MJPHD

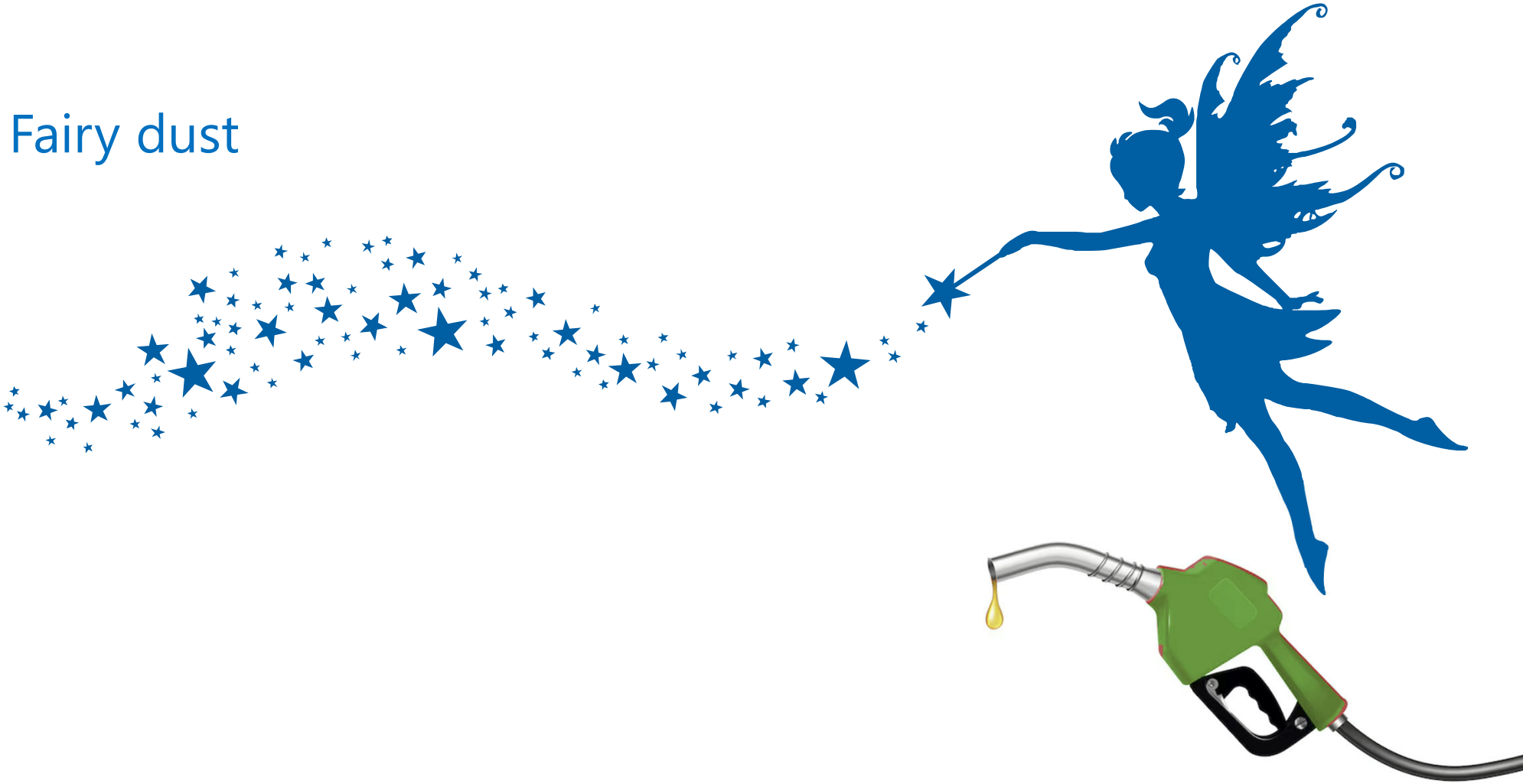
SUSTAINABILITY AND ITS IMPACT ON THE CHEMICAL INDUSTRY

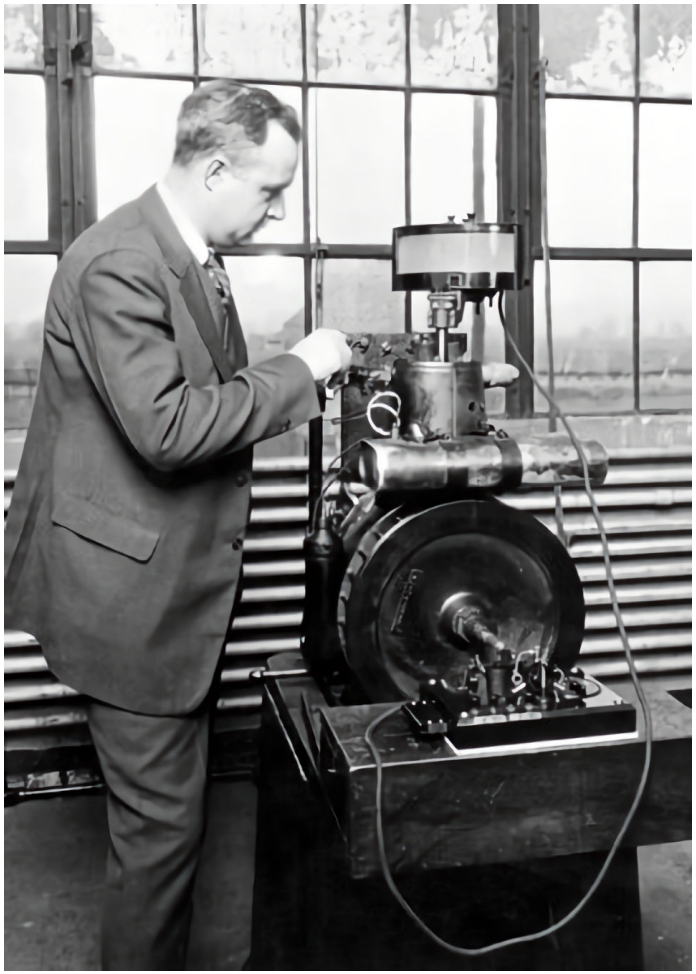
MARK JONES
CREATIVE DIRECTOR
MJPHD, LLC

Engineering Sciences S-135: Biochemical Engineering and Synthetic Life

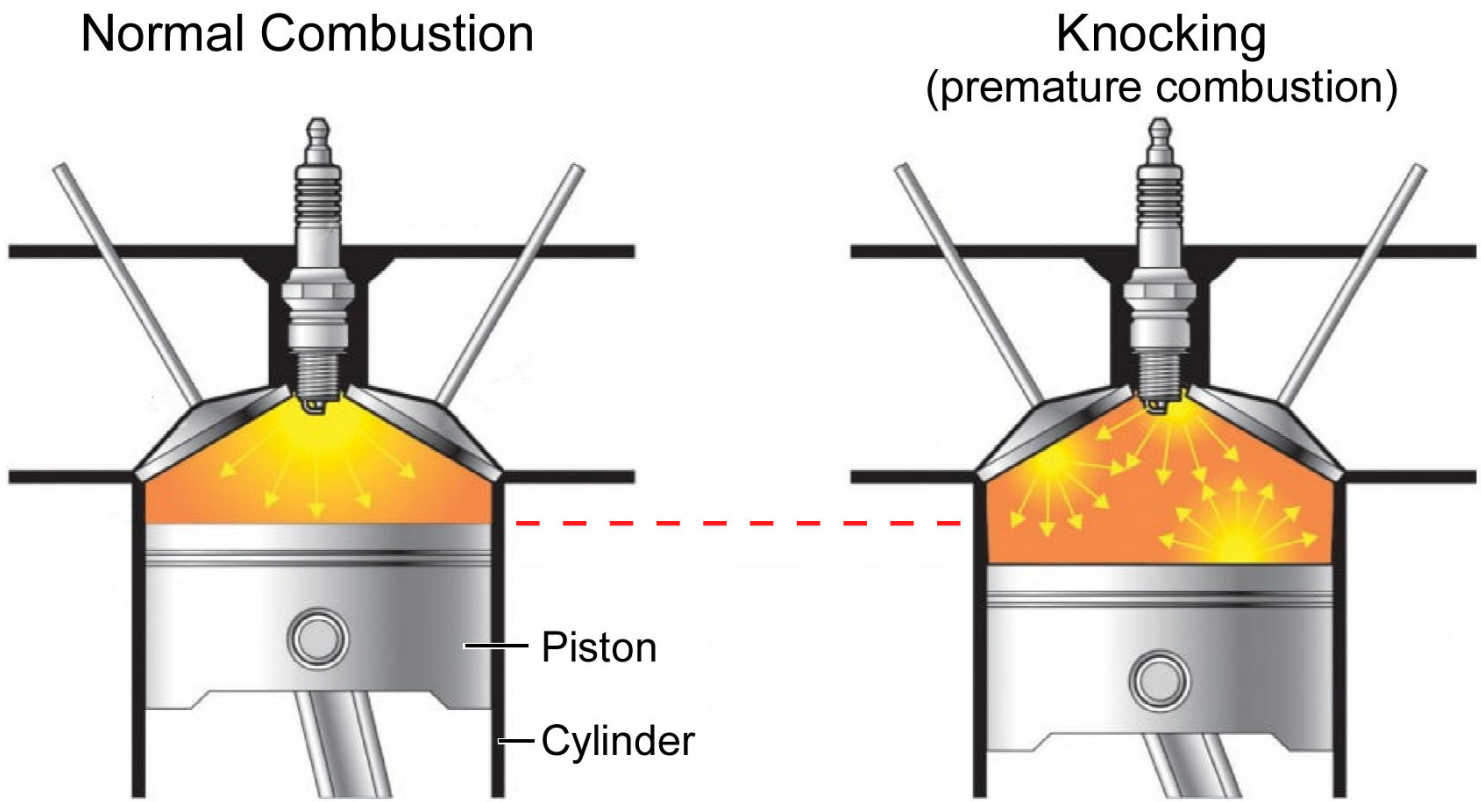
9 July 2026

Fairy dust





KNOCKING


Normal Combustion
Knocking
(premature combustion)
Piston
Cylinder

Patented Feb. 23, 1926. 1,573,846

UNITED STATES PATENT OFFICE.

THOMAS MIDGLEY, JR., OF DAYTON, OHIO, ASSIGNOR, BY MESNE ASSIGNMENTS, TO GENERAL MOTORS CORPORATION, OF DETROIT, MICHIGAN, A CORPORATION OF DELAWARE.

METHOD AND MEANS FOR USING MOTOR FUELS.

Application filed April 15, 1922. Serial No. 553,270.

To all whom it may concern:

Be it known that I, THOMAS MIDGLEY, Jr., a citizen of the United States of America, residing at Dayton, county of Montgomery, and State of Ohio, have invented certain new and useful Improvements in Methods and Means for Using Motor Fuels, of which the following is a full, clear, and exact description.

This invention relates to fuels, such, for example as kerosene and gasoline, employed in the operation of internal-combustion engines and to the art of burning the fuels in an engine. The present tendency is to produce lower grades of gasoline in order to obtain a sufficient output for the increasing demand for motor fuels and to reduce the compressions of the engines so that these lower grades of fuel may be used without knocking. As the lowering of engine compression reduces the efficiency of the engine, a still greater output of fuel is required to meet the increase in fuel required to operate larger and less efficient engines. The principal objects of the present invention are to overcome these difficulties and to provide a means for using either low or high grades of motor fuel more efficiently and so reduce the quantity of fuel used.

The present application is a continuation

duced, the engine heats rapidly, the efficiency of the engine is reduced and, if the initial pressure is very high, engine parts may be injured. The highest pressure at which a mixture may be burned in a cylinder without producing a fuel knock varies with the different fuels and, to some extent, with the temperature, position of spark plugs and other conditions within the engine. This pressure I term the "critical compression pressure" of the fuel.

The average critical compression pressure of kerosene is about 50 pounds, of the proper grades of gasoline about 75 pounds and of the better grades of gasoline about 125 pounds. The latter grade of gasoline is produced in limited quantities and is not available universally to the consumer. The commoner grades of fuel, such as kerosene and gasoline, having critical compression pressures below 75 pounds are used generally, and in internal-combustion engines for house lighting systems, trucks, tractors, and automobiles are designed to operate on these kinds of fuel.

I have found that the critical compression pressure of a fuel of the type mentioned above is increased by incorporating therewith any one of a large number of compounds containing metallic elements, i. e.,

TETRAETHYL LEAD

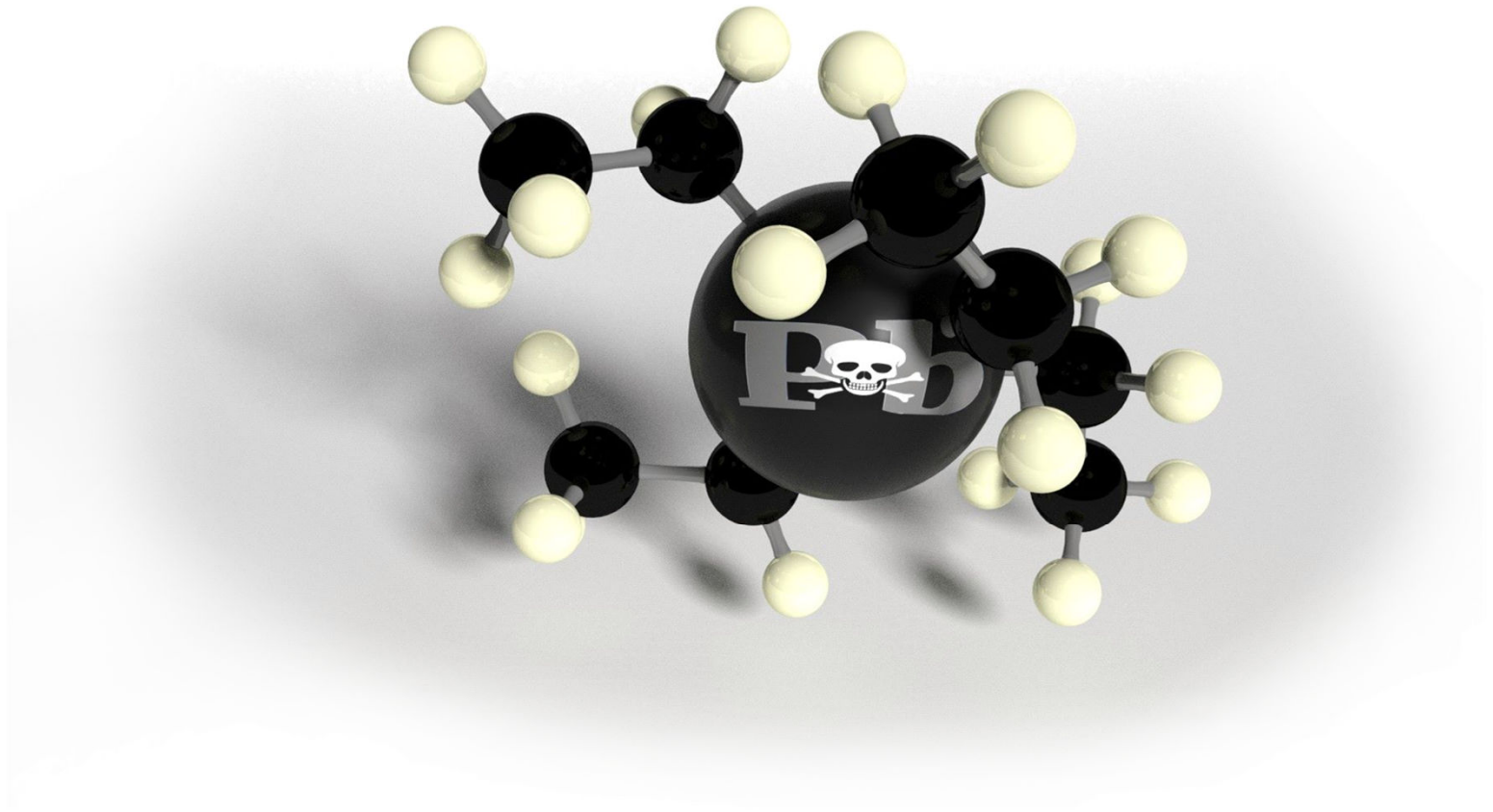
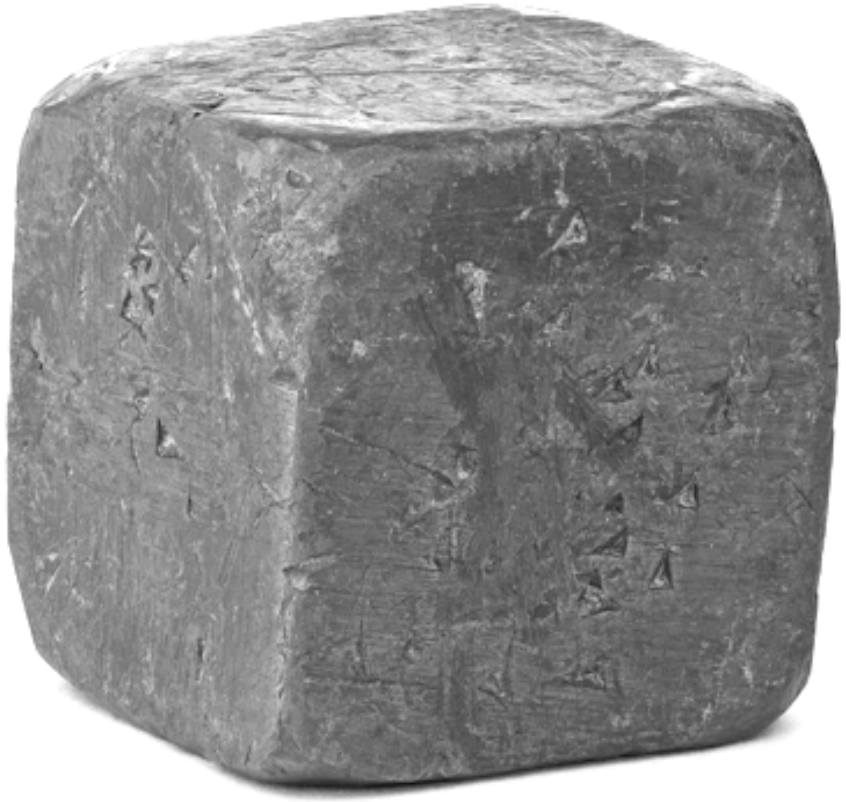


Table 1. Relative Antiknock Effectiveness of Various Compounds[a]

tetraethyllead	118	tetraethyltin	4
tetraphenyllead	73	triphenylarsine	1.6
iron pentacarbonyl	50	xylidine	1.6
nickel carbonyl	35	diphenylamine	1.5
diethyl telluride	27	*N*-methylaniline	1.4
triethylbismuth	24	dimethylcadmium	1.2
diethyl selenide	7	aniline	1.0
stannic chloride	4.1	ethanol	0.1

[a] Vs aniline = 1 on a mole basis. From ref 1e, by permission of Springer-Verlag and Ethyl Corp.

