Overview of the Shale Gas Boom and its Impact on the Chemical Industry

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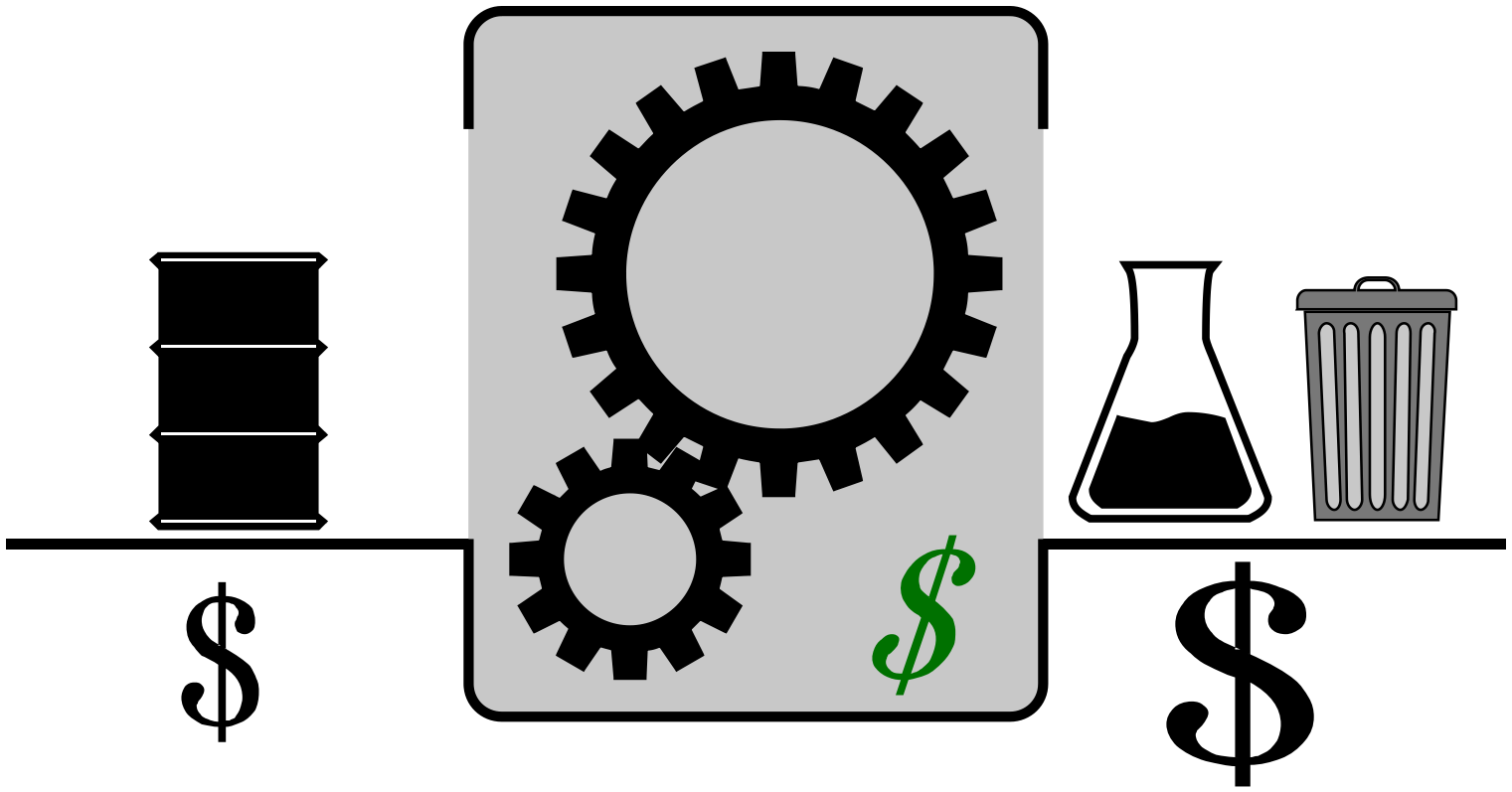
Executive External Strategy and Communications Fellow
The Dow Chemical Company

7 March 2016

Chemical Industry - Simplified

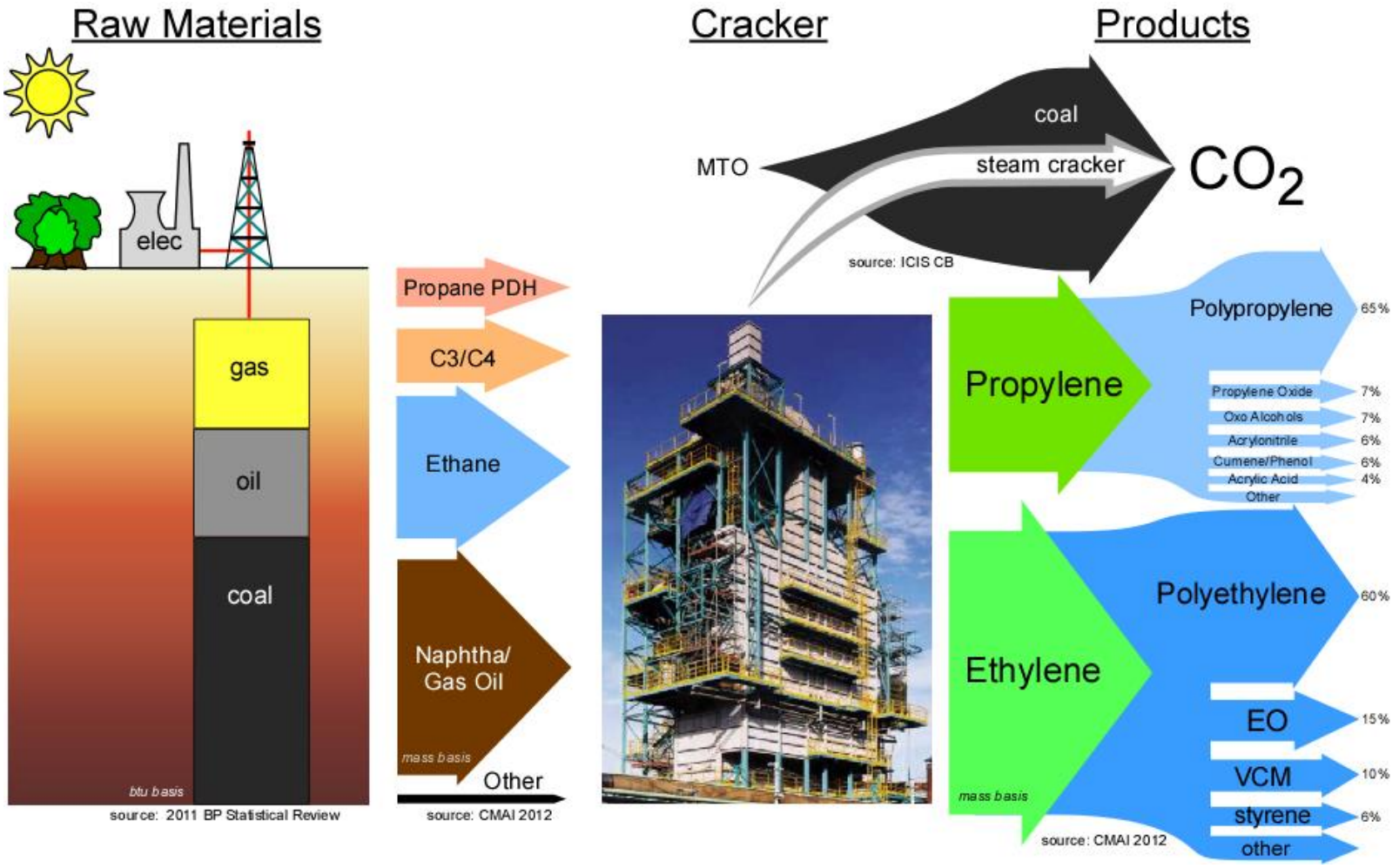


Chemical Industry Key Concepts

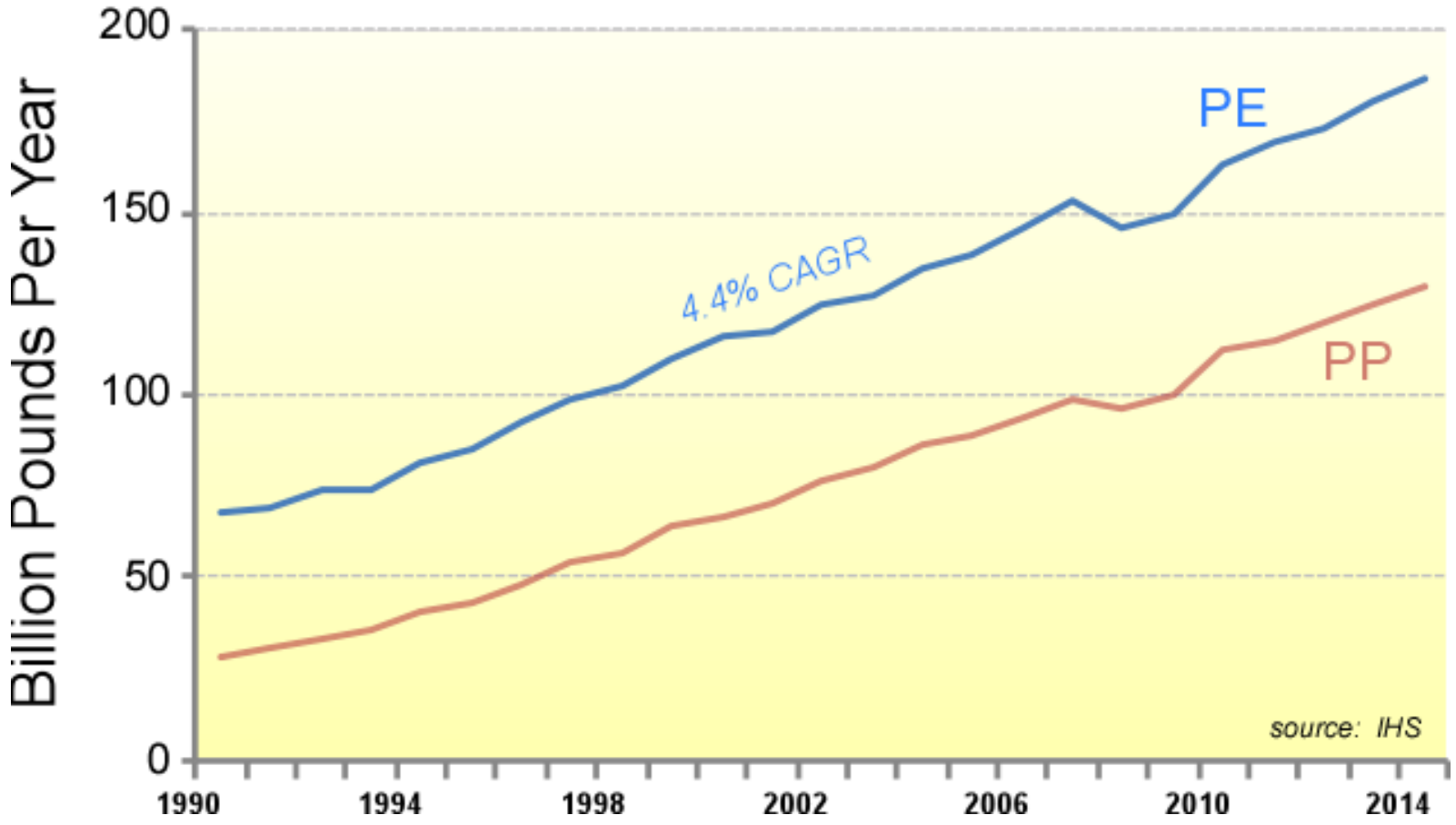
- Capital
- Risk
- Scale
- Purity
- Commoditization

Birth of Modern Chemicals

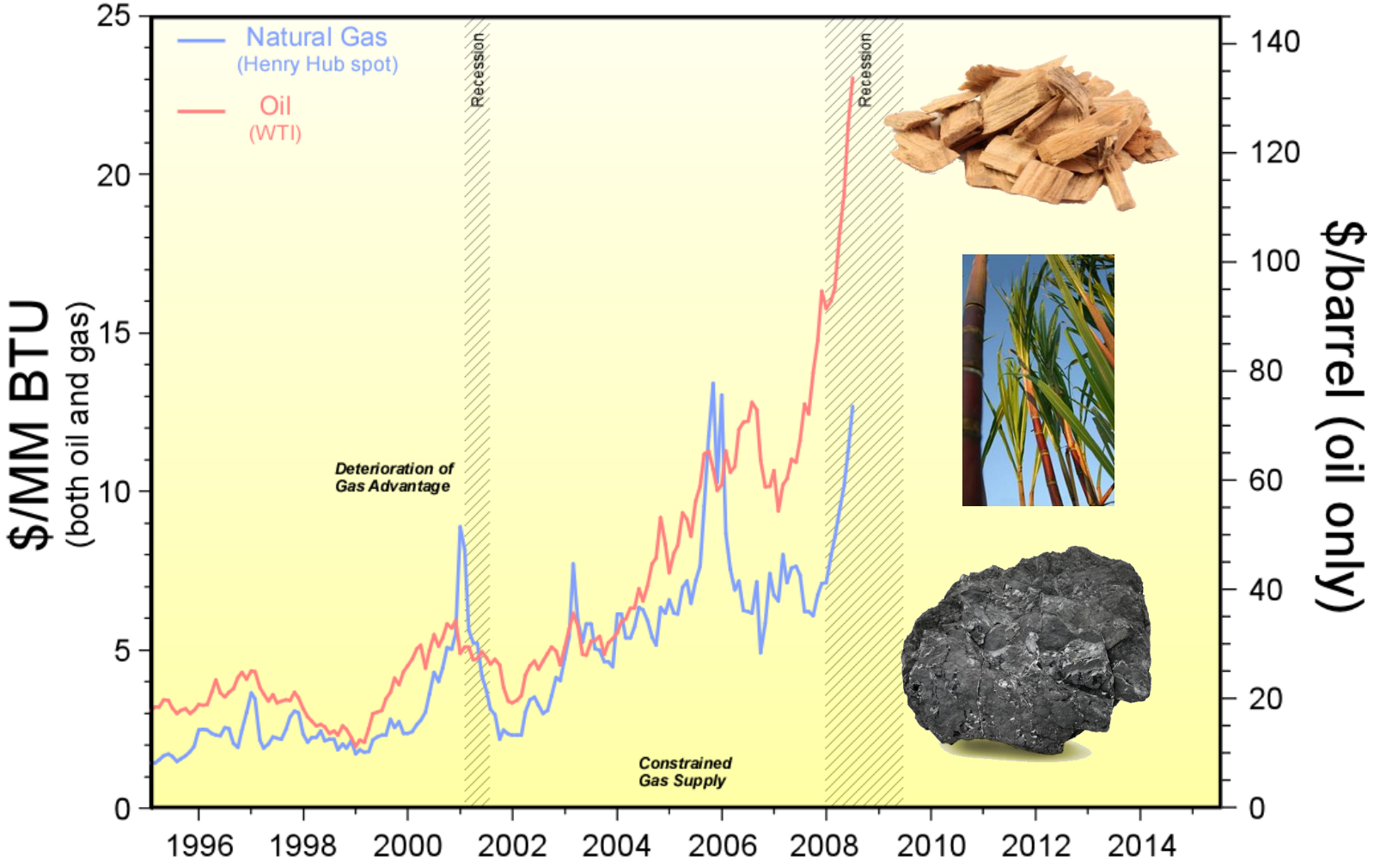
Chemical Industry Snapshot



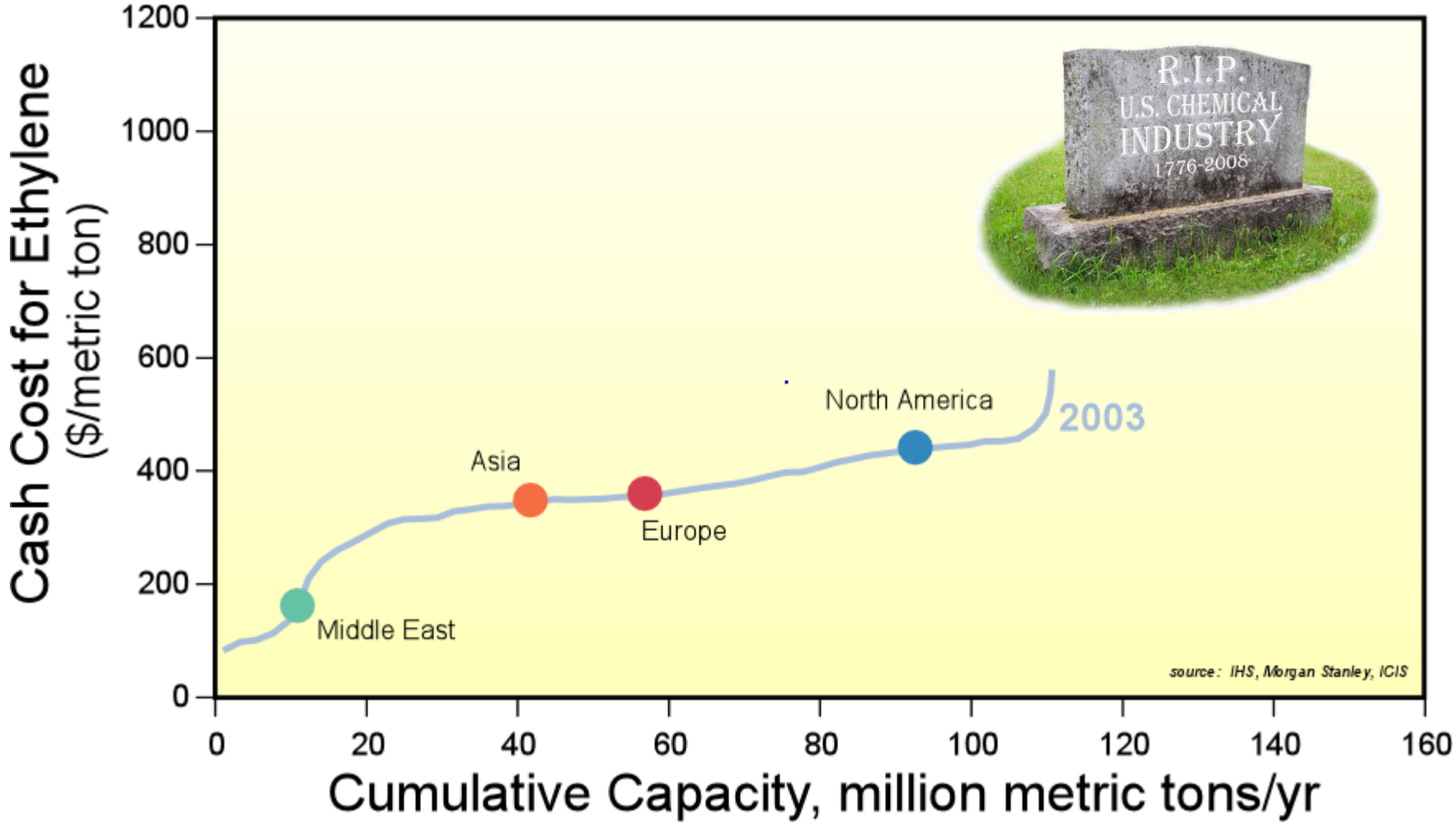
Polyolefin Growth



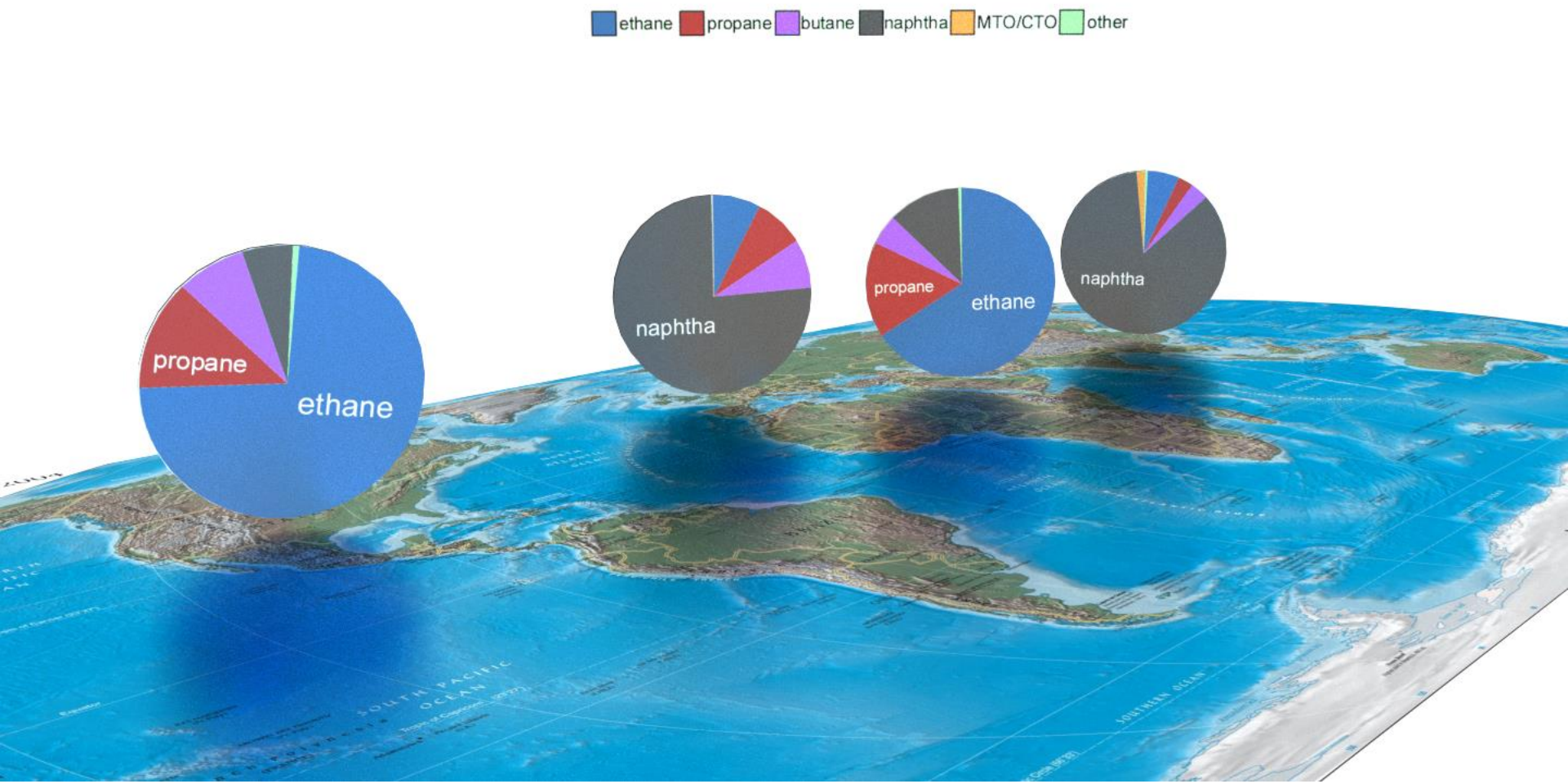
Our Previous Reality…..



