Sustainable Decision Making:
Distinguishing Between Hype and Reality

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Executive External Strategy and Communications Fellow

The Dow Chemical Company

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Global Innovation for Sustainability Symposium

Dow.com/innovation

I Waste Time and Money At Home

I Waste Time and Money At Home

I Waste Time and Money At Home

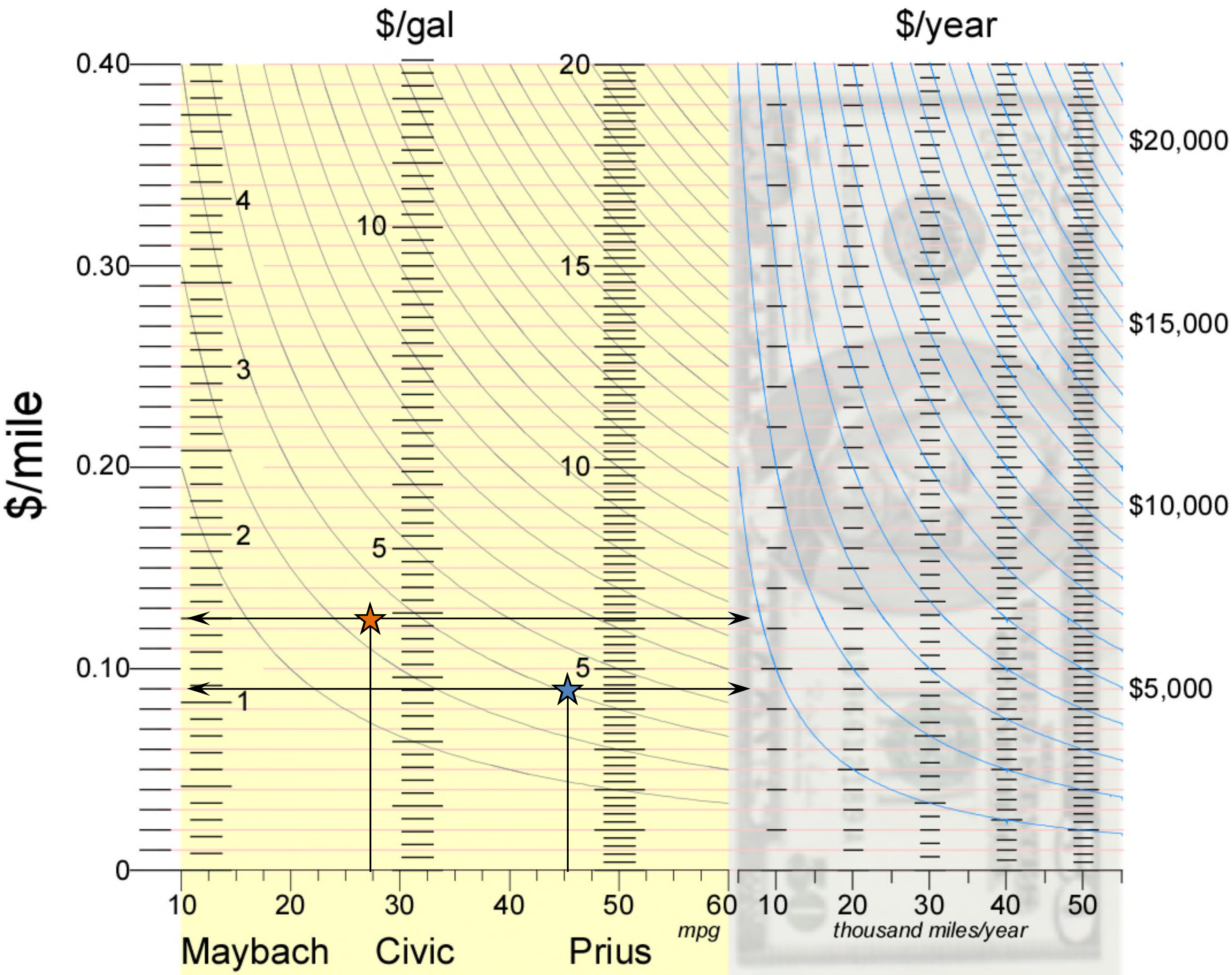
I Waste Time and Money At Home

I Waste Time and Money At Home

Green-e Energy CERTIFIED

I Waste Time and Money At Home

I Waste Time and Money At Home



I Save Time by Using Fossil Fuels

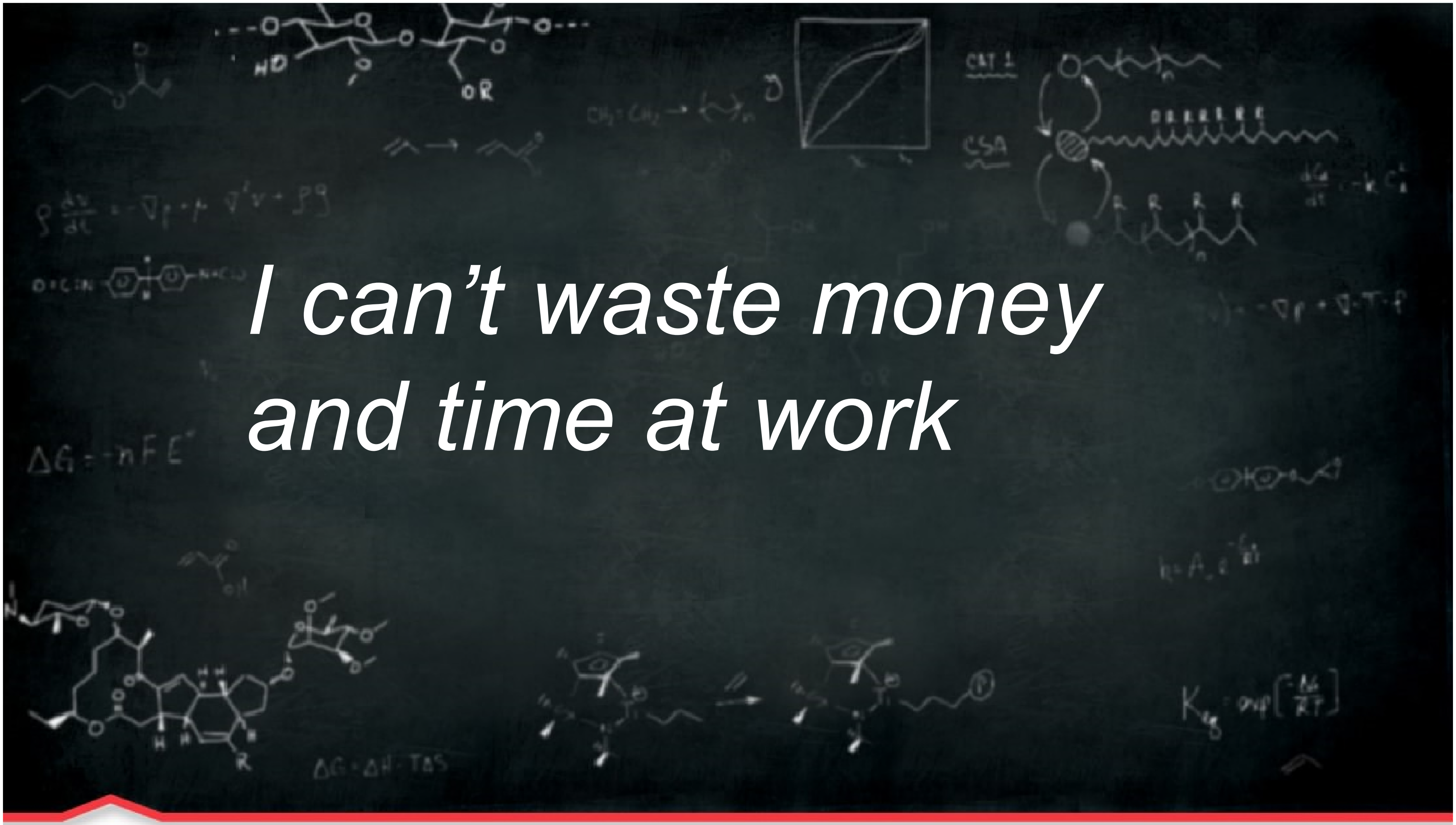
I Waste Time and Money At Home

I Waste Time and Money At Home

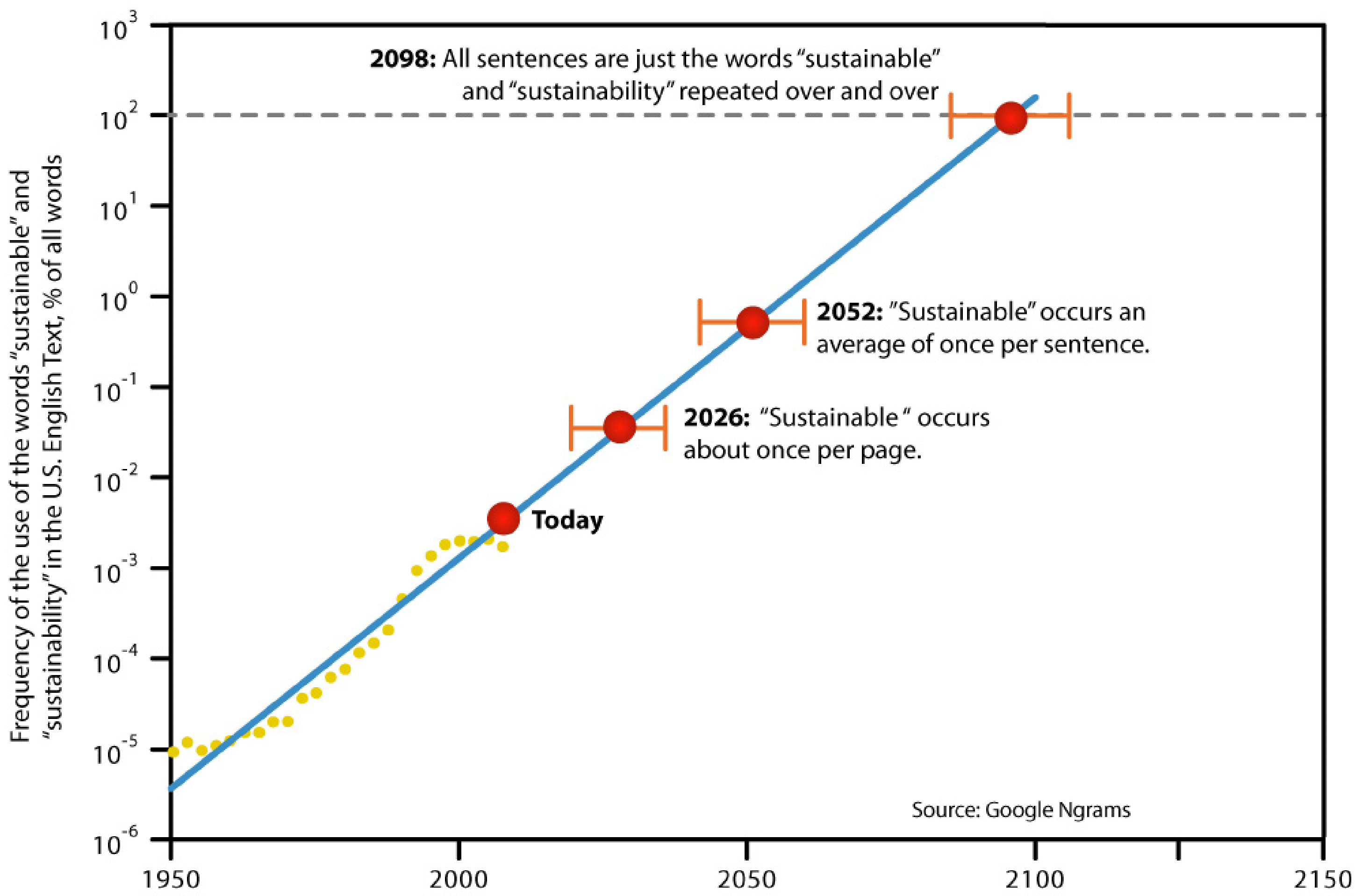
I Waste Time and Money At Home

I Waste Time and Money At Home

Return Shareholder Value



Sustainability is Unsustainable?

