

# Chemical Industry Sustainability and Shale Gas Trends



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## ■ I Waste Time and Money At Home



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# ■ I Waste Time and Money At Home





*I'm destroying the planet  
slower than you are.*



## ■ I Save Time by Using Fossil Fuels



■ I Waste Time and Money At Home



**I Waste Time and Money At Home**



## ■ I Waste Time and Money At Home



## ■ Some Things I Do For Sustainability Save Me Money



*but “customer” satisfaction is an issue*

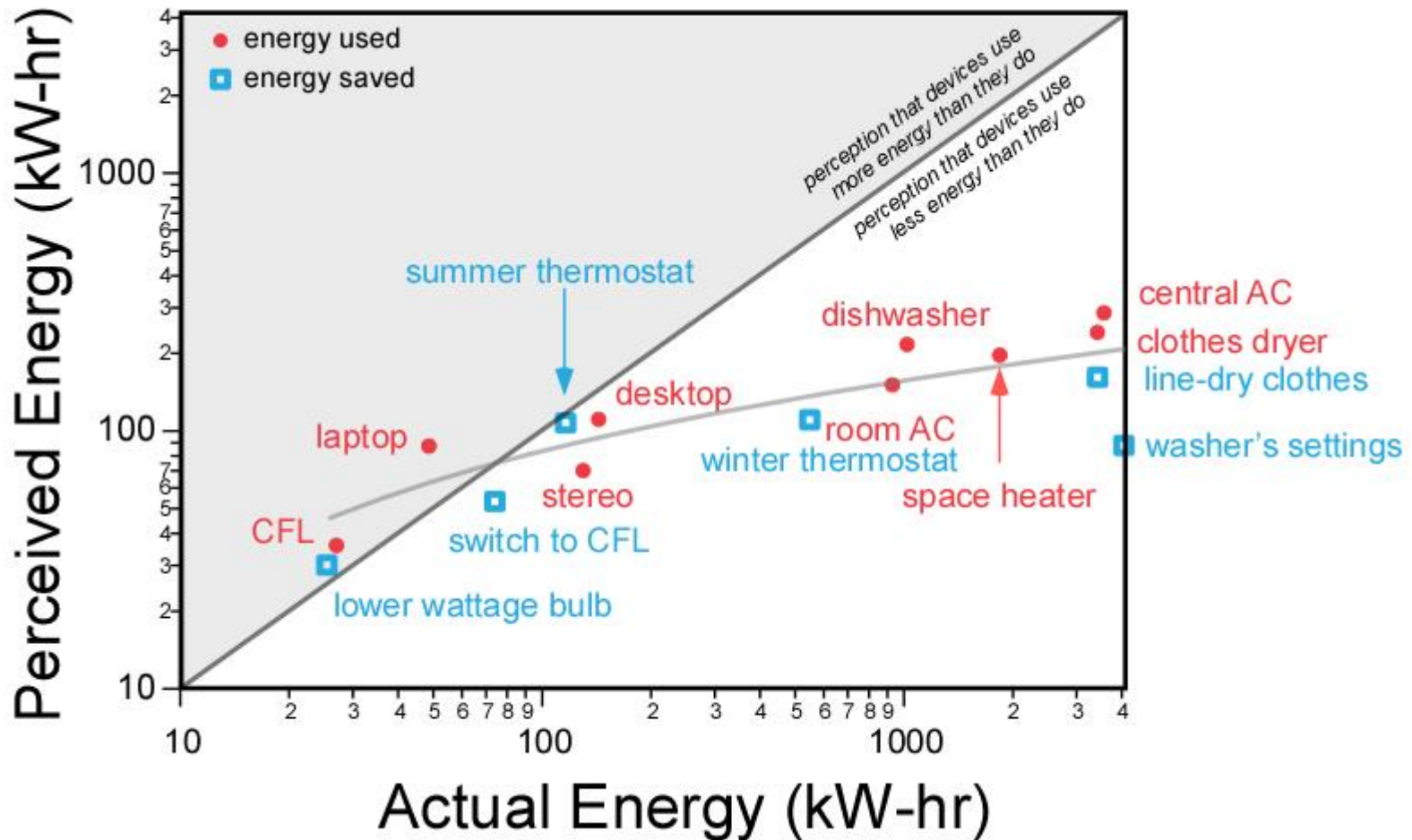
## ■ Embodied Fossil Energy







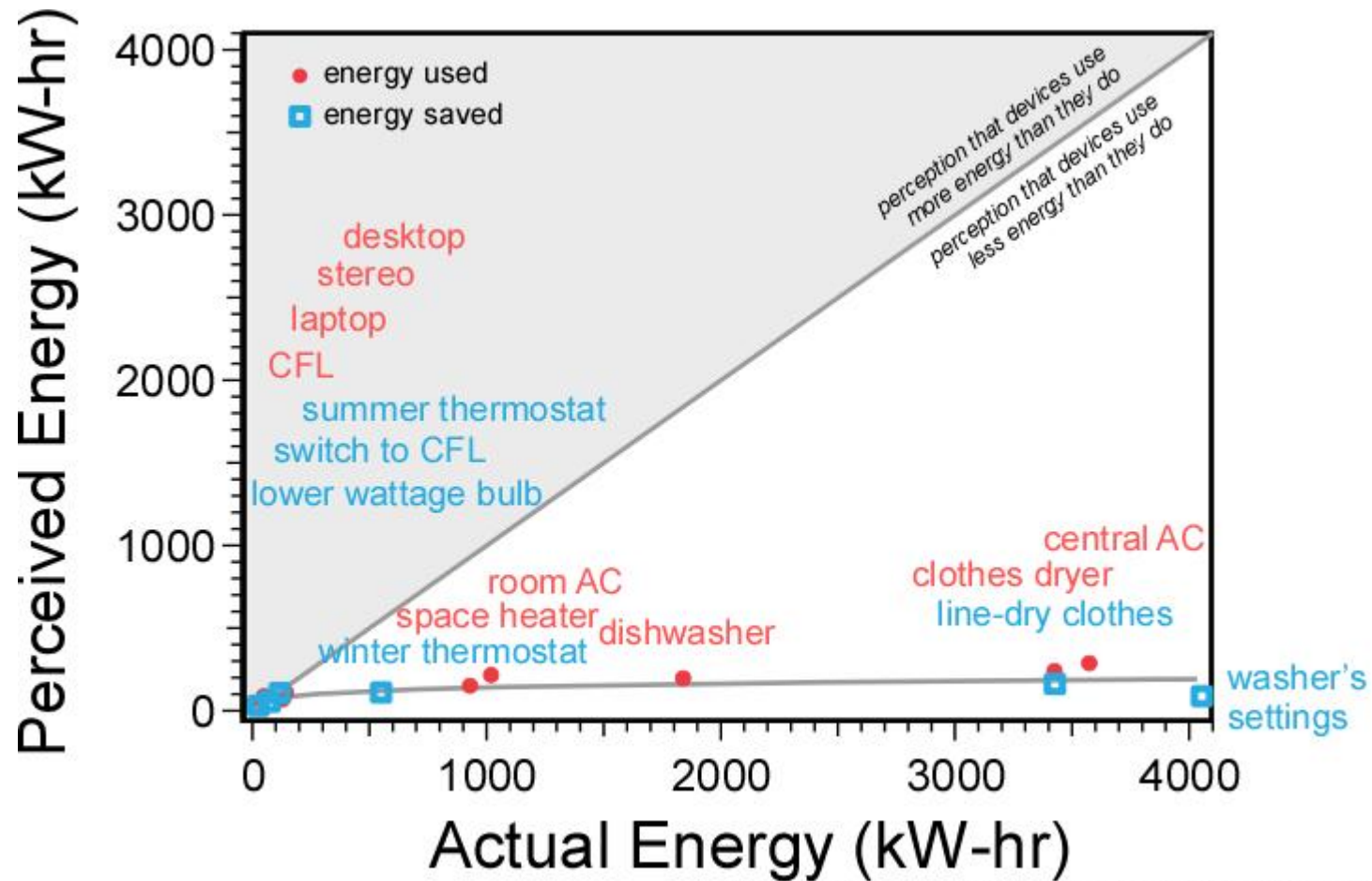
# ■ Perception vs Reality



Attari, Shahzeen; DeKay, Michael L.; Davidson, Cliff I.; de Bruin, Wandi Bruine; "Public perceptions of energy consumption", PNAS, [www.pnas.org/cgi/doi/10.1073/pnas.1001509107](http://www.pnas.org/cgi/doi/10.1073/pnas.1001509107).

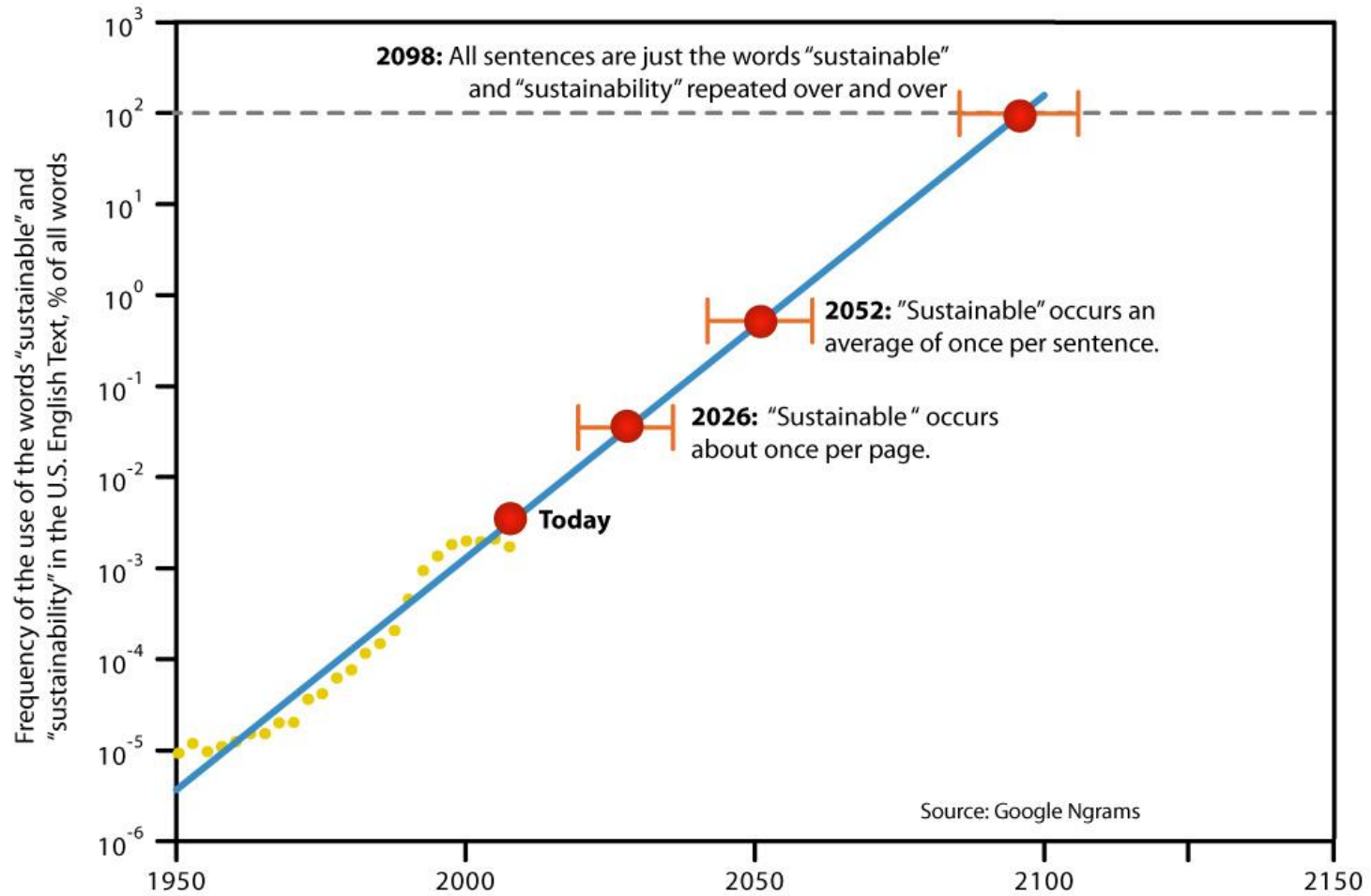


## ■ Perception vs Reality



Attari, Shalzeen; DeKay, Michael L.; Davidson, Cliff I.; de Bruin, Wandl Bruine; "Public perceptions of energy consumption", PNAS, [www.pnas.org/cgi/doi/10.1073/pnas.1001509107](http://www.pnas.org/cgi/doi/10.1073/pnas.1001509107).

# ■ Sustainability is Unsustainable?



<http://imgs.xkcd.com/comics/sustainable.png>



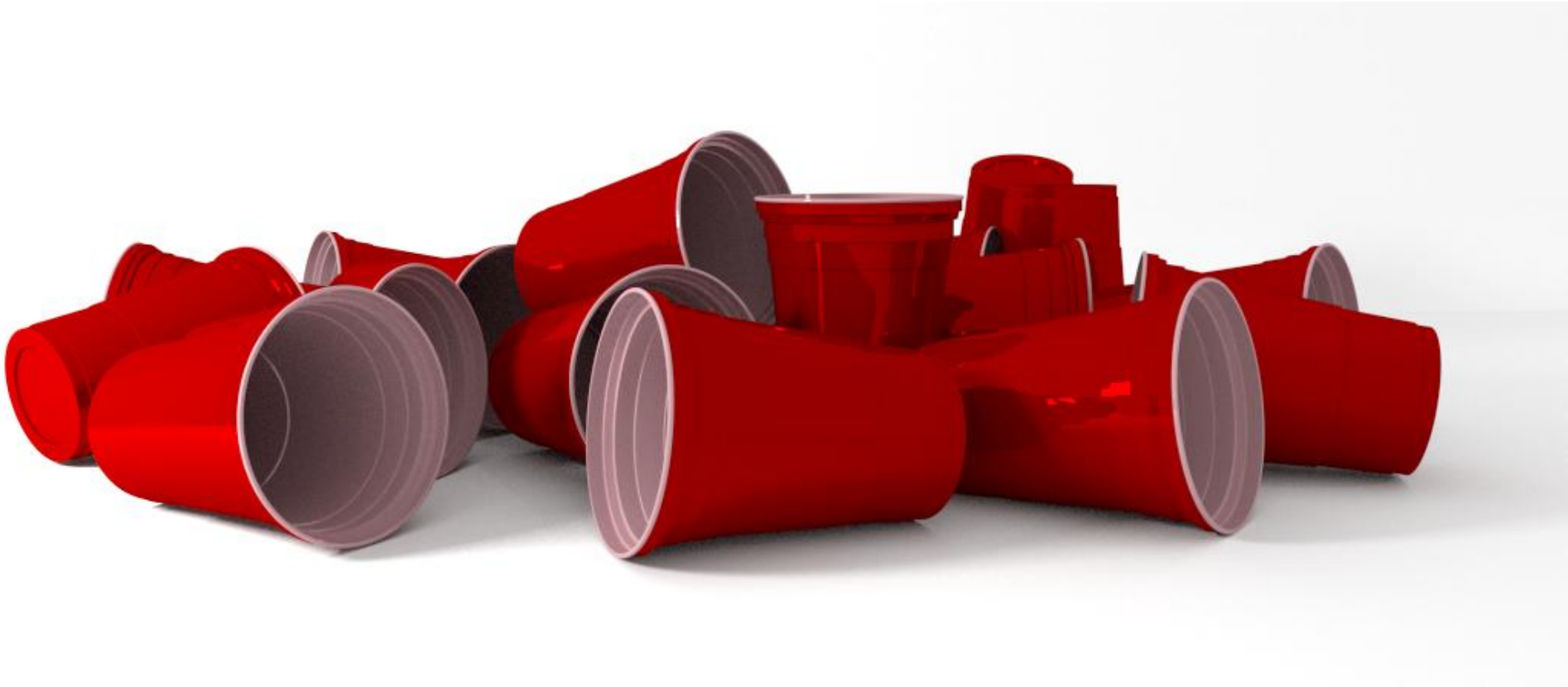
## ■ Metaphor for Sustainability



■ Ordered



**Disordered**



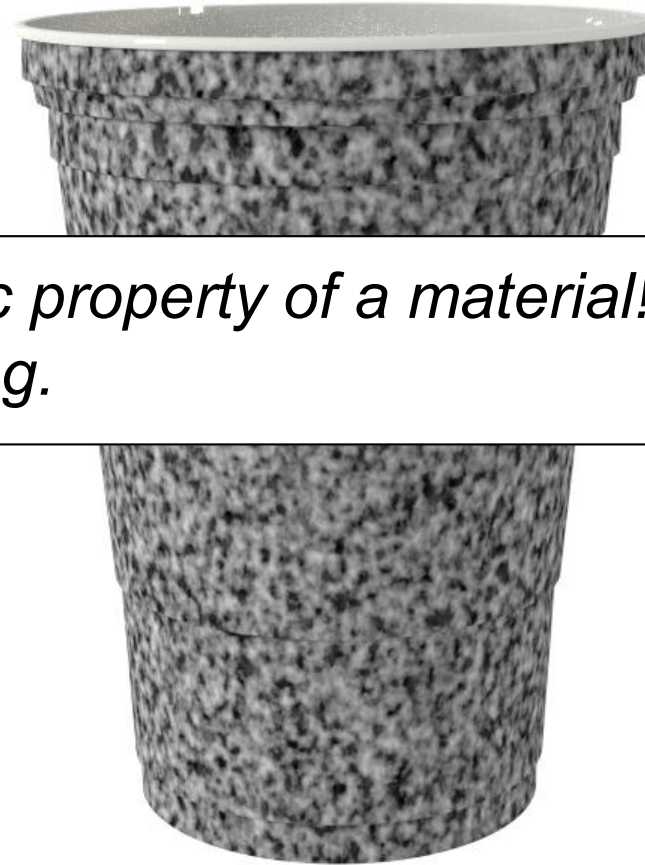
## ■ Sustainable?