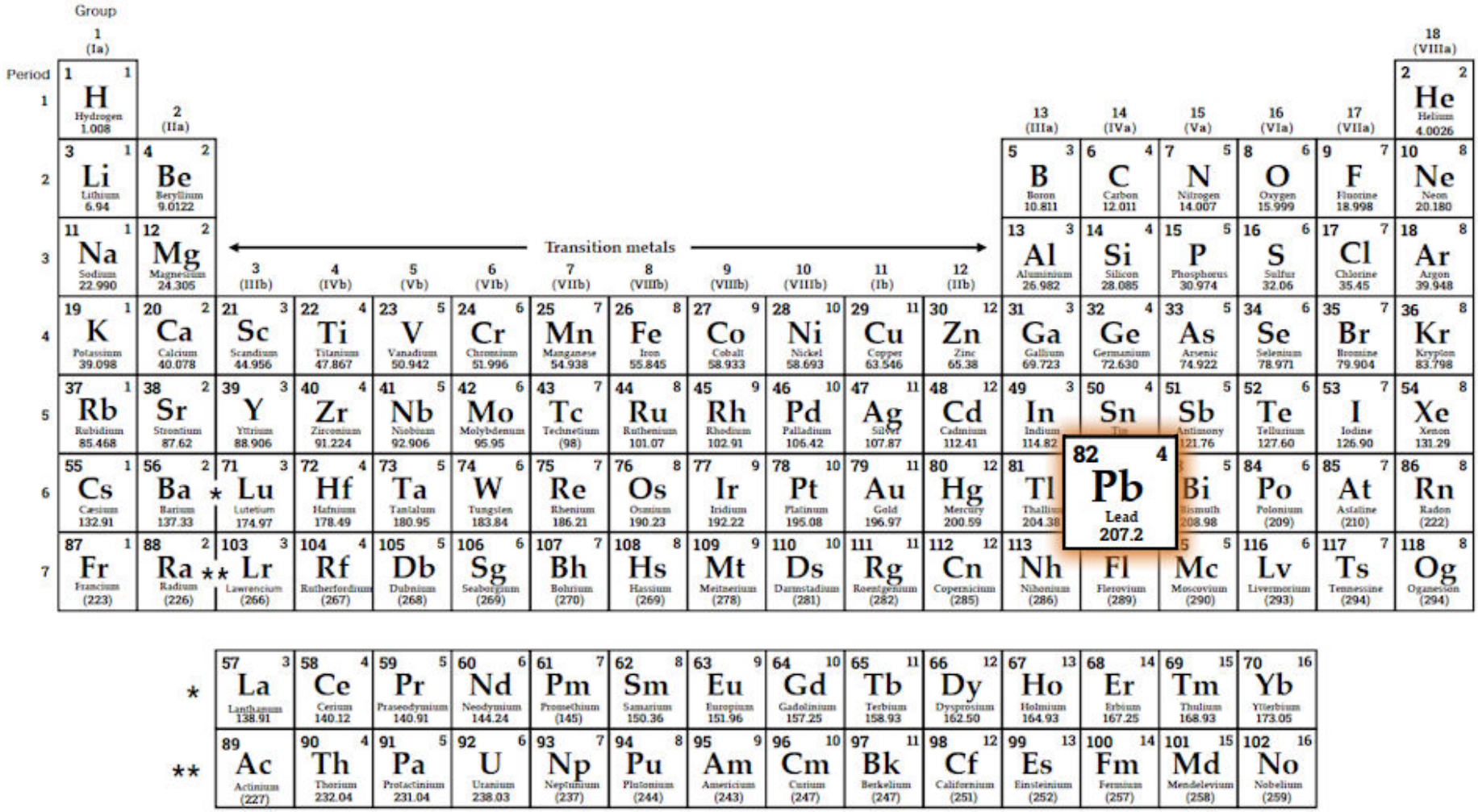


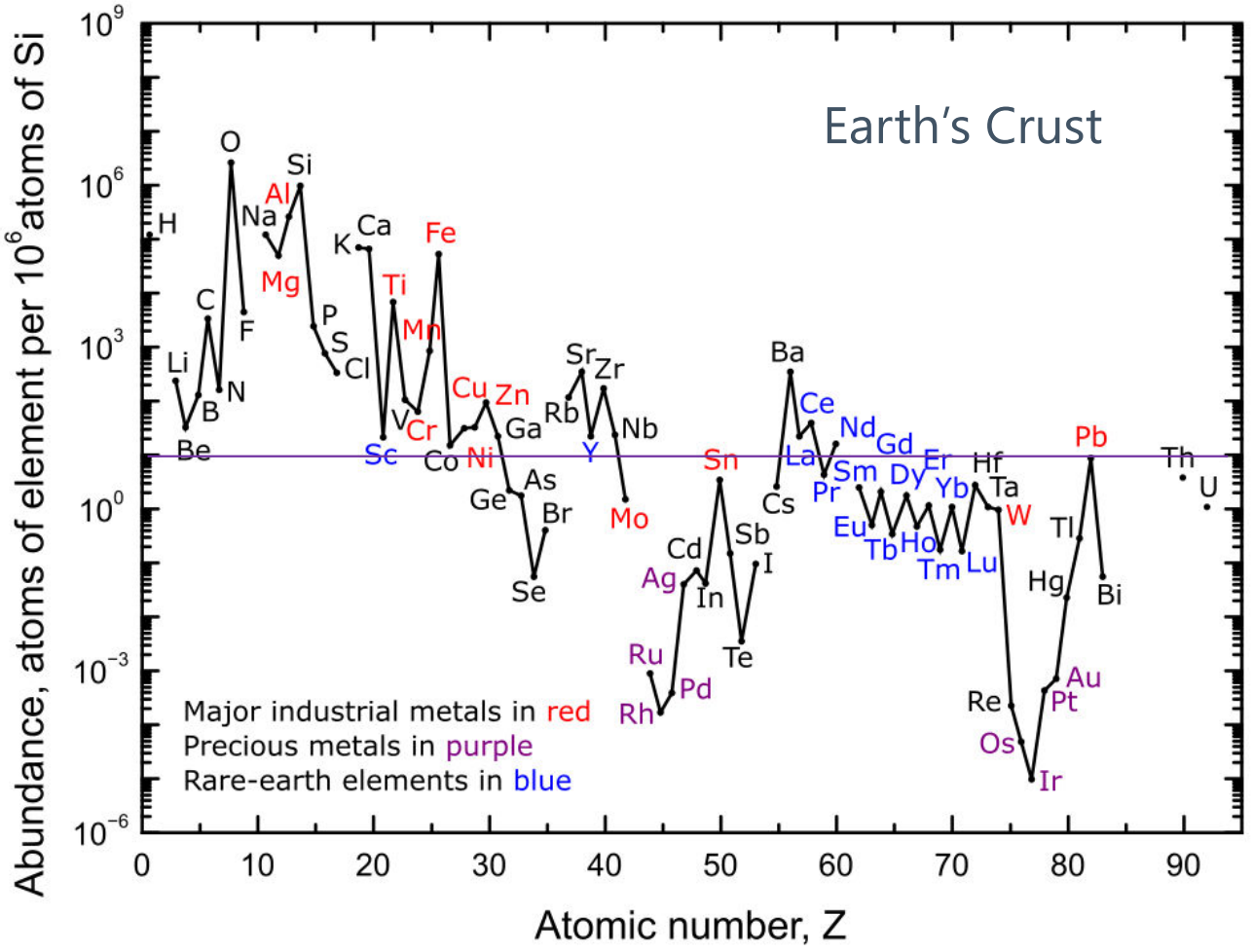
82

Pb

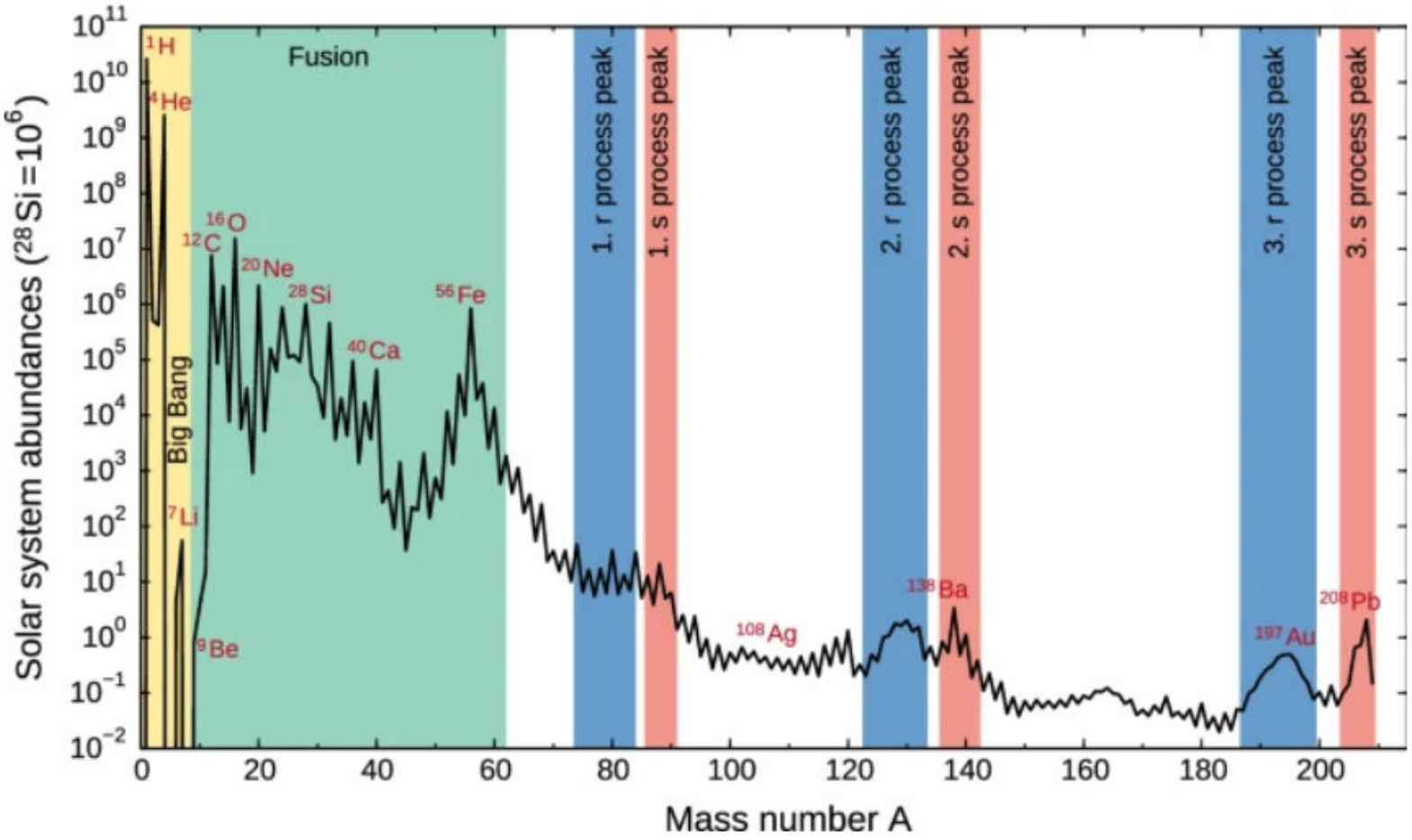
Lead

207.2



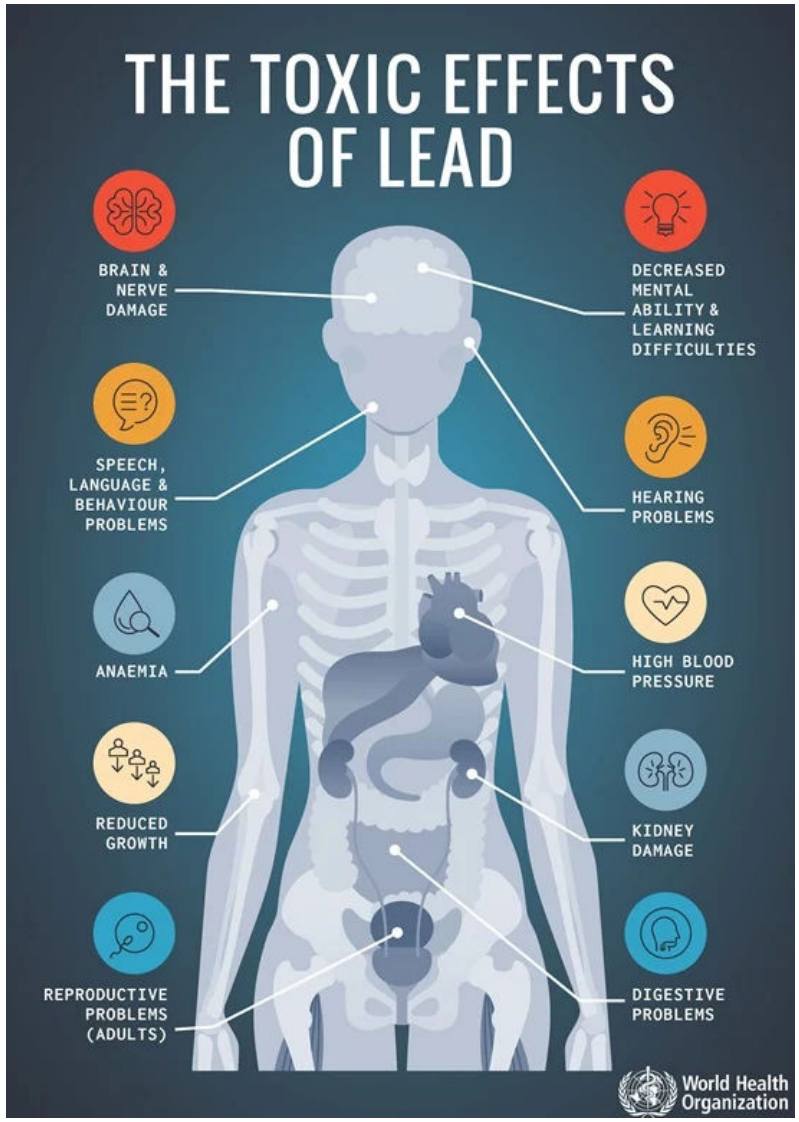


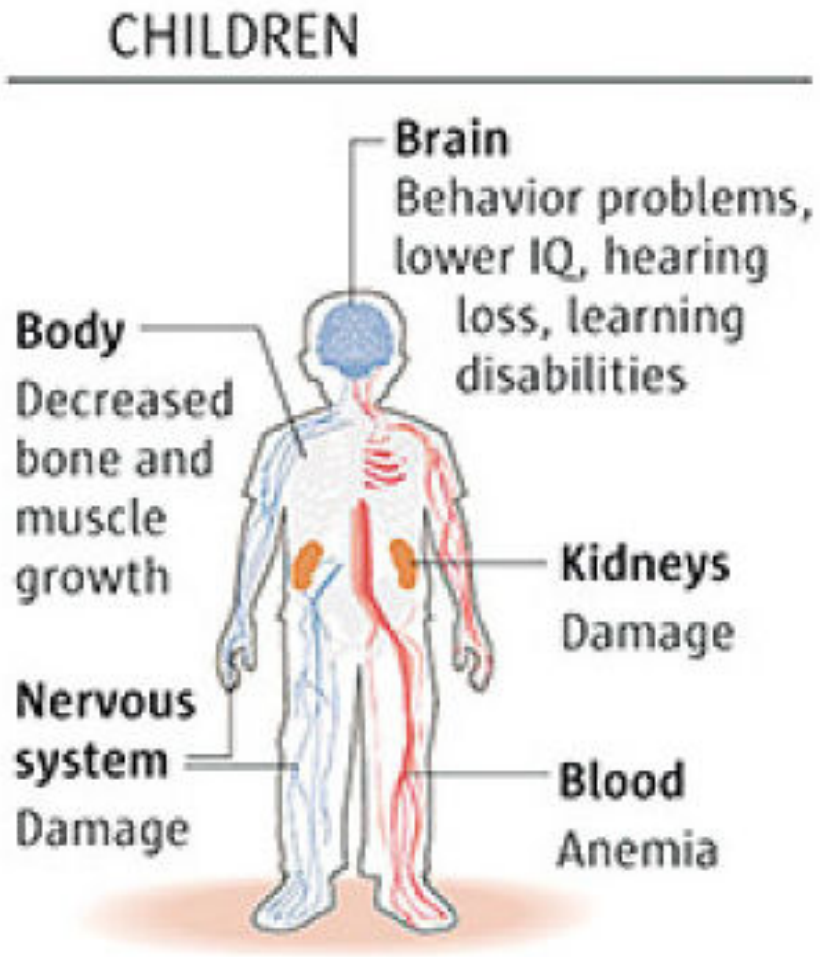
By Gordon B. Haxel, Sara Boore, and Susan Mayfield from USGS; vectorized by User:michbich - http://pubs.usgs.gov/fs/2002/fs087-02/, Public Domain, https://commons.wikimedia.org/w/index.php?curid=11215468



Arcones, A., Thielemann, FK. Origin of the elements. *Astron Astrophys Rev* **31**, 1 (2023). https://doi.org/10.1007/s00159-022-00146-x

source: NASA; Hubble Space Telescope image of the Veil Nebula


THE TOXIC EFFECTS OF LEAD
BRAIN & NERVE DAMAGE
DECREASED MENTAL ABILITY & LEARNING DIFFICULTIES
SPEECH, LANGUAGE & BEHAVIOUR PROBLEMS
HEARING PROBLEMS
ANAEMIA
HIGH BLOOD PRESSURE
REDUCED GROWTH
KIDNEY DAMAGE
REPRODUCTIVE PROBLEMS (ADULTS)
DIGESTIVE PROBLEMS
World Health Organization


CHILDREN
Brain
Behavior problems, lower IQ, hearing loss, learning disabilities
Body
Decreased bone and muscle growth
Kidneys
Damage
Nervous system
Damage
Blood
Anemia

…the best available science which shows there is no safe level of exposure to lead.

There is no level of exposure to lead that is known to be without harmful effects.

There is no level of exposure to lead that is known to be without harmful effects.

https://www.epa.gov/ground-water-and-drinking-water/basic-information-about-lead-drinking-water
https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health
https://www.atsdr.cdc.gov/csem/leadtoxicity/physiological_effects.html

TEL stops knock at 1 part per thousand

Ethanol requires 10%


Danger


Danger
Risk
Tolerance


Risk
Tolerance
Danger
Benefit

William Stanley Jevons

Wrote *The Coal Question* (1865), in which he observed that increases in energy production efficiency leads to more, not less, consumption.

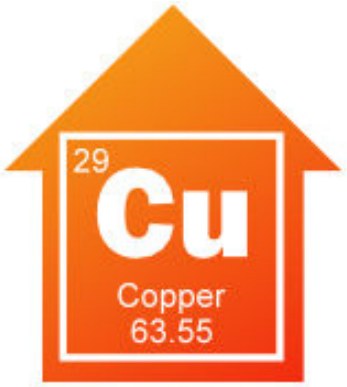
Jevon's paradox

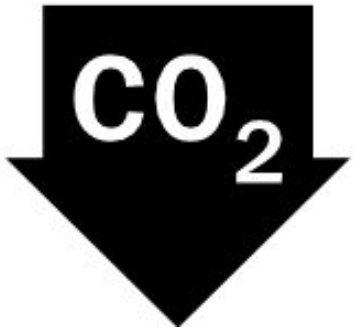

GREAT LAKES TRADER

2030

7.5%

2.8 B kg





225 million tons

~2 tons

~8g/ton

?

~80 ppm

Thought experiment: no electric cars but Pb into gasoline to equal Pb emissions just from Cu. 12.5X lower than peak concentration but not zero.

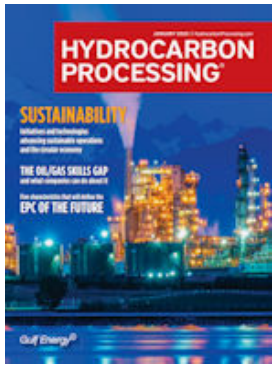
MJPhD


JIF
CREAMY
PEANUT BUTTER
7g
PROTEIN
NET WT 16 OZ (1 LB) 454g
The Mosler Safe Co.
Southwest
DASANI
PURIFIED WATER
16.9 FL OZ (1.06 PT) 500 mL

MJPhD

Sustainability Definition

> The process of managing available resources, investments and technologies to maintain and optimize operations for greater safety, reliability, efficiency, and environmental and social awareness.



Sustainability Definition

Sustainability means meeting our own needs without compromising the ability of future generations to meet their own needs.

Brundtland Commission

Sustainability Definition

> Sustainability is the ability to continue a defined behavior indefinitely. Environmental sustainability is the ability to maintain rates of renewable resource harvest, pollution creation, and non-renewable resource depletion that can be continued indefinitely.
>
> *thwink.org*

Sustainability Definition

> Sustainability is wondrously complicated. Every person will give you a slightly different definition of sustainability. That's because sustainability really can be applied to almost anything in life.

Arizona State University School of Sustainability

What is the Best Definition?

1. The process of managing available resources, investments and technologies to maintain and optimize operations for greater safety, reliability, efficiency, and environmental and social awareness.
2. Meeting our own needs without compromising the ability of future generations to meet their own needs.
3. The ability to continue a defined behavior indefinitely.
4. Wondrously complicated.

Sustainability Definition

Sustainability means meeting our own needs without compromising the ability of future generations to meet their own needs.

Brundtland Commission

THREE PILLARS OF SUSTAINABILITY

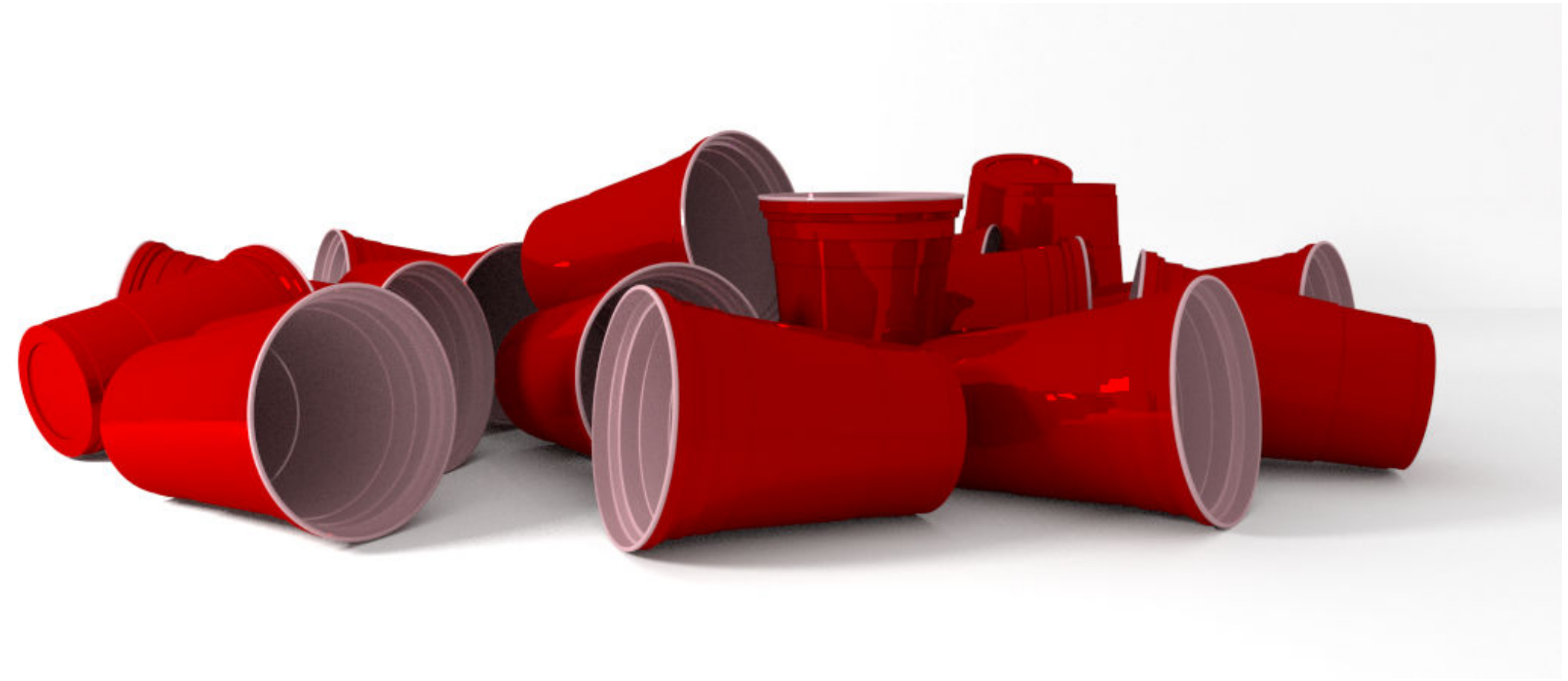
UN Sustainable Development Goals

UN Sustainable Development Goals

Metaphor for Sustainability

ORDERED

DISORDERED

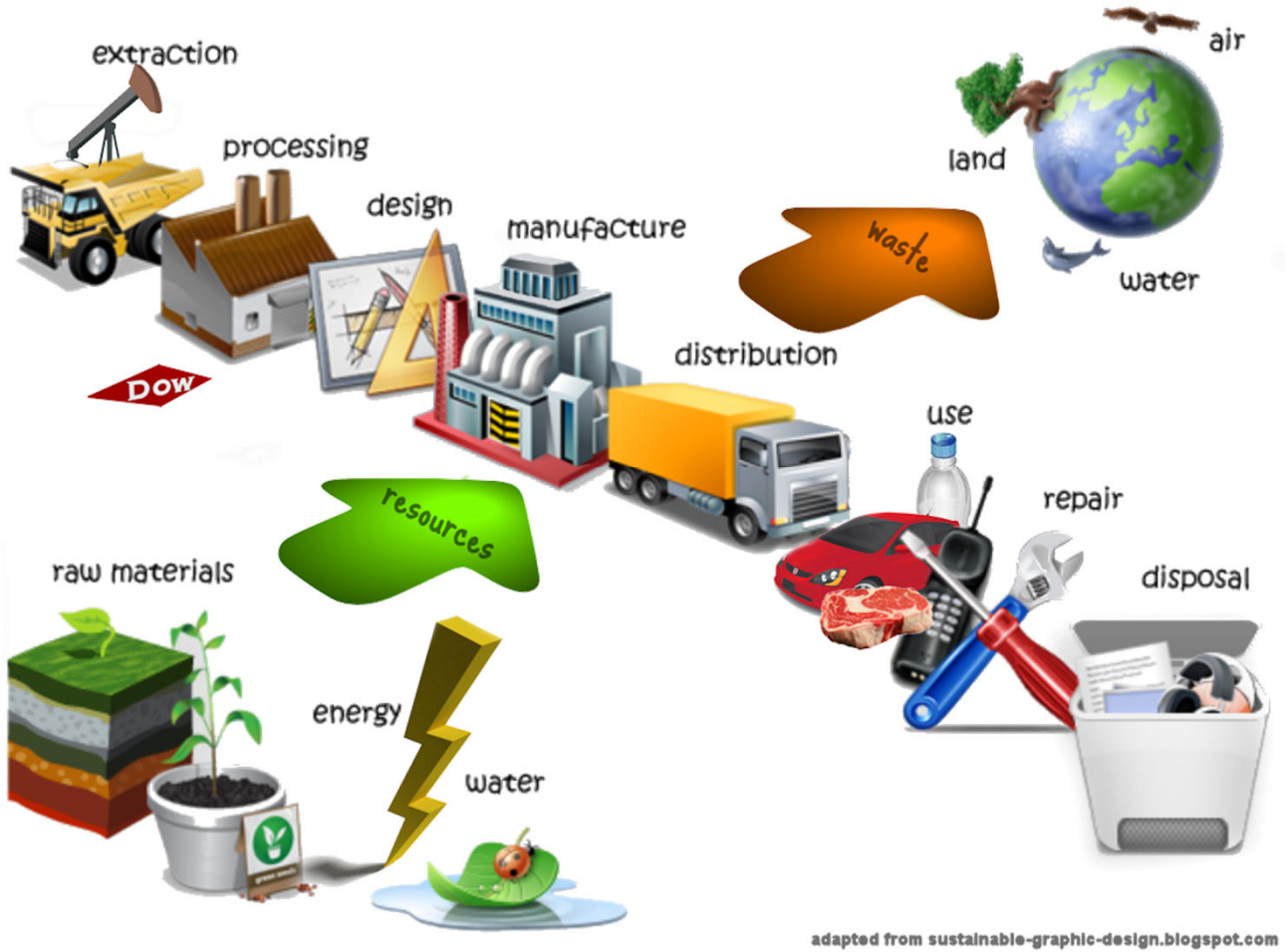


Is This Cup Sustainable?

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

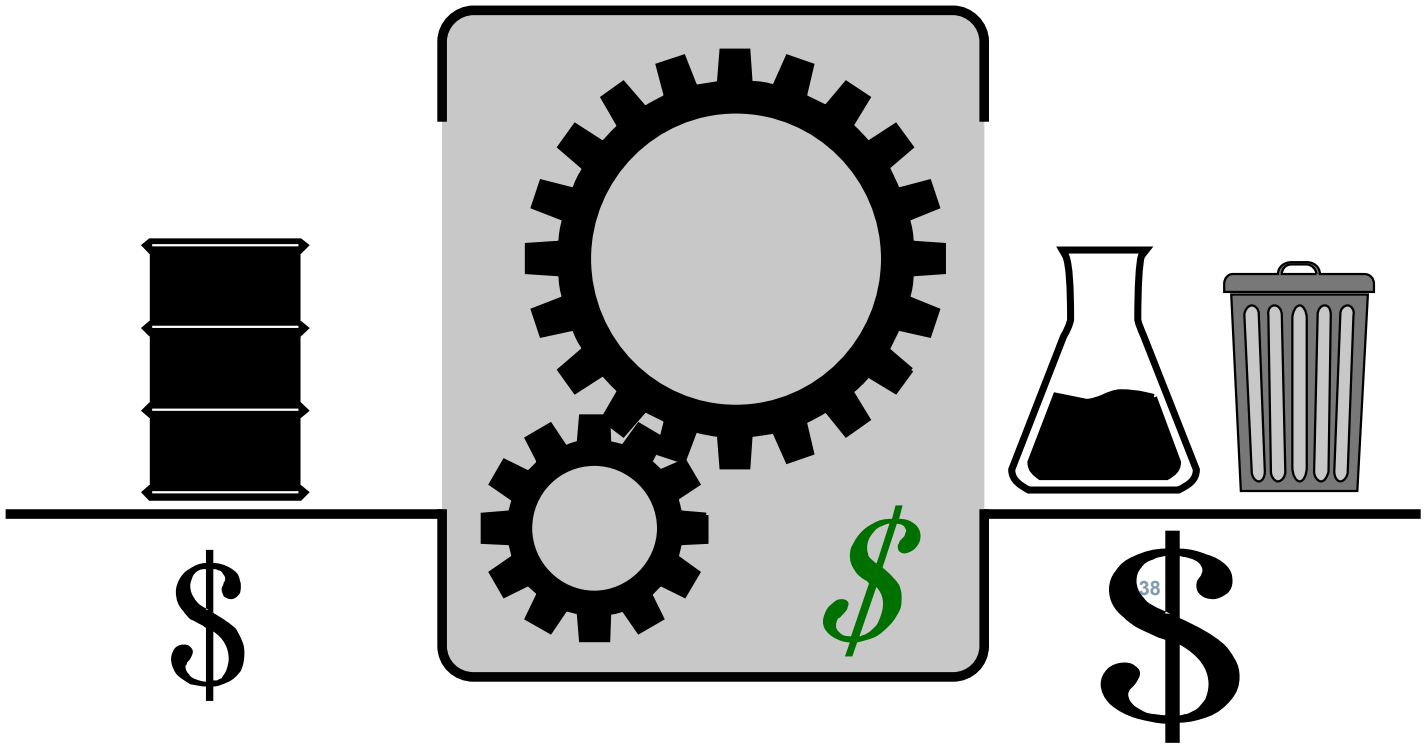
How about this one?

LIFE CYCLE ASSESSMENT



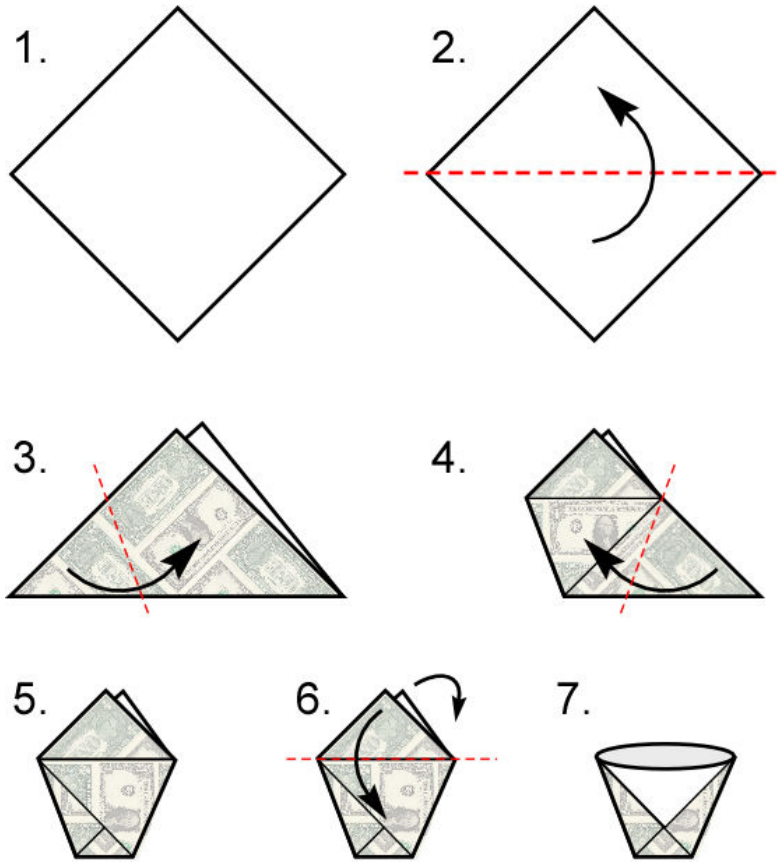
adapted from sustainable-graphic-design.blogspot.com

Simplified Chemical Industry



SCALE

SCALE



Make a cup with an 8½” square and another with a 4¼” square


Web Exclusive

Why Big Always Wins: Examining Economies of Scale

Origami teaches one of the fundamental tenets of chemical engineering

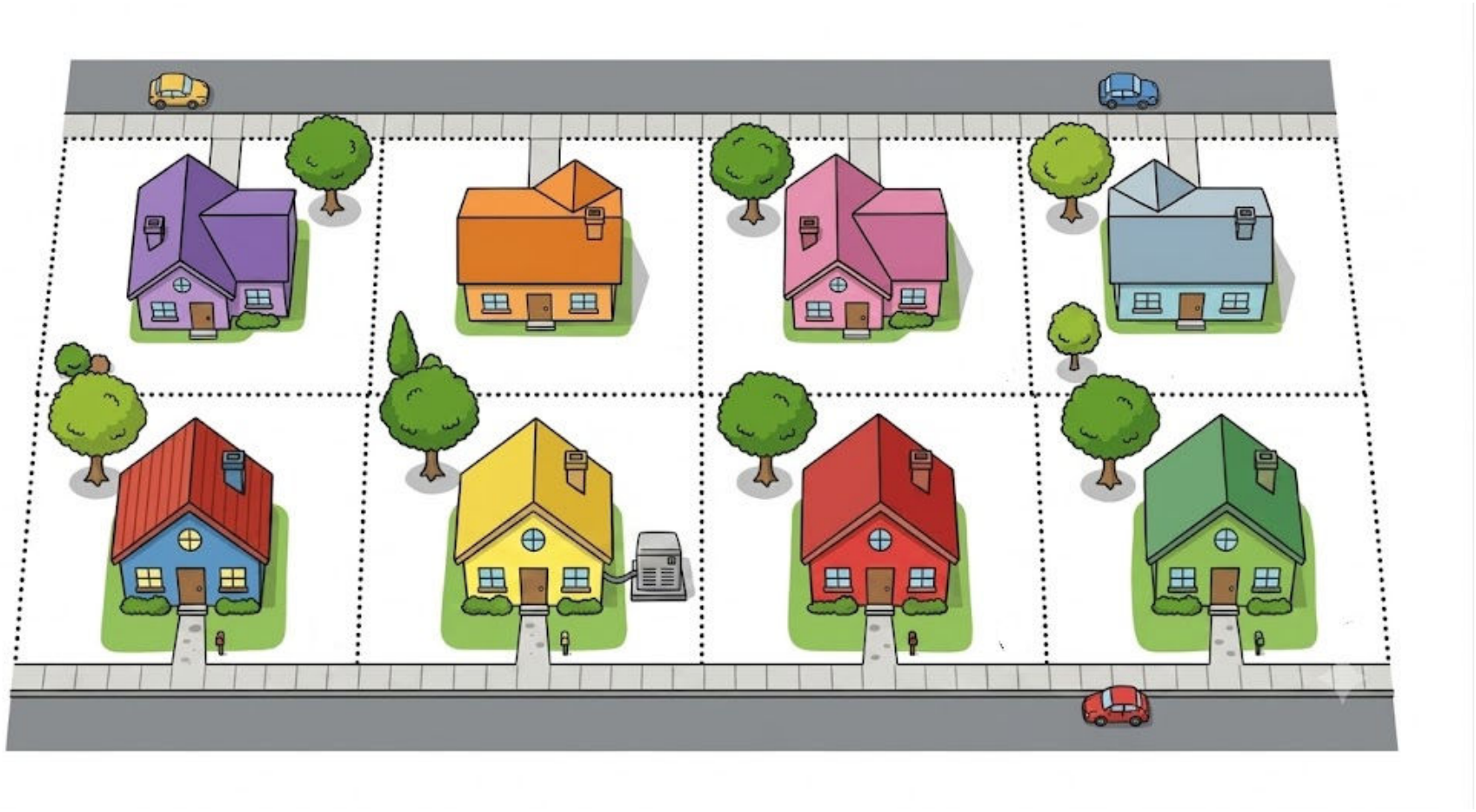
Mark E. Jones
The Dow Chemical Company

Bigger is better. That simple statement summarizes one of the fundamental principles of chemical engineering. It is a statement that we frequently want to ignore, but if capital efficiency is the main concern, it is always true. All engineers need an occasional reminder and can be aided by a tactile exercise showing the inescapability of the bigger-is-better mentality. Origami provides a simple means to illustrate that bigger truly is better in cases where the capital efficiency of containing and moving material is the parameter.