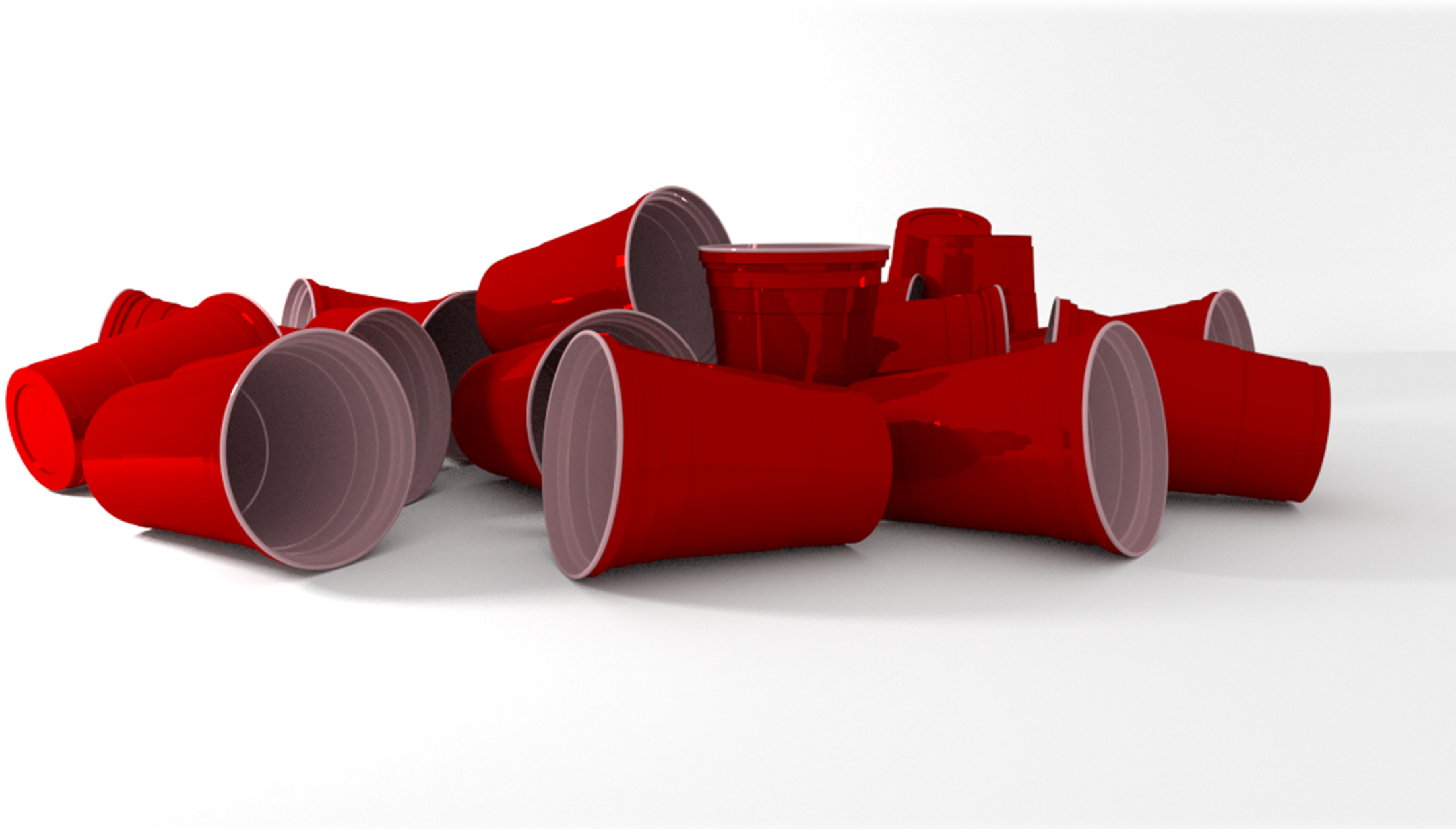


http://imgs.xkcd.com/comics/sustainable.png

Metaphor for Sustainability

Ordered

Disordered



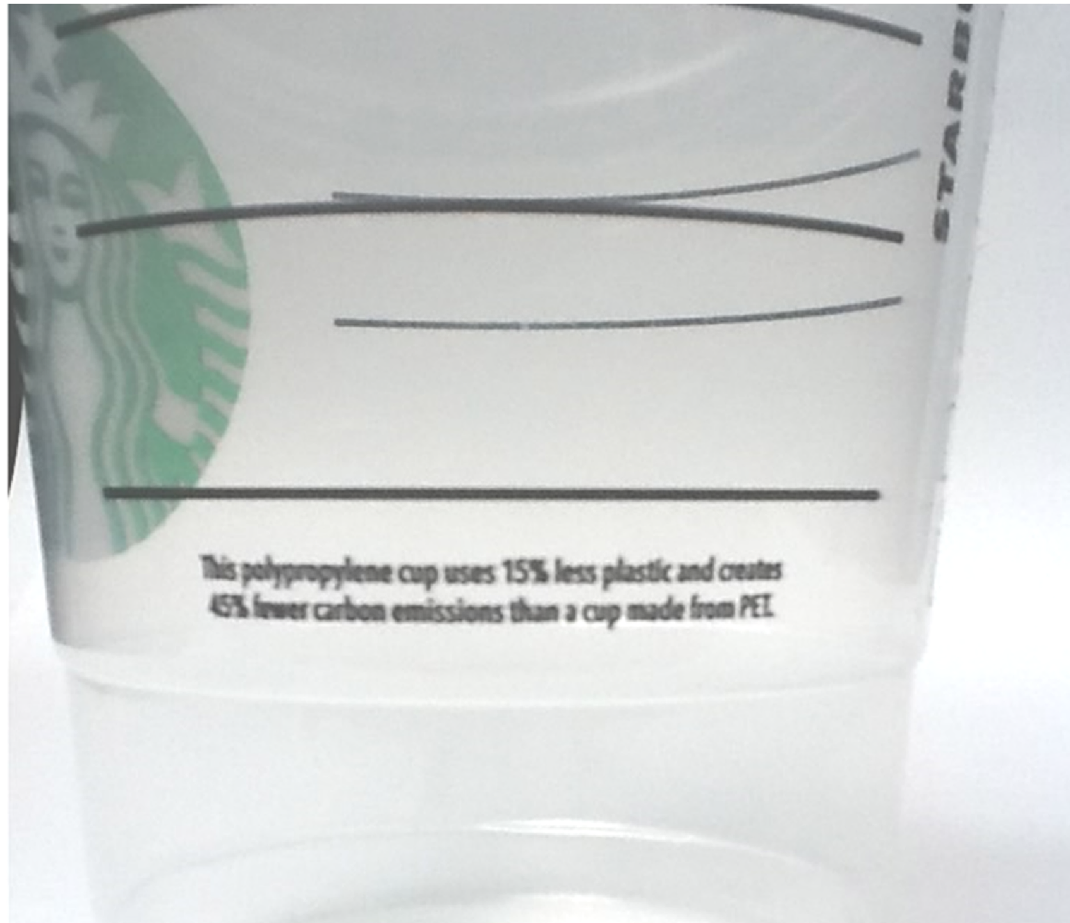
Sustainable?

Is this Cup Sustainable?

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

How about this one?

Signs of Hope



Which is more sustainable?

plastic

paper

Which is more sustainable?

8 hours

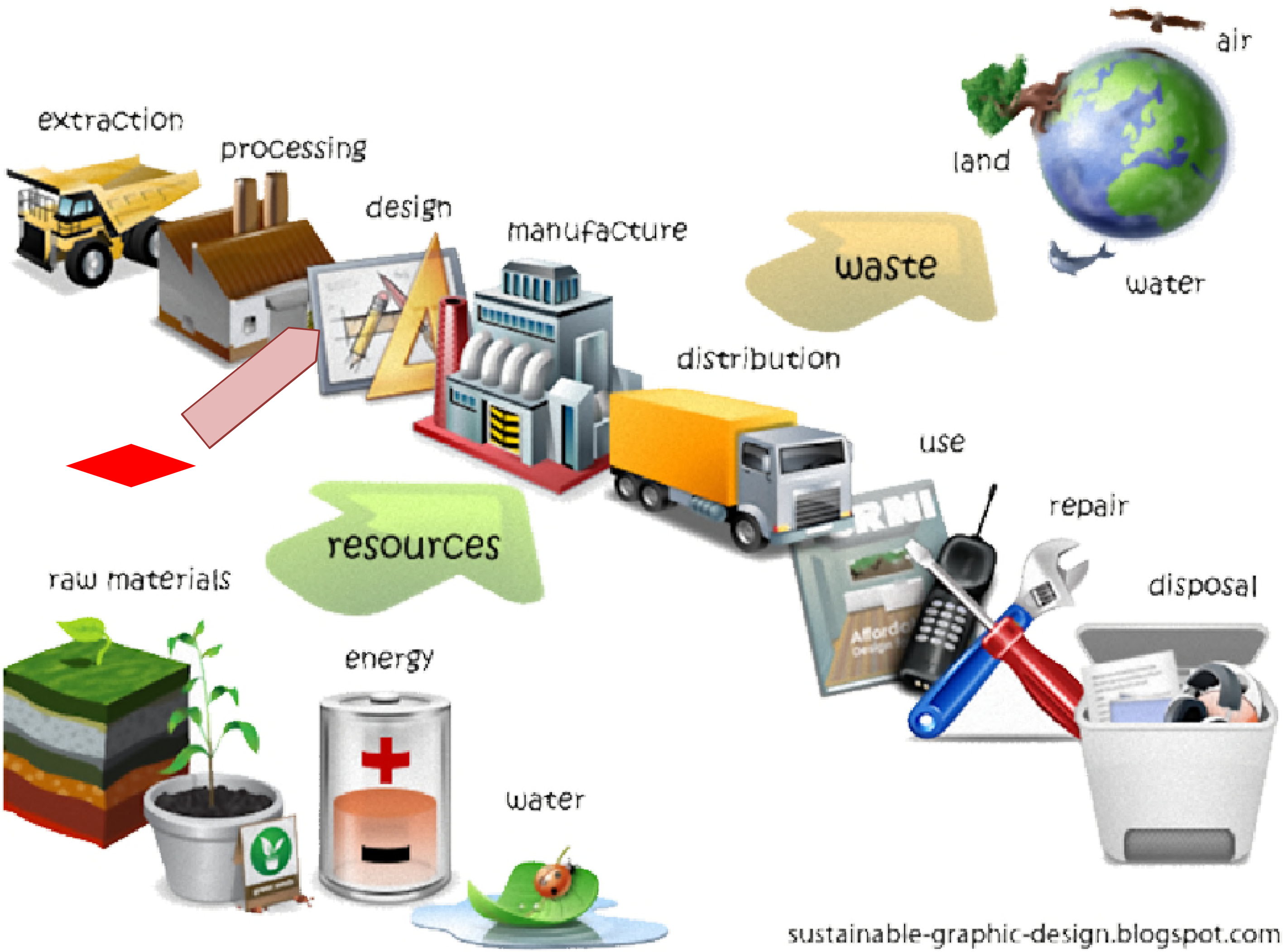
1 mile

Which is more sustainable?

