **Widespread application in vertical wells (1950s – 80s)**
  - Evolution in fluid technologies – acids, oils, water, gels, foams
  - First 500,000 lb frac job (1968)
- **Horizontal drilling becomes economically viable in 1980s**
  - Hydraulic fracturing applied to horizontal wells by early 1990s
- **Horizontal drilling and fracturing applied to shale resources: Barnett Shale in 2003.**

CURRENT STATE OF THE ART



- **Horizontal Drilling**
  - Process begins just as with a vertical well
  - Exposes significantly more reservoir rock to well bore surface (3000’-8000’)
  - Fewer wells drilled to access same reservoir volume
- **Multi-stage Fracturing**
  - Many fractures along lateral
  - Isolation between frac stages focuses energy to each section of the wellbore
  - Pre-installed ports or shaped-charge perforations can provide multiple points of fracture initiation in each stage

CHK HYDRAULIC FRAC'ING FACTS - 2011

- **1,493 Wells Hydraulically Fractured in 2011**
  - 16,903 Stages
- **7,193,434' of Lateral Treated (or 1,362.4 miles)**
  - The distance between Oklahoma City to New York City is 1,370 miles (straight line)
- **Water Used: 6.627 Billion Gallons**
  - 6,397,700,000 Gallons of Fresh Water (96.5%)
  - 229,300,000 Gallons of Recycled Water (3.5%)
- **Proppant Used: 7.367 Billion Pounds (3.68 million tons)**
  - Equivalent to the total mass of 10 Empire State Buildings.
- **Average Fluid and Proppant Per Well:**
  - 4.44 Million Gallons
  - 4,934,000 lbs. of Proppant

RAW FUEL SOURCE WATER EFFICIENCY

Energy resource	Range of gallons of water used per MMBtu of energy produced
Conventional (vertical) natural gas	**1 – 3**
Chesapeake deep shale natural gas *	**0.84 – 3.32**
Coal (no slurry transport) (with slurry transport)	2 – 8 13 – 32
Nuclear (processed uranium ready to use in plant)	8 – 14
Conventional (vertical) oil	**8 – 20**
Chesapeake deep shale / tight sand oil **	**8.15 – 20.13**
Synfuel - coal gasification	11 – 26
Oil shale petroleum	22 – 56
Oil sands petroleum	27 – 68
Synfuel - Fisher Tropsch (Coal)	41 – 60
Enhanced oil recovery (EOR)	21 – 2,500
Biofuels (Irrigated Corn Ethanol, Irrigated Soy Biodiesel)	**> 2,500**

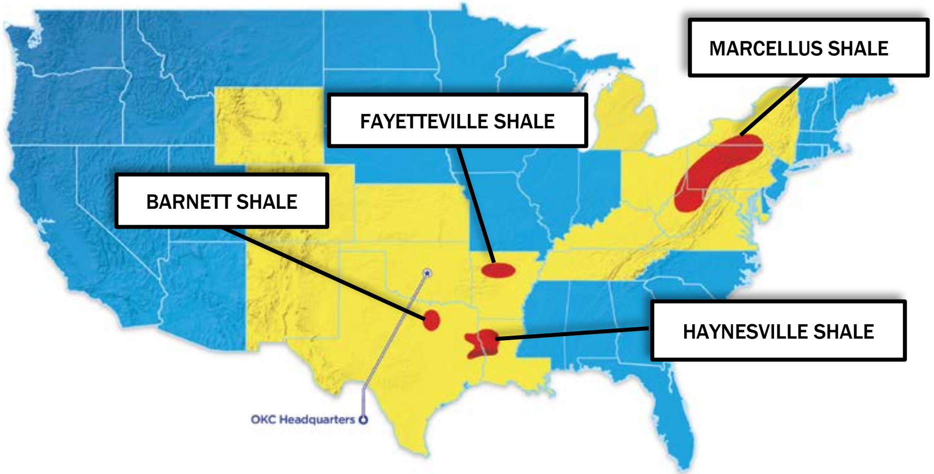
Source: USDOE 2006 (other than CHK data)
*Includes processing which can add 0 - 2 gallons per MMBtu
**Includes refining which consumes major portion (90%) of water needed (7-18 gal per MMBtu)
Solar and wind not included in table (require virtually no water for processing)
Values in table are location independent (domestically produced fuels are more water efficient than imported fuels)

AIR & WATER ISSUES DRIVE REGULATION

<u>Factors driving those regulations are *exceedingly* local:</u>

- Water required and abundance/scarcity of surface water
- Alternative sources and competing uses
- Groundwater characteristics and local geology
- Produced water characteristics and cost to process for reuse
- Availability of subsurface disposal zones
- Pre-existing mining and extraction activity
- Transportation and road use
- Environmental sensitivity and protection
- Proximity to population centers and public exposure
- Other industrial activity and local economic objectives

