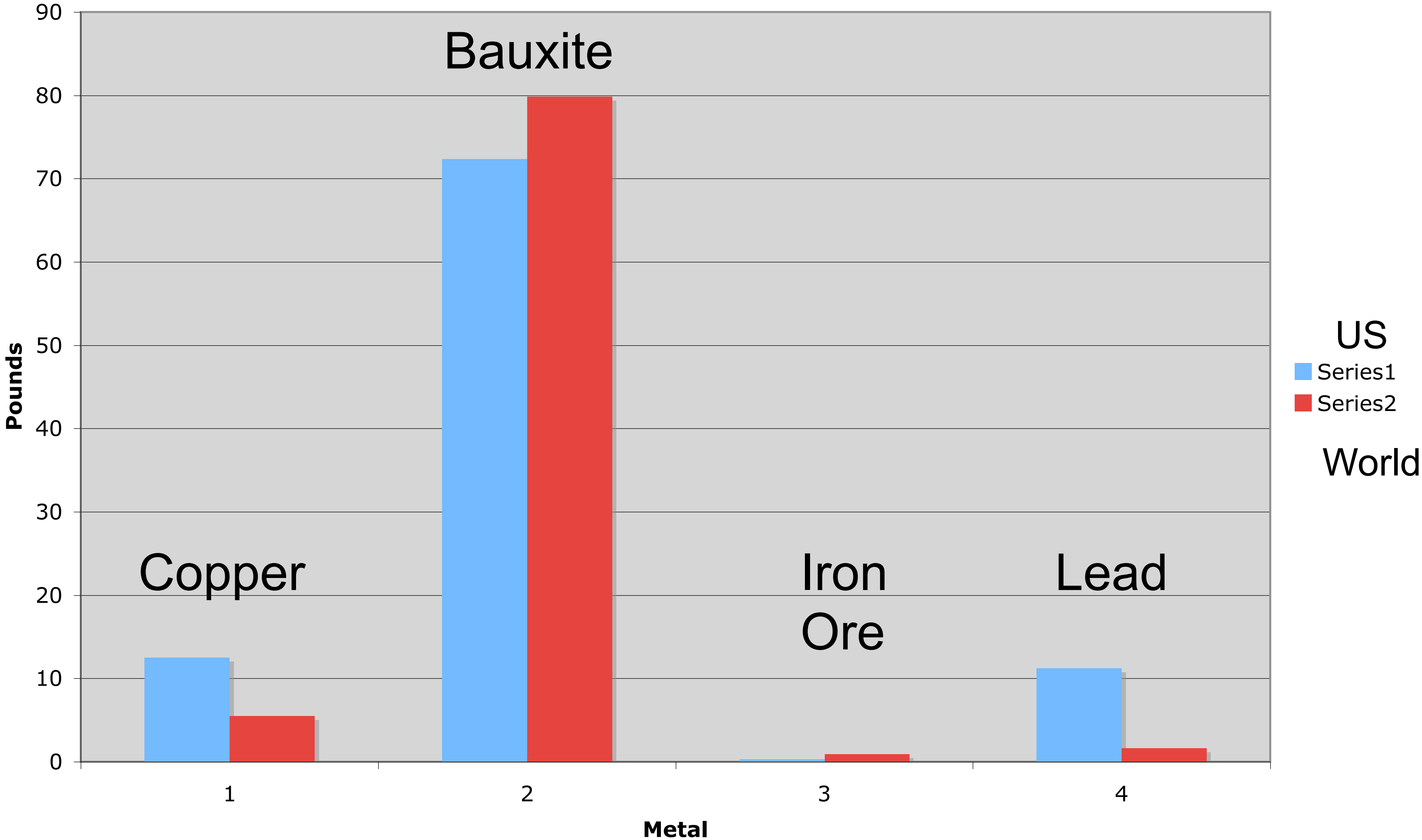
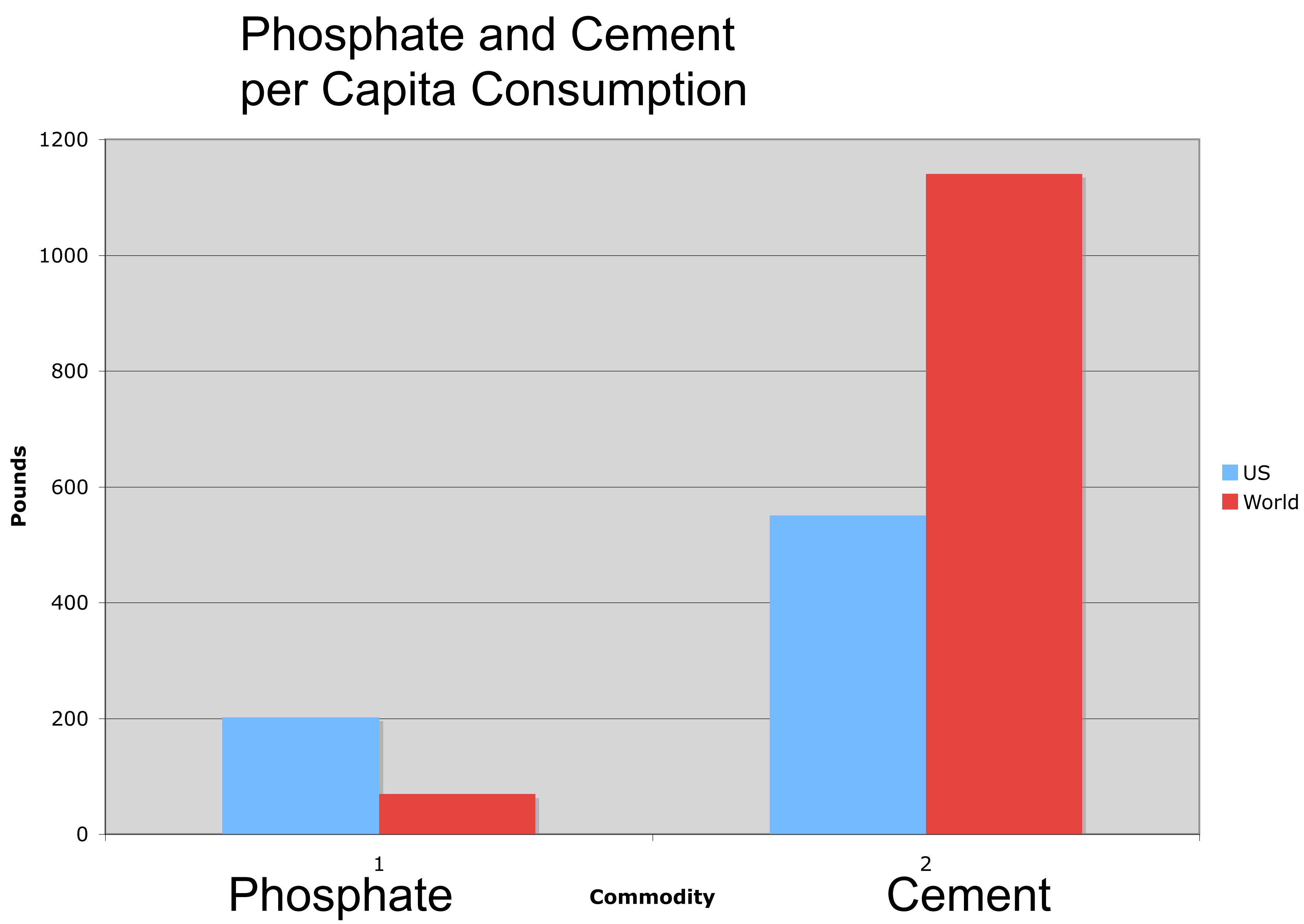
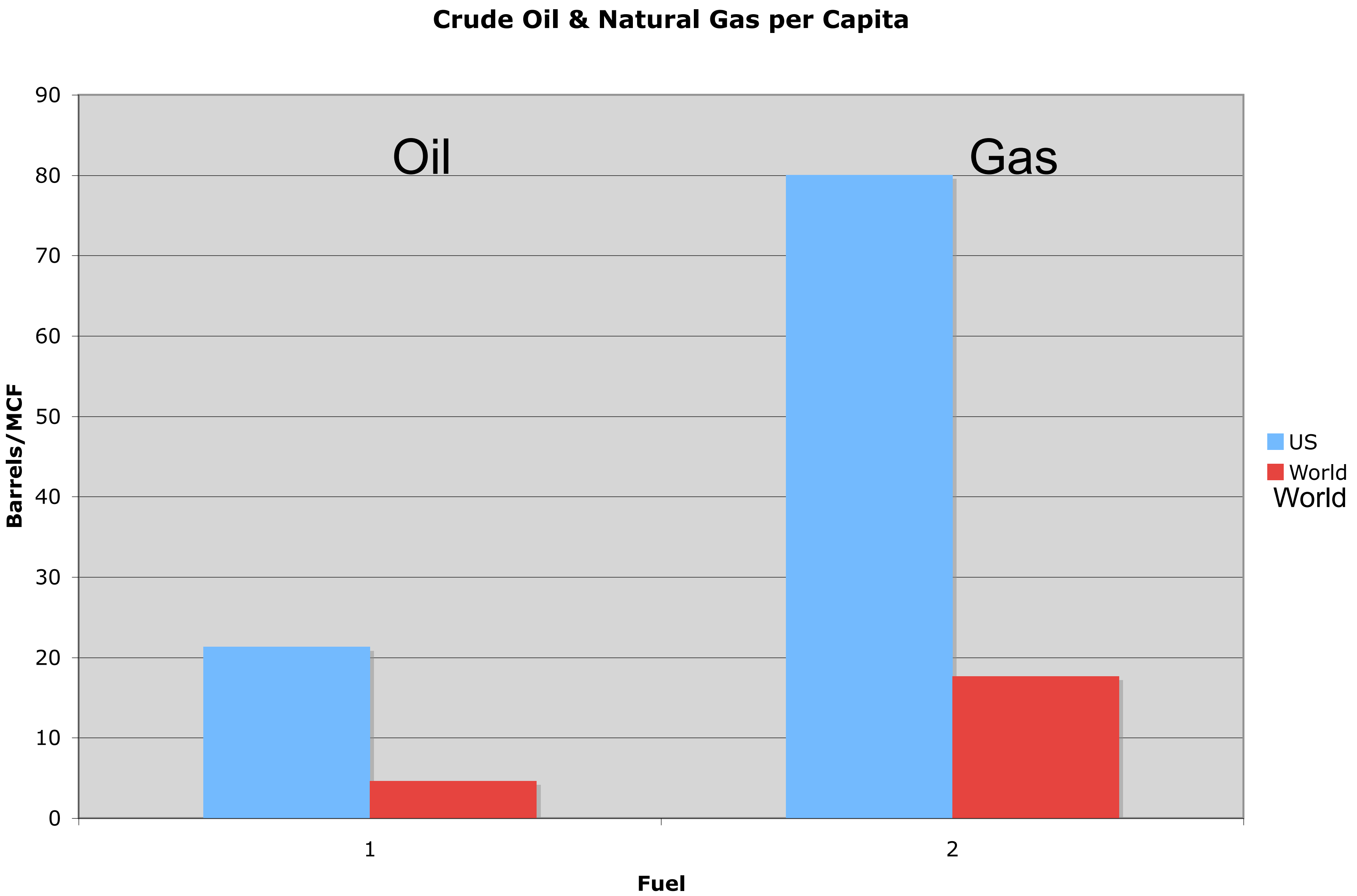
Consuming the Earth: Where are we going?

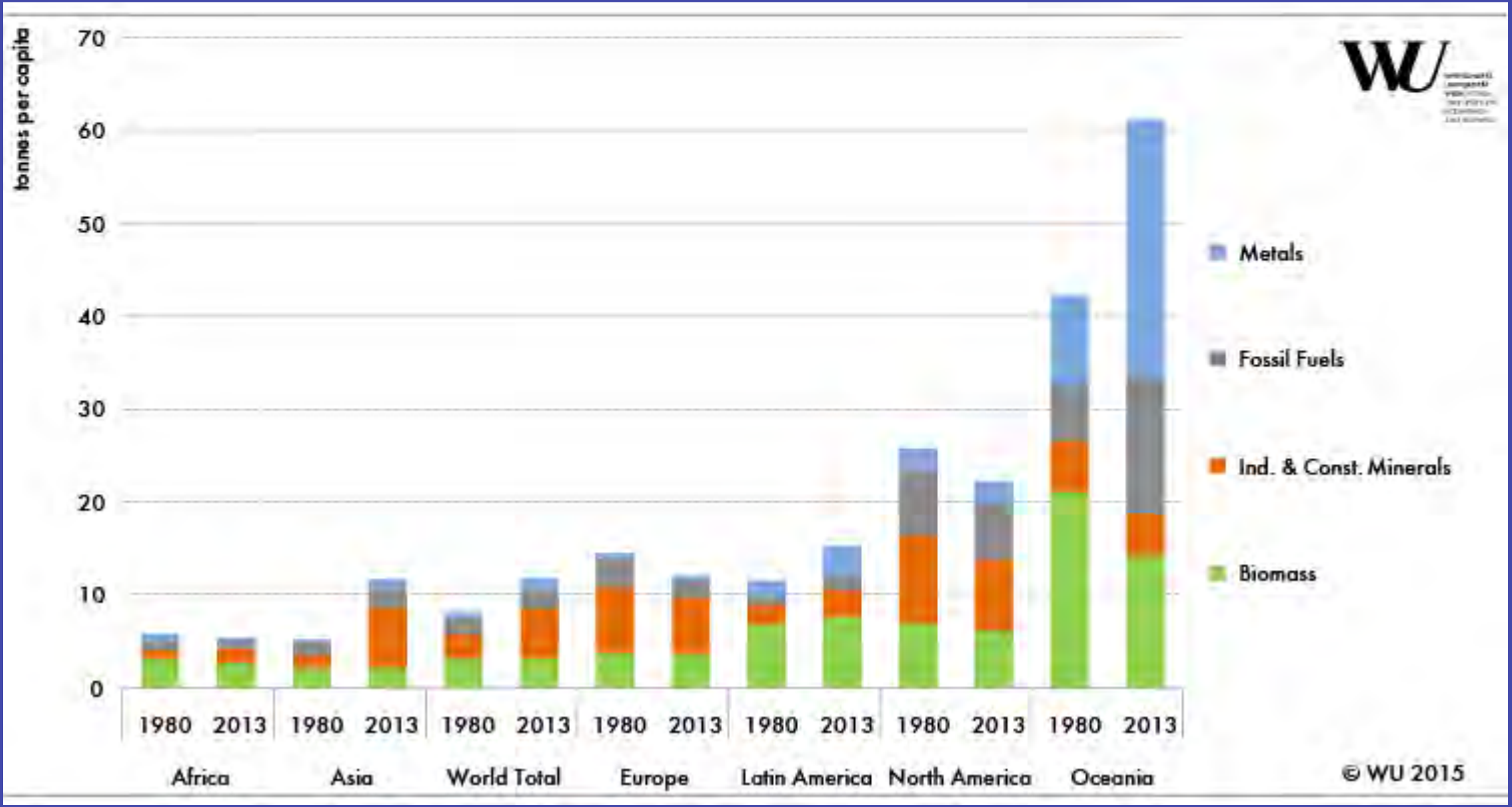
US and World per Capita Consumption




Phosphate and Cement
per Capita Consumption
1200
1000
800
600
400
200
0
Pounds
US
World
1
2
Phosphate
Commodity
Cement


Crude Oil & Natural Gas per Capita
90
80
70
60
50
40
30
20
10
0
Barrels/MCF
Oil
Gas
1
2
Fuel
US
World
World

Global resource extraction per capita by world region 1980 vs. 2013



This figure illustrates global resource extraction (only economically used extraction) per capita in 1980 and 2013 by major material category.