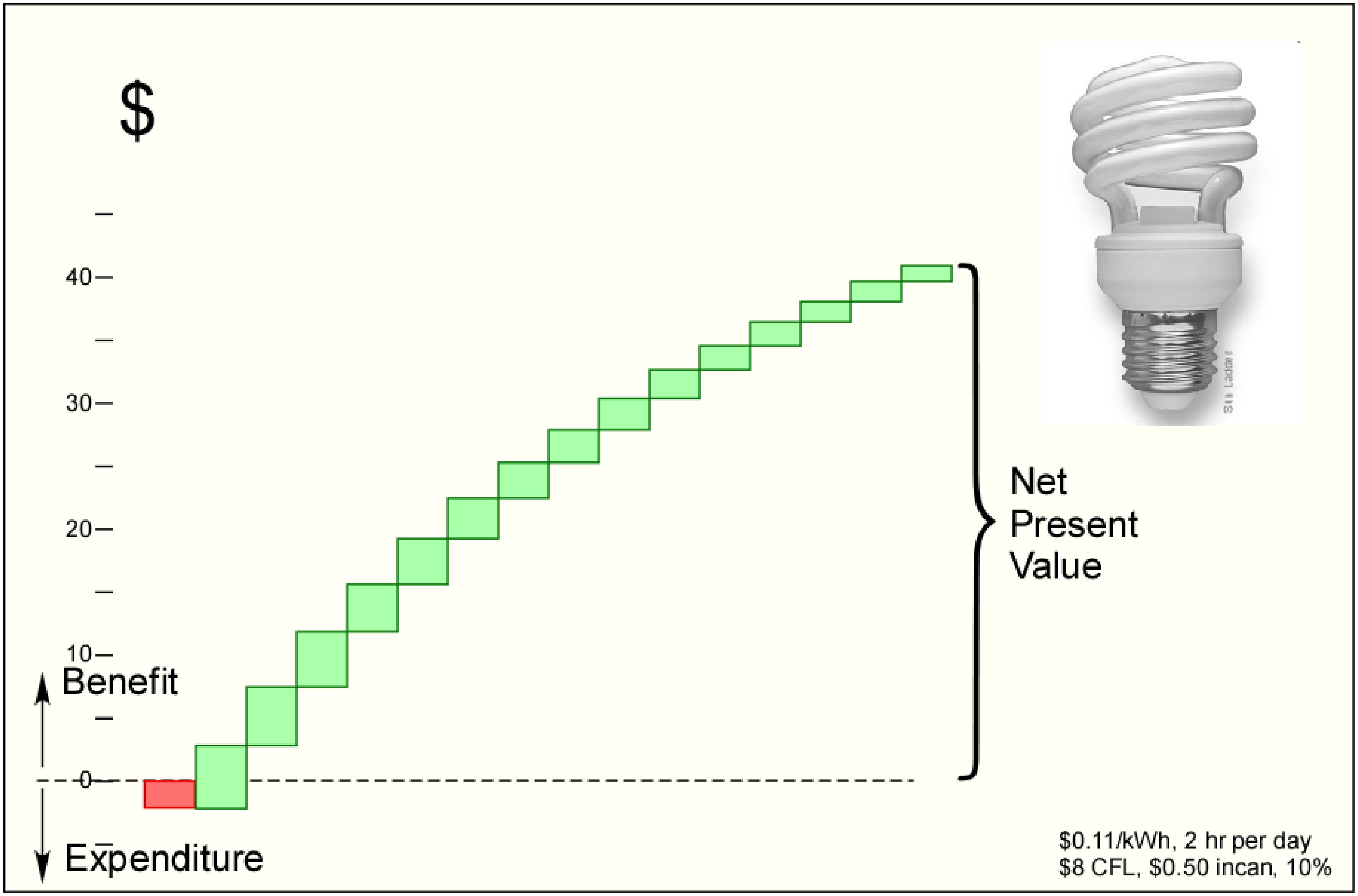
A meat-eater in a Prius

A vegan in a Hummer

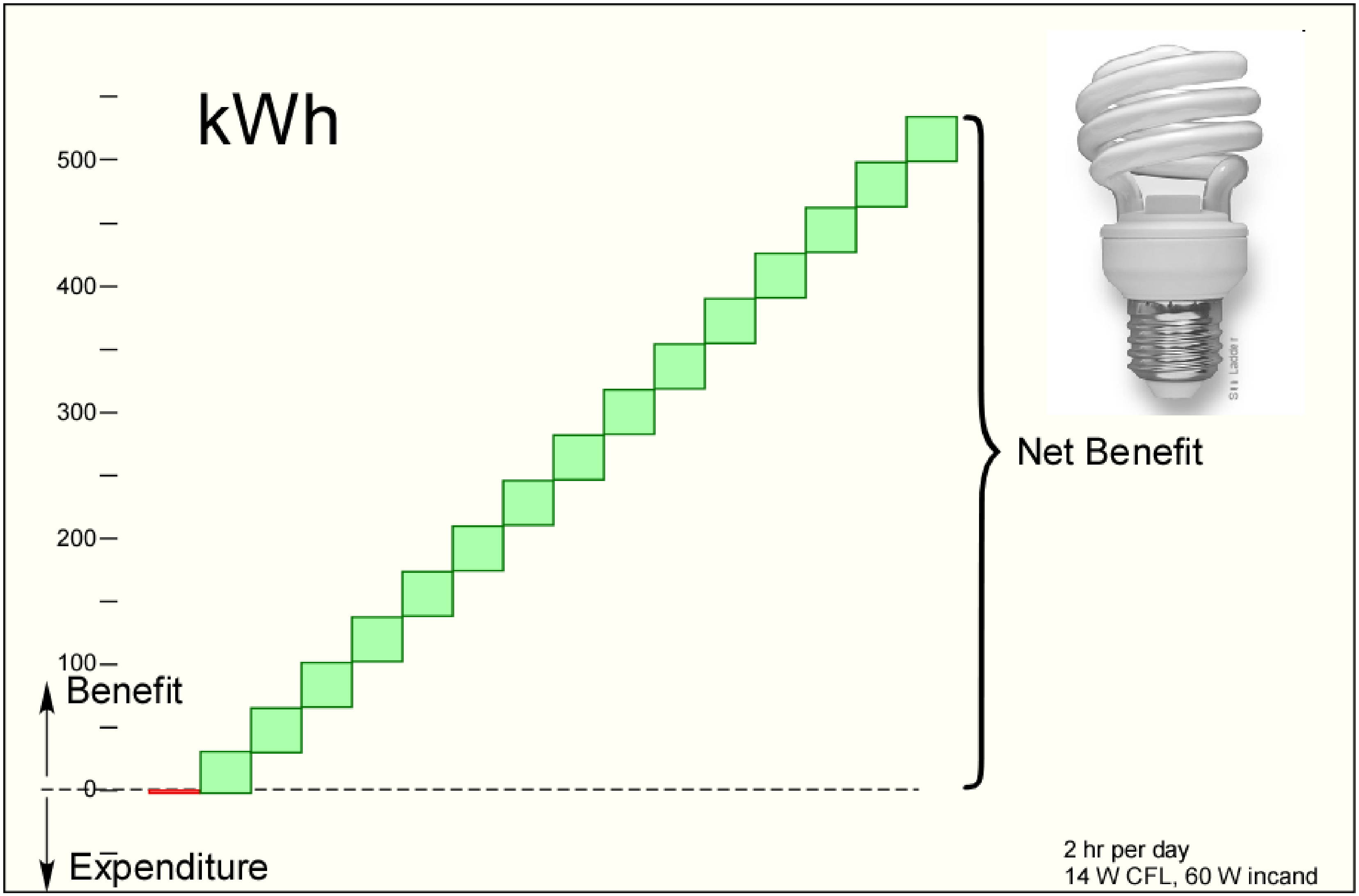
Life Cycle Analysis



Financial Way of Looking At Benefit

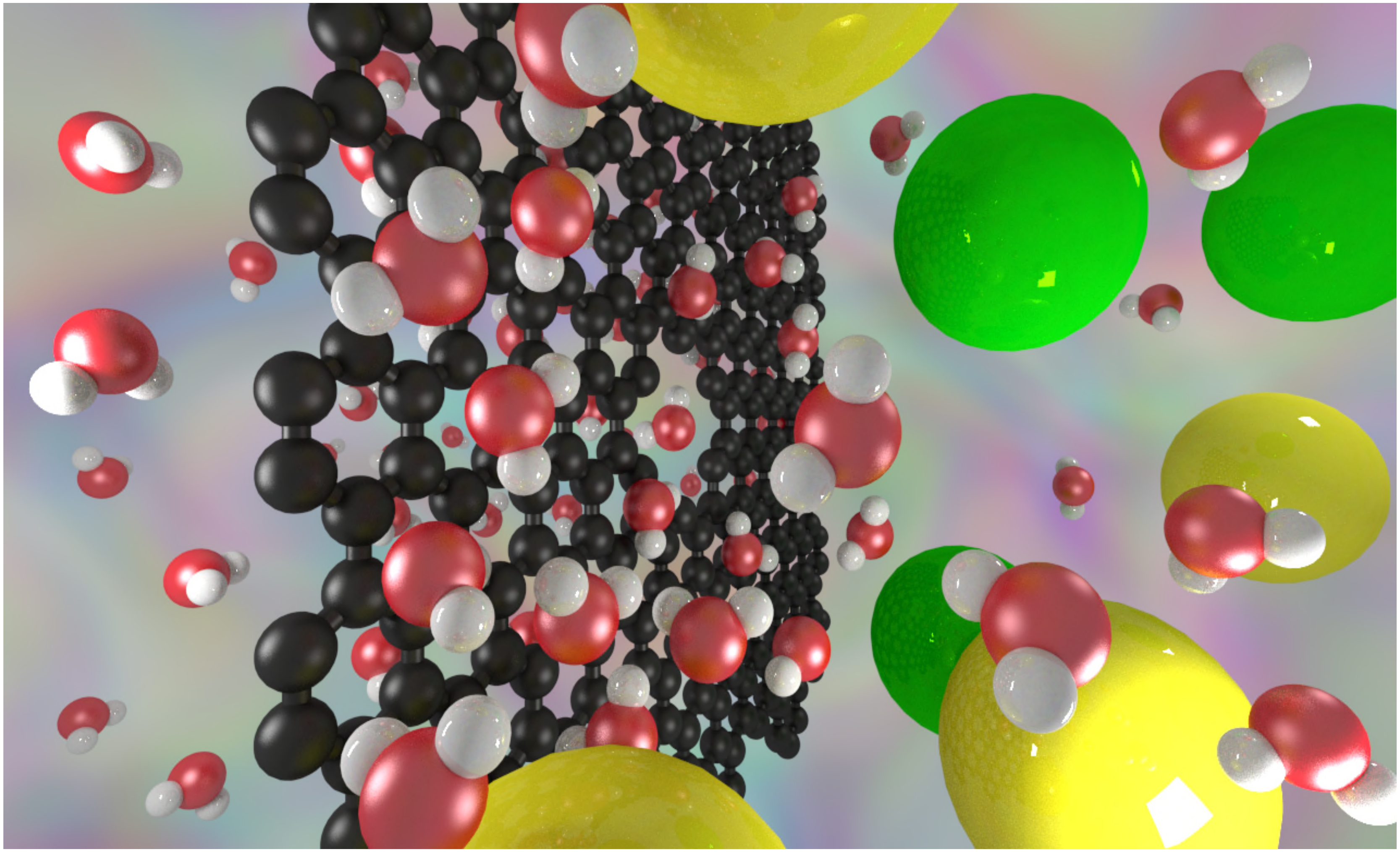


Why Not Sustainability?