## ■ Is this Cup Sustainable?



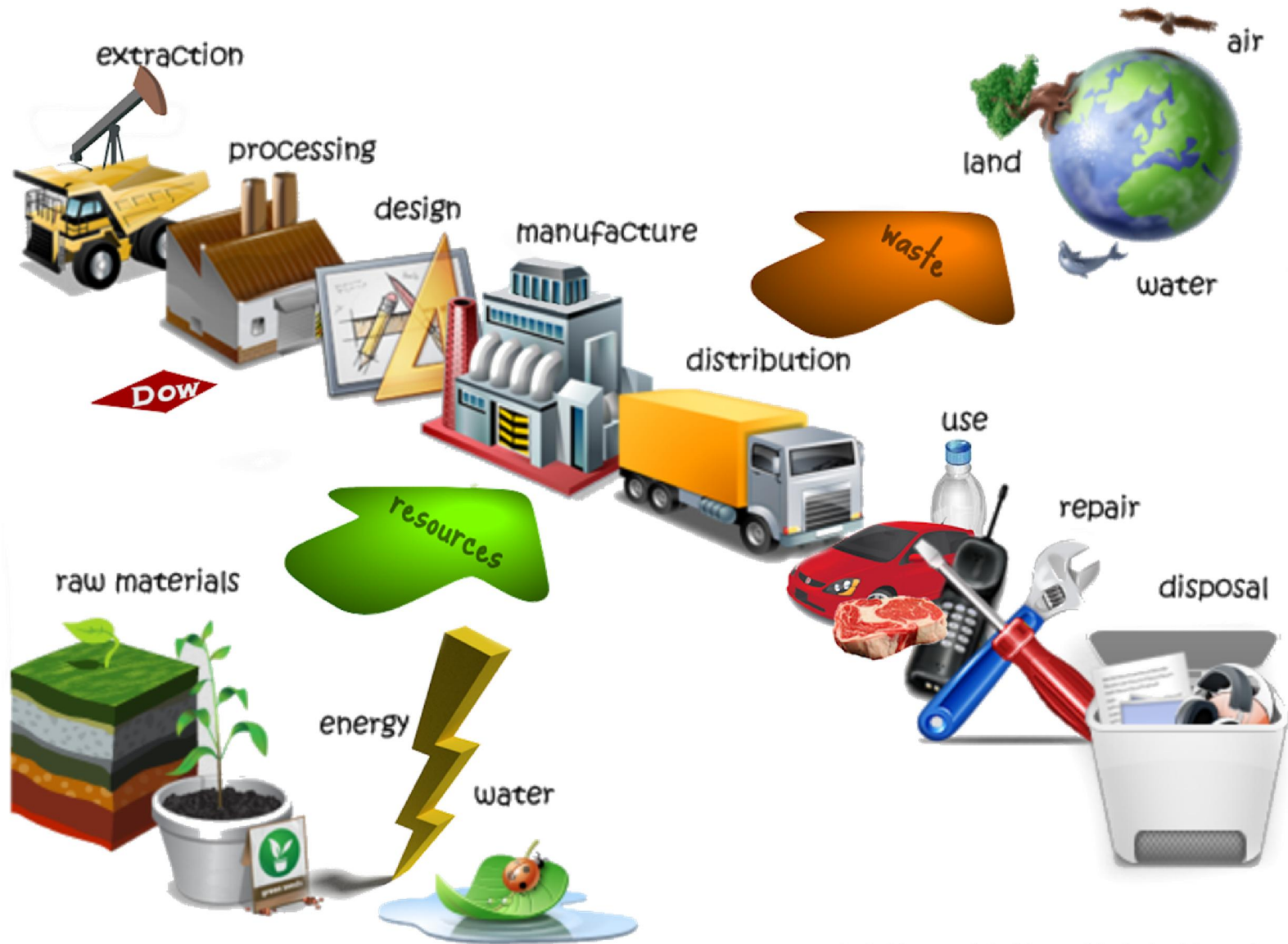
*Sustainable is not an intrinsic property of a material!  
You can't know by just looking.*



**How about this one?**



# Life Cycle Assessment



adapted from [sustainable-graphic-design.blogspot.com](http://sustainable-graphic-design.blogspot.com)



■ Which is more sustainable?

*plastic*



*paper*

■ Which is better?

*streaming*



*physical media*

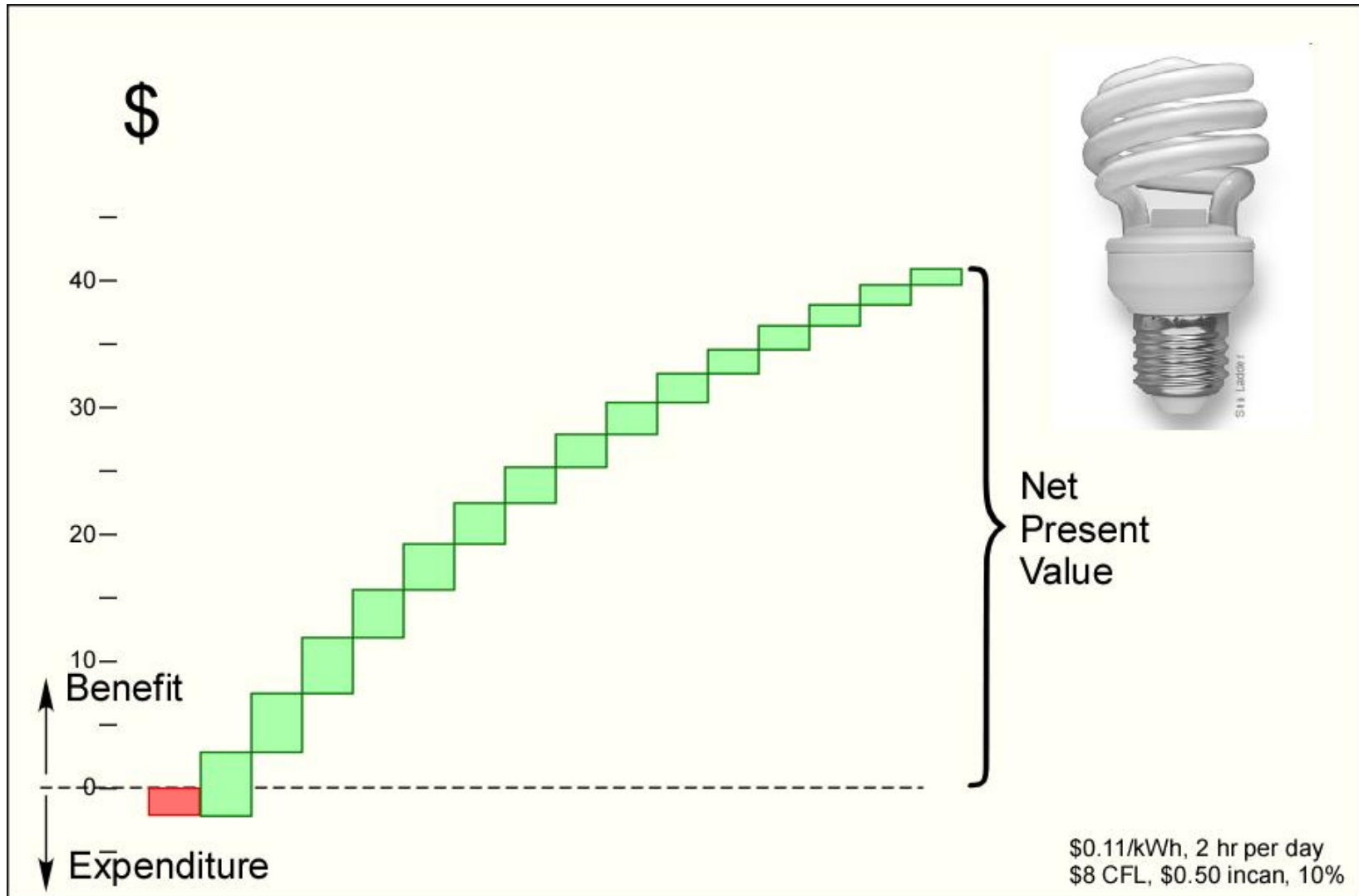
■ Which is more sustainable?

