UNCONVENTIONAL RESOURCES

TAKING ON THE WORLD'S TOUGHEST ENERGY CHALLENGES

Unconventional Resources: Turning Conventional Paradigms Upside Down

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ExxonMobil

Outline

- Definitions
- Historical Context and Importance
- What's Unconventional About Unconventional Resources?
- Challenges
- Pace of Discovery, Production and Innovation
- Outlook

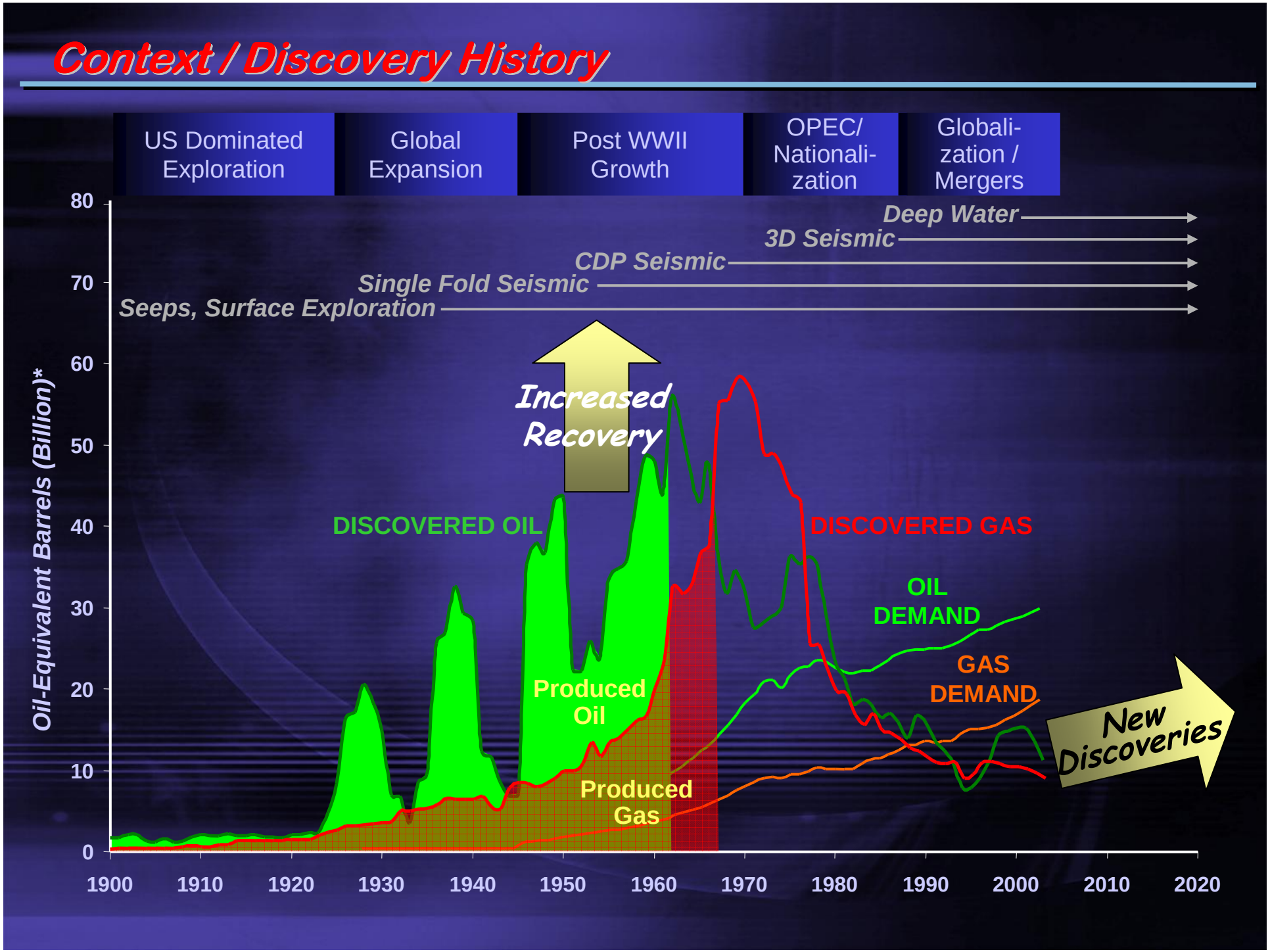
Definitions

- **un·con·ven·tion·al** [uhn-k*uh* n-ven-sh*uh-n*] : **not conforming to existing rule**
- **un·con·ven·tion·al re·source** [uhn-k*uh* n-ven-sh*uh-n*/ **ree-sawrs, -sohrs, -zawrs, -zohrs, ri-sawrs, -sohrs, -zawrs, -zohrs**]: an oil and gas resource **not bound by or conforming to conventional geologic rule or precedent**

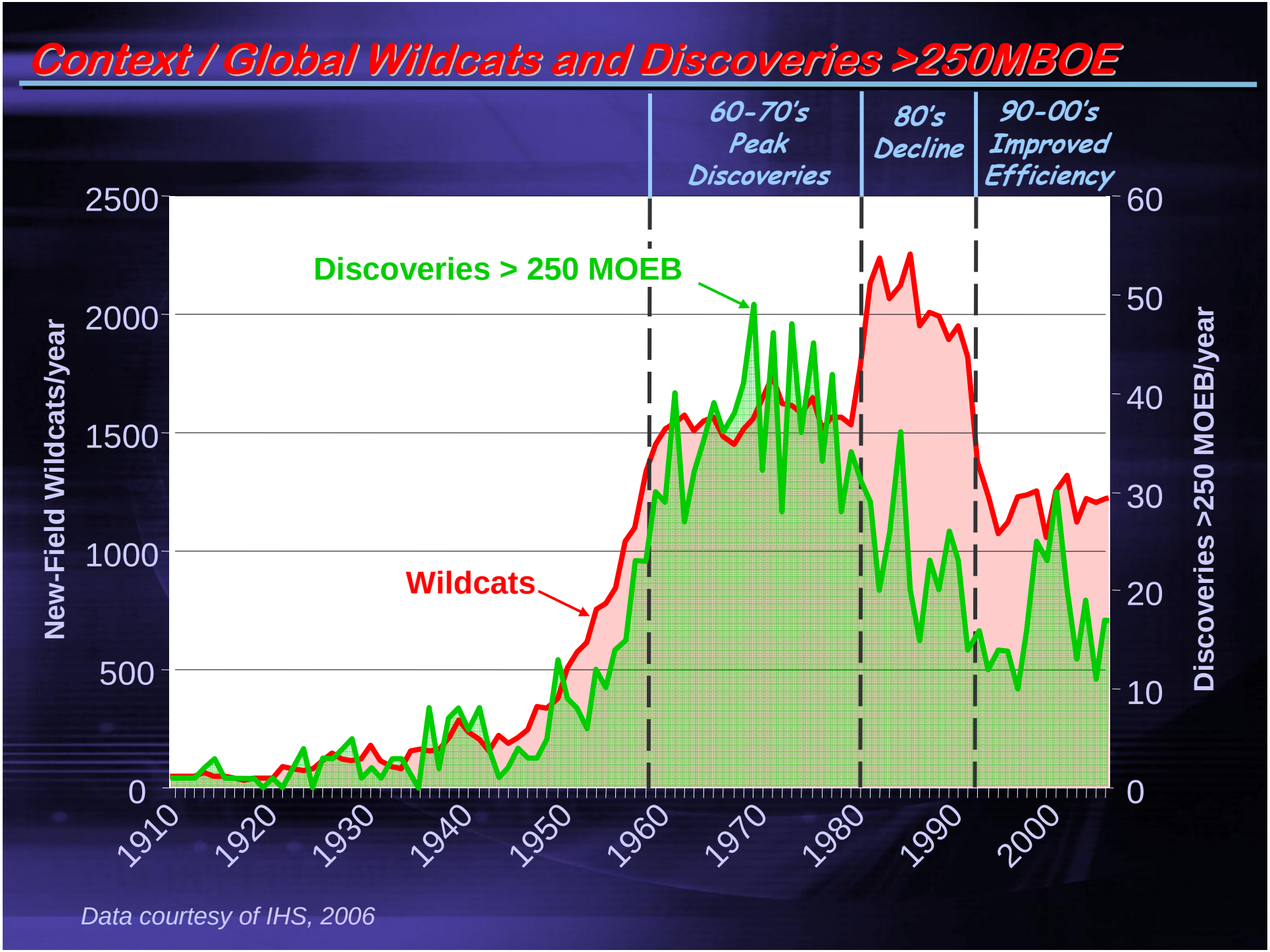
  - Stubborn rocks (low permeability)
    - e.g. tight gas (TG), shale gas (SG)
    - require physical stimulation (fracturing)
  - Stubborn "fluids" (high viscosity to solid kerogen)
    - e.g. heavy oil (HO), oil shale (OS)
    - require thermal stimulation

➔ *Technology-leveraged resources*
➔ *Stimulation to achieve commercial production*