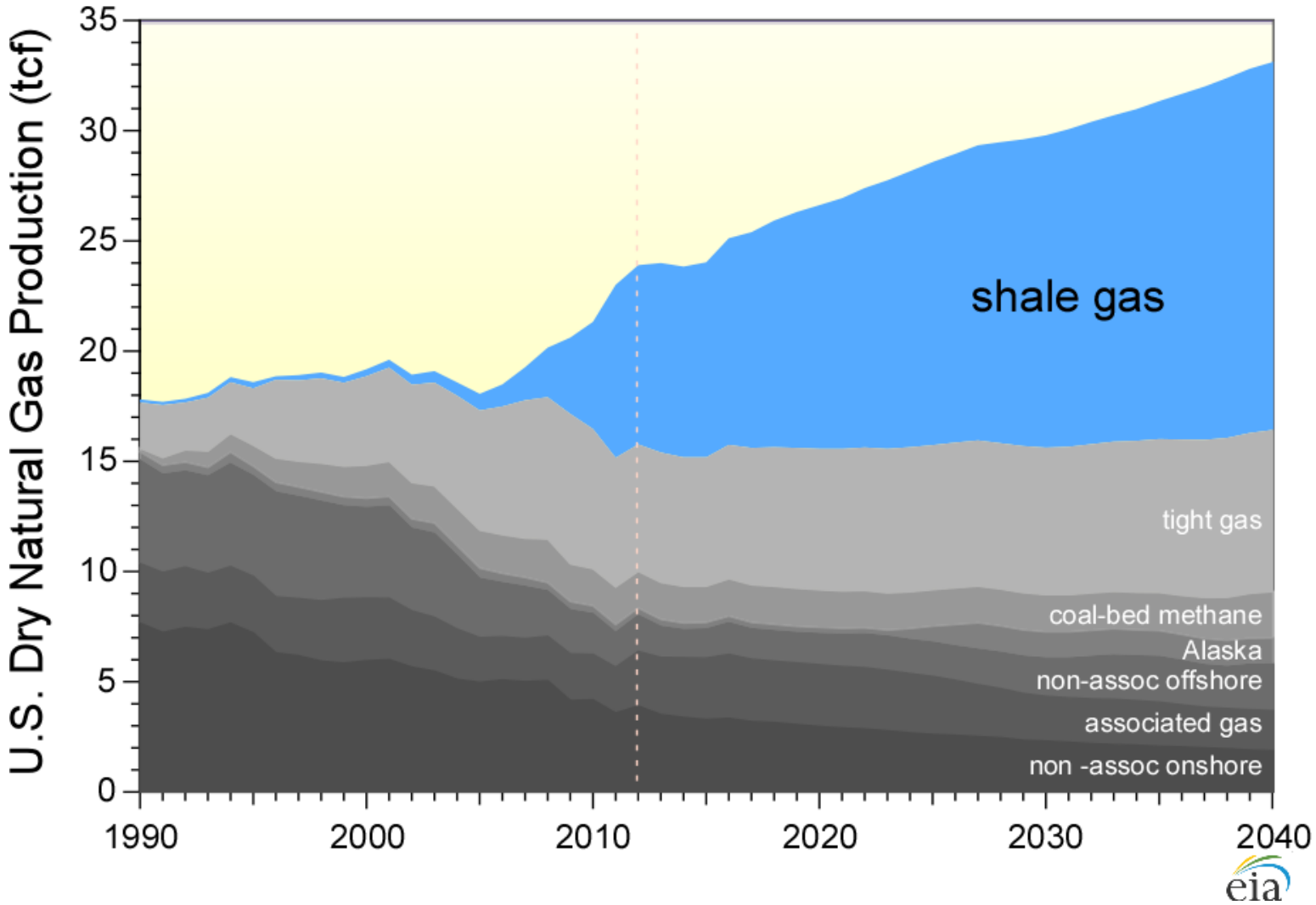
Ethylene Cumulative Supply - 2003



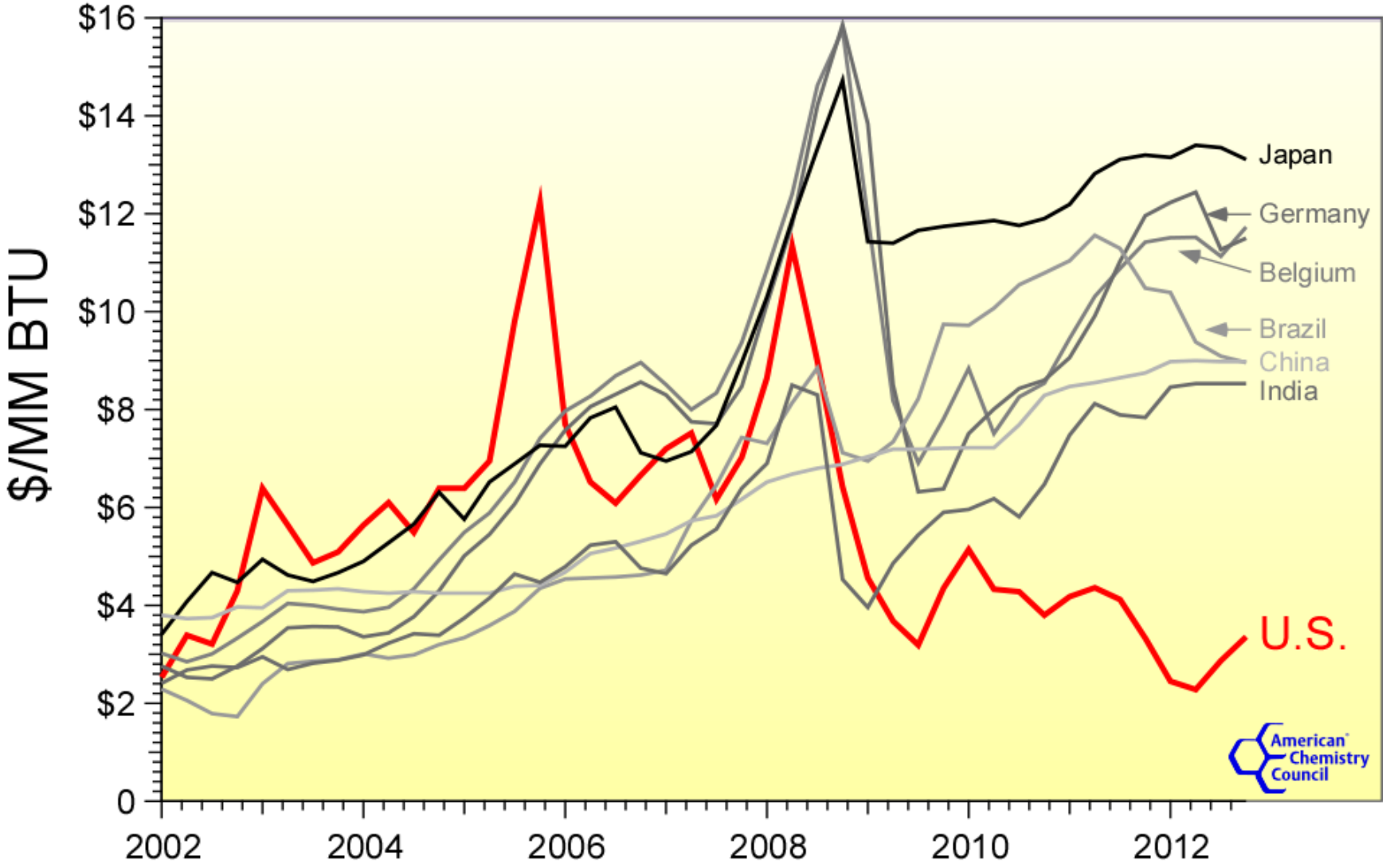
Global Feedstock Slates Differ



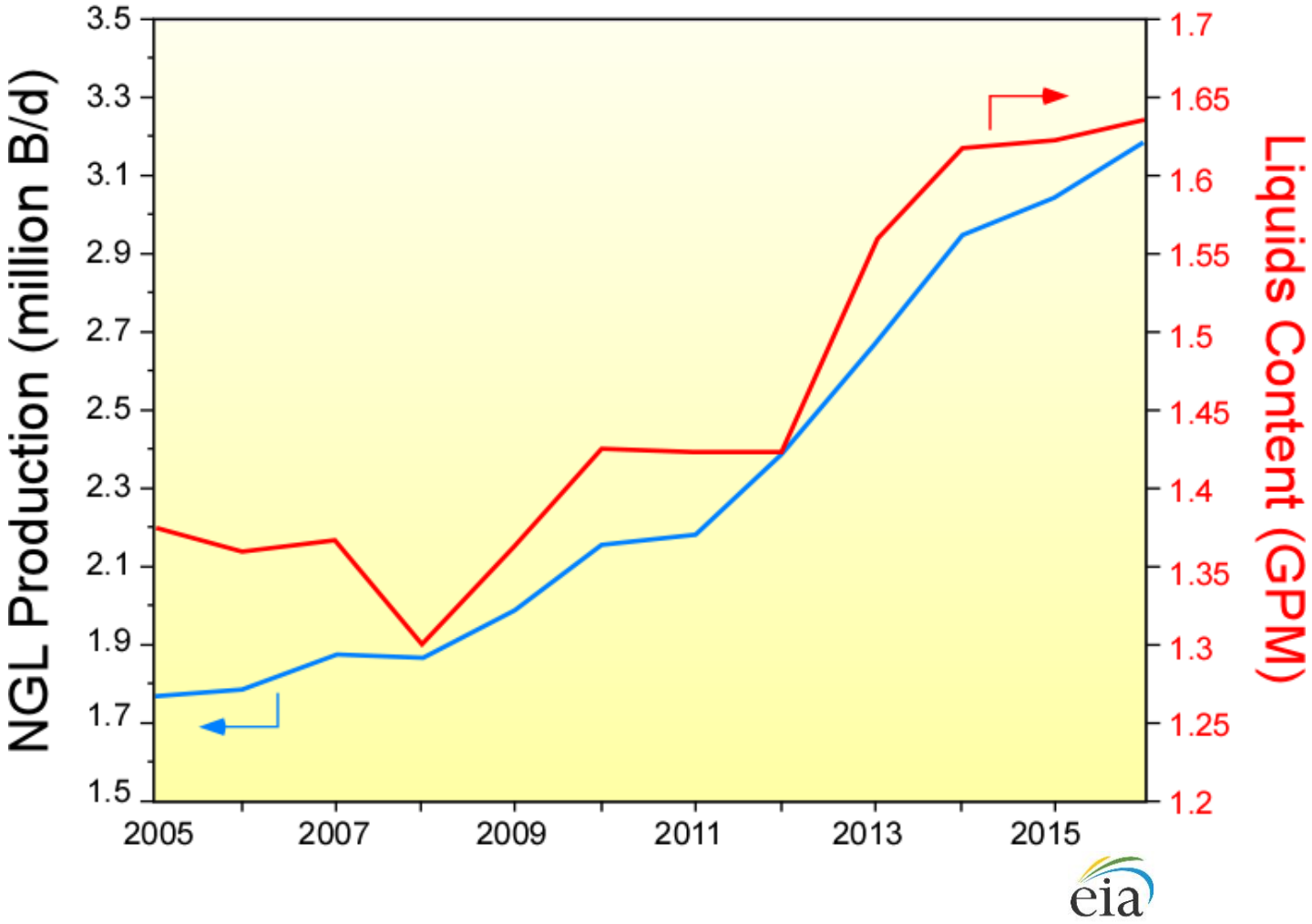
Shale Gas Growth



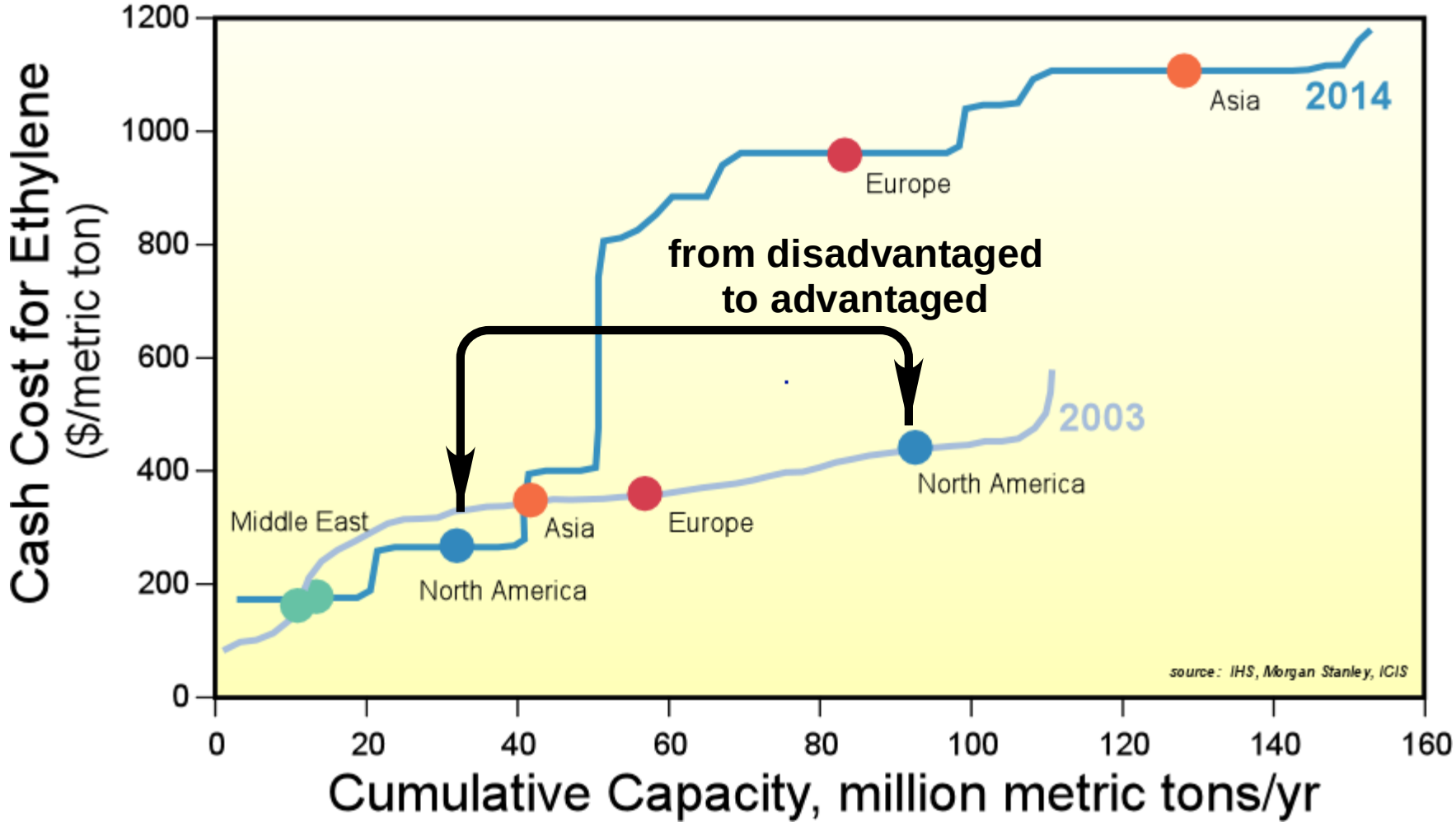
Global Gas Price



Growth in NGLs

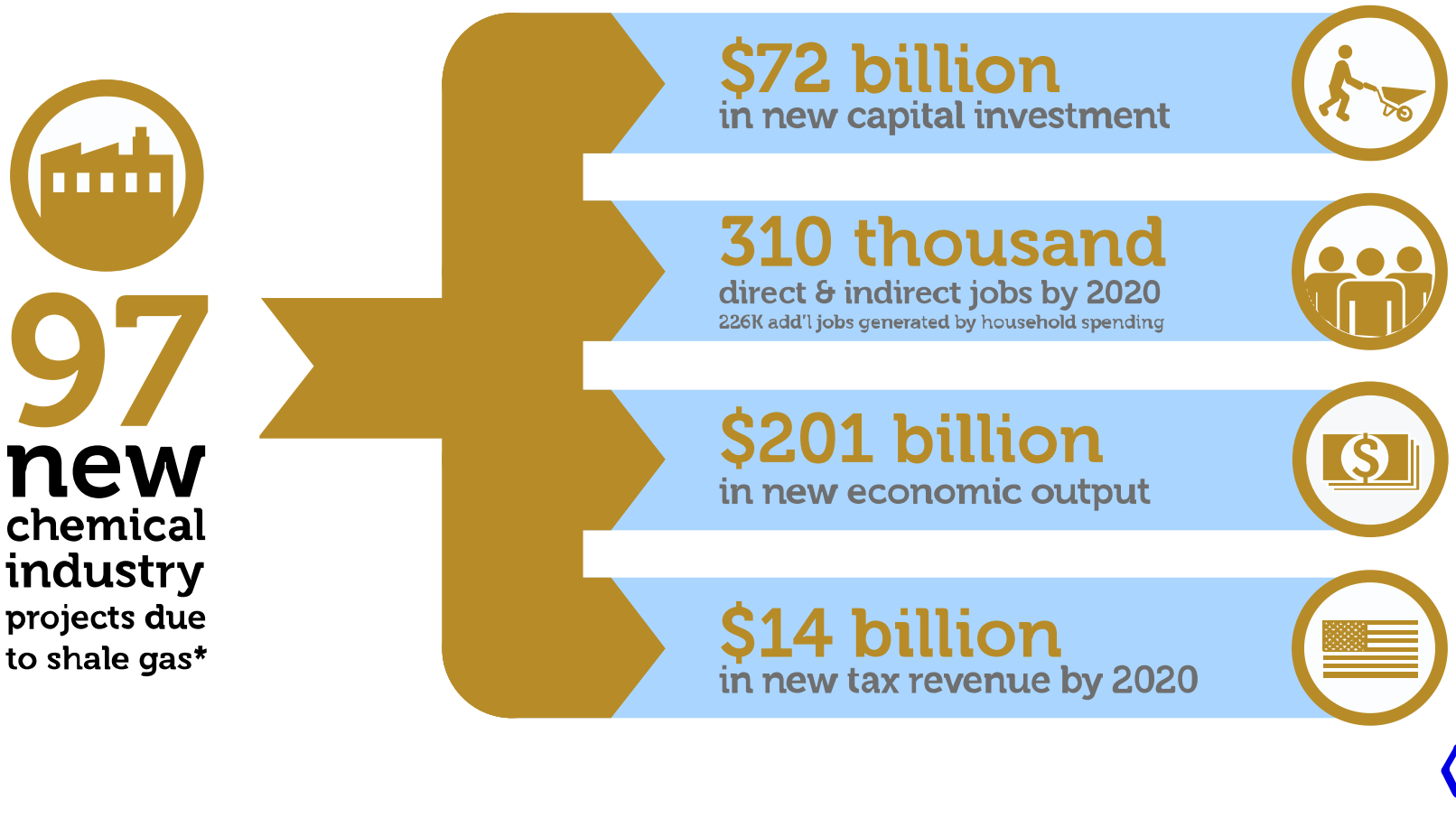


Rapid Change



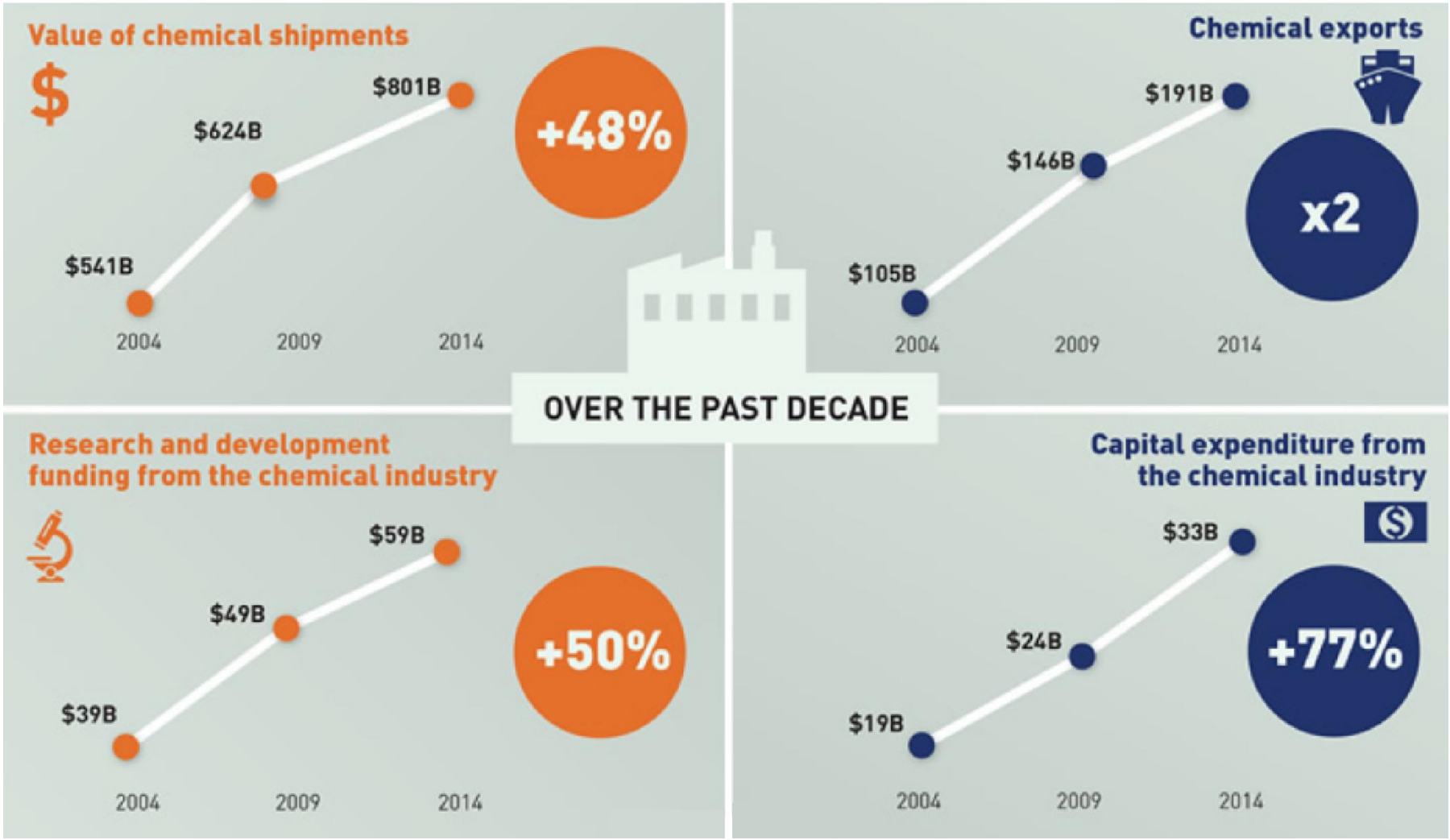
Live Long and Prosper

Economic Impact of Shale Gas



American Chemistry Council

Industry Growth

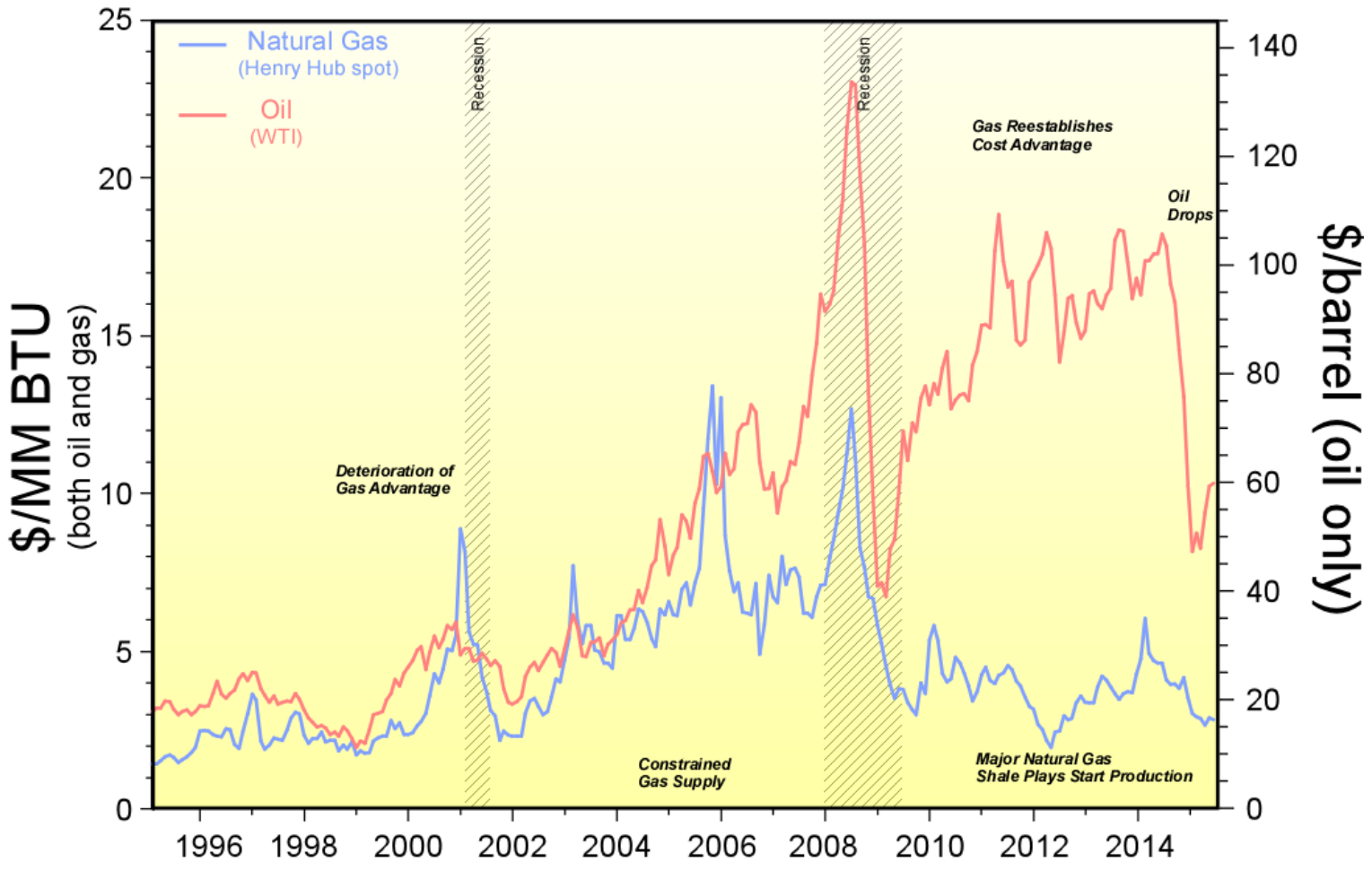


American Chemistry Council