MJPhD

SCALE

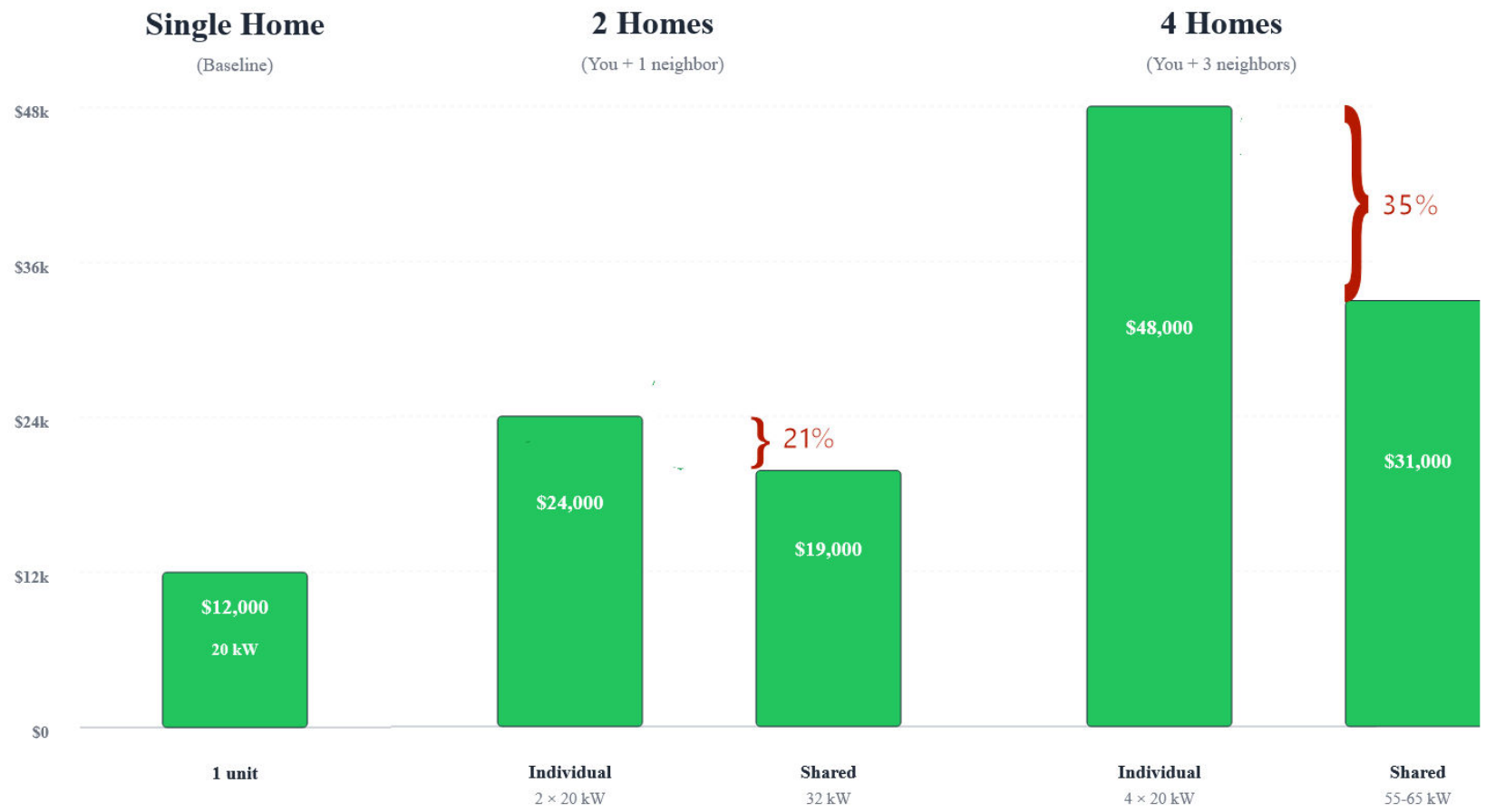
Scale Example: Whole House Generators



Scale Example: Whole House Generators

Scale Example: Whole House Generators

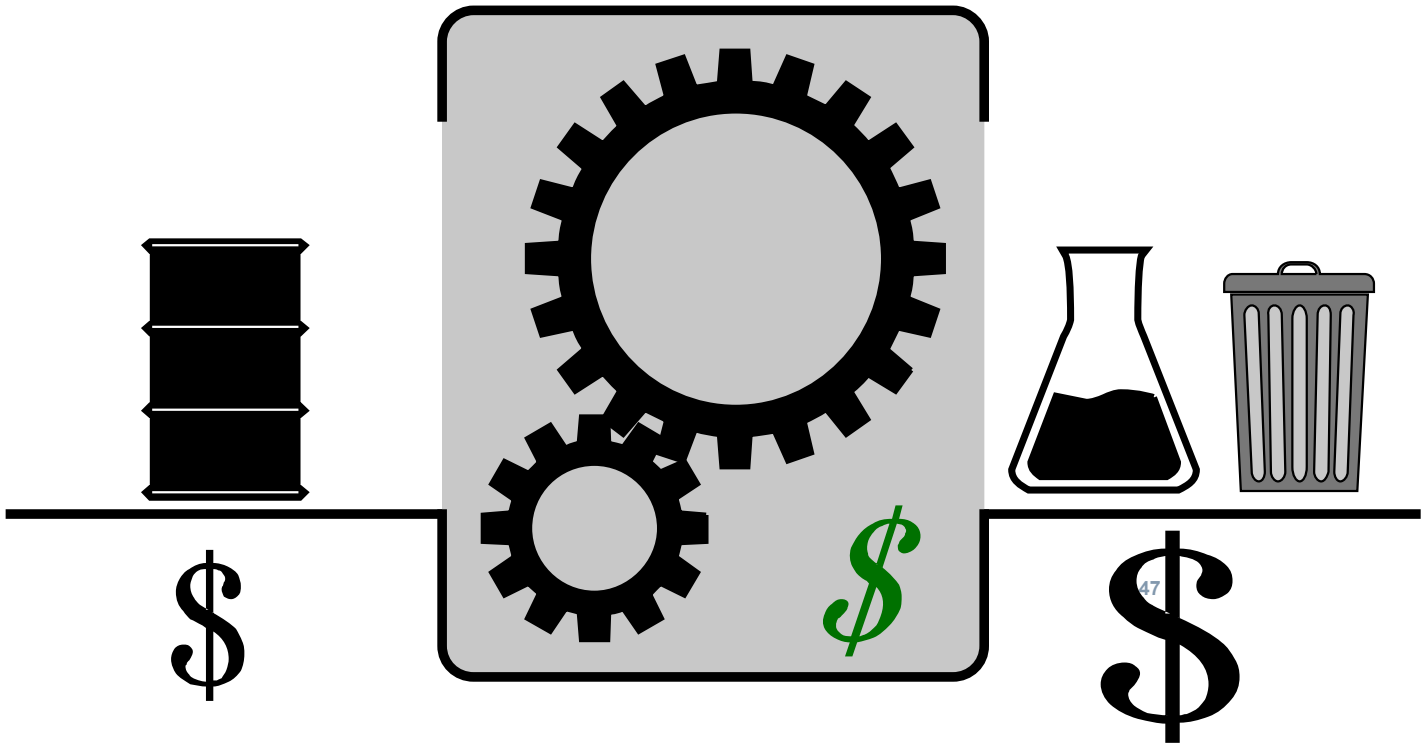
Scale Example: Whole House Generators



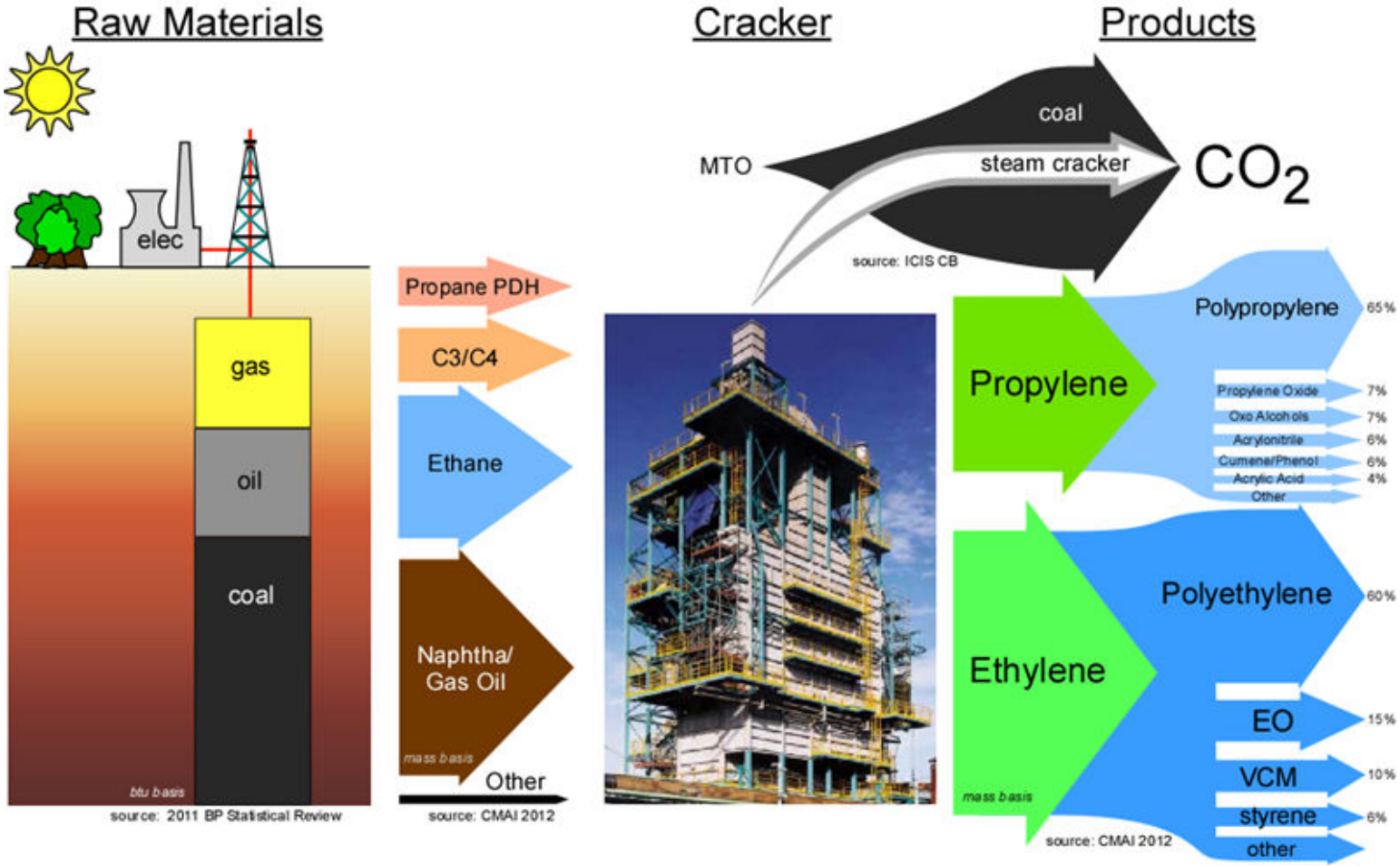
Scale Always Wins

If you are moving mass around, scale reduces cost faster than experience.

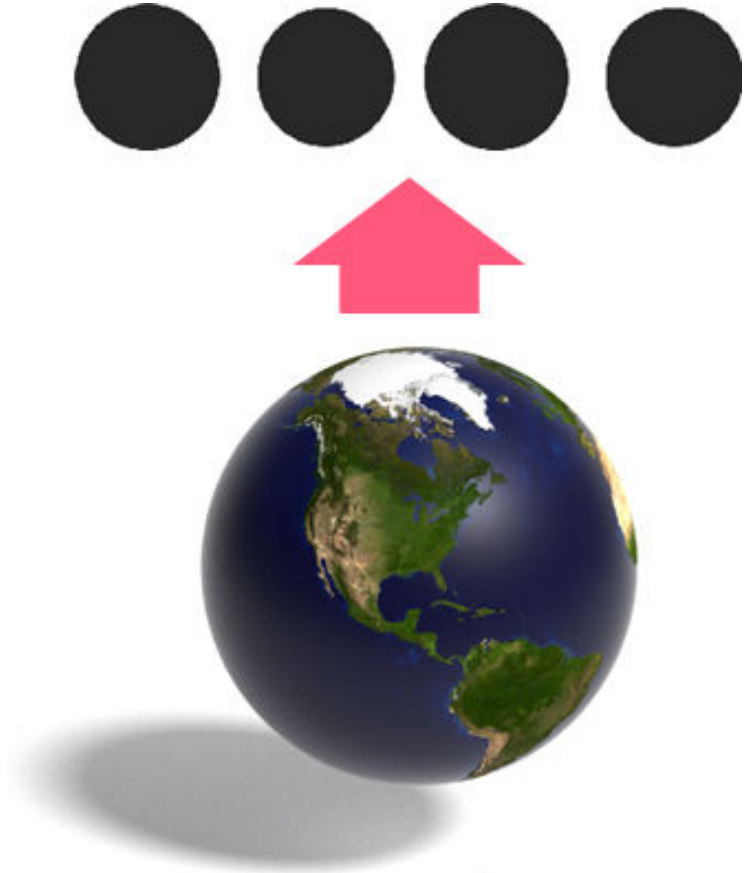
Simplified Chemical Industry



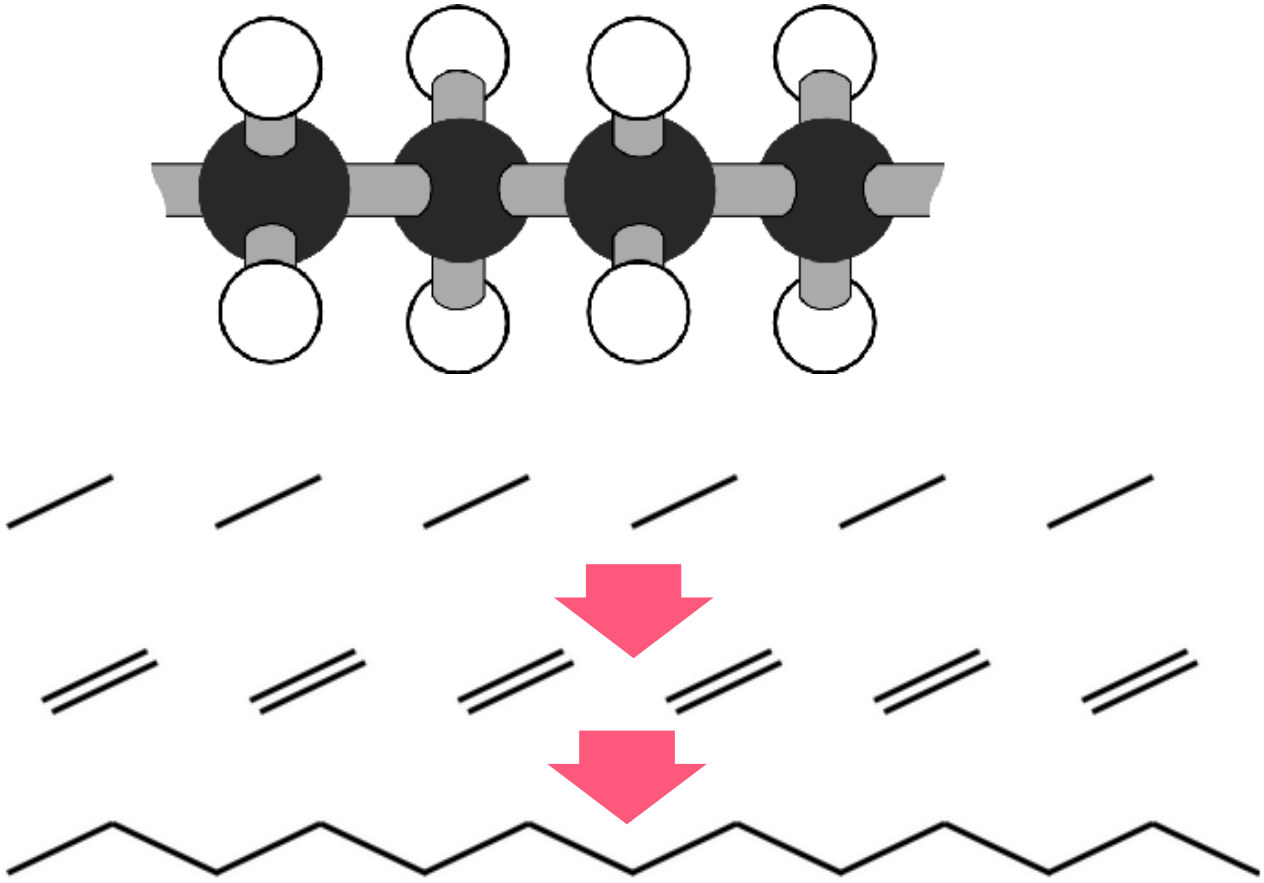
MODERN CHEMICAL INDUSTRY

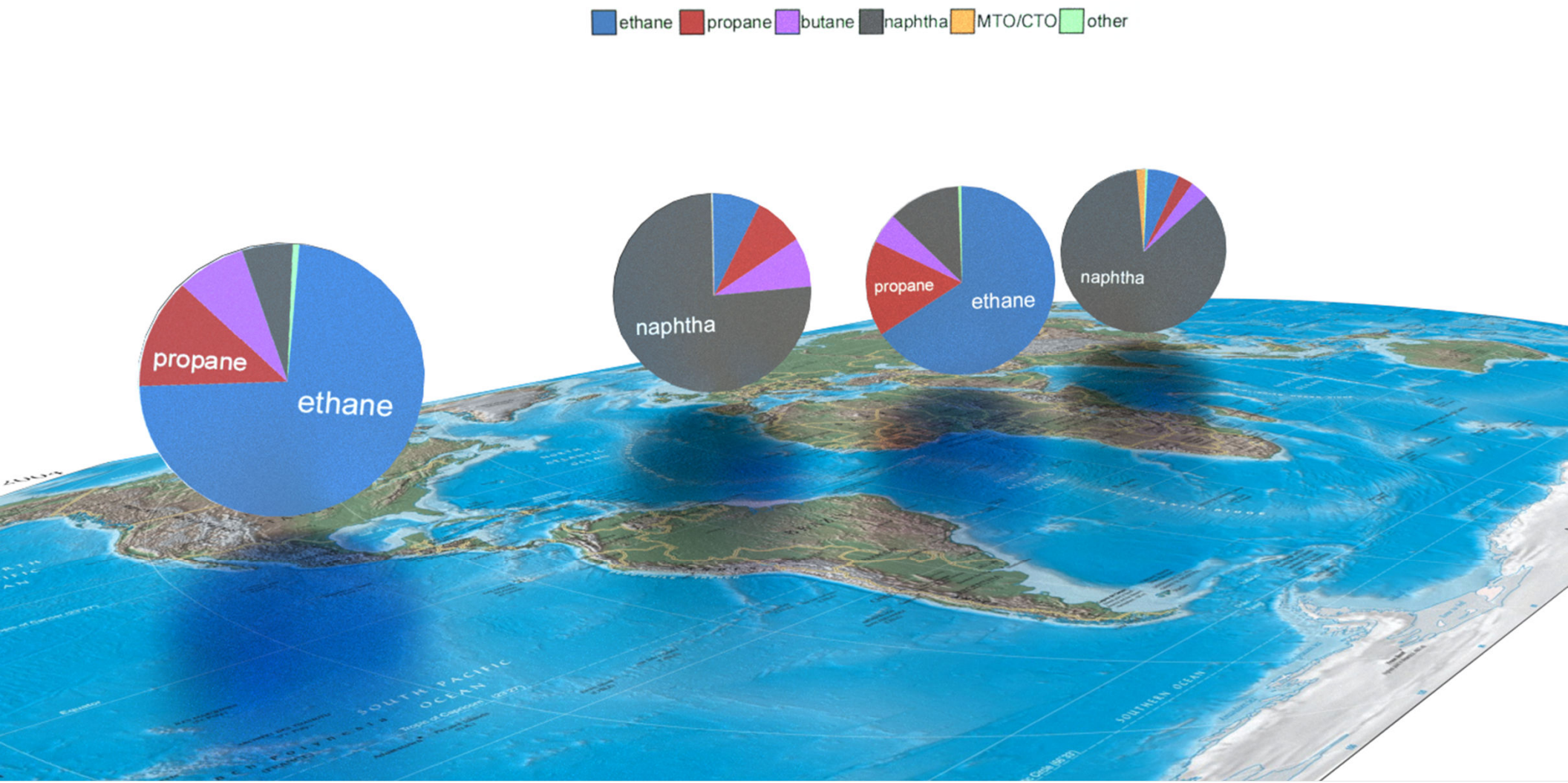


ROUGH INDUSTRY MASS BALANCE

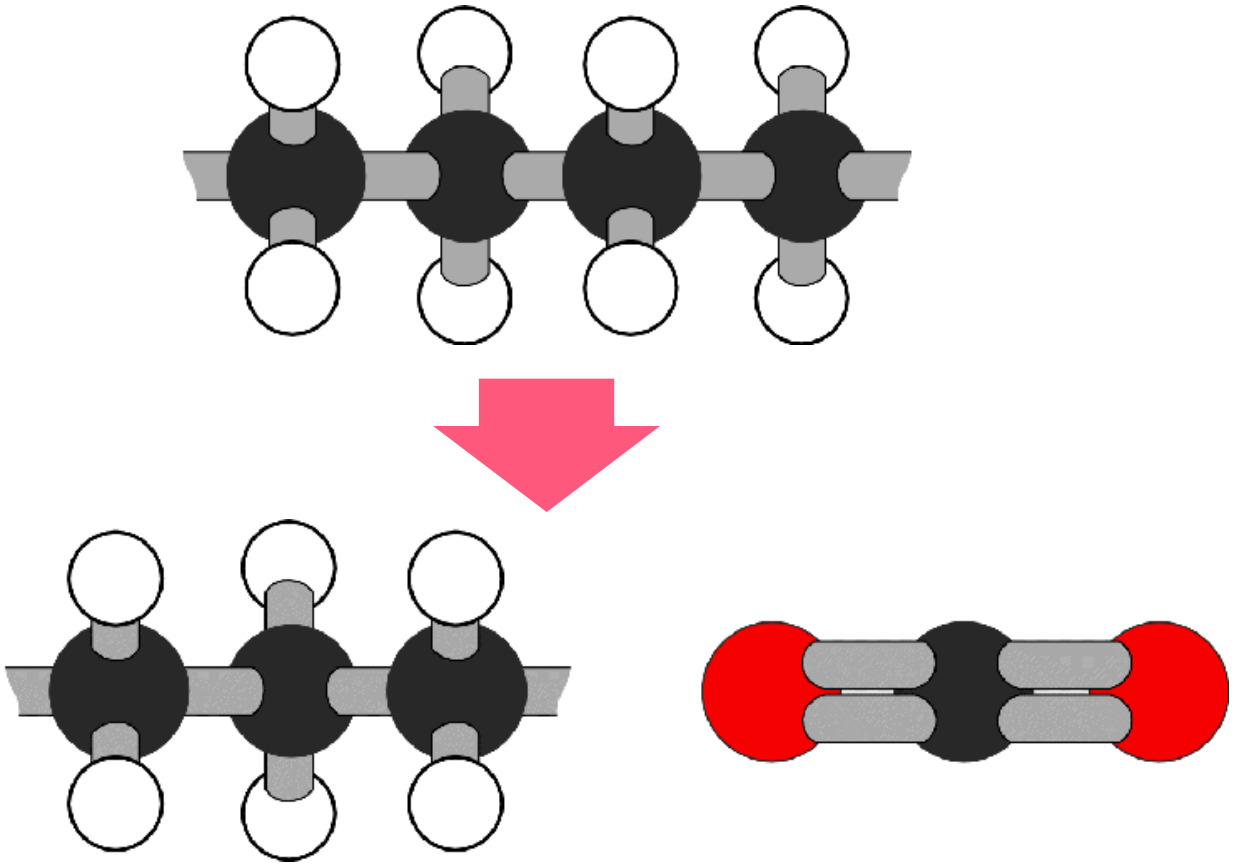


Chemical Transformation

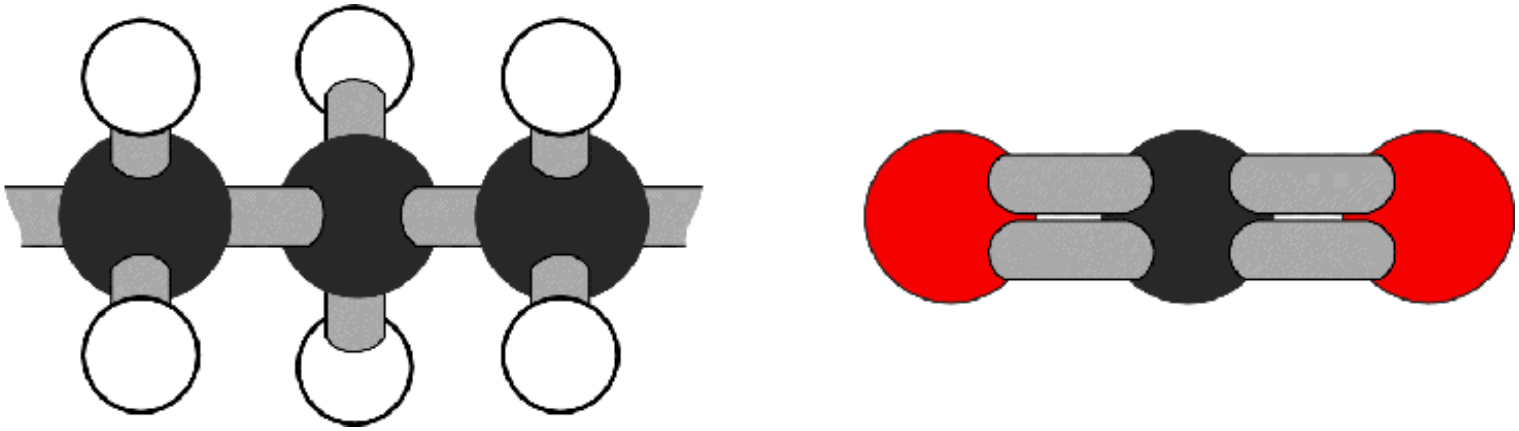



ethane
propane
butane
naphtha
MTO/CTO
other
propane
ethane
naphtha
propane
ethane
naphtha
SOUTH PACIFIC OCEAN
SOUTHERN OCEAN