What If Scenarios

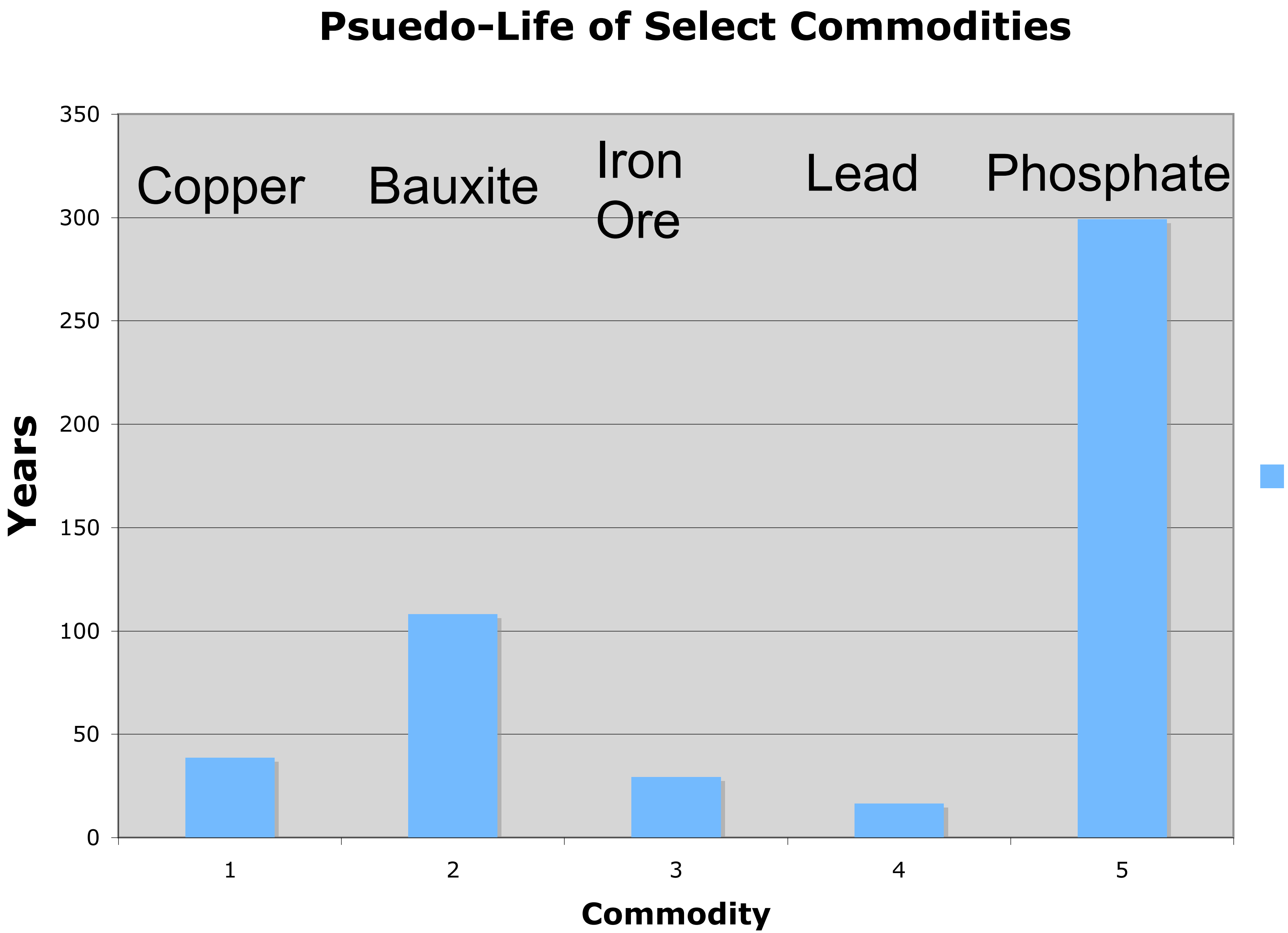
- We are calculating psuedo-life spans for selected resources
- A psuedo-life (PL) is the time it would take to exhaust a resource at the present rate of consumption
- PL = Proven Reserves / Annual Consumption

PL = 10 million tons / 1 million t/y = 10 years

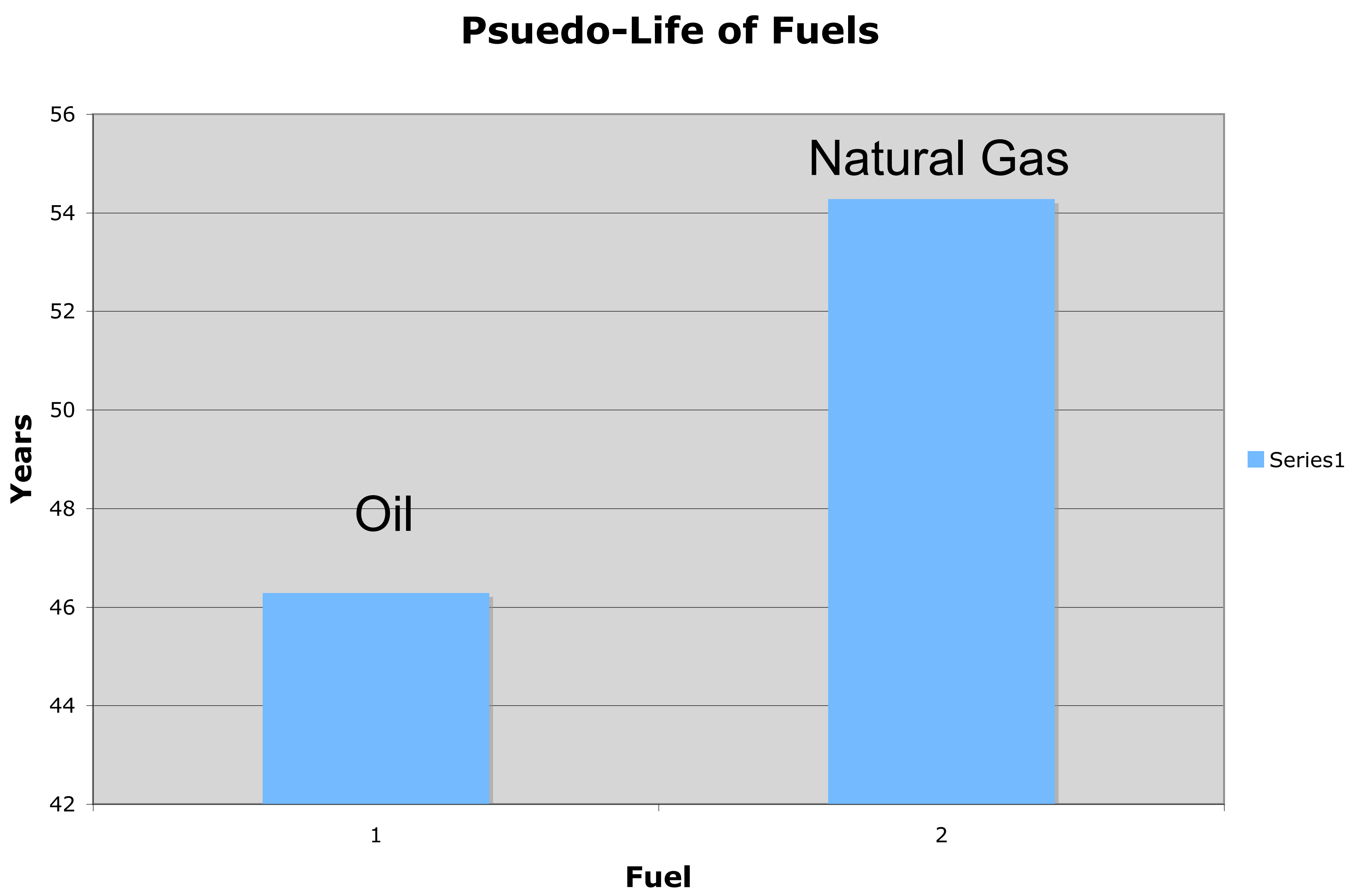
- We can vary reserves and consumption to create scenarios under different conditions: What if . . . Scenarios

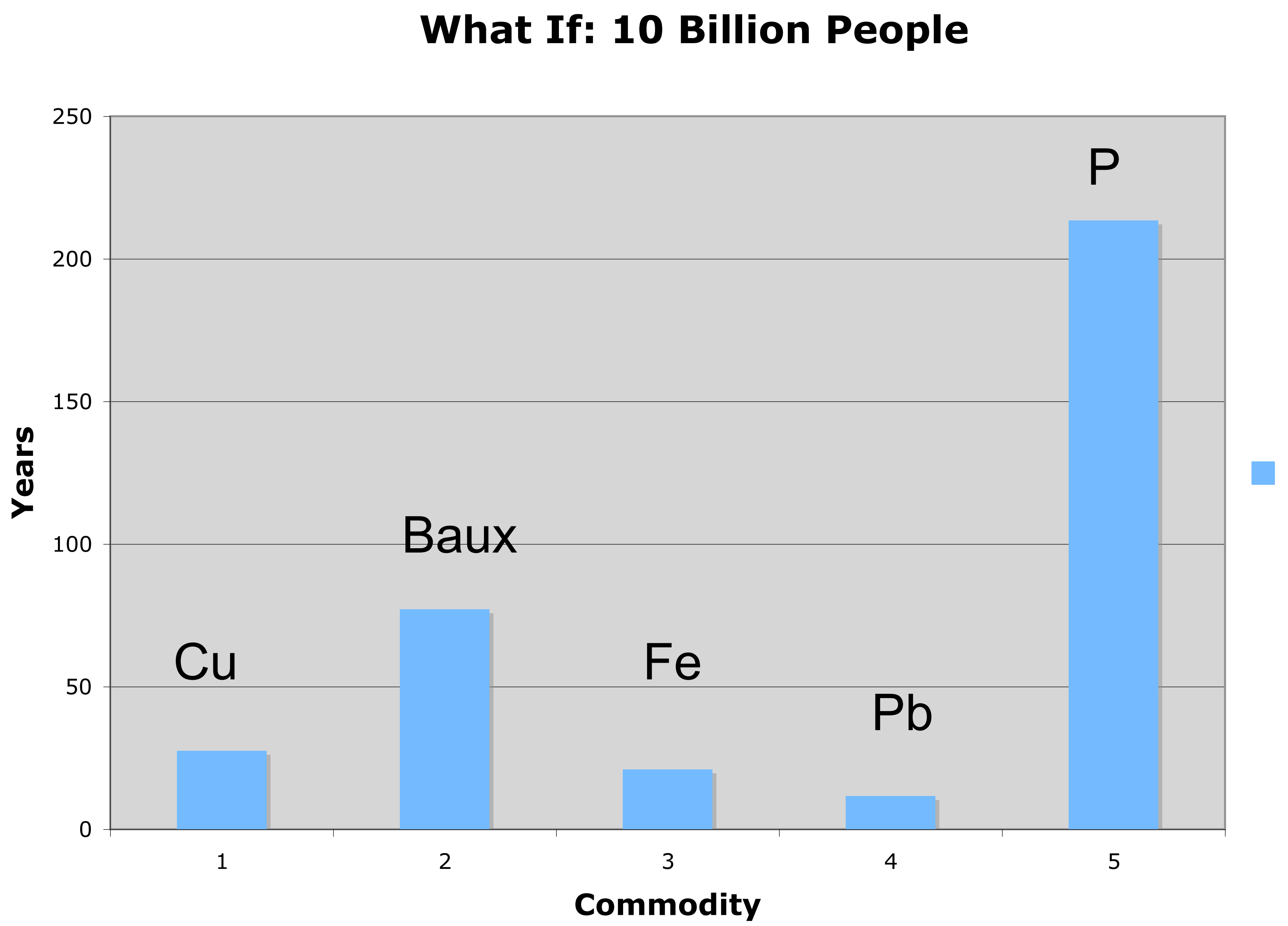
What Are We Assuming?