Context / Discovery History

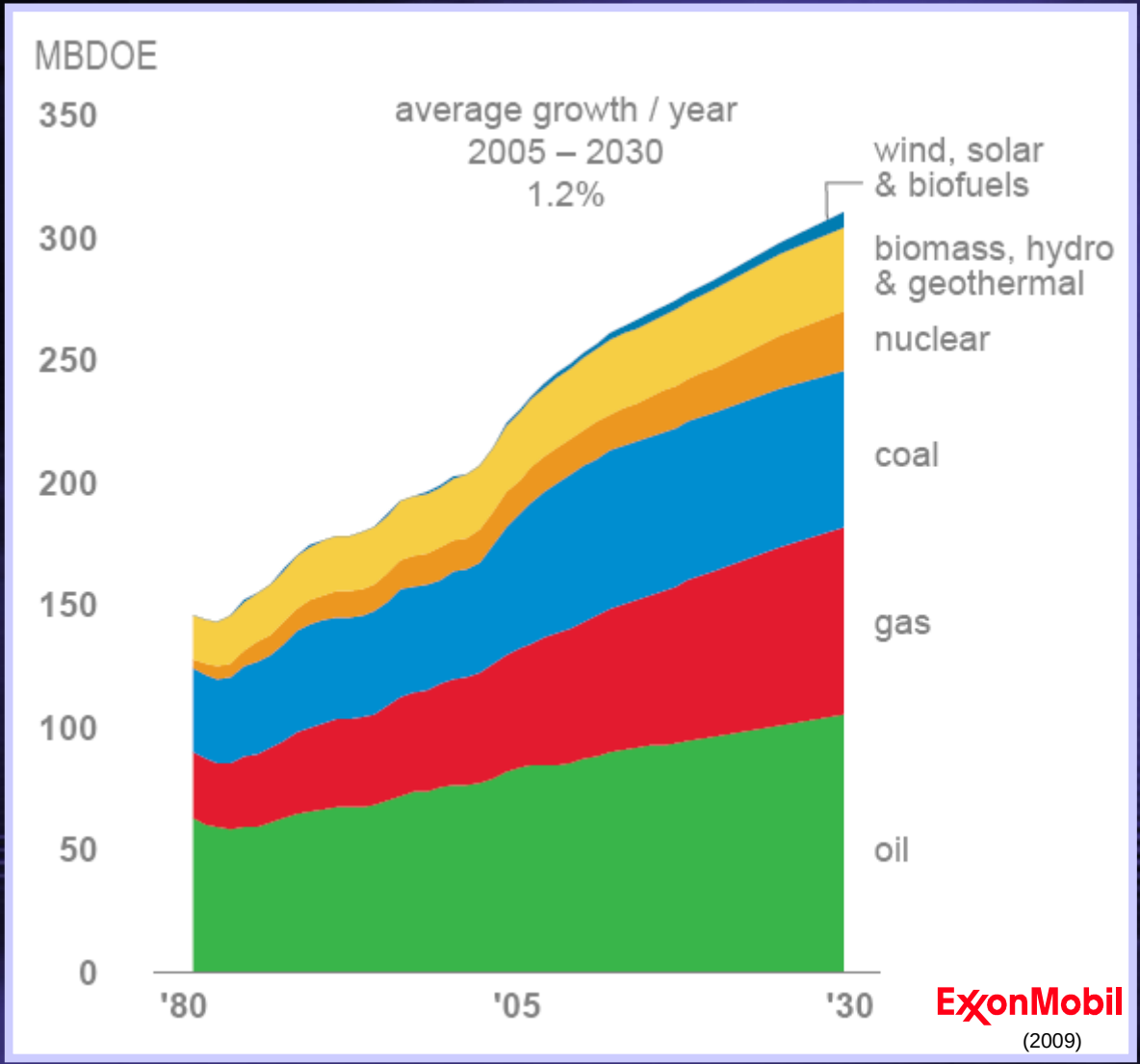


Context / Global Wildcats and Discoveries >250MBOE



Data courtesy of IHS, 2006

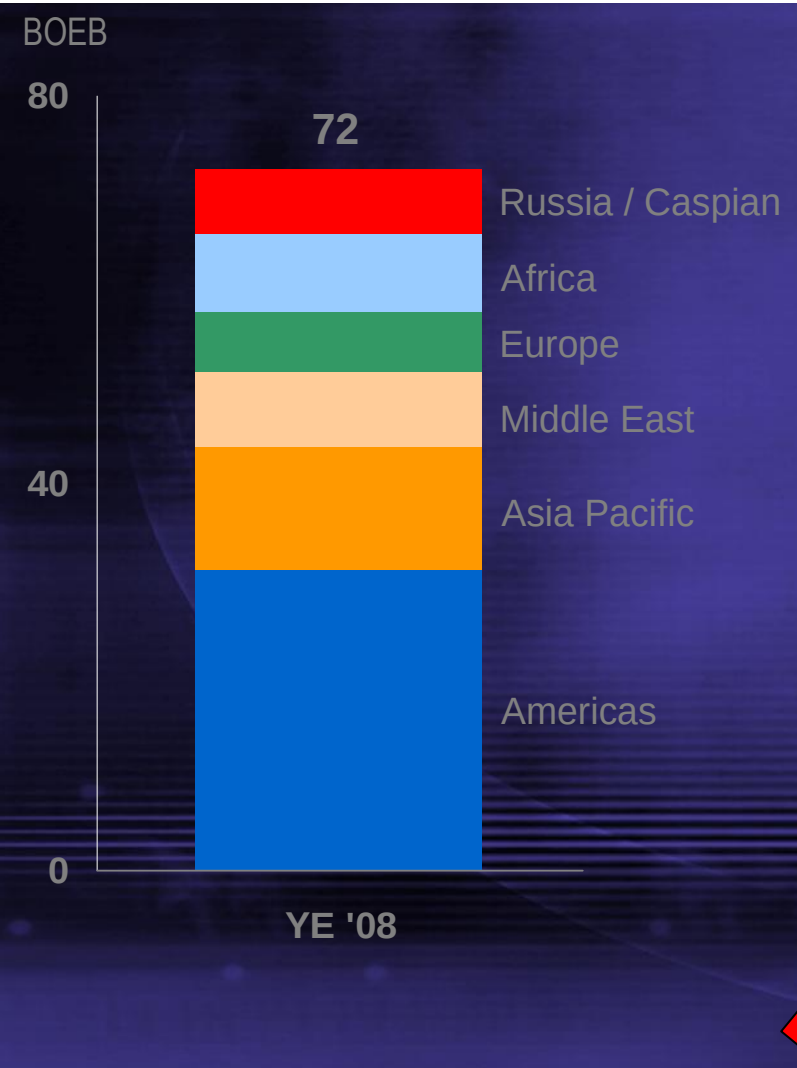
Context / Energy Demand to 2030



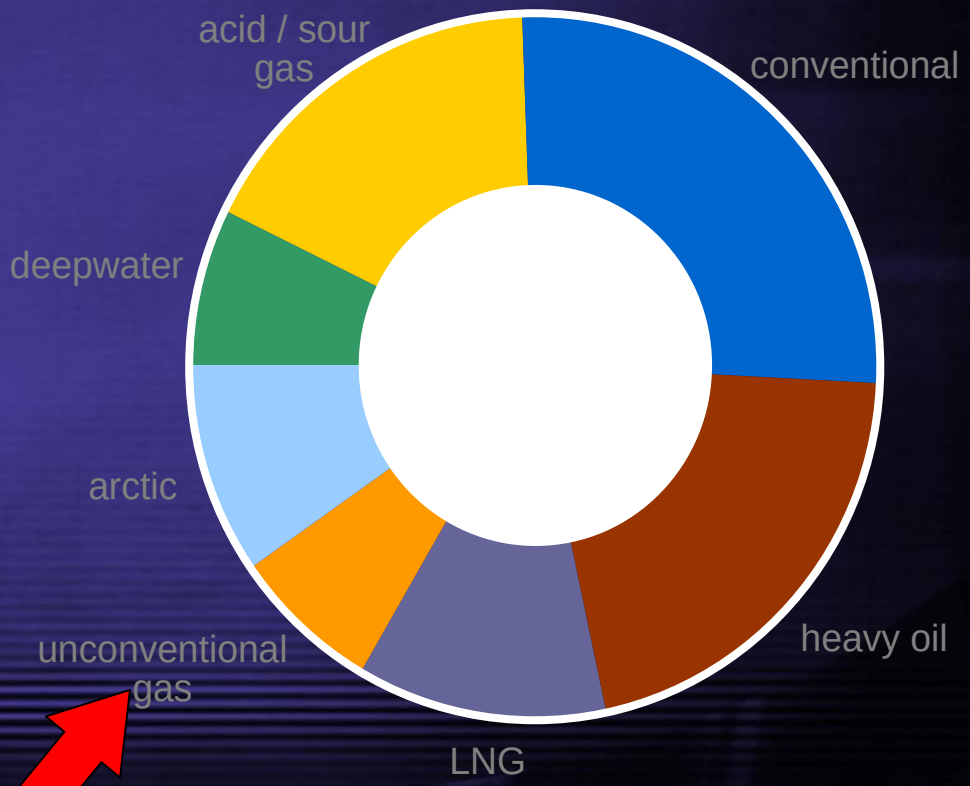
- Economic growth will drive increasing demand for energy
- Oil and gas are indispensable
  - Unconventional oil and gas will be important contributors to our energy future