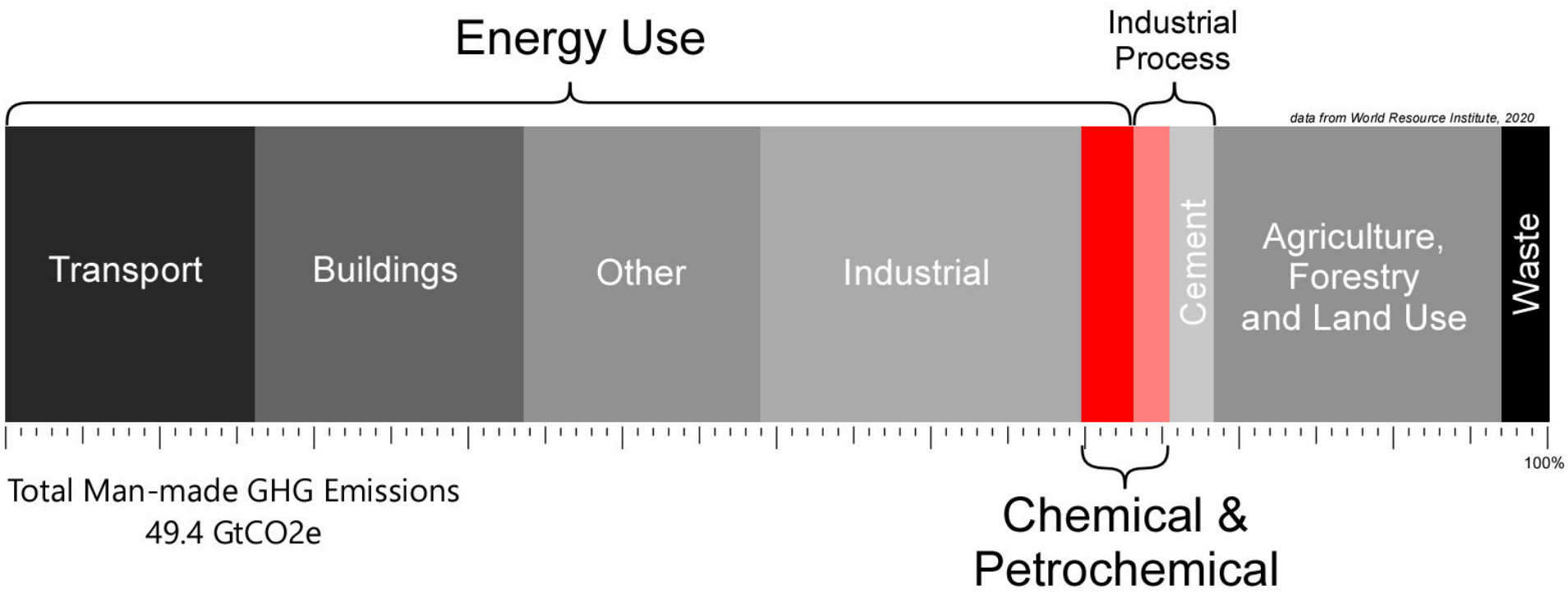
Rough Mass Balance



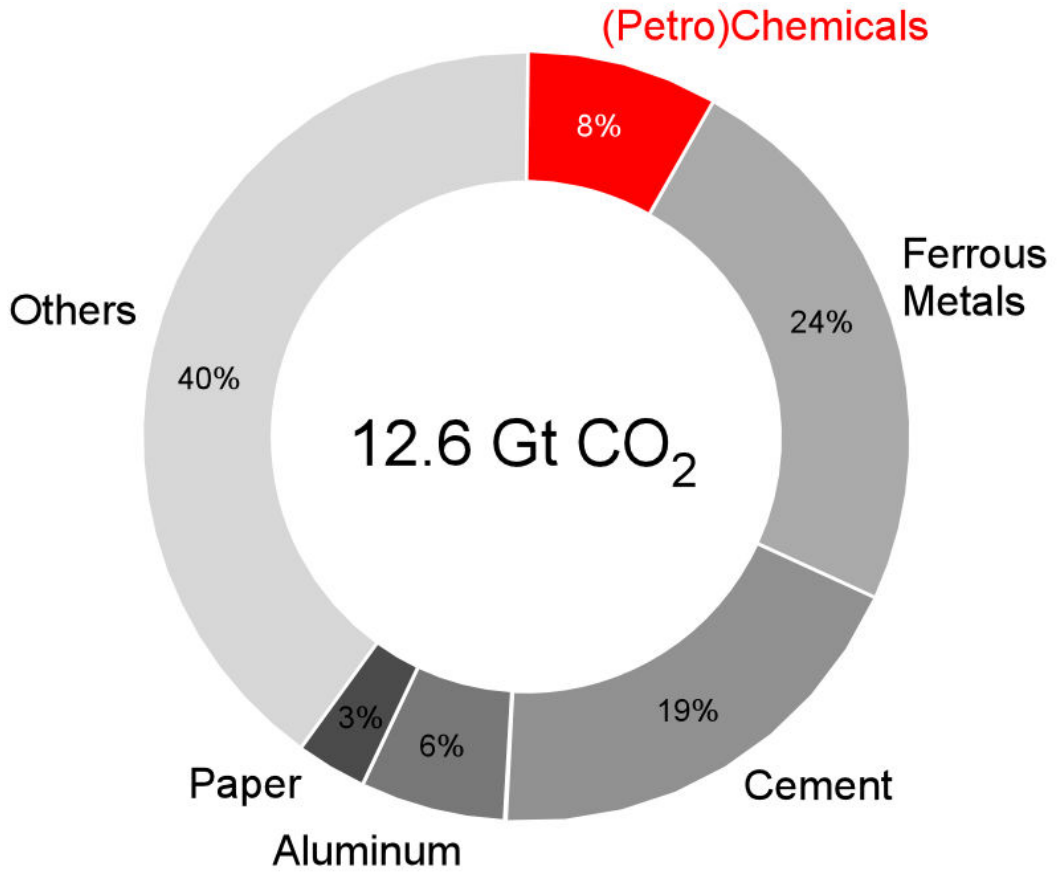
IMPLICATIONS



Carbon Footprint of Industry

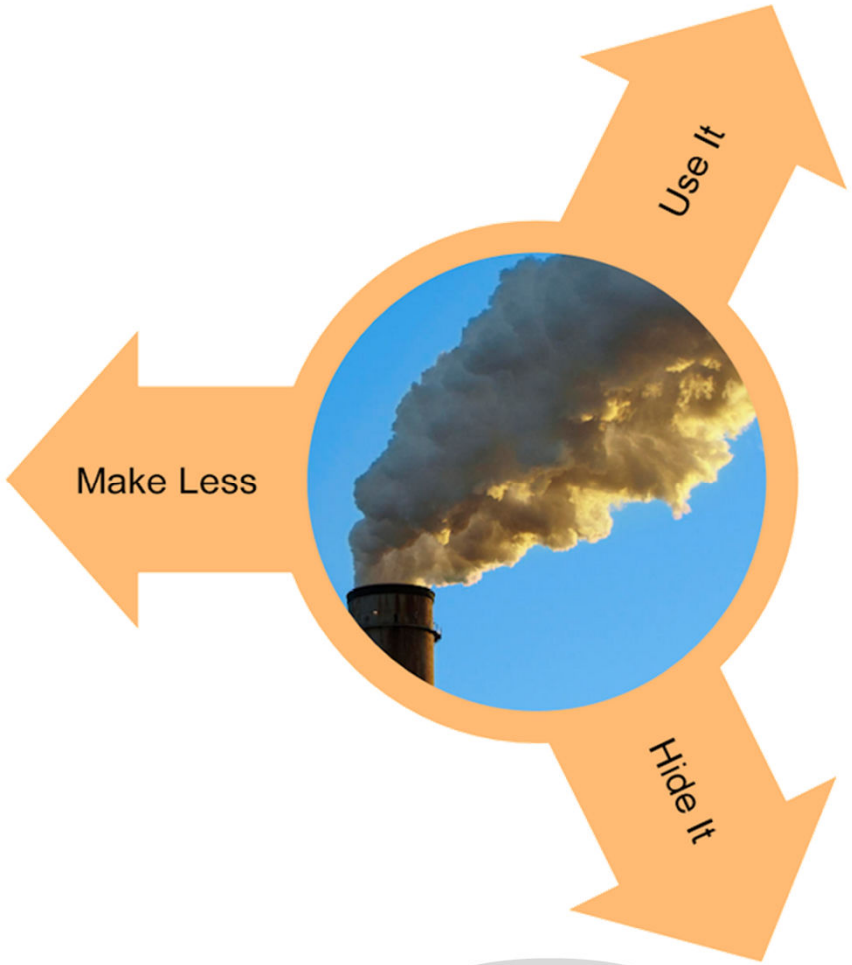


GLOBAL CO2 EMISSIONS FROM INDUSTRY



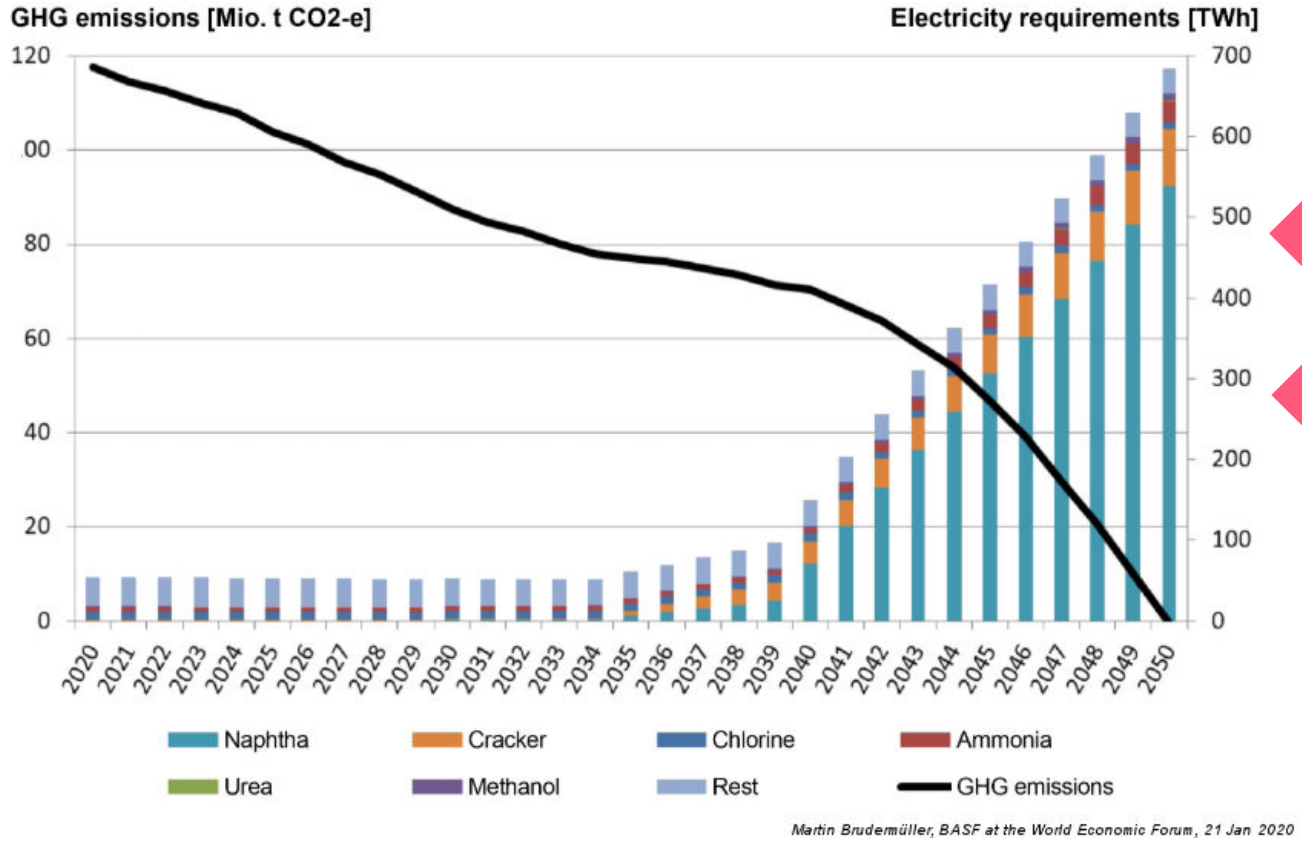
Martin Brudemuller, BASF at the World Economic Forum, 21 Jan 2020

Options For CO_2



Plan For Zero Emissions

Electricity requirements to achieve greenhouse gas neutrality in the German chemical industry



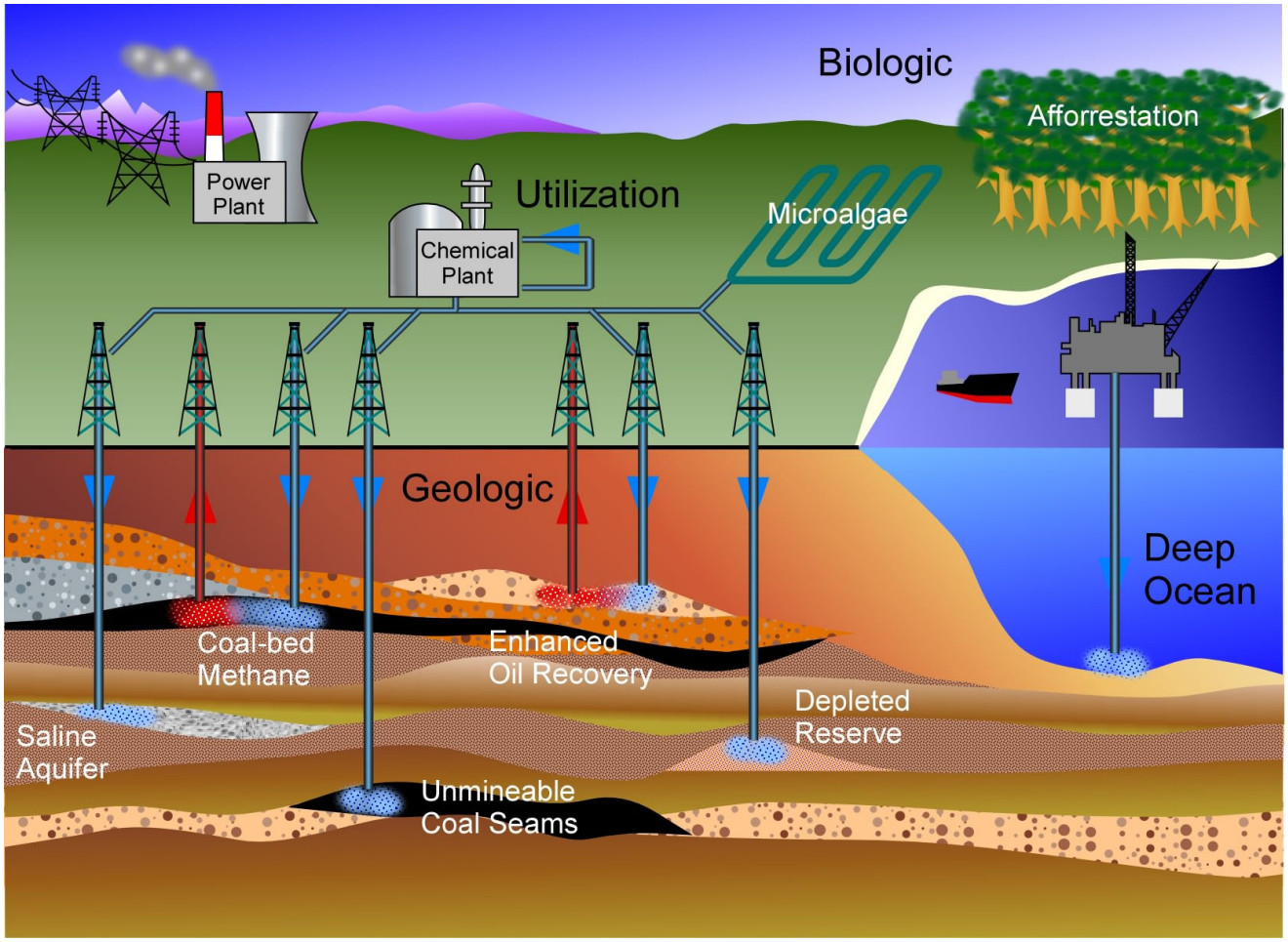
Martin Brudermüller, BASF at the World Economic Forum, 21 Jan 2020

490 for all Germany today

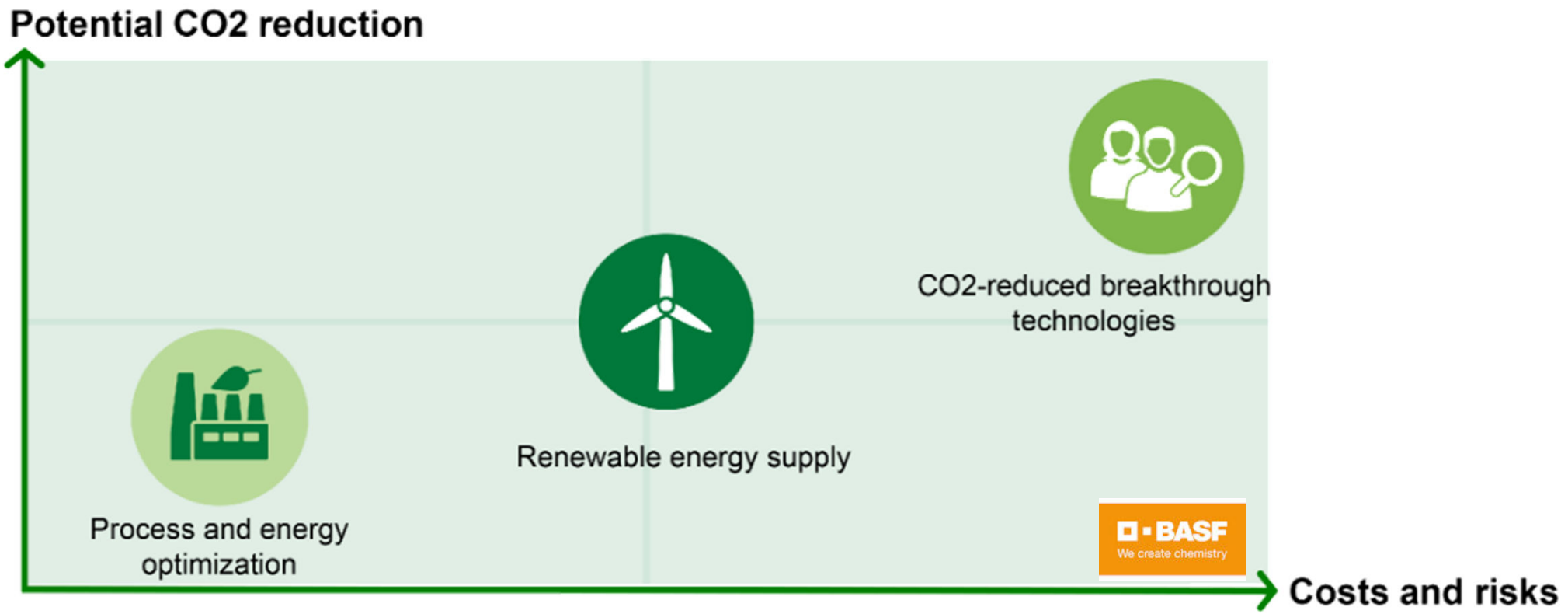
270 for all industry

MJPhD

HIDE IT

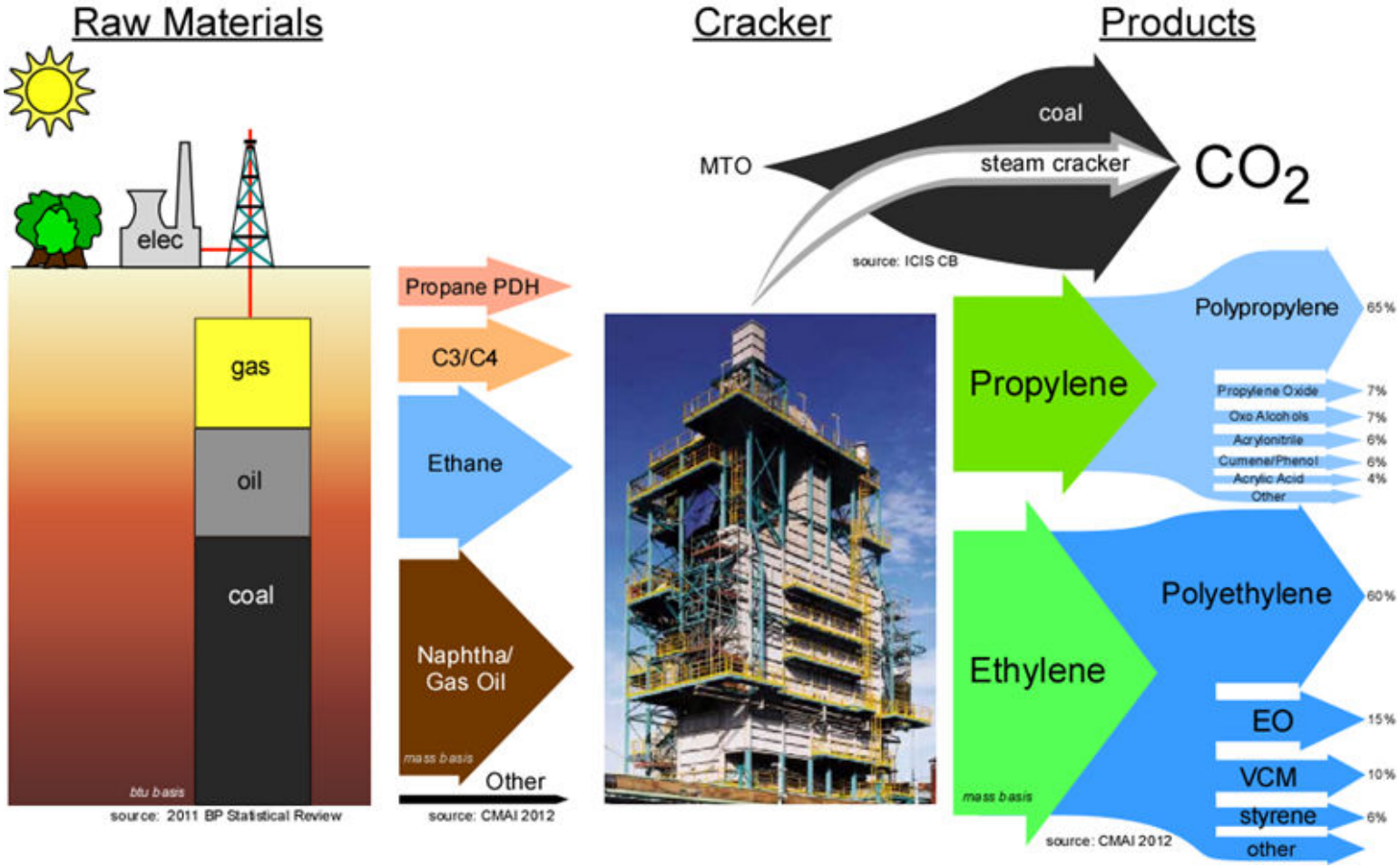

Biologic
Afforestation
Power Plant
Utilization
Chemical Plant
Microalgae
Geologic
Deep Ocean
Coal-bed Methane
Enhanced Oil Recovery
Depleted Reserve
Saline Aquifer
Unmineable Coal Seams

Potential Solutions For Direct Emissions

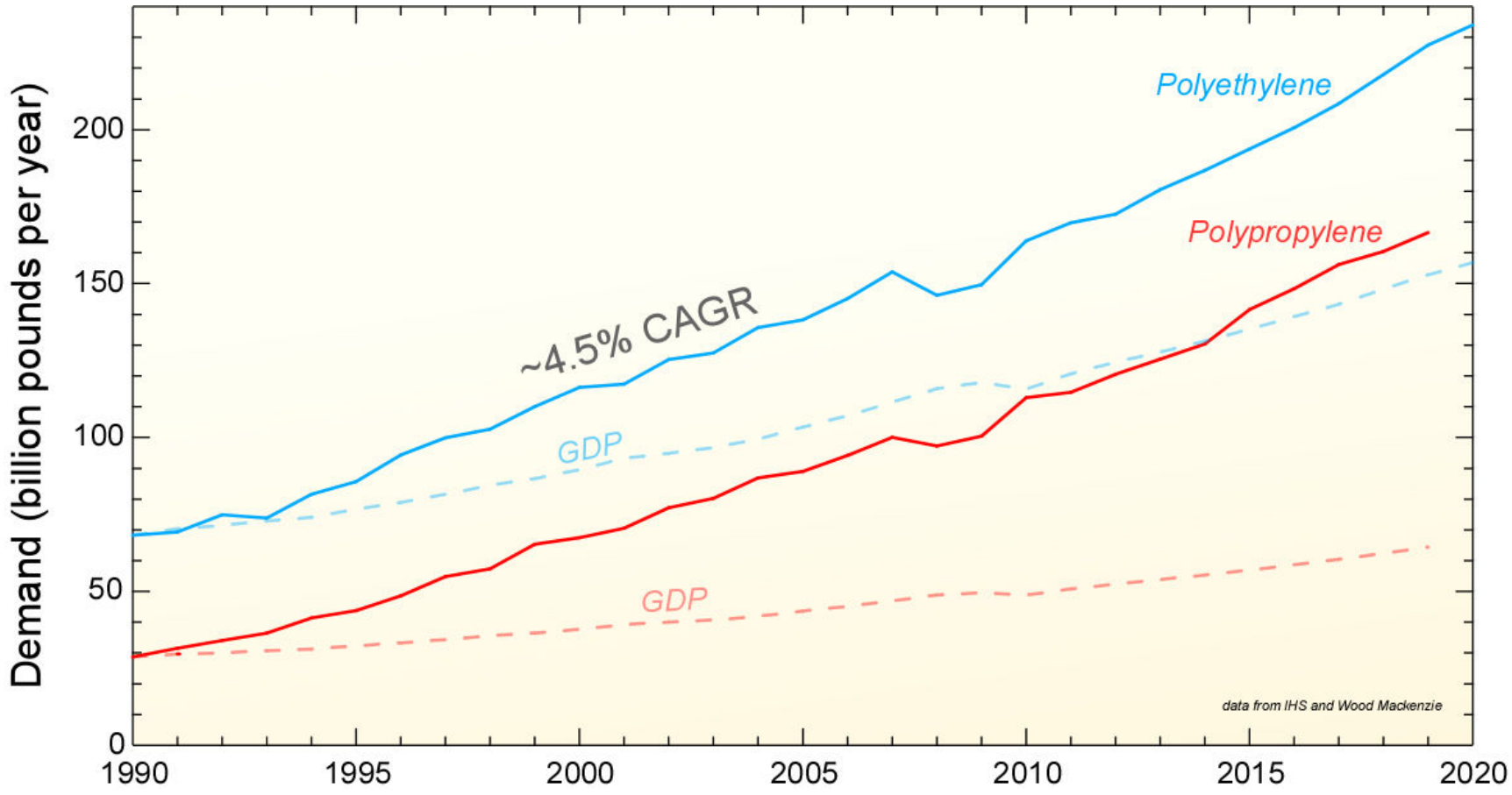


Martin Brudermüller, BASF at the World Economic Forum, 21 Jan 2020

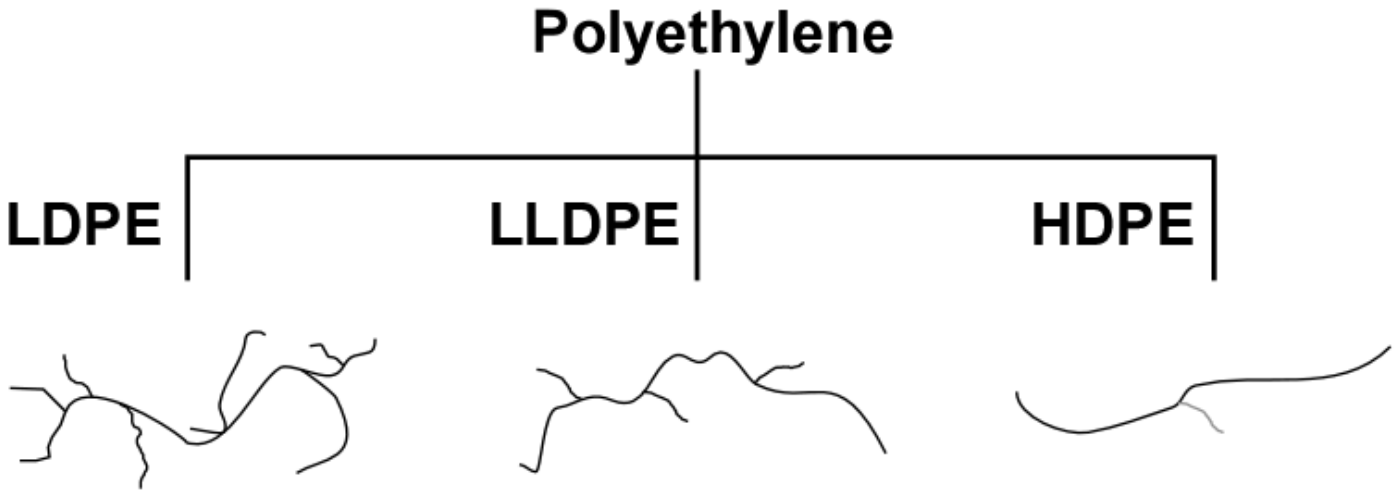
MODERN CHEMICAL INDUSTRY



GROWING >GDP


Demand (billion pounds per year)
0
50
100
150
200
1990
1995
2000
2005
2010
2015
2020
Polyethylene
Polypropylene
~4.5% CAGR
GDP
GDP
data from IHS and Wood Mackenzie

Three Kinds of Polyethylene



LDPE	LLDPE	HDPE
high-pressure radical polymerization	catalytic co-polymerization of ethylene and α-olefin	organometallic catalysis
lots of branching	controlled branching	limited branching
low density polyethylene	*linear low density polyethylene*	*high density polyethylene*

Bad Omen

THE COLLINS WORD OF THE YEAR 2018 IS...

SINGLE-USE

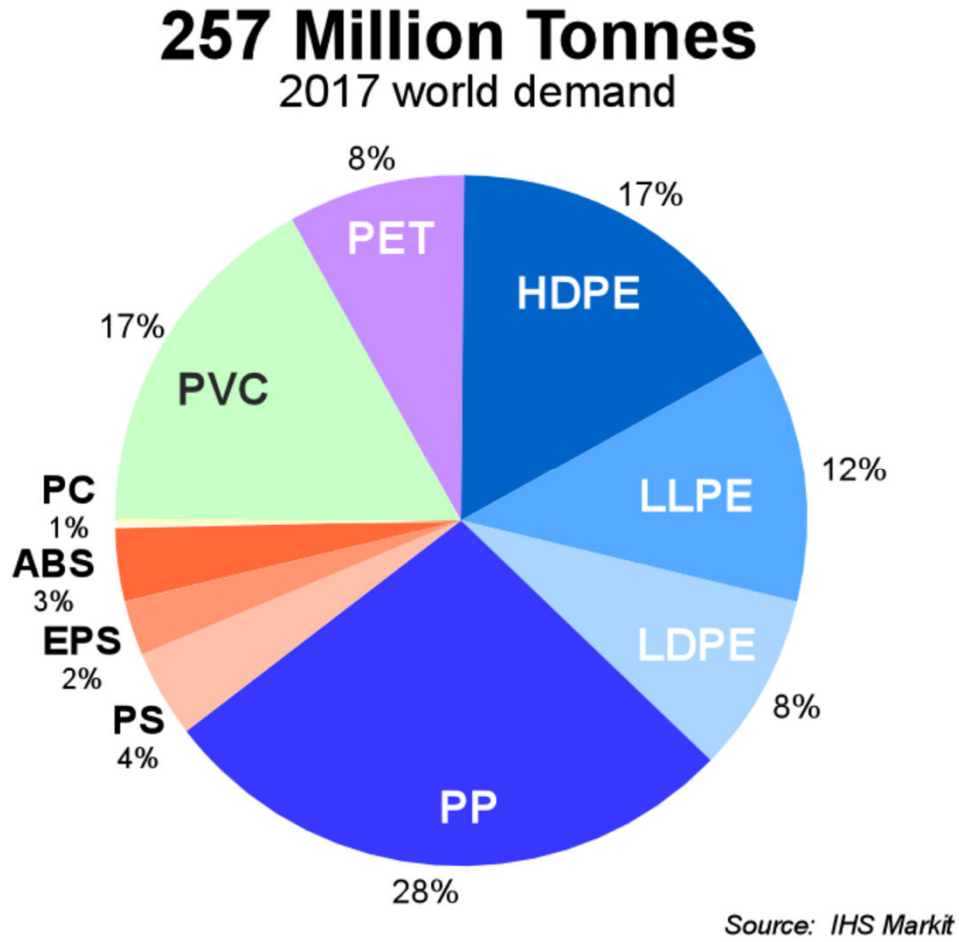
'Single-use', a term that describes items whose unchecked proliferation are blamed for damaging the environment and affecting the food chain, has been named Collins' Word of the Year 2018.

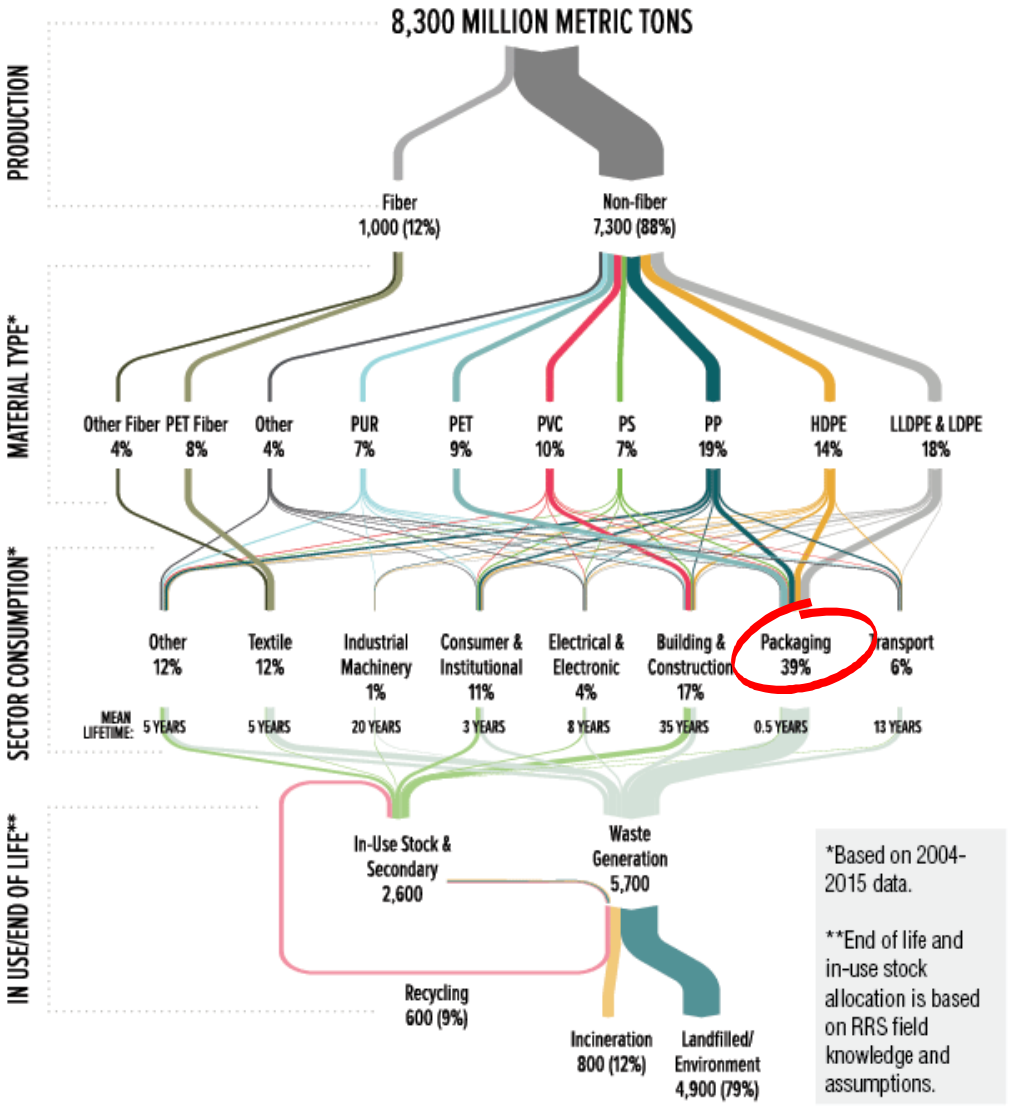
Single-use refers to products – often plastic – that are 'made to be used once only' before disposal. Images of plastic adrift in the most distant oceans, such as straws, bottles, and bags have led to a global campaign to reduce their use.

The word has seen a four-fold increase since 2013, with news stories and images such as those seen in the BBC's Blue Planet II steeply raising public awareness of the issue.