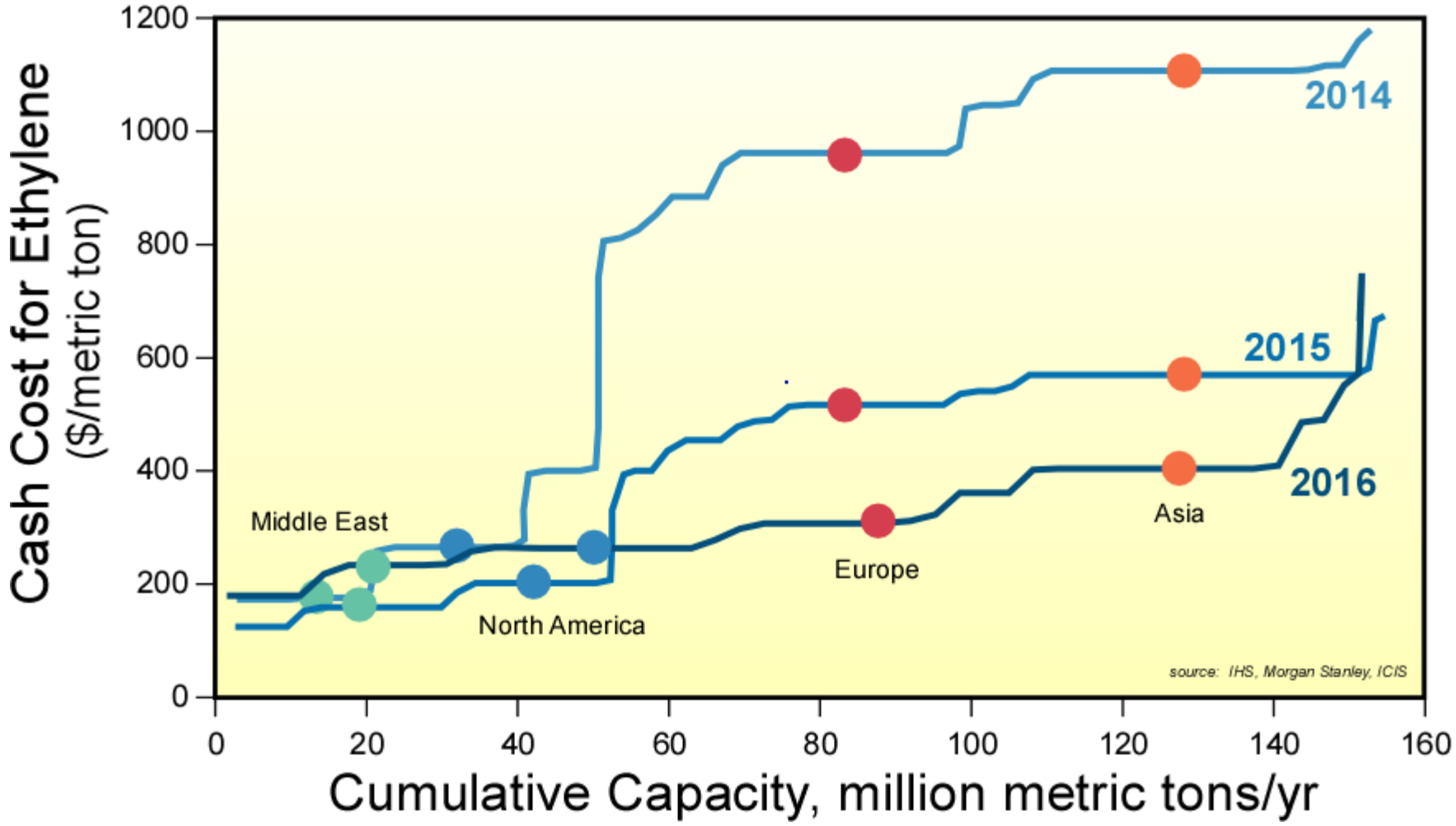
DOW

Exciting Times

Energy Cost

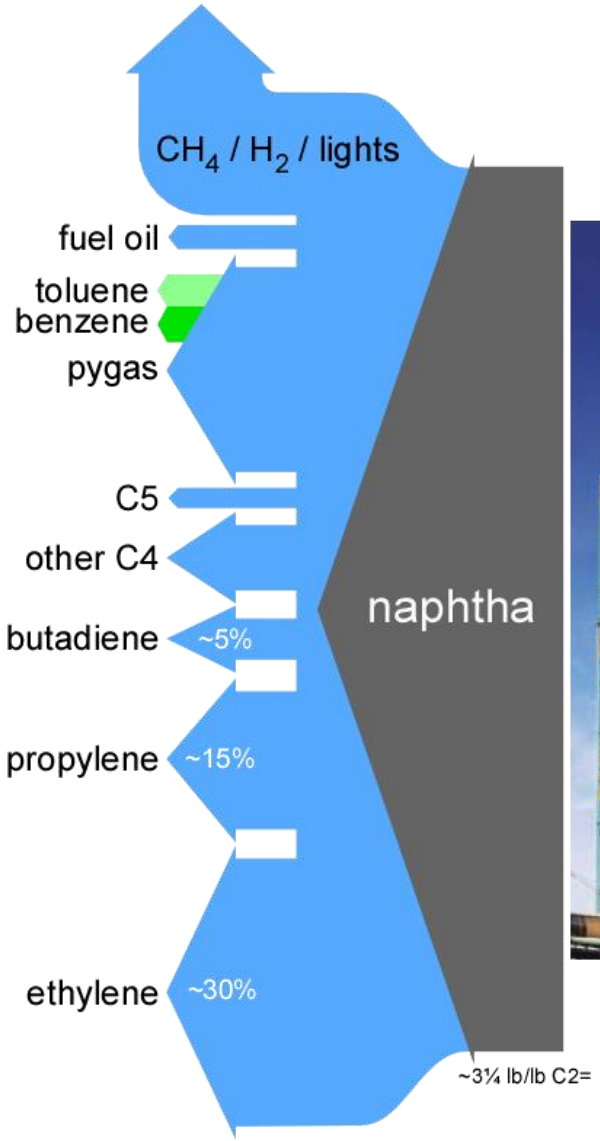

Natural Gas
(Henry Hub spot)
Oil
(WTI)
Recession
Recession
Deterioration of
Gas Advantage
Constrained
Gas Supply
Gas Reestablishes
Cost Advantage
Oil
Drops
Major Natural Gas
Shale Plays Start Production
$/MM BTU
(both oil and gas)
$/barrel (oil only)
0
5
10
15
20
25
0
20
40
60
80
100
120
140
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

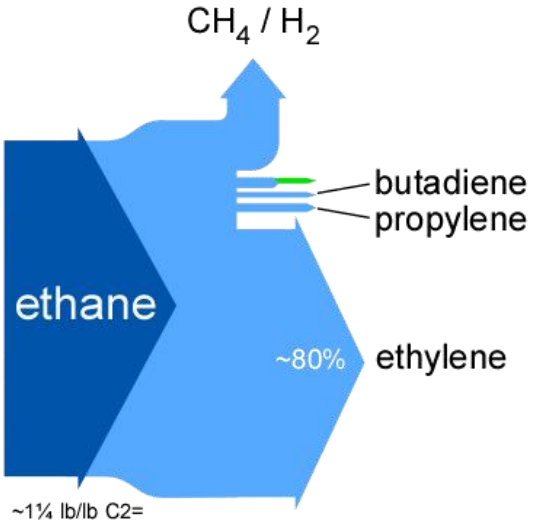
Falling Oil Prices



NGLs Still Advantaged In The U.S.

