THE MYTH OF 100 YEARS OF GAS SUPPLY

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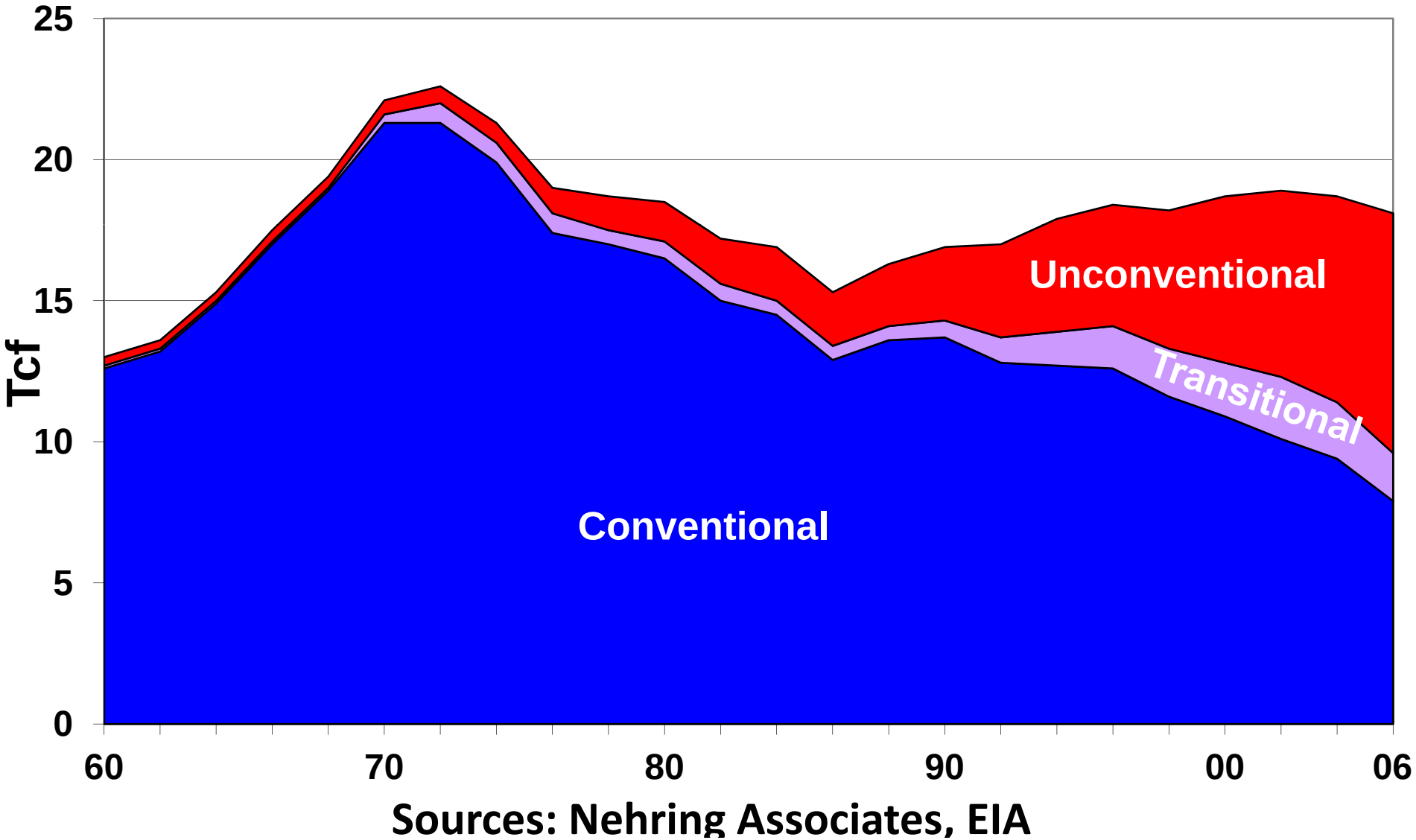