Collins
Pioneers in dictionary publishing since 1819

Lots of Polymers Made



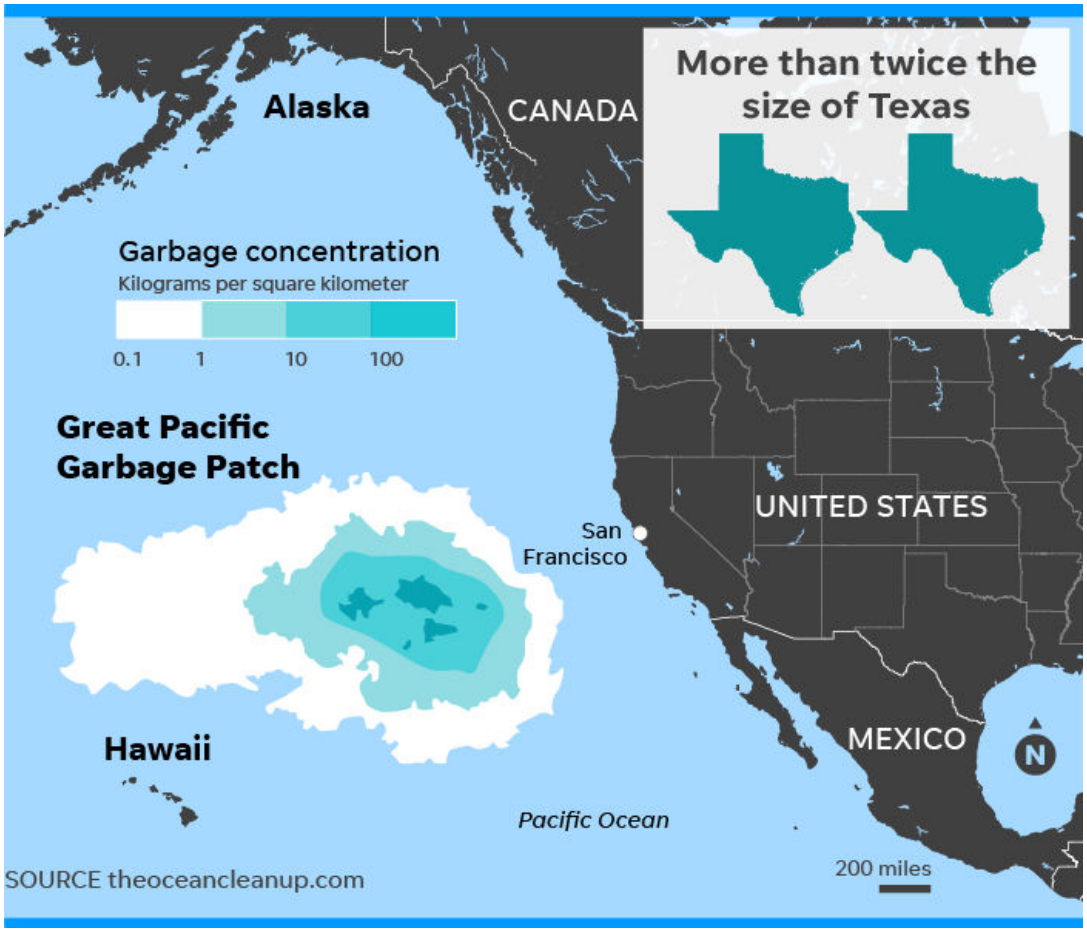


packaging 39%

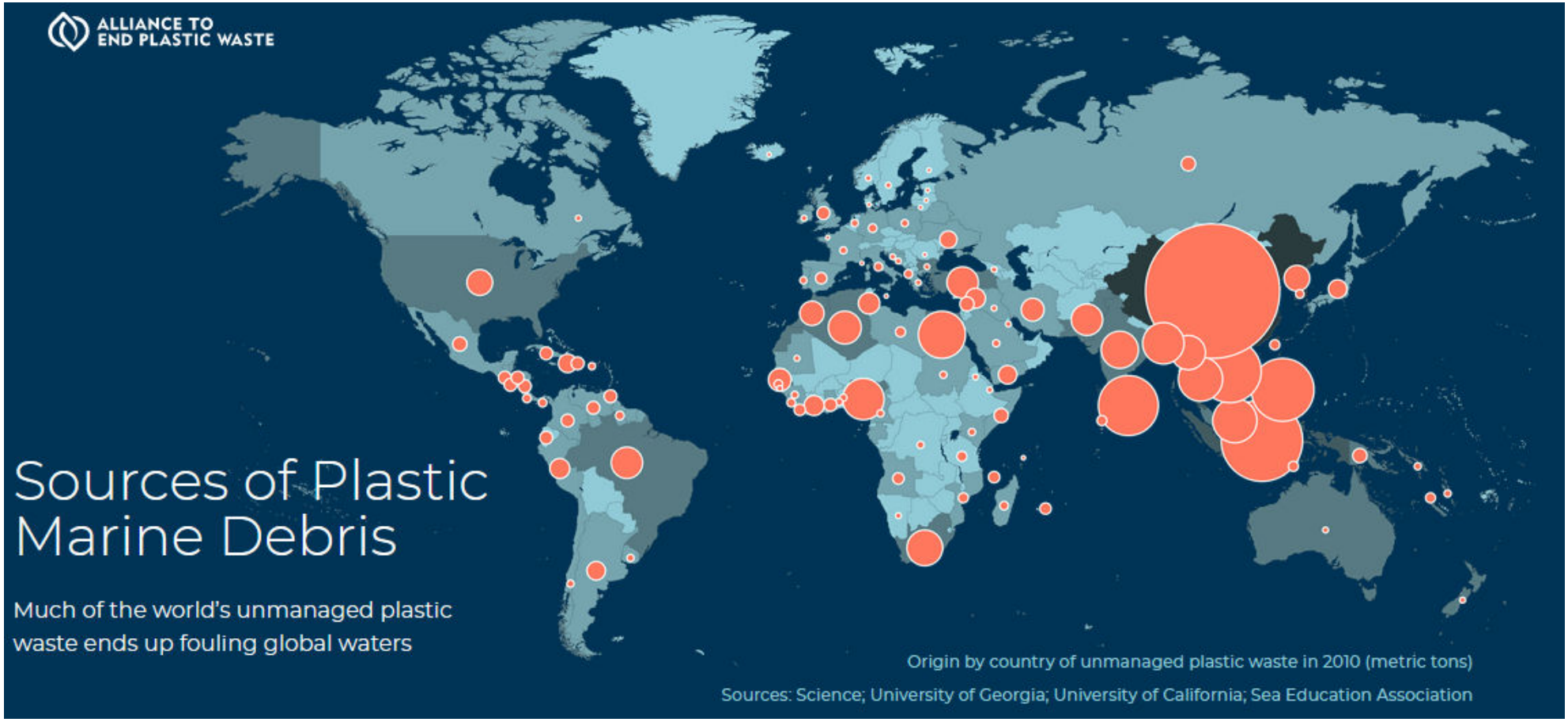
World Without Packaging

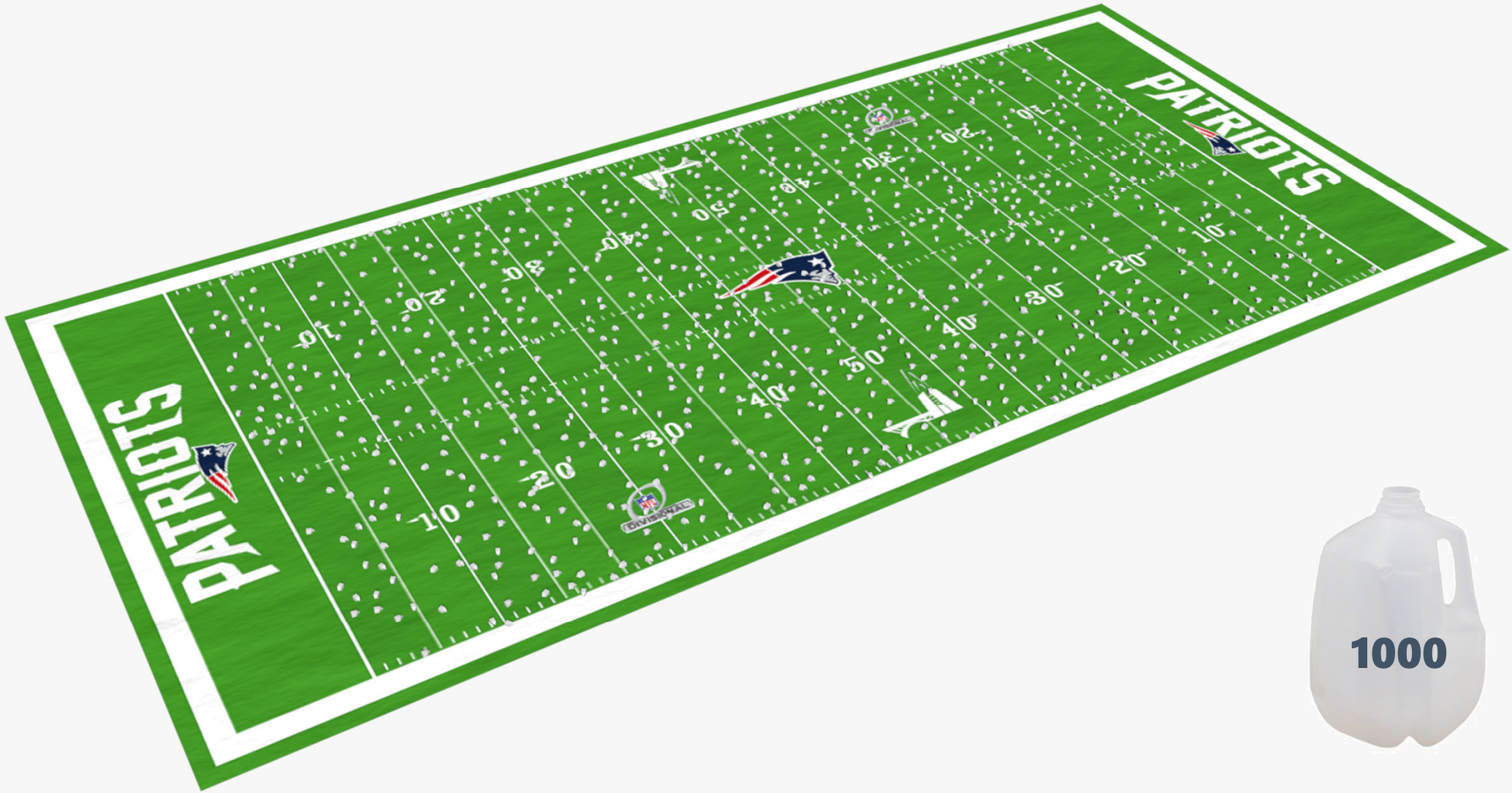
Ocean Plastic

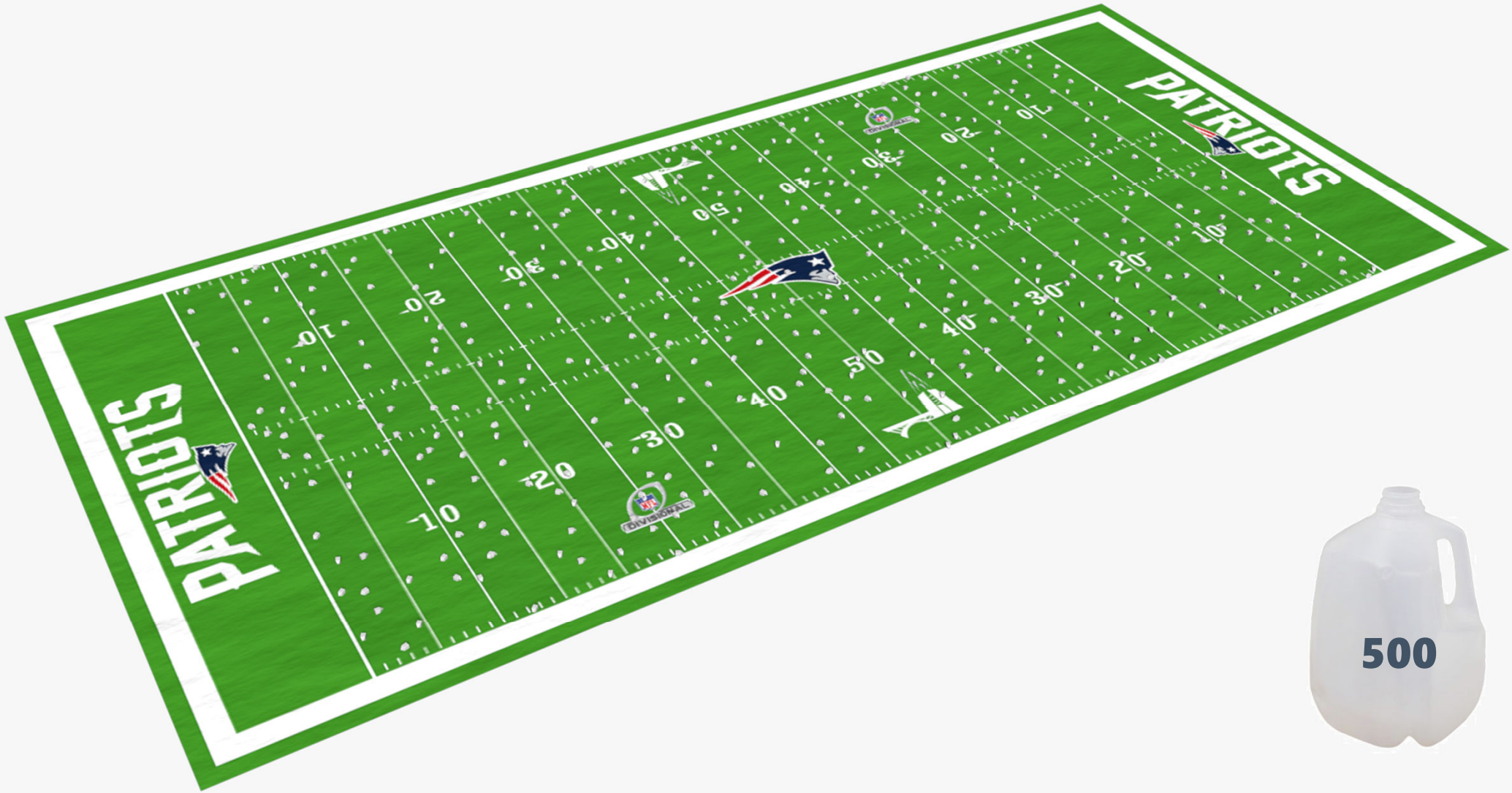
The Pacific Gyre



Source of Ocean Plastic




PATRIOTS
PATRIOTS
1000


PATRIOTS
PATRIOTS
500


PATRIOTS
PATRIOTS
10
20
30
40
50
40
30
20
10

200


PATRIOTS
PATRIOTS
100

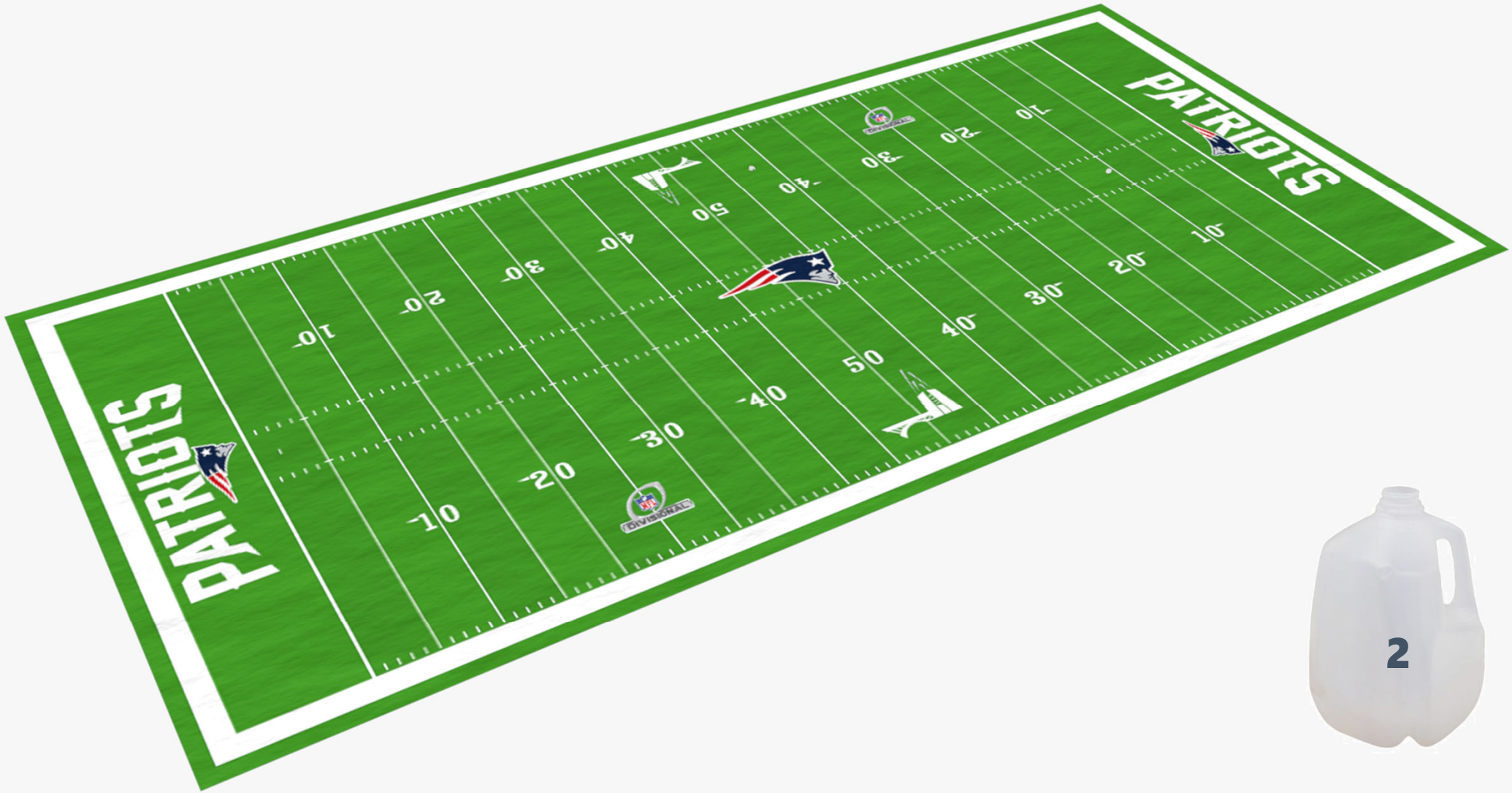

PATRIOTS
PATRIOTS
50


PATRIOTS
PATRIOTS
10
20
30
40
50
40
30
20
10

20


PATRIOTS
PATRIOTS
10
20
30
40
50
40
30
20
10

5


PATRIOTS
PATRIOTS
10
20
30
40
50
40
30
20
10
2

1

Gyre Concentration In Milk Jugs Per Football Field

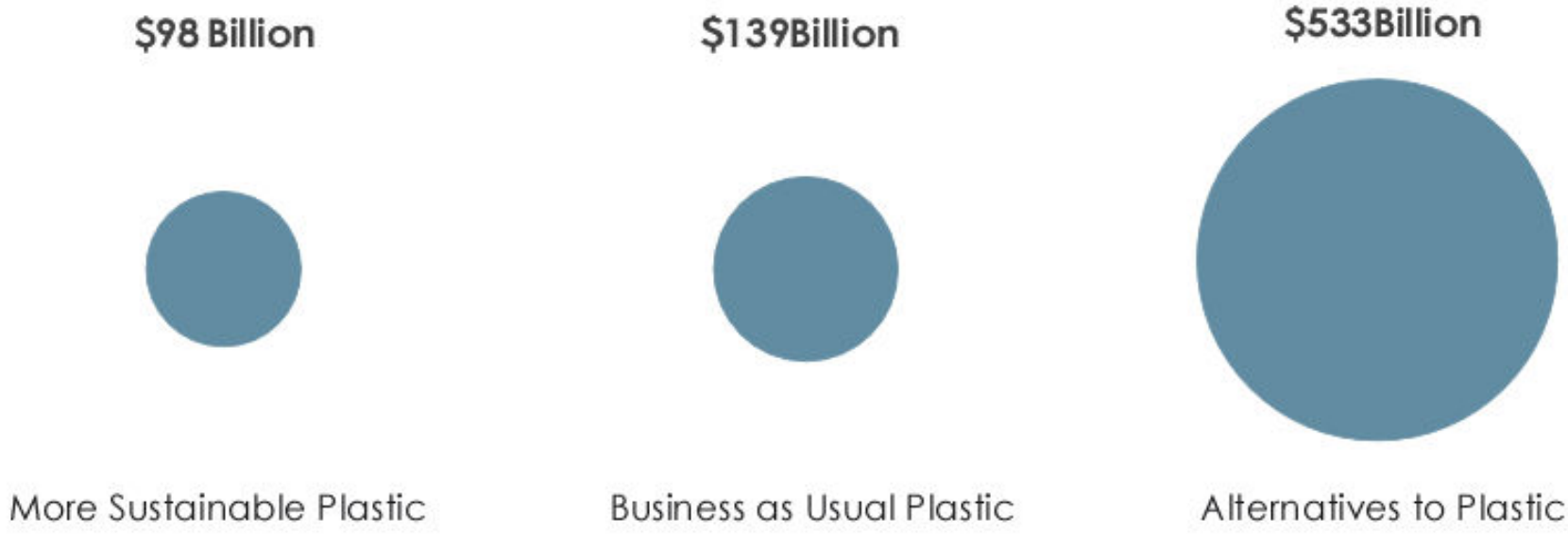
1. 1000
2. 500
3. 200
4. 100
5. 50
6. 20
7. 10
8. 5
9. 2
10. 1

In The Pacific Gyre At Point of Highest Plastic Concentration

5


5

ALTERNATIVES COST MORE

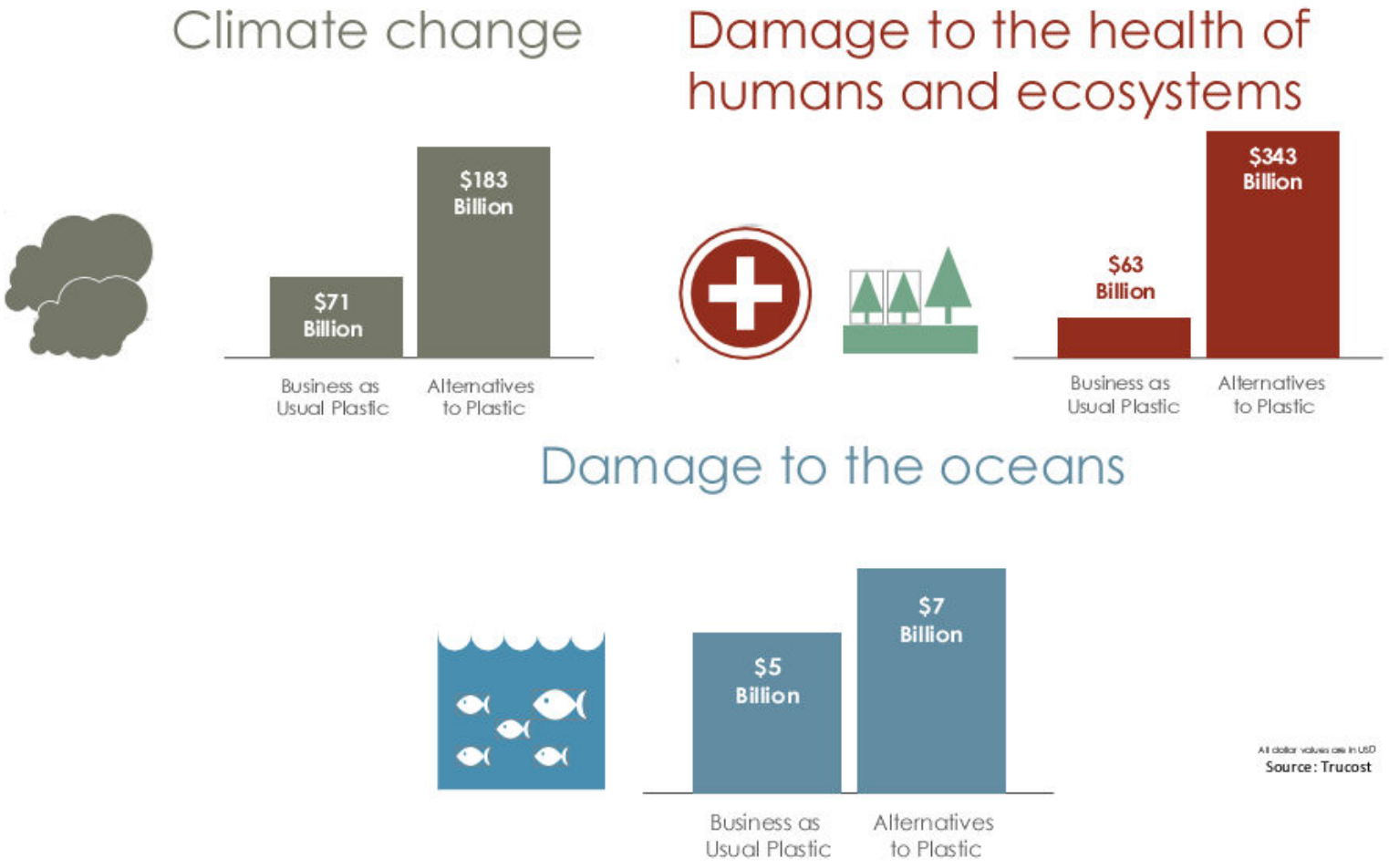


The cost of using alternative materials is approximately four times that of using plastic (in a business as usual scenario). We're producing more and more consumer goods, so choosing the material that creates the least impact is important.

Source: Trucost

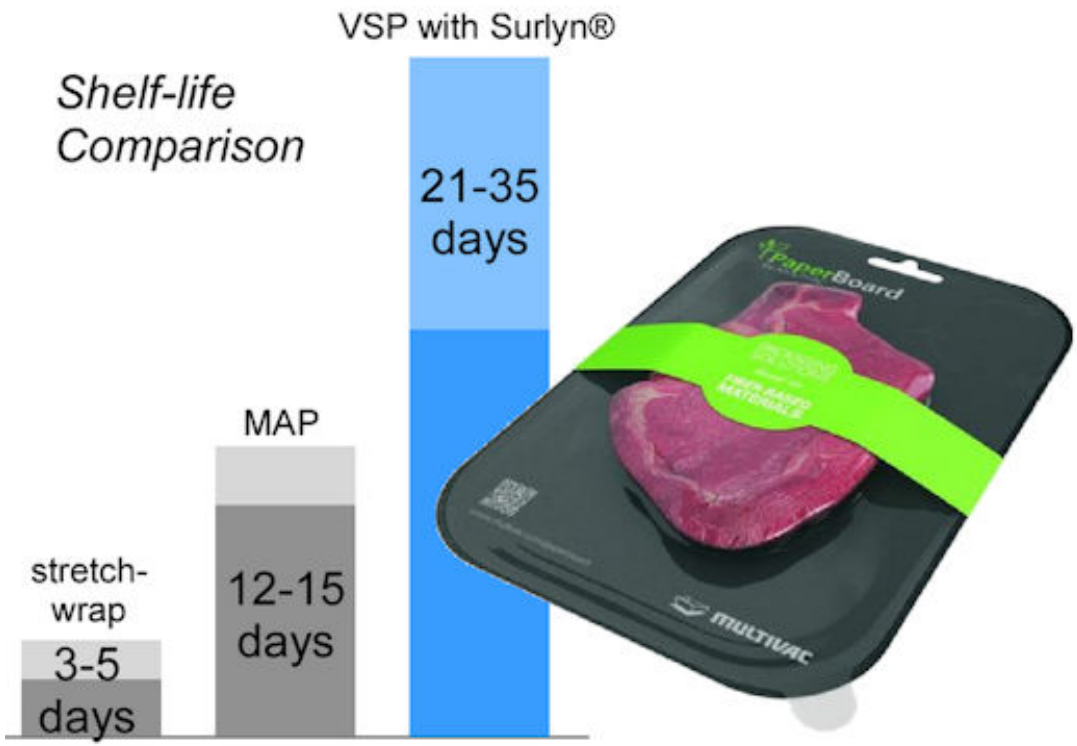
Source: American Chemistry Council TRUCOST report

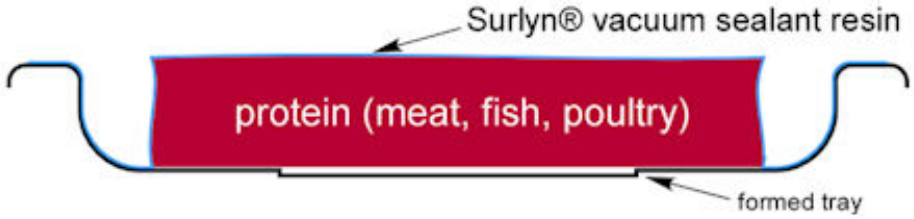
Alternatives Have Higher Environmental Costs