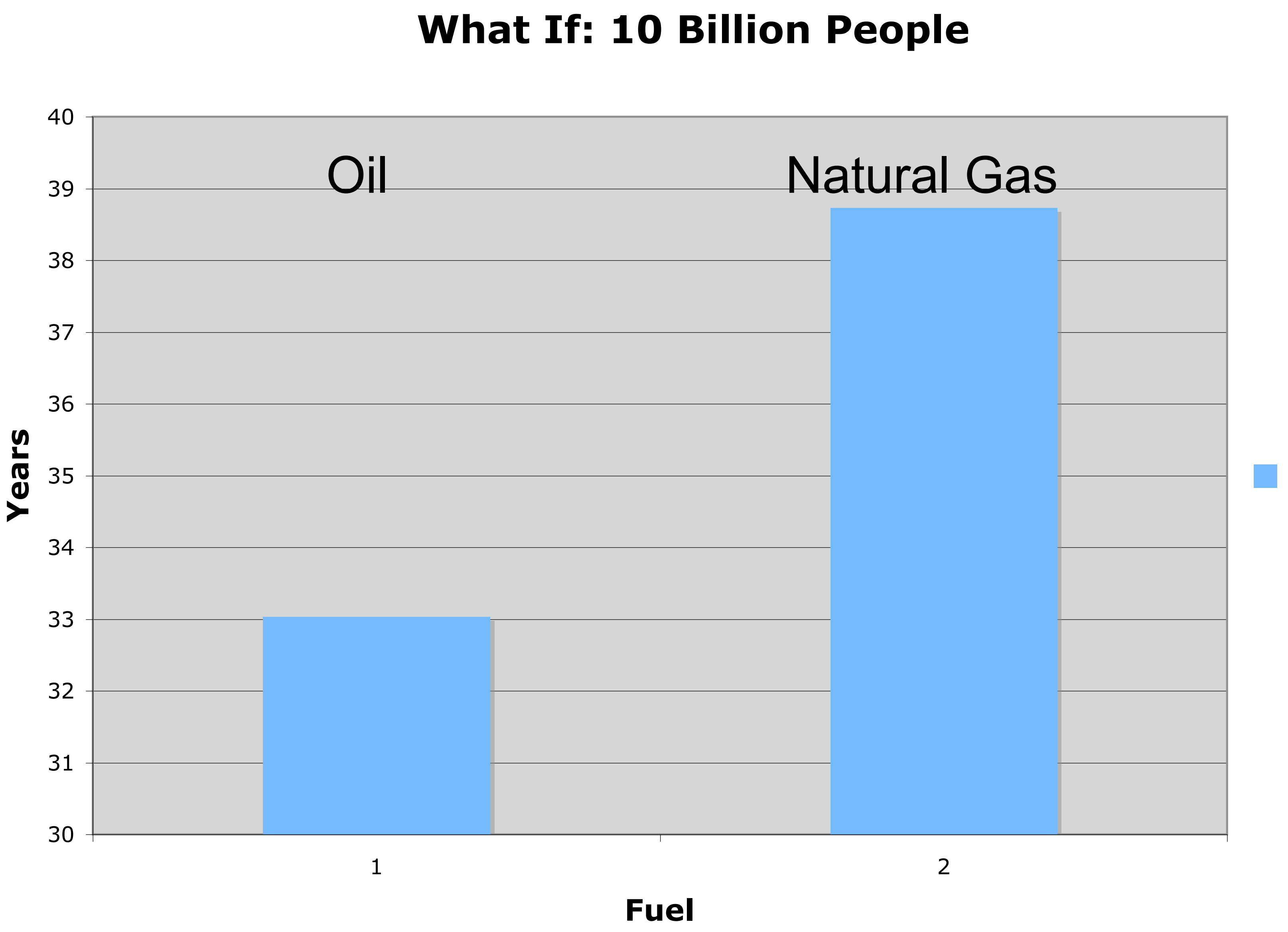
- Population data is from the *2015 World Population* data sheet
- Resources are the 2016 USGS Mineral Summary Estimates of Reserves or the 2015 EIA Estimate of Proven Reserves
- Economic conditions remain the same, unless changed for the scenario
- A few other (hidden) assumptions



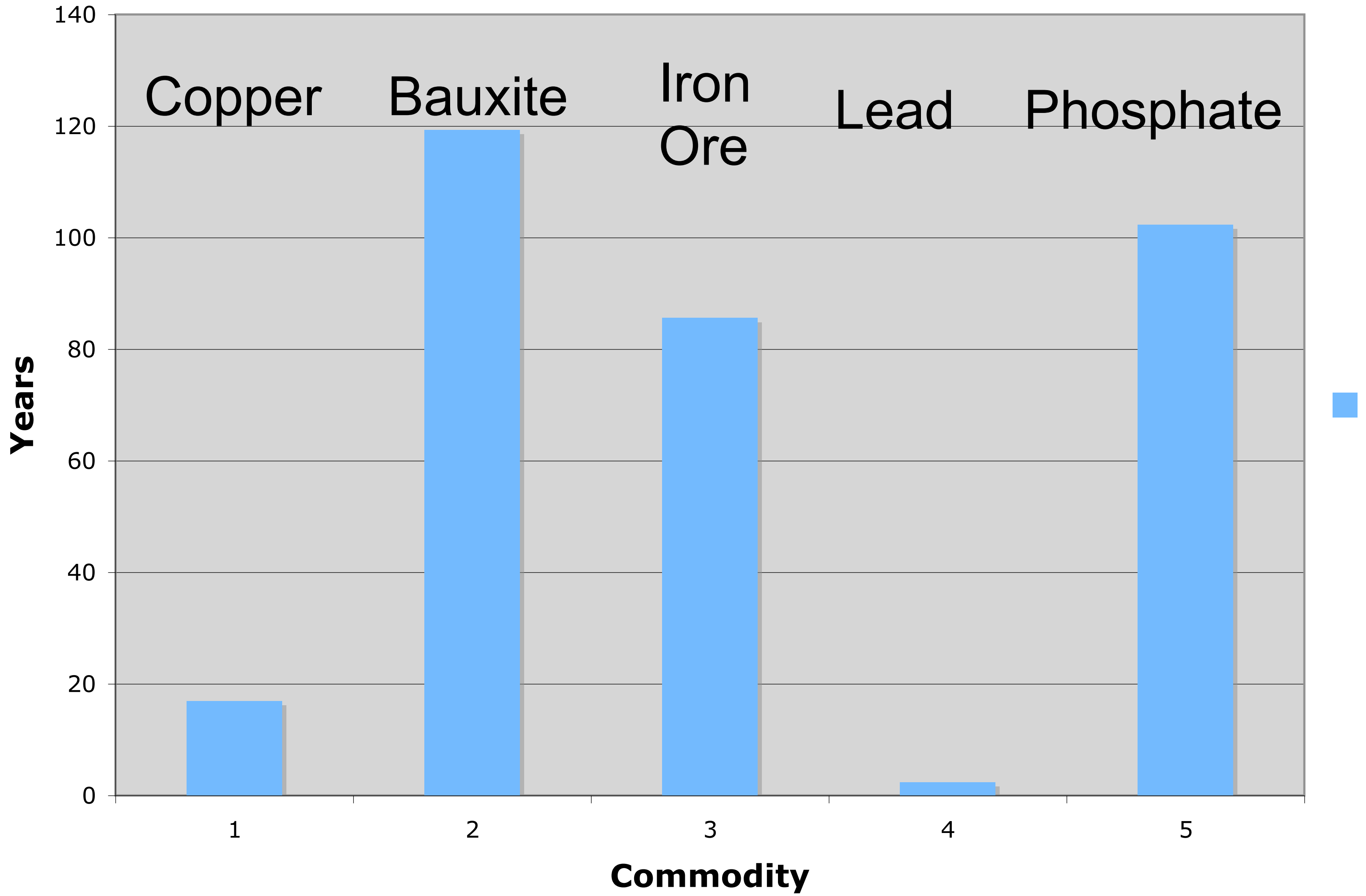
Psuedo-Life of Select Commodities
Years
350
300
250
200
150
100
50
0
Copper
Bauxite
Iron Ore
Lead
Phosphate
1
2
3
4
5
Commodity

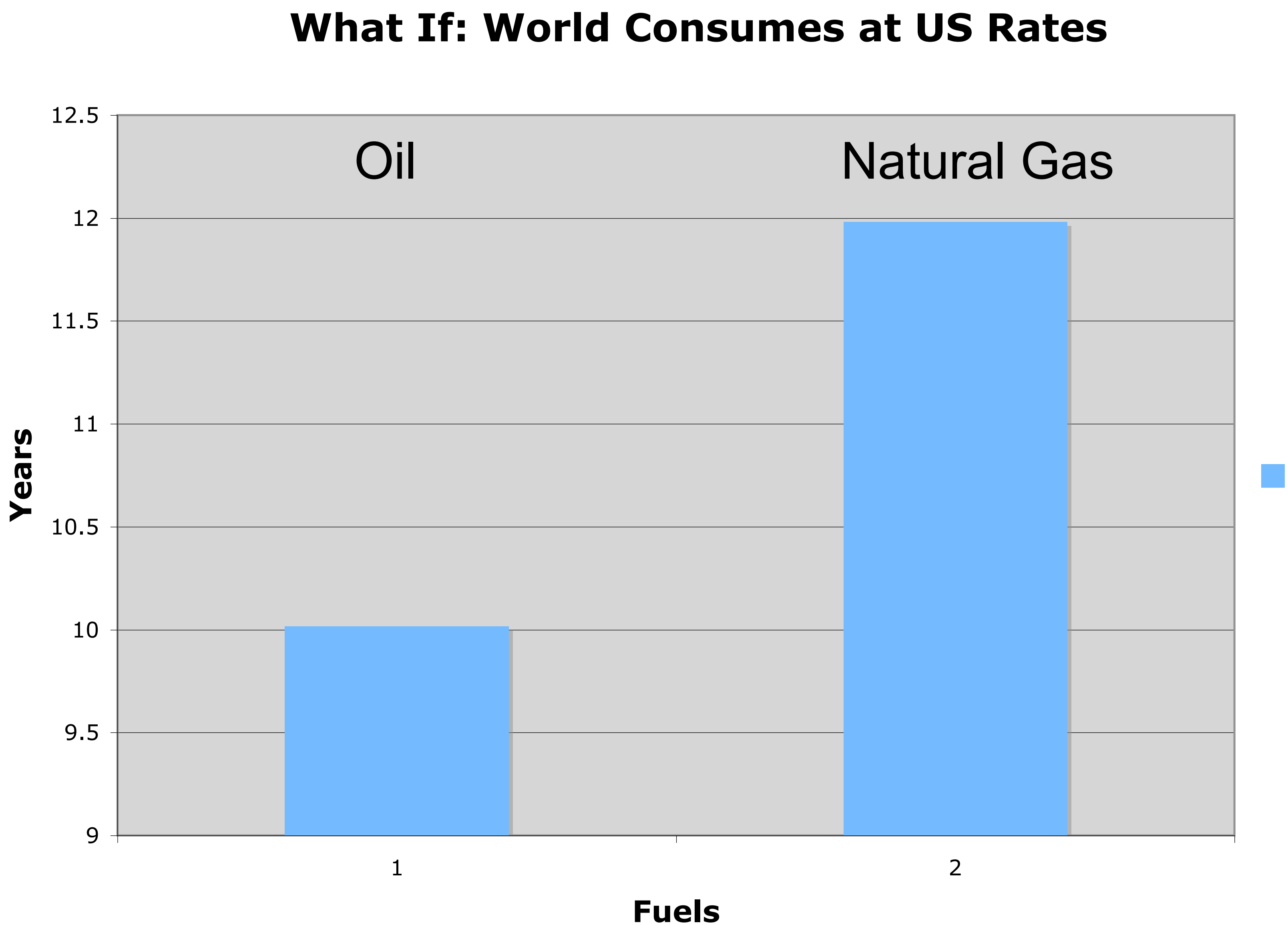

Psuedo-Life of Fuels
Years
56
54
52
50
48
46
44
42
Oil
Natural Gas
1
2
Fuel
Series1


What If: 10 Billion People
Years
250
200
150
100
50
0
Cu
Baux
Fe
Pb
P
1
2
3
4
5
Commodity


What If: 10 Billion People
Oil
Natural Gas
Years
Fuel
40
39
38
37
36
35
34
33
32
31
30
1
2