ExxonMobil Resource Base

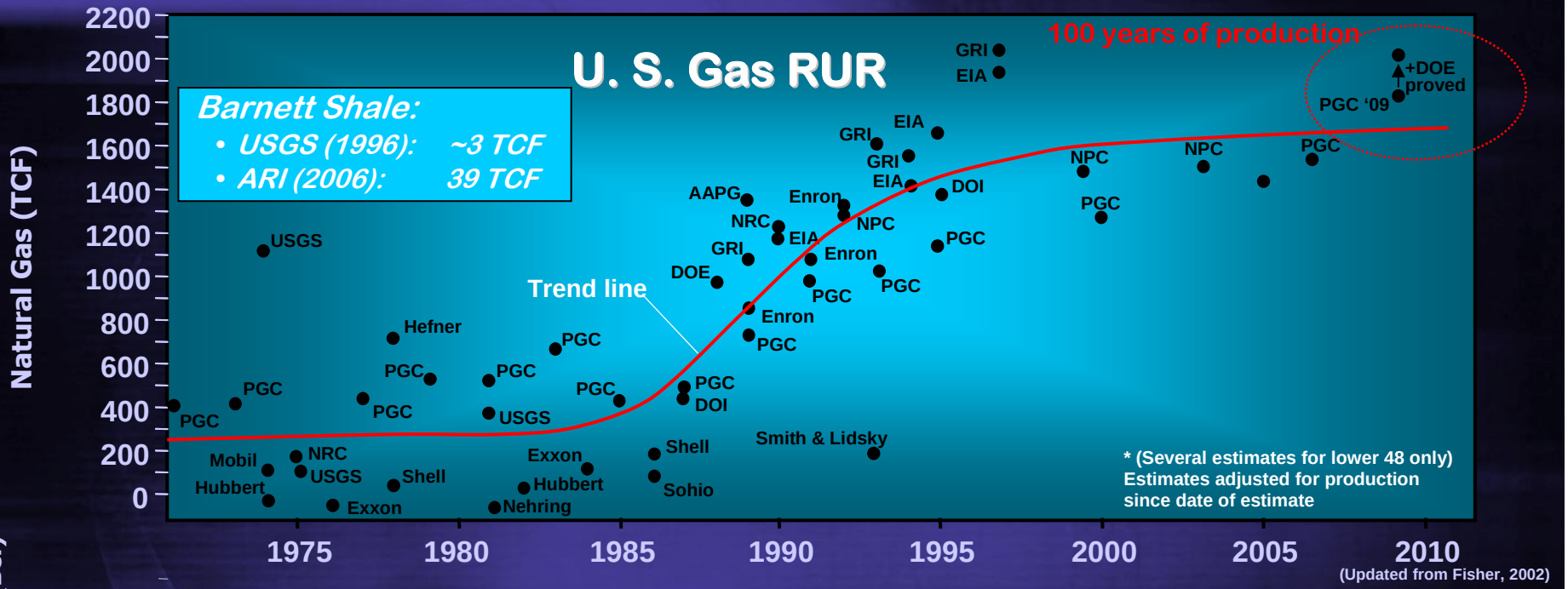
resource distribution

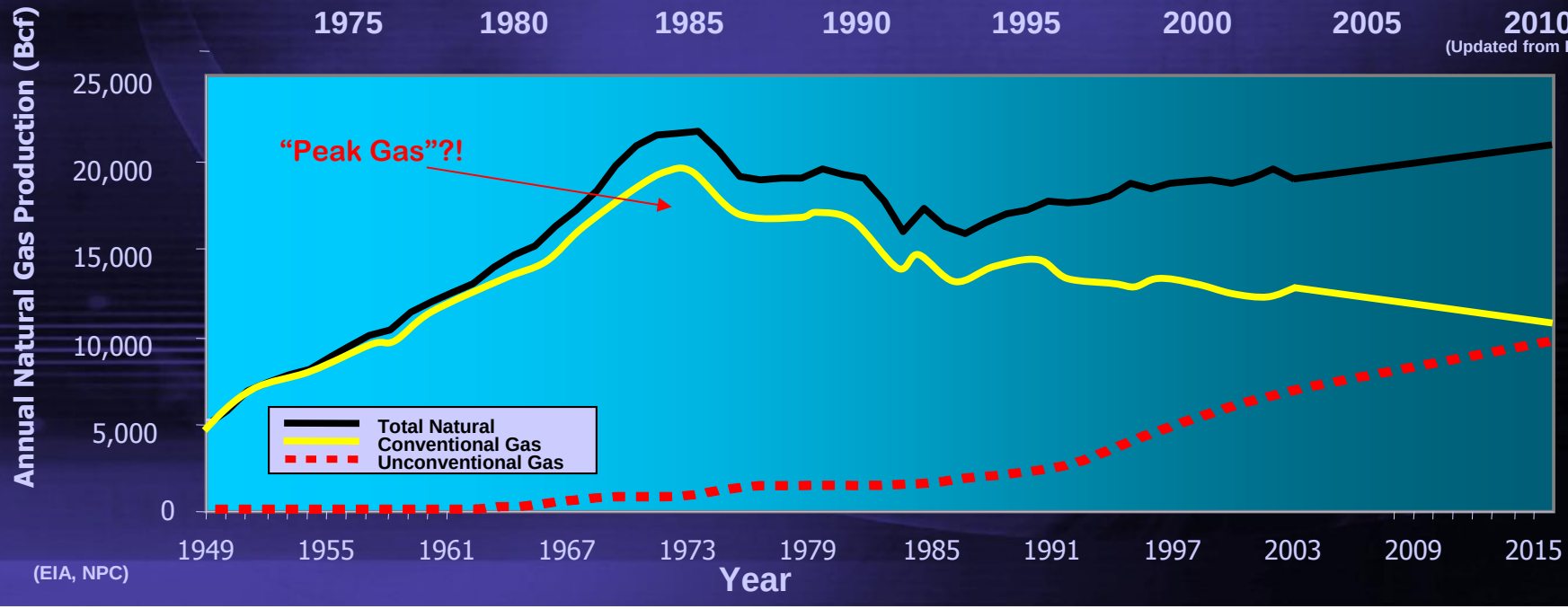


resource type

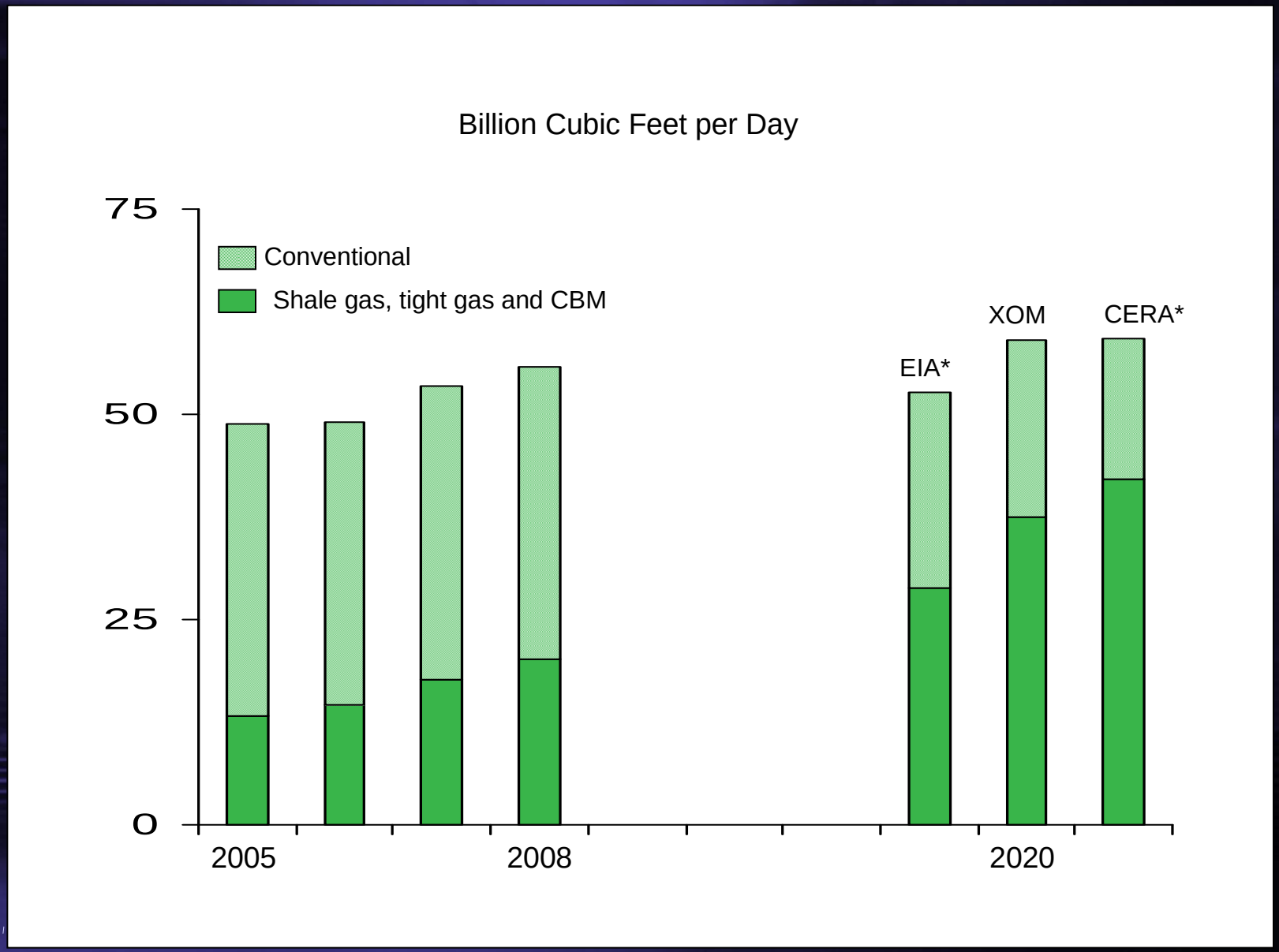


Emergence of Unconventional Gas