*A meat-eater in a Prius*

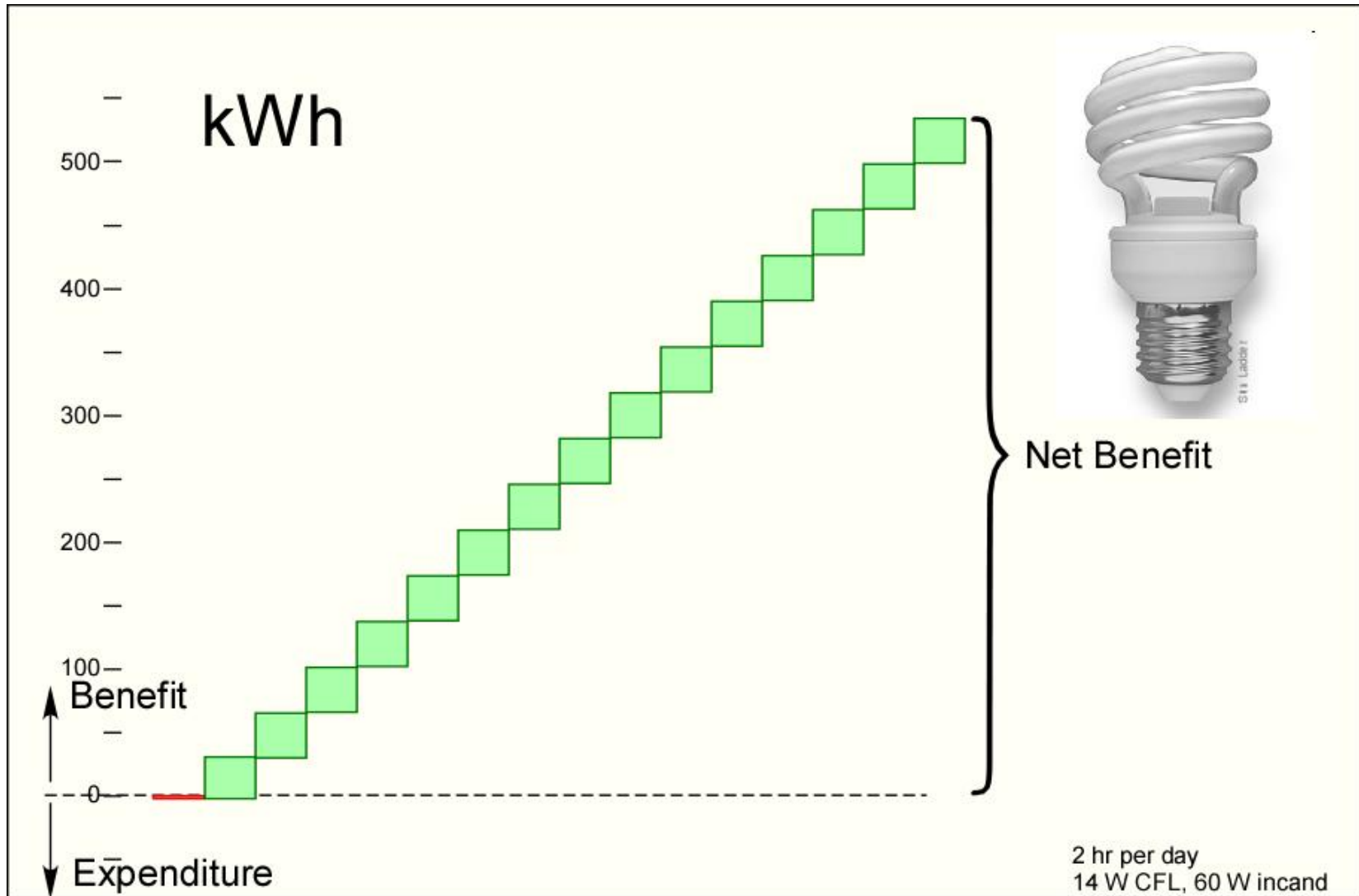


*A vegan in a Hummer*

## Financial Way of Looking At Benefit

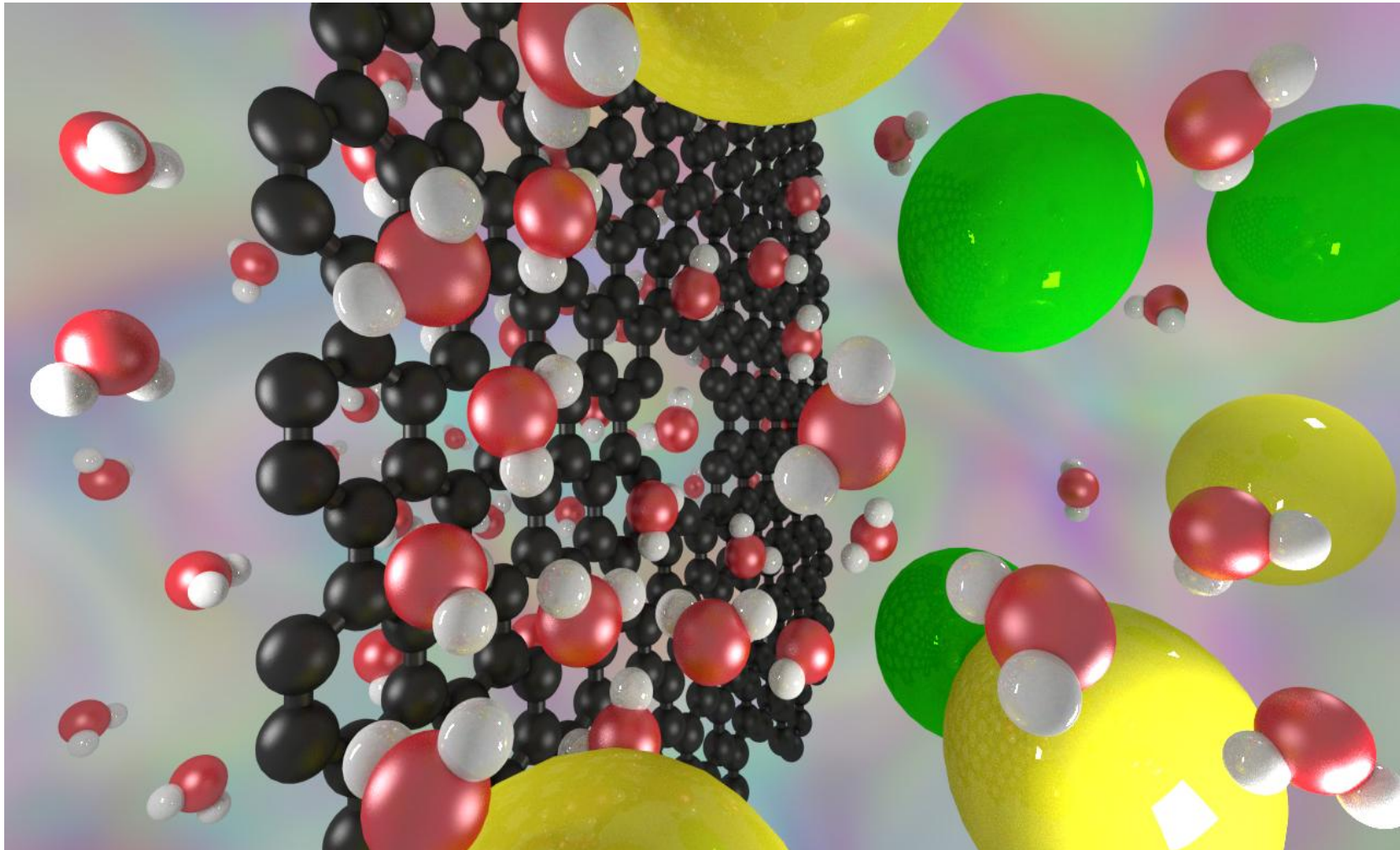


# ■ Why Not Sustainability?



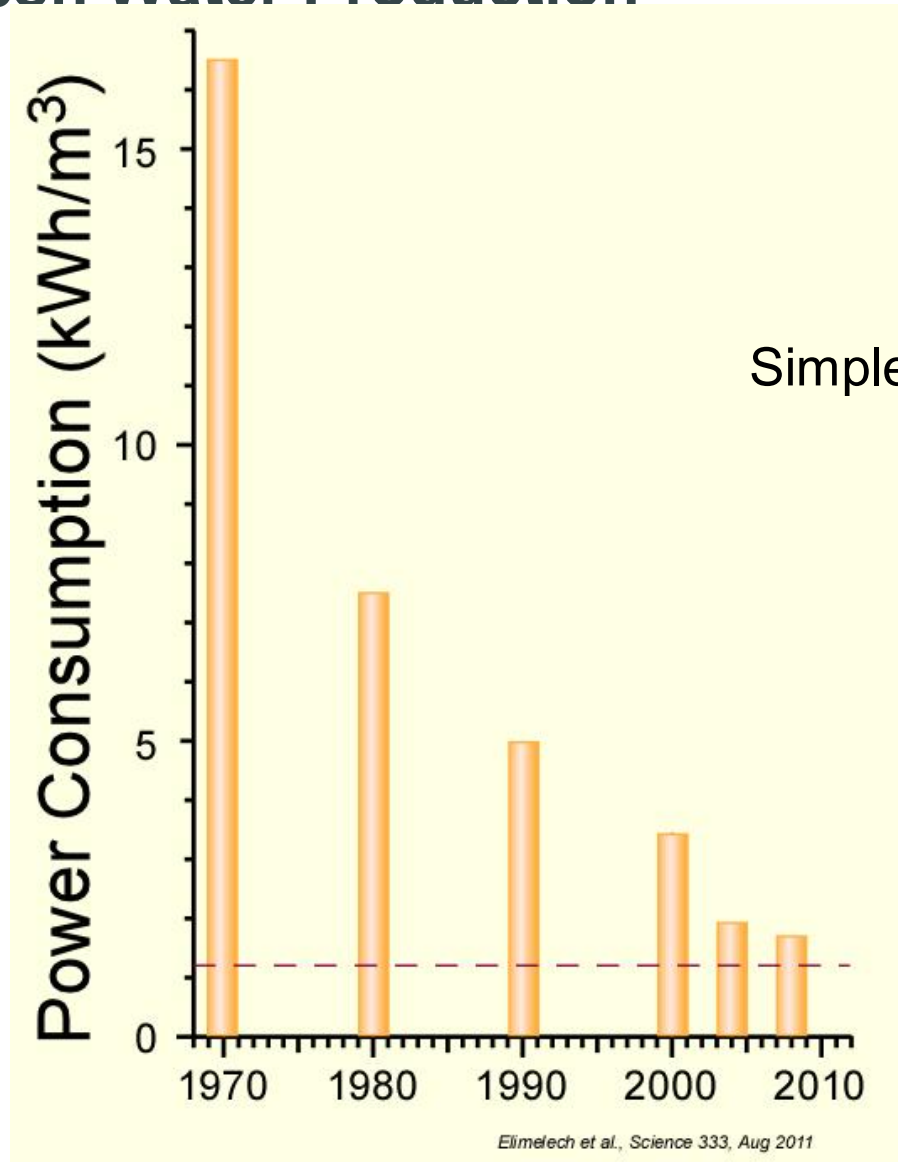


## ■ Misconceptions Demean Advances

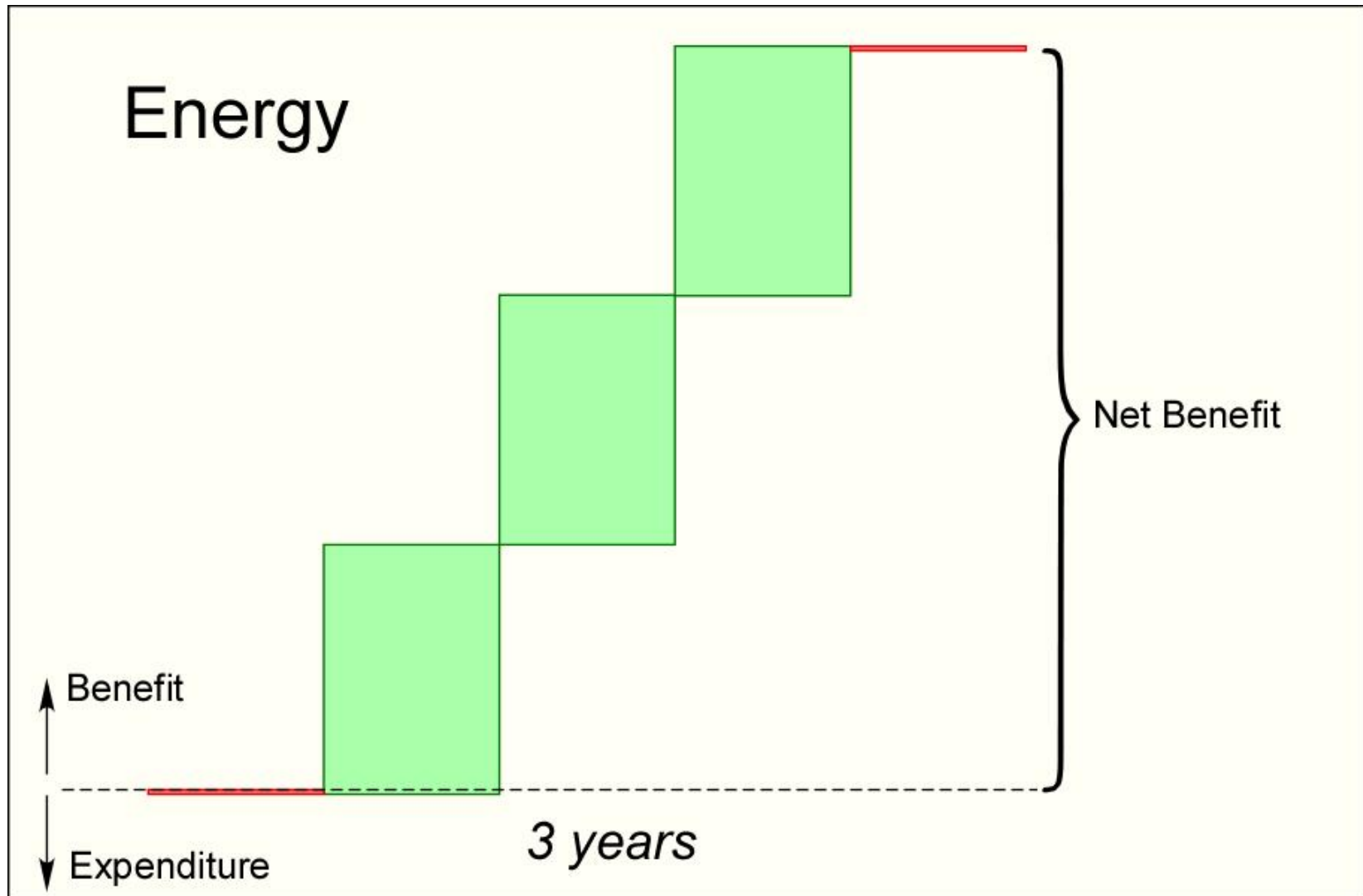




## ■ Fresh Water Production



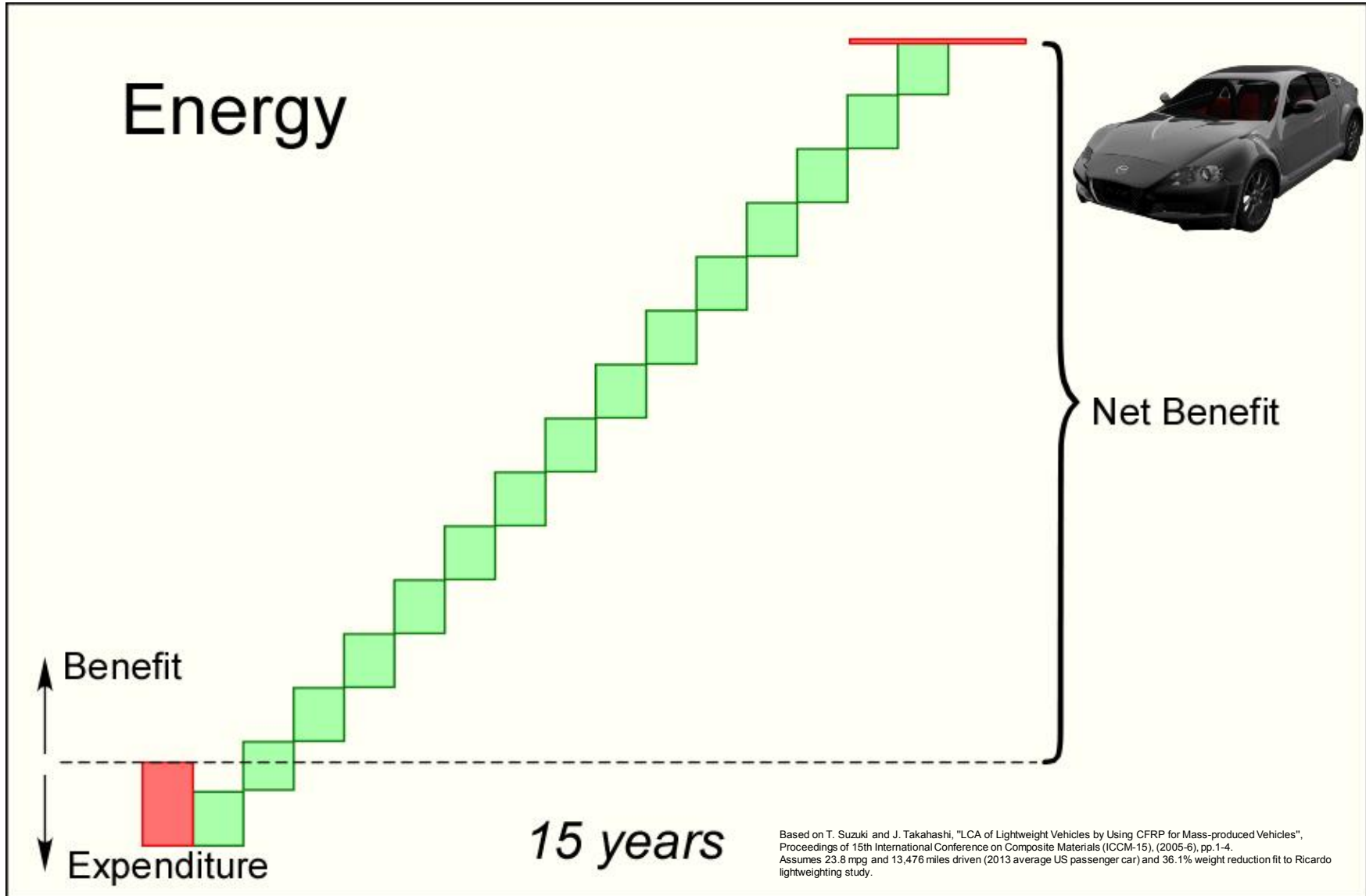
## ■ RO Cartridge Benefit



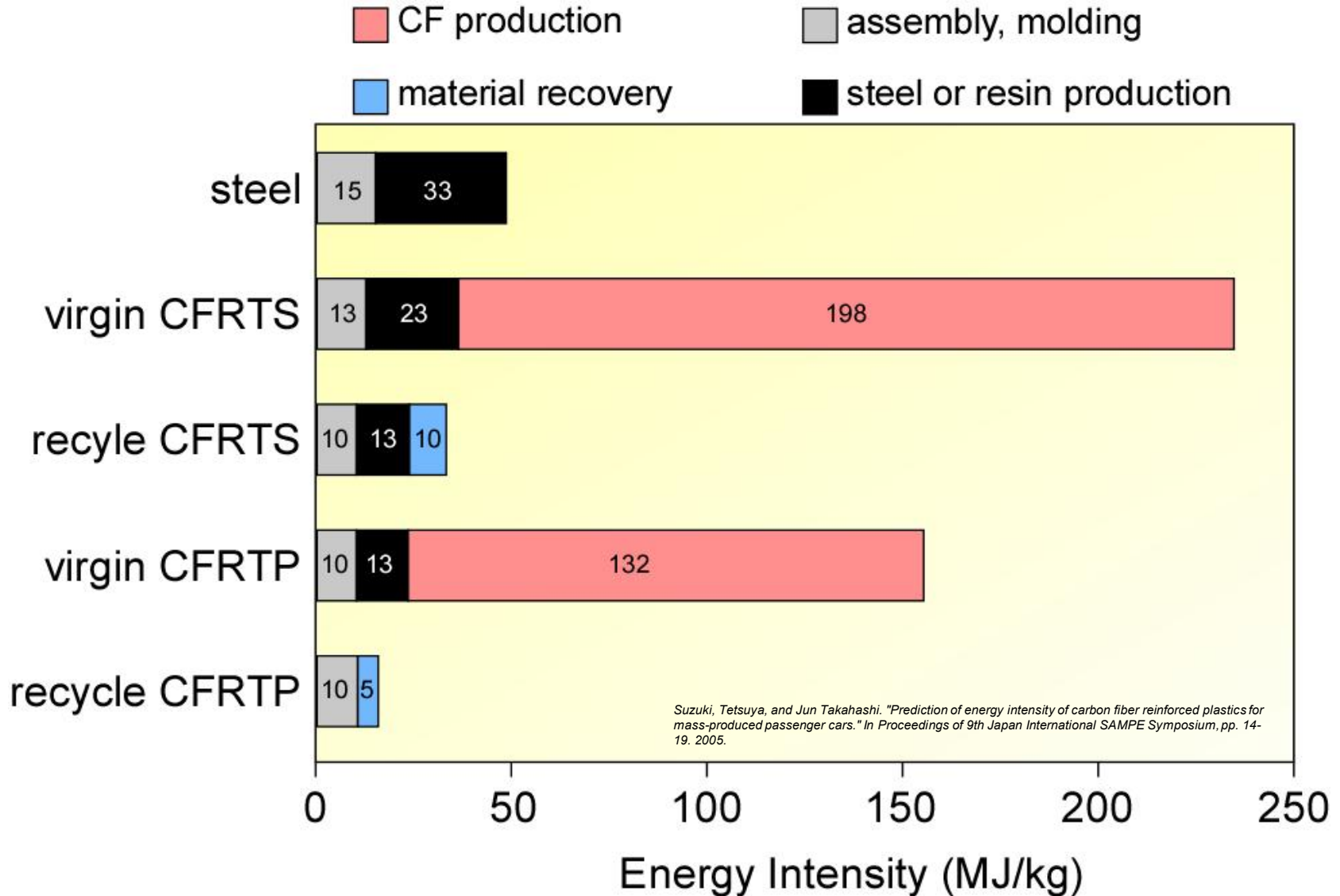
54.5 mpg



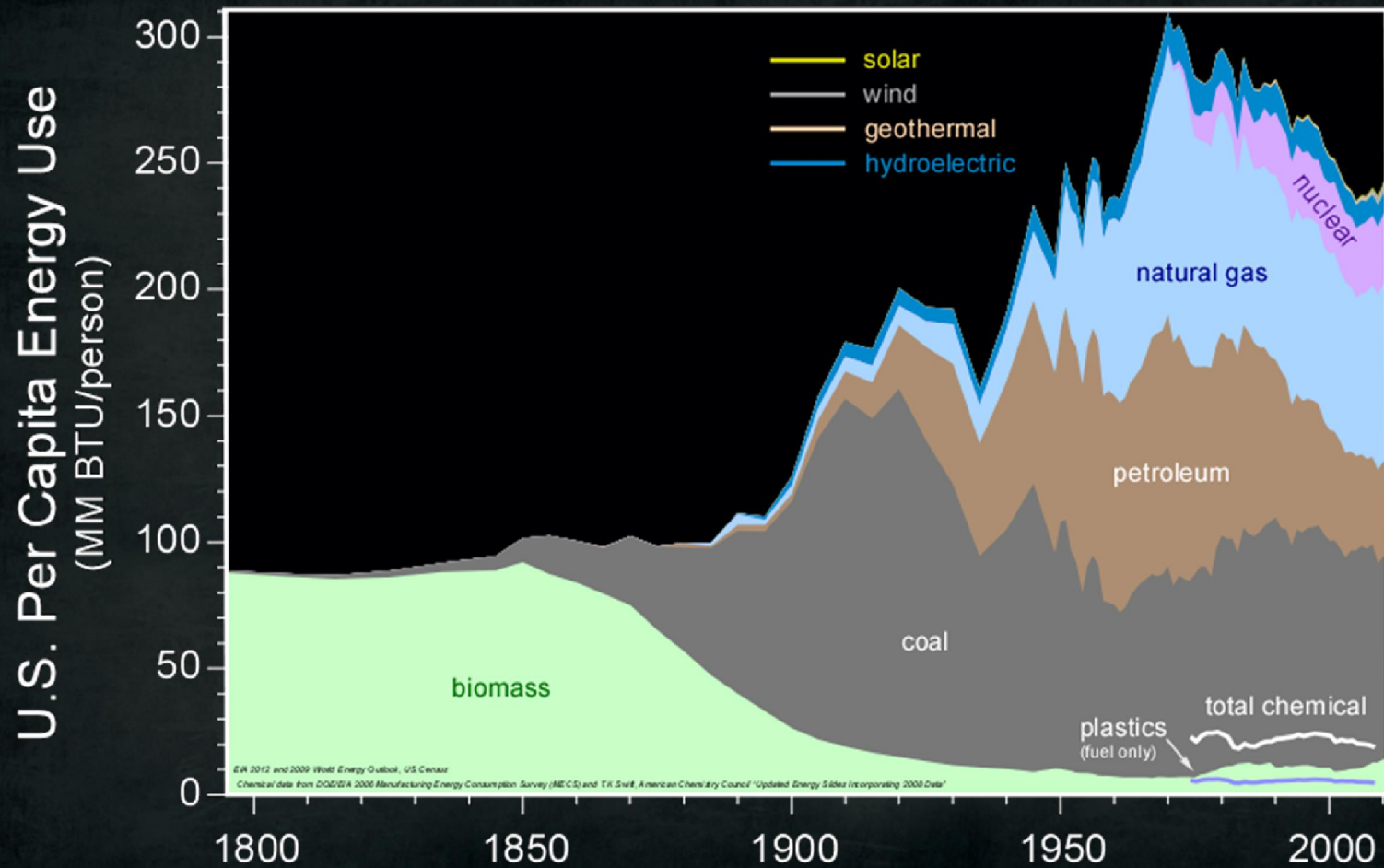
# Carbon Fiber Benefit



## ■ Importance of Recycle



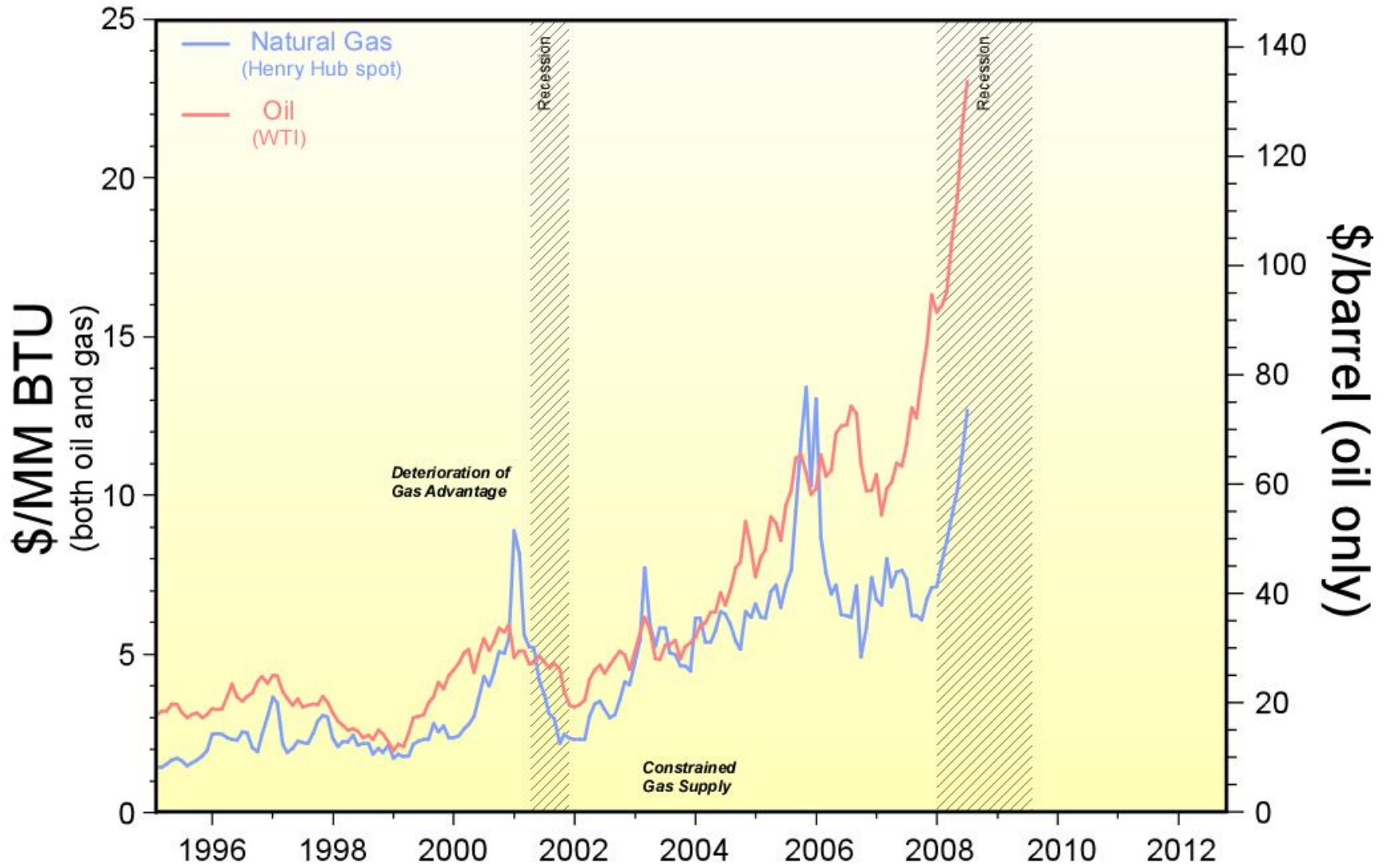