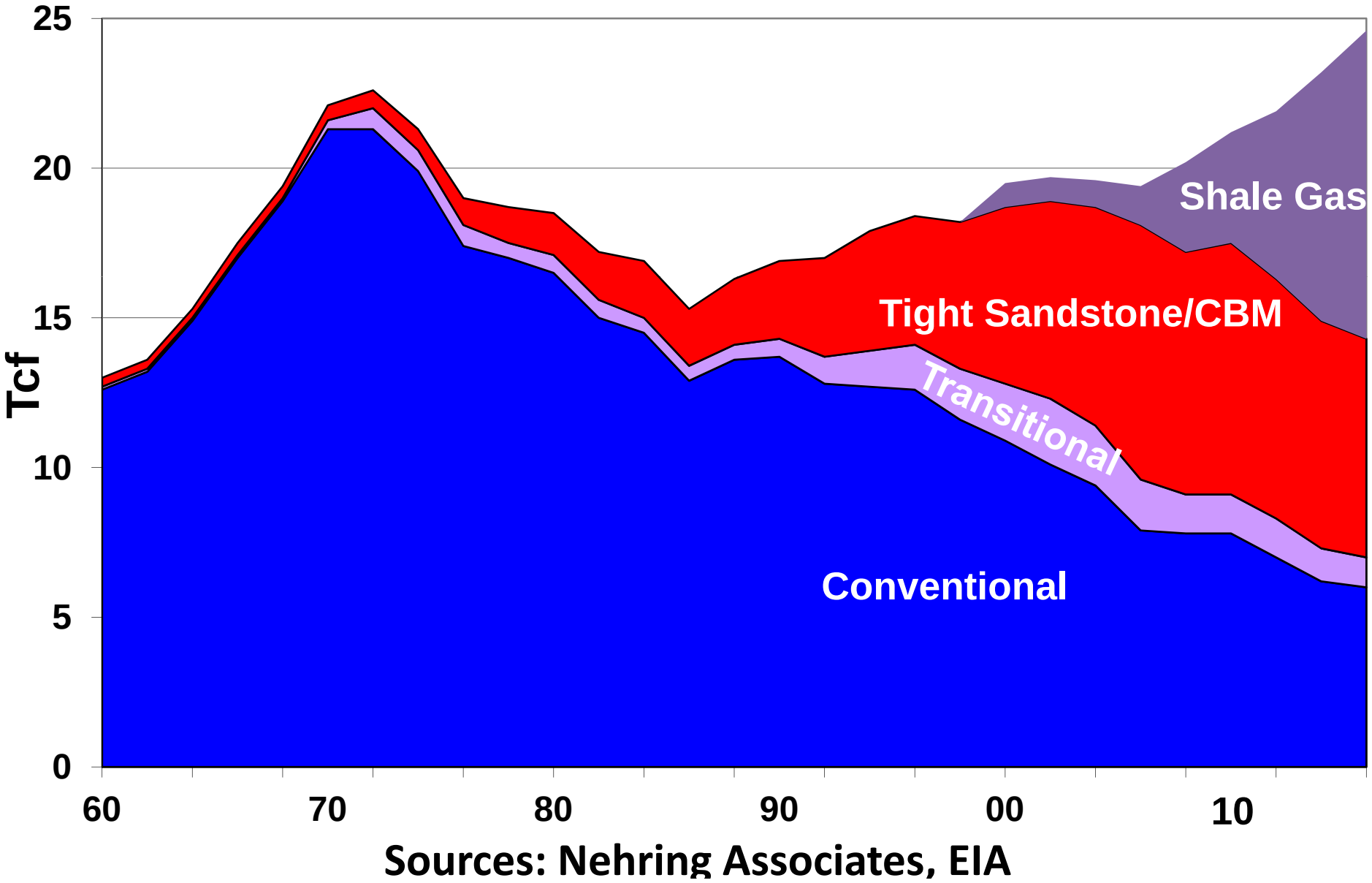
Fig. 1. Natural Gas Production by Type in the Contiguous U.S., 1960-2006