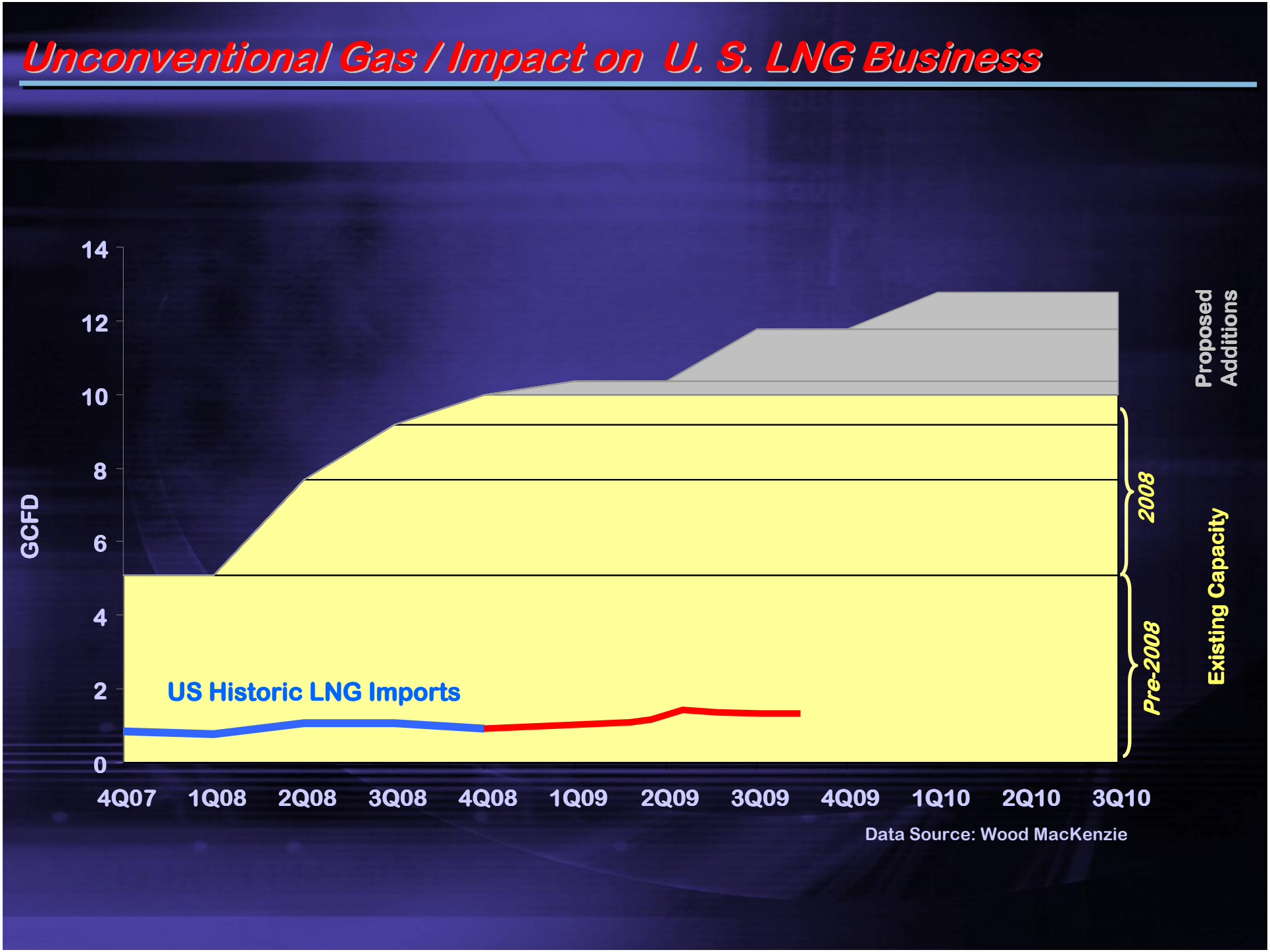




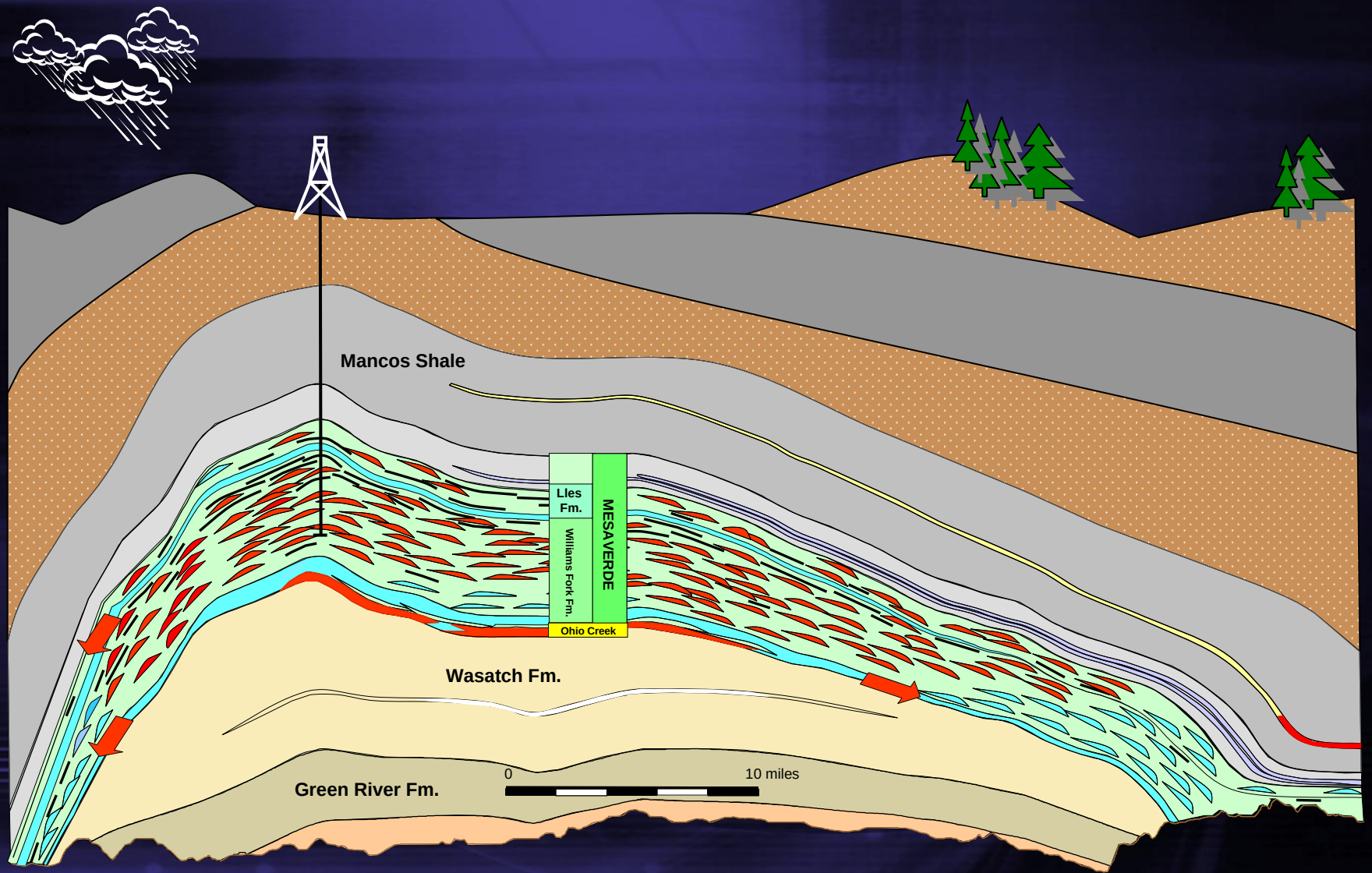
Exxon Mobil Production Outlook



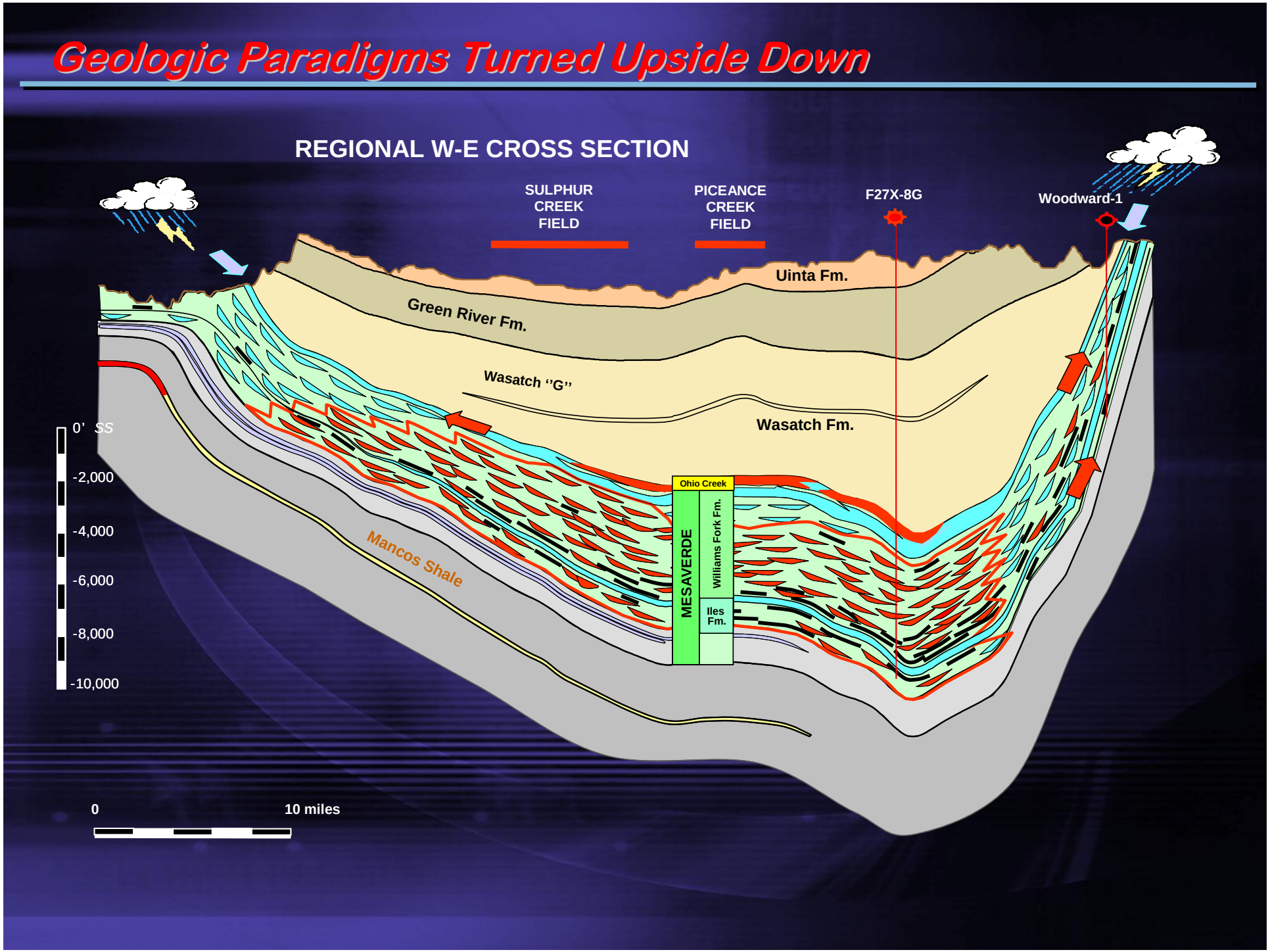
Unconventional Gas / Impact on U. S. LNG Business