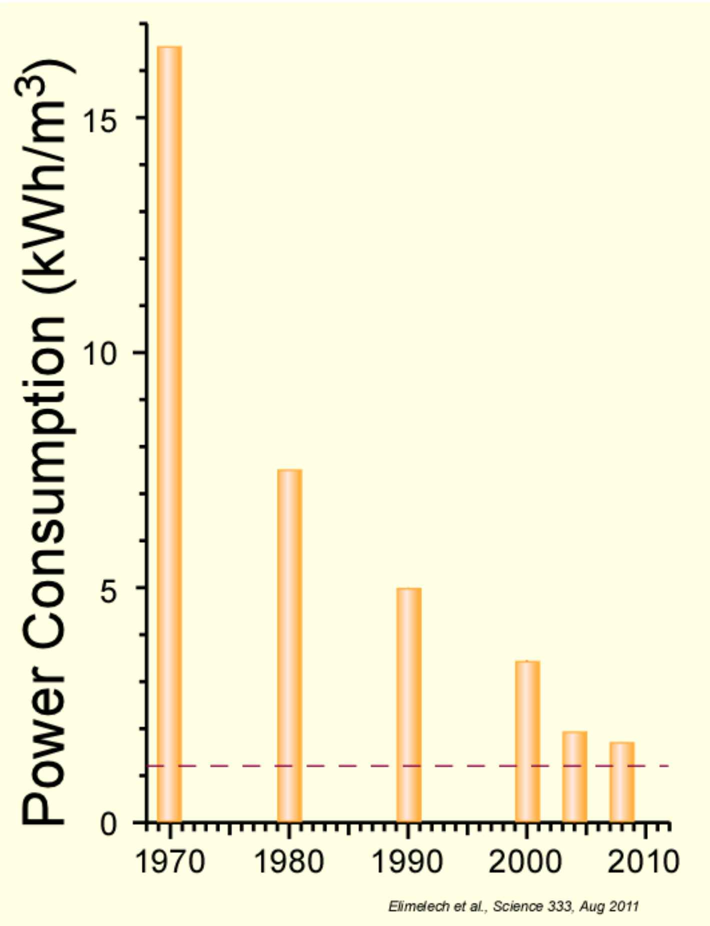

Dow
®

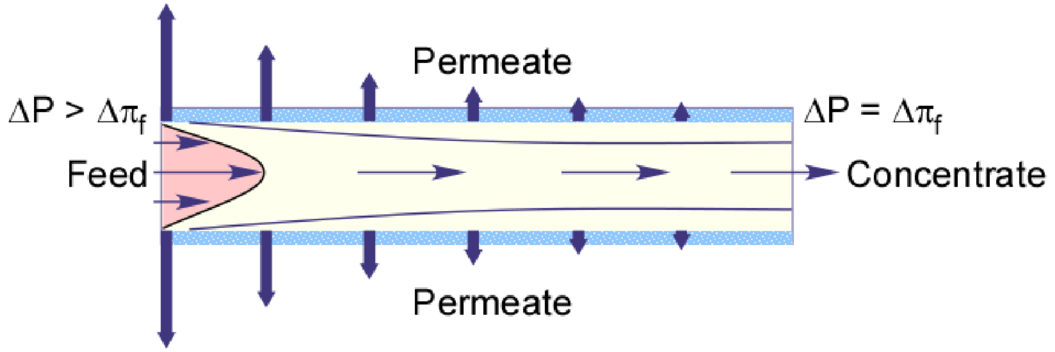
Misconceptions Demean Advances

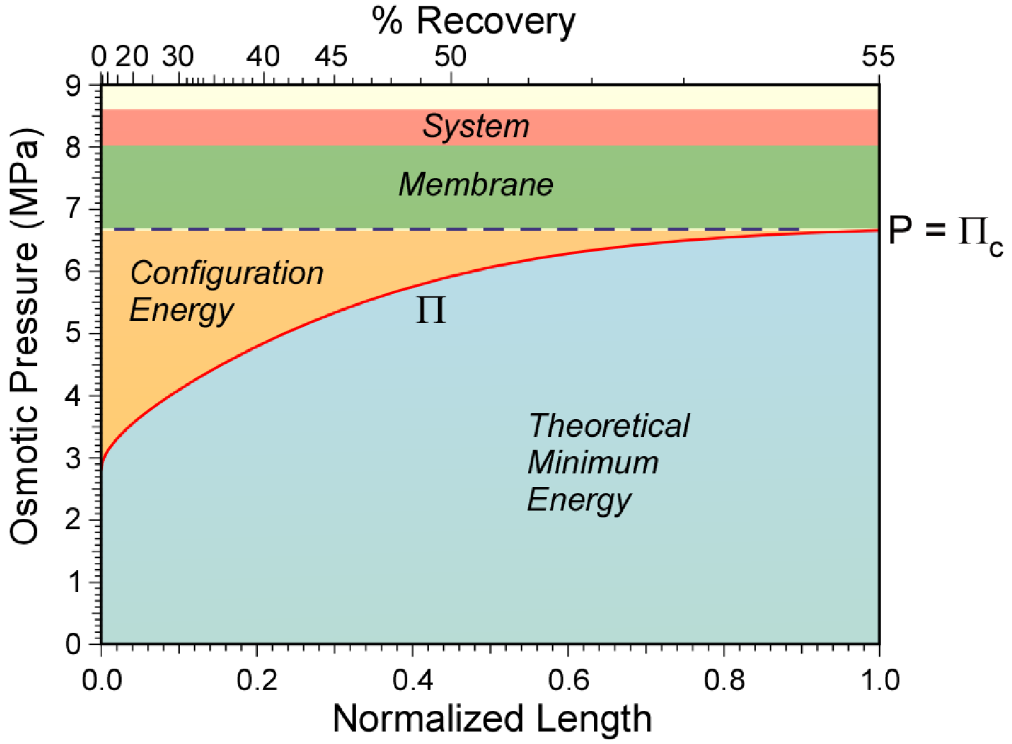


Fresh Water Production

Simple Distillation ~600 kWh/m^3



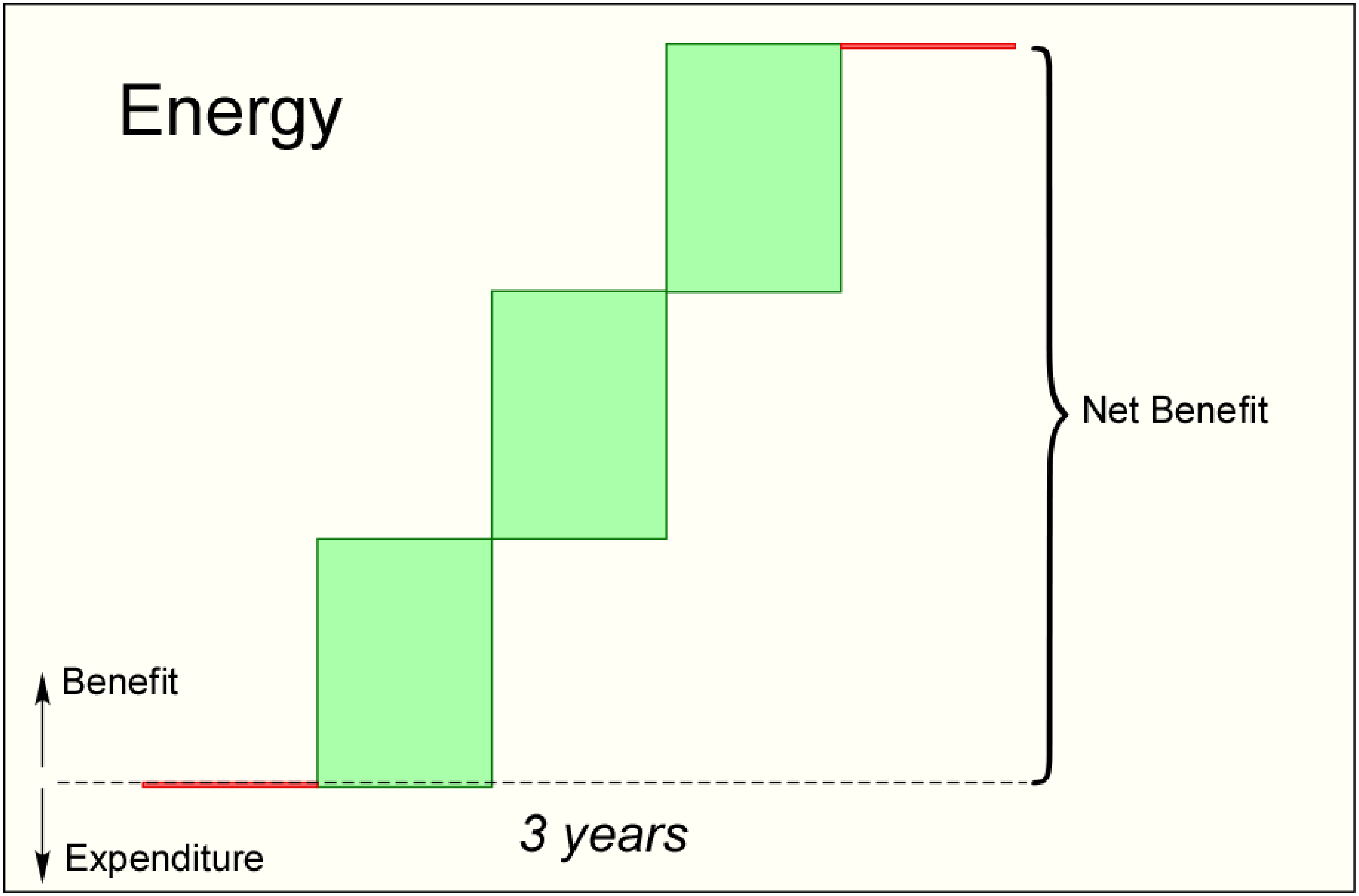




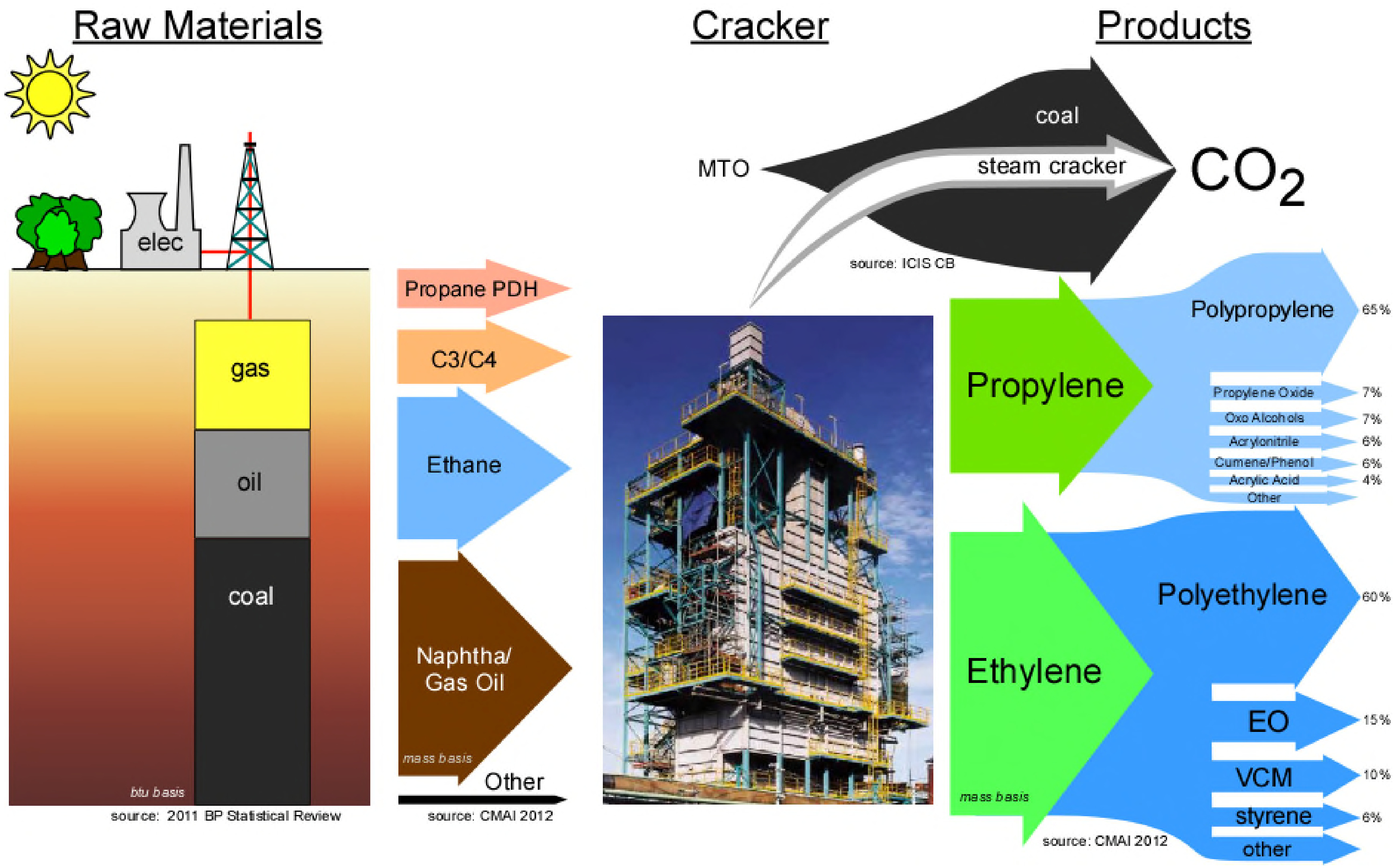
Energy-efficient DOW FILMTEC™ Water Treatment Membranes yield savings on water purification

Process	**Operating Energy Consumption** (Kwh/m³)	**Customer Energy Savings 2005-2015** (Barrels of Oil-eq)
Multi Stage Flash (MSF)	13.5 - 25.5	242 million
Multi Effect Distillation (MED)	6.5 – 11	82 million
Reverse Osmosis	3 - 3.5	