## ■ Per Capita Energy Use



**Roll Coal**



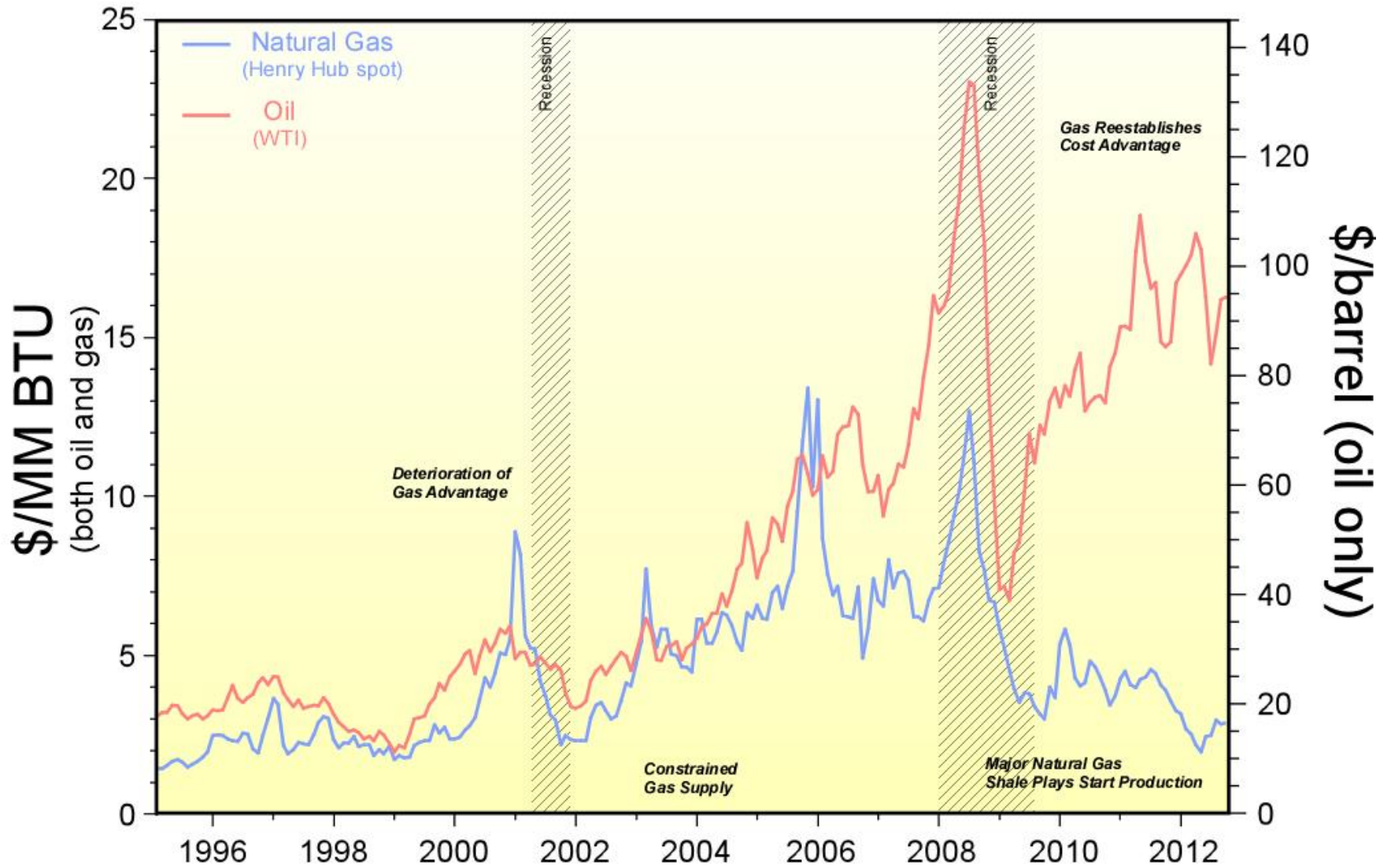
# Recent Industry History



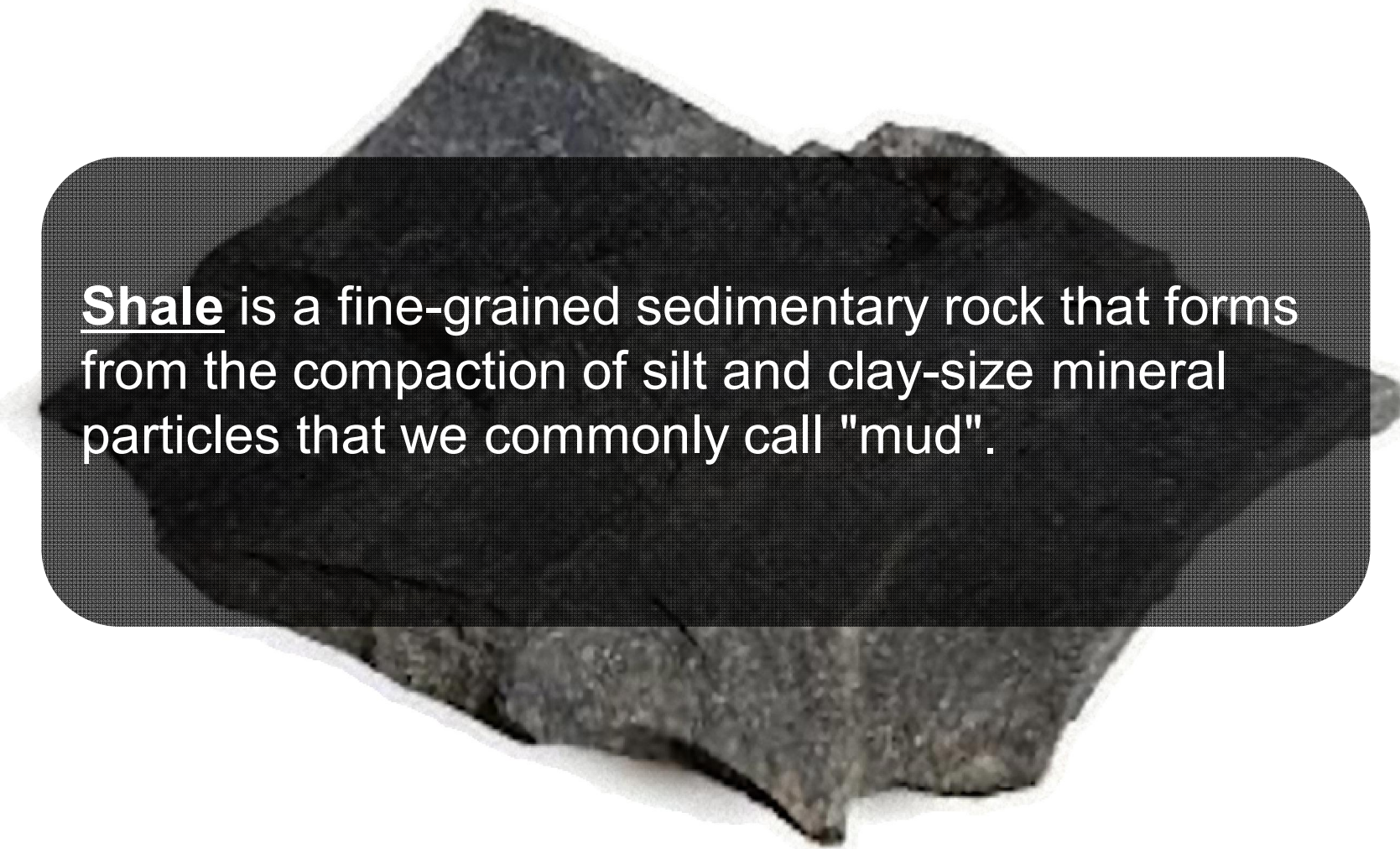




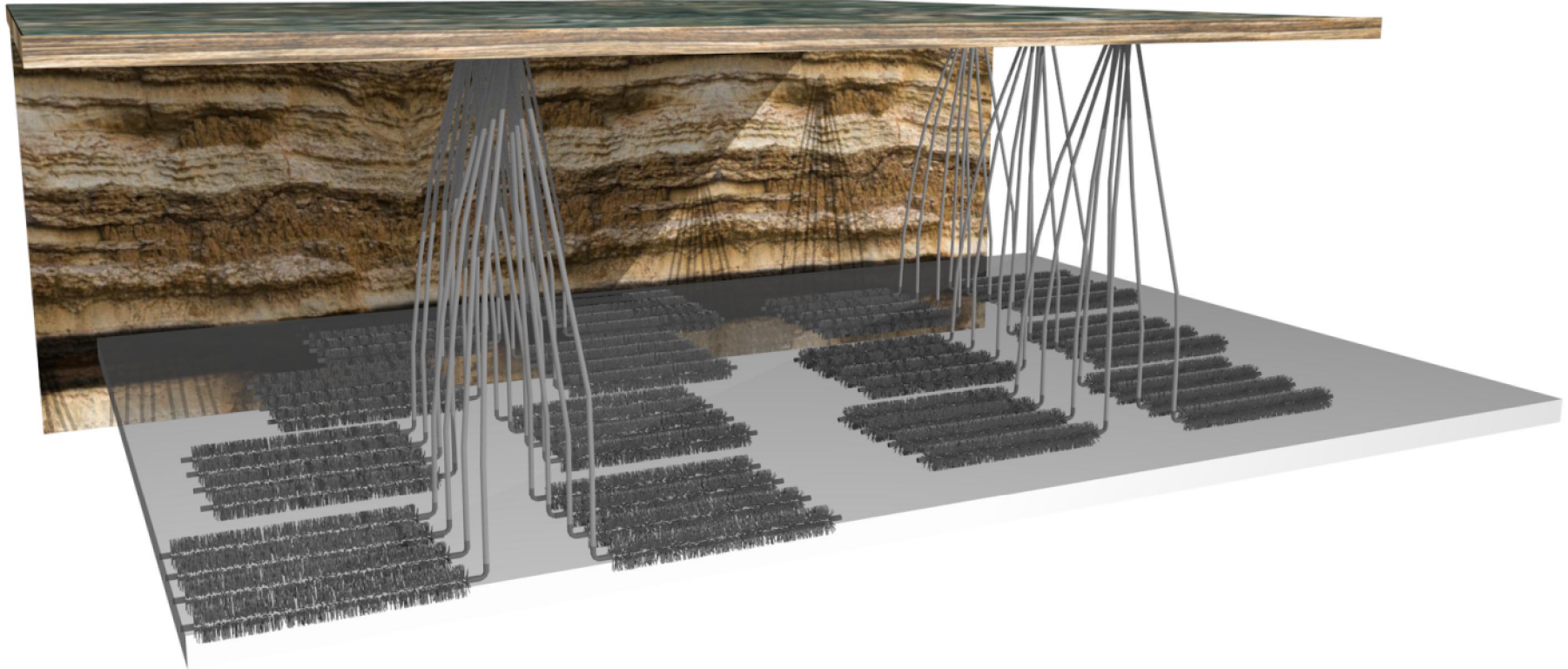
# Recent Industry History







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



Live Long and Prosper



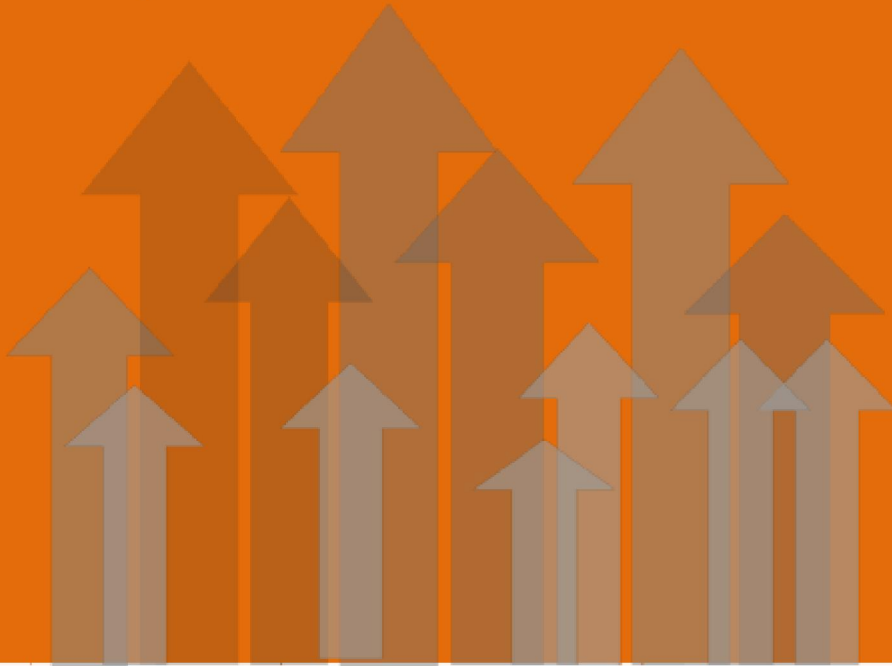
# Announced Projects



## ■ Economic Impact of Shale Gas

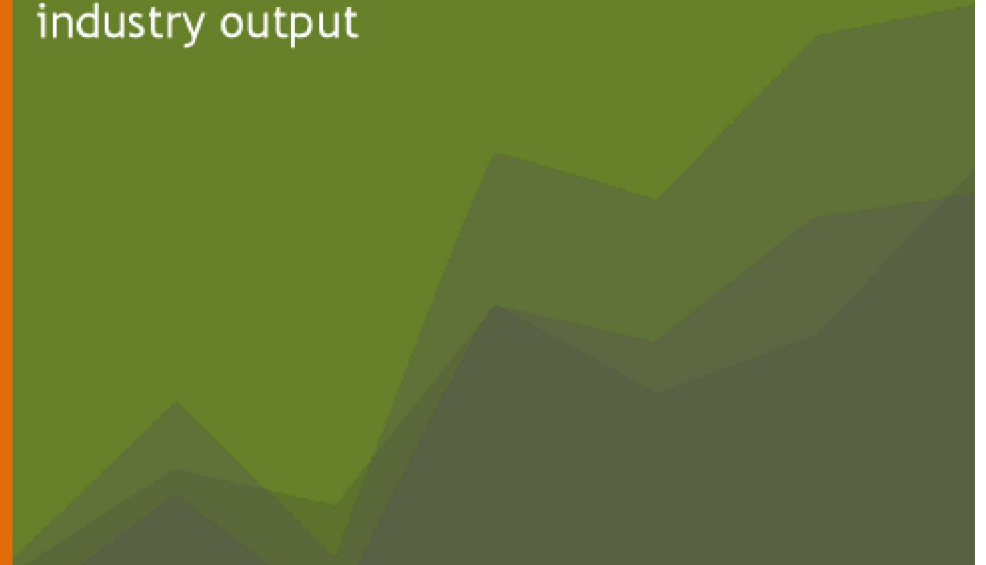
# 637,000

Permanent NEW jobs by 2023  
throughout the U.S. economy from  
\$81 billion in new chemical industry  
output