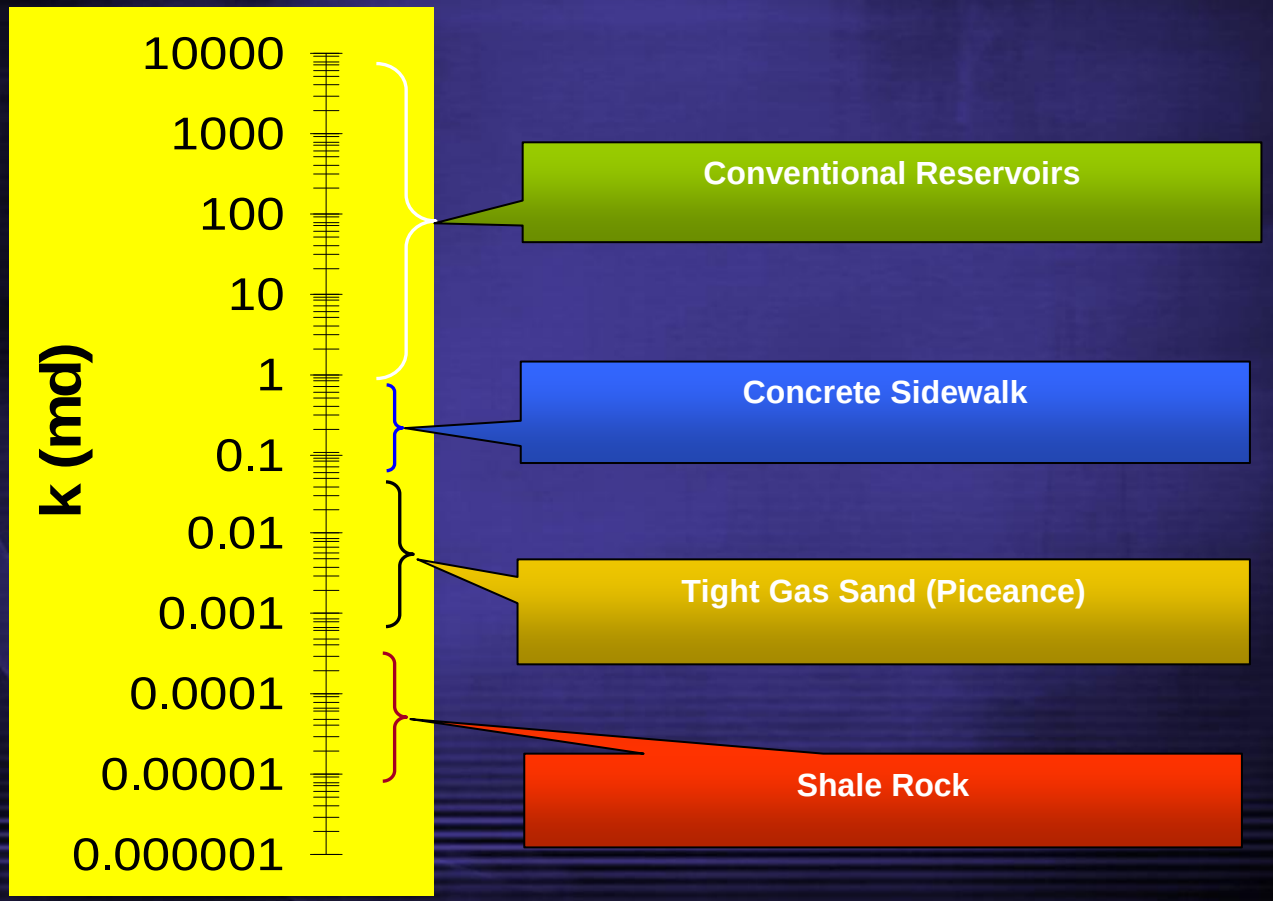
A Conventional Perspective



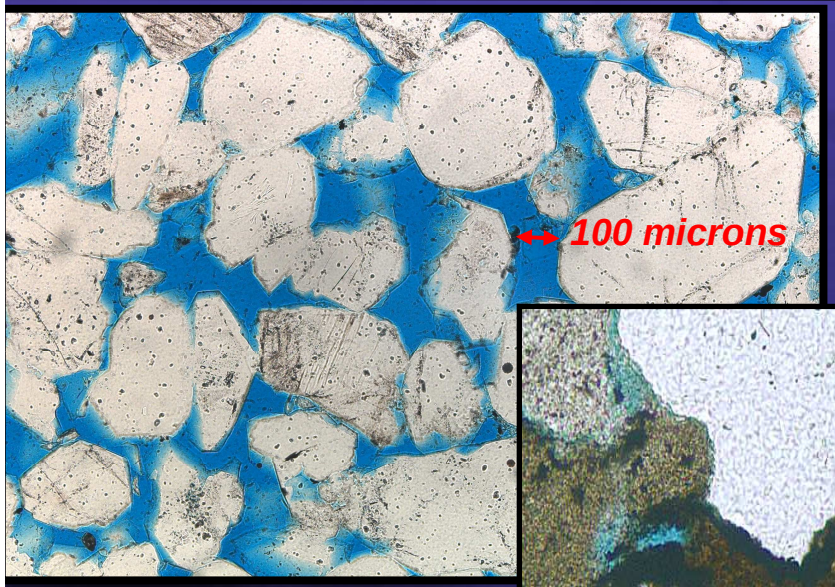
Geologic Paradigms Turned Upside Down



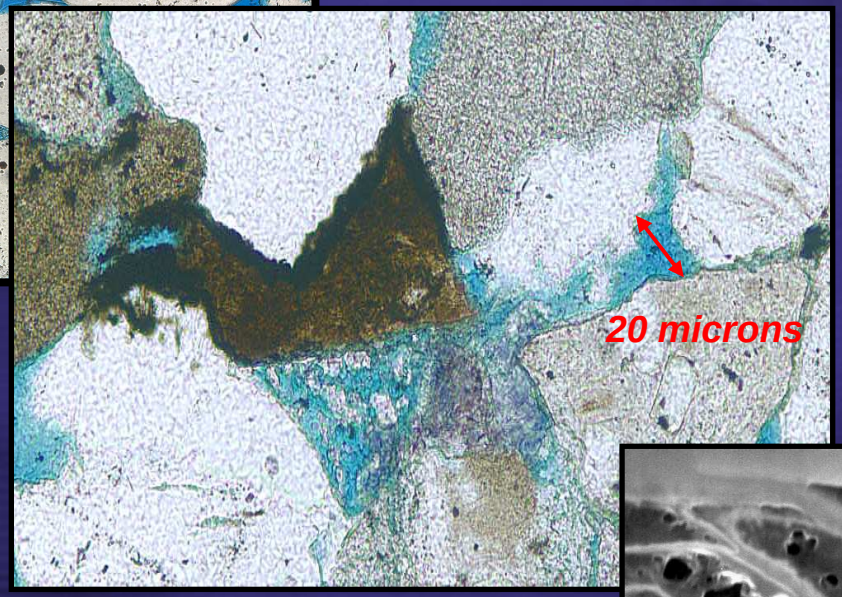
Unconventional Gas Challenges / Permeability



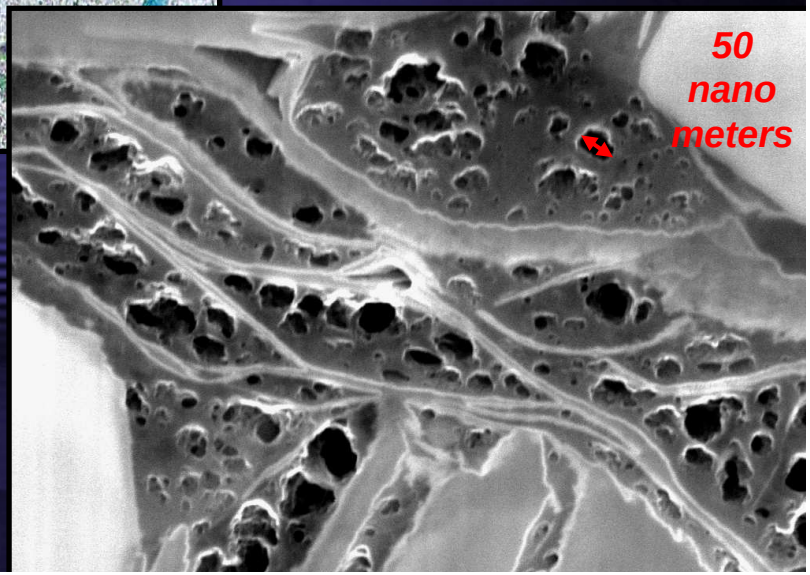
Unconventional Gas Challenges / Porosity