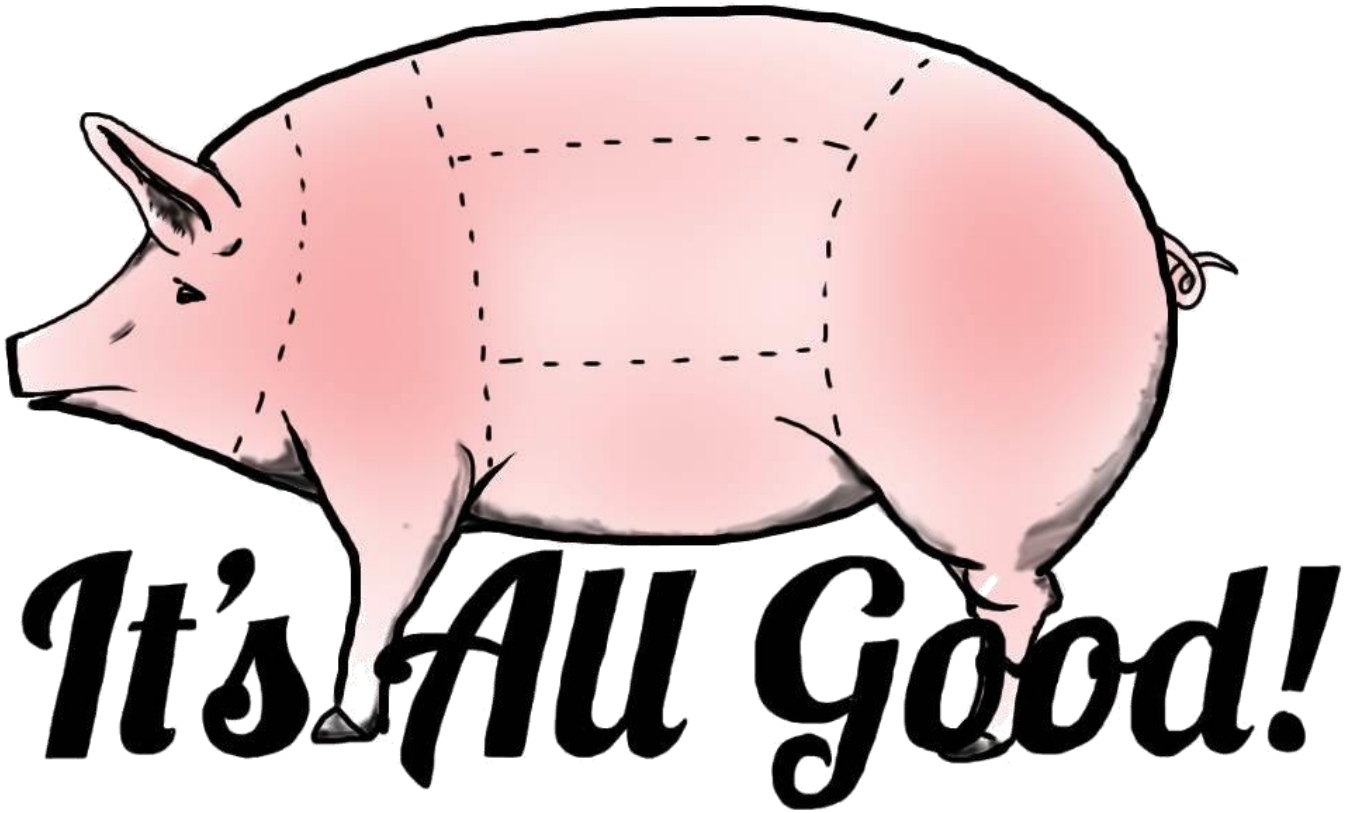
Naphtha vs Ethane Cracking Comparison



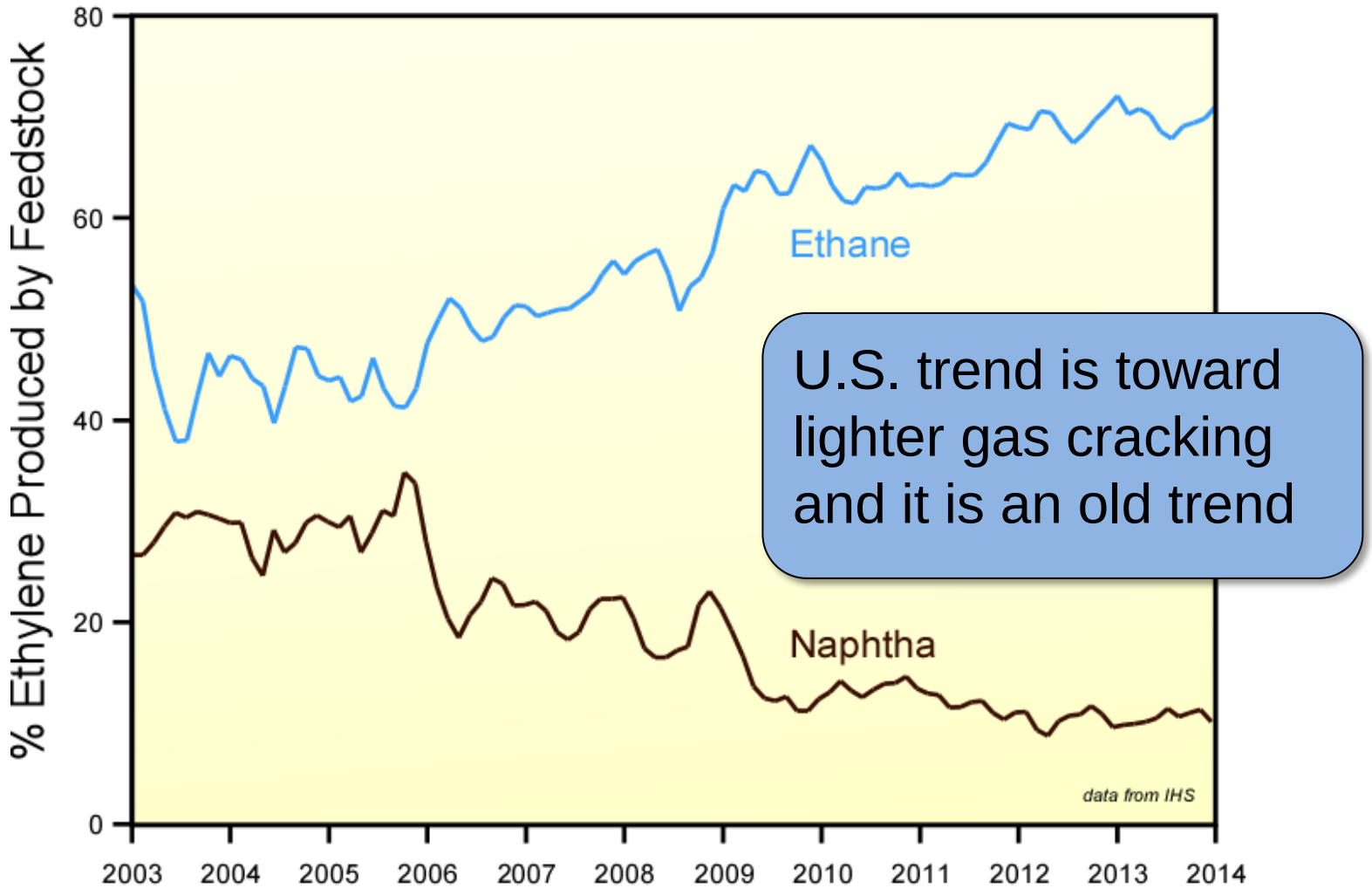


same amount of ethylene

All Reaction Products Find Uses

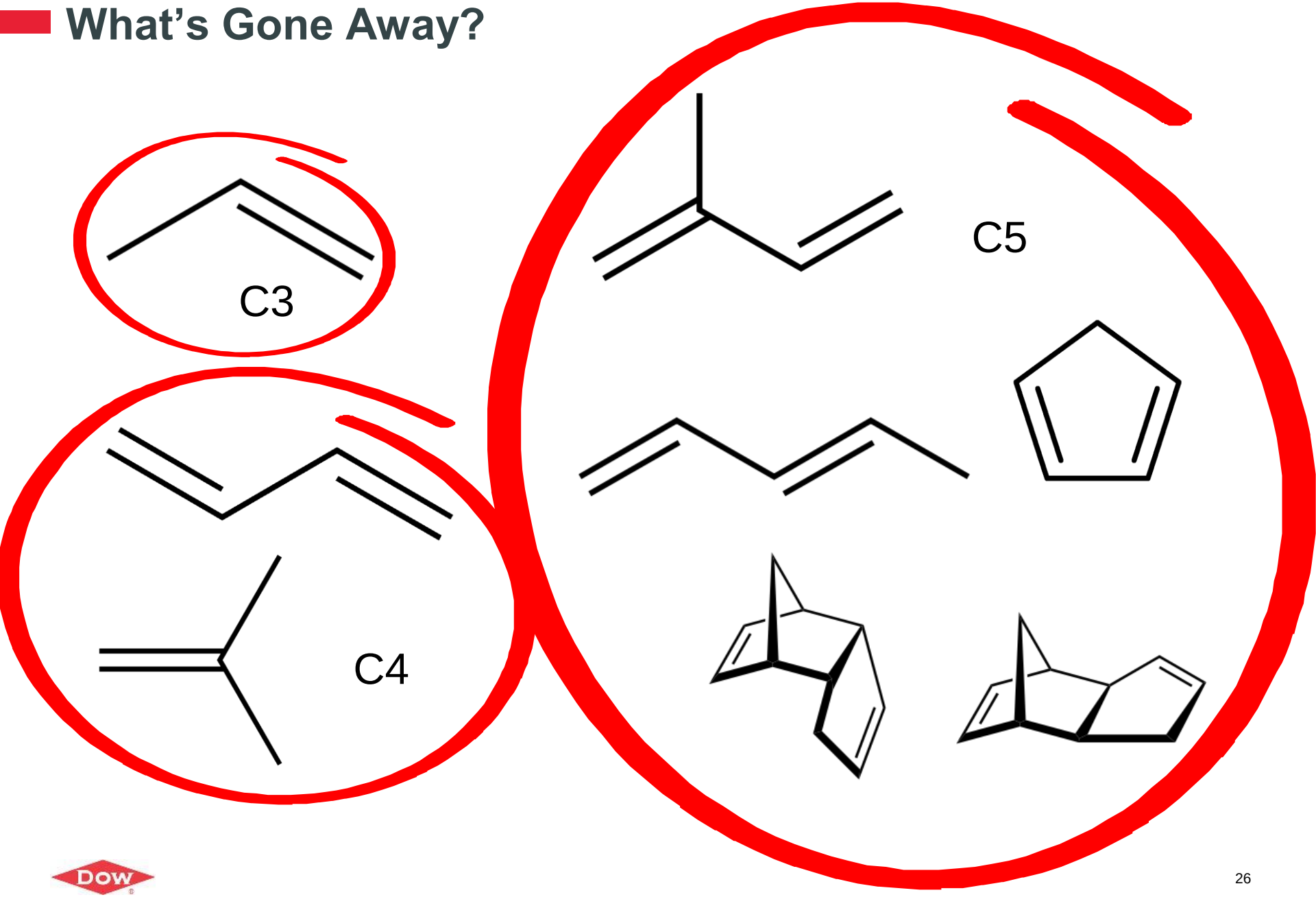


US Trend

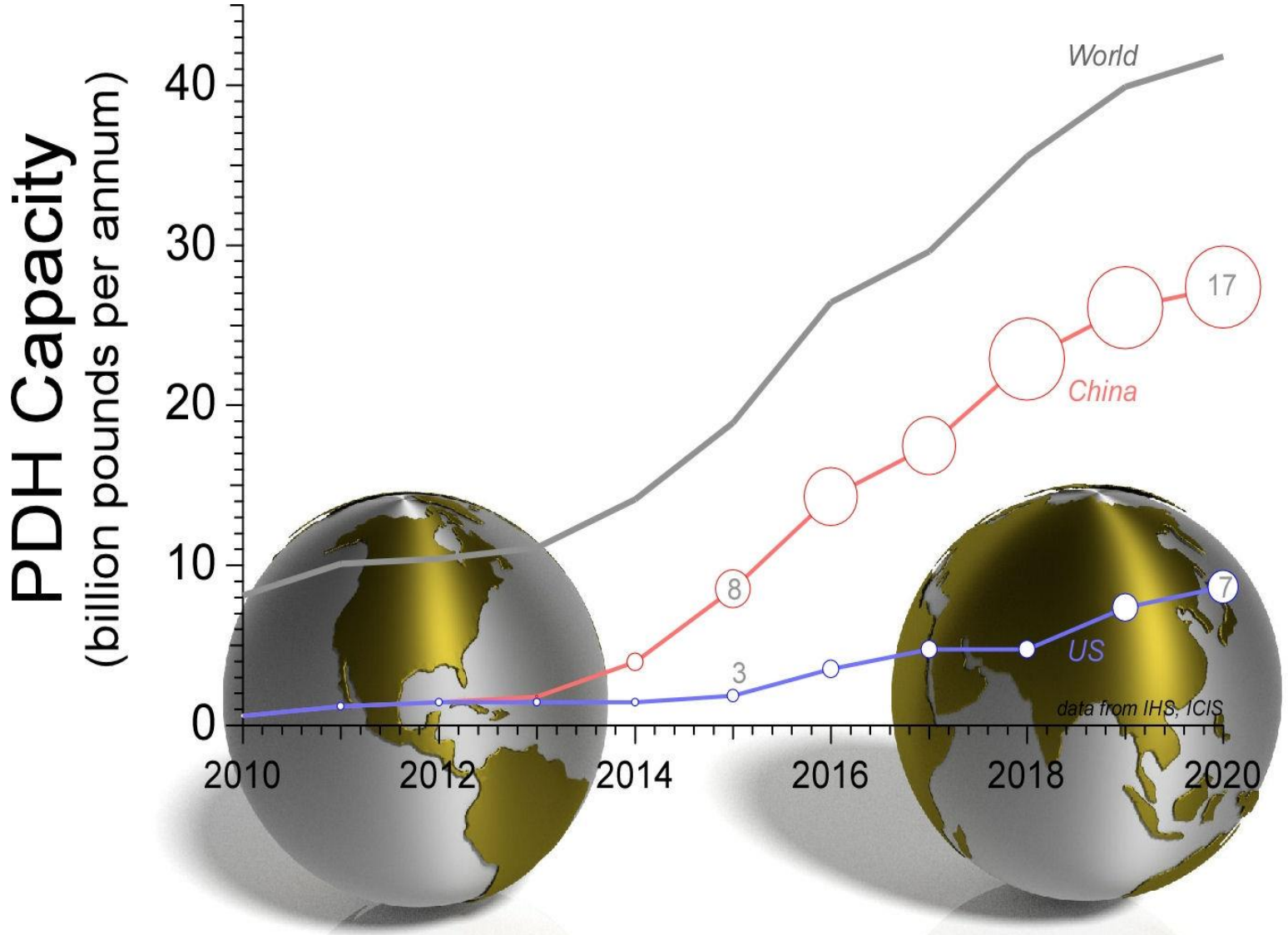


U.S. trend is toward lighter gas cracking and it is an old trend

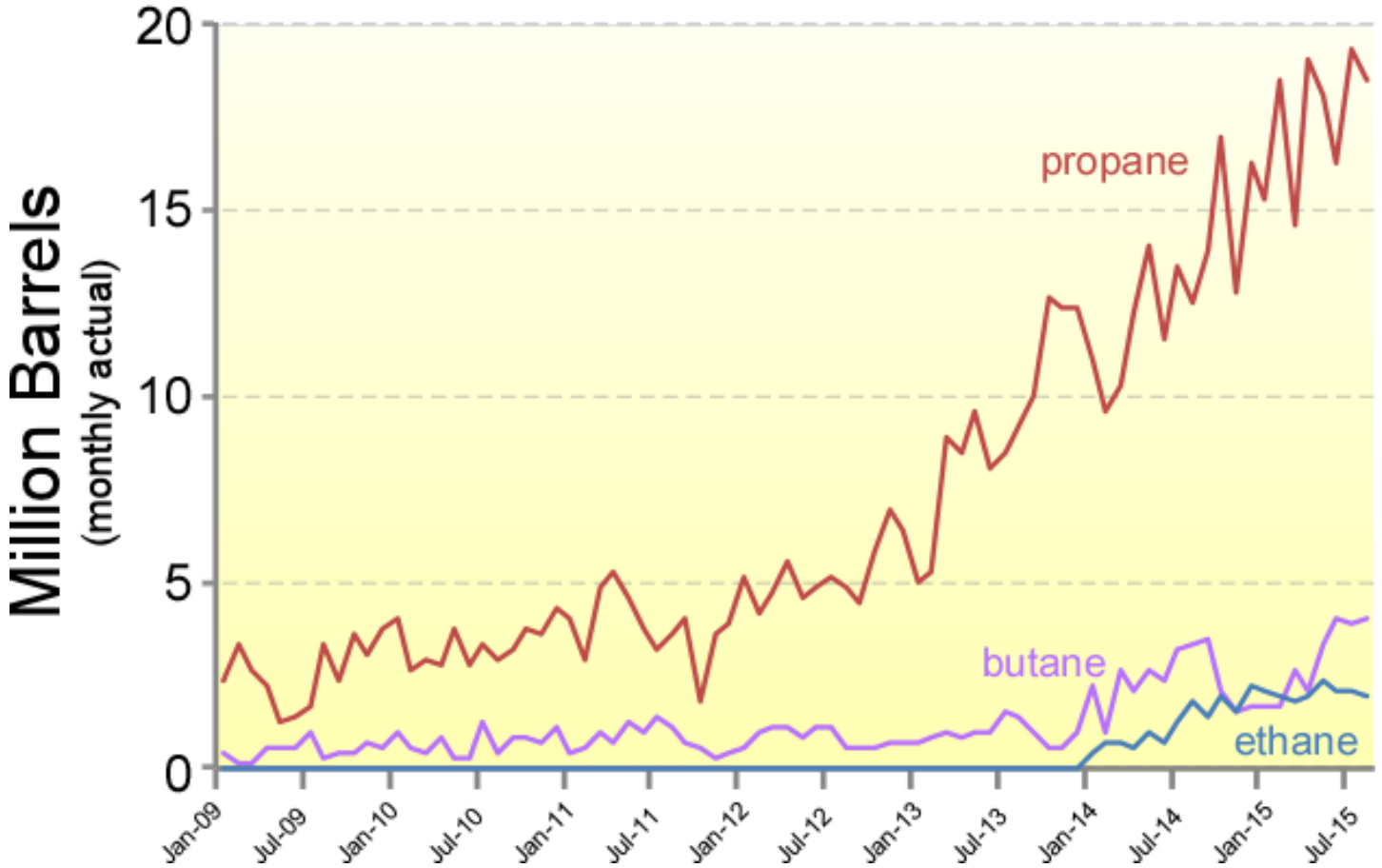
What's Gone Away?



PDH


PDH Capacity
(billion pounds per annum)
40
30
20
10
0
2010
2012
2014
2016
2018
2020
World
China
US
17
8
7
3
data from IHS, ICIS

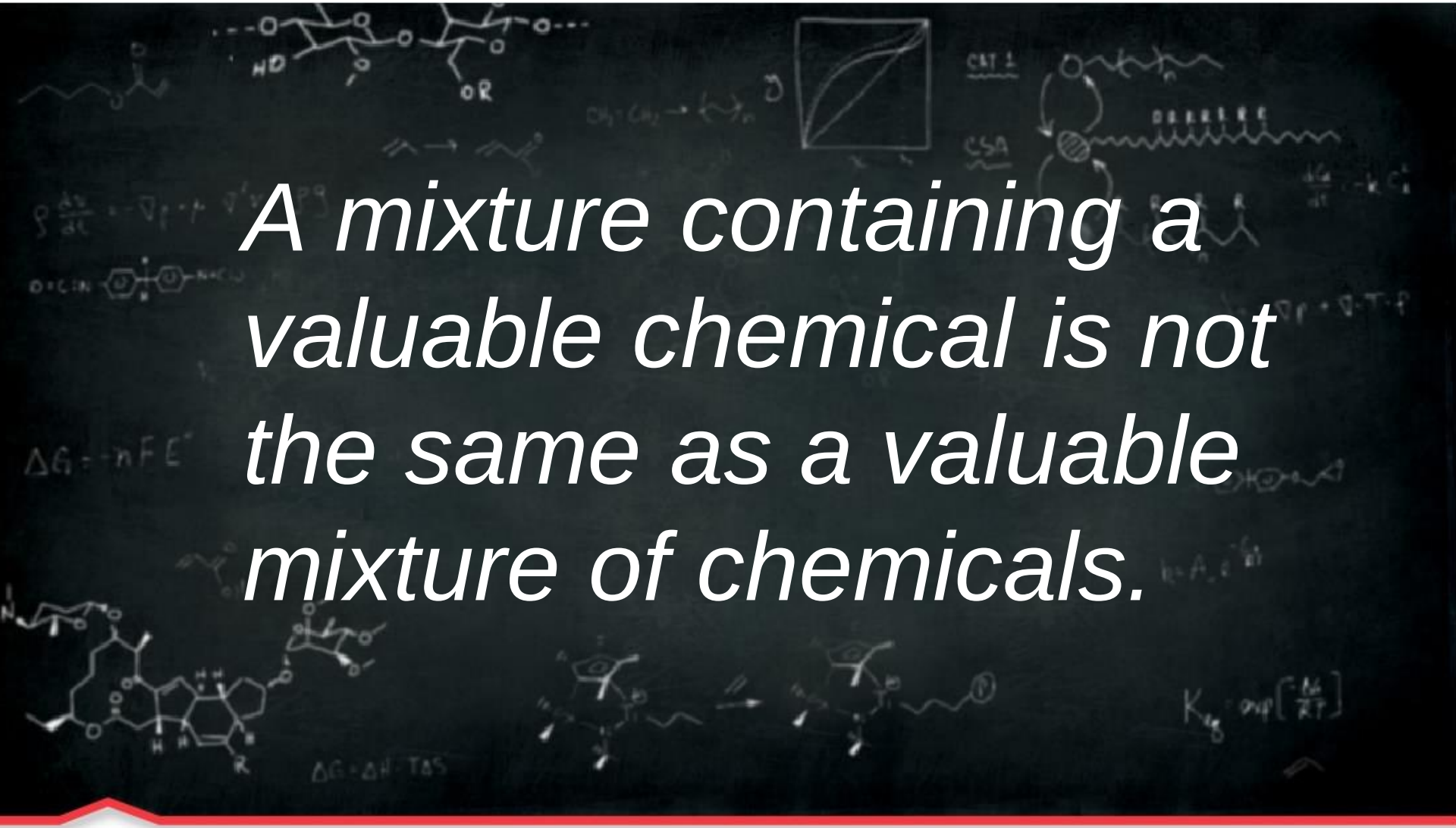
NGL Export


Million Barrels
(monthly actual)
20
15
10
5
0
propane
butane
ethane
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15

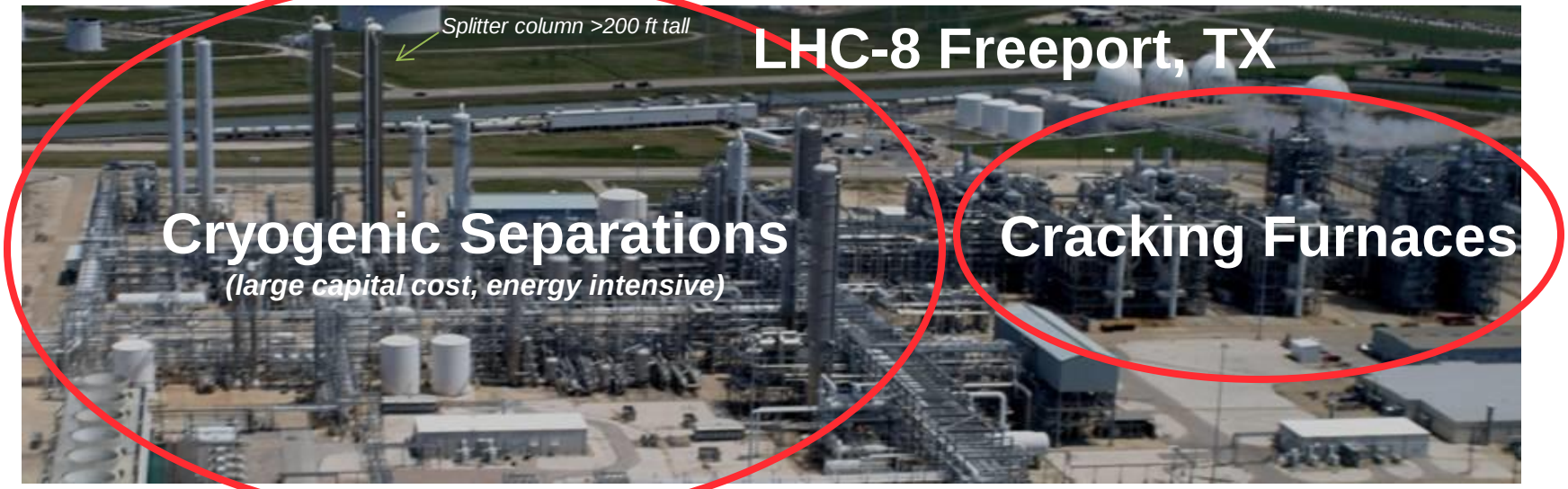
Scale Always Wins

If you are moving mass and heat around, and cost of production is most important, scale always wins.