# \$243 billion

Permanent NEW U.S. economic output by  
2020 from \$81 billion in new chemical  
industry output



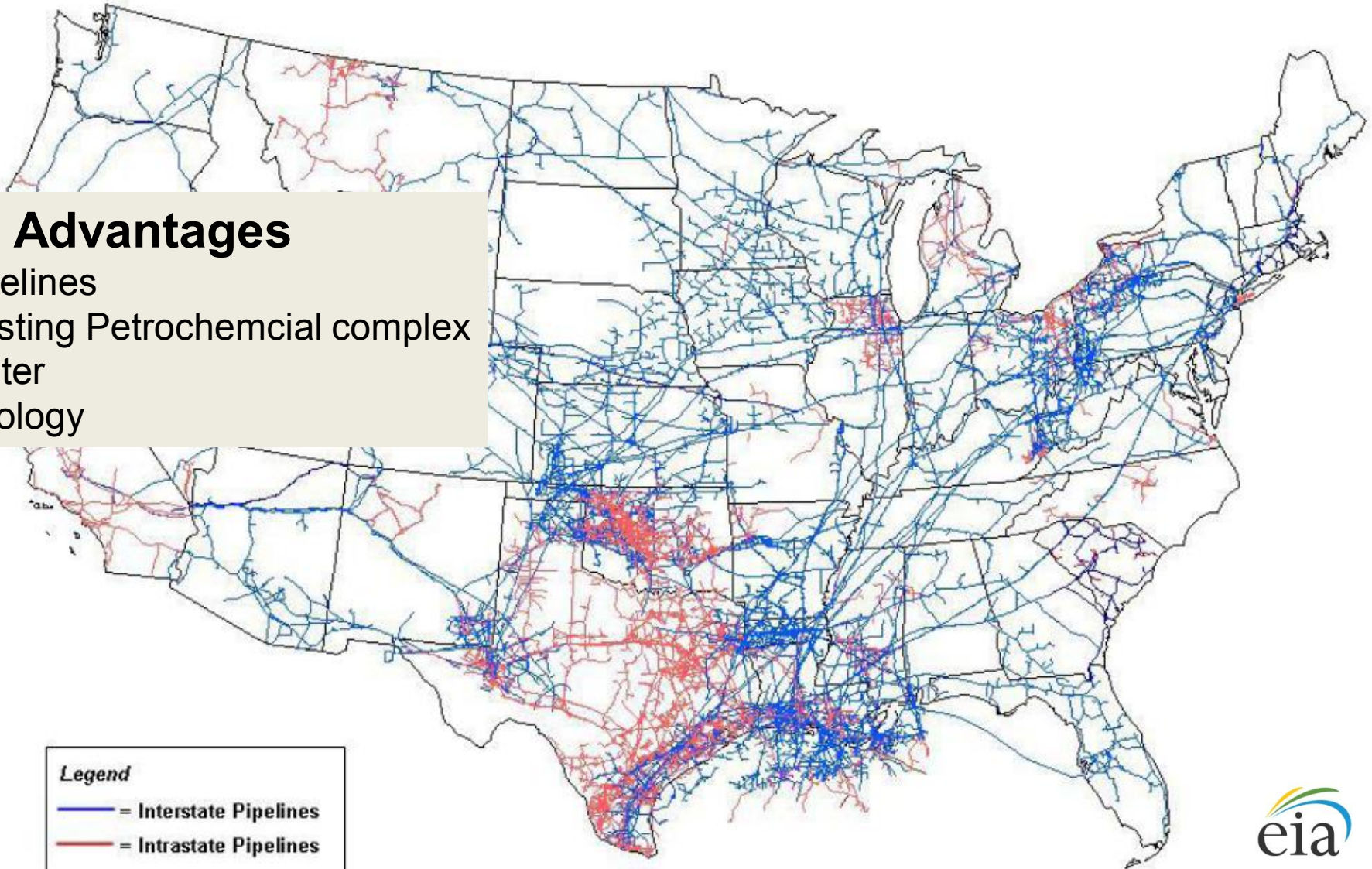
*Based on \$100 billion in potential U.S. chemical investment  
announced as of February 2014*



## ■ Robust Transmission Infrastructure

### US Advantages

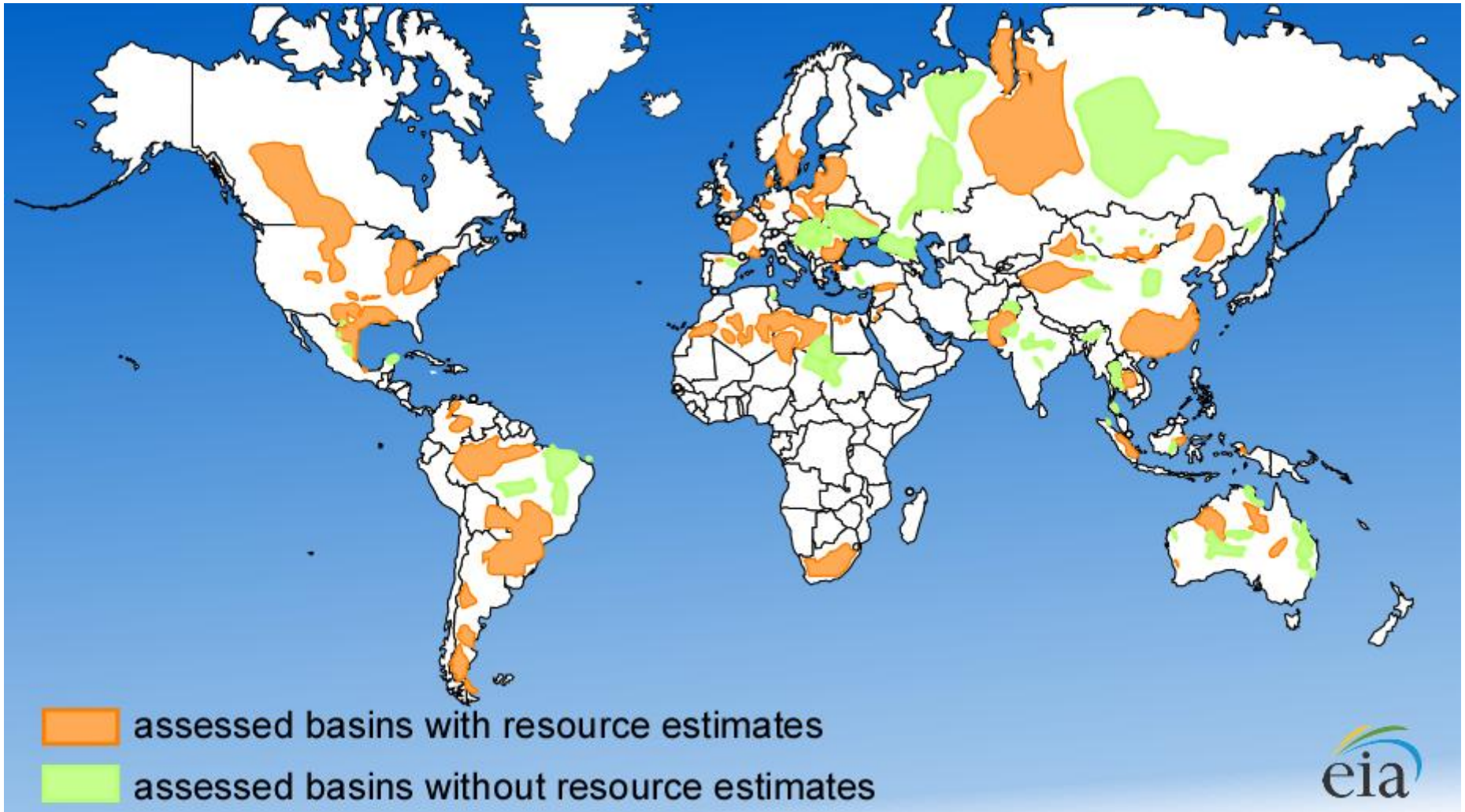
- Pipelines
- Existing Petrochemical complex
- Water
- Geology