Sources: Nehring Associates, EIA

Fig. 2. Natural Gas Production by Type in the Contiguous U.S., 1960-2012



Sources: Nehring Associates, EIA

THE PROMISE

- New technologies have proved their potential
- Increasing production occurring despite plummeting prices
- Therefore [*trumpet flourish*]: 100 years or more of gas supply
- Cornucopia of benefits

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THE REALITY

- Geologic constraints – majority of new gas areas are low productivity
- Costs count – recent production increases limited to a few low cost areas
- Low cost areas are geographically limited

- The promise of a 100 years of gas supply is thus a classic **overpromote – a myth** (in the pejorative sense)

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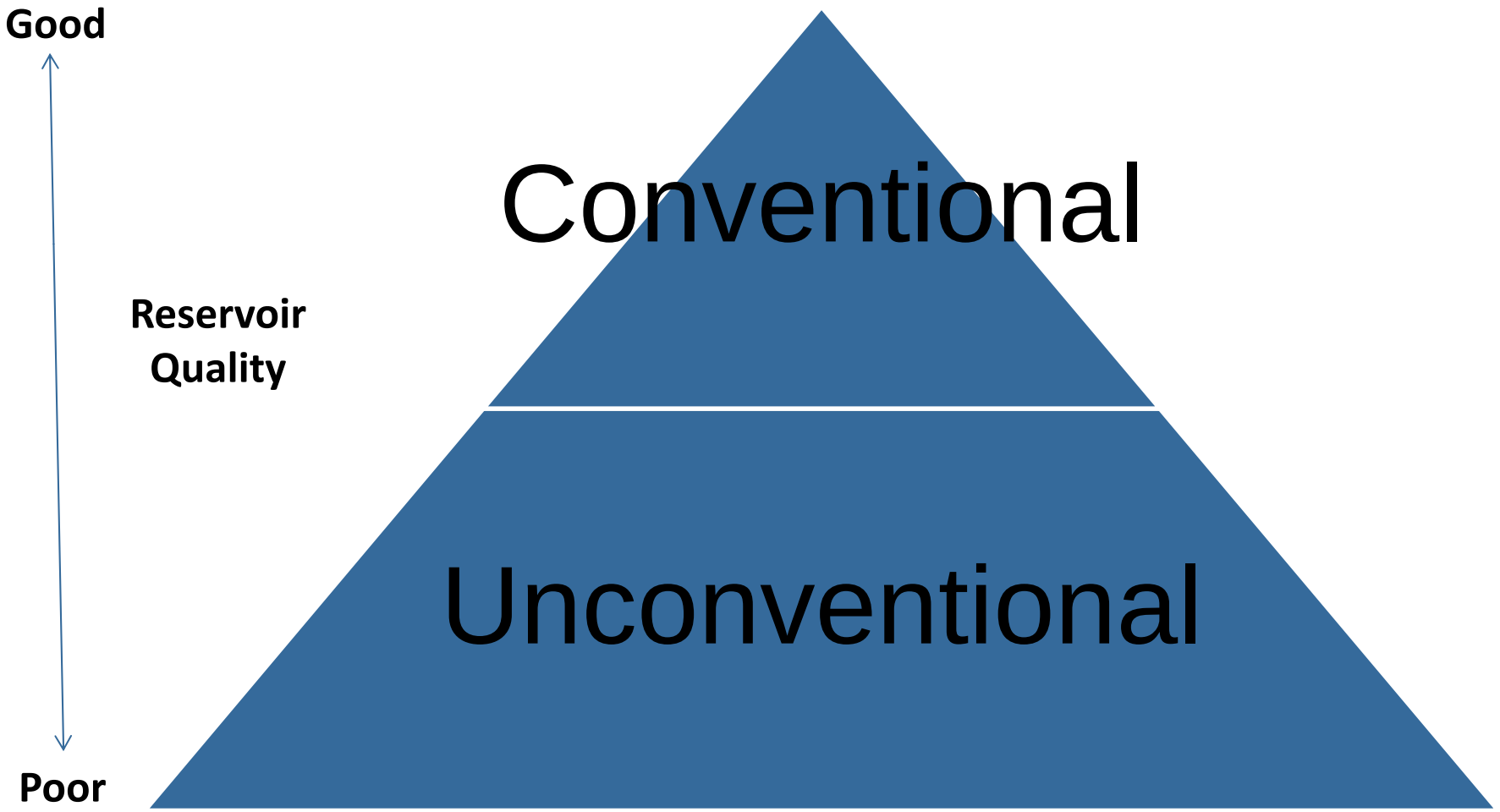
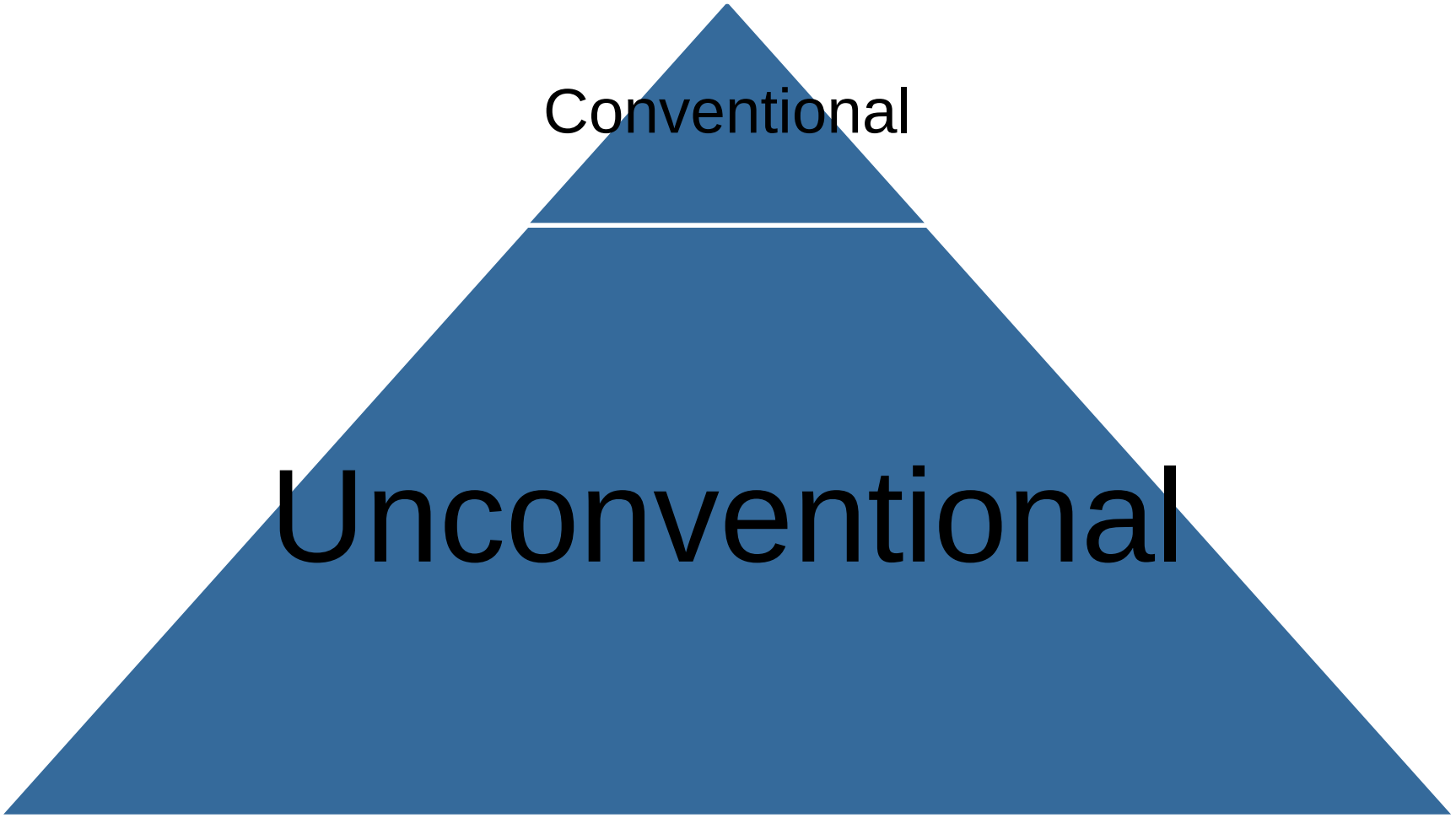
Intellectual Foundations: The Resource Pyramid