Conventional Gas Pore Space



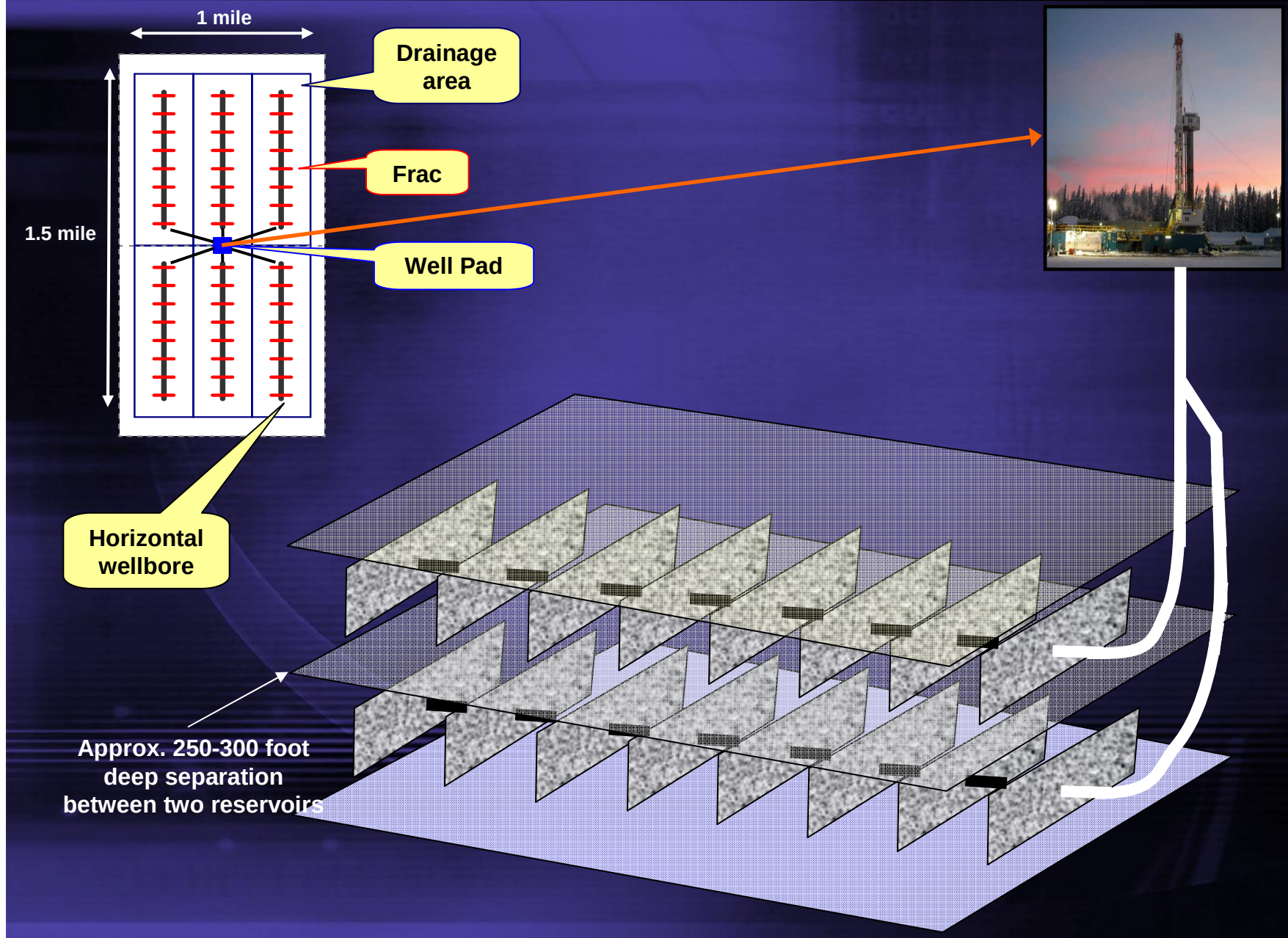
Tight Gas Pore Space



Shale Gas Pore Space

Diameter of average human hair is about 100 microns

Unconventional Gas Challenges / Production



Unconventional Gas Challenges / Level of Investment

Marcellus Shale

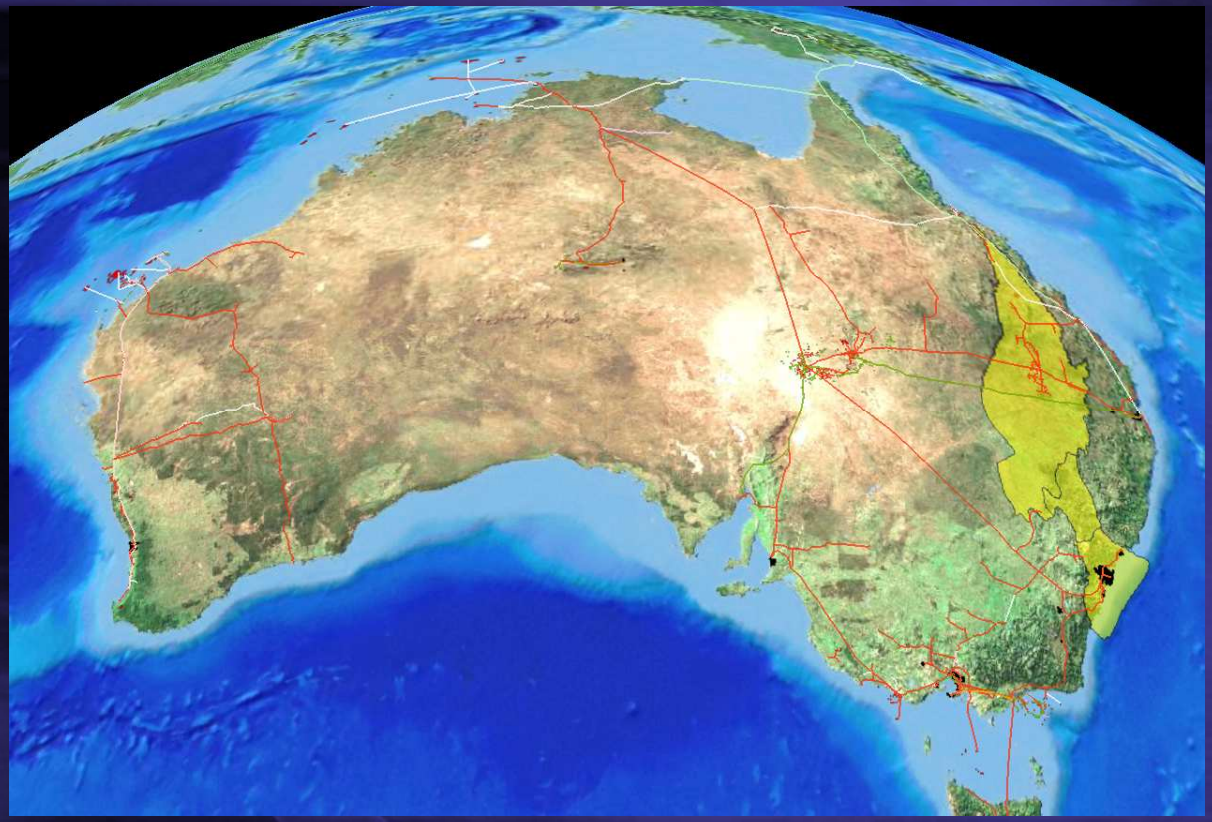
Industry acreage position: >7.5M acres

- **Average well cost: $4.00M**
- **Average EUR: 4 GCF/well**
- **Average well spacing: 80 acres**

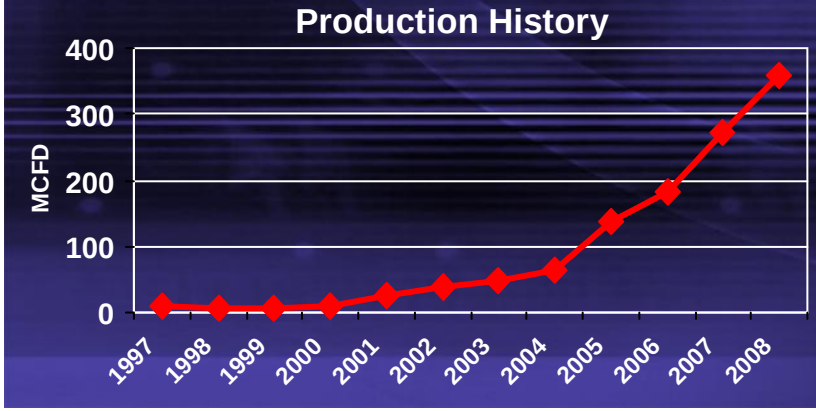
Assume half of the industry acreage might be productive

- **➢~50,000 well locations**
- **➢~190 TCF of gas ultimately produced**
- **➢$190 billion (for drilling and completions only)**

Challenging Unconventional Dogma / Commercial Models

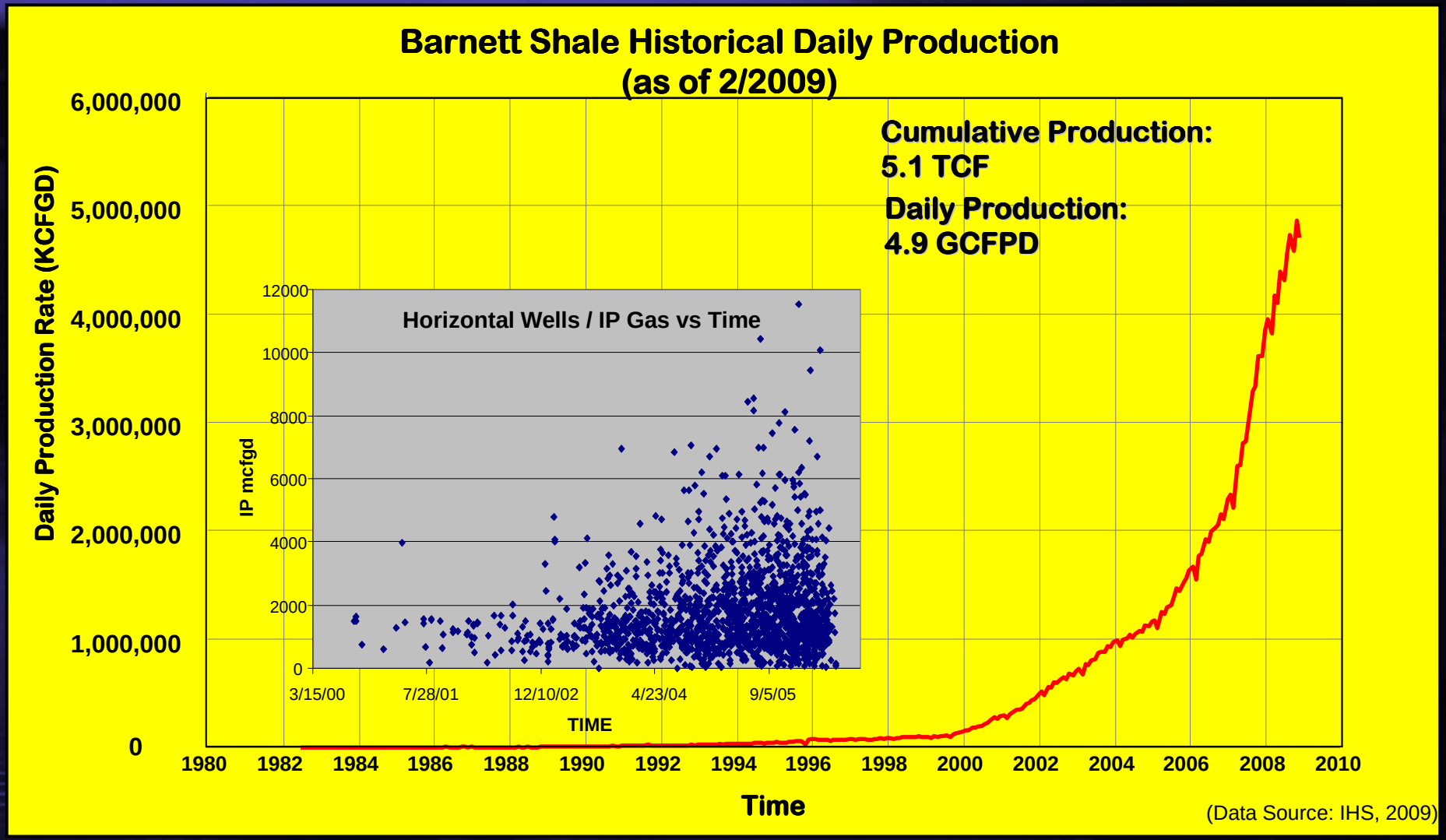


- Old Paradigm
  - "Australia gas" synonymous with the NWS or Gippsland
  - Eastern Australia CBM is modest-sized resource
  - Need to sell CBM to local gas markets
    - + Local gas markets are saturated
  - Gas is too dry, ramp-up too long for LNG feedstock



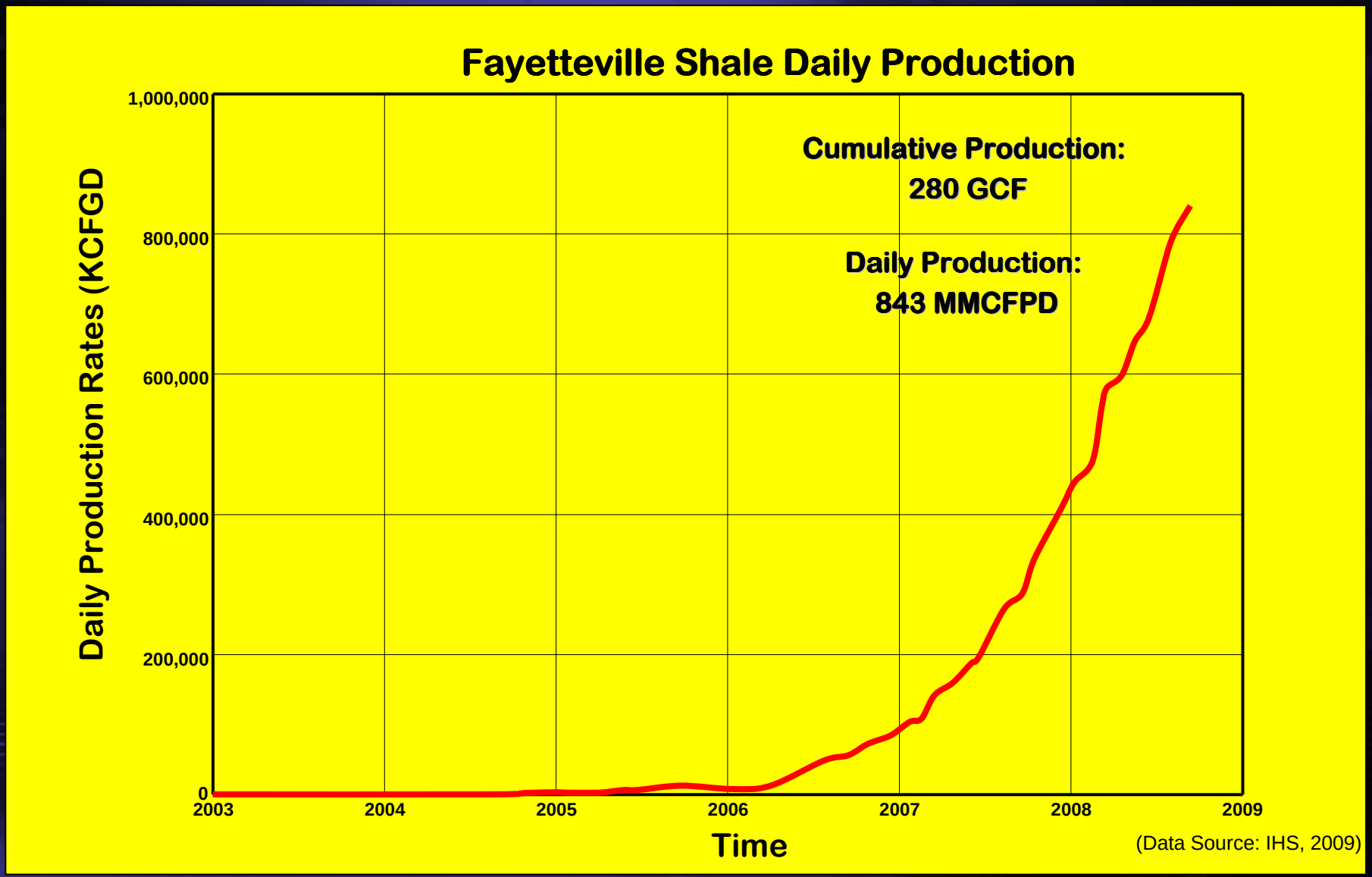
- New Paradigm
  - Eastern Australia CBM is a very large resource
  - Look for markets outside Australia
    - + Export via LNG