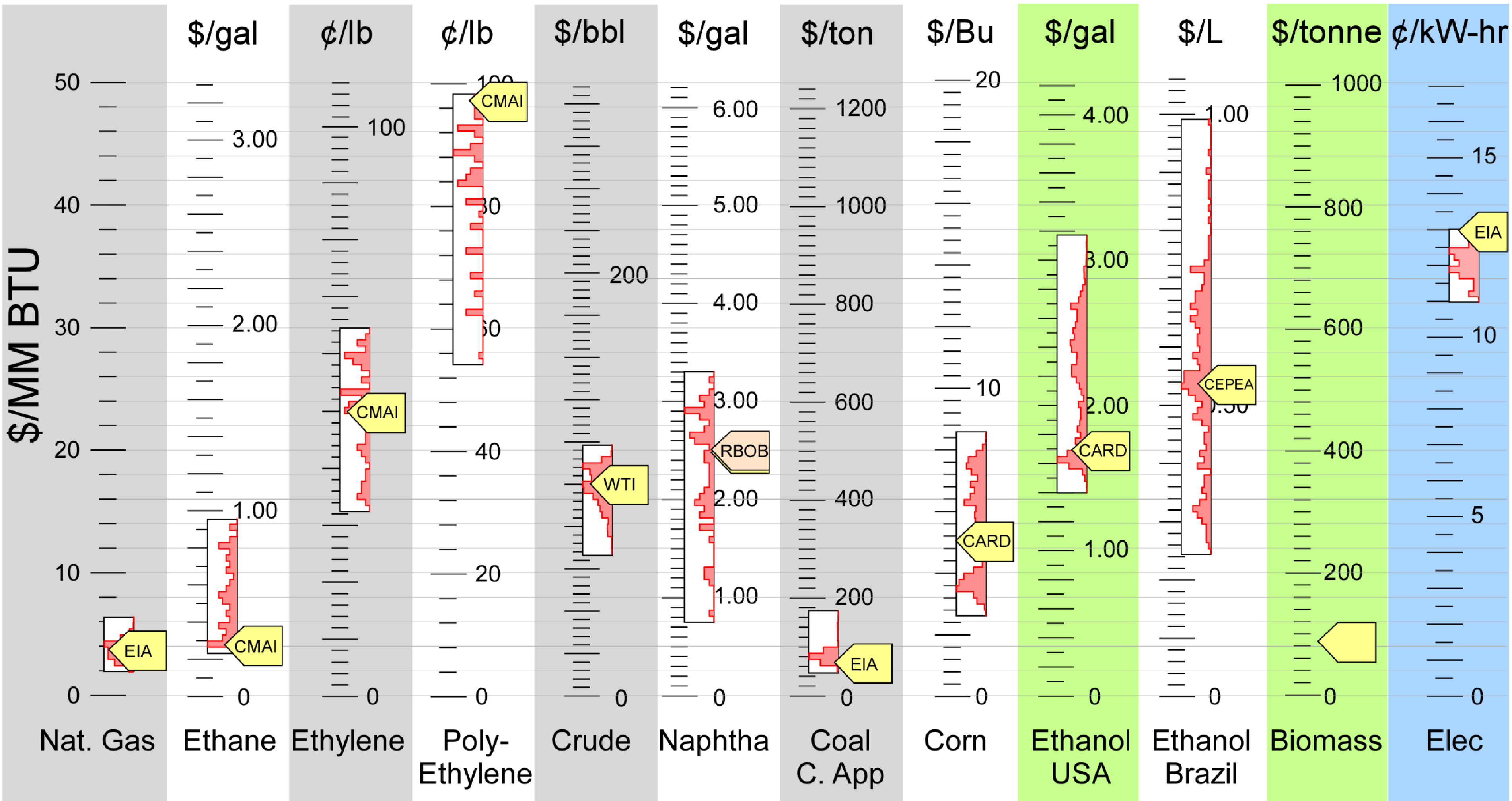
RO Cartridge Benefit



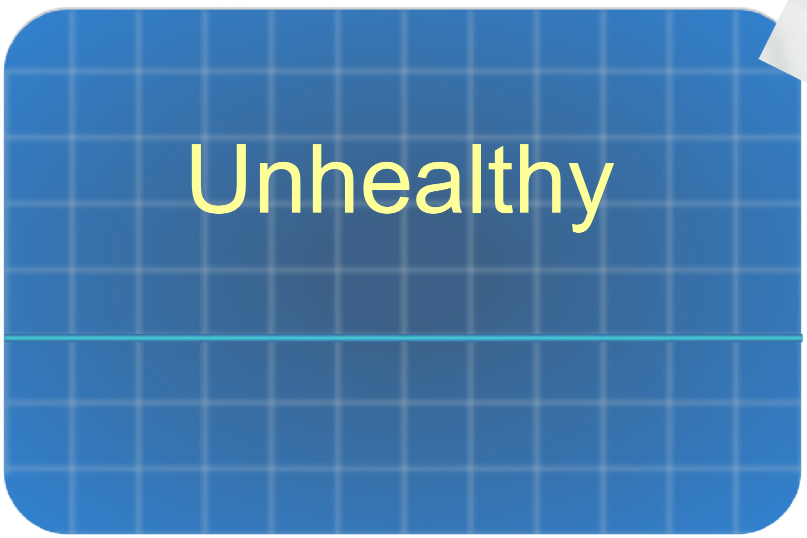
Chemical Industry Snapshot



Chemicals and Energy

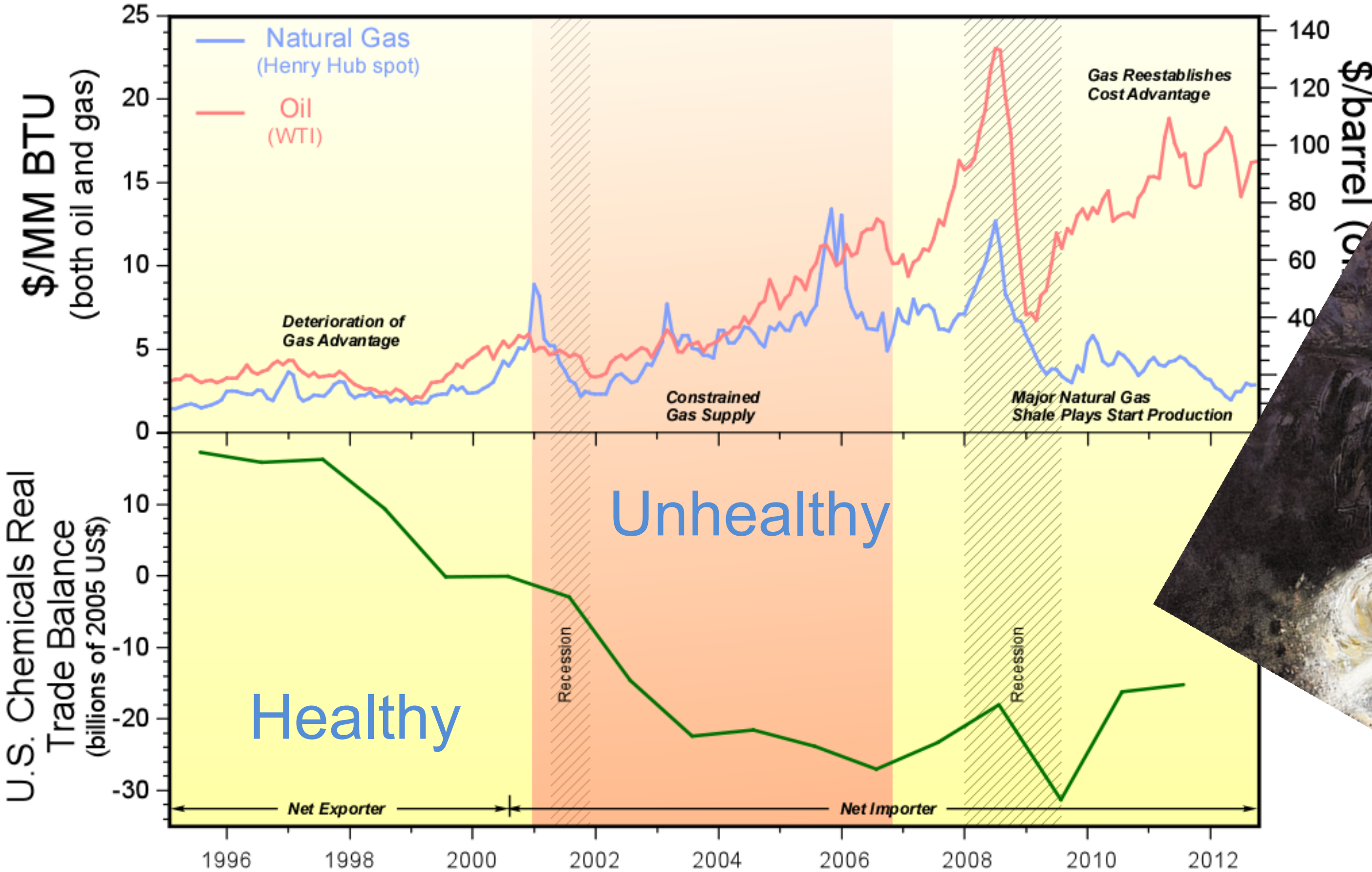


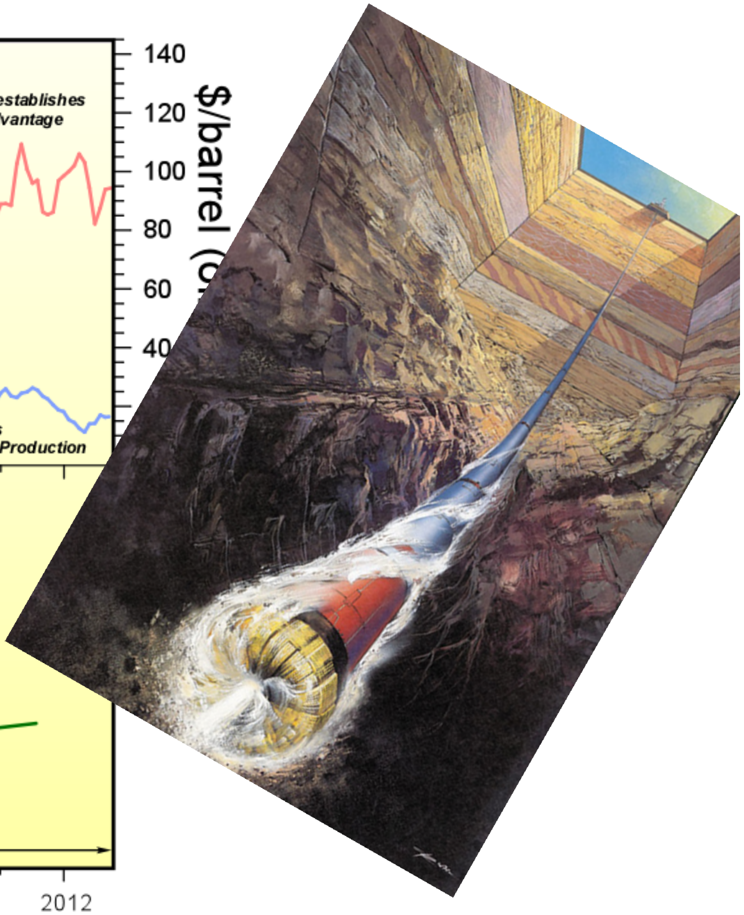
What Unhealthy Looks Like




R.I.P.
U.S. CHEMICAL
INDUSTRY
1776-2008

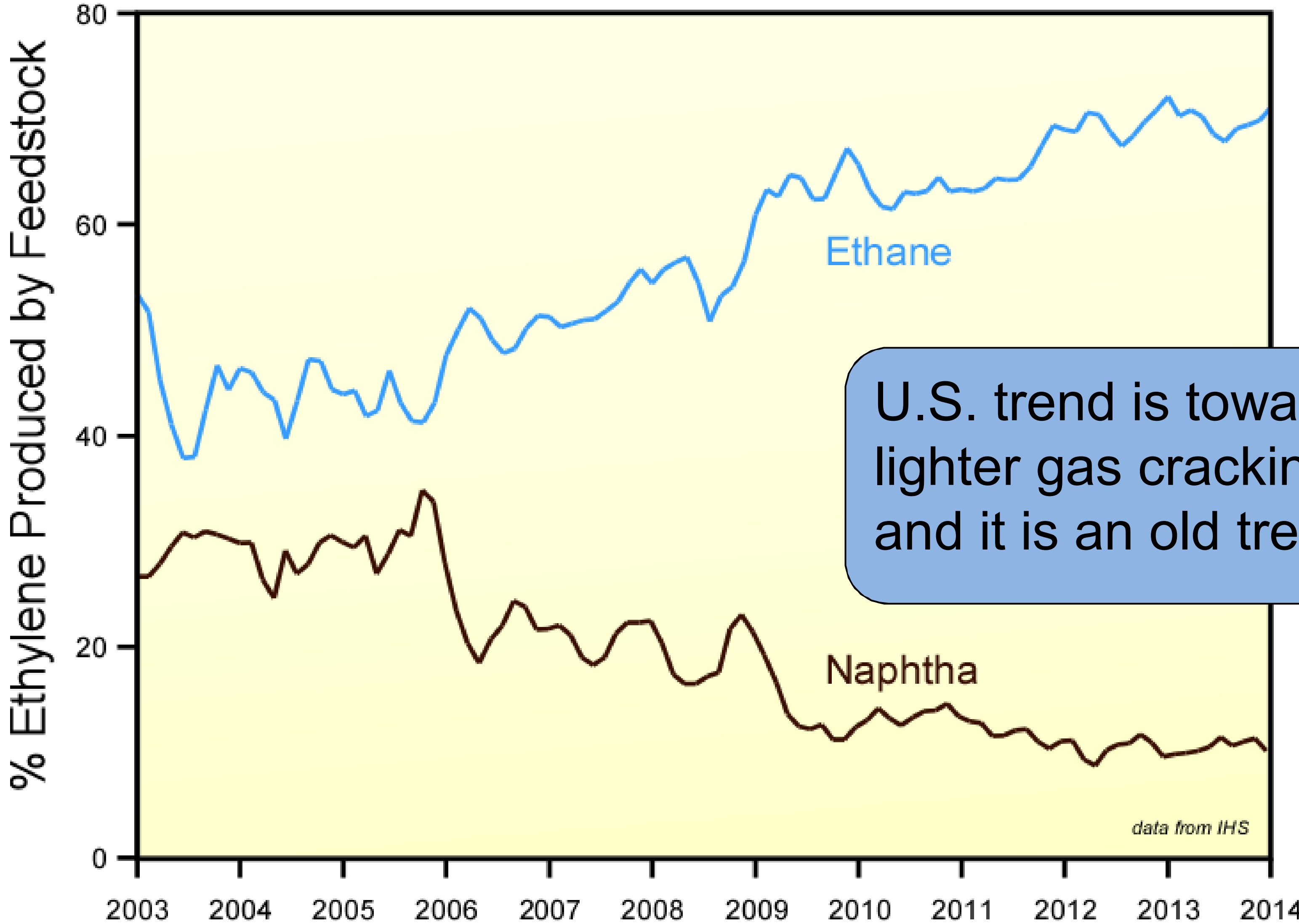
Chemical Industry Health





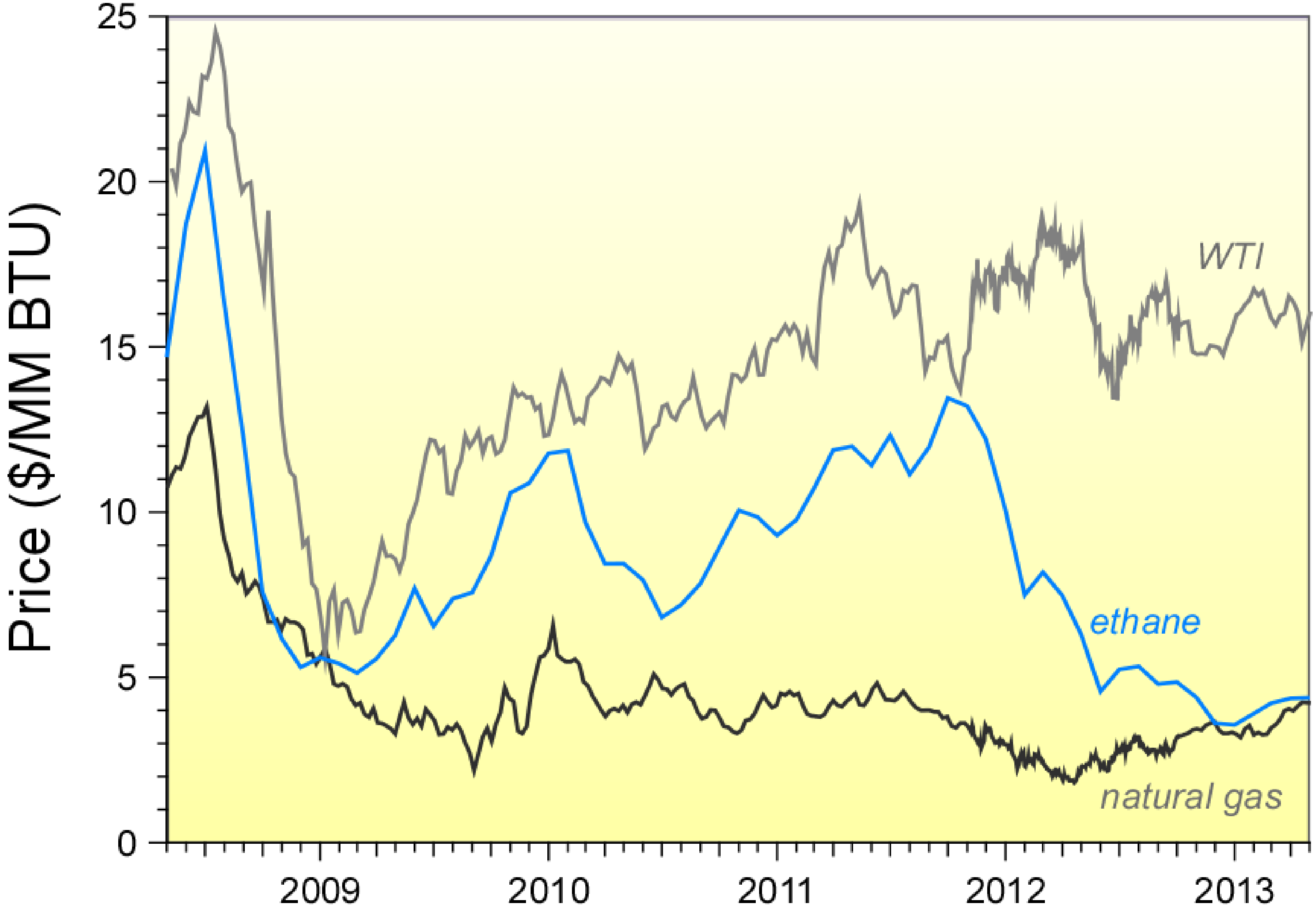
IHS Global Insight, "The Economic and Employment Contributions of Shale Gas in the US", prepared for America's Natural Gas Alliance, December 2011.

US Trend

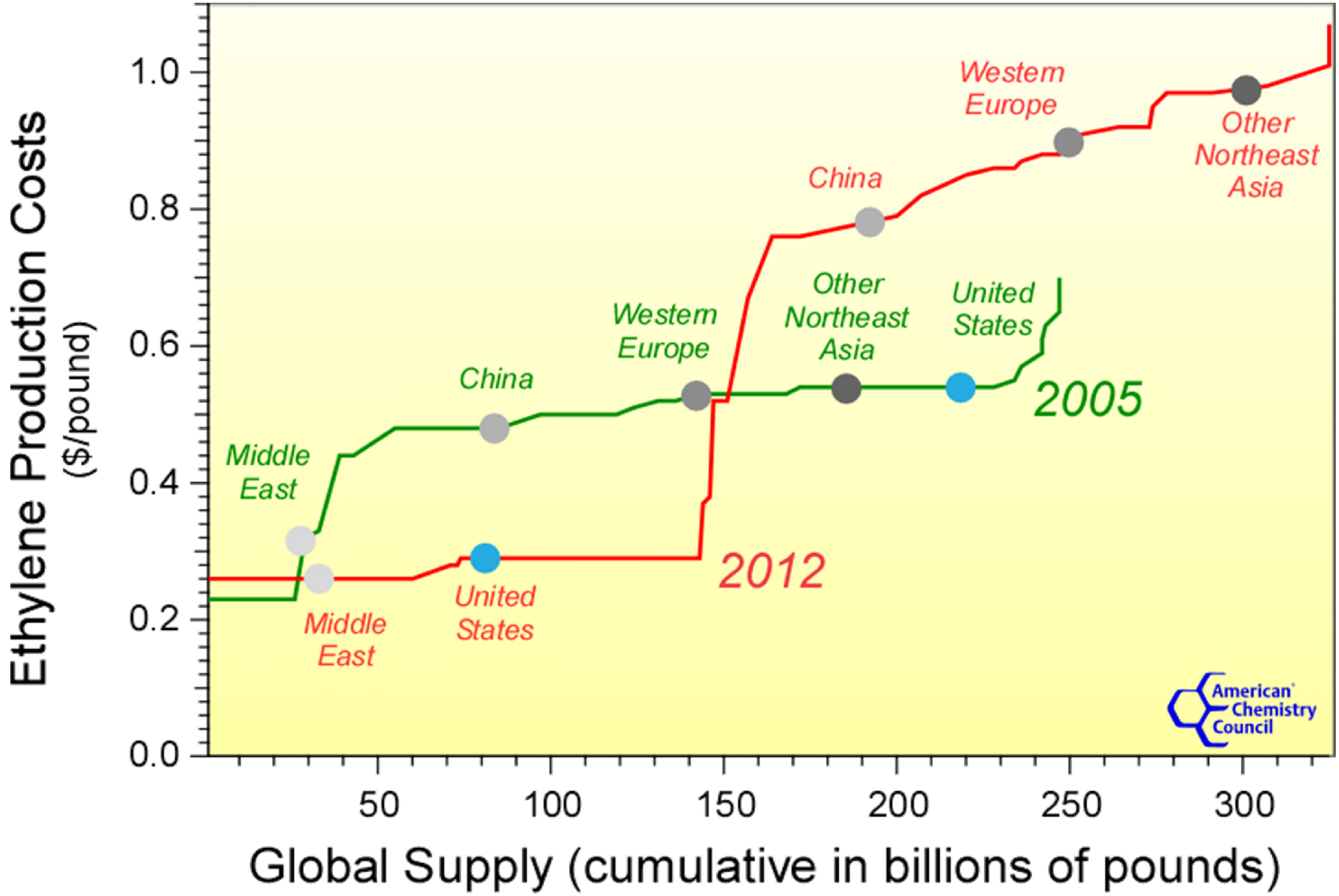


U.S. trend is toward lighter gas cracking and it is an old trend

Ethane Price Now Tracks Gas



Impact of Low Gas Prices



Live Long and Prosper

Economic Impact of Shale Gas

97 new chemical industry projects due to shale gas*

$72 billion in new capital investment

310 thousand direct & indirect jobs by 2020
226K add'l jobs generated by household spending