Source: American Chemistry Council TRUCOST report

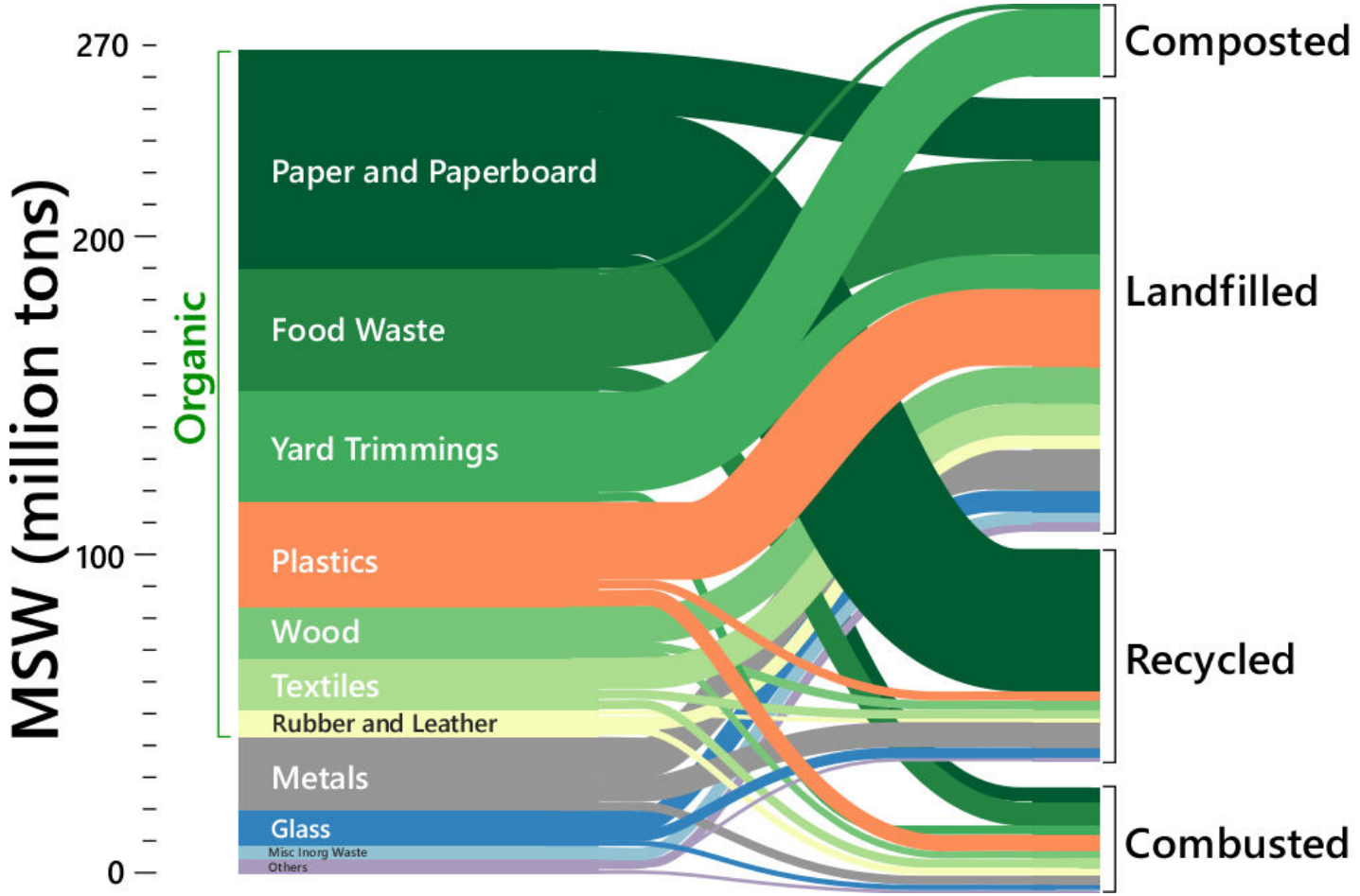
PLASTIC PROVIDES BENEFITS





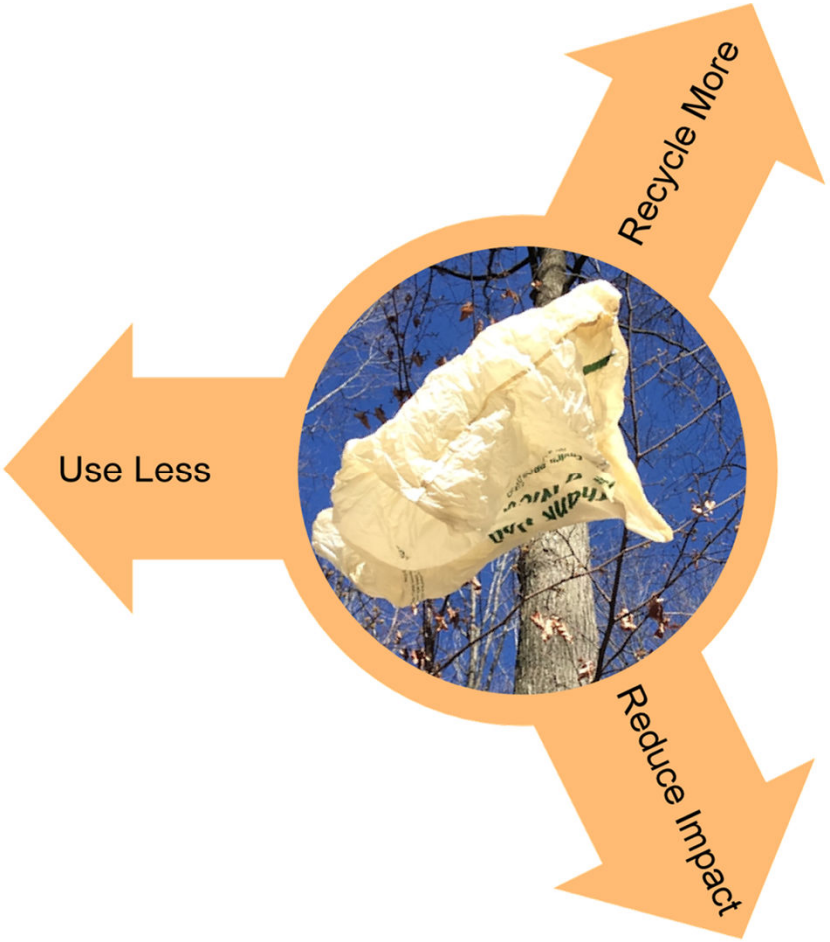
Plastic Provides Benefits

U.S. TRASH

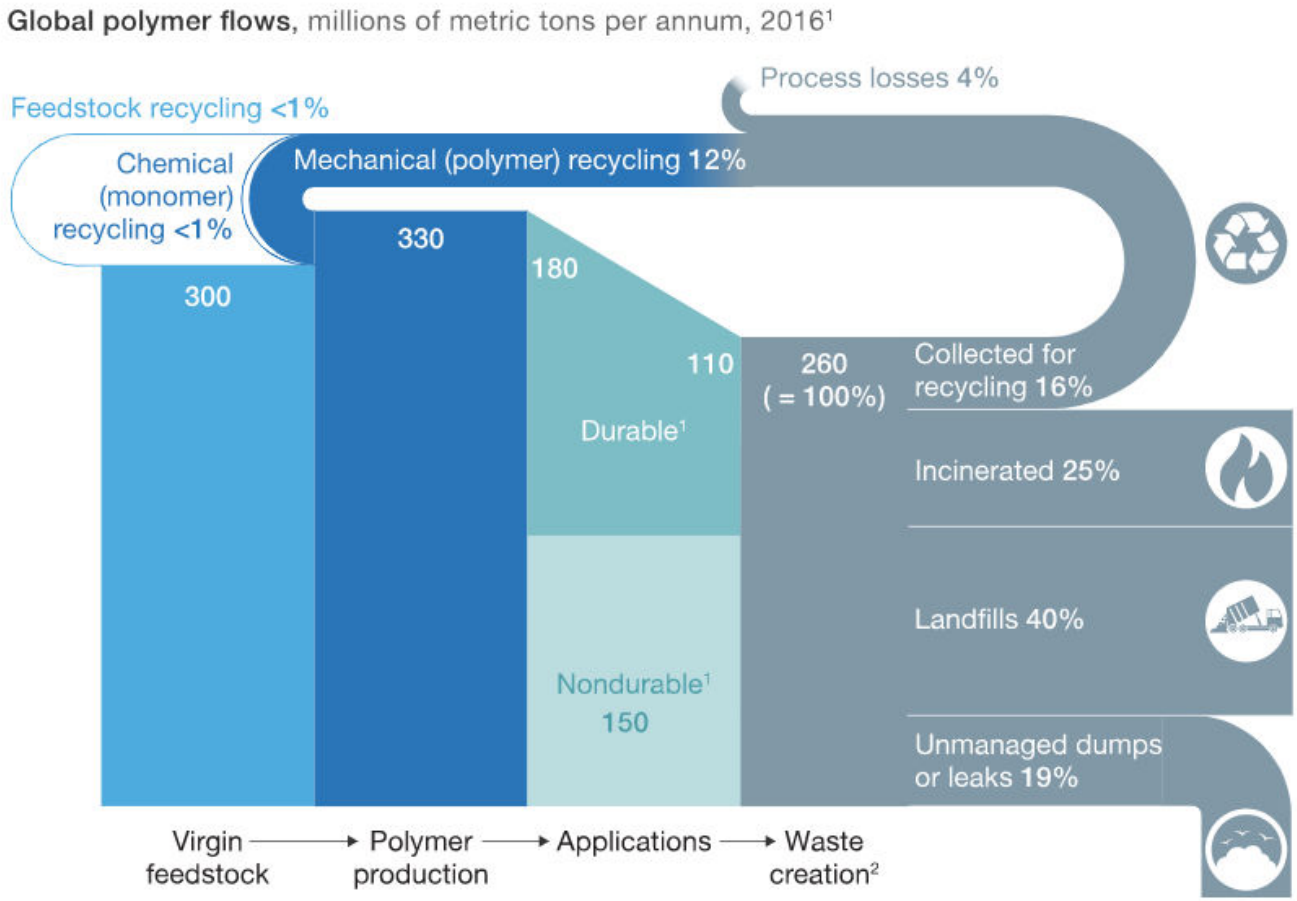


MJPHD

Possible Solutions



WHERE DOES PLASTIC GO?



USE LESS WITH MORE EFFICIENT PACKAGING

EDIBLES		NON-EDIBLES
Edible Oils	Rice & Grains	Paint & Coatings
Ketchup & Other Condiments	Breakfast Cereal	Detergents & Cleaning Products
Sauces	Dry Baking Products (flour, sugar, etc.)	Motor Oil & Fuel Additives
Soups	Ground Coffee	Seeds
Honey & Syrups	Snack foods	Cat Litter
Water & Juices		De-icer Pellets
Dry Pet Food or Treats		Fine Aggregates (filter sand, etc.)

EDISON AWARDS
2015

R&D 100
2015
R&D 100 Winner

MJPhD

Re-Closable Cap
- Precision pouring
- Maximum filling content utilization

Flexible Design
- Four Print Surfaces
- Superior drop resistance
- Reduce excess head space
- Improved dispensing
- Collapses easily

Top and Bottom Handles
- Easy handling

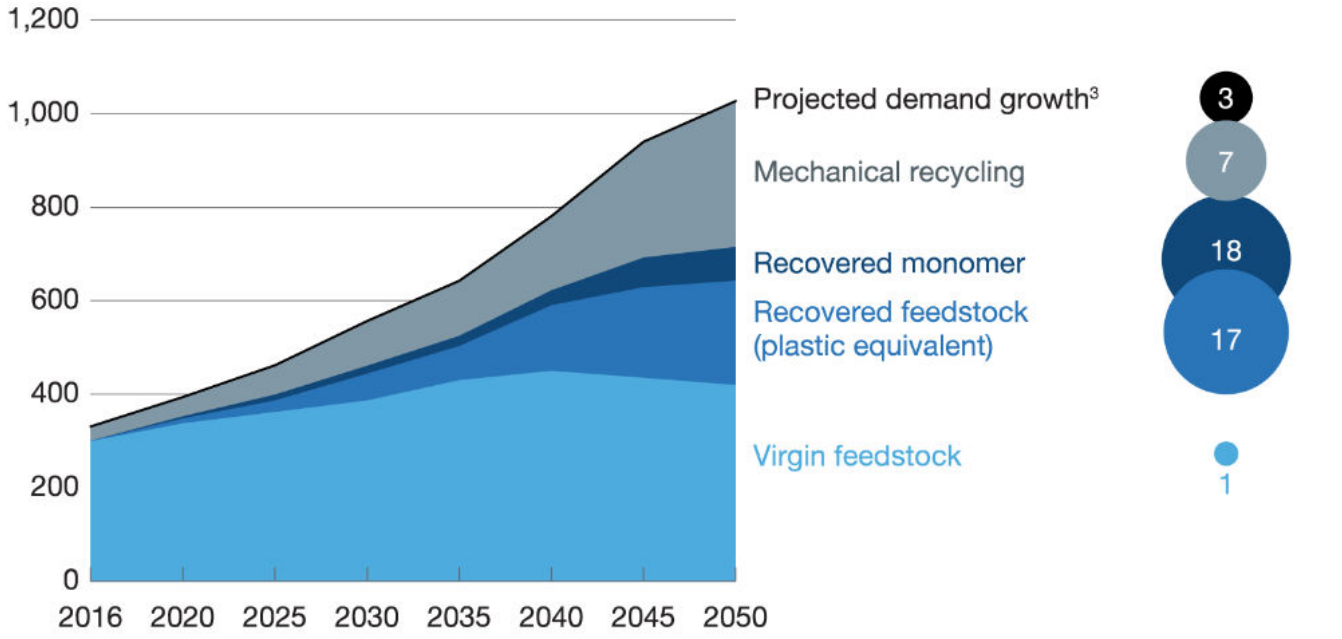
Cubic Shape
- Shelf Stable & Maximizes Shipping Efficiency

Space Saving
- Ships and Stores Flat when Unfilled

ENABLE RECYCLING

By 2050, nearly 60 percent of plastics production could be based on plastics reuse and recycling.

Global polymer demand 2016–50 and how it could be covered, millions of metric tons[1]



[1]Scenario based on a multi-stakeholder push to boost recycling, regulatory measures to encourage recycling, consistent progress on technologies, and $75-per-barrel oil price.
[2]Compound annual growth rate. Mechanical recycling limited by downcycling and applicable materials, monomerization limited by applicability to condensation polymers only, pyrolysis limited by likely rise in input costs.
[3]After demand reduction, assuming annual global GDP growth of 3.1%.

Waste Reduction Hierarchy

Provide Alternatives

RECOVER

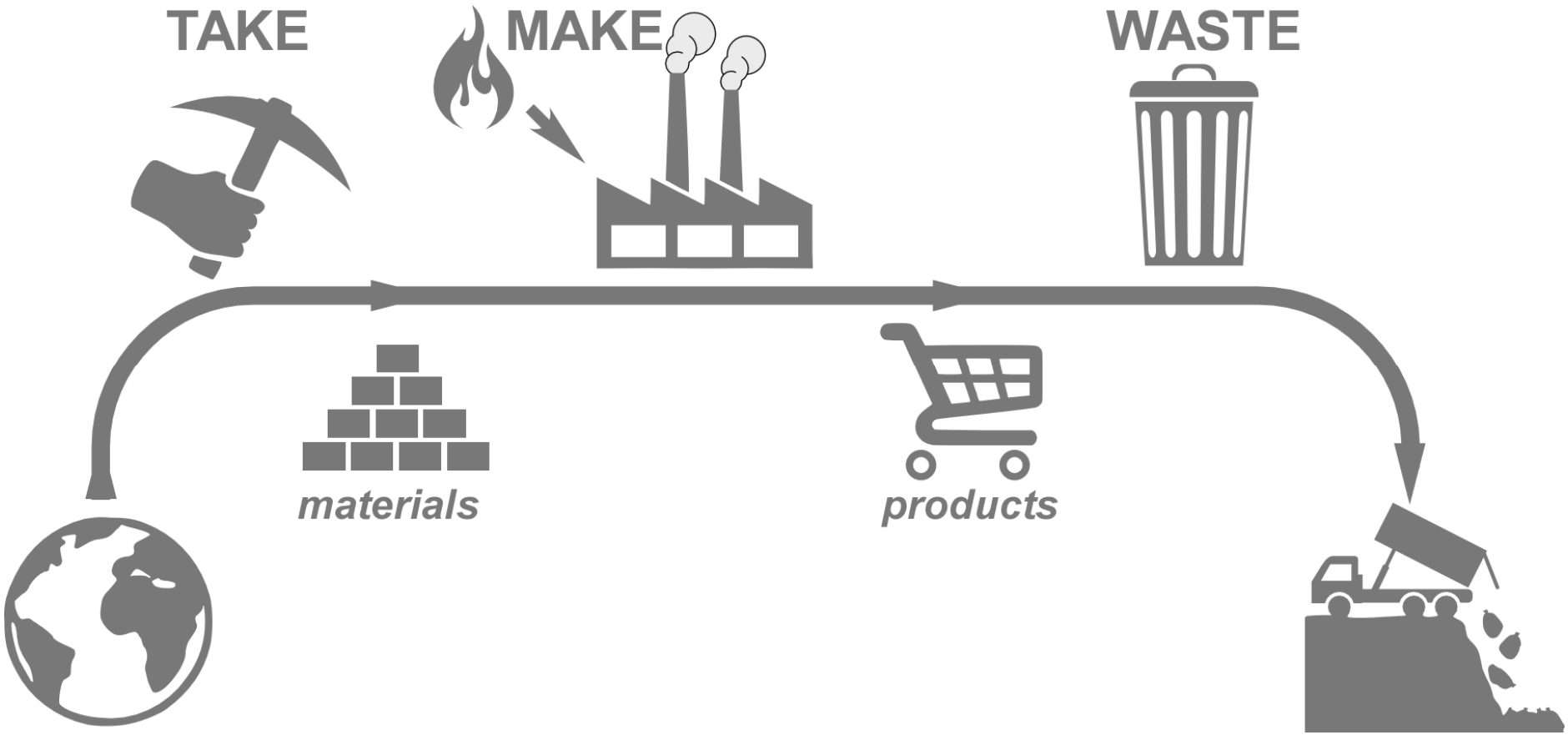

ENERGYBAG
THE PLACE FOR YOUR PLASTIC LEFTOVERS
IF YOU DON'T BIN IT, BAG IT
3-MONTH PILOT PROGRAM TO RECOVER NON-RECYCLED PLASTICS
ENERGYBAG
THE PLACE FOR YOUR PLASTIC LEFTOVERS