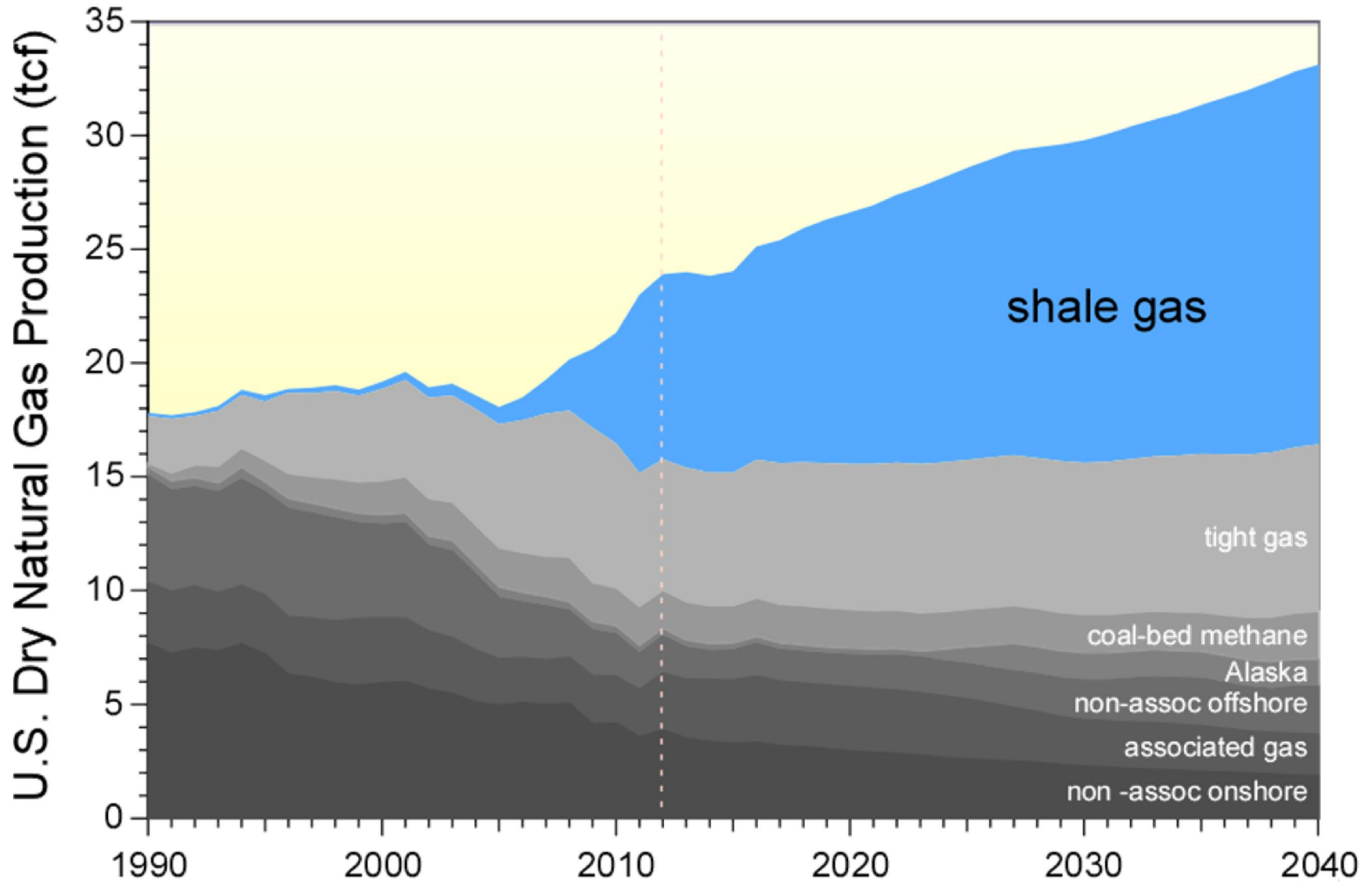
*Legend*

- = Interstate Pipelines
- = Intrastate Pipelines

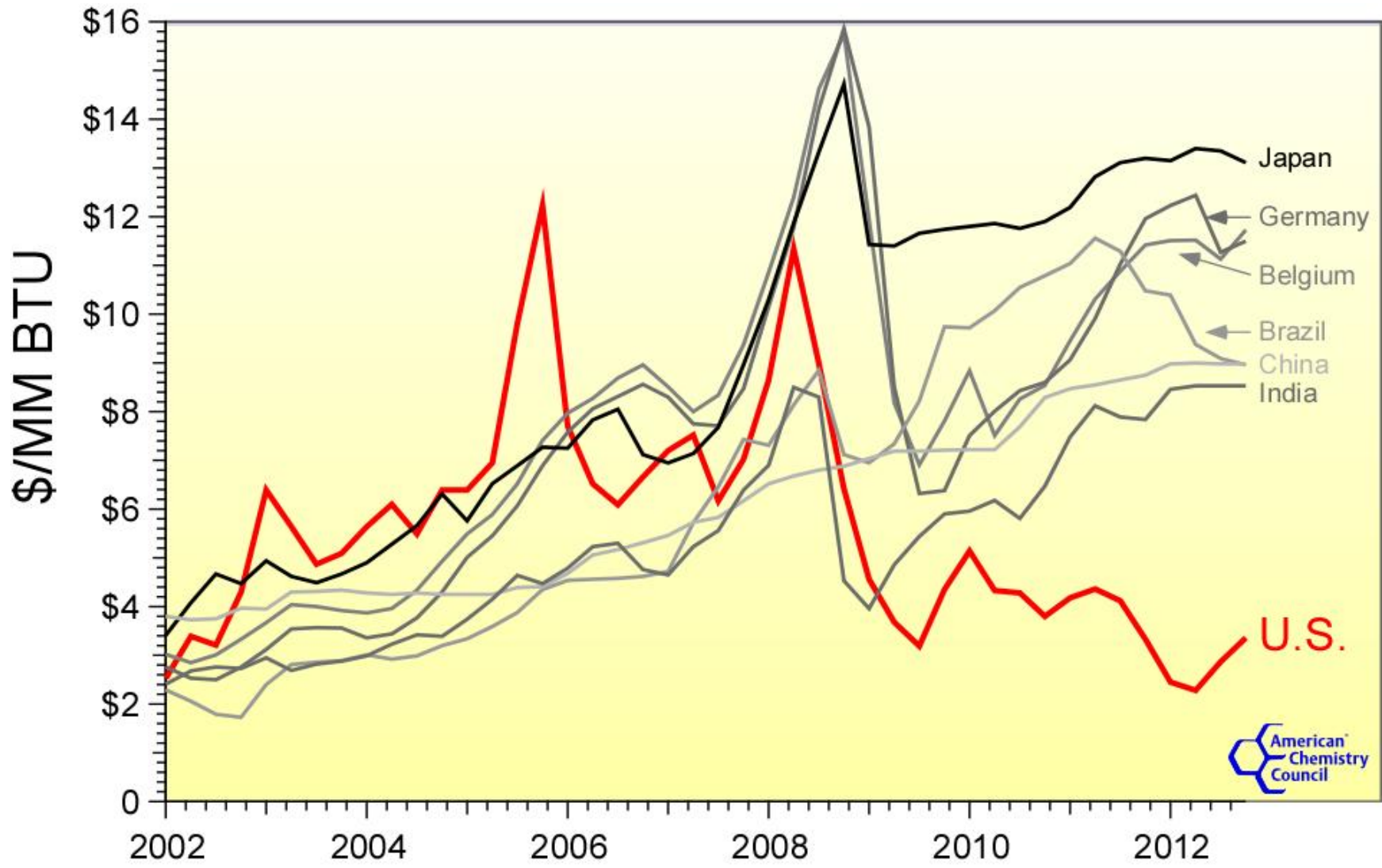
## ■ Mud Happened in Many Places



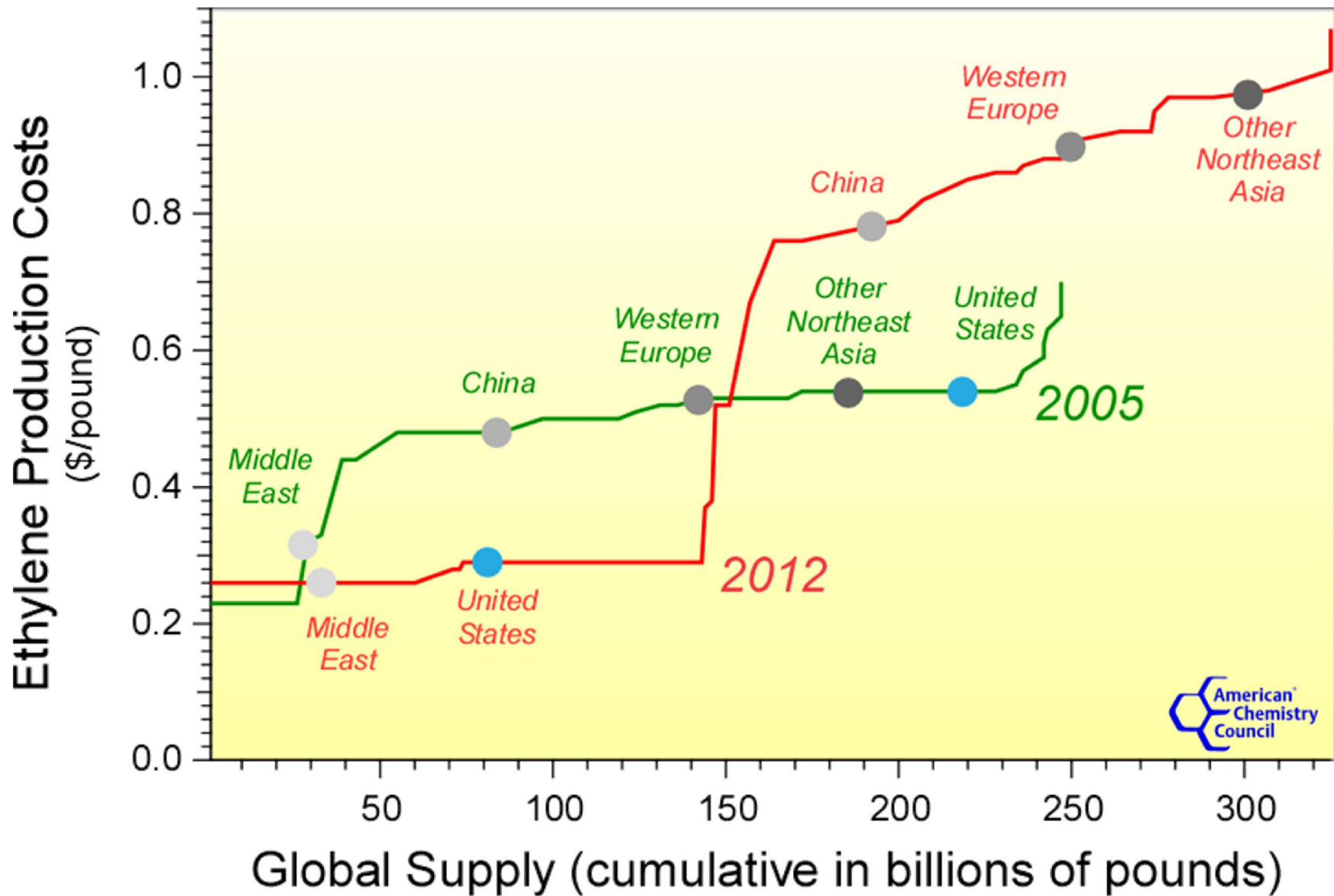
# Shale Gas Growth



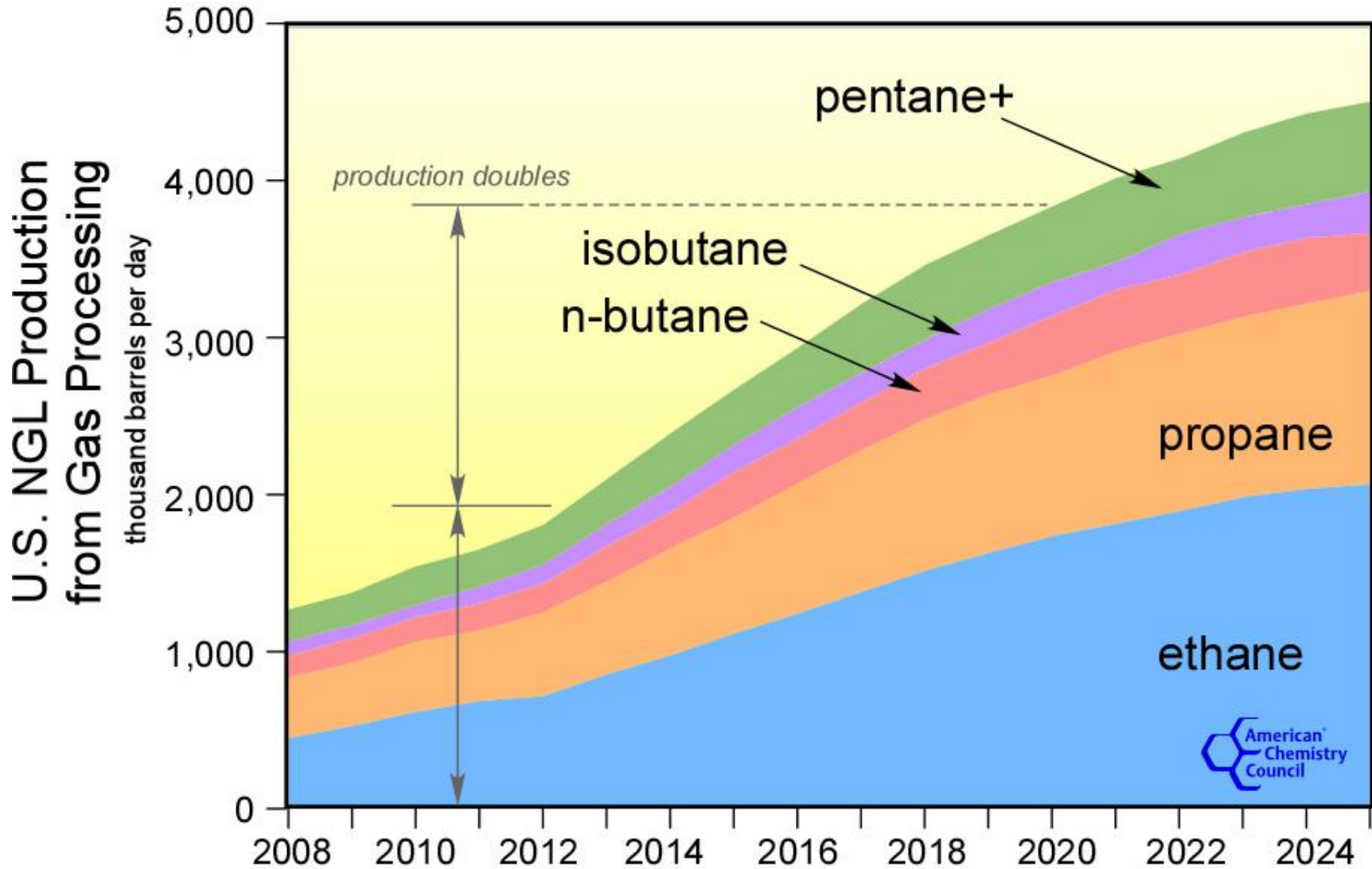
# Global Gas Price



## ■ Impact of Low Gas Prices



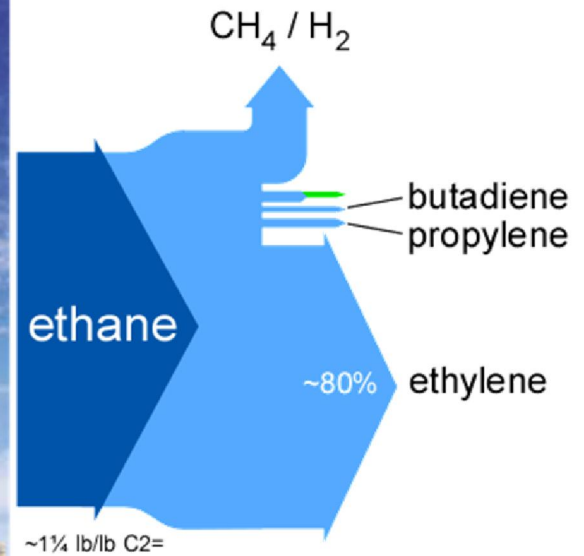
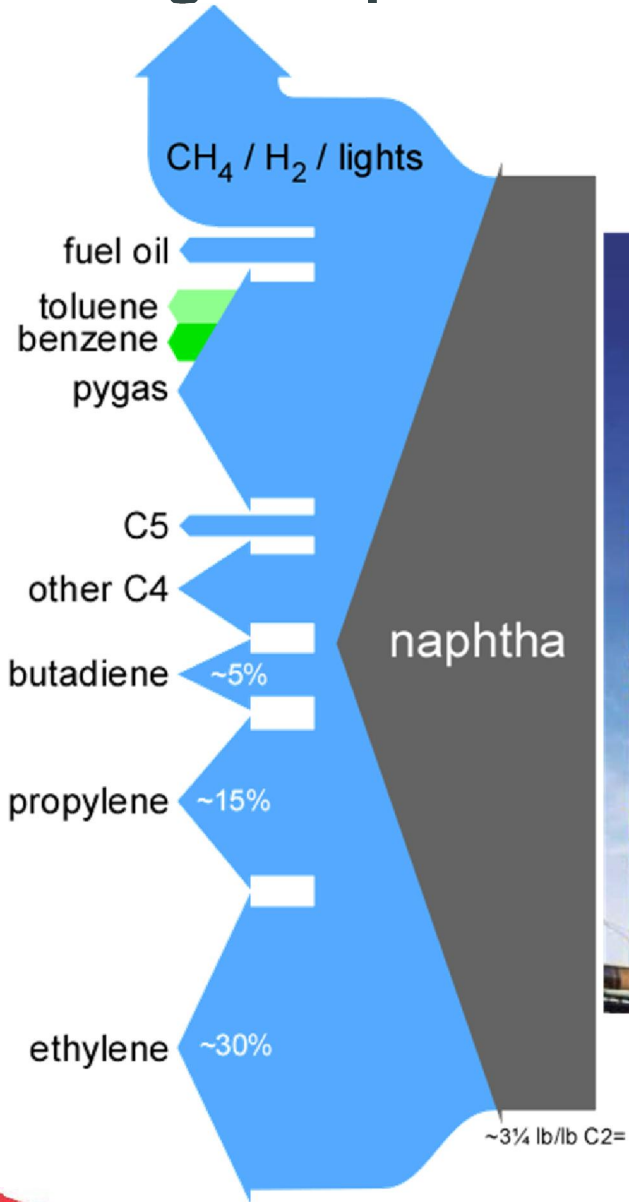
## ■ NGL Production Doubles by 2020