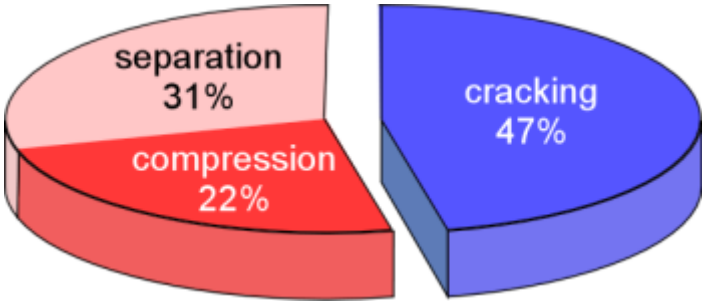
Source of Confusion



Make The Cracker Better

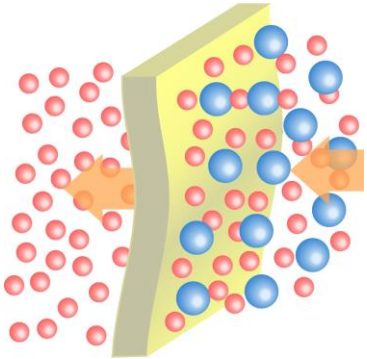


Energy Use



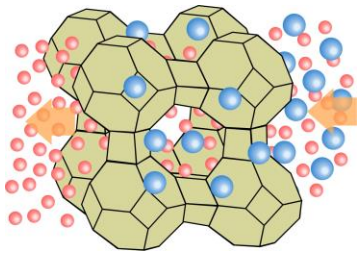
Ethane Cracker Specific
Energy Consumption

Alternatives

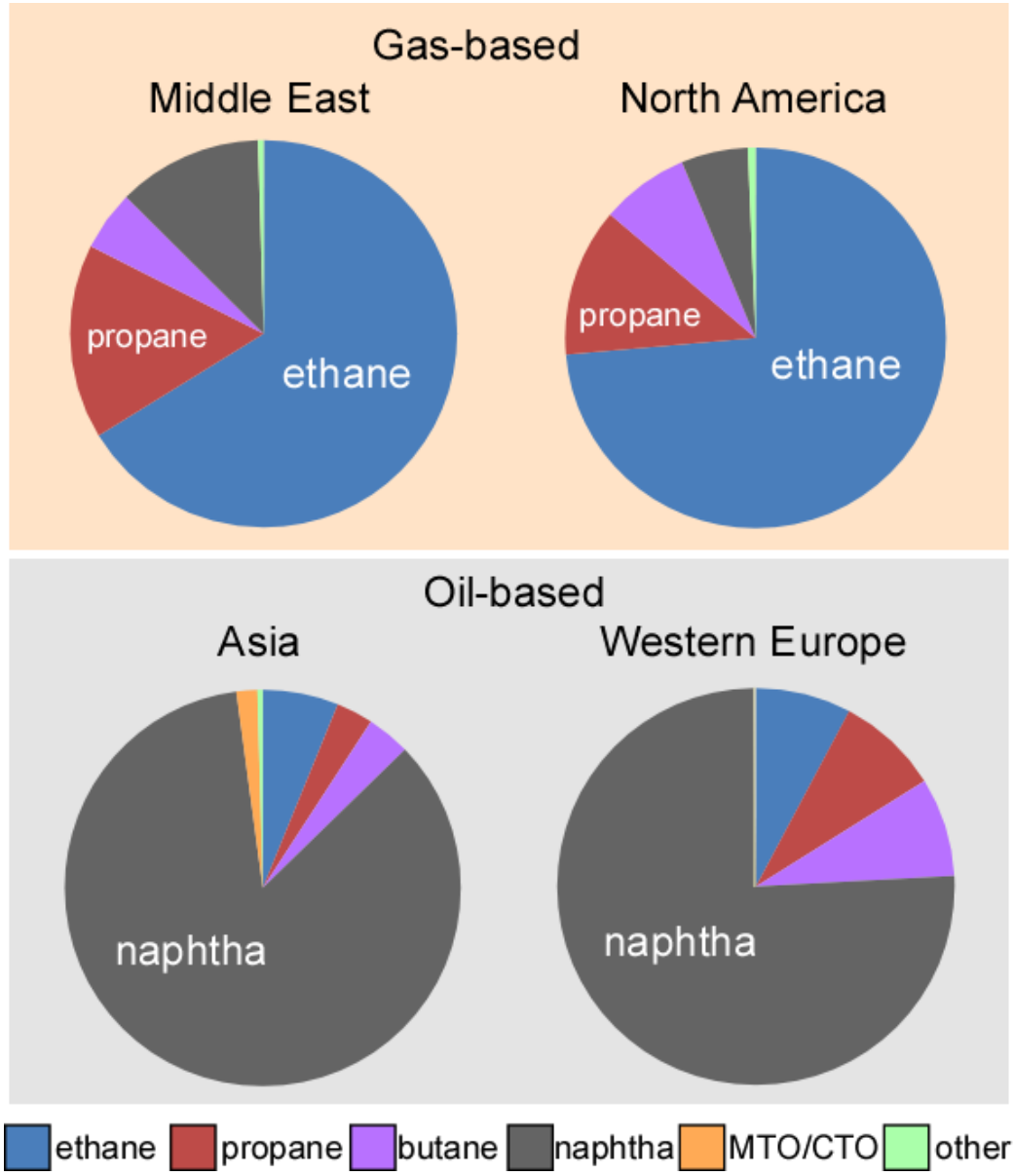


Membrane Separations

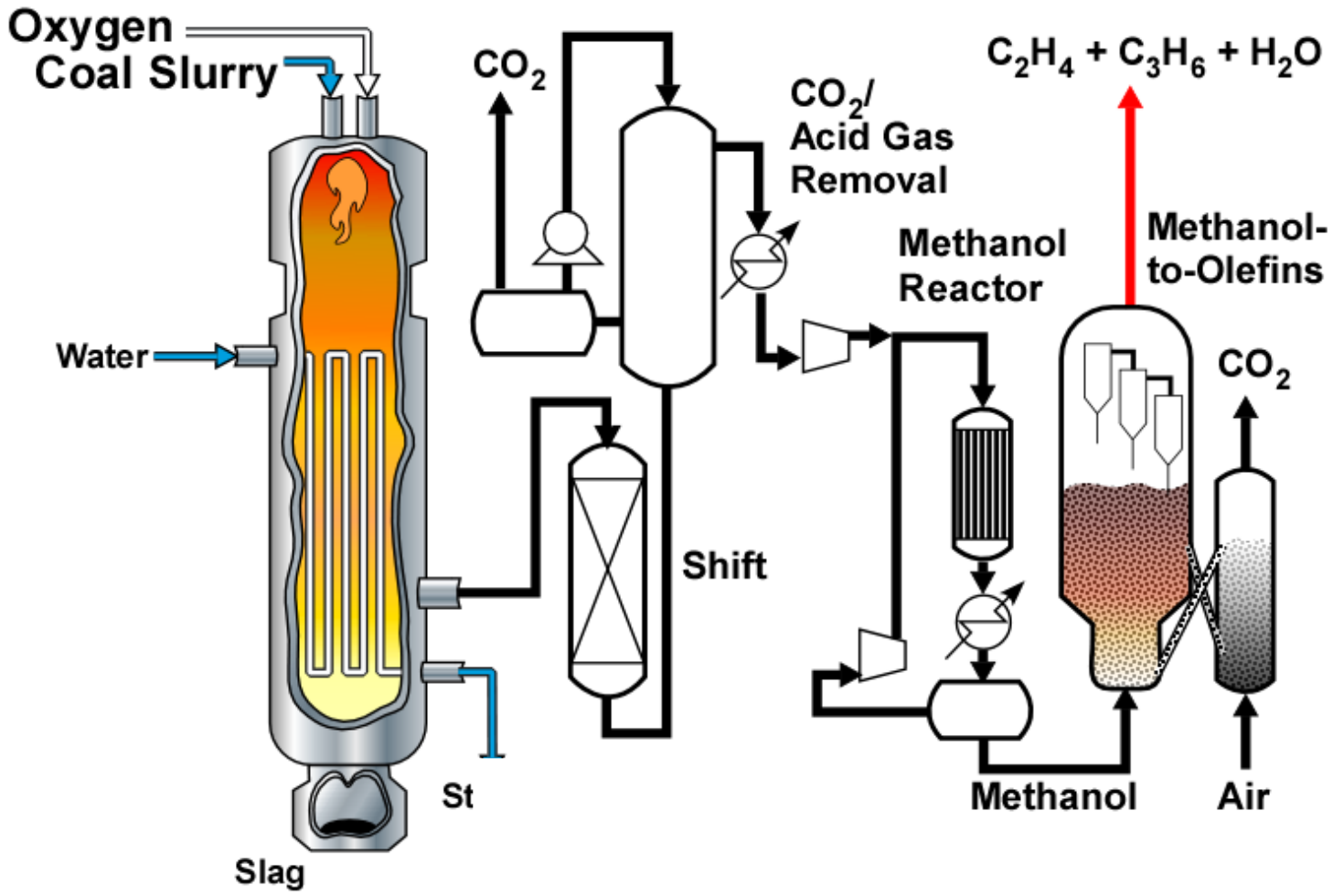
Adsorbent Separations



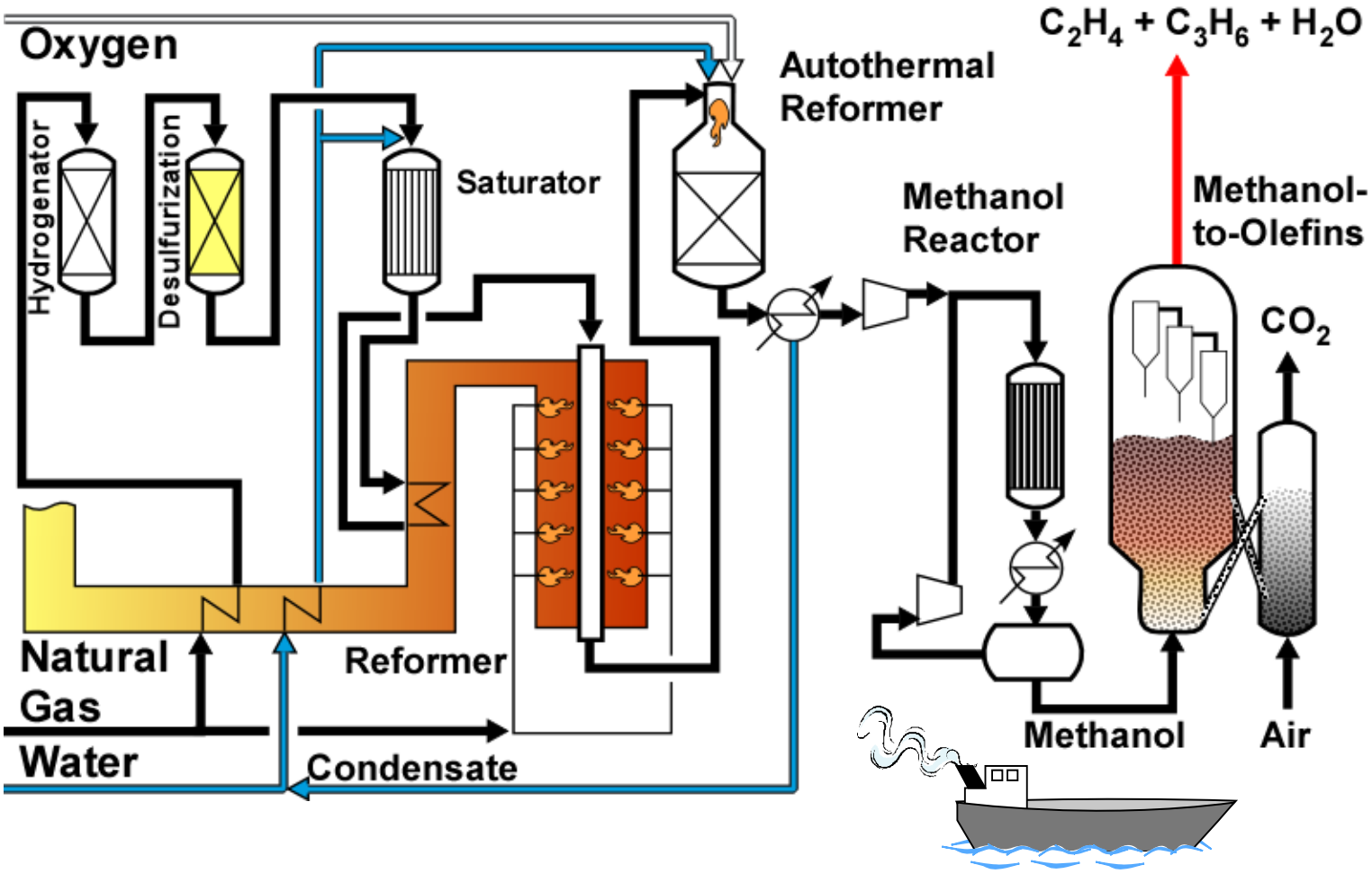
New Addition to Feedstock Slate



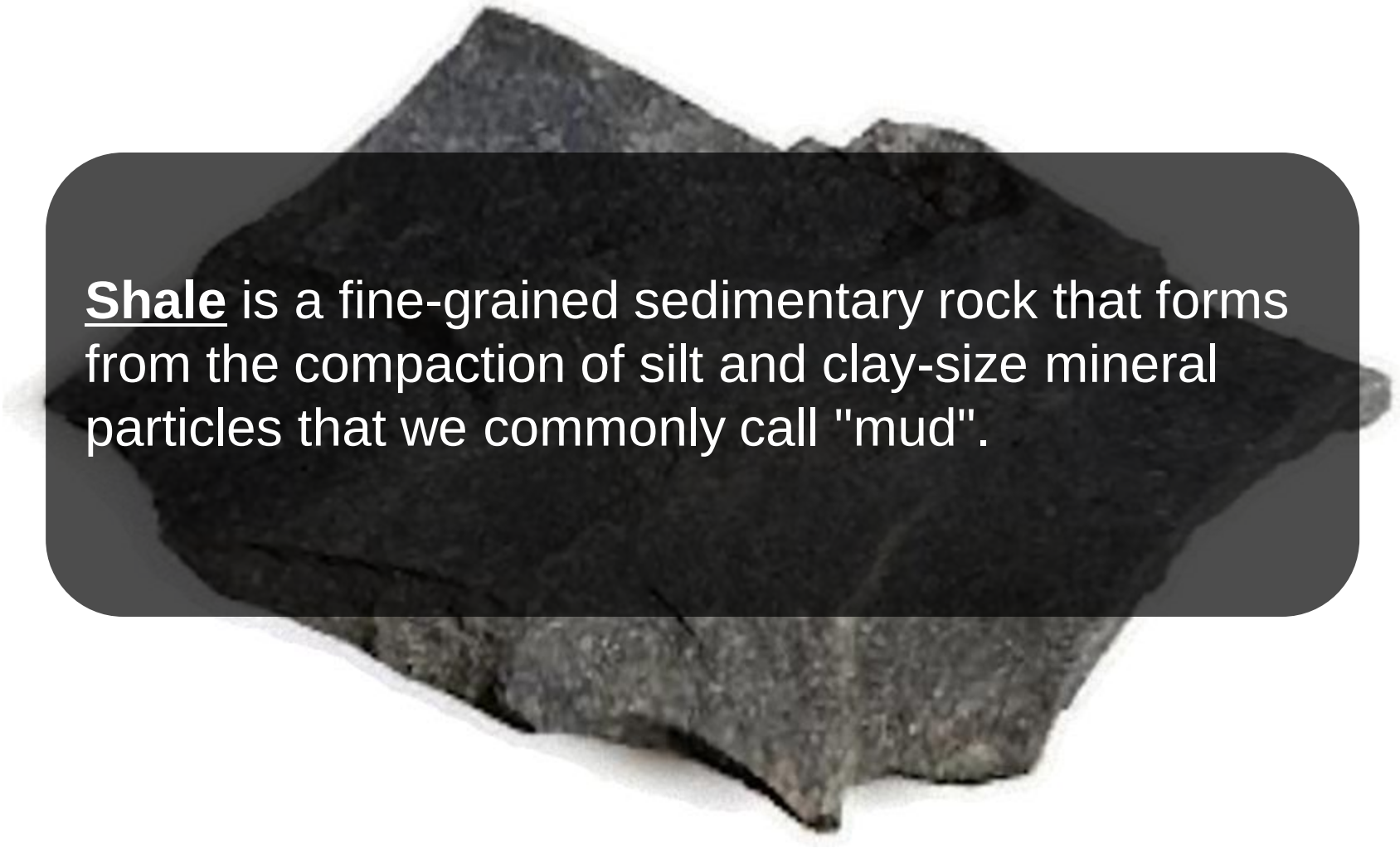
Coal-to-Olefins



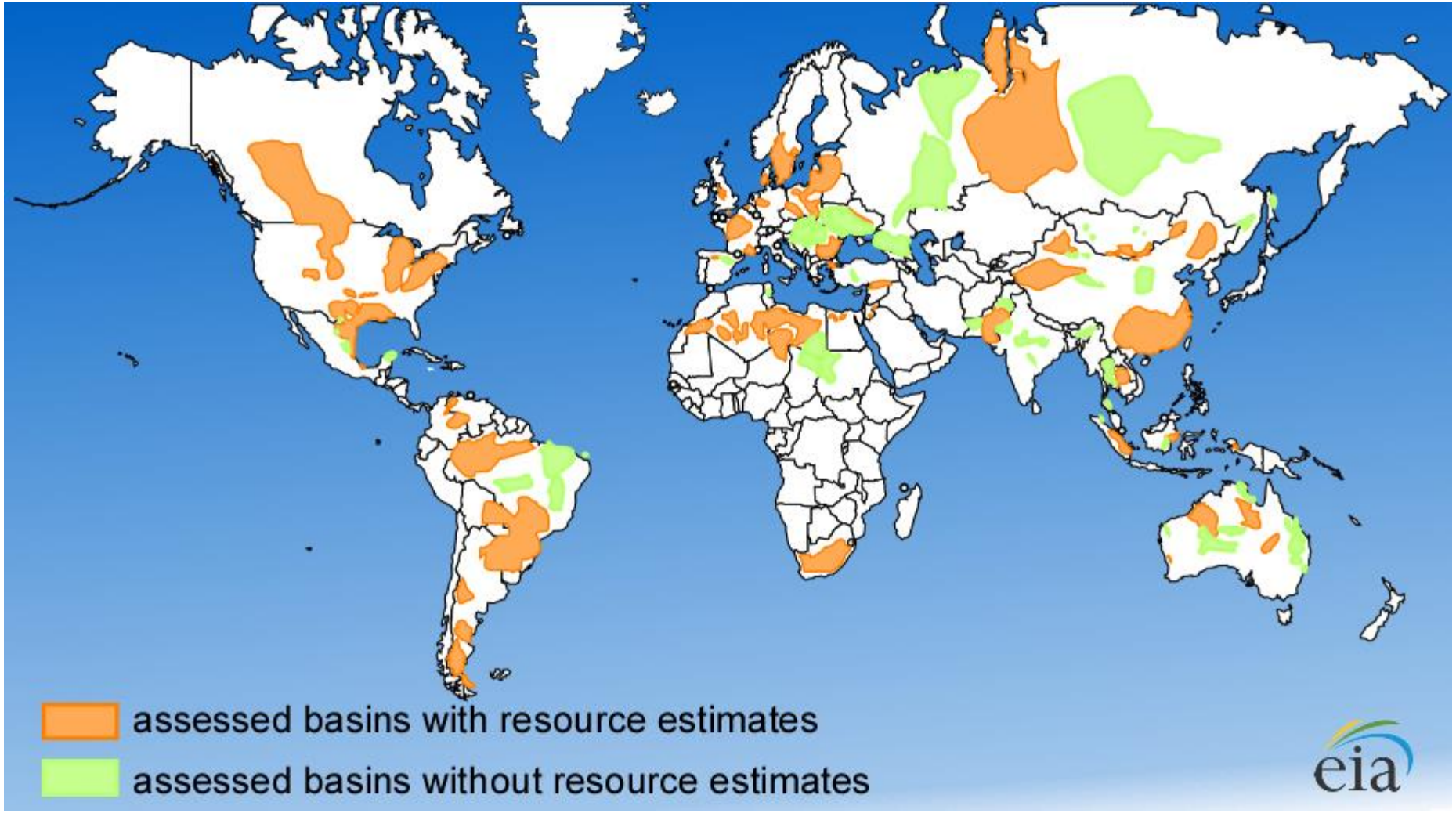
Methanol-to-Olefins



Announced Projects

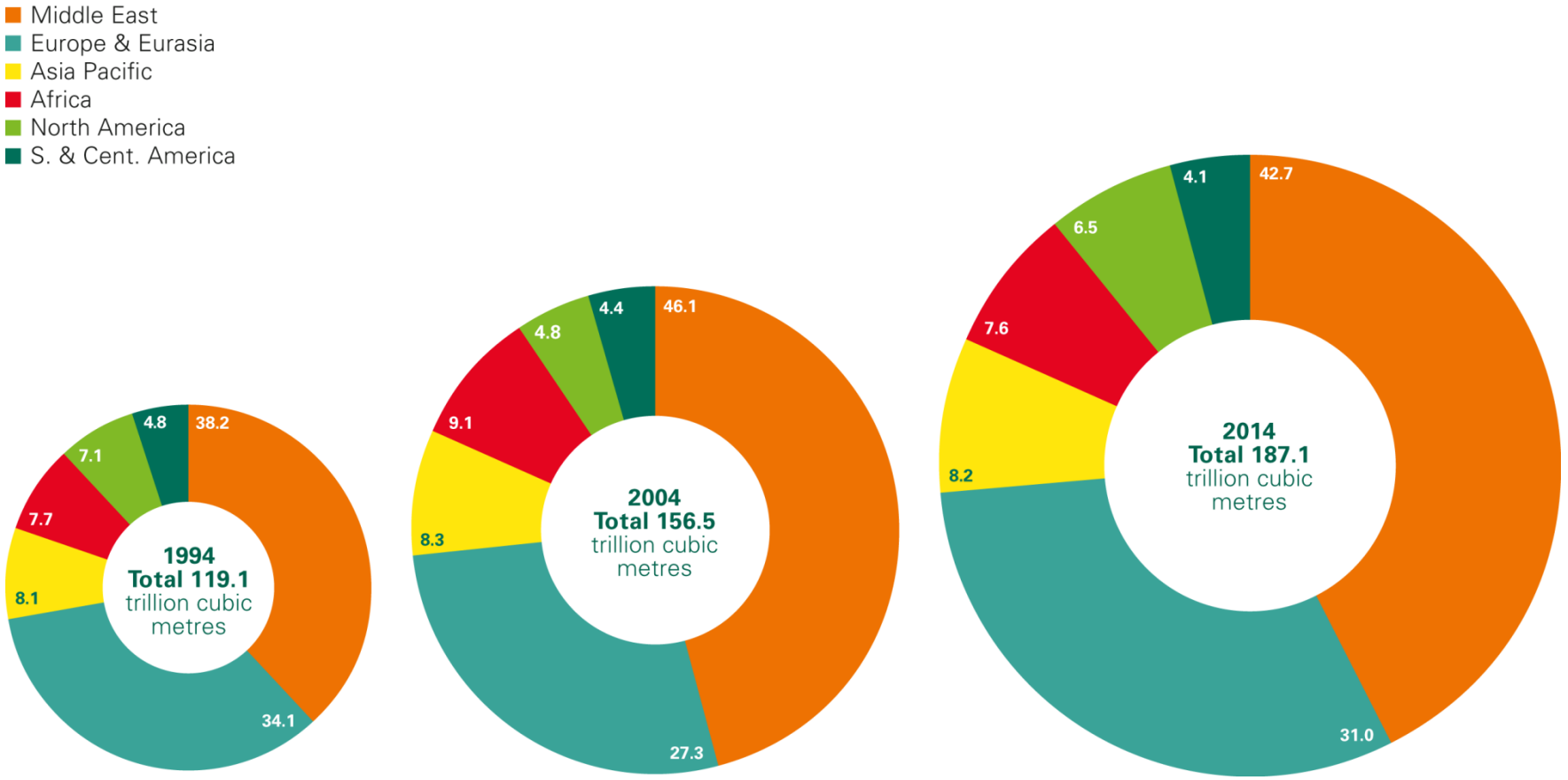


Shale is a fine-grained sedimentary rock that forms from the compaction of silt and clay-size mineral particles that we commonly call "mud".