VARIETY IN GAS SHALE PLAYS



	Haynesville	Marcellus	Barnett	Fayetteville
Dominant Lithology	Calcareous Mudstone	Argillaceous Mudstone	Siliceous Mudstone	Siliceous Mudstone
Brittle/Ductile	Ductile	Moderate	Brittle	Moderate
Natural Fractures	Absent	Present	Present	Present
Depth TVD	10,000' - 13,500'	1,500' - 8,000'	5,400' - 9,600'	1,200' - 7,500'
Thickness (net)	150' - 350'	75' – 300'	250 - 500'	50' - 200'
Average log porosity	10%	6%	7%	6.5%
Pressure (psi/foot)	0.84	0.61	0.46	0.42
Gas-in-place (bcfe/section)	190	130	65	55
Anticipated recovery factor	28%	30%	40%	38%
Avg. EUR/horizontal well (bcfe)	6.5	5.25	3.0	2.6
Targeted avg. IP rate	14.1	4.1	3.1	2.3

CHEMICAL BLEND DICTATED BY LOCAL ROCK AND FLUID PROPERTIES

Additive	Barnett	Haynesville	Marcellus	Eagle Ford	Utica	Granite/ Colony Wash
Friction Reducer	✓	✓	✓	✓	✓	✓
Biocide	✓	✓	✓	✓	✓	✓
KCl Substitute				✓	✓	✓
Scale Inhibitor	✓	✓	✓		✓	
Surfactant			Occasional	✓	✓	✓
Non-Emulsifier				✓	✓	✓
Gel	Occasional	✓	Occasional	✓	✓	✓
Cross-linker		✓		✓	✓	
Breaker	Occasional	✓	Occasional	✓	✓	✓
Hydrochloric Acid	✓	✓	✓	✓	✓	Occasional
Corrosion Inhibitor	✓	✓	✓	✓	✓	Occasional
Iron Control	✓	✓	✓	✓	✓	Occasional

NEW TECHNOLOGY #1 – 'GREEN' ADDITIVES

- Concerns about toxicity of frac fluids fueling interest in "green" frac additives
- Major frac providers marketing under a variety of names: "CleanStim"… "OpenFrac"… "Green Line"… "SmartCare"
- Major concerns are concentrations required for equivalent effectiveness, and cost/benefit balance for each additive
- Due to inconsistencies on definitions of "greenness", Chesapeake embarked on our own evaluation… GreenFrac®

GreenFrac®

Chesapeake ENERGY

- **Initiated in 2009**
- **Primary Drivers:**
  - Minimize Risk of Exposure To Workers During Hydraulic Fracturing Activities
  - Minimize Environmental Impact of Surface Spills
- **Evaluate – Eliminate – Replace**