Emergence of Unconventional Gas / Barnett Shale

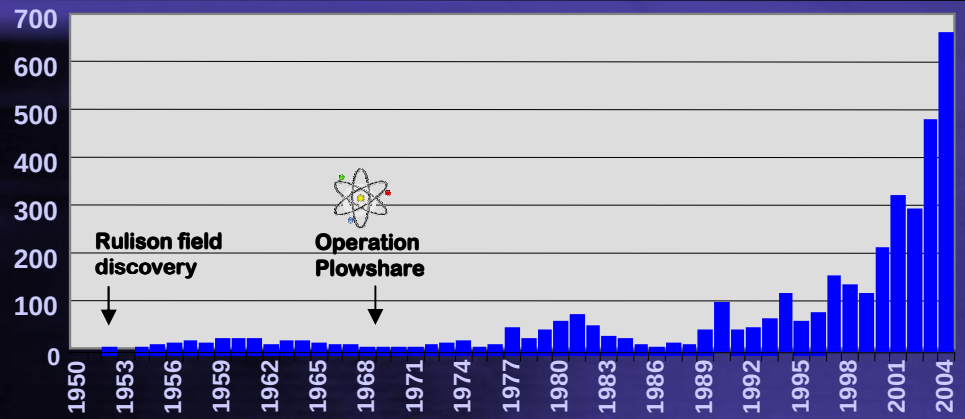


- Discovery well (vertical, CO_2 ,nitrogen foam frac)
- Massive hydraulic fracs
- First horizontal well; first 3D seismic
- First light sand (slickwater) frac
- Refrac
- Simul-fracs

Emergence of Unconventional Gas / Fayetteville Shale

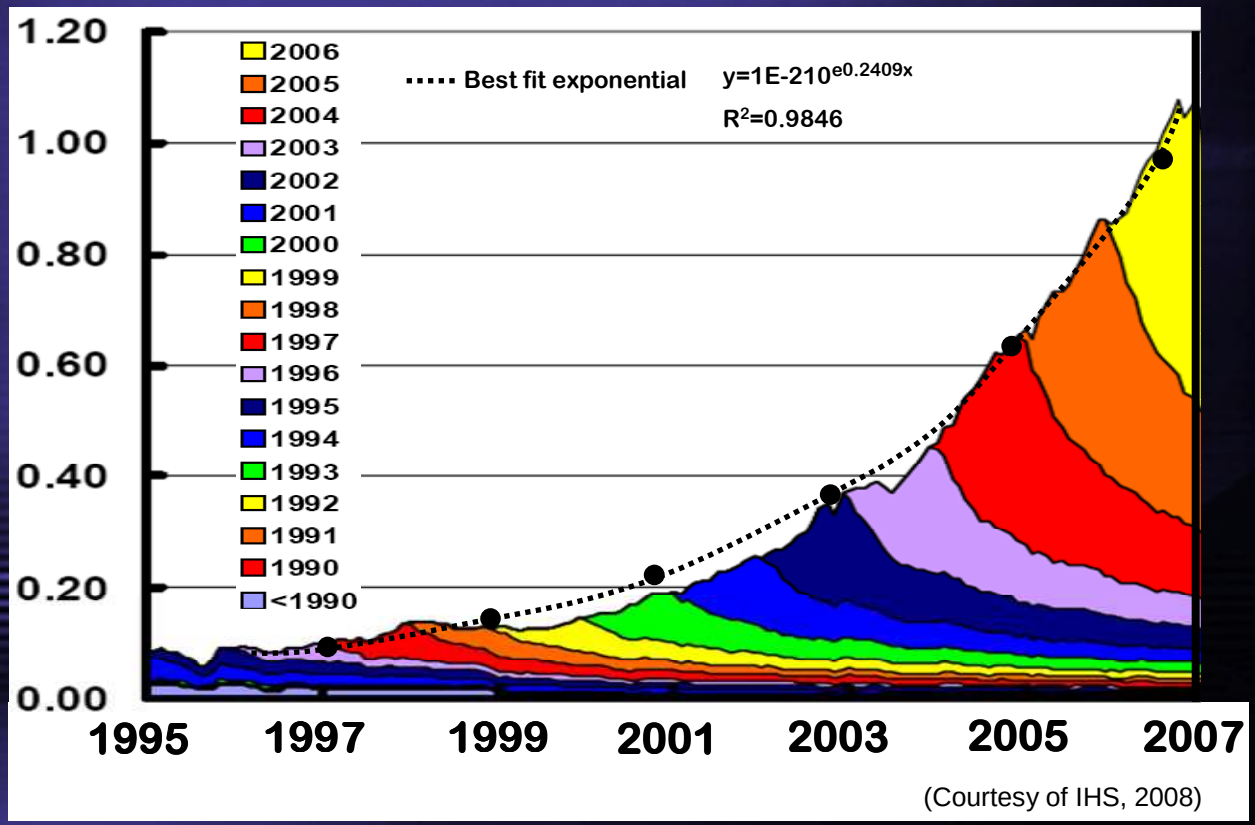


Emergence of Unconventional Gas / Piceance Basin



- Mesaverde tight gas potential recognized in early 1950's (Rulison field discovery)
- Massive nuclear and hydraulic fracs deemed unsuccessful
- Increased drilling activity due to increased gas price and advancement of frac technology

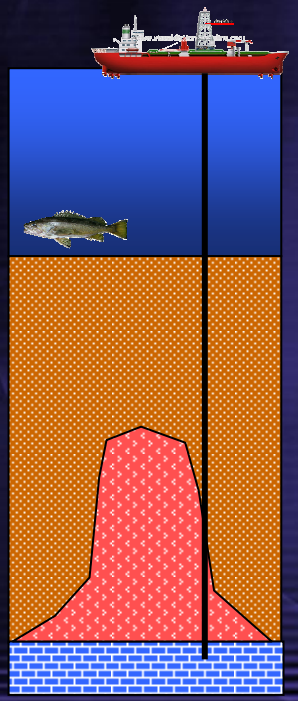
- Exponential growth in production starting in 1995
- Production has been limited by take-away capacity and attendant low price



(Courtesy of IHS, 2008)

Deepwater / New Frontiers

Brazil Santos Sub-Salt



Ultra deep water

2000-3000 m

Post-salt sediments

Variable salt thickness

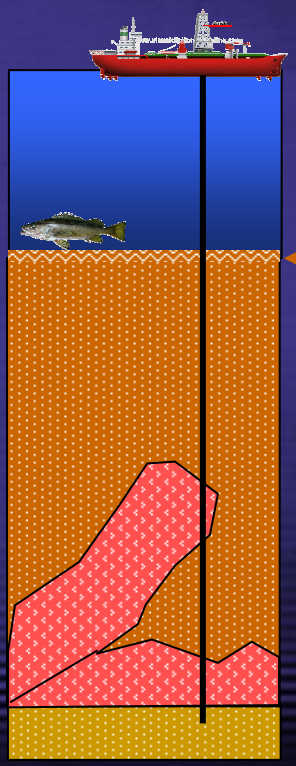
5000-6000 m

Heterogeneous carbonate reservoir

+ variable permeability

TD: 8000 m (>25,000')