Citrus Heights
Sacramento
2 mi

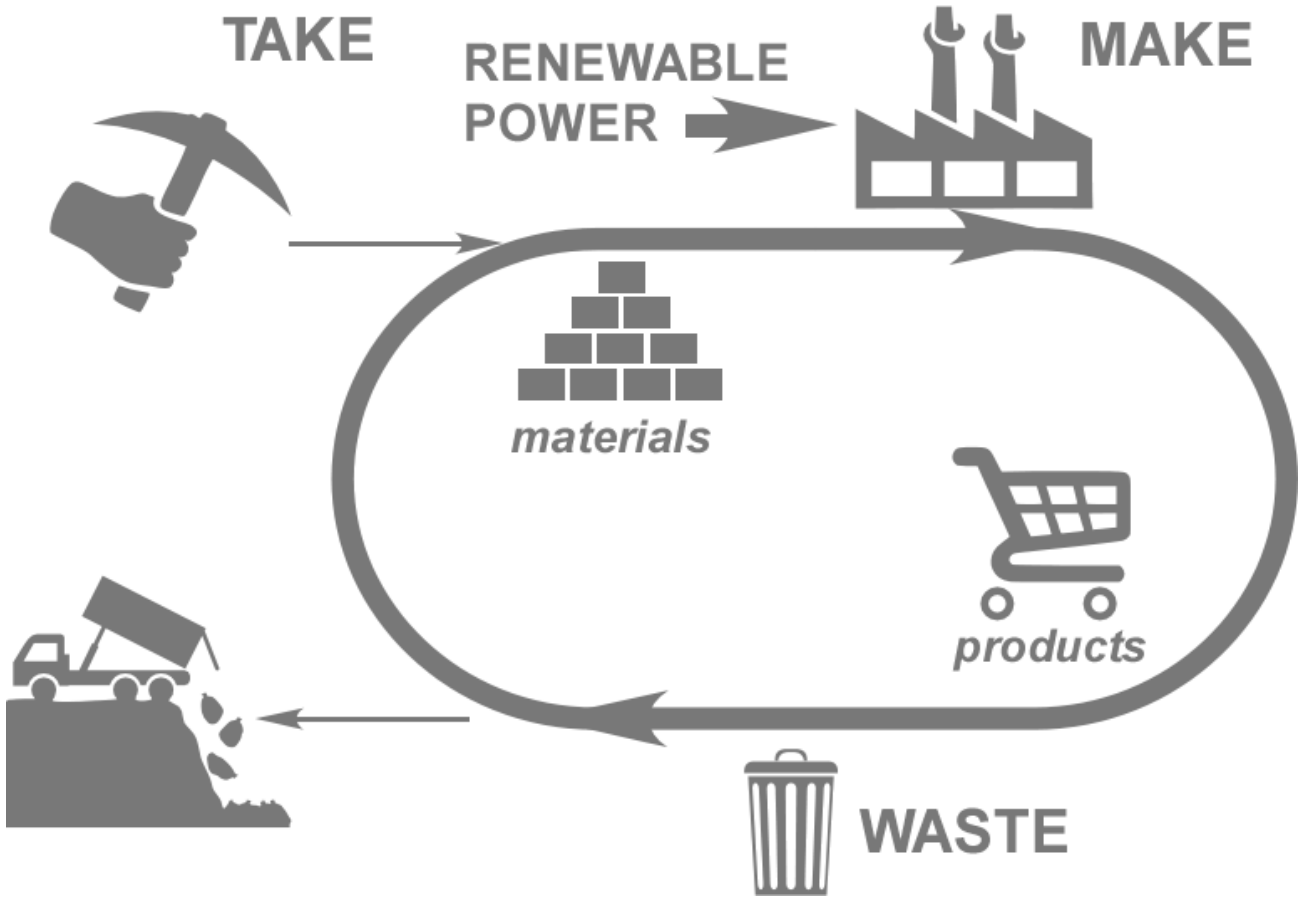

Hefty
ENERGYBAG
NON-RECYCLED PLASTICS
COLLECTION PROGRAM
20

DISAPPEAR

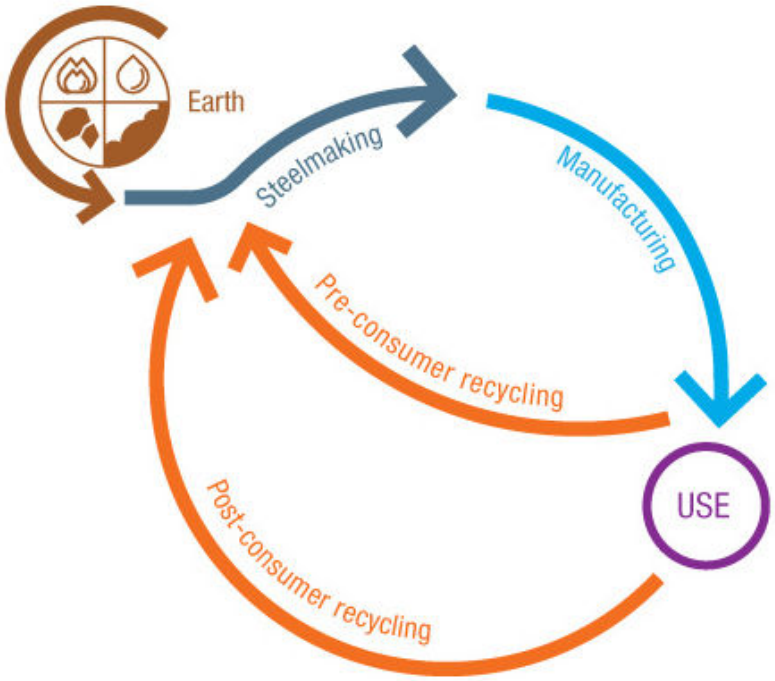
LINEAR ECONOMY

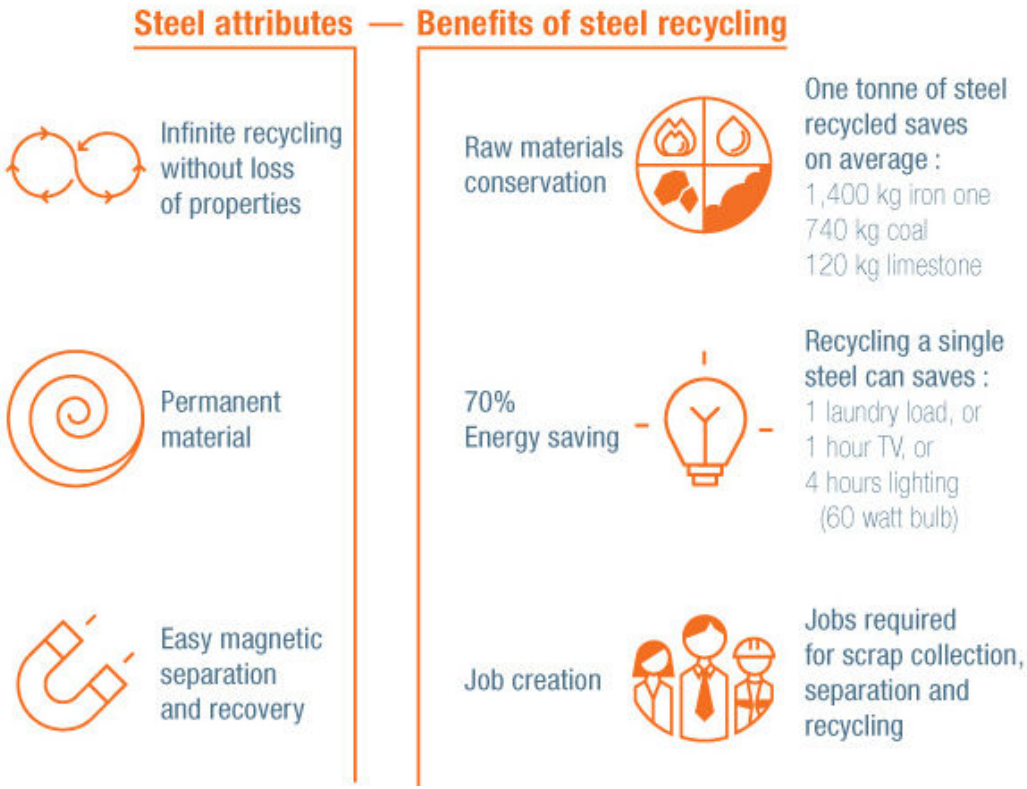


CIRCULAR ECONOMY



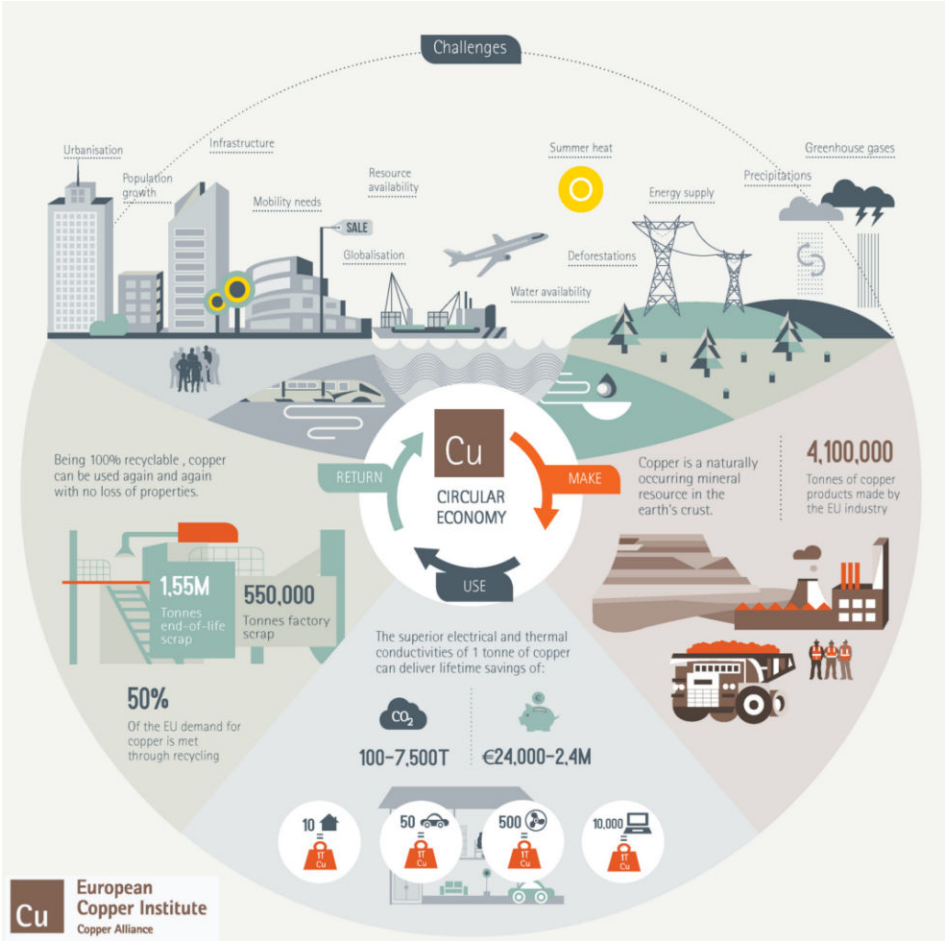
SUCCESSFUL CIRCLES



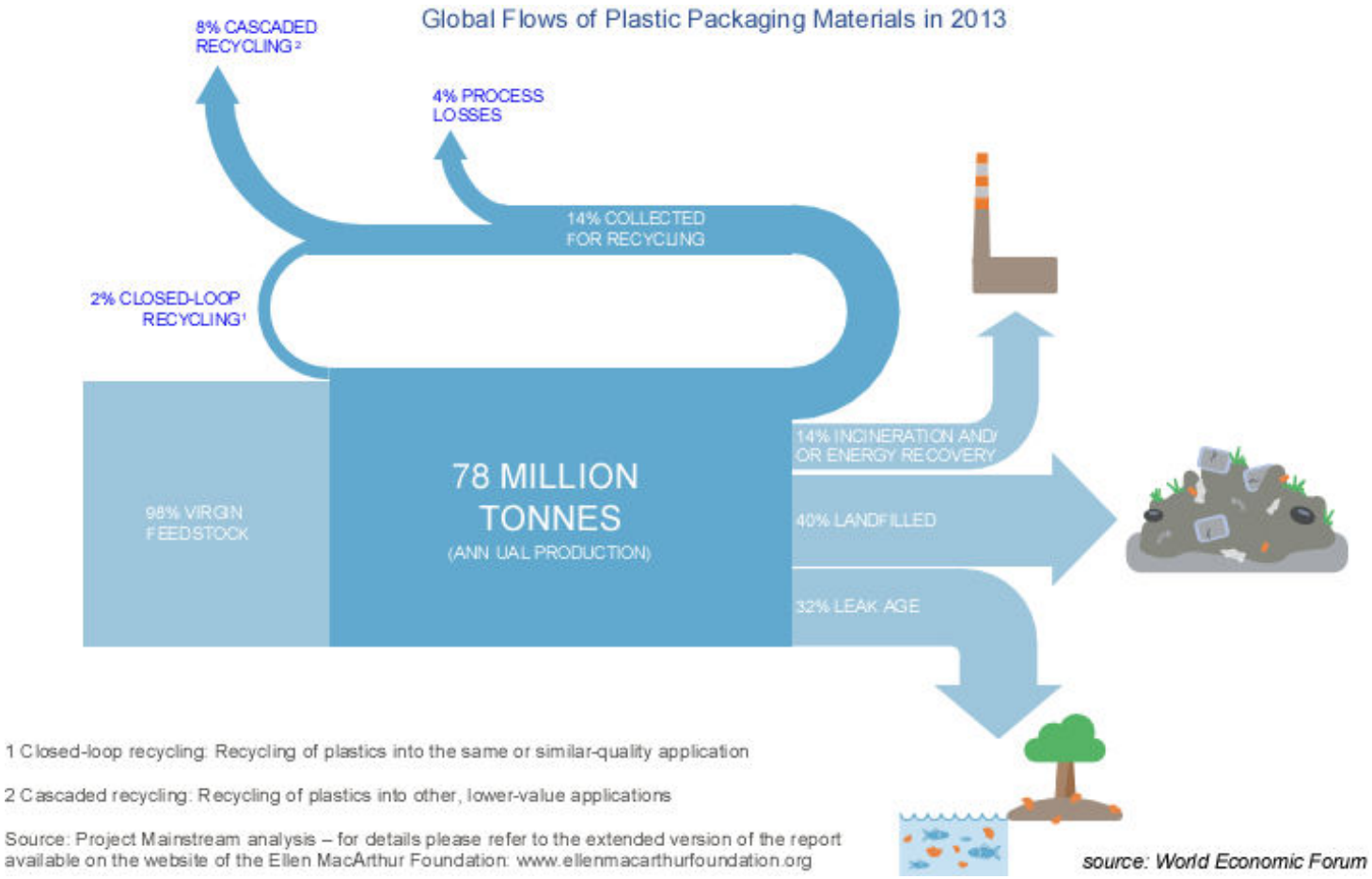


http://circulareconomy-worldsteel.org/

SUCCESSFUL CIRCLES



PROBLEMATIC CIRCLES

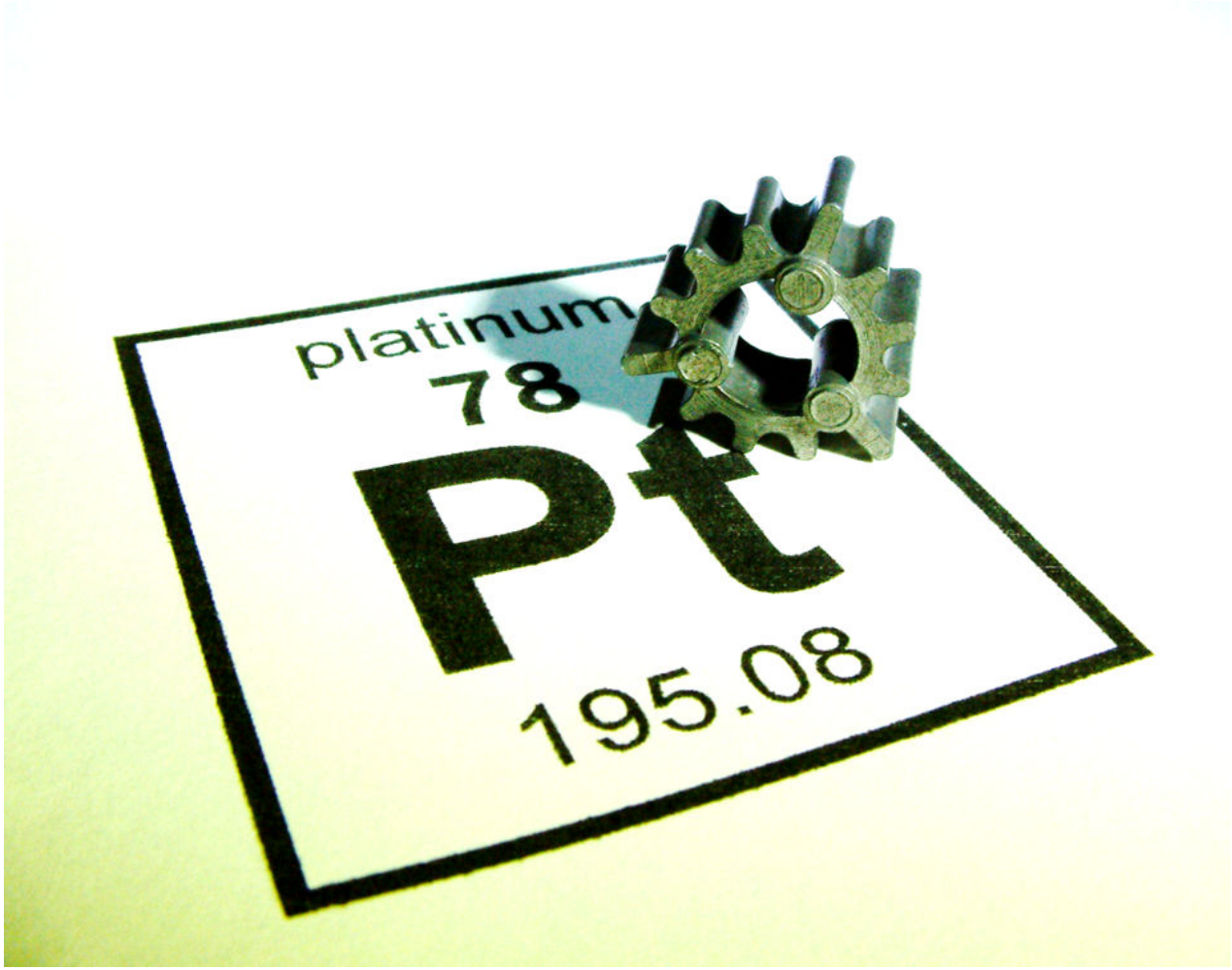


Orthogonal Axes


Case Study

Noble Metal Recycling

Platinum Catalyst



Which Is Most Valuable

~3¢

Recycling Prices

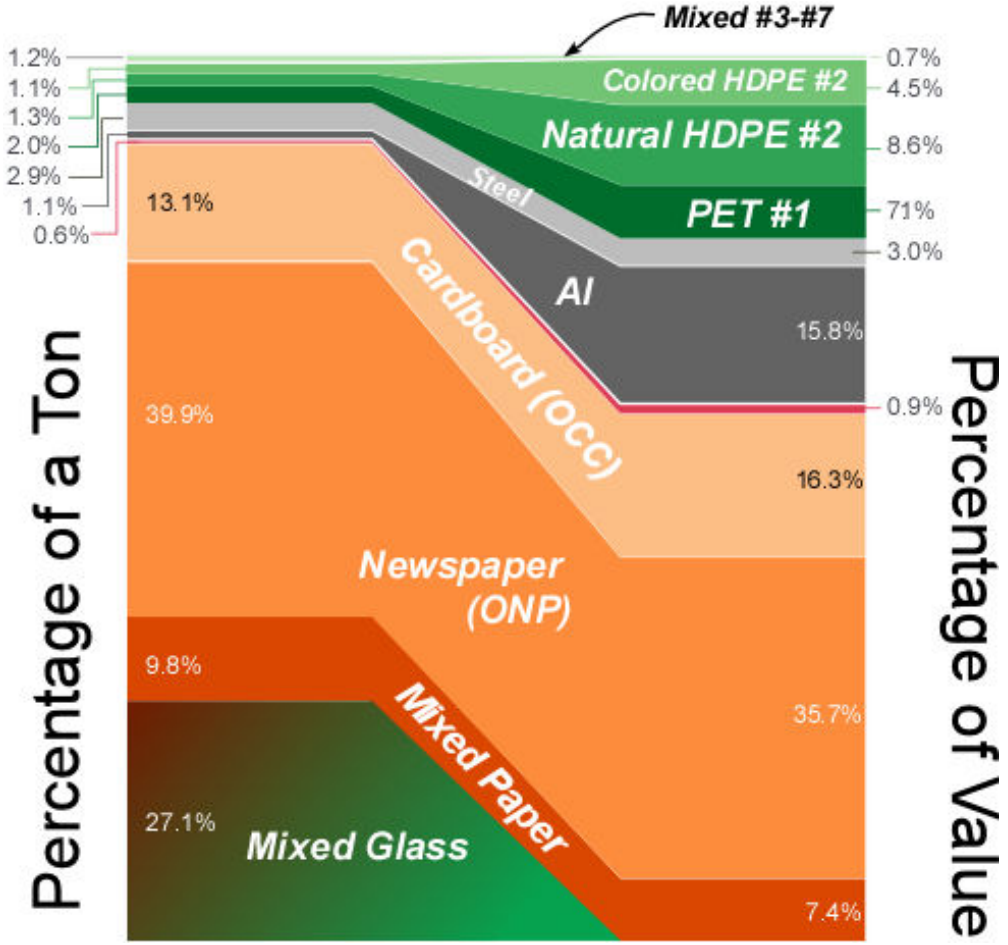
0.61¢ 0.01¢ 14¢ 0.22¢ 0.20¢




~3¢

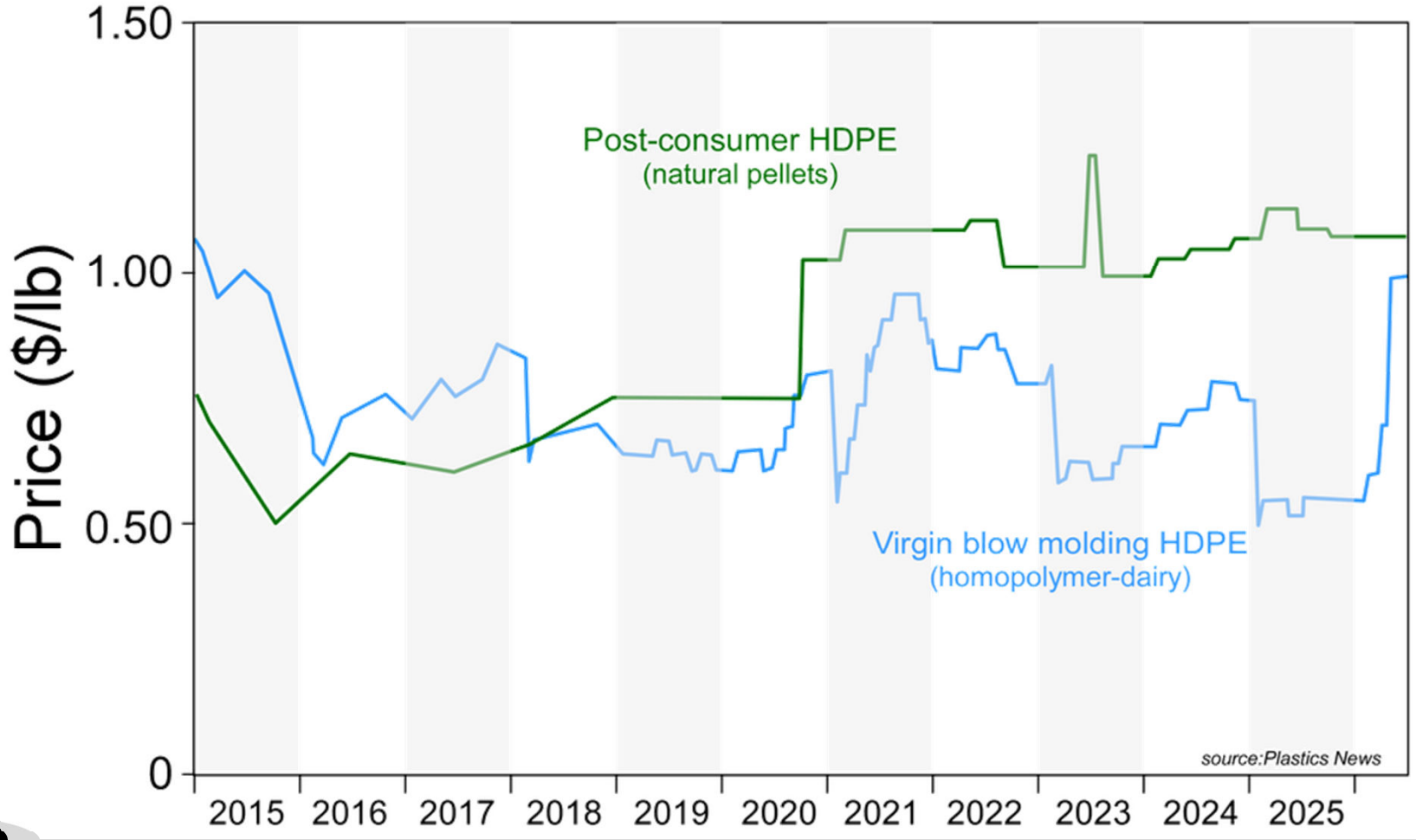


VALUE OF RECYCLED MATERIALS



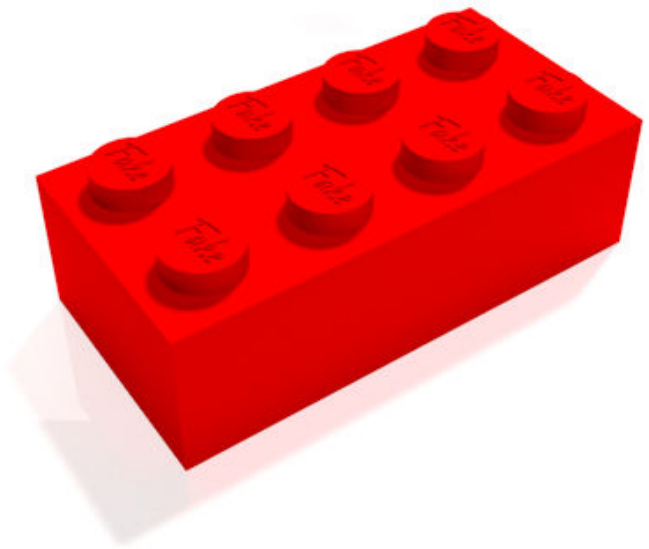
source: RRS from recycling.com and published in November 2015 Resource Recycling

GOOD NEWS

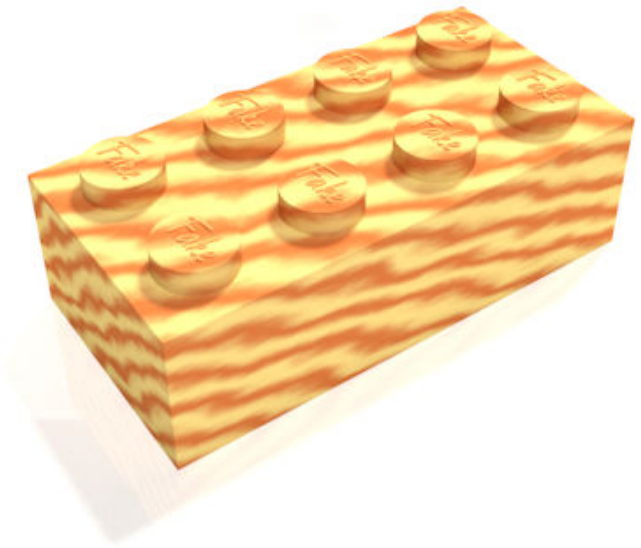

1.50
1.00
0.50
0
Price ($/lb)
Post-consumer HDPE
(natural pellets)
Virgin blow molding HDPE
(homopolymer-dairy)
source:Plastics News
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025


Case Study

LEGO SEARCHES FOR ABS REPLACEMENT

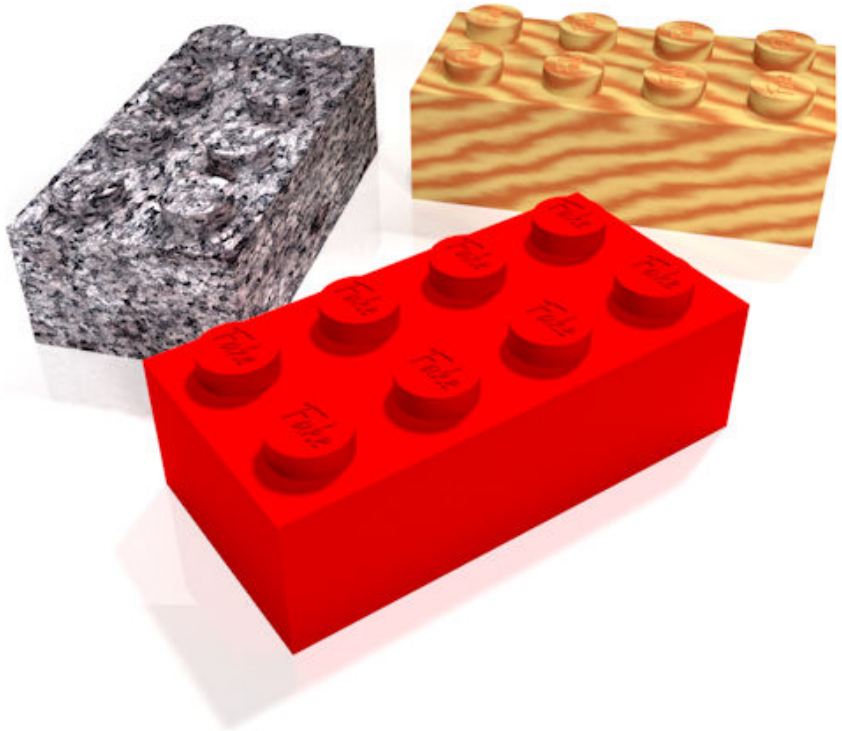


Wood?



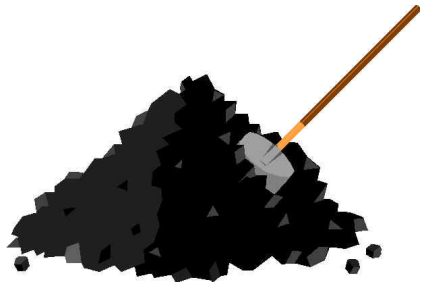
GRANITE

Which Is More Sustainable



Lots Of Bricks

CHEMICAL INDUSTRY



60%

40%

Traditional Feedstocks
(naphtha, NGL)

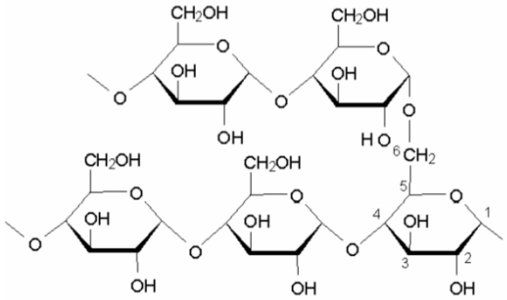
methane

Non-traditional Feedstocks

BIOMASS

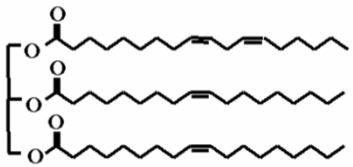
Sugar & Starch

- » refined global commodity
- » 150 MM tonnes
- » 12-25 ¢/lb
- » carbohydrate



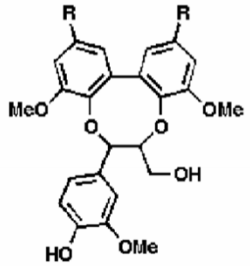
Fats & Oils`

- » refined global commodity
- » 150 MM tonnes
- » ~~15-40 ¢/lb~~ $1.20/lb
- » functionalized hydrocarbon

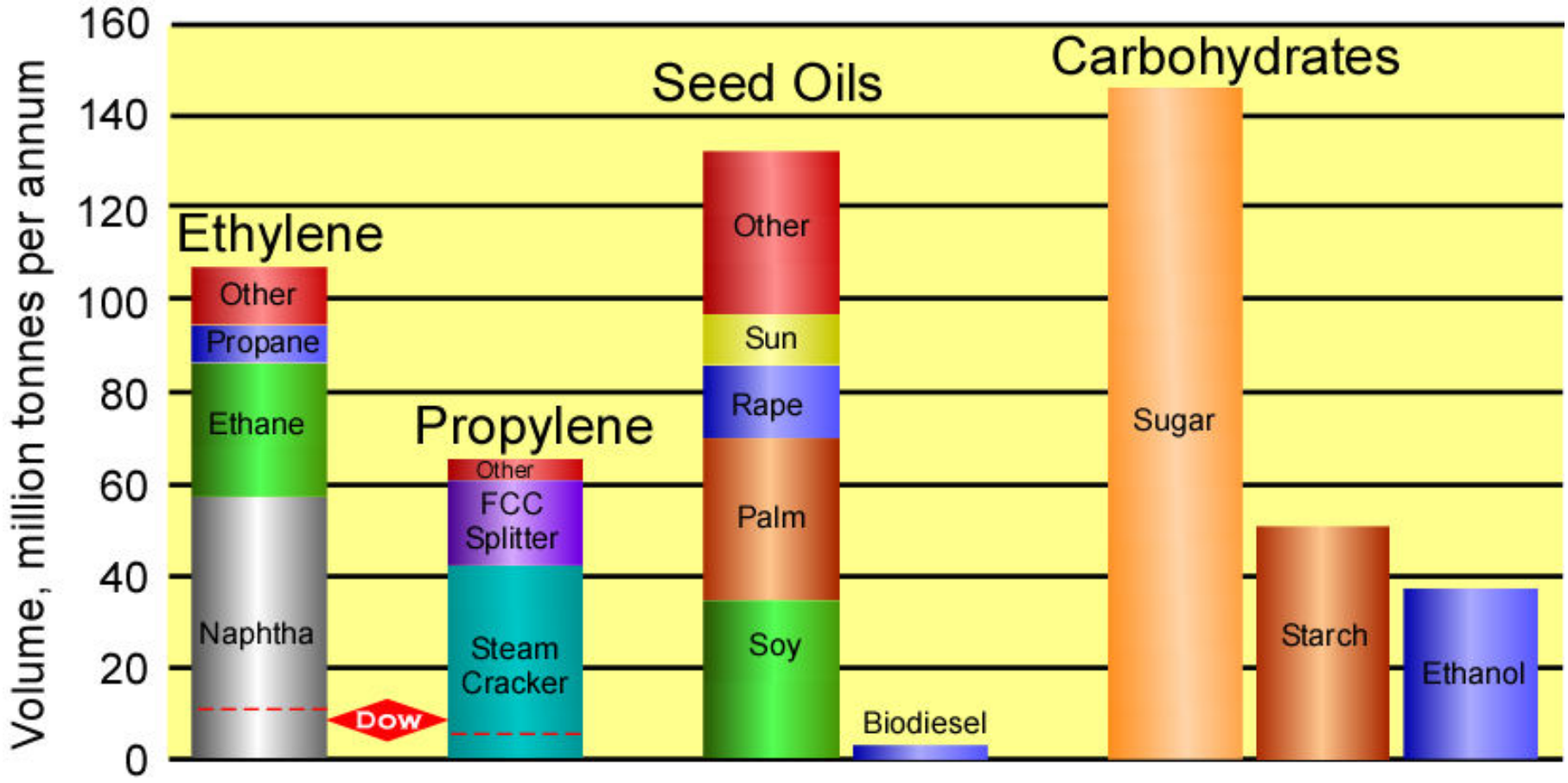


Lignocellulosics

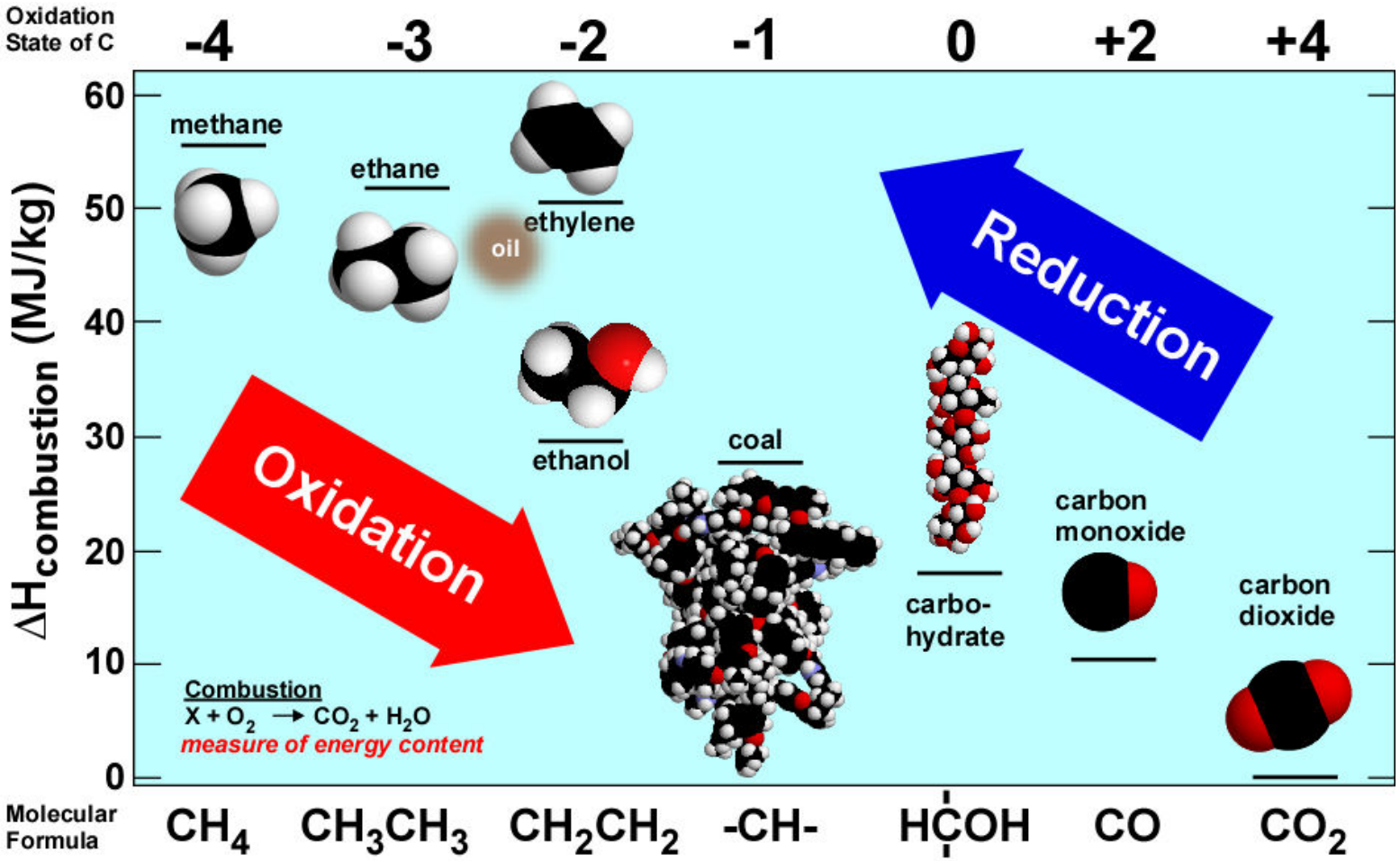
- » crude product
- » no supply chain
- » fuel value
- » 100 G tonnes
- » aromatic hydrocarbon and carbohydrate