## ■ Ethane Export



# Cracking Comparison

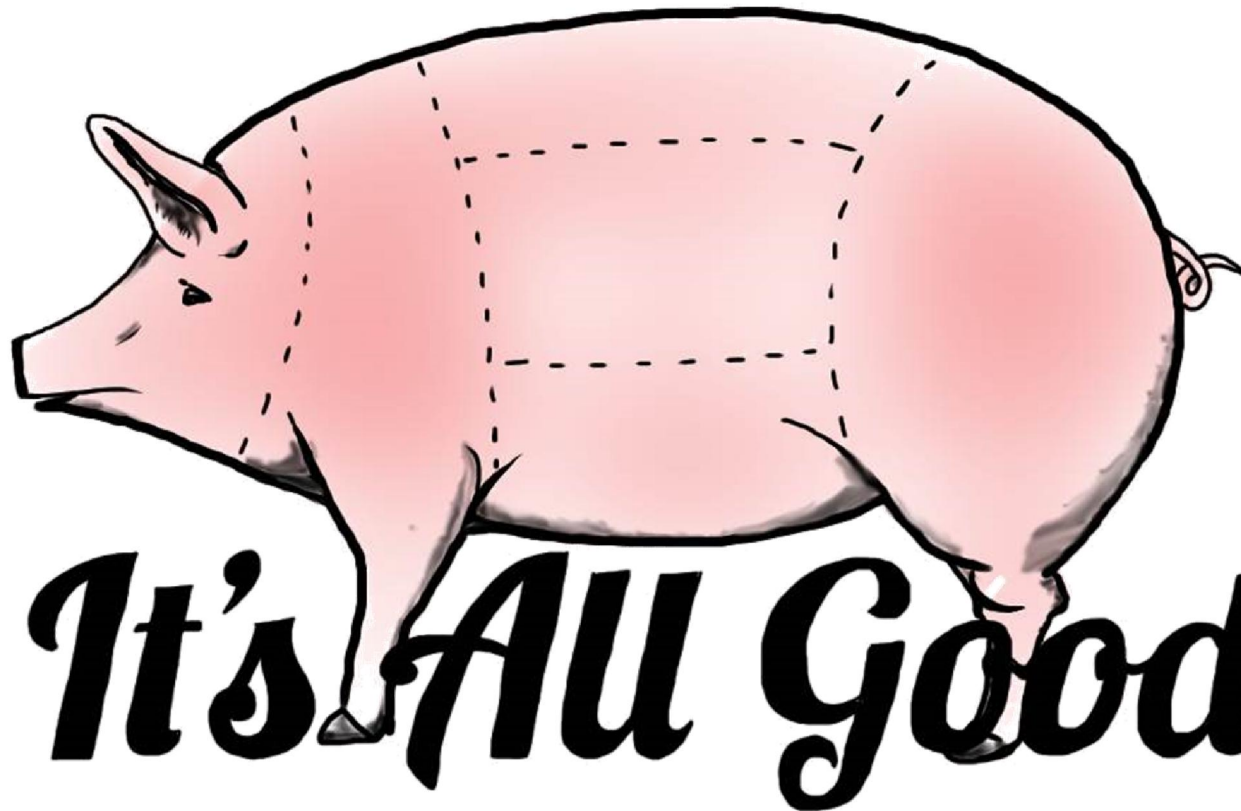


*same amount of ethylene*





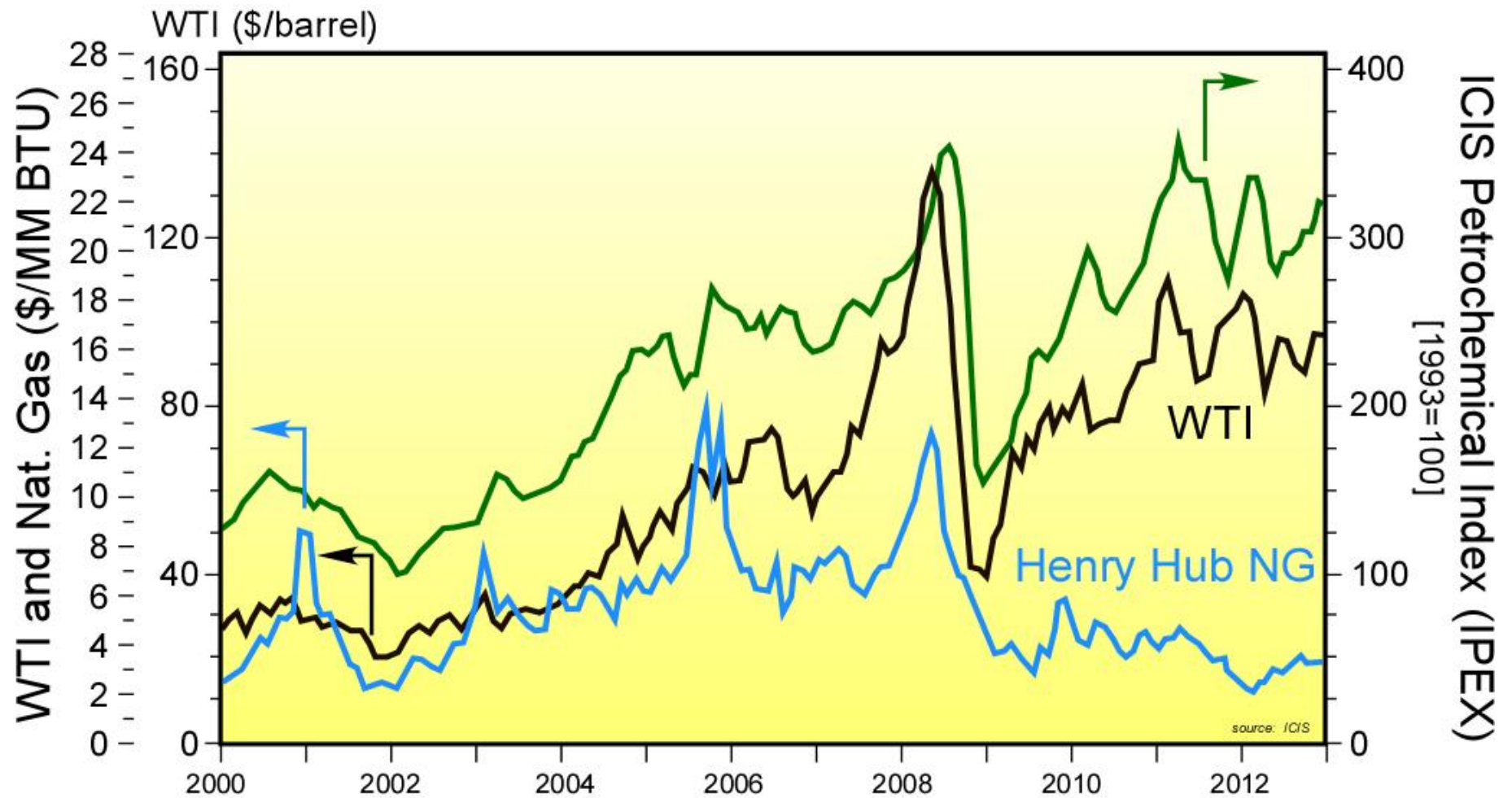
■ All Reaction Products Find Uses



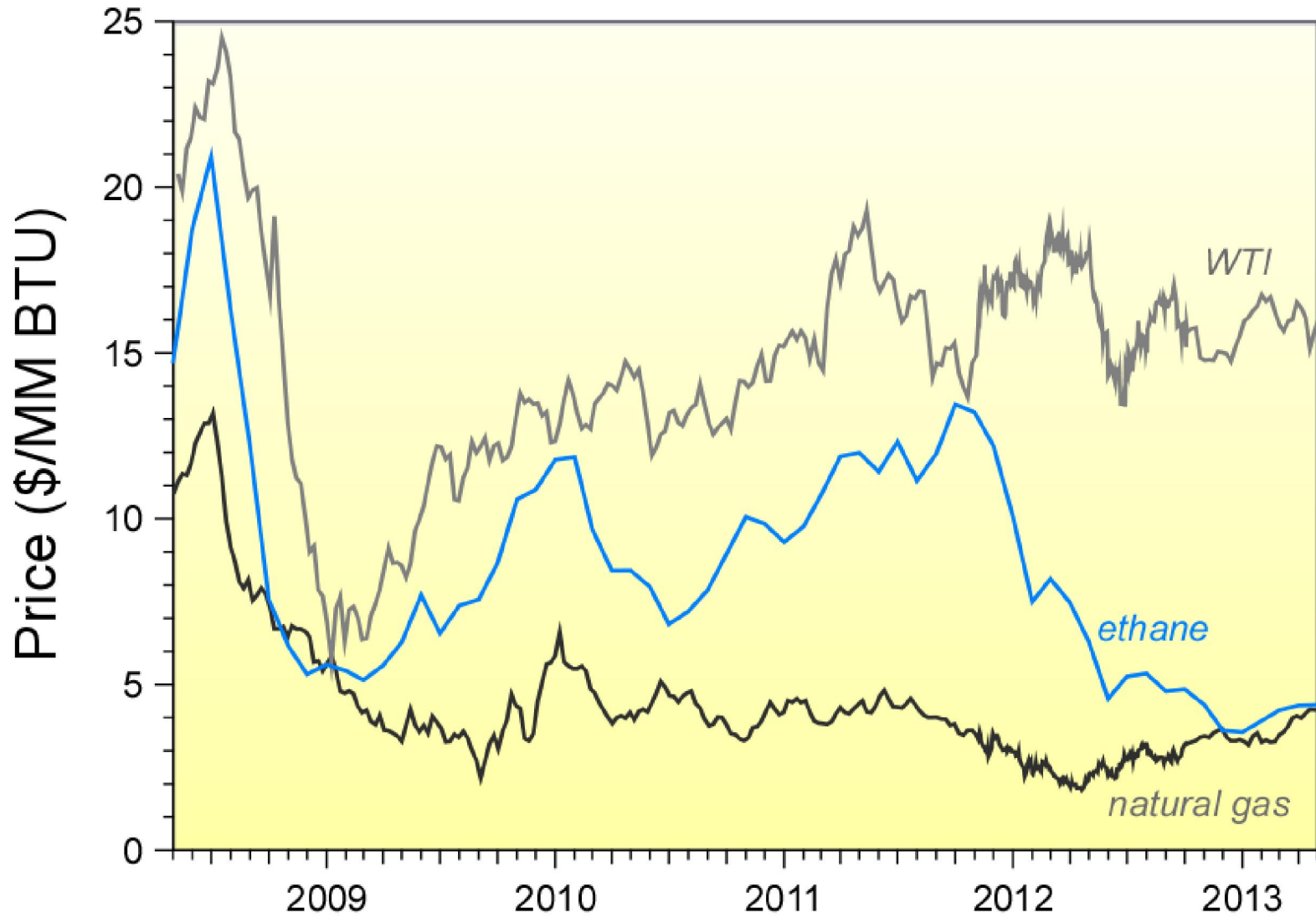
*It's All Good!*



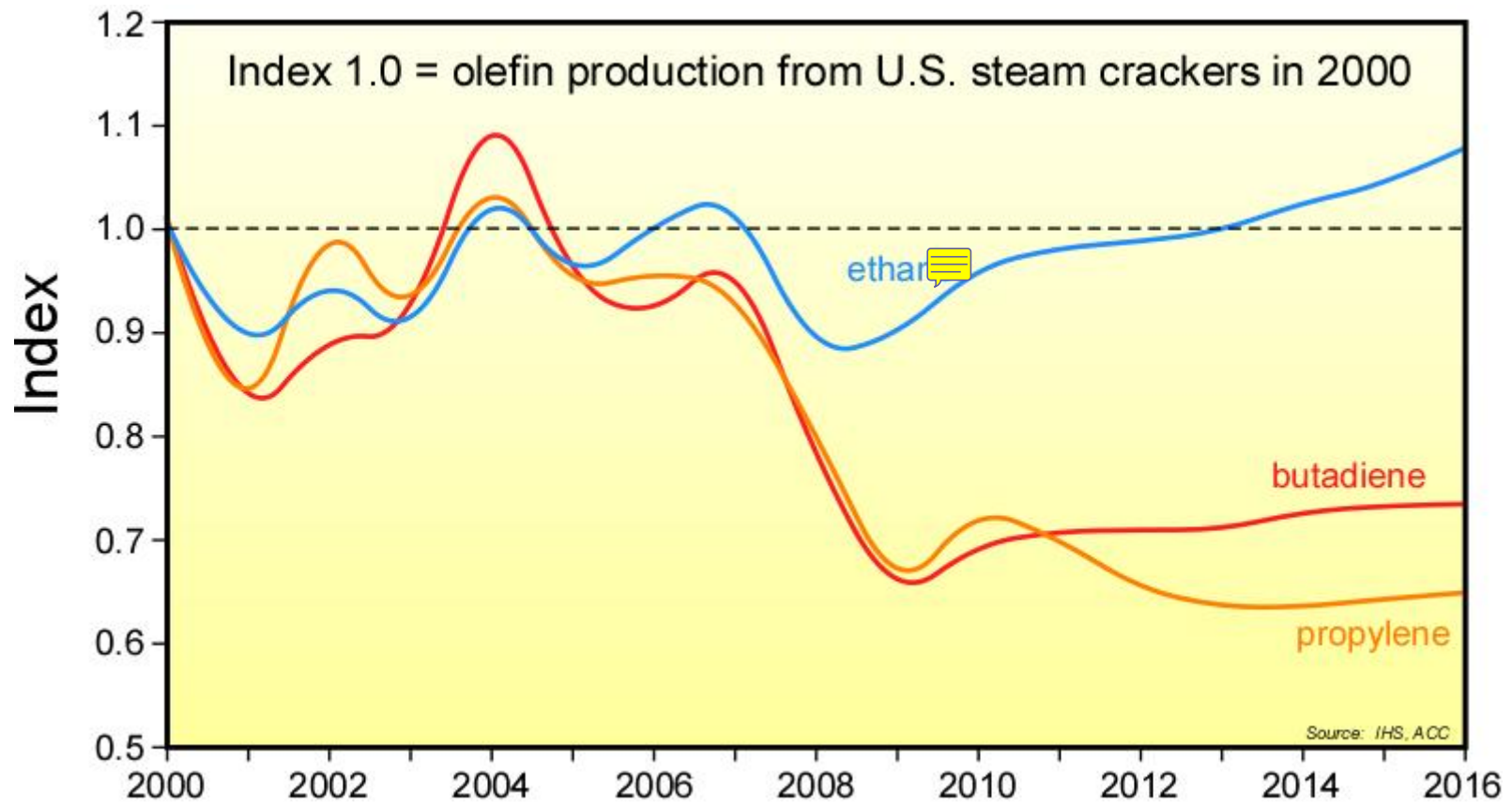
## ■ Chemical Price Follows Oil



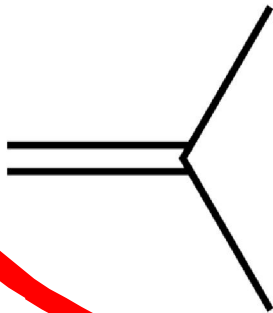
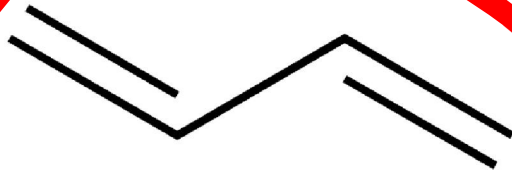
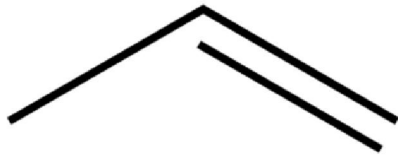
## Ethane Price Now Tracks Gas



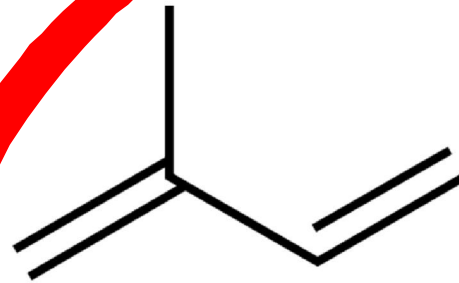
## ■ Production of C3/C4 Dropped



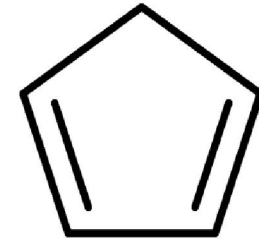
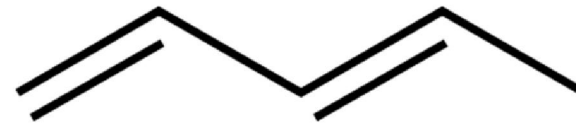
# What's Gone Away?