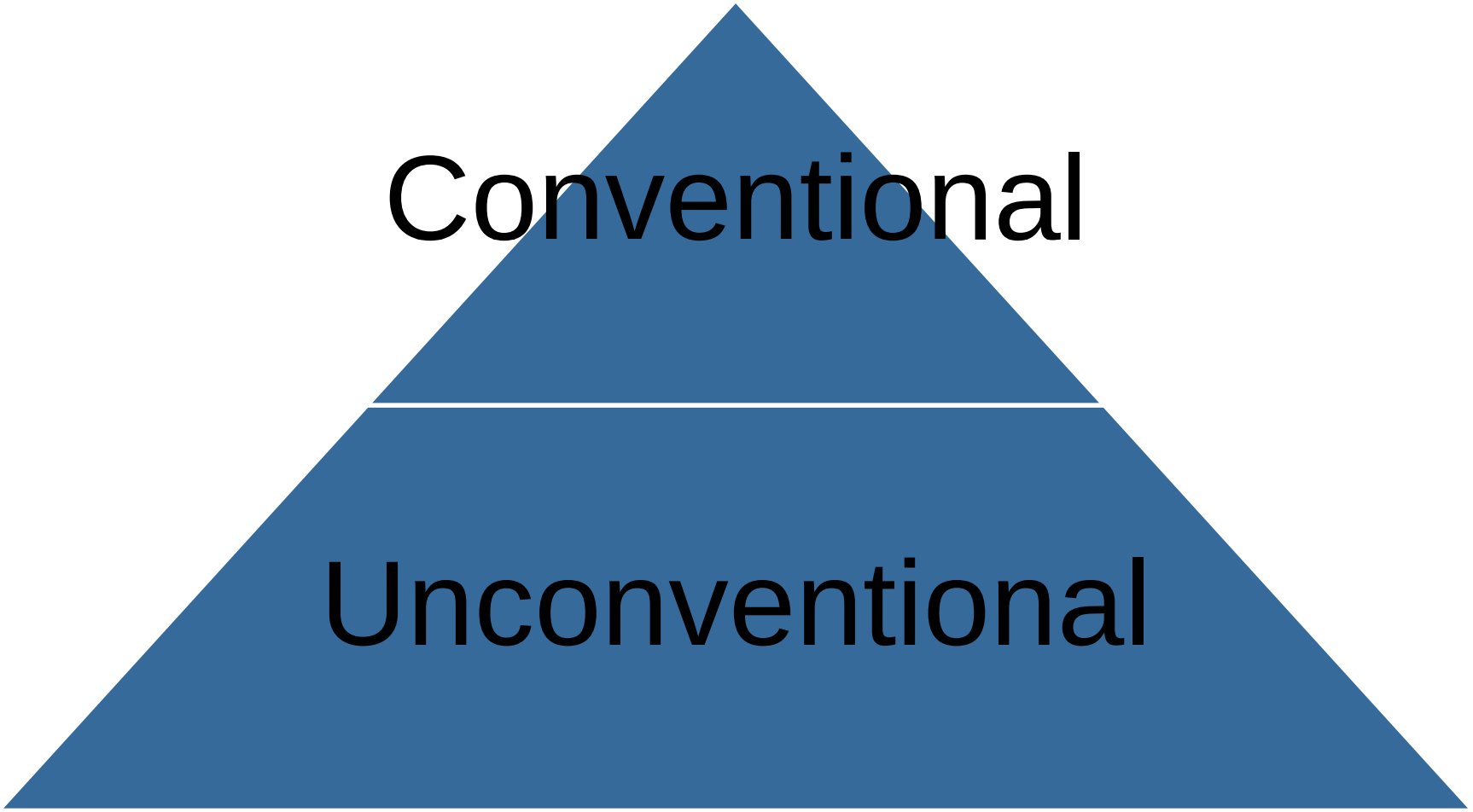


Source: Steve Holditch, SPE

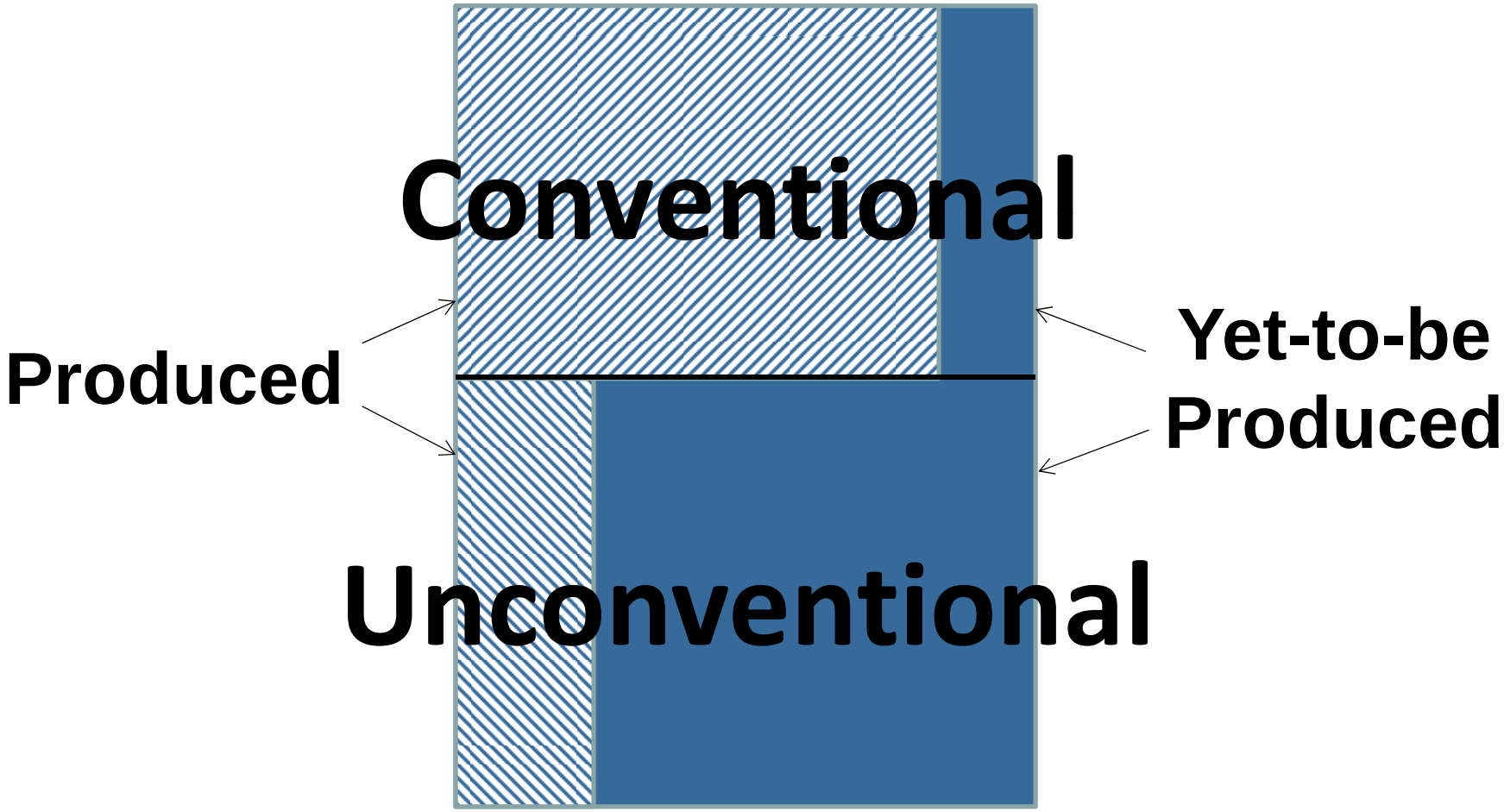
The U.S. Gas Resource Pyramid
View 1) Reservoir Rock Volume (12:1 Ratio)



The U.S. Gas Resource Pyramid
View 2) Porous Reservoir Rock Volume
(3:1 Ratio)



The U.S. Gas Resource ~~Pyramid~~ Rectangle
View 3) Recoverable Gas (1:1 Ratio)



HOW MUCH GAS DO WE NEED TO PROVIDE 100 YEARS OF SUPPLY?