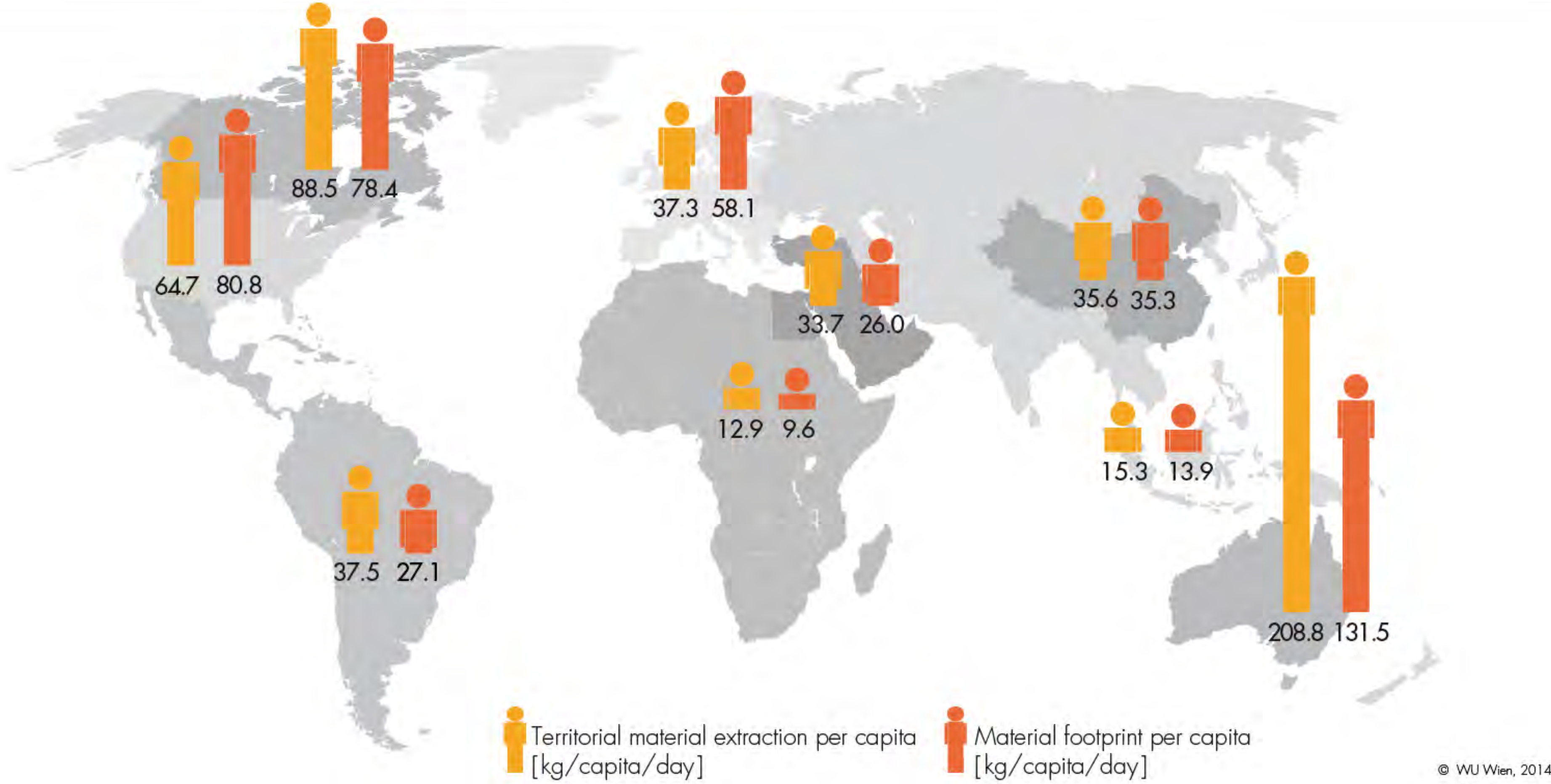
What-If: World Consumption at US Rates





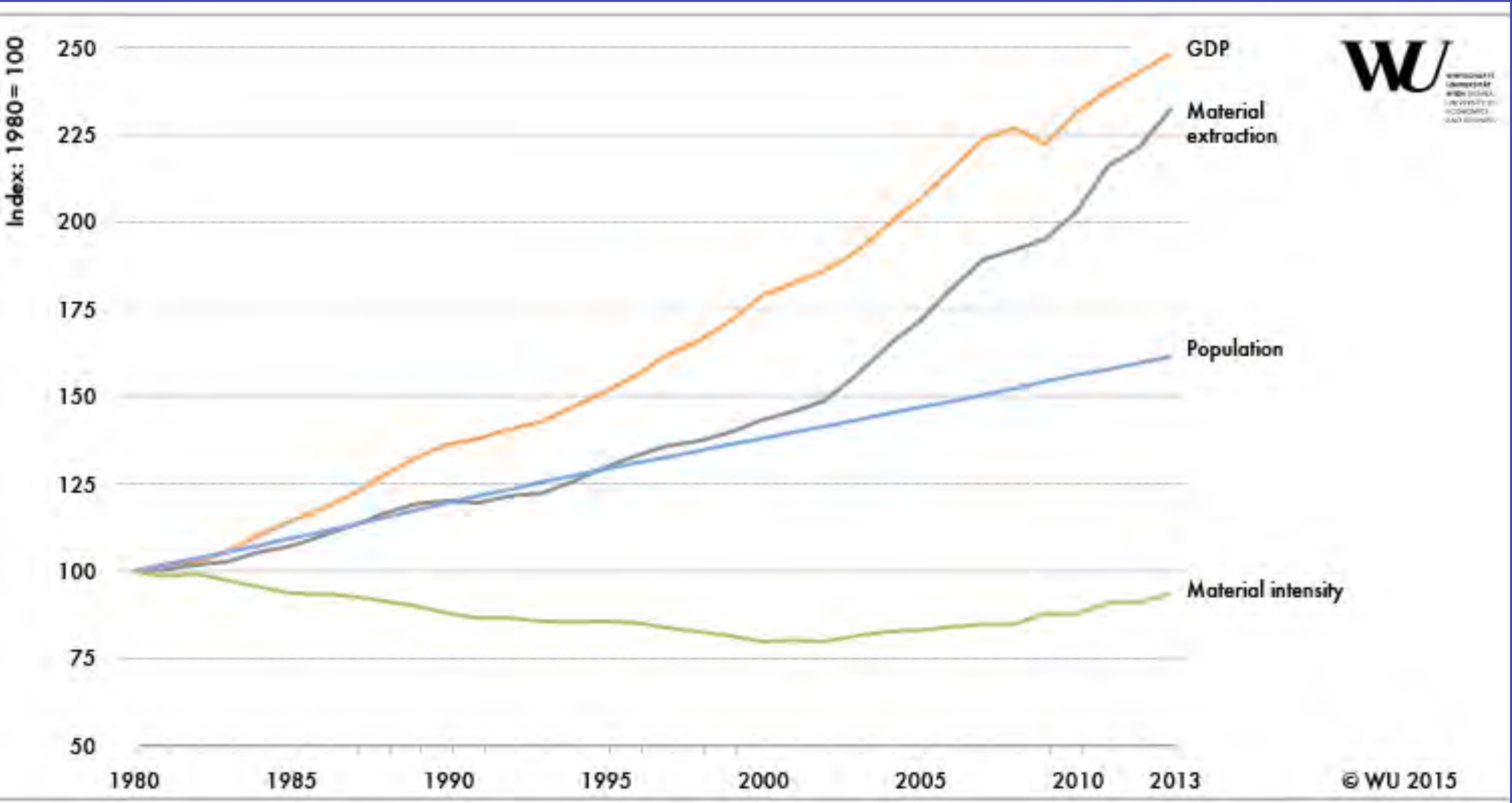
What If: World Consumes at US Rates
Oil
Natural Gas
12.5
12
11.5
11
10.5
10
9.5
9
Years
1
2
Fuels

Material consumption per capita and day in 2007



In this figure, material consumption per capita and day is illustrated, using the indicator "Raw Material Consumption". Material consumption equals domestic resource extraction plus imports (and the indirect resource flows of imports) minus exports (and the indirect resource flows of exports). One full rucksack (world average consumption per capita and day) equals 27 kilograms of material consumption. The numbers only include economically used materials and thus exclude unused materials, such as overburden from mining.

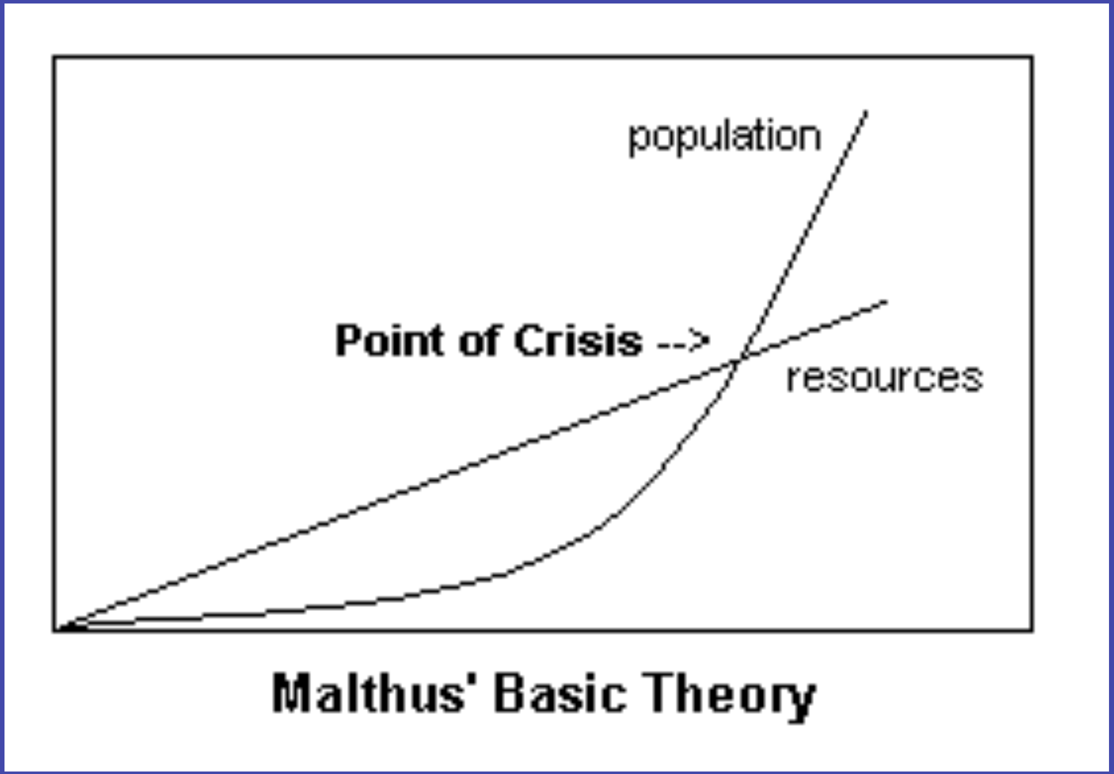
Trends in Global Resource Extraction, GDP & Material Intensity



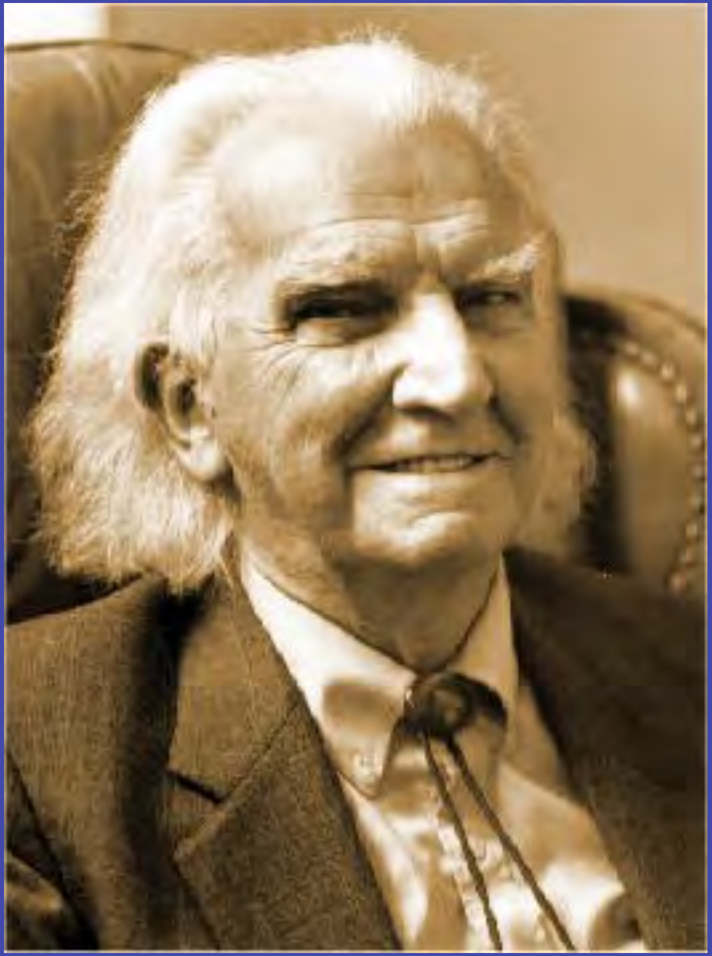
This figure illustrates global trends in resource extraction, GDP, population and material intensity in indexed form (1980 equals a value of 100)

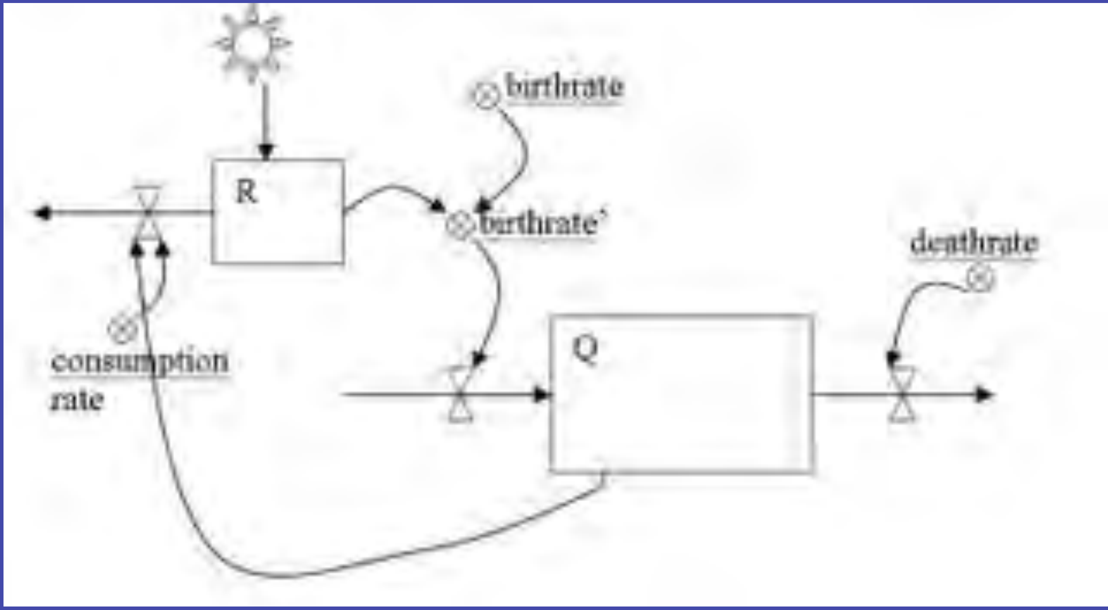
A Very Brief History of Sustainability Thinking

http://transform.ricoh.co.uk/wp-content/uploads/2014/03/Sustainable-thinking.jpg



Thomas Malthus
1798 “Essay on the Principle of Population”