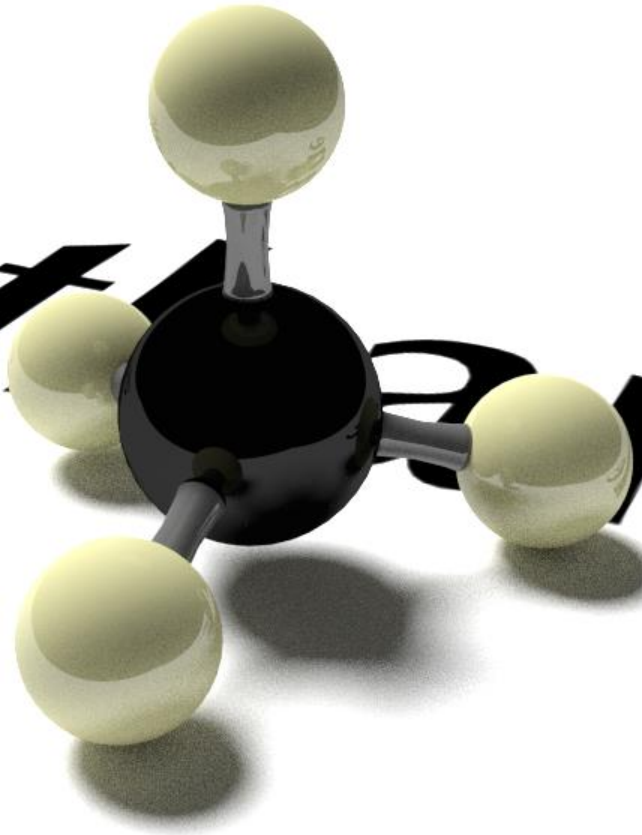

assessed basins with resource estimates
assessed basins without resource estimates
eia

Distribution of proved gas reserves: 1994, 2004 and 2014

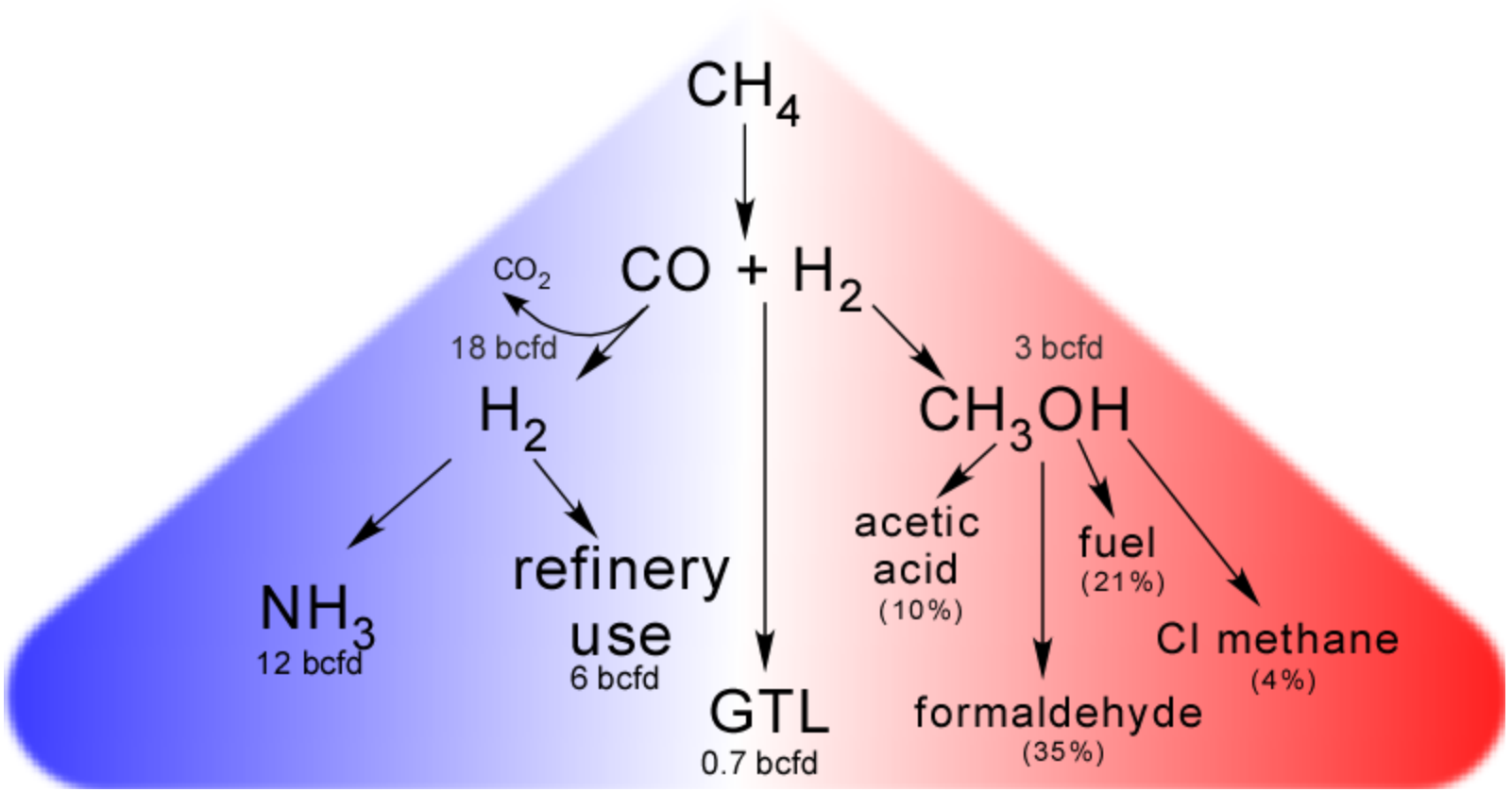
Percentage



Methane

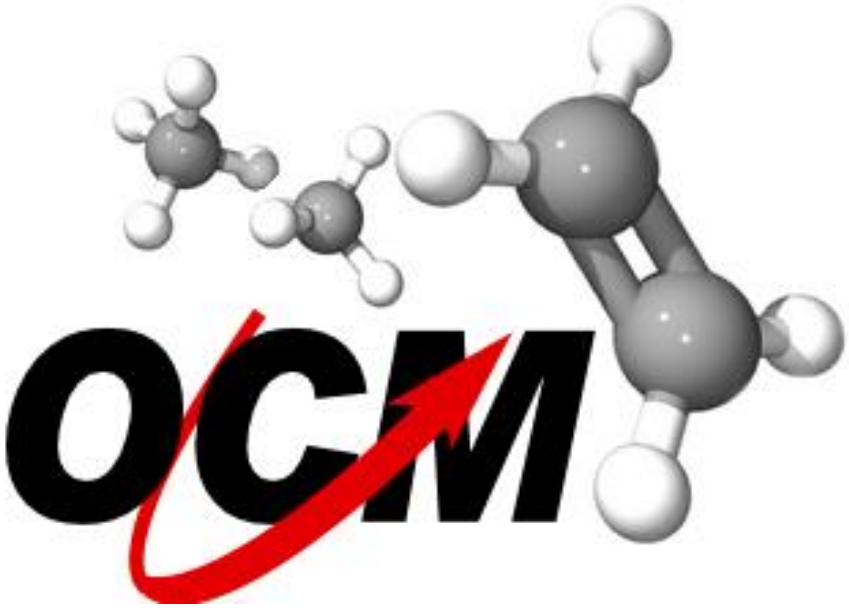


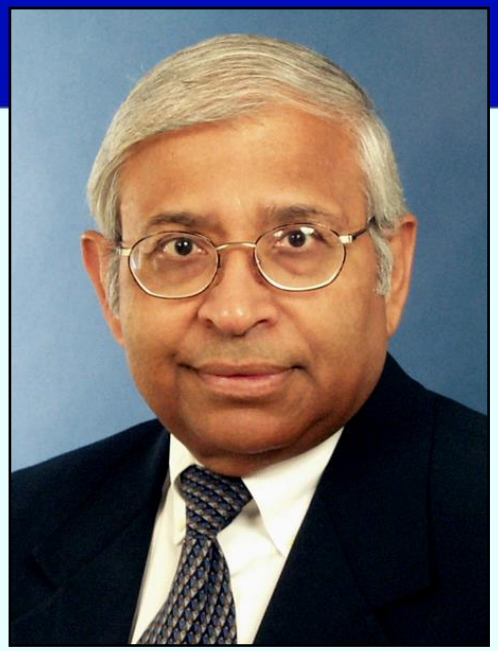
Direct Methane Use



2008 industry data from BP and CMAI

Long History





Dr. Madan M. Bhasin

Retired Corporate Fellow

The Dow Chemical Company

Elected 2006

For the development of efficient catalysts for the production of ethylene oxide and for contributions to the fundamental understanding of catalysts.

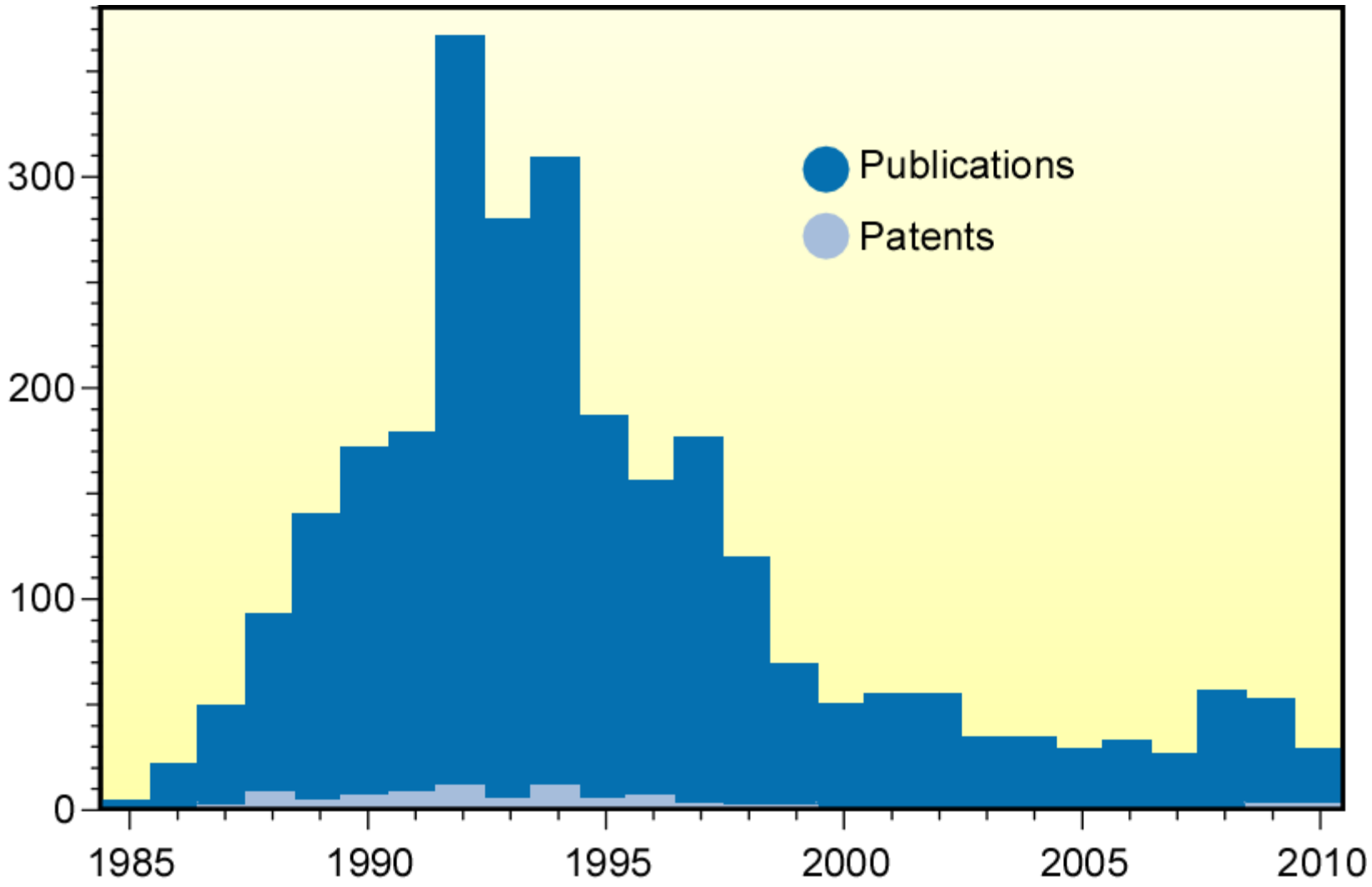
Currently:

Chief Scientific Adviser, Mid-Atlantic Technology, Research & Innovation Center

NATIONAL ACADEMY OF ENGINEERING

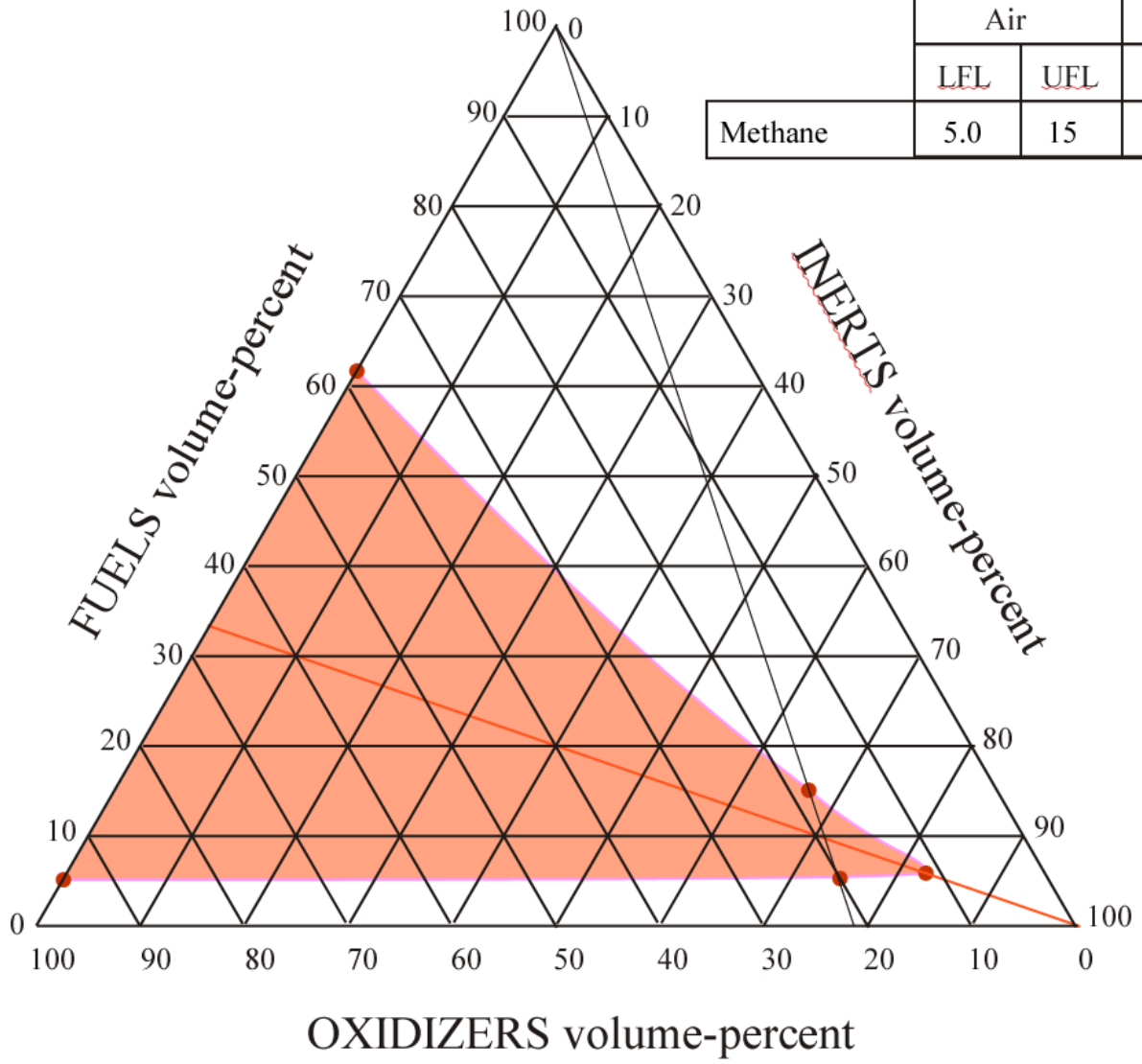
OF THE NATIONAL ACADEMIES

Activity Peaked and Fell



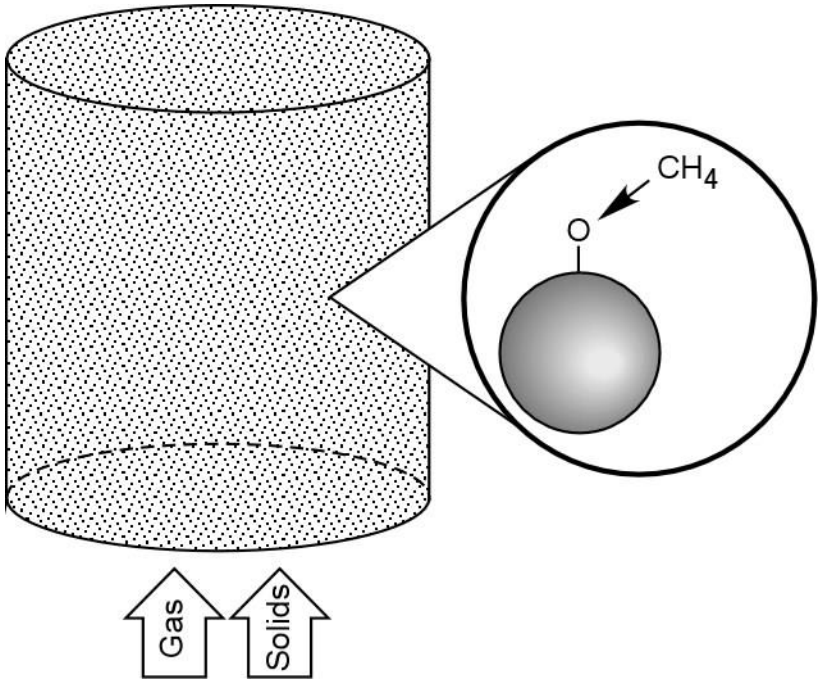
Constraints

	Air		Oxygen			
	LFL	UFL	LFL	UFL	COC	AIT
Methane	5.0	15	5.0	61.9	12	630



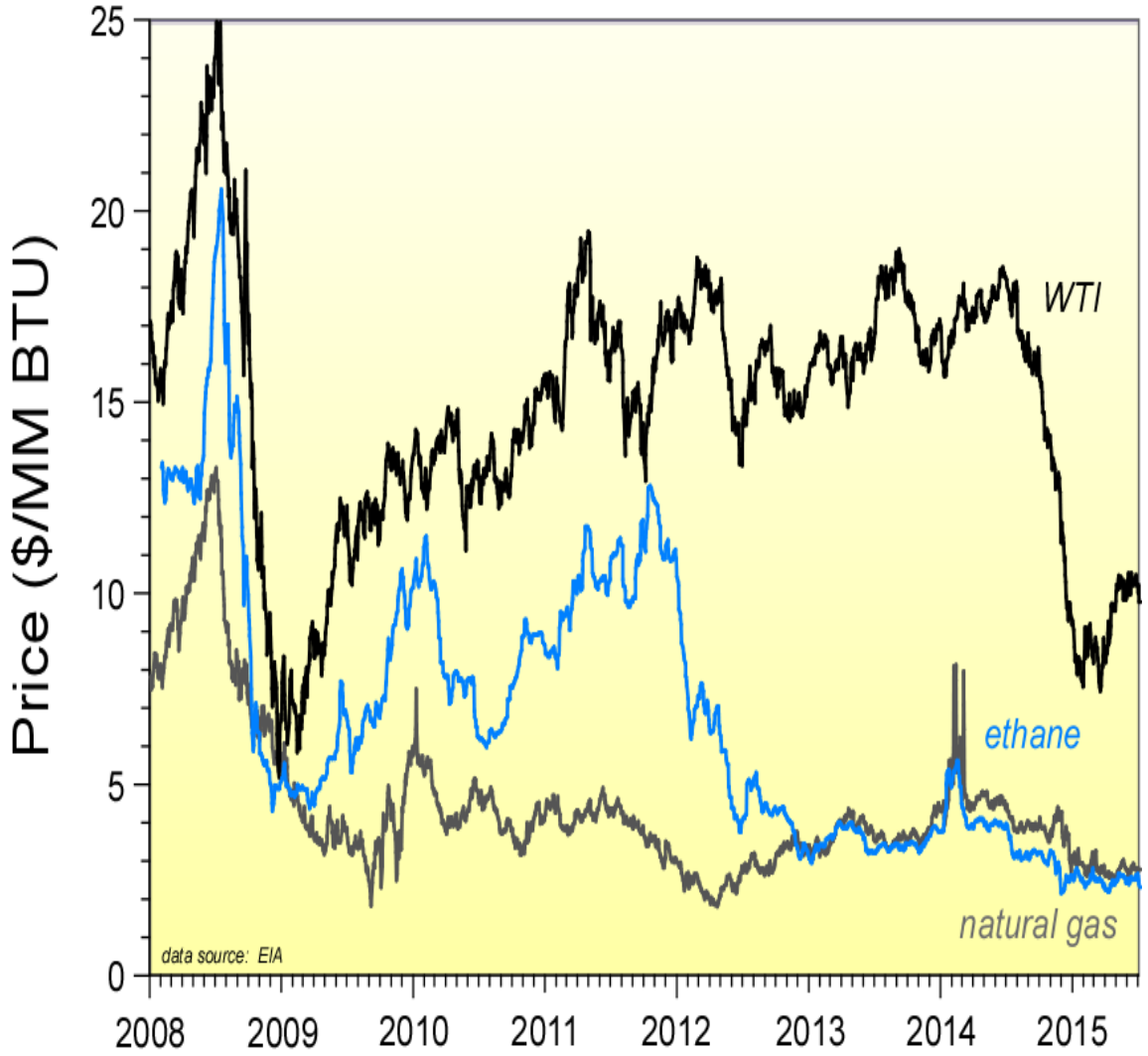
Oxygen Storage Riser Idea

- Solids density in riser sets concentration of “oxidant”
- Riser velocity sets reaction time
- Reactor constrains both capacity and rate



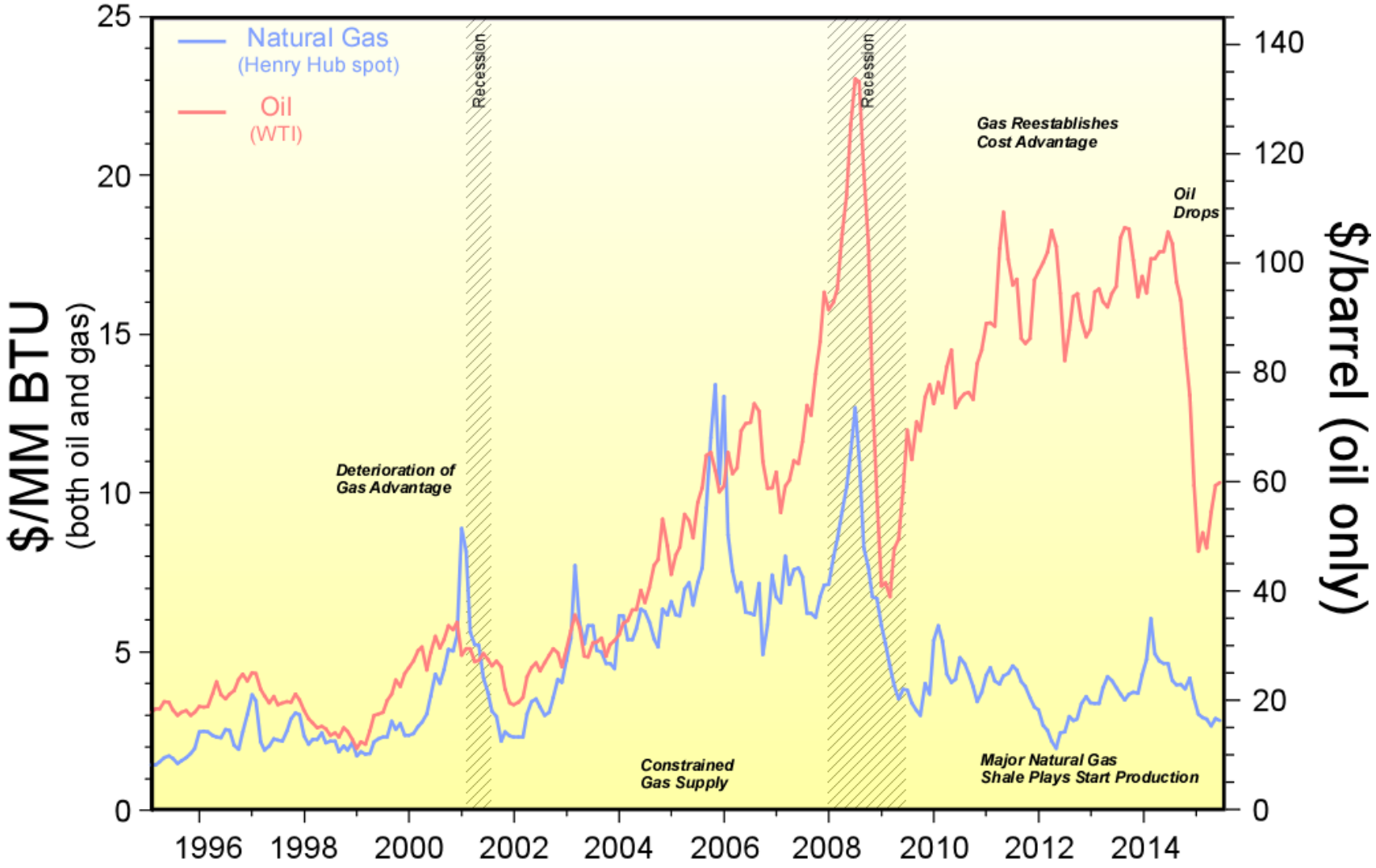
For it to work, must have oxygen capacity, rate and regenerability.

Methane

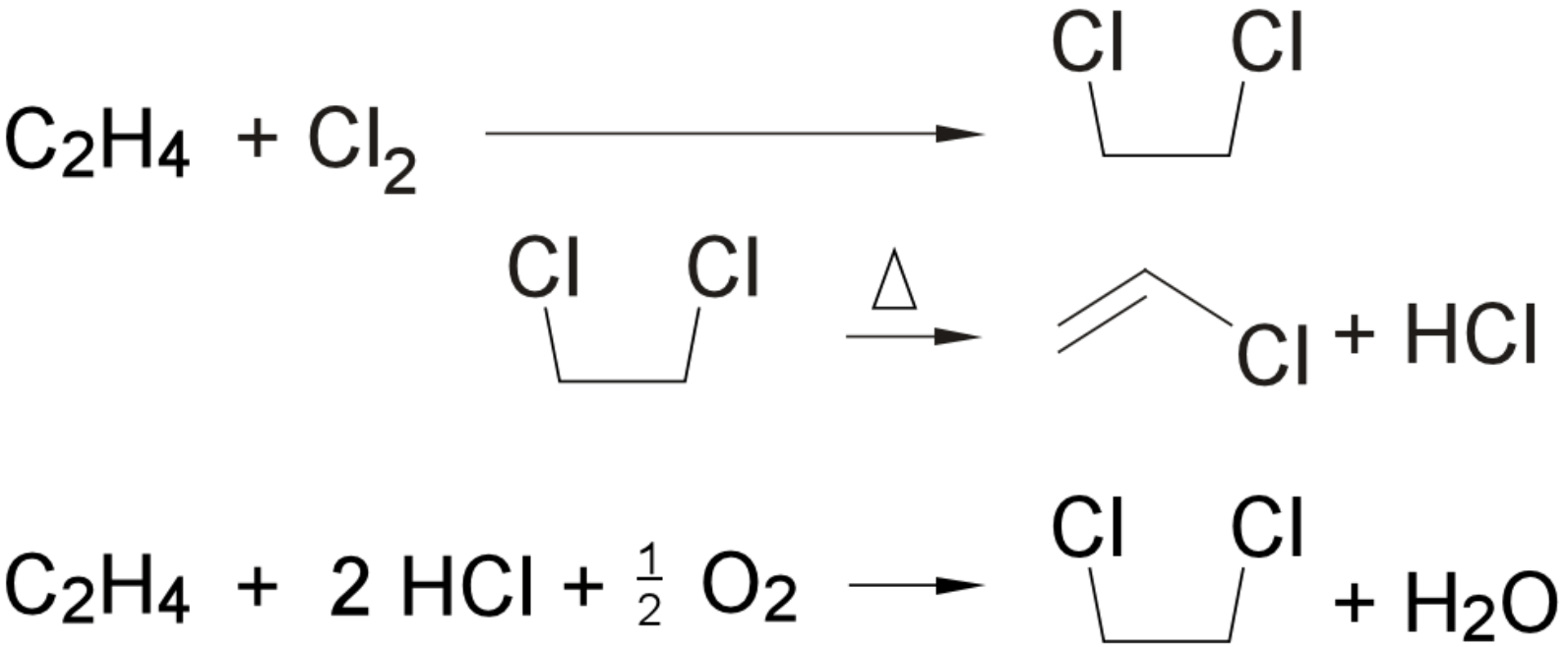

Price ($/MM BTU)
25
20
15
10
5
0
2008
2009
2010
2011
2012
2013
2014
2015
WTI
ethane
natural gas
data source: EIA


Case Study

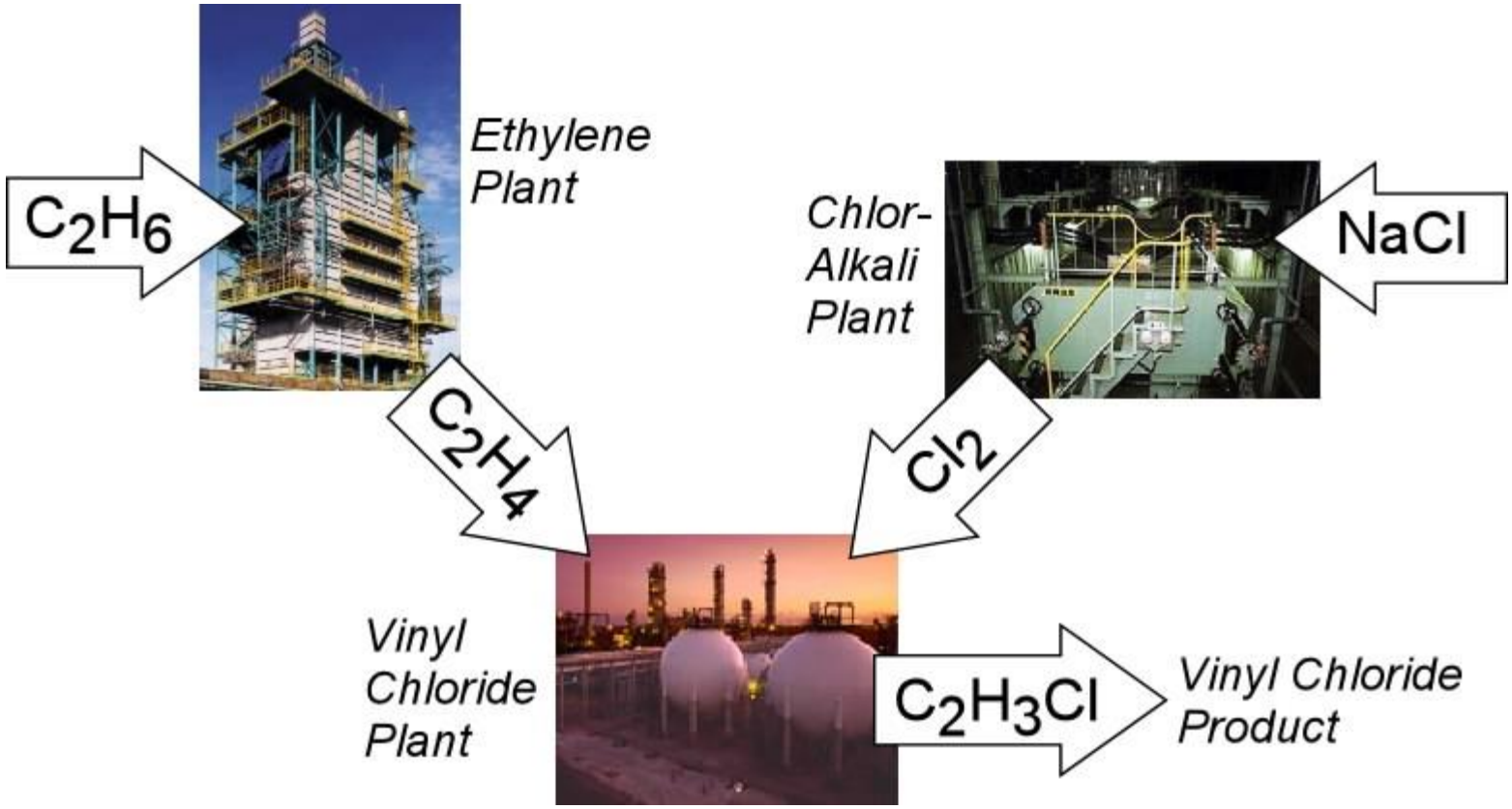
Energy Cost


Natural Gas
(Henry Hub spot)
Oil
(WTI)
Recession
Recession
Deterioration of
Gas Advantage
Constrained
Gas Supply
Gas Reestablishes
Cost Advantage
Oil
Drops
Major Natural Gas
Shale Plays Start Production
$/MM BTU
(both oil and gas)
$/barrel (oil only)
0
5
10
15
20
25
0
20
40
60
80
100
120
140
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