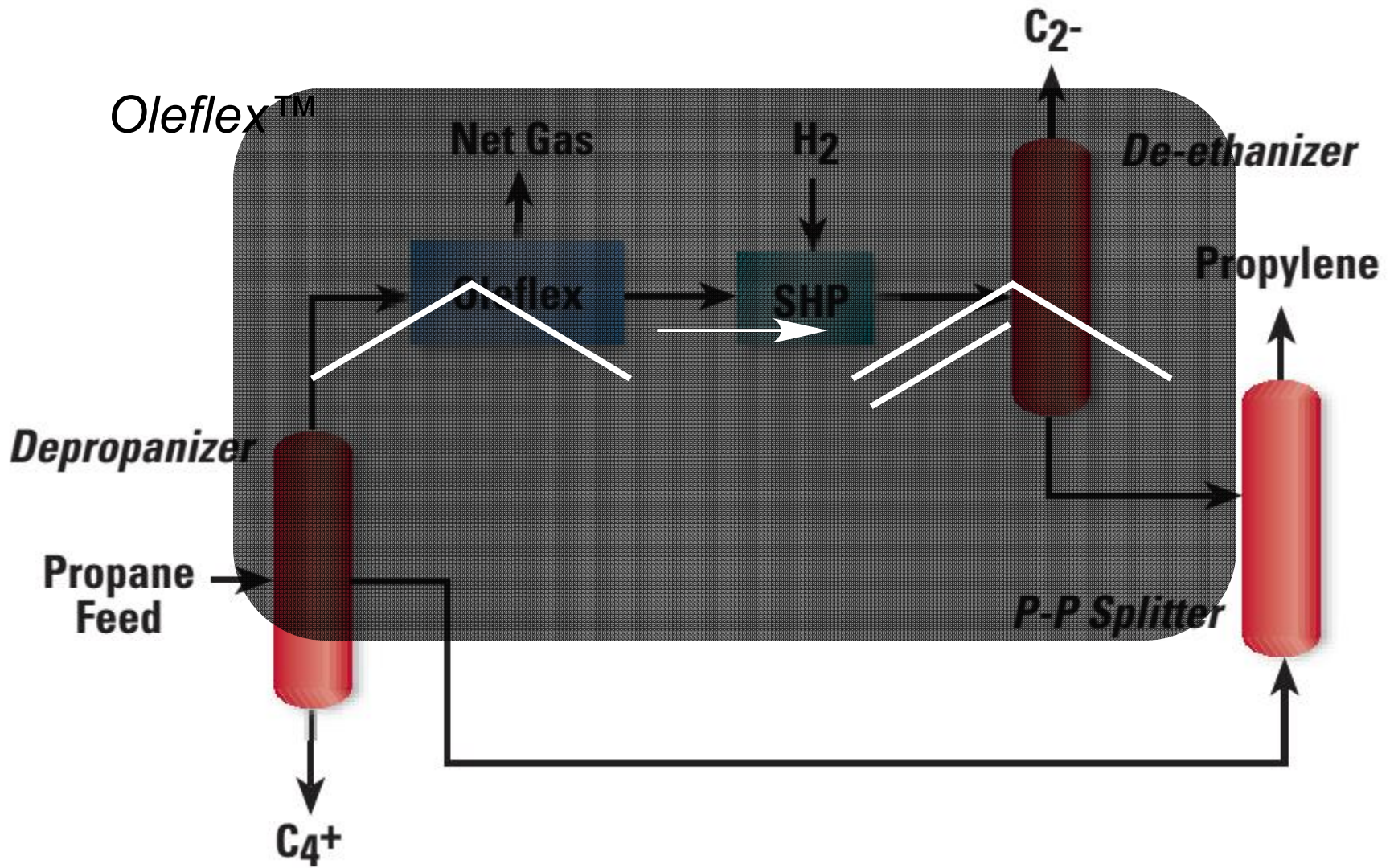
C4



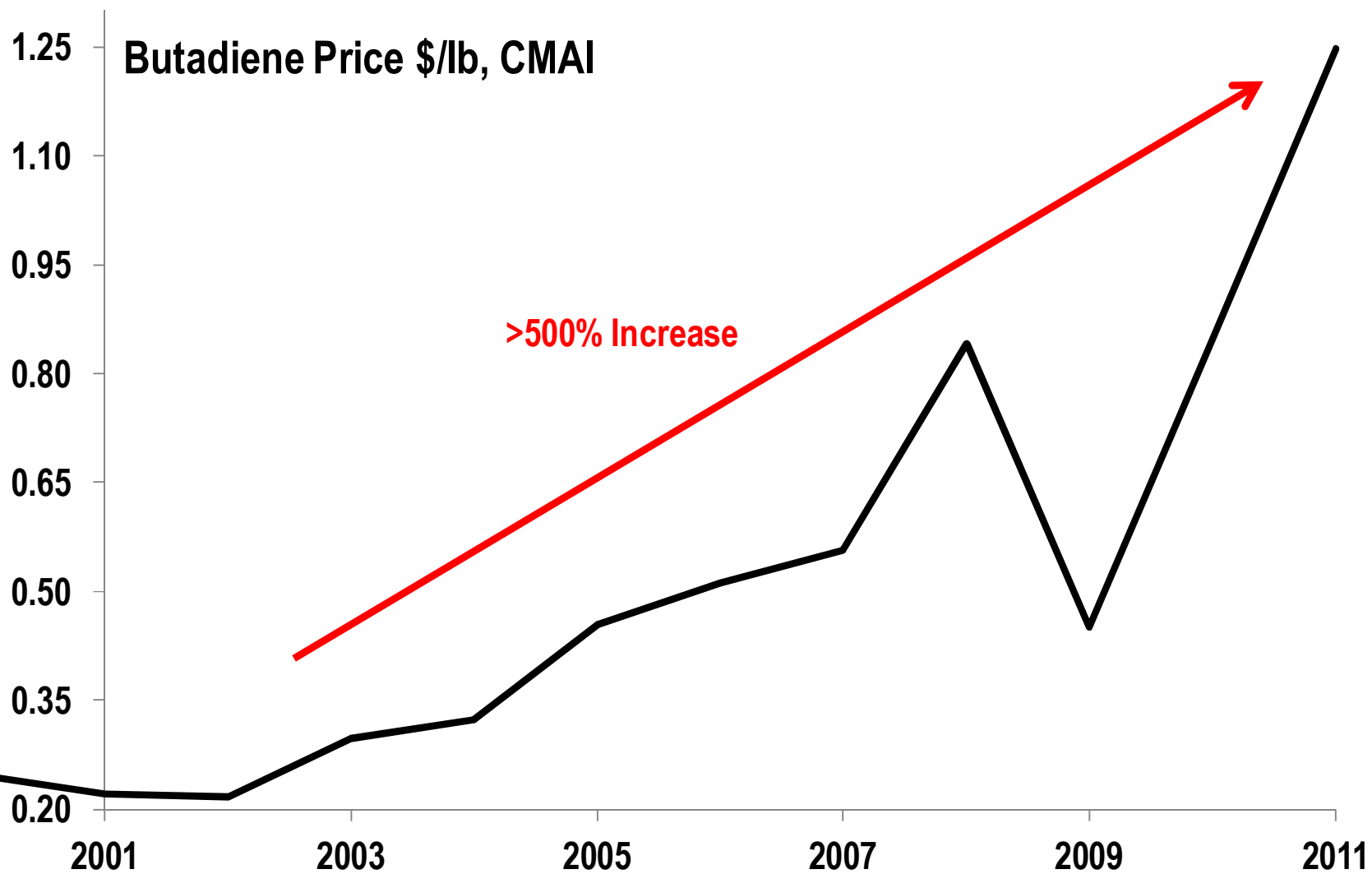
C5



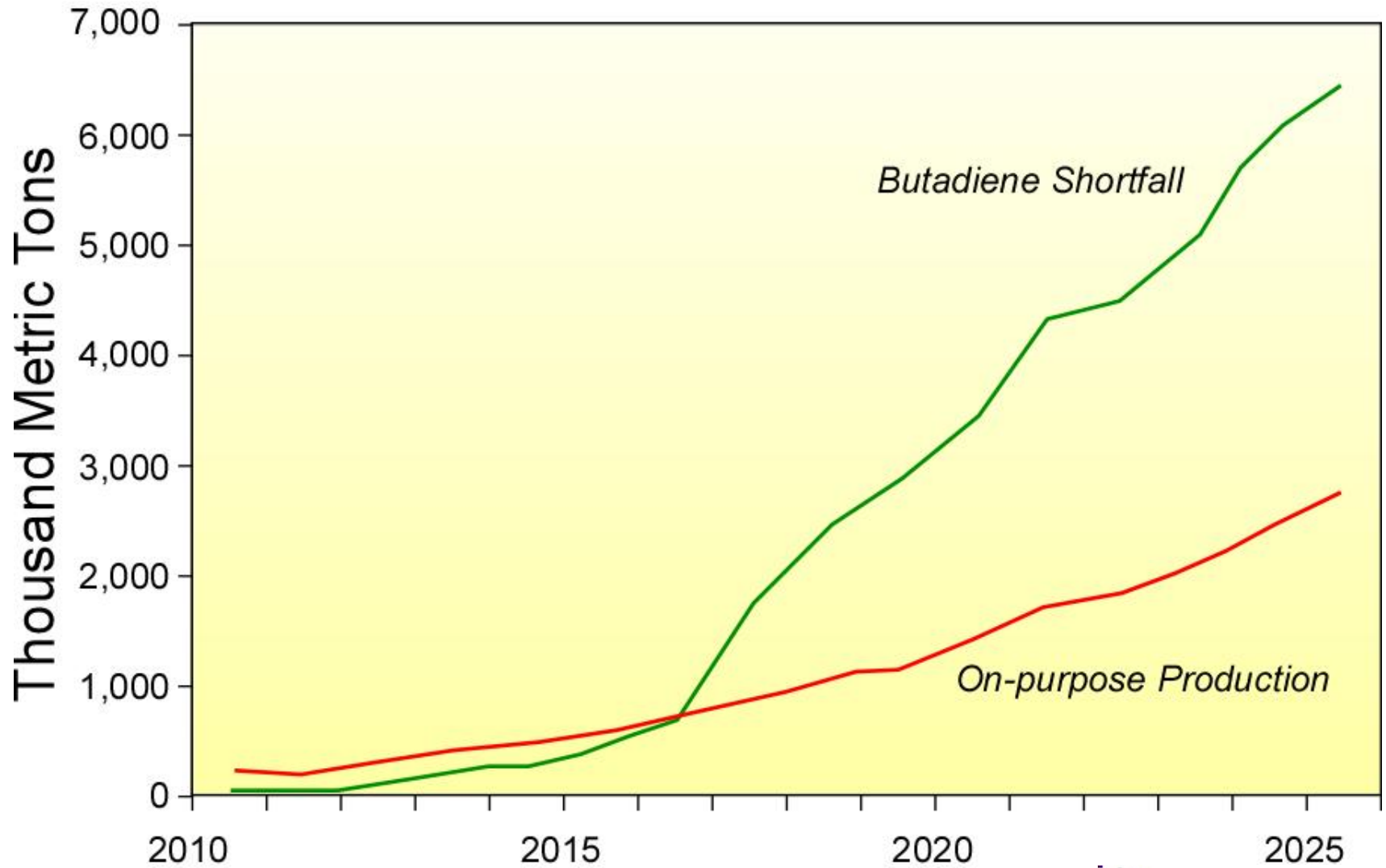
# ■ On-demand Propylene Production



# ■ Butadiene Price Inflation

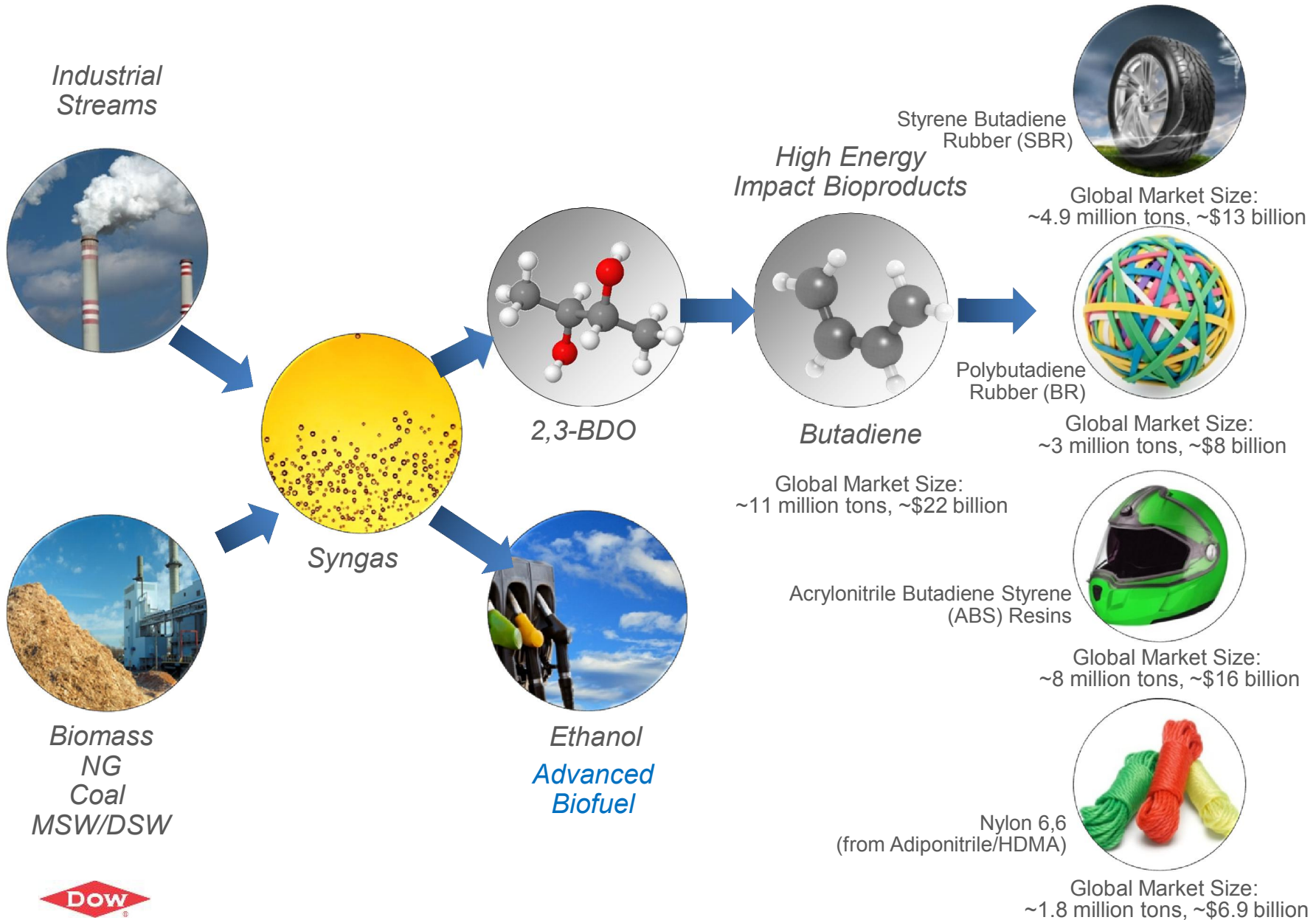


# ■ Butadiene Shortfall

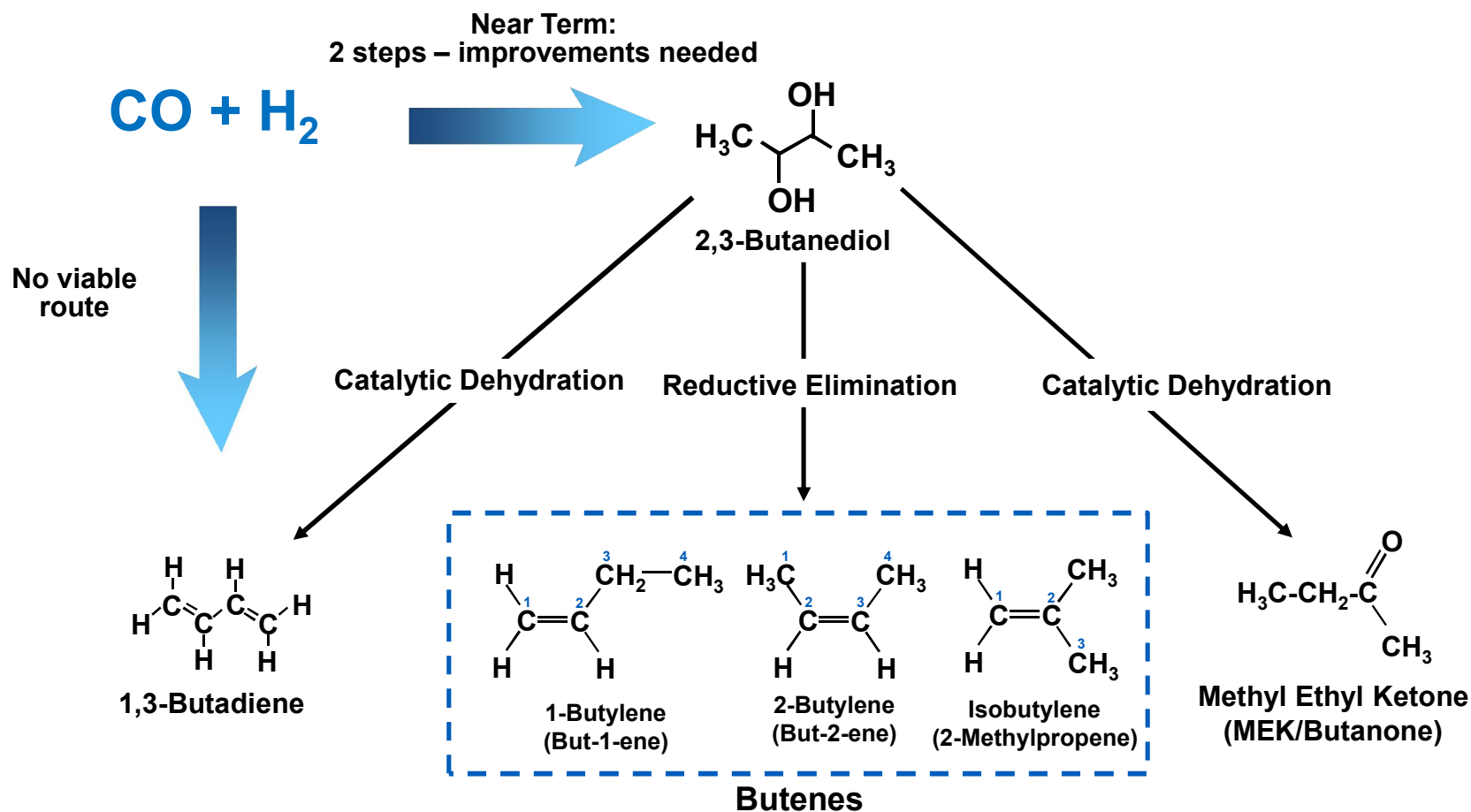




# Biology to Make C4



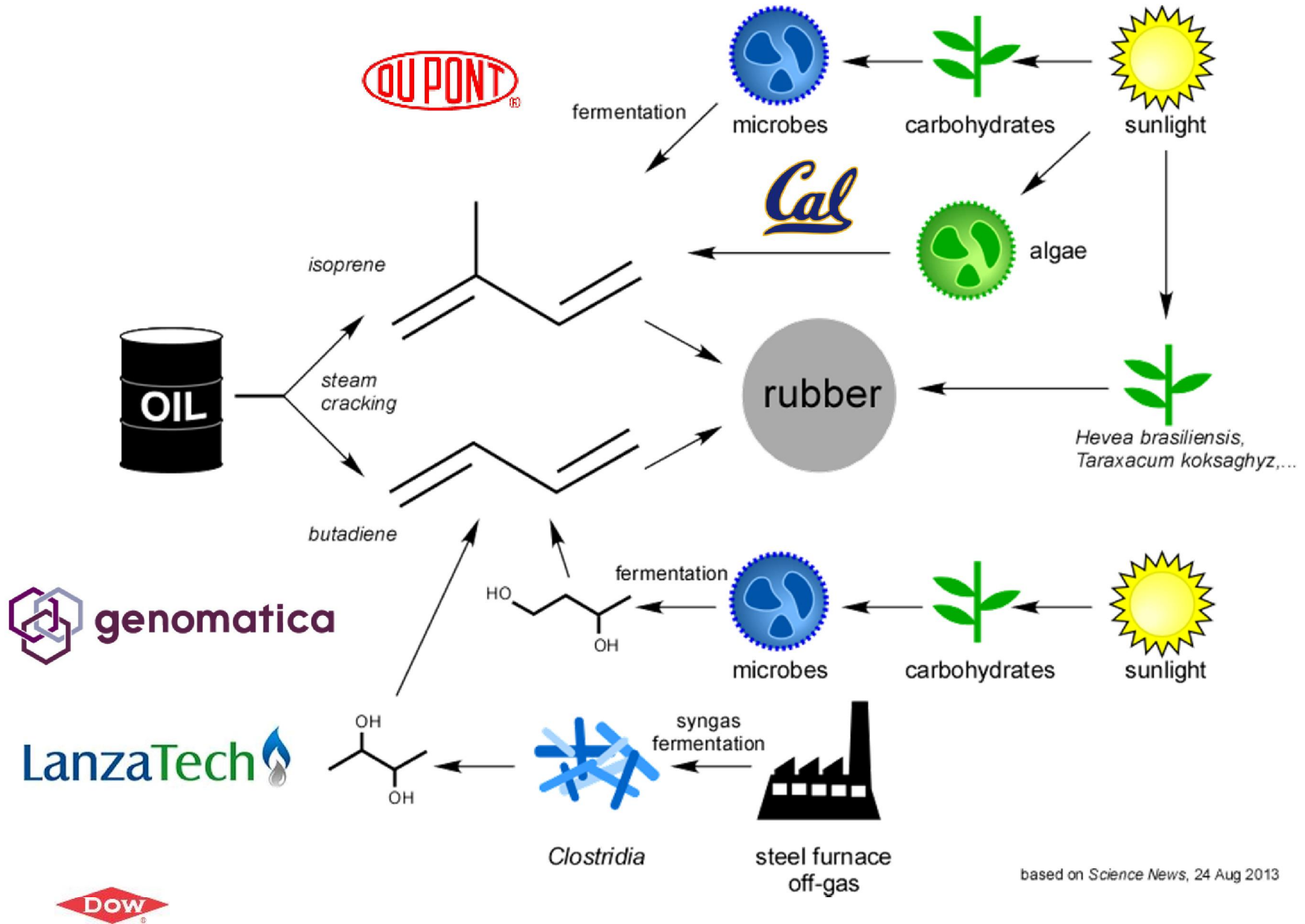
# Route to Key C4 Chemicals



**New Route to C<sub>4</sub>'s without current supply challenges**



# Rubber Monomers



based on Science News, 24 Aug 2013

# Adiponitrile