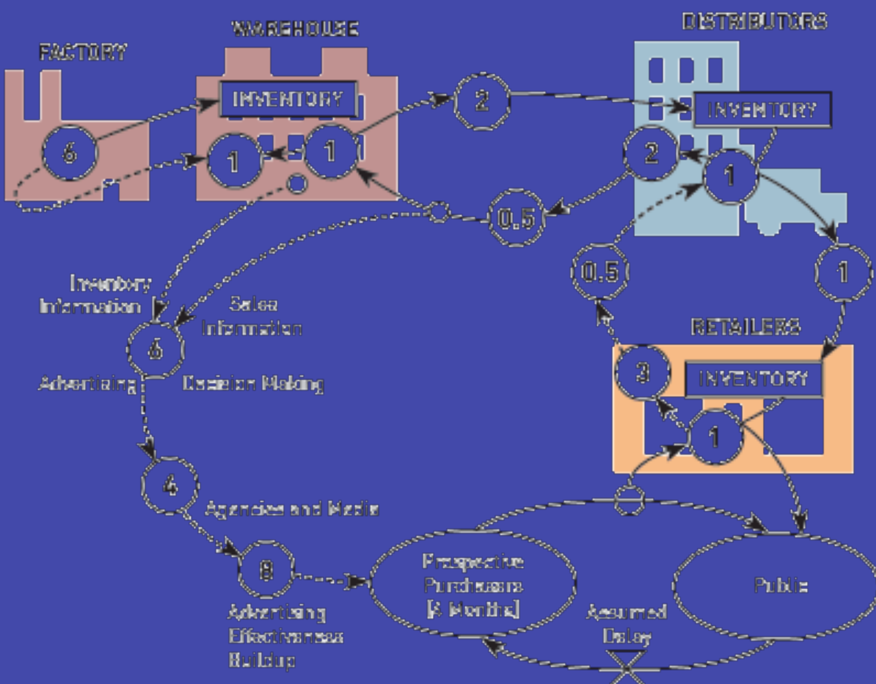




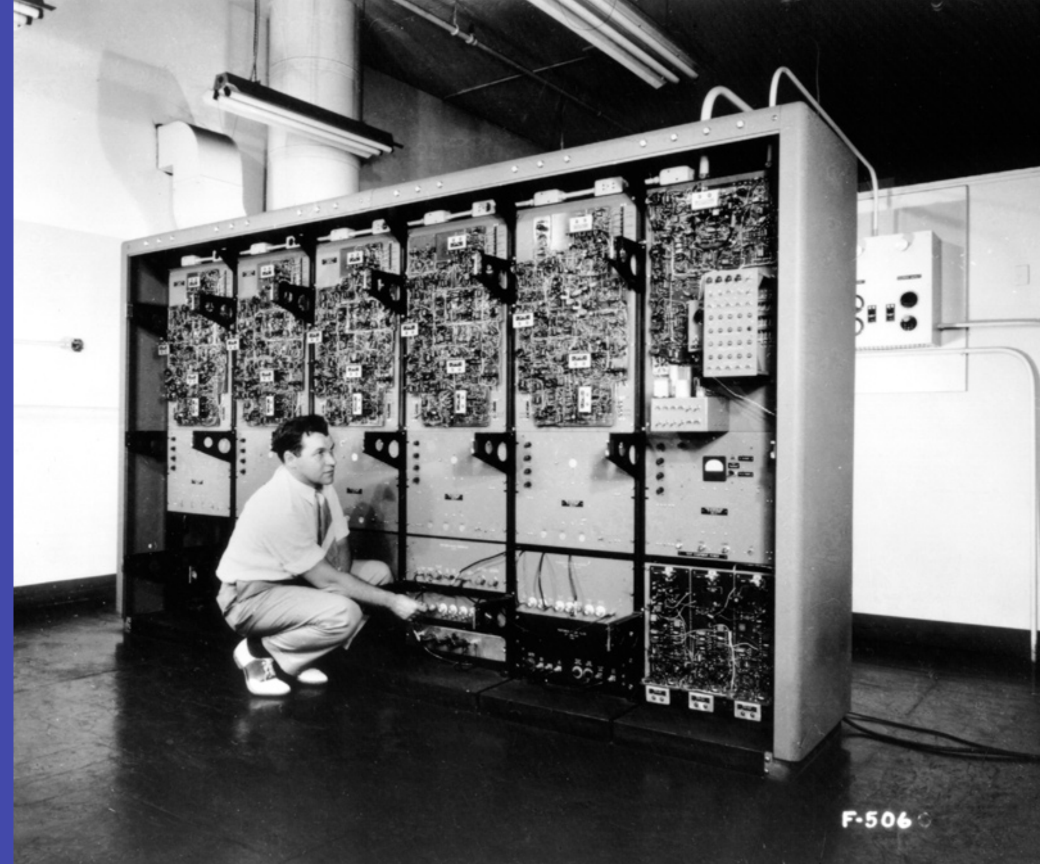
Kenneth Boulding
1966 Spaceship Earth

Jay Forrester
1996

Exhibit 1: Modeling System Dynamics

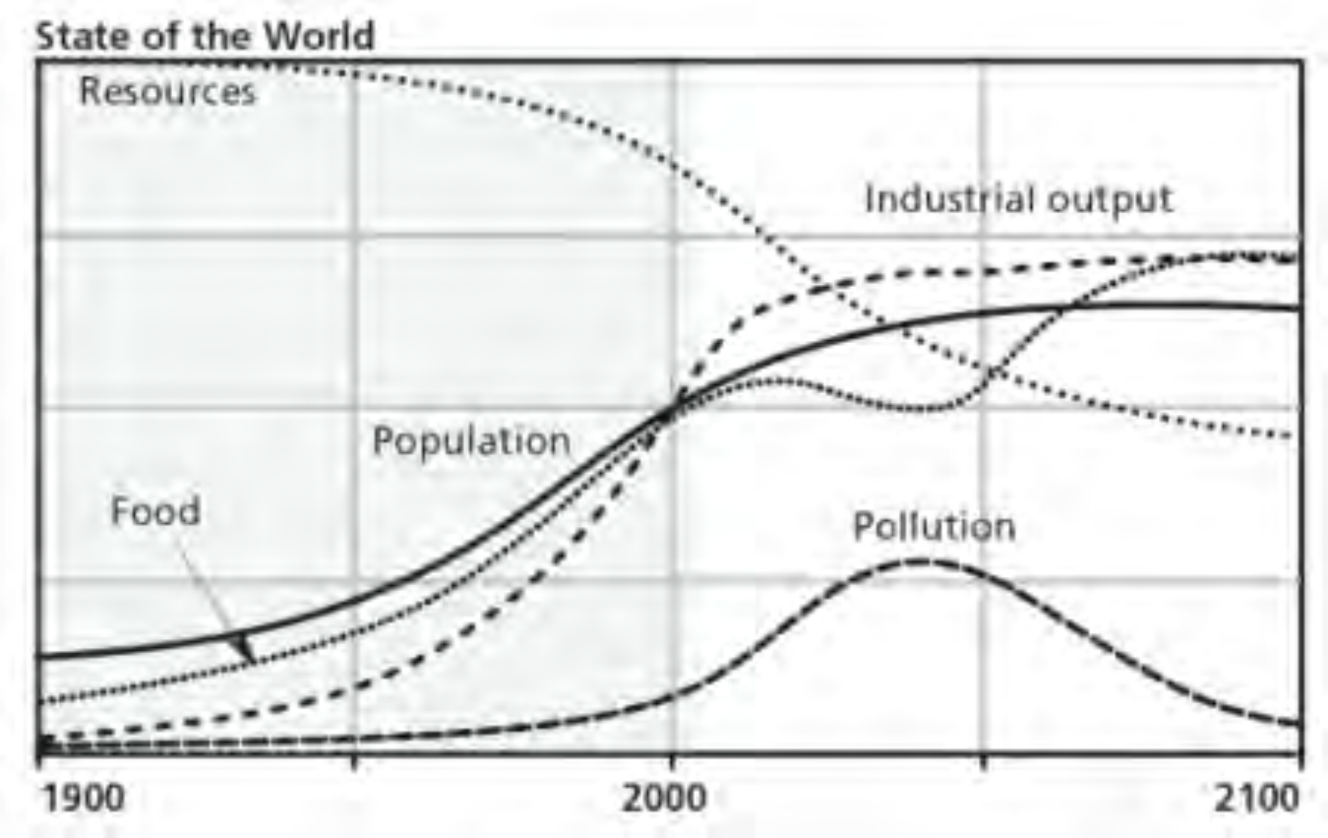


Source: Adapted from "Industrial Dynamics: A Major Breakthrough for Decision Makers," *Harvard Business Review*, July–August 1958



Forrester and Whirlwind 1951 (MIT)

Dennis Meadows and The Club of Rome 1971 Limits to Growth



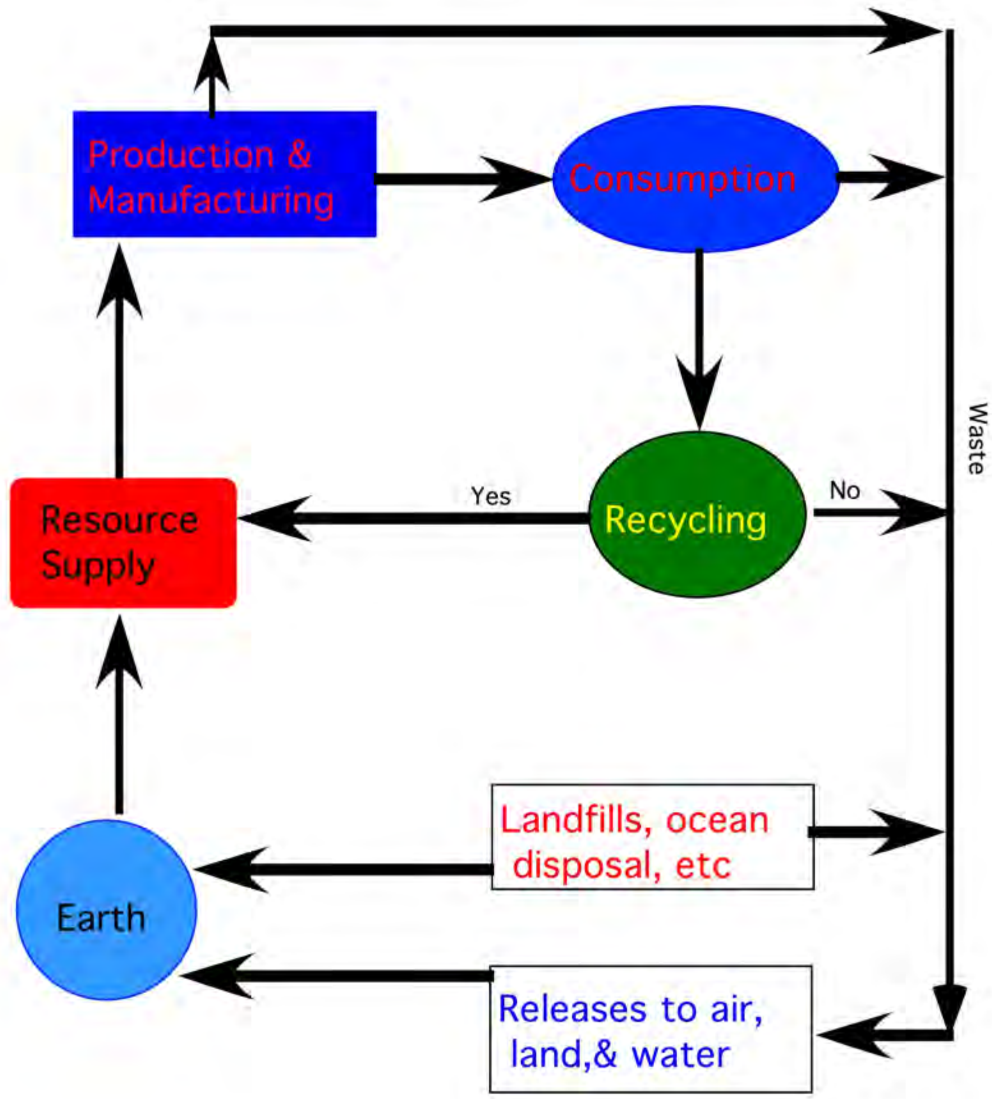
Critiques of Meadows et al (1)

- Used unfamiliar commodity measurements
- Mineral and fuel resources were seriously under estimated in the models
- There was no allowance for technological developments
- There was no provision for a price mechanism.

Critiques of Meadows et al (2)

- Recent discussions, most notably the Brundland report (1987), on sustainability have attempted to incorporate future generations into the economic analysis.
- What/who is a future generation? **Not alive now**.
- Pearce argues that capital consists of three parts: Man-made, human, and natural resources. As natural resources are depleted, the total stock of capital may be maintained or even increased if there is an offsetting increase in human capital or manufactured capital.

Materials Flow Cycle



Modified from USGS(1998)

Recycling

Recycling

Recycling: not

THE BAKELITE MOMENT

'I know this will be an important invention.'
Baekeland's diary, 11 July 1907

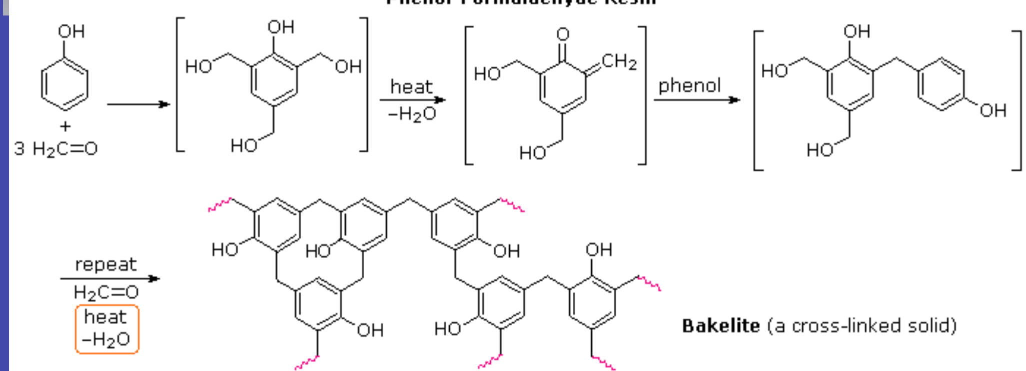
After five years of intensive research, the breakthrough came on 11 July 1907. It was all about finding the right conditions.

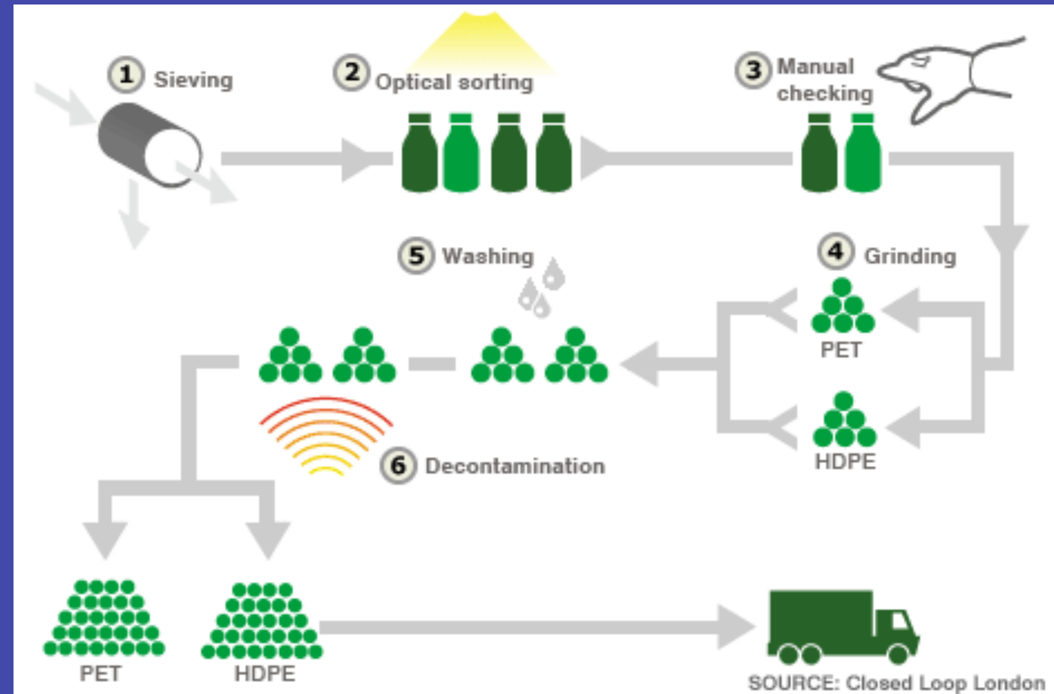
As he came closer to his goal, Baekeland worked solidly for five days in his laboratory next to his home in Yonkers, New York.

He was experimenting with two chemicals, formaldehyde and phenol. It was only when he combined them at over 150°C, under pressure and with an alkaline catalyst, that his dream became a reality.

Baekeland worked quickly, improving his material and designing the Bakelizer, a machine that would control the violence of the reaction.