- **2500 – 3000 trillion cubic feet (TCF)**

- 26.2 TCF (2013 U.S. consumption)
- 2-2.5 X 1200 TCF (US cumulative gas production thru 2013)
- 4-5X 604 TCF (US gas production, 1980-2012)

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MASSIVE GAS RESOURCES REQUIRE MASSIVE GAS PLAYS

• Monster Mega (400+ TCF)	1	600 TCF
• Super Mega (100-400 TCF)	3	750
• Large Mega (60-100 TCF)	5	400
• Small Mega (30-60 TCF)	10	450
• Large Major (15-30 TCF)	15	300
• Small Major (3-15 TCF)	20	200

• Total – 2700 TCF (54 plays)

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U.S. MASSIVE GAS PLAY POTENTIAL

• Monster Mega (400+ TCF)	0	0 TCF
• Super Mega (100-400 TCF)	1	250
• Large Mega (60-100 TCF)	0	0
• Small Mega (30-60 TCF)	4	180
• Large Major (15-30 TCF)	6	120
• Small Major (3-15 TCF)	15-20	150-200
• Total: 700-750 TCF (26-31 plays)		

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GEOLOGIC LIMITS ON TECHNOLOGY

- Low porosity (low density)
- Low Total Organic Carbon (TOC)
- Immature or overmature
- High ductility (shales)
- Low pressure (CBM)

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KEY LESSONS LEARNED

- Variability within plays and the ability to map, explain, and predict this variability
- Salience of well density and completion practices
- Importance of cost of production
  - Supply curve instead of technically recoverable resources

- Development of assessment methods that incorporate these lessons

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SHALE GAS

- Largest of new resources (includes tight oil)
- Not enough mega plays
  - Marcellus: only super mega play
  - Only four other mega plays: Barnett, Eagleford, Haynesville, and Utica
- Only a few other major plays
- Cumulative (thru 2012): 67 TCF
- Ultimate potential: 460-760 TCF

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TIGHT SANDSTONES/CARBONATES

- Mostly major plays – at least 24
  - Only two (barely) posible mega plays
- Leading source of unconventional production thru 2010
- Mostly mature – majority of plays developed and peaked between 1995 and 2005
- Cumulative (thru 2012): 140 TCF
- Ultimate Potential: 270-340 TCF

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COALBED METHANE

- Most disappointing unconventional resource
- Only one mega play (Fruitland CBM)
- Four small major plays
- Most remaining potential is high cost
- Cumulative (thru 2012): 31 TCF
- Ultimate Potential: 56-70 TCF

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TRANSITIONAL RESOURCES

- Limited – major geological constraints
  - Deepwater – low thermal gradient
  - Deep/Ultra Deep - poor reservoir quality and thermal destruction
- All have peaked (Deep in 1970s!)
- Cumulative (thru 2012): 55 TCF
- Ultimate Potential: 77-100 TCF

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CONVENTIONAL RESOURCES

- Great resource, but highly mature
- Few sizeable discoveries in the past 25 years
- Cumulative (thru 2012): 882 TCF
- Ultimate Potential: 975-1050 TCF

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REMAINING US GAS RESOURCES BY BROAD TYPE

- Conventional 93-168 TCF
- Transitional 22-45 TCF
- Unconventional 549-926 TCF
- Total 664-1139 TCF

(27-46 years @ 25 TCF/year)

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IMPLICATIONS: PRODUCTION AND PRICES

- Production likely to plateau by 2020
- Production greater than 25 TCF/year likely to be maintained only to 2025-2040
- Low cost (<$4/Mcf) resources will be largely developed by 2020; gas development from 2020 to 2030 will need $5-8/Mcf prices
- Because post-2020 wells will have lower productivity, maintaining production will require more rigs drilling for natural gas

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IMPLICATIONS: DEMAND

- Expanding markets for natural gas is an idea whose time has gone
- Increasing use for transportation would require displacing traditional uses
- Gas supply insufficient and too expensive to displace coal and nuclear for generation
- Other than pipeline exports to eastern Canada and Mexico, exports (specifically LNG) are not good for domestic consumers

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CONCLUSIONS

- Expanded domestic gas resources are not a game-changer; they only provide us with a long extra-period

- A natural gas economy for the United States is not a possibility if it is to be based primarily on domestic gas resources

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