$201 billion in new economic output

$14 billion in new tax revenue by 2020

American Chemistry Council

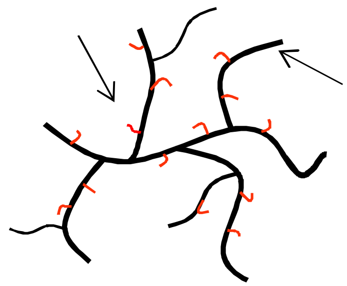
Unapologetically Polyethylene

- improving our production methods
- making improved materials
- replacing materials with larger footprints
- creating advantages in use

The Evolution of Polyethylene

LDPE

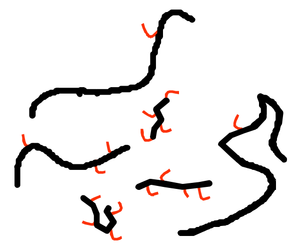
Radical mechanism (1933)
- Ethylene only polymerization
- Very high temperature & pressure
- Complicated kinetics



Highly Branched:
- Excellent flow properties
- Fast extrusion rates
- Poor mechanical properties

LLDPE

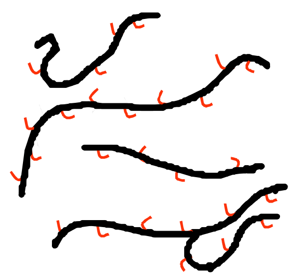
Coordination catalysis (1950's)
- Ethylene/α-olefin polymerization
- Low Temperature & Pressure
- Ti, Cr catalysts
- Multiple catalytic sites



Linear Backbone:
- PE homopolymer: crystalline
- Copolymers: flexible and tough
- Blend of polymers produced

mPE

"Single Site" catalysts (1990's)
- Ethylene/α-olefin polymerization
- Molecular catalysts
- Kinetics the same for each catalytic site

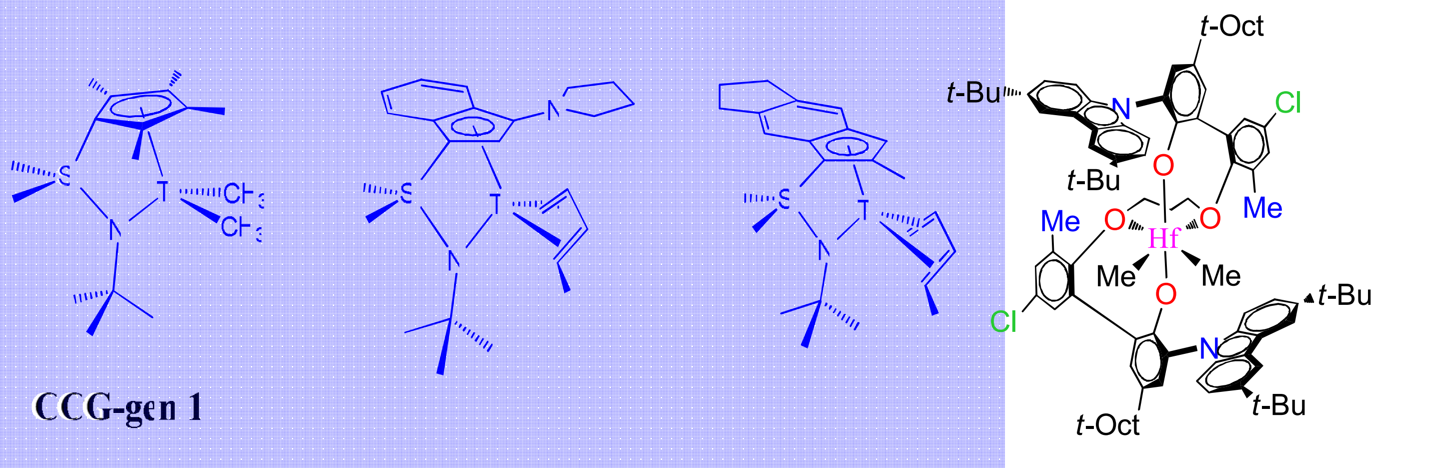


Homogeneous Polymers:
- Narrow molecular weight distribution
- Narrow comonomer distribution
- New monomer combinations
- Long chain branching

Counter-intuitive Catalysis Improves Process

Polyethylene: Higher Efficiency and Plant Throughput Through Improved Catalyst Design

$TiCl_4/MgCl_2/Cl_2AlEt$



HEC-3 **CCG-gen 1**

Increasing Thermal Stability and Efficiency

Stand-up pouch packaging reduces waste and brings energy savings

Package Type	Contents	Impact per 100 oz Cereal		
		Landfill Discards* (g)	Process GHG** (kg CO^2 Eq)	Total Energy** (MJ)
Paperboard and HDPE Liner	11 oz	380.0	.861	12.1
Stand-Up Pouch	12 oz	117.5	.265	9.25

Reduction vs Box	
Landfill Discards	**68%**
GHG	**69%**
Energy	**23%**

Flexible Packaging Examples

Flexible packaging helps increase shelf life

Using only a few grams of flexible plastic packaging extends the shelf life of a cucumber by more than three times.

FLEXIBLE PLASTIC PACKAGING
HELPS IN-STORE WASTE
REDUCE
3 percent to under 1 percent
BY INCREASING
SHELF LIFE

Source: Incpen

Food Packaging

Modern agriculture is the use of land to convert petroleum into food.

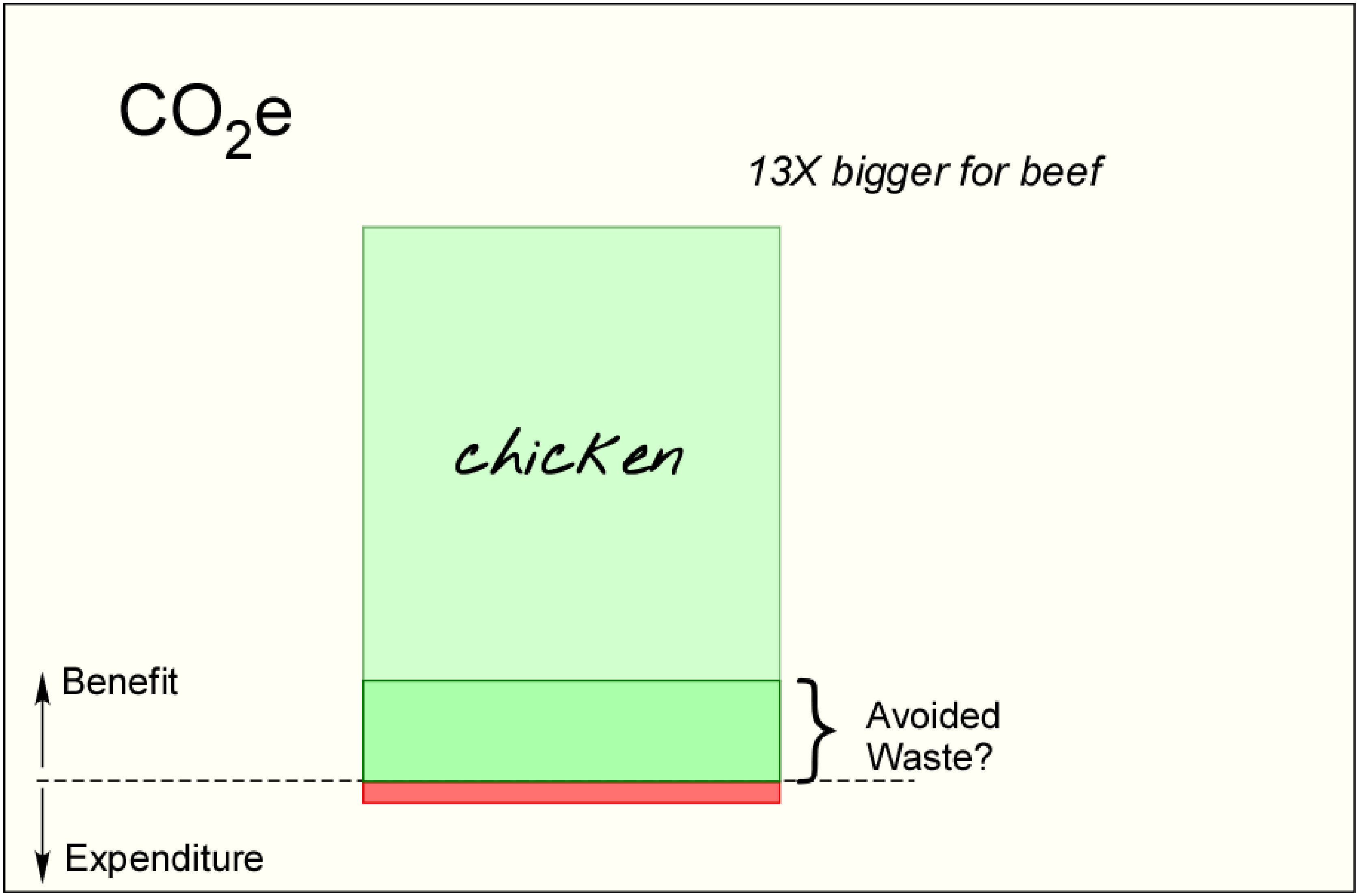
Al Bartlett

40 kWh/kg

Pimentel and Pimentel, 2003

~22% wasted

FAO, 2012


CO_2e
13X bigger for beef
chicken
Benefit
Avoided
Waste?
Expenditure

Demand for Bioproducts?

Midland Daily News
1 January 2012

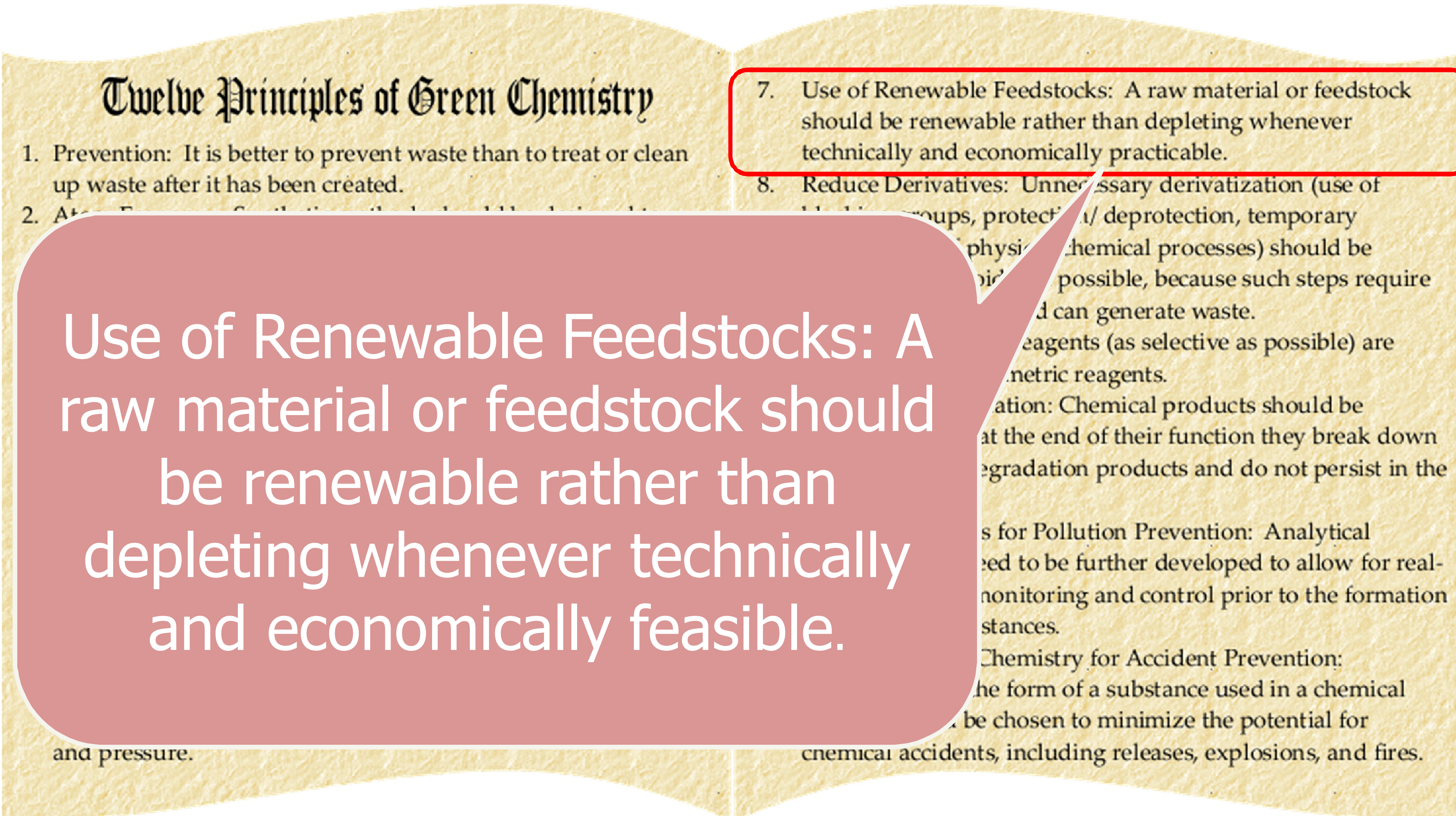
Delta Airlines Napkin
April 2012

Green Chemistry Principles

Twelve Principles of Green Chemistry

1. Prevention: It is better to prevent waste than to treat or clean up waste after it has been created.
2. Atom Economy: Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
3. Less Hazardous Chemical Syntheses: Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. Designing Safer Chemicals: Chemical products should be designed to effect their desired function while minimizing their toxicity.
5. Safer Solvents and Auxiliaries: The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.
6. Design for Energy Efficiency: Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.
7. Use of Renewable Feedstocks: A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.
8. Reduce Derivatives: Unnecessary derivatization (use of blocking groups, protection/ deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.
9. Catalysis: Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. Design for Degradation: Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.
11. Real-time analysis for Pollution Prevention: Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.
12. Inherently Safer Chemistry for Accident Prevention: Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

Green Chemistry Principles



Twelve Principles of Green Chemistry

1. Prevention: It is better to prevent waste than to treat or clean up waste after it has been created.
2. At...

and pressure.