Phenol-Formaldehyde Resin





1. PET Polyethylene Terephthalate Soda bottles: widely recycled
2. HDPE High Density Polyethylene Milk bottles: recycled
3. PVC Polyvinyl Chloride Pipes, outdoor furniture: some recycled
4. LDPE Low Density Polyethylene Dry cleaning bags: some recycled
5. PP Polypropylene Bottle caps, straws: rarely recycled
6. PS Polystyrene Styrofoam peanuts: some recycled
7. Other Tupperware, other food containers: very rarely recycled

Recycling requires

1. A market

2. Materials that can be recycled

But why bother?

Exhibit 1: Energy Savings Per Ton Recycled* (Million Btu)

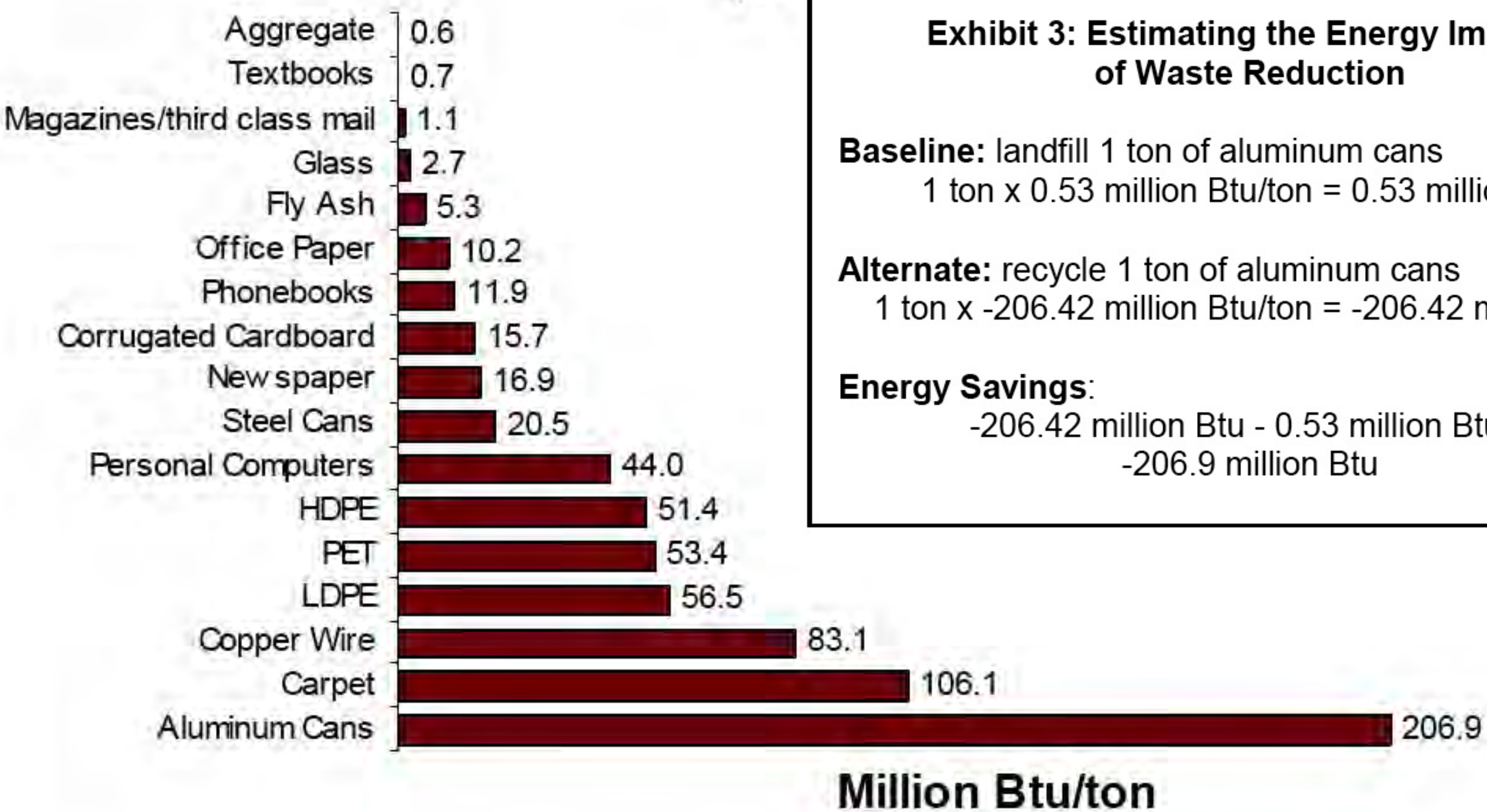


Exhibit 3: Estimating the Energy Impacts of Waste Reduction

Baseline: landfill 1 ton of aluminum cans
1 ton x 0.53 million Btu/ton = 0.53 million Btu

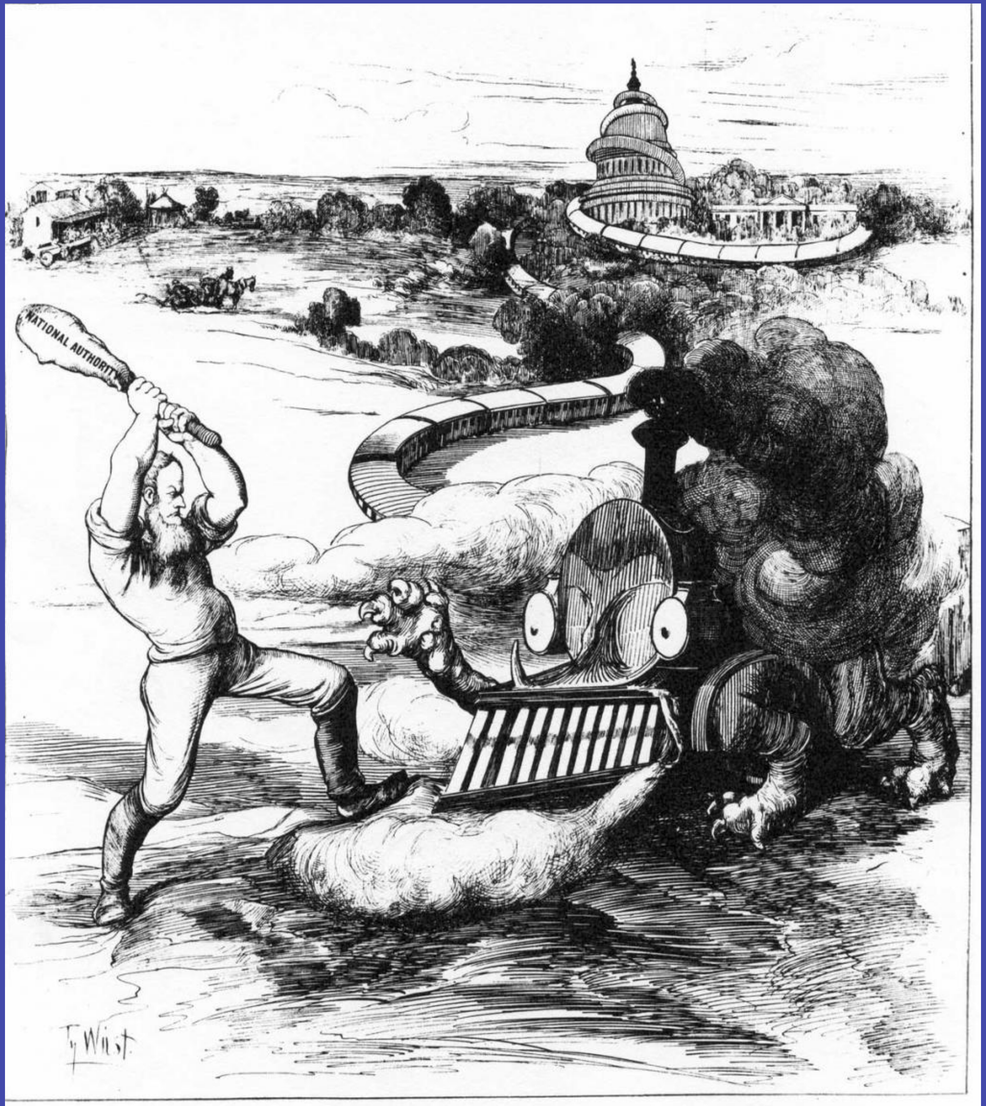
Alternate: recycle 1 ton of aluminum cans
1 ton x -206.42 million Btu/ton = -206.42 million Btu

Energy Savings:
-206.42 million Btu - 0.53 million Btu = -206.9 million Btu

* Assumes recycled materials would otherwise have been landfilled. Includes embedded energy.

Choate et al 2005: http://www.epa.gov/climatechange/wycd/waste/downloads/Energy%20Savings.pdf

Does Government Have a Role in Sustainability? Is Government Contemplating Such a Role?



THE FARMER AND THE RAILROAD MONSTER
WHICH WILL WIN?

http://www.antitrustinstitute.org/sites/default/files/cartoon_rr_lg.jpg

Table 6. Development legislation of the post-frontier period.

Legislation/Program	Year	Public Purpose
Indian Lands Leasing Act	1891	Authorized mineral leases on Indian land[1].
Stock Raising Homestead Act	1916	Authorized mineral location and claims on homestead claims[2].
Mineral Leasing Act	1920	Authorized and governs leasing of public lands for development of deposits of coal, oil, gas and other hydrocarbons, sulfur, phosphate, potassium, and sodium[3].
Various Acts to create Hydro-electric Dams	1933 to 1944	The "New Deal" featured the building of many high profile dams. These provided employment, river transportation, recreation, irrigation, and inexpensive electricity[4].
Mc Mahon Act	1946	Established the Atomic Energy Commission. Commission uranium purchases created an industry boom, until purchases ended in 1970[5].
Strategic and Critical Minerals Production Act	1950	Authorized government stockpiling of "strategic" minerals, effecting production subsidies for many[6].
Federal Aid Highway Act	1956	Authorized construction of the U.S. Interstate Highway System, increasing the demand for aggregates, cement and steel[7].
Intermodal Surface Transportation and Efficiency Act (ISTEA)	1991 to present	Continually funds transportation infrastructure expansion and repair, sustaining the construction industry and its materials suppliers[8].

1. California State University, 2000§.
2. Feriancek, 2001b§.
3. U.S. Fish and Wildlife Service, 2000§.
4. U.S.Bureau of Reclamation, 2001§.
5. Uranium Institute in London, 1989§.
6. U.S. Department of Agriculture, 2000§.
7. Weingroff, R.F., 1996§.
8. U.S. Bureau of Transportation Statistics, undated§.

GLOBAL TRENDS
PARADOX OF PROGRESS

A publication of the National Intelligence Council

JANUARY 2017
NIC 2017-001

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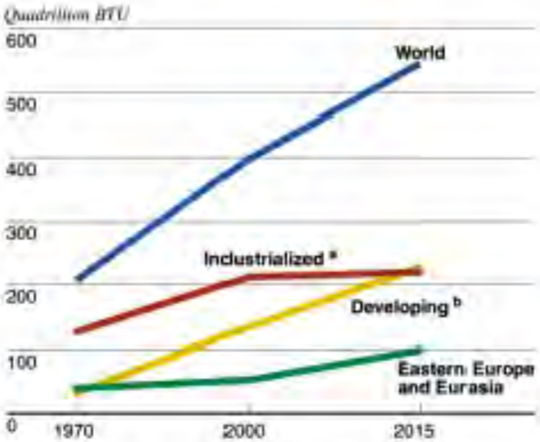
To view electronic version:
www.dni.gov/nic/globaltrends

World Energy Consumption: 1970-2015

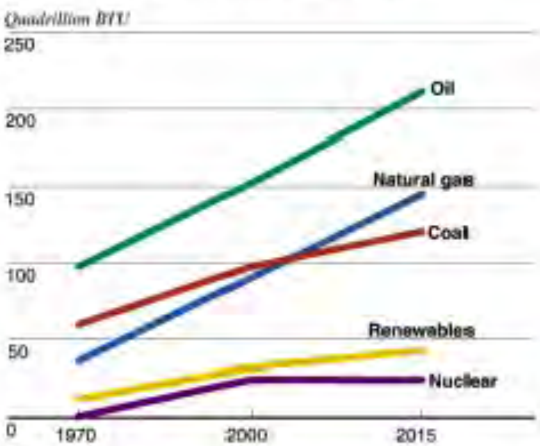
World Energy Consumption



[a] Includes: United States, Canada, Mexico, Japan, United Kingdom, France, Germany, Italy, Netherlands, other Europe, and Australia.

[b] Includes: Developing Asia (China, India, South Korea, other Asia), Turkey, Africa, Brazil).

World Energy Consumption by Fuel Type



Source: International Energy Outlook, 1998; US Department of Energy.