Gulf of Mexico Lower Tertiary



Ultra deep water

1200-3000 m

Rugose sea floor

Post-salt sediments

Complex salt geometry

5000-7000 m

Turbidite sandstone reservoir

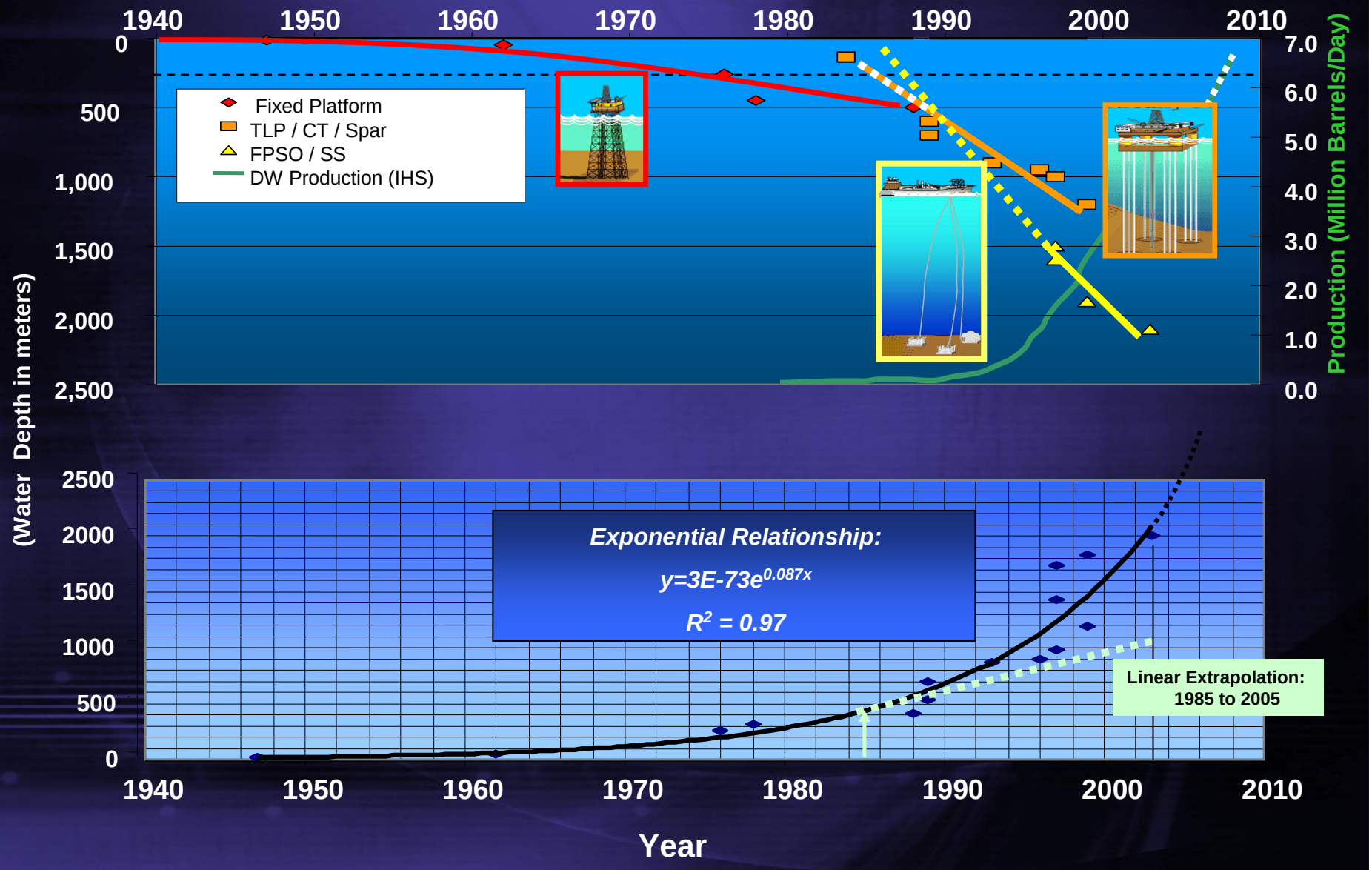
+ low permeability

+ moderate porosity

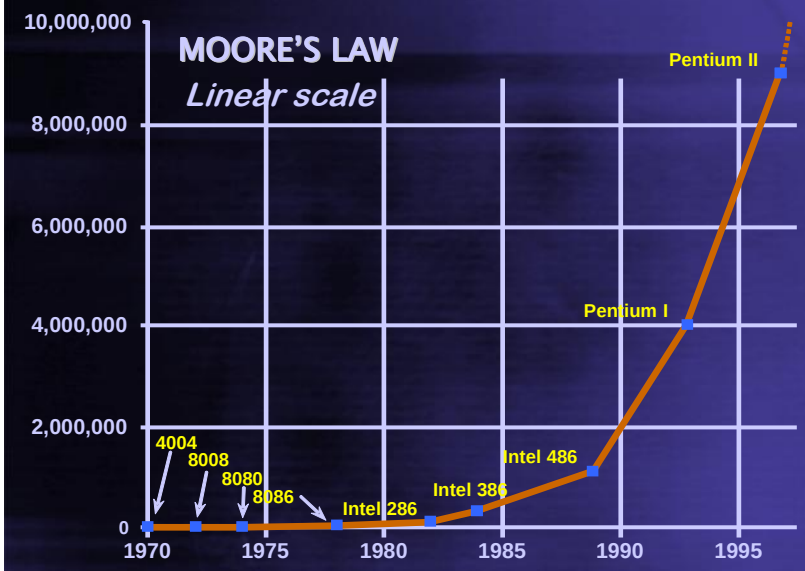
+ overpressure

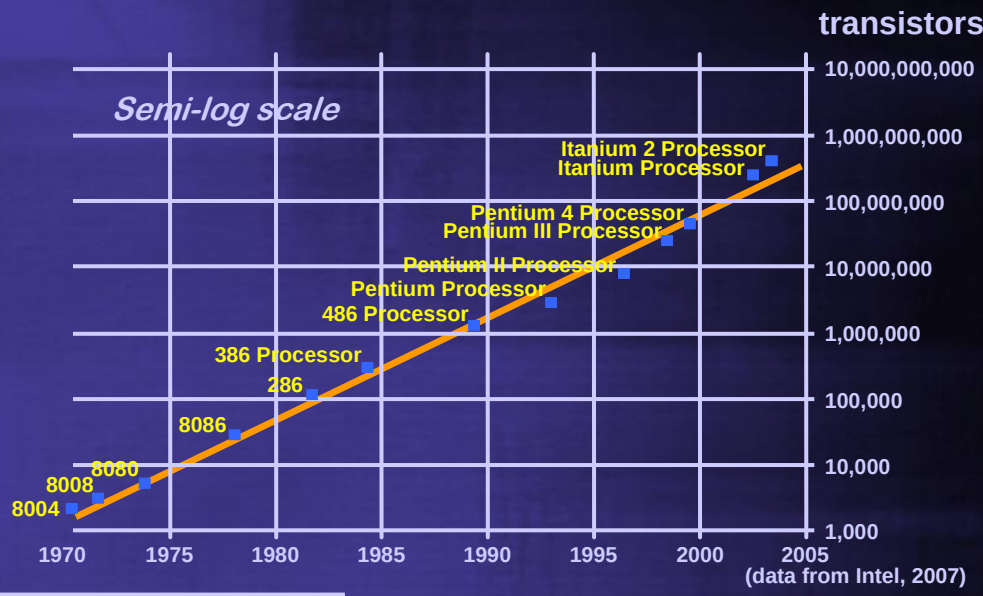
TD: 9000 m (<30,000')

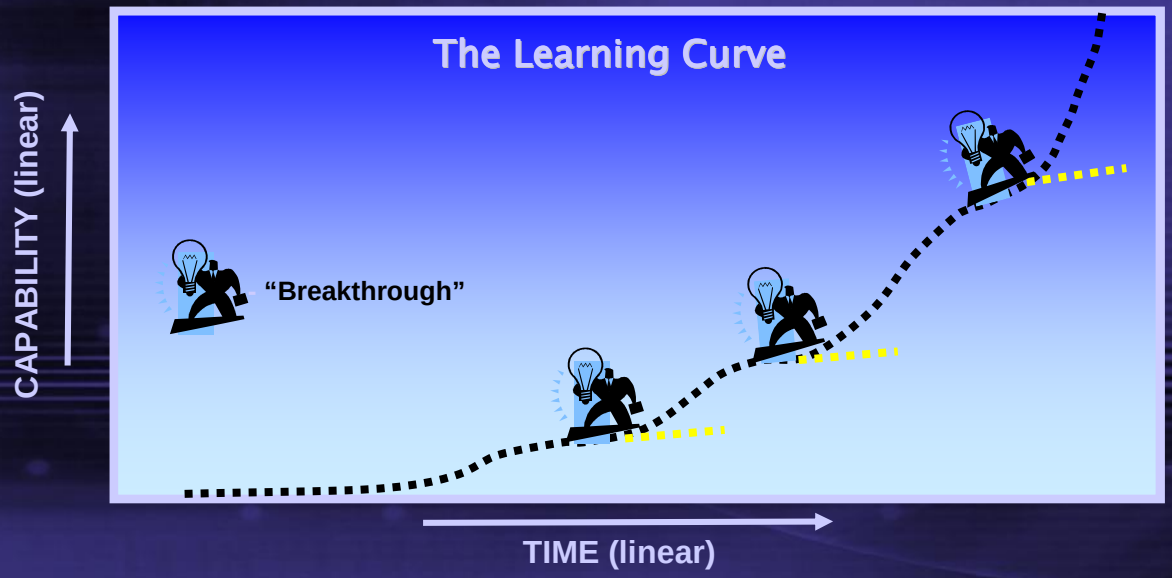
The Pace of Innovation / Water Depth Capability



The Inexorable Pace of Innovation







- Exponential, accelerating growth
- Succession of S-curves
  - Each succeeding curve has shorter base, longer ramp

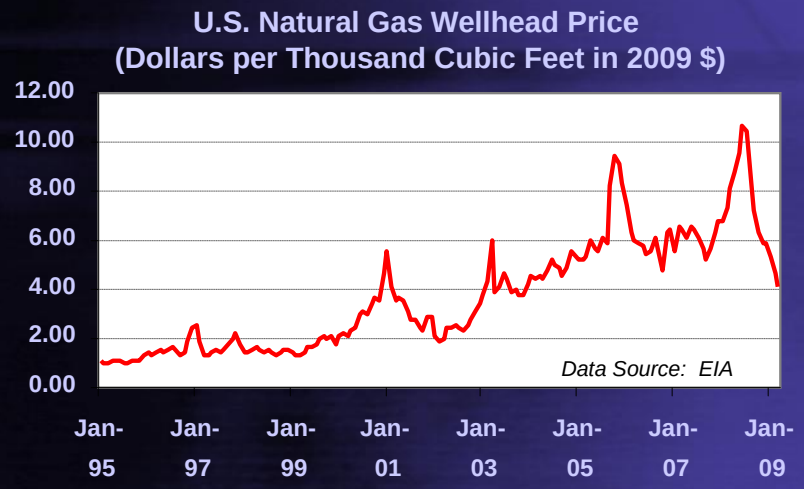
Intrinsic Value of Unconventional Resources

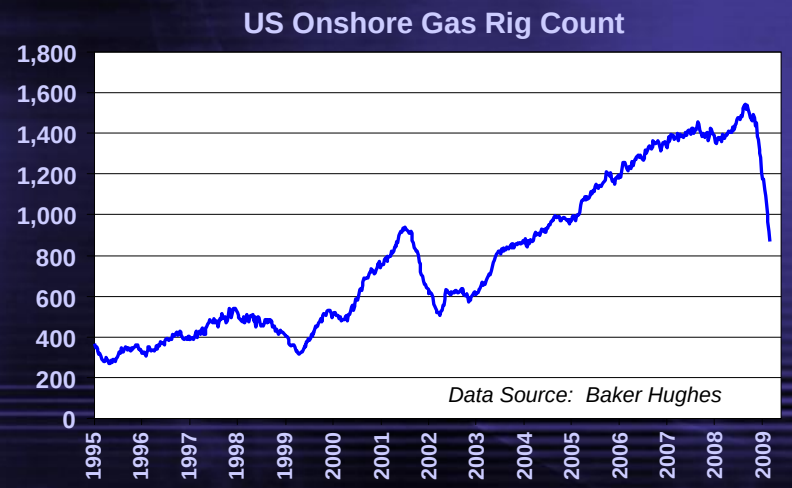
- "Materiality" - Large opportunities available
- "Security" - In politically stable countries
- "Optionality" - "Piloting", development pace allow for significant reaction to learning and changing market conditions
- "Sustainability" - Scope for multi-decade production profiles
- "Commercial Viability" - Opportunities exist in countries importing gas, offering existing infrastructure, attractive fiscal terms and favorable business environment / outlook

  + Favorable early entry & lease holding costs, modest entry work program requirements

- "Technology" - Technology is a key value lever

Unconventional Gas / An Outlook and Remaining Challenges





Outlook

- A "breather" followed by continued production growth in North America and beyond
  - Unconventional gas will be competitive with imported or other new indigenous conventional sources of gas
  - Will provide material, strategically important resource
- Continued growth of global resource base of unconventional gas

Key Challenges

- Develop a predictive understanding of subsurface controls
  - "Rock revival"
  - Focus on fundamental science
- Innovate new technologies for detection, drilling, stimulation, enhanced recovery and water control
- Reduce surface footprint and water demand

"The conventional view serves to protect us from the painful job of thinking."

John Kenneth Galbraith

Grateful Acknowledgements to the ExxonMobil team pursuing Unconventional Resources