BIOFEEDSTOCKS

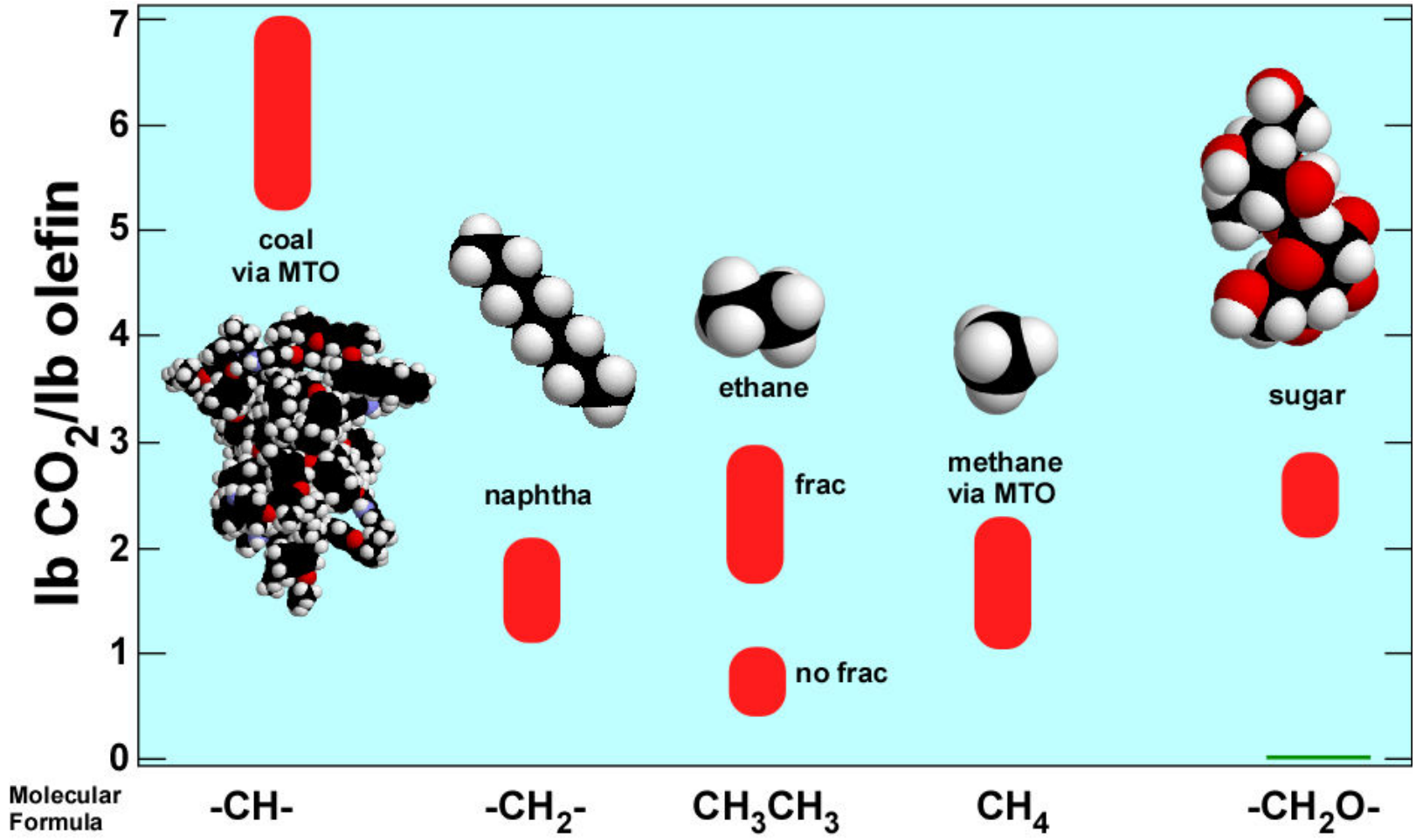


CHEMICAL CHALLENGE

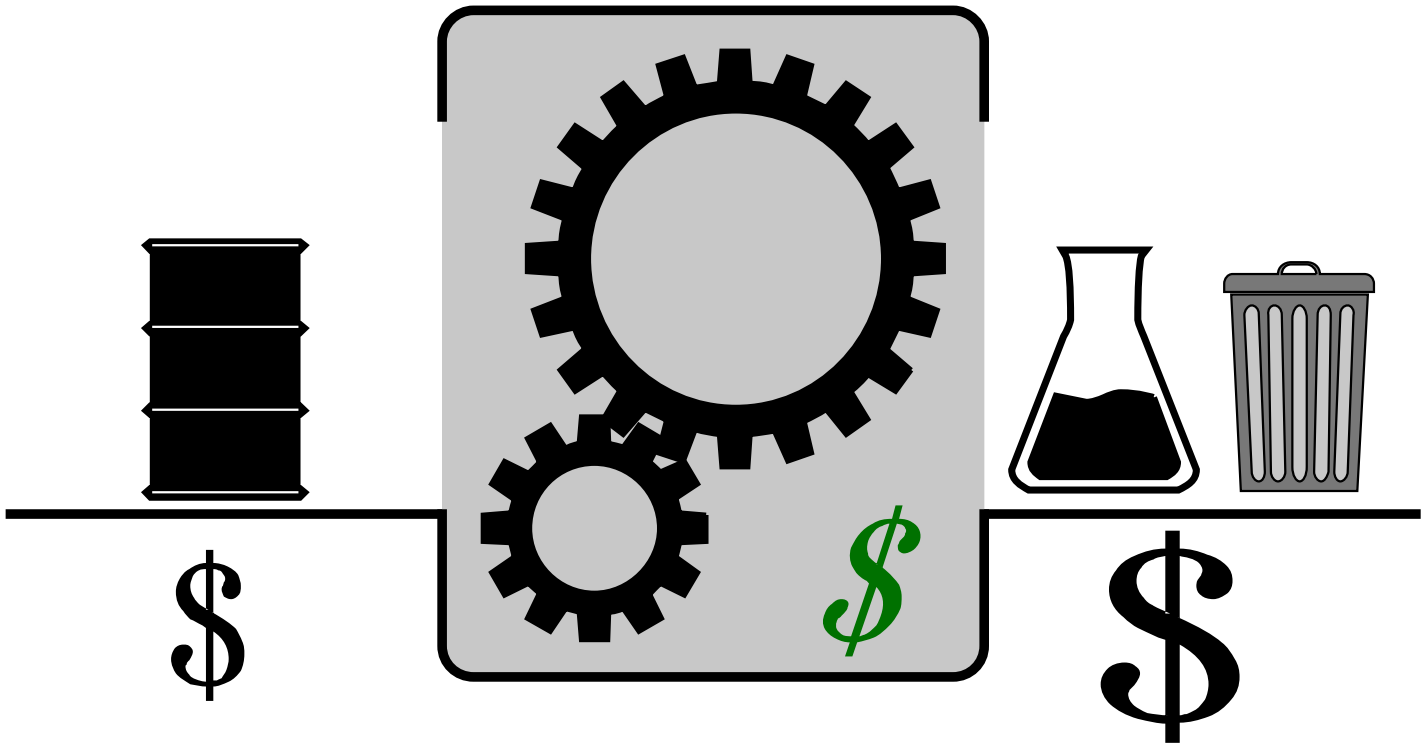


MJPhD

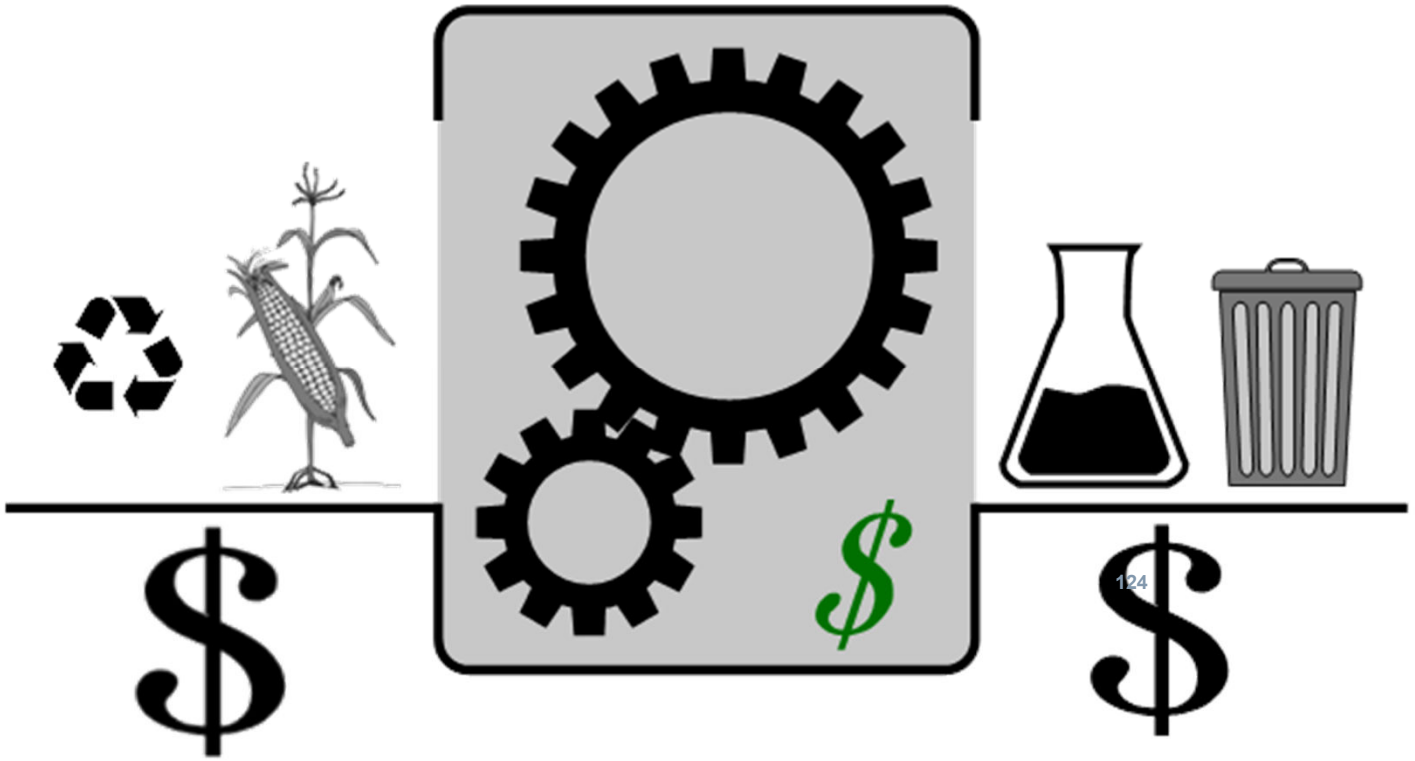
OLEFIN PRODUCTION



Simplified Chemical Industry

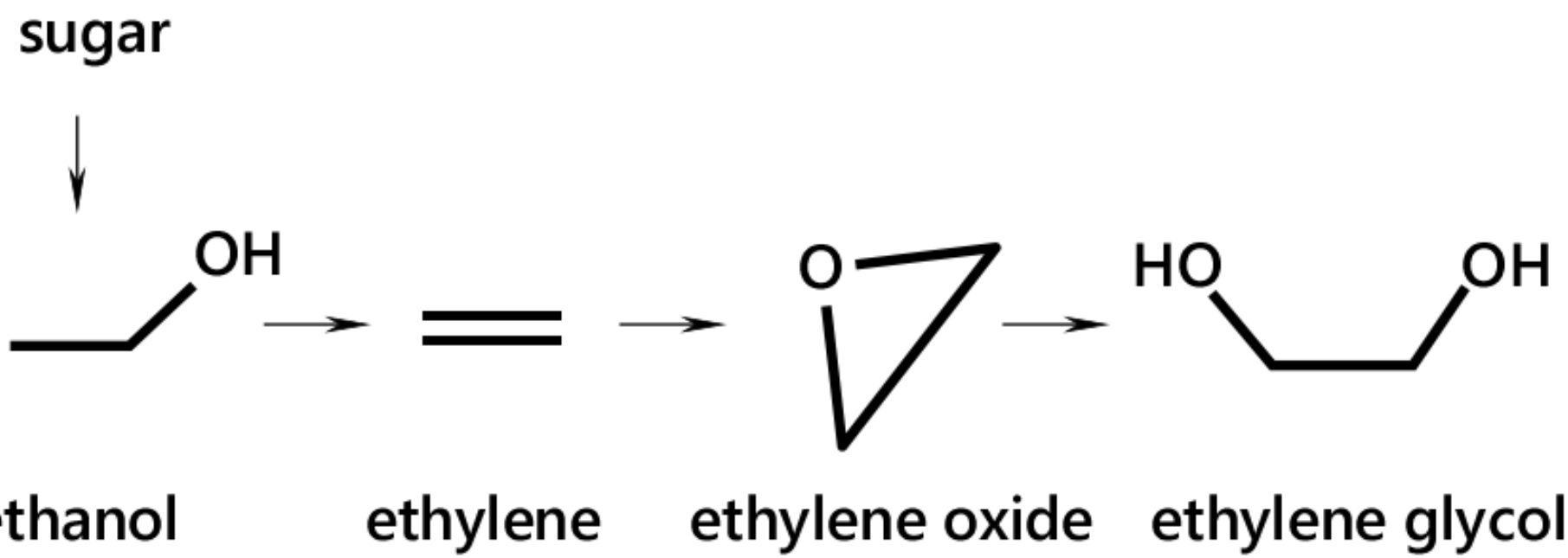


Simplified Chemical Industry

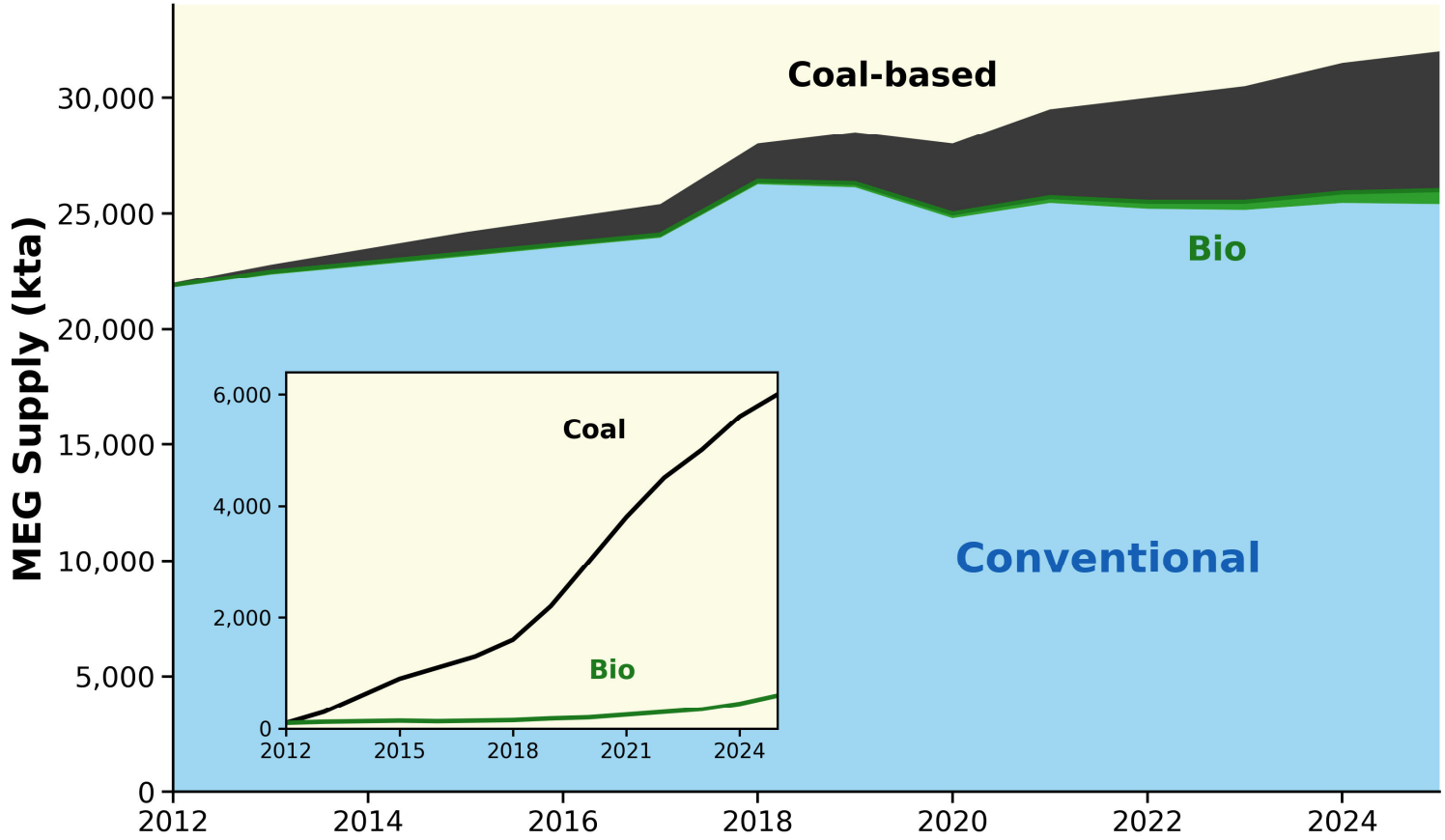


Feedstocks Everywhere Is A Problem

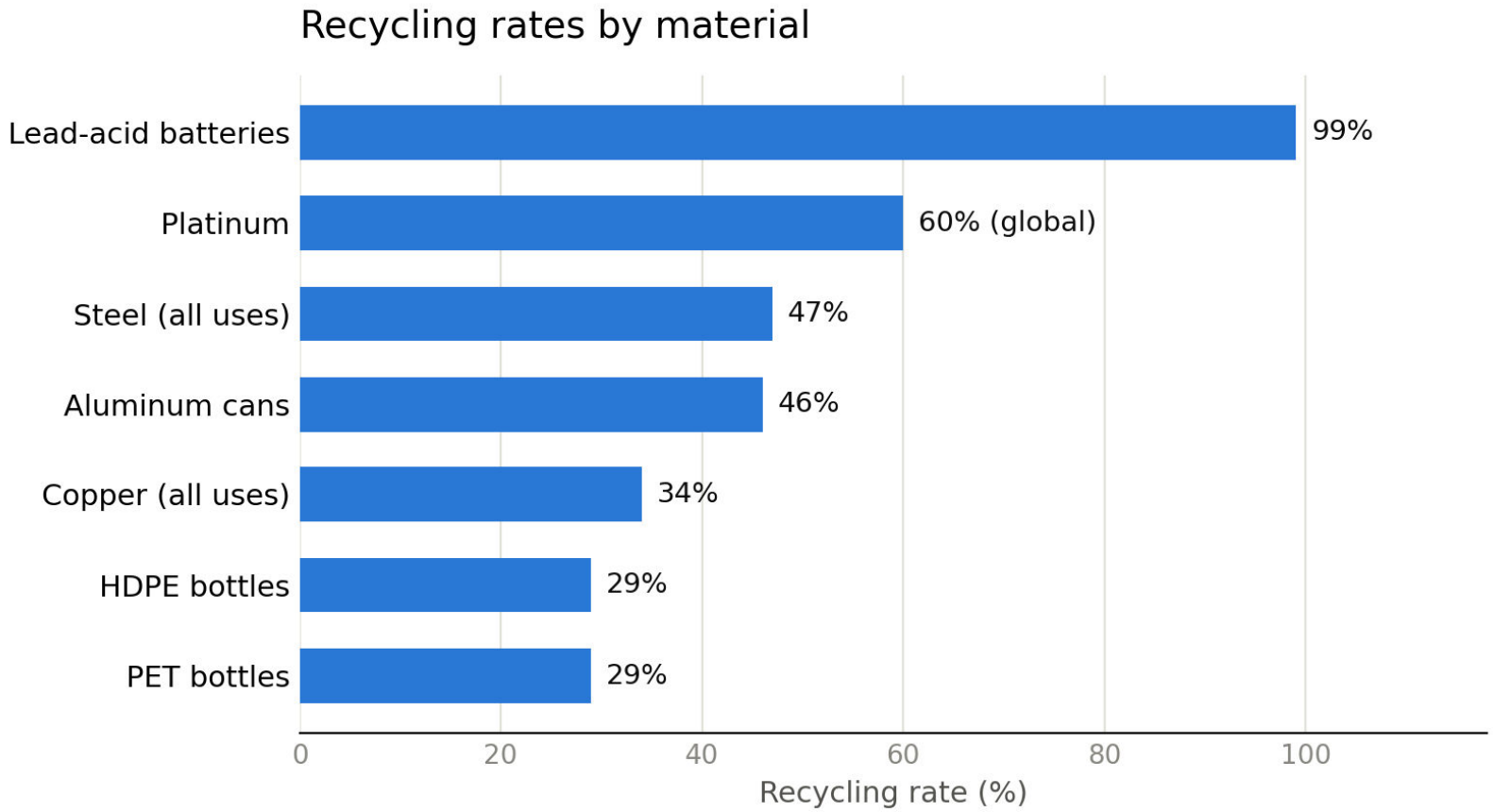
BIOETHYLENE GLYCOL



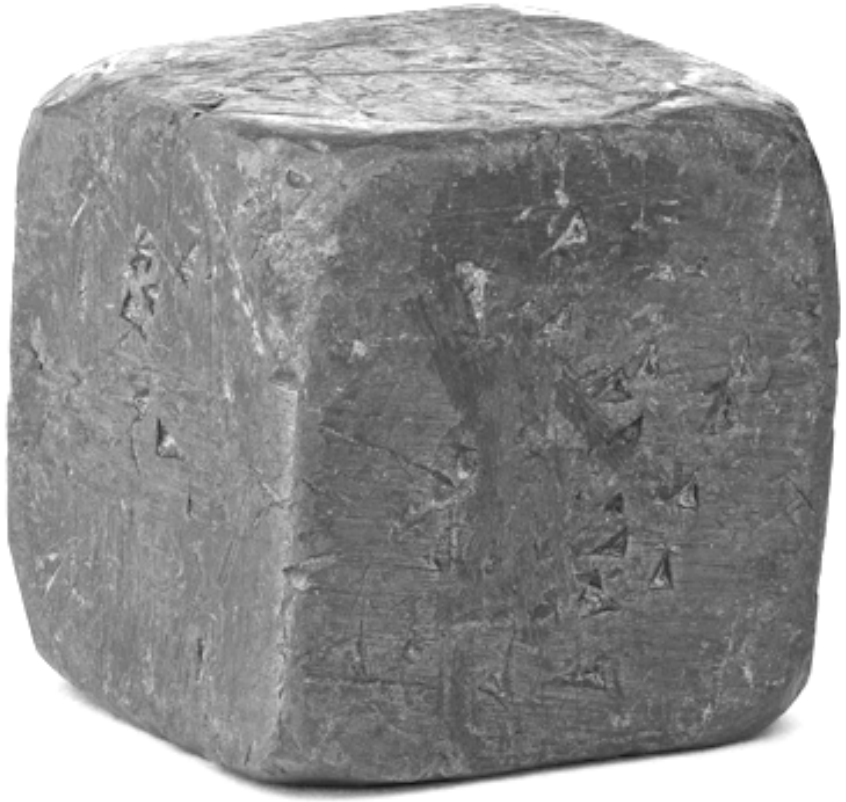
MONO ETHYLENE GLYCOL



Recycling Rates



Lead-acid: US product collection rate (BCI). Steel/copper: US, all end-of-life uses (NIST/Statista).
Aluminum: US cans only (Aluminum Association). PET/HDPE: US bottles only (EPA 2018).
Platinum: global end-of-life rate, no comparable US figure available (IEA 2021).



82

Pb

Lead

207.2



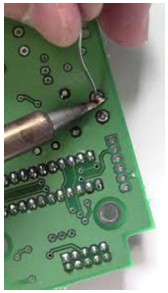










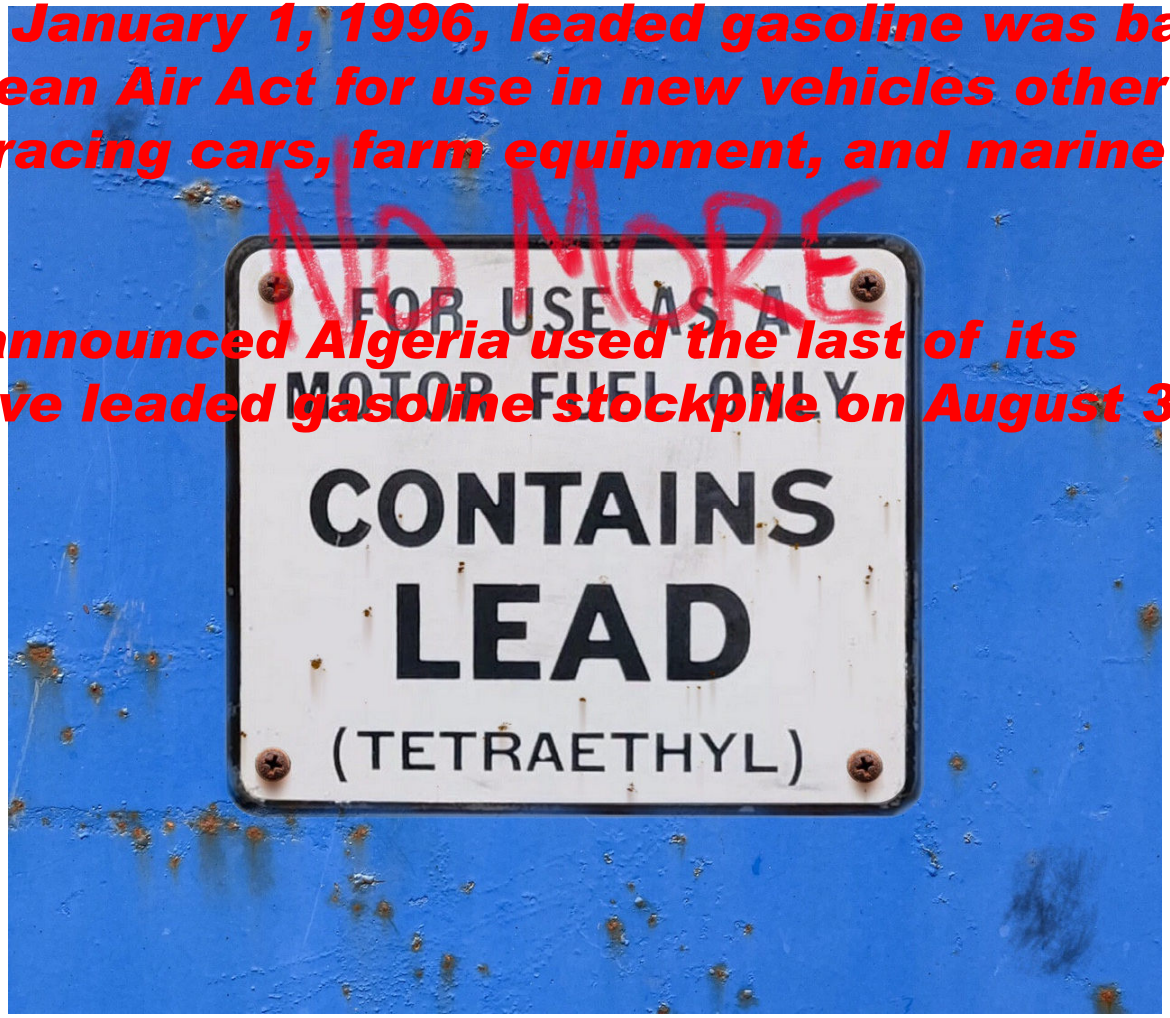



MJPhD

Tetraethyl lead alone formed problematic deposits in engines. Midgley's solution was to add organohalides to purposely form volatile lead compounds. Halogenated organics, like 1,2-dibromoethane and 1,2-dichloroethane, became part of the additive package. Lead would be swept out of the engine, out of the tailpipe. Midgley compounded the bad idea of placing lead into gasoline by ensuring it would be dispersed into the atmosphere. He clearly knew of the chronic impacts of lead but must have believed "the solution to pollution is dilution."

Effective January 1, 1996, leaded gasoline was banned by the Clean Air Act for use in new vehicles other than aircraft, racing cars, farm equipment, and marine engines.

The UN announced Algeria used the last of its automotive leaded gasoline stockpile on August 30, 2021.




UN 1203
FLAMMABLE LIQUID 3
HAZCHEM 3YE
PACKAGING GROUP II
HAZARDOUS
KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING OR USING
DO NOT SWALLOW
FLAMMABLE LIQUID
AVGAS 100LL
CONTAINS: GASOLINE, LOW BOILING POINT NAPHTHA 99 - 100% W/W
BENZENE 0.1 - <0.5% W/W
LEAD COMPOUND 0 - 0.125% W/W
GASOLINE
APPLICATION:
EMERGENCY:
200 LITRES
FLYING FUELS

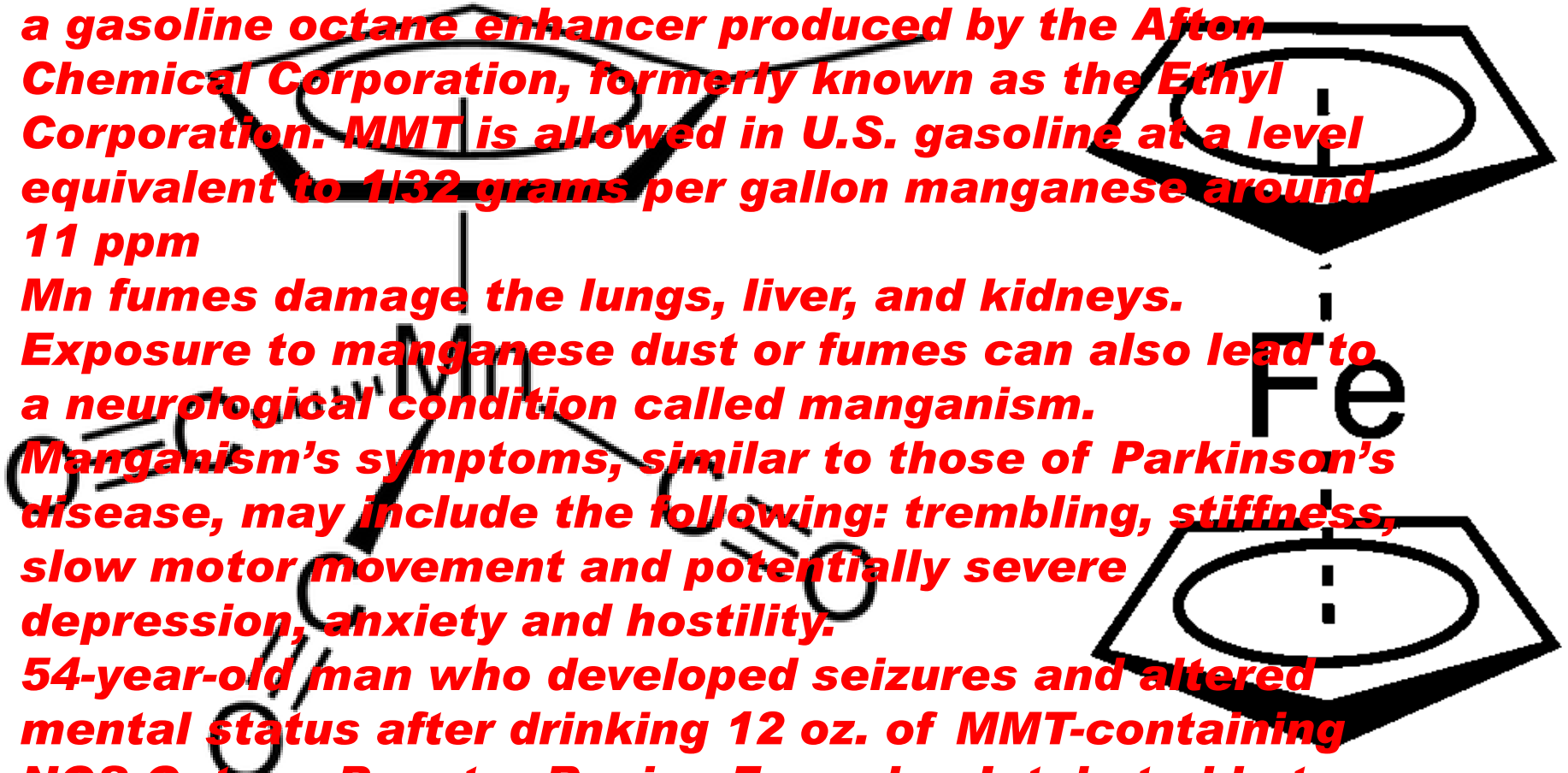

3X
THE
BOOST
HI-PERFORMANCE
LUCAS
OIL PRODUCTS
INC.
A REAL
OCTANE
BOOSTER
RACING FORMULA
TESTED - Increases Octane
Rating by 3 Full Numbers
STOPS PINGING
DANGER: COMBUSTIBLE. Harmful
or fatal if swallowed. Read carefully
DIRECTIONS and DANGER on side panel.
5.25 fl oz. U.S. Made in USA 155 mL

Methylcyclopentadienyl manganese tricarbonyl (MMT) is a gasoline octane enhancer produced by the Afton Chemical Corporation, formerly known as the Ethyl Corporation. MMT is allowed in U.S. gasoline at a level equivalent to 1/32 grams per gallon manganese around 11 ppm

Mn fumes damage the lungs, liver, and kidneys. Exposure to manganese dust or fumes can also lead to a neurological condition called manganism.

Manganism's symptoms, similar to those of Parkinson's disease, may include the following: trembling, stiffness, slow motor movement and potentially severe depression, anxiety and hostility.

54-year-old man who developed seizures and altered mental status after drinking 12 oz. of MMT-containing NOS Octane Booster Racing Formula. Intubated but lived.




Danger


Danger
Risk
Tolerance


Risk
Tolerance
Danger
Benefit

MJPHD.net