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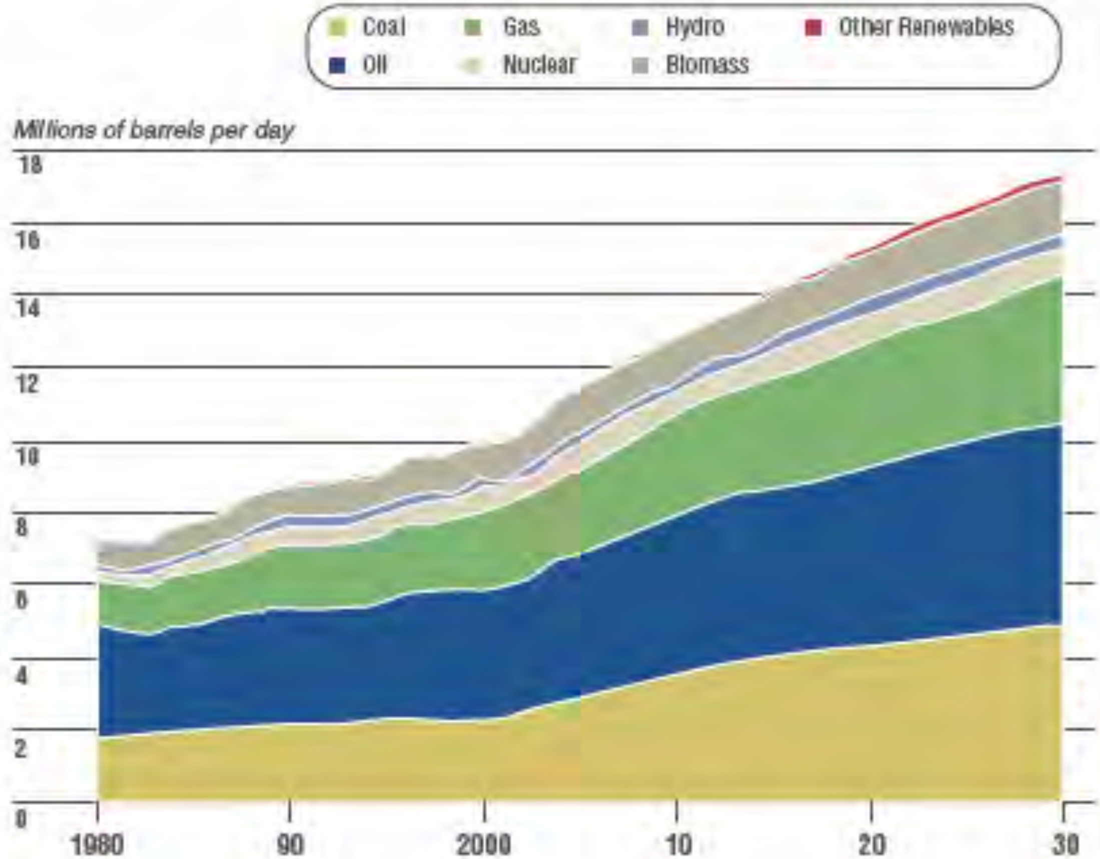
Breakdown of Likely Energy Sources



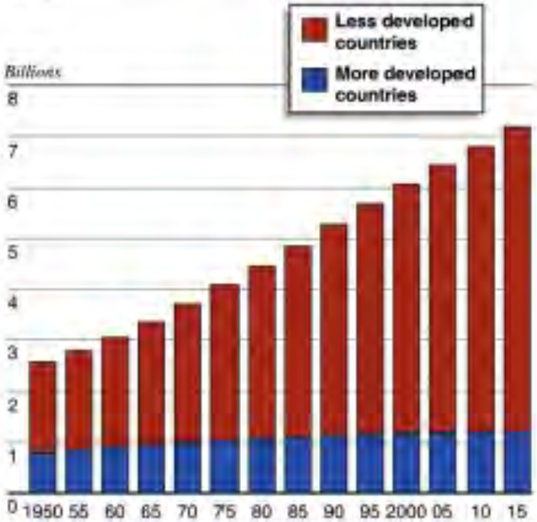
Note: Global demand grows by more than half over the next quarter of a century, with coal use rising in absolute terms.

Source: PFC Energy International.

CIA/NIC 2010

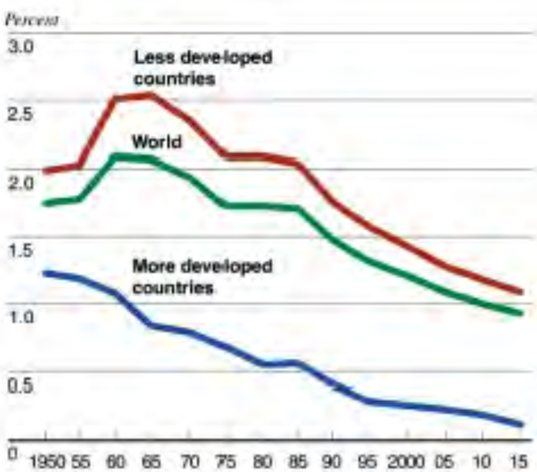
Global Population: 1950-2015

Total



Source: US Bureau of the Census.

Growth Rates



Source: US Bureau of the Census.

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Countries With Youth Bulges in 2000 and 2015[a]

Latin America
- Dominican Republic
- Grenada
- Haiti
- Honduras
- Nicaragua

Sub-Saharan Africa
- Benin
- Botswana
- Burkina Faso
- Burundi
- Central African Republic
- Chad
- Comoros
- Congo, Democratic Republic of the
- Congo, Republic of
- Cote d'Ivoire
- Eritrea
- Ethiopia
- Kenya
- Lesotho[c]
- Malawi
- Mali
- Mozambique
- Namibia
- Niger
- Nigeria
- Rwanda
- Sao Tome and Principe
- Senegal
- Sudan
- Swaziland
- Tanzania
- Togo
- Uganda
- Zambia
- Zimbabwe

Middle East
- Gaza Strip
- Jordan
- Lebanon
- Libya
- Iran
- Iraq
- Saudi Arabia[b]
- Syria
- West Bank
- Yemen

Asia/Pacific
- Marshall Islands
- Solomon Islands
- Tonga

[a] A country is considered to have a youth bulge if the ratio of the population aged 15 to 29 to the population aged 30 to 54 exceeds 1.27.

[b] Saudi citizens only; does not include the large number of guest workers.

[c] Lesotho did not have a youth bulge in 2000.

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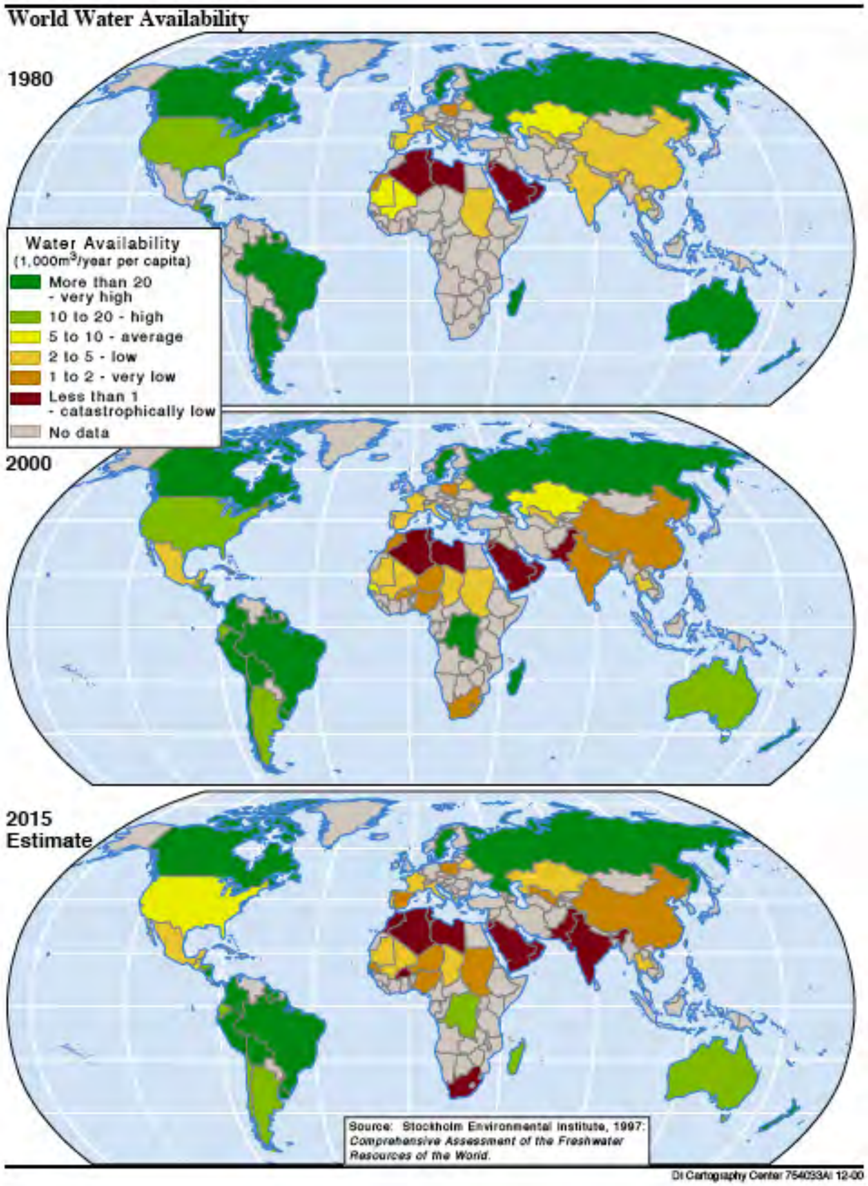
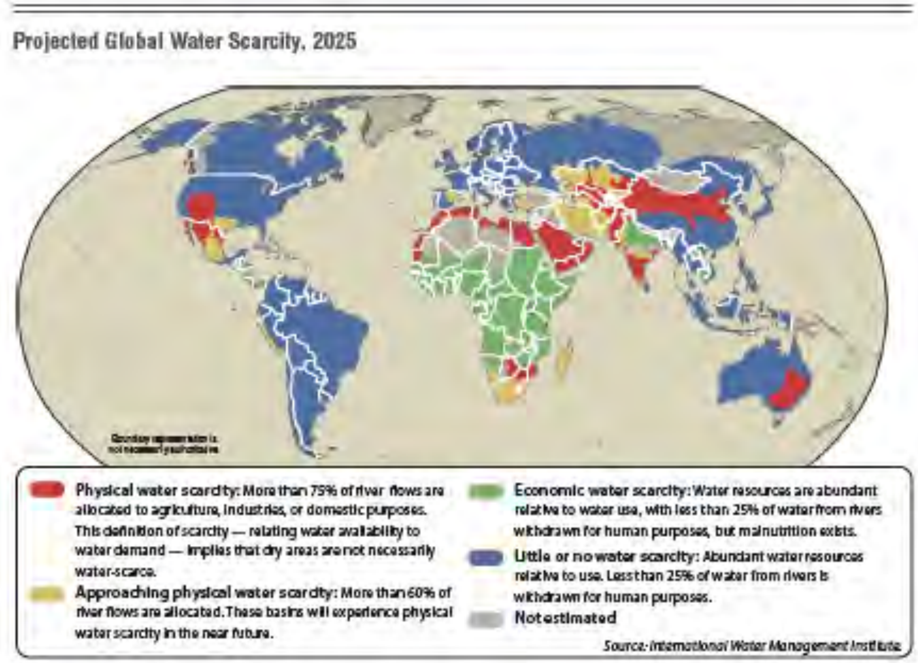
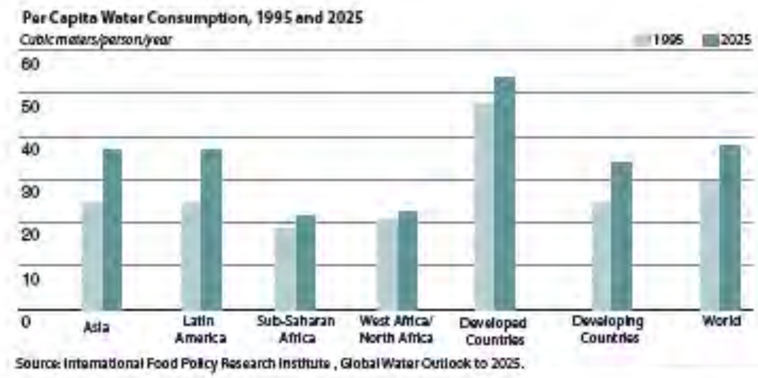
CIA/NIC 2010


World Water Availability
1980
Water Availability
(1,000m³/year per capita)
More than 20 - very high
10 to 20 - high
5 to 10 - average
2 to 5 - low
1 to 2 - very low
Less than 1 - catastrophically low
No data
2000
2015 Estimate
Source: Stockholm Environmental Institute, 1997: Comprehensive Assessment of the Freshwater Resources of the World.
DI Cartography Center 754033AI 12-00

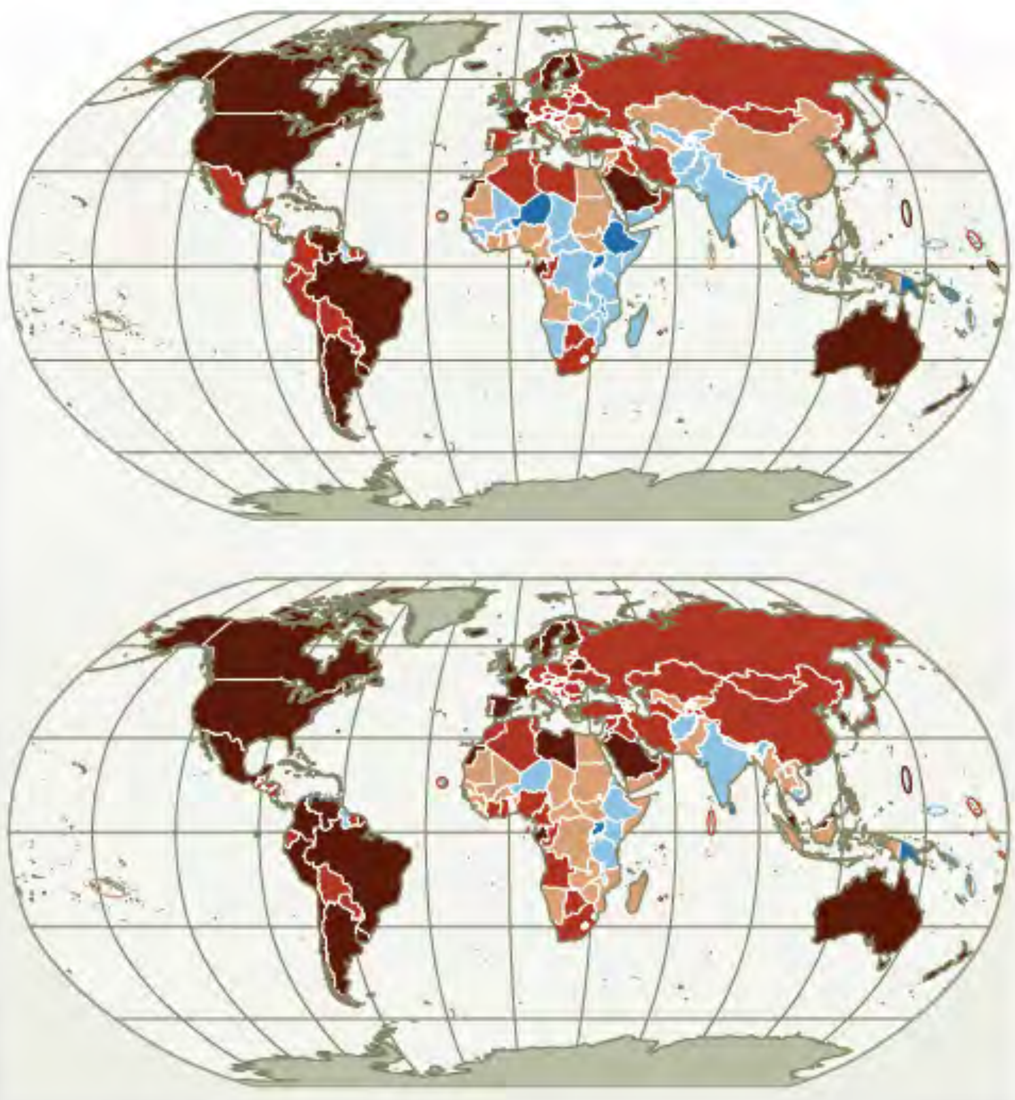

Projected Global Water Scarcity, 2025
Physical water scarcity: More than 75% of river flows are allocated to agriculture, industries, or domestic purposes. This definition of scarcity — relating water availability to water demand — implies that dry areas are not necessarily water-scarce.
Approaching physical water scarcity: More than 60% of river flows are allocated. These basins will experience physical water scarcity in the near future.
Economic water scarcity: Water resources are abundant relative to water use, with less than 25% of water from rivers withdrawn for human purposes, but malnutrition exists.
Little or no water scarcity: Abundant water resources relative to use. Less than 25% of water from rivers is withdrawn for human purposes.
Not estimated
Source: International Water Management Institute.