7. Use of Renewable Feedstocks: A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.
8. Reduce Derivatives: Unnecessary derivatization (use of ...oups, protection/ deprotection, temporary ... physical/chemical processes) should be ... possible, because such steps require ... can generate waste.

...eagents (as selective as possible) are ...metric reagents.

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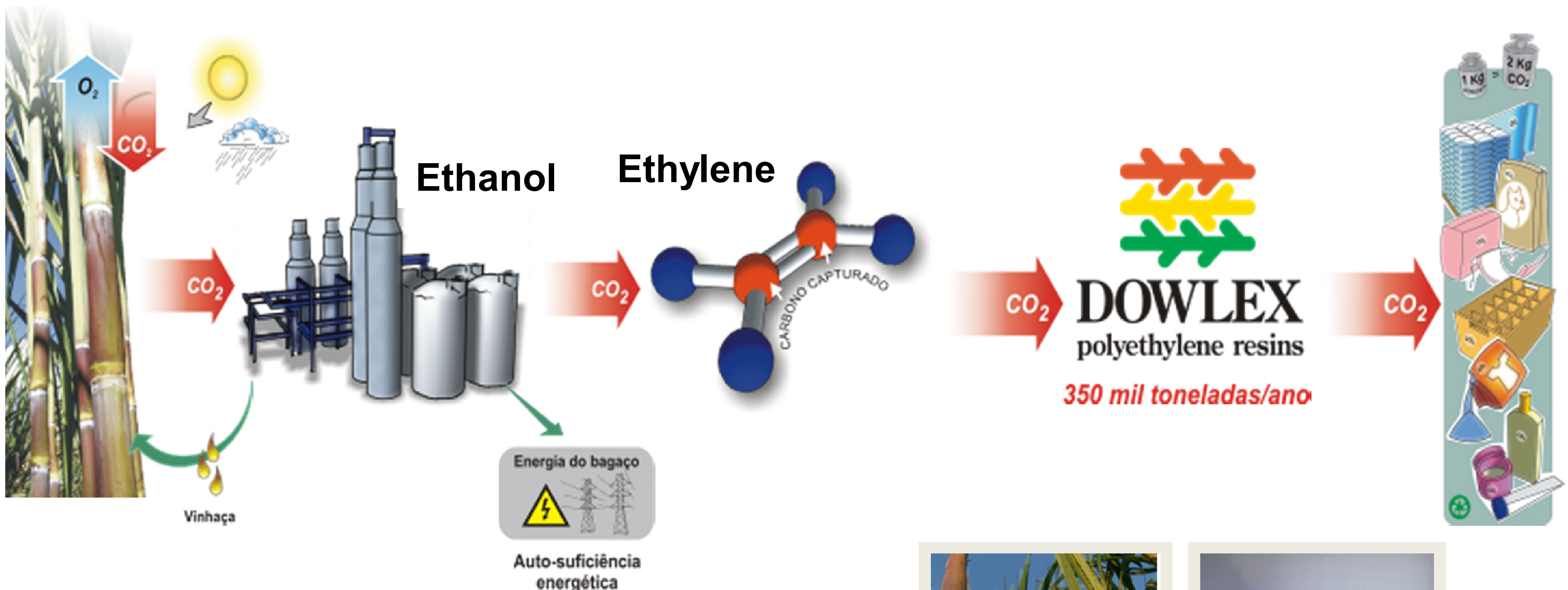
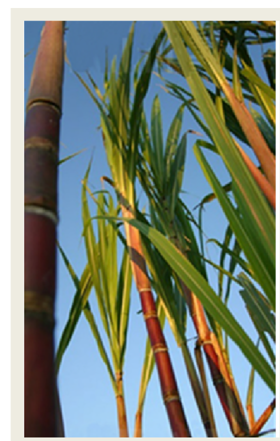
...Chemistry for Accident Prevention: ...he form of a substance used in a chemical ... be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

Use of Renewable Feedstocks: A raw material or feedstock should be renewable rather than depleting whenever technically and economically feasible.

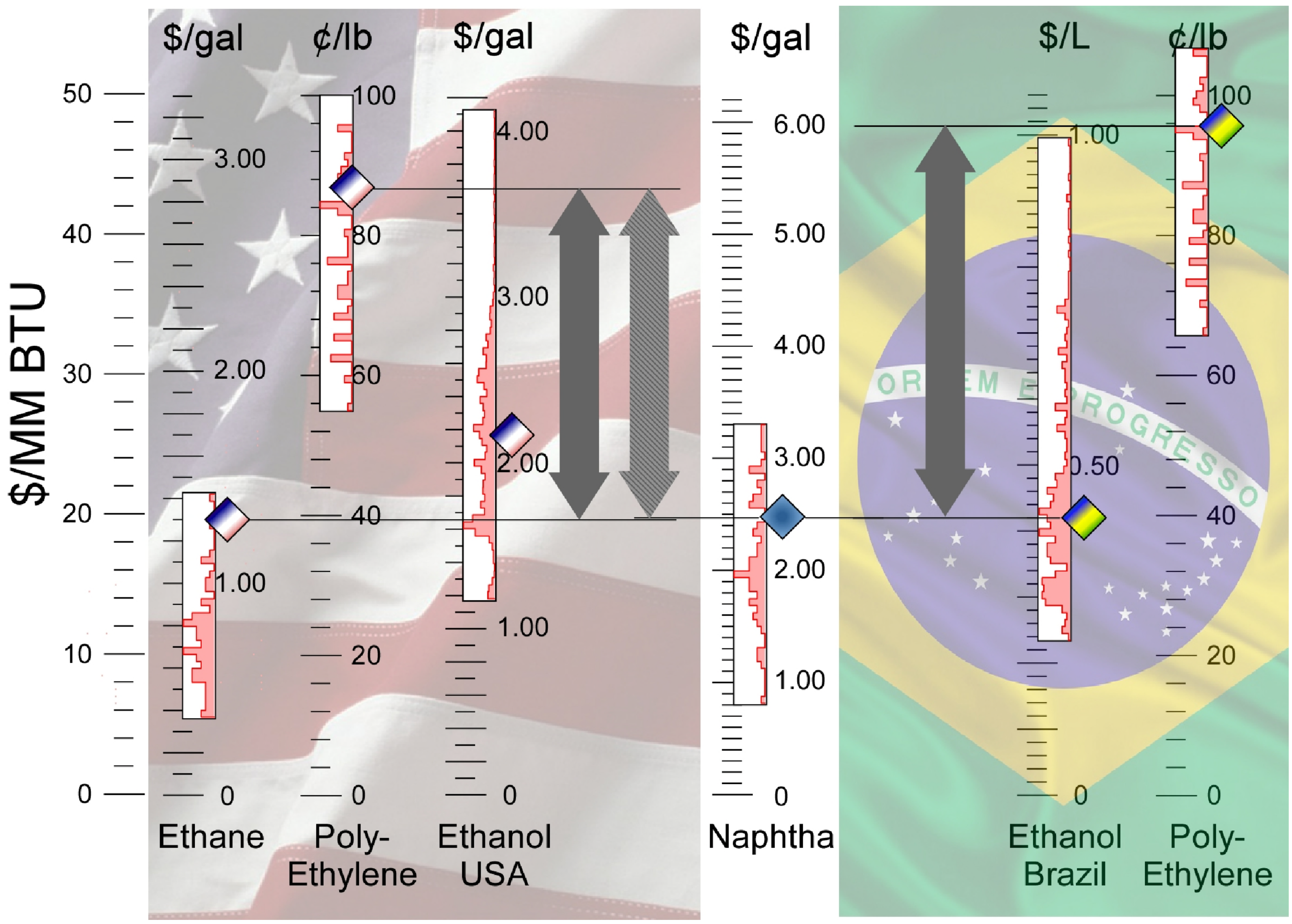
Cane to Polyethylene



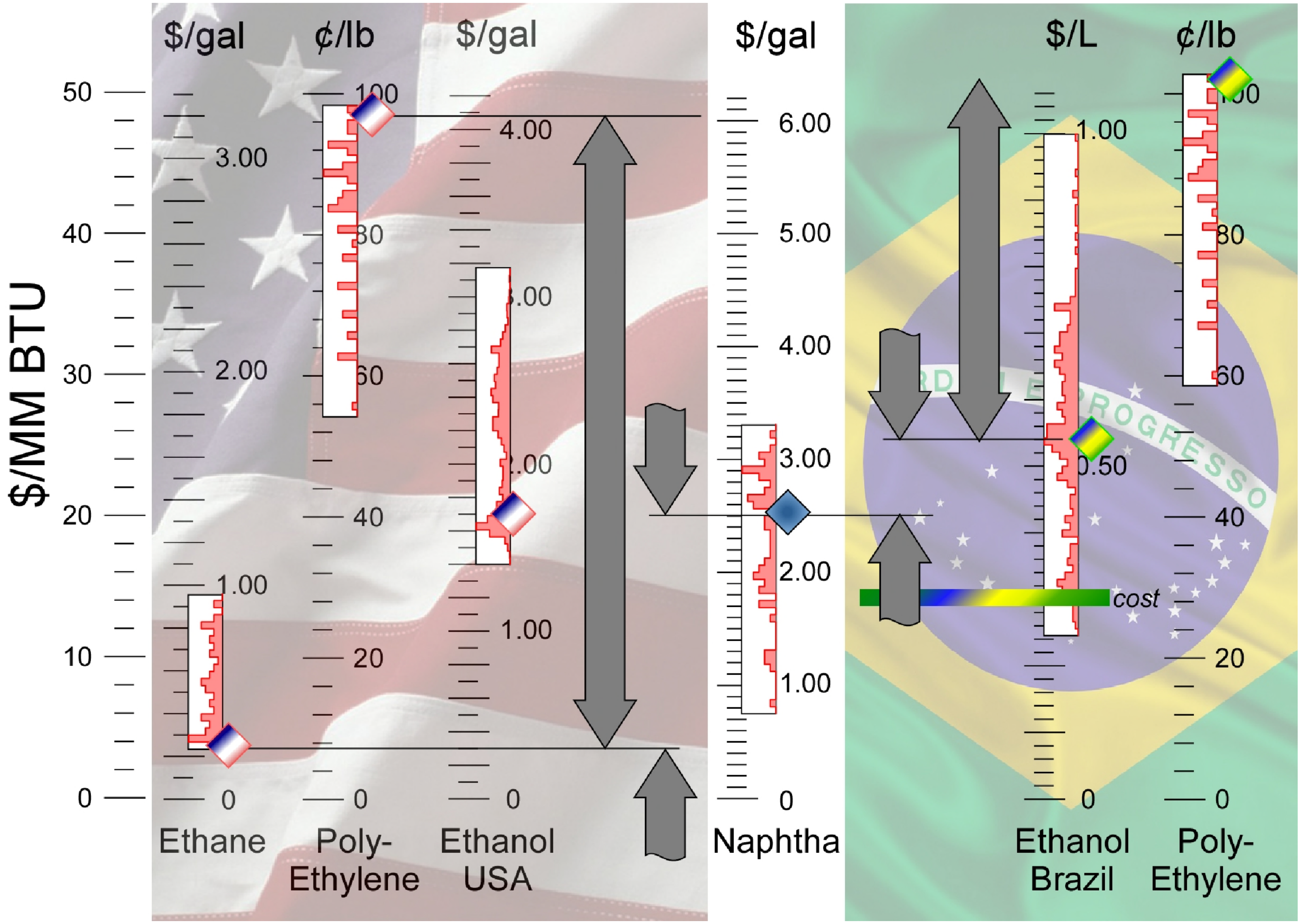
Fully-integrated facility in Brazil
Utilizes state-of-the-art Dow polymerization catalysis