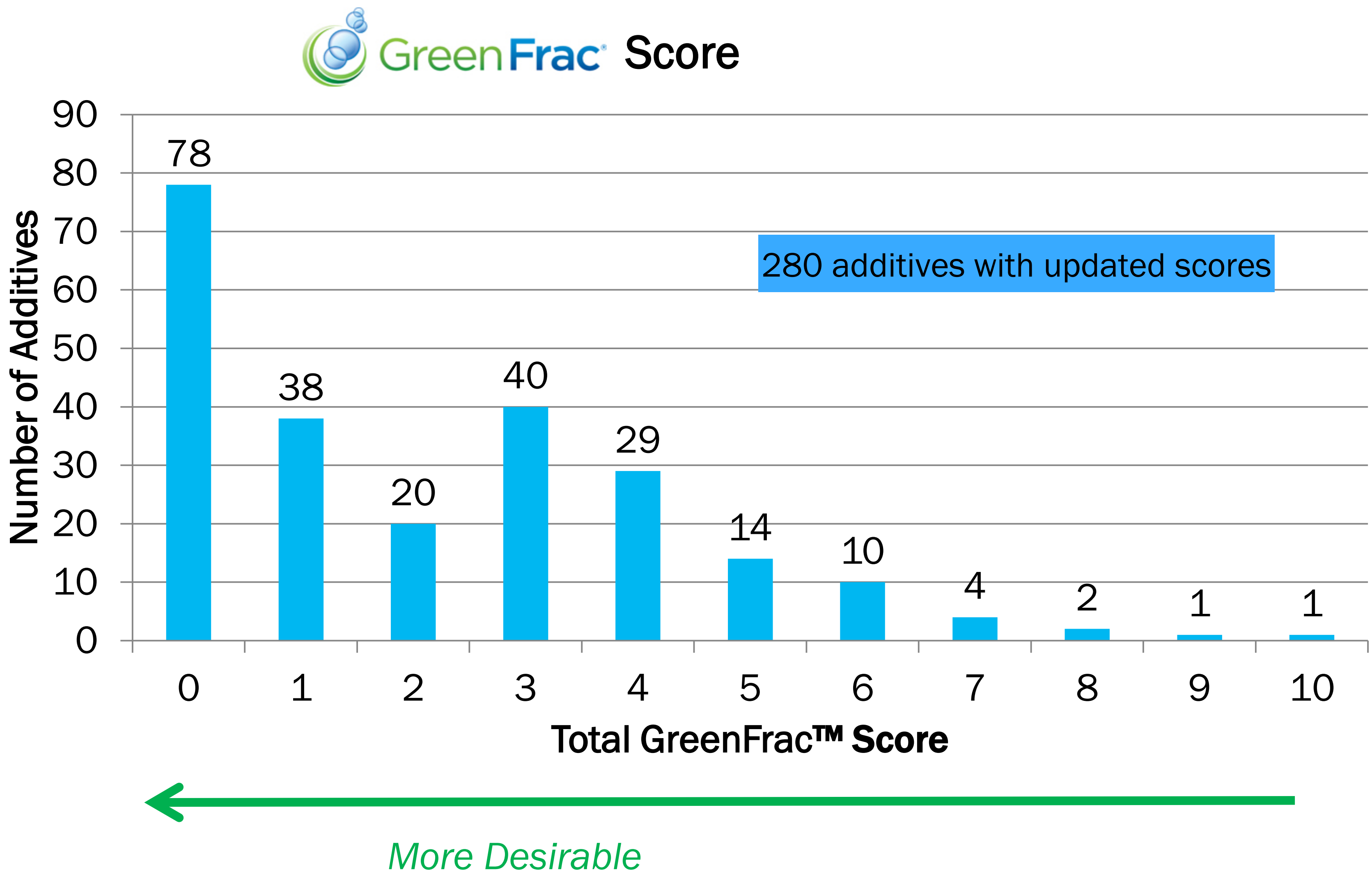
Establish Chesapeake "Green" Chemistry Definition

- **Poll Fracturing Additive Suppliers Regarding Similar Activities**
  - Pressure Pumping Companies
  - Specialty Chemical Suppliers
- **Research U.S. Regulations**
  - EPA, CERCLA, SARA
  - CWA, SDWA
  - U.N. Hazard Classification
- **Research International Regulations**
  - OSPAR
  - CEFAS
  - U.N. GHS
  - OECD
- **Research NGO Concerns**
  - The Endocrine Society
  - TEDX

14 criteria for Chesapeake GreenFrac scorecard

- Extremely Hazardous Substance per Section 302 of the EPCRA
- Toxic Chemical per Section 302 of the EPCRA
- Priority Pollutant per Clean Water Act
- Persistent Bioaccumulative Toxin per EPA
- Known carcinogen per International Agency on the Research of Cancer, the US EPA (Group A and B1) or the National Toxicology Program
- "Toxic" or "Environmentally Hazardous Substance" in DOT hazard description
- Biodegradability
- Bioaccumulation
- Toxicity
- Regulated Contaminants under the Safe Drinking Water Act
- Hazardous Air Pollutant by the EPA
- Confirmed endocrine disruptor by The Endocrine Society, the National Institute for Environmental Health and the International Programme on Chemical Safety
- Developmental or reproductive toxin per California Proposition 65
- Delayed (Chronic) Health Hazard

FRAC ADDITIVE EVALUATION



NEW TECHNOLOGY #2 – LPG FRACTURING, OR "GASFRAC"

- **Pros**:
  - Uses no water, potential driver in areas of scarcity
  - Propane is an ideal fluid for water sensitive formations
  - Potential to capture and sell the propane.
  - No polymer residue
  - Readily flows back

- **Cons**:
  - Safety !!!!
  - Increased costs due to materials and poor logistics and efficiency
  - Limits treatment to 200,000 lbs. per stage at 60 BPM
  - A loss in hydrostatic compared to water, resulting in higher surface pressures.
  - Flowback and capture of propane is difficult and poses safety concerns
  - Drillout is typically more difficult.
  - Pump down and clean-out fluids are much more costly and troublesome

SUMMARY

- Hydraulic Fracturing is a well-established technology that can be and has been performed with a wide variety of techniques and materials
- The combination of hydraulic fracturing with horizontal drilling has been the groundbreaking event in Unconventional Oil and Gas development
- If there is anything new about current oil and gas operations, it is in their increased scale and their location, as these widely distributed shale resources are being developed in areas with little or no recent oilfield activity
- Local factors dominate the main points of discussion around unconventional oil and gas development
- New technologies on the horizon may offer incremental benefits to current practice, but costs and benefits still must be balanced