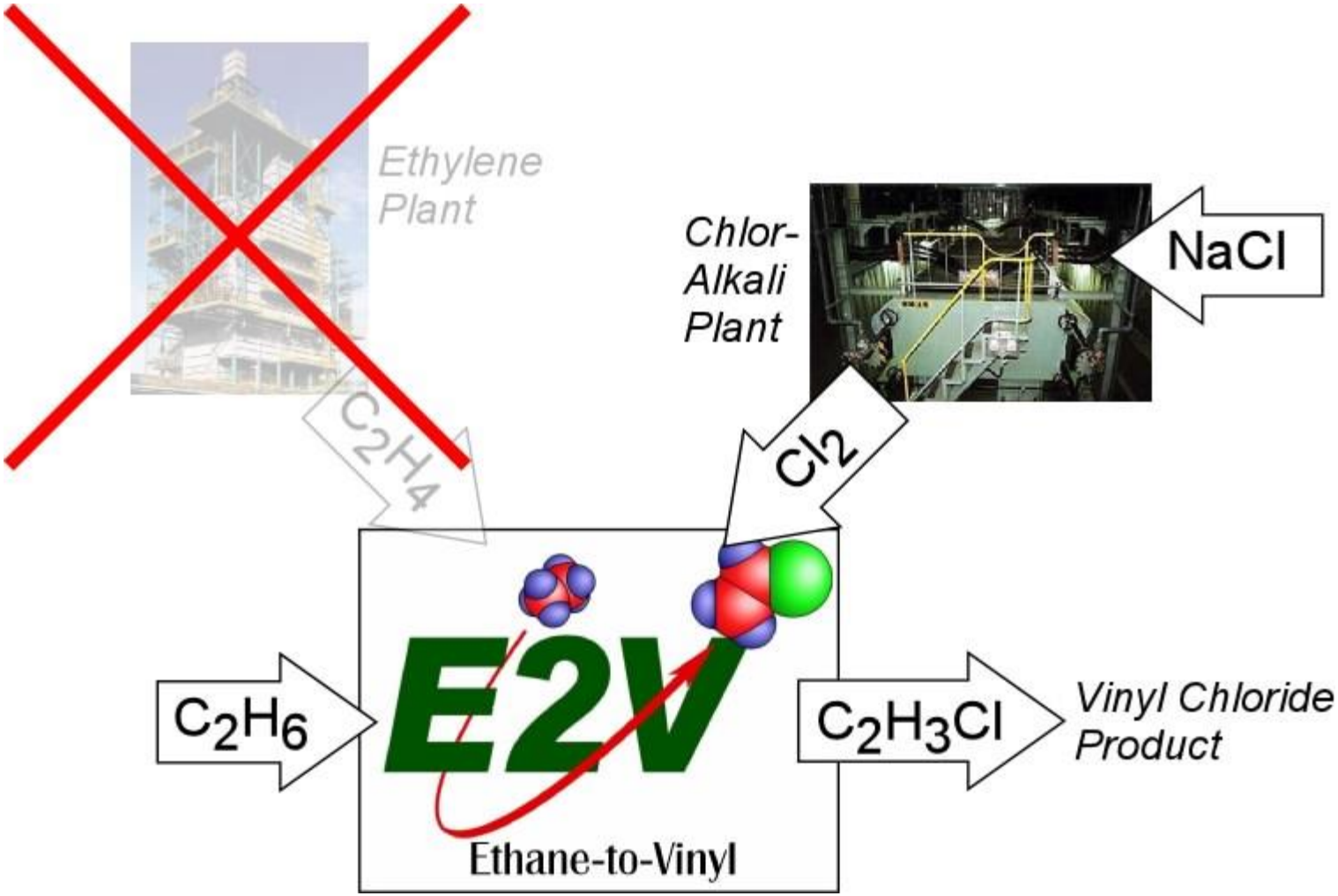
Conventional Production



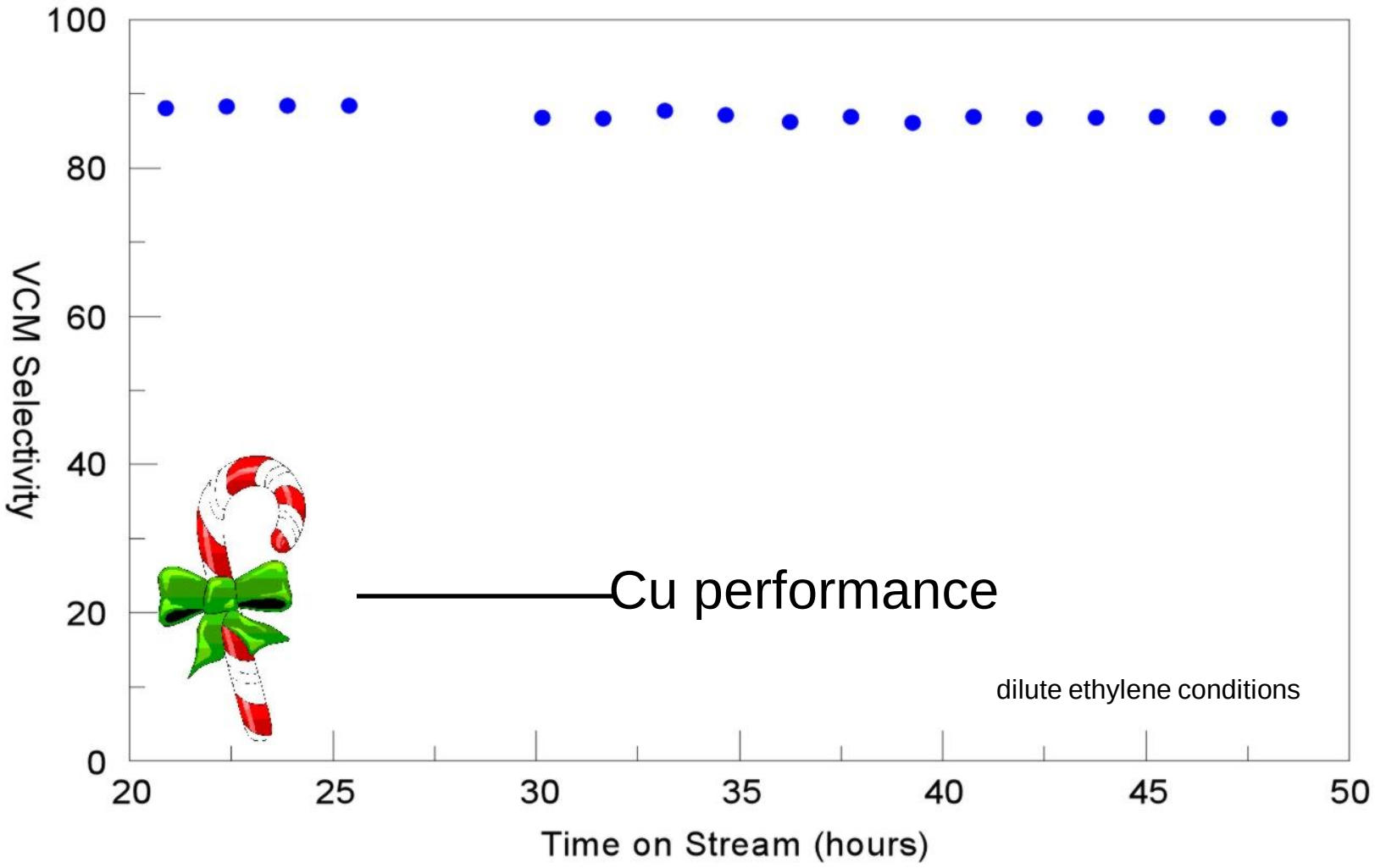
Conventional VCM



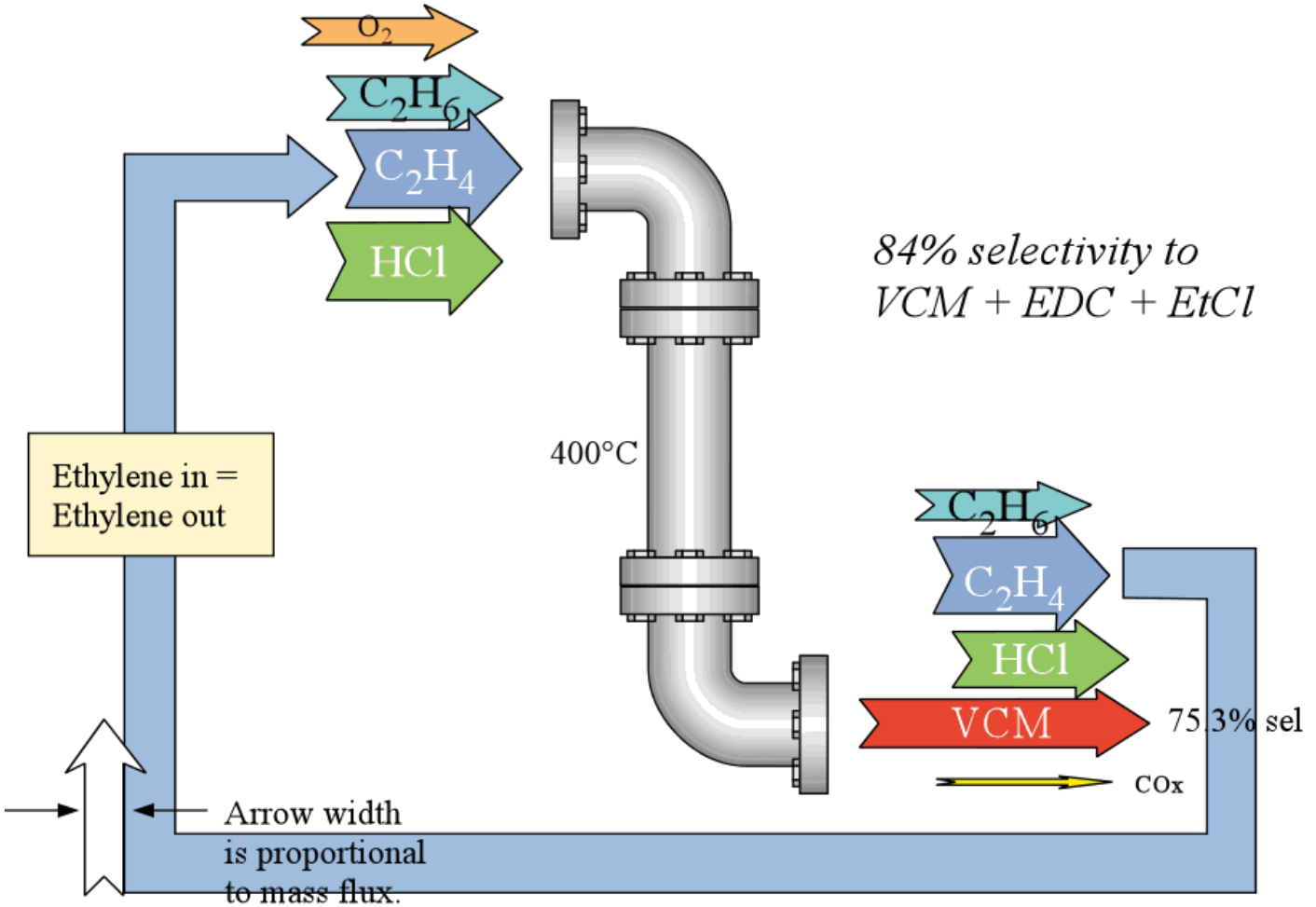
E2V


Ethylene Plant
C_2H_4
Chlor-Alkali Plant
NaCl
Cl_2
C_2H_6
E2V
Ethane-to-Vinyl
C_2H_3Cl
Vinyl Chloride Product

Breakthrough

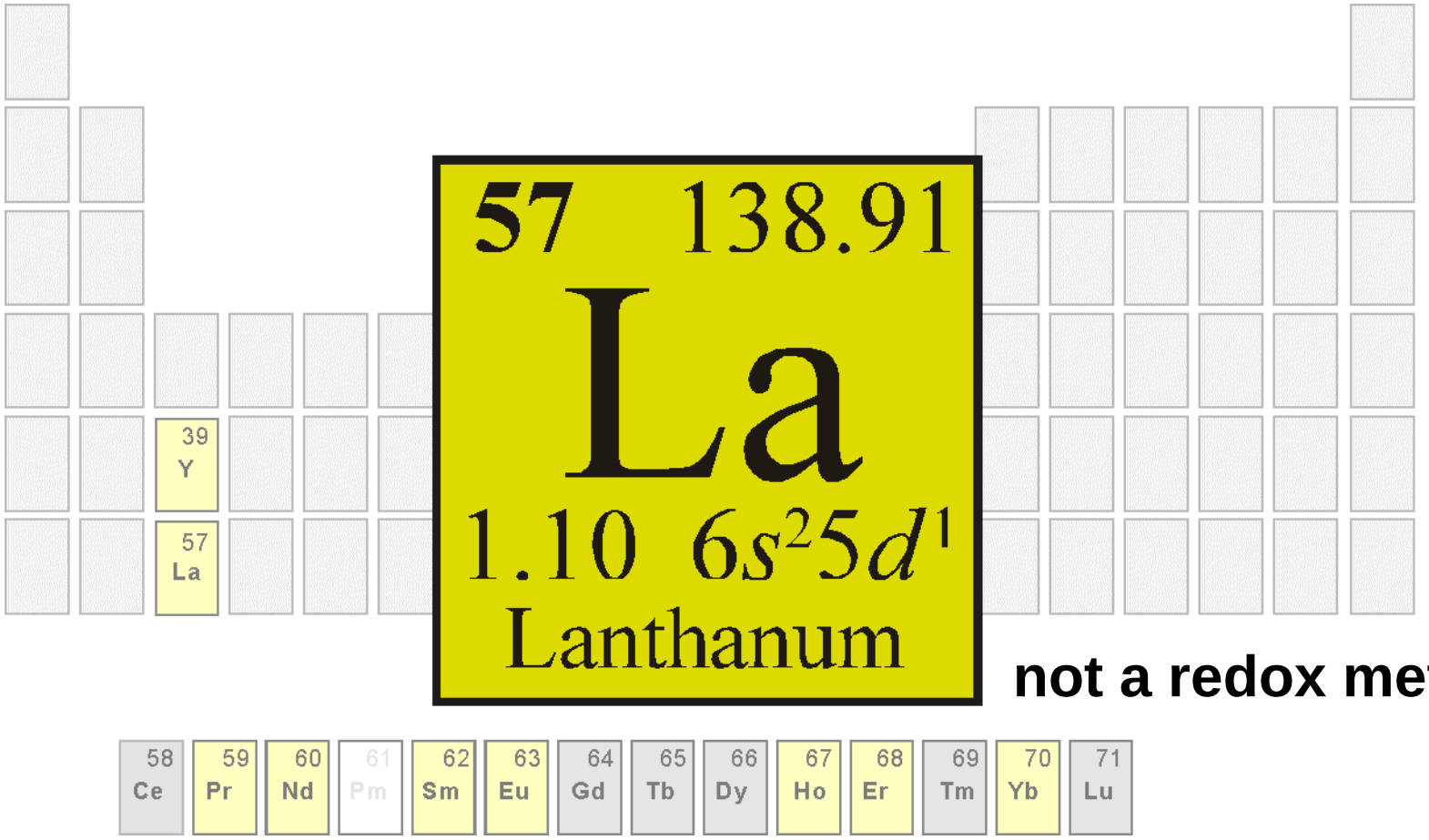


Lab Results



1/21/99 R1

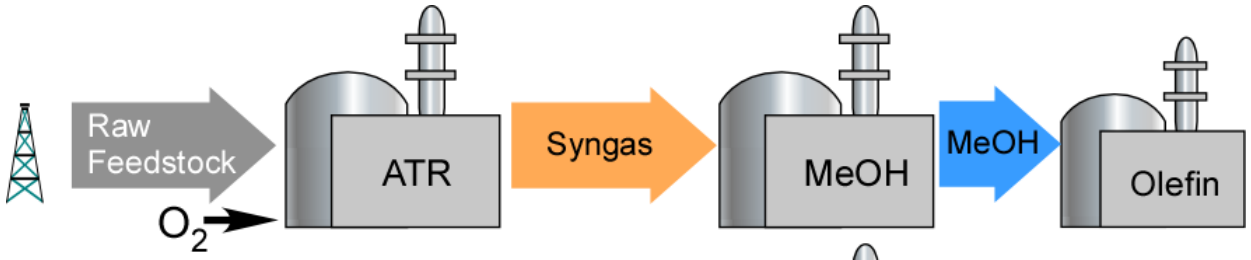
Lanthanide Catalyst



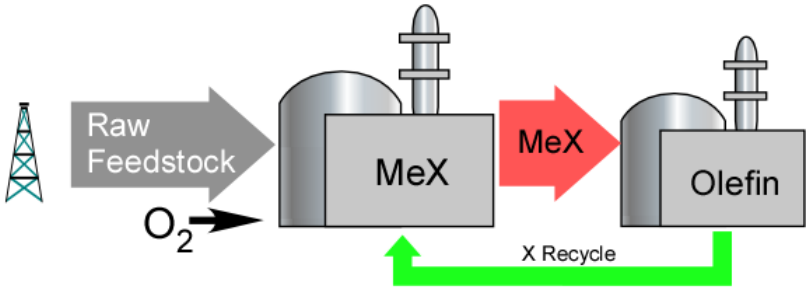
not a redox metal!

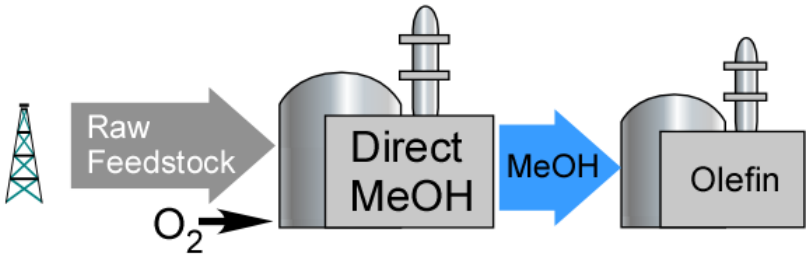
Options for Olefins

Syngas / MeOH

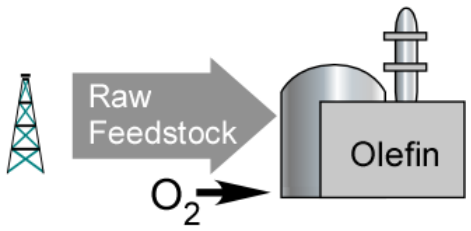


Avoid syngas

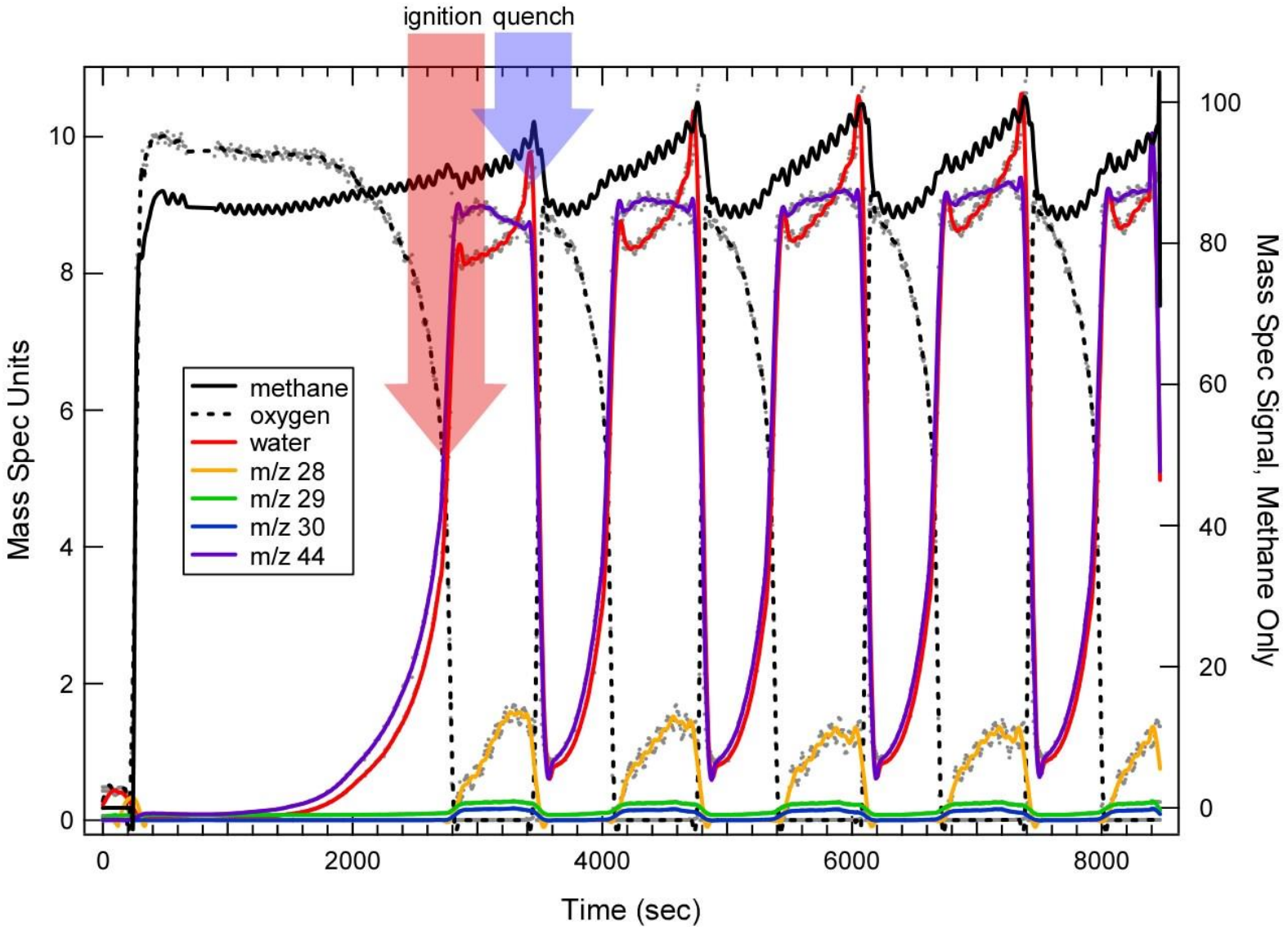




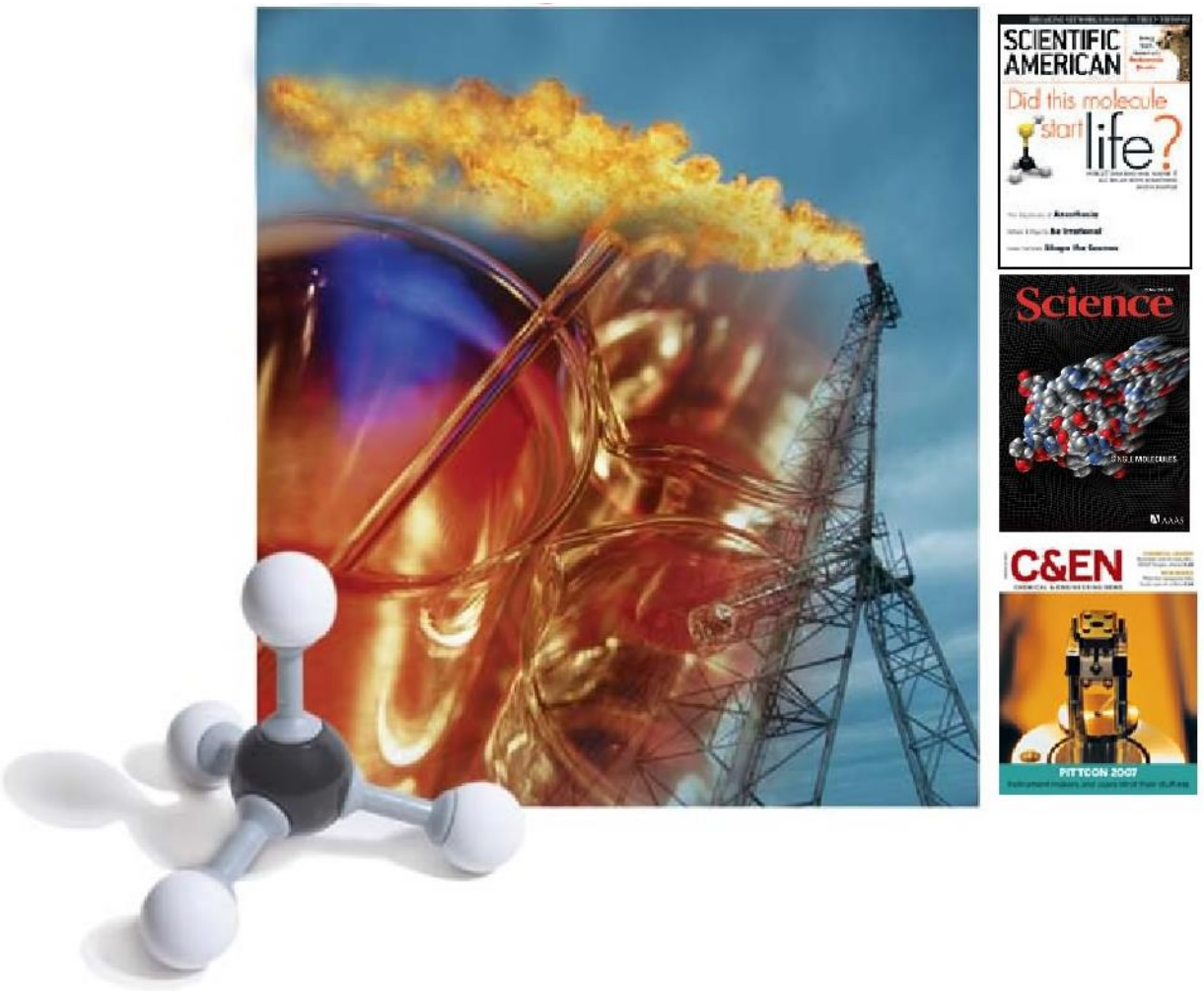
Avoid intermediates
(methane coupling)



Experience From 2004



The Dow Methane Challenge



1991 Top 50 U.S. Chemical Companies

1991 Top 50 U.S. Chemical Companies Today

updated from version shown in on 10 Sept 2015

Chemical Industry Key Concepts

- Capital-*don't want to spend it*
- Risk-*won't tolerate it*
- Scale-*economics demand it*
- Purity-*markets demand it*
- Commoditization-*avoid it*