Ethanol in 2008

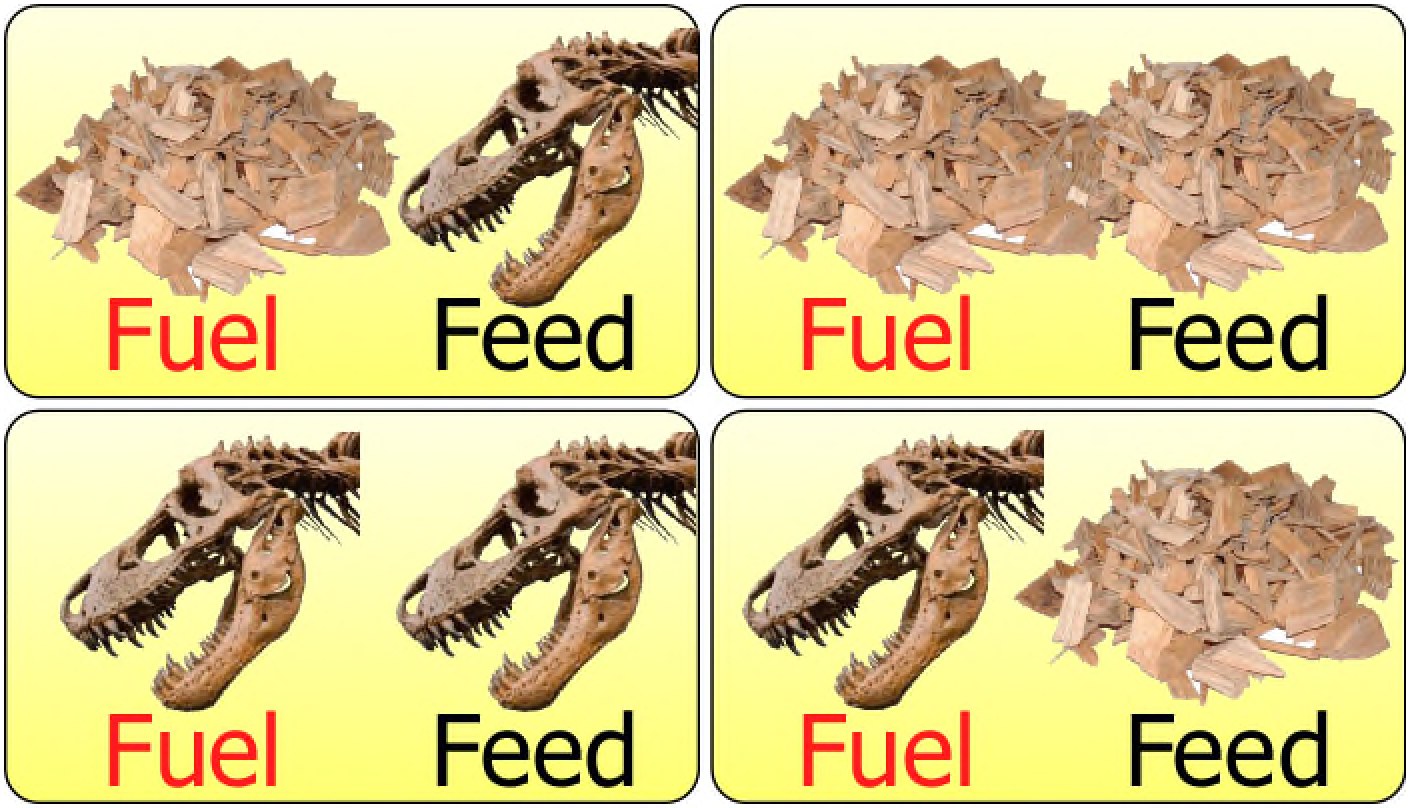


Ethanol Now

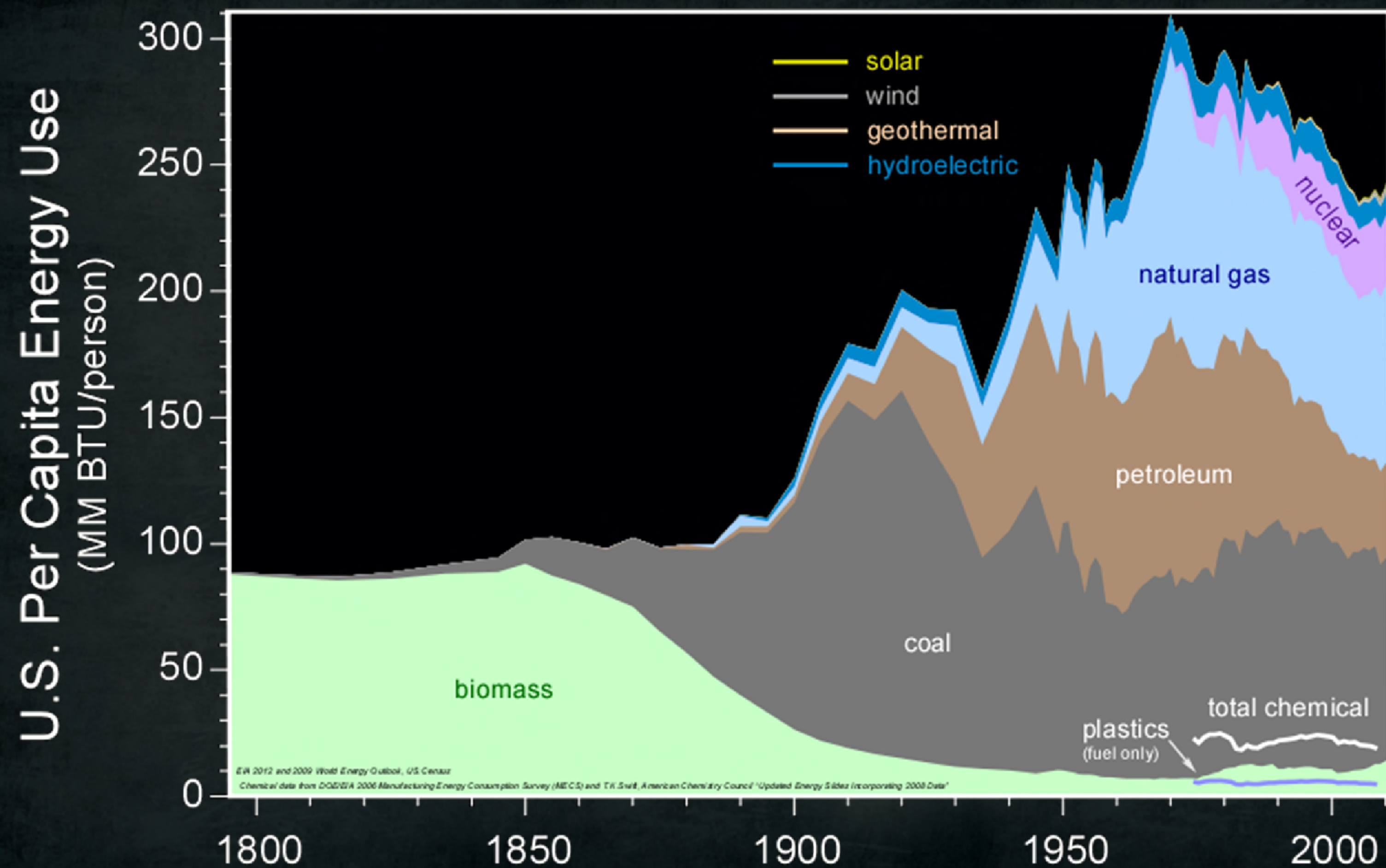


$/MM BTU
0
10
20
30
40
50
$/gal
¢/lb
$/gal
$/gal
$/L
¢/lb
3.00
2.00
1.00
0
100
80
60
40
20
0
4.00
3.00
2.00
1.00
0
6.00
5.00
4.00
3.00
2.00
1.00
0
1.00
0.50
0
100
80
60
40
20
0
cost
Ethane
Poly-
Ethylene
Ethanol
USA
Naphtha
Ethanol
Brazil
Poly-
Ethylene

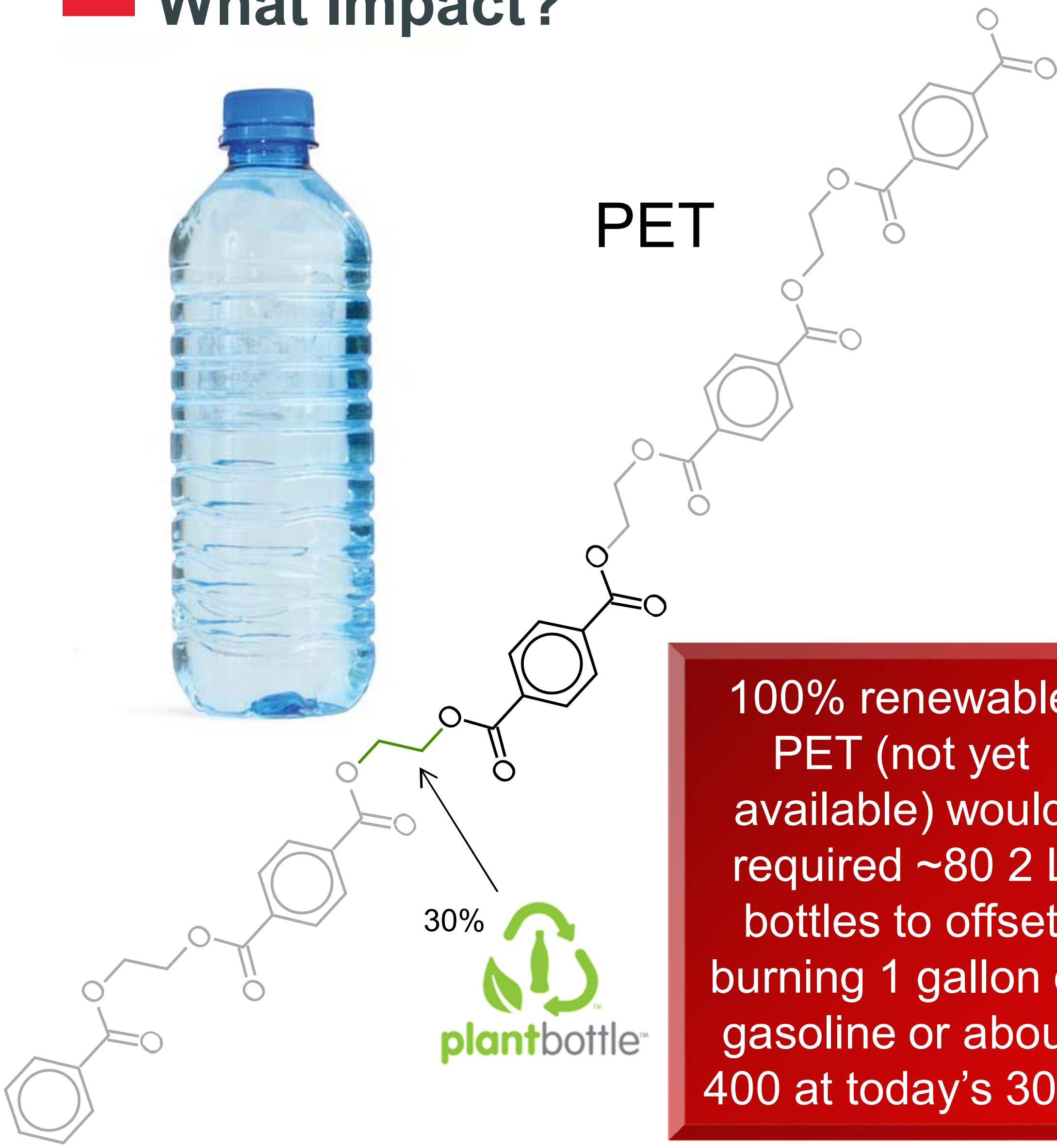
Two Carbon Flavors



Per Capita Energy Use



What Impact?



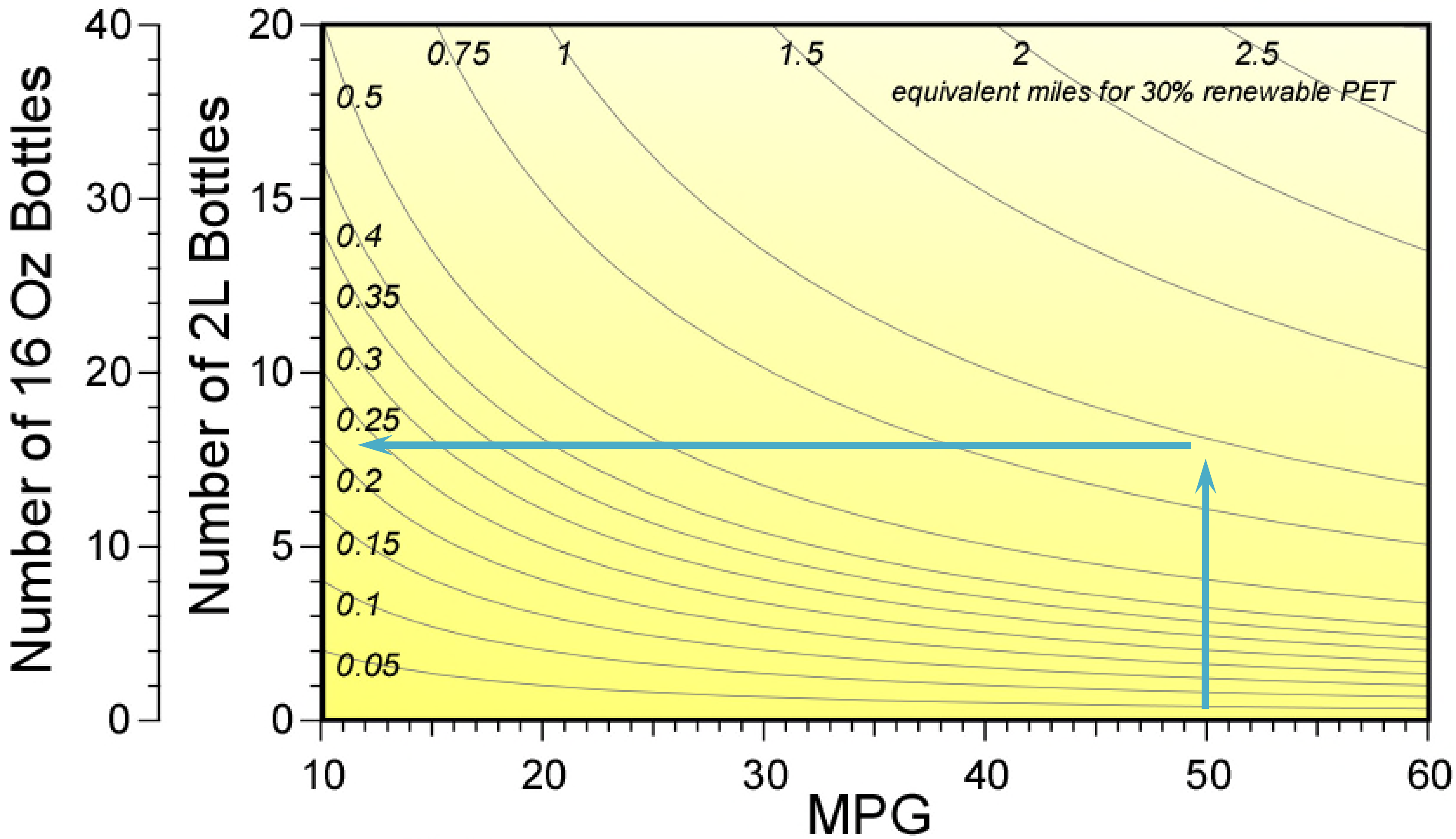
100% renewable PET (not yet available) would required ~80 2 L bottles to offset burning 1 gallon of gasoline or about 400 at today's 30%

material	per capita consumption (lb/yr)
PET packaging	17
petroleum	6619
natural gas	8037
coal	6439
gasoline	2495
sand and gravel	13923
cement	512
iron ore	340
salt	403
beef	54.3
chicken	55.7

data from HIS, 2012 ERS USDA, 2011 National Mining Assoc., World Bank

DOW

PET Comparison



Go After the 21,000 lbs

The End