Per Capita Water Consumption, 1995 and 2025
Cubic meters/person/year
1995
2025
60
50
40
30
20
10
0
Asia
Latin America
Sub-Saharan Africa
West Africa/ North Africa
Developed Countries
Developing Countries
World
Source: International Food Policy Research Institute, Global Water Outlook to 2025.

CIA/NIC 2010

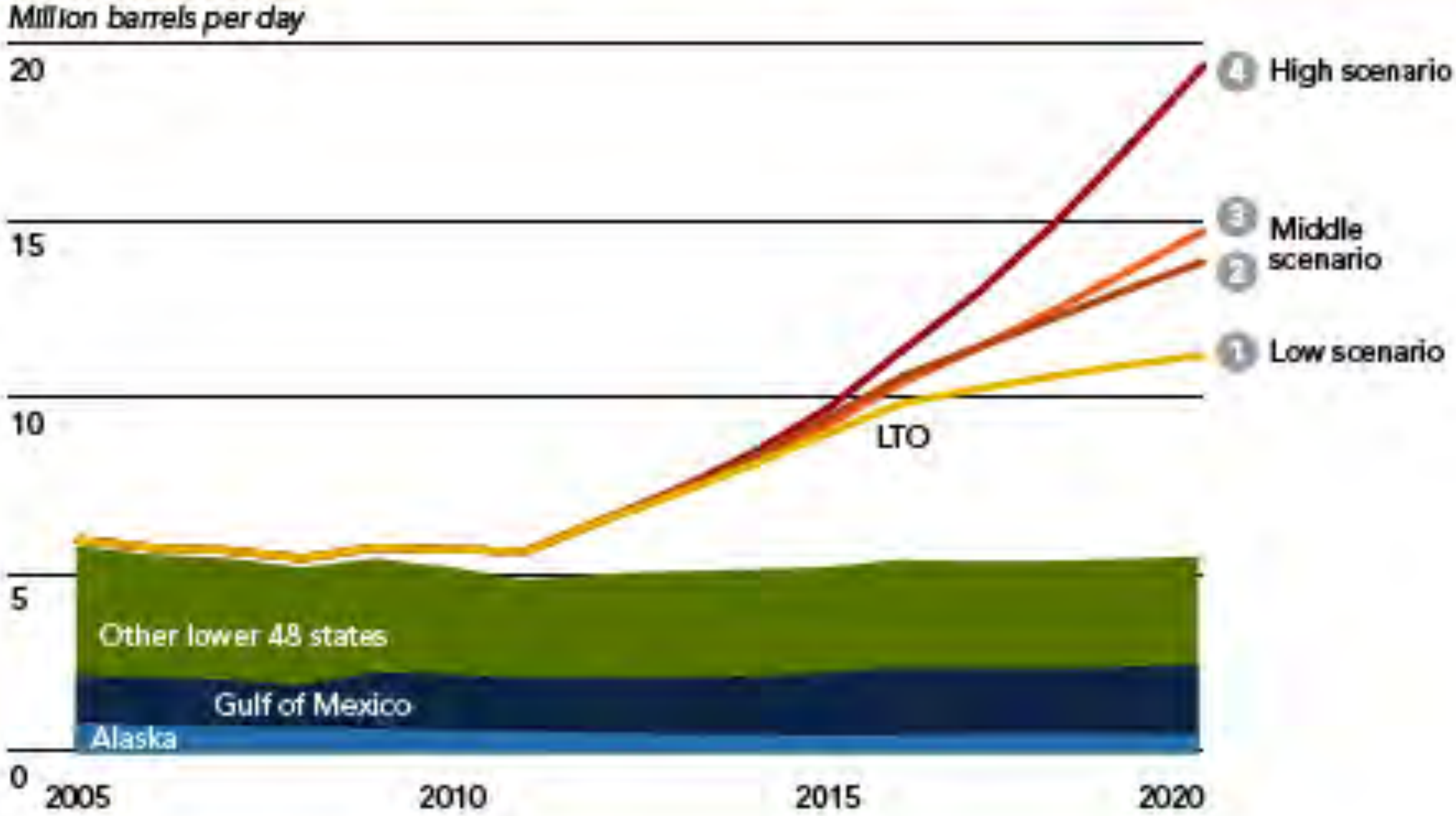
THE URBAN PROPORTION OF THE POPULATION, 2010-2030

The proportion of the population living in urban areas, 2010 estimates and 2030 projections. Data are drawn from the United Nations Population Division (2010). The criteria that define an urban area were selected by individual states.



CIA/NIC 2010

SHALE OIL (LIGHT TIGHT OIL) US PRODUCTION ESTIMATES, 2005-2020



Source: HPDI; EIA; team analysis for NIC.

CIA/NIC 2005

Italian Constitution Referendum 2016
Siena, Italy

Global Trends 2017

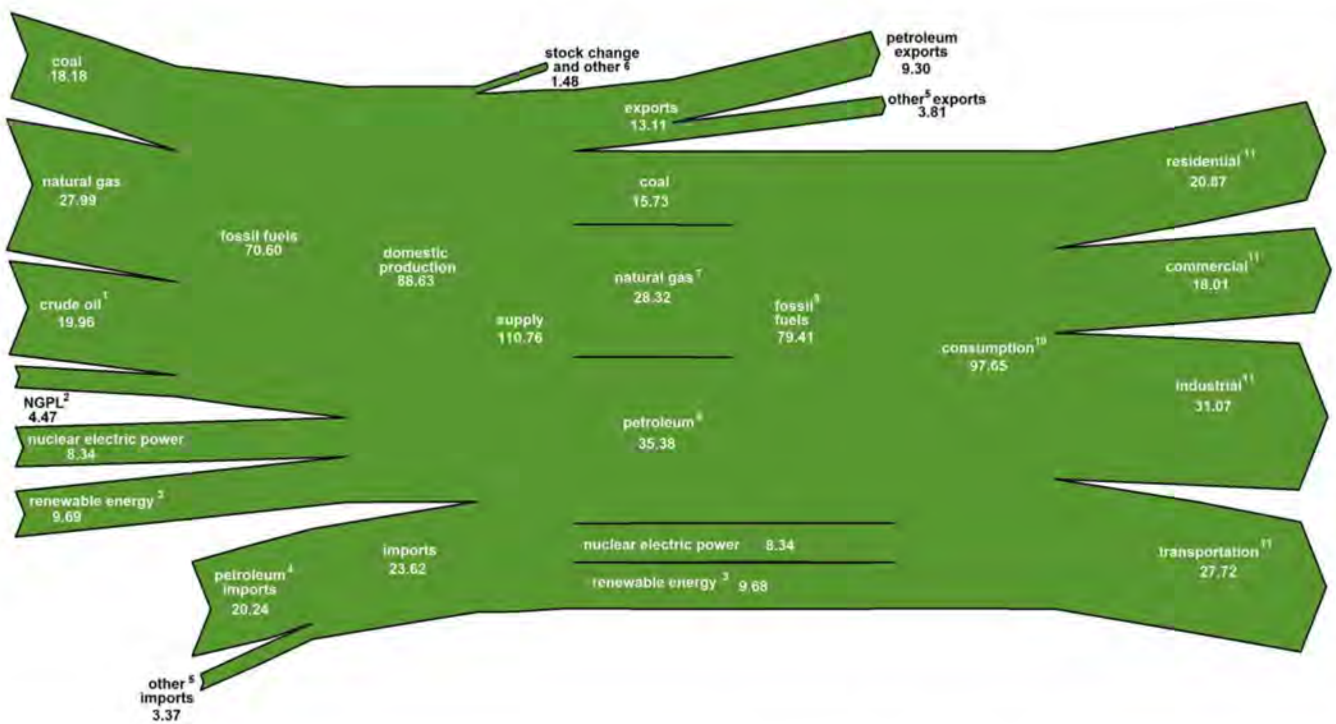
The Bottomline

These trends will converge at an unprecedented pace to make governing and cooperation harder and to changethe nature of power—fundamentally altering the global landscape. …. Within states, political order will remain elusive and tensions high until societies and governments renegotiate their expectations of one another. …

What do we know about the sources of energy? Are we gaining or losing energy when we extract and process various sources?

U.S. Energy Flow, 2015

quadrillion Btu



[1] Includes lease condensate.
[2] Natural gas plant liquids.
[3] Conventional hydroelectric power, biomass, geothermal, solar, and wind.
[4] Crude oil and petroleum products. Includes imports into the Strategic Petroleum Reserve.
[5] Natural gas, coal, coal coke, biofuels, and electricity.
[6] Adjustments, losses, and unaccounted for.
[7] Natural gas only; excludes supplemental gaseous fuels.
[8] Petroleum products, including natural gas plant liquids, and crude oil burned as fuel.
[9] Includes -0.02 quadrillion Btu of coal coke net imports.
[10] Includes 0.23 quadrillion Btu of electricity net imports.
[11] Total energy consumption, which is the sum of primary energy consumption, electricity retail sales, and electrical system energy losses. Losses are allocated to the end-use sectors in proportion to each sector's share of total electricity retail sales. See Note 1, "Electrical System Energy Losses," at the end of U.S. Energy Information Administration, *Monthly Energy Review* (April 2016), Section 2.

Notes: • Data are preliminary. • Values are derived from source data prior to rounding for publication. • Totals may not equal sum of components due to independent rounding.

Sources: U.S. Energy Information Administration, *Monthly Energy Review* (April 2016), Tables 1.1, 1.2, 1.3, 1.4a, 1.4b, and 2.1.

What do we know about the sources of energy? Are we gaining or losing energy when we extract and process various sources?

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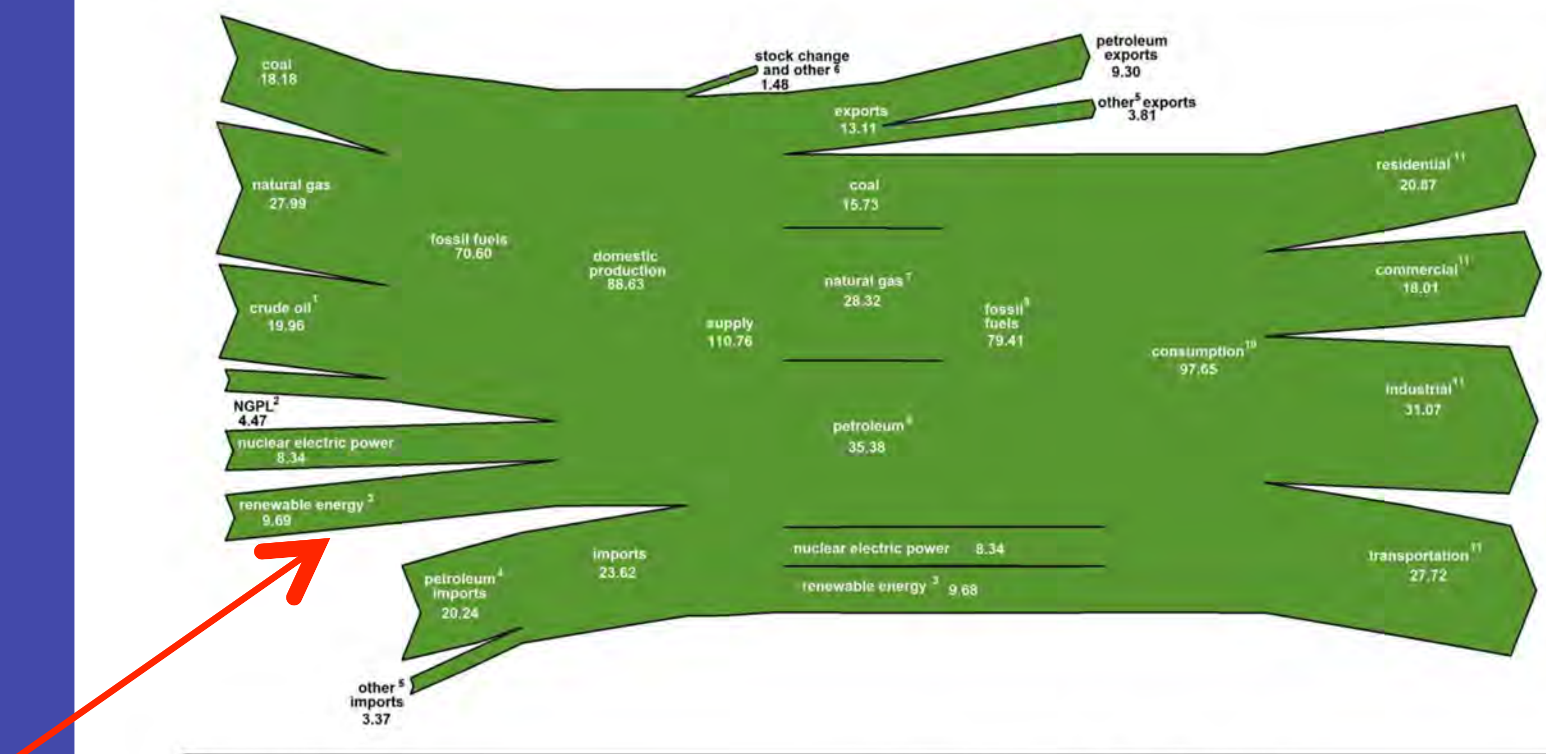

[1] Includes lease condensate.
[2] Natural gas plant liquids.
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Sources: U.S. Energy Information Administration, *Monthly Energy Review* (April 2016), Tables 1.1, 1.2, 1.3, 1.4a, 1.4b, and 2.1.

Summary

- Present resource consumption patterns pose problems for later generations even if the population stabilizes by 2100.
- As the population approaches 10 billion people present resource consumption patterns pose significant problems for present and future generations in 25 to 100 years

Summary

- Most resource consumption patterns within the US cannot be extended to the rest of the world without major problems of supply developing very quickly.
- Economists recognize problems of resource supply created by increasing global populations.
- Note that our discussion does not address carbon dioxide/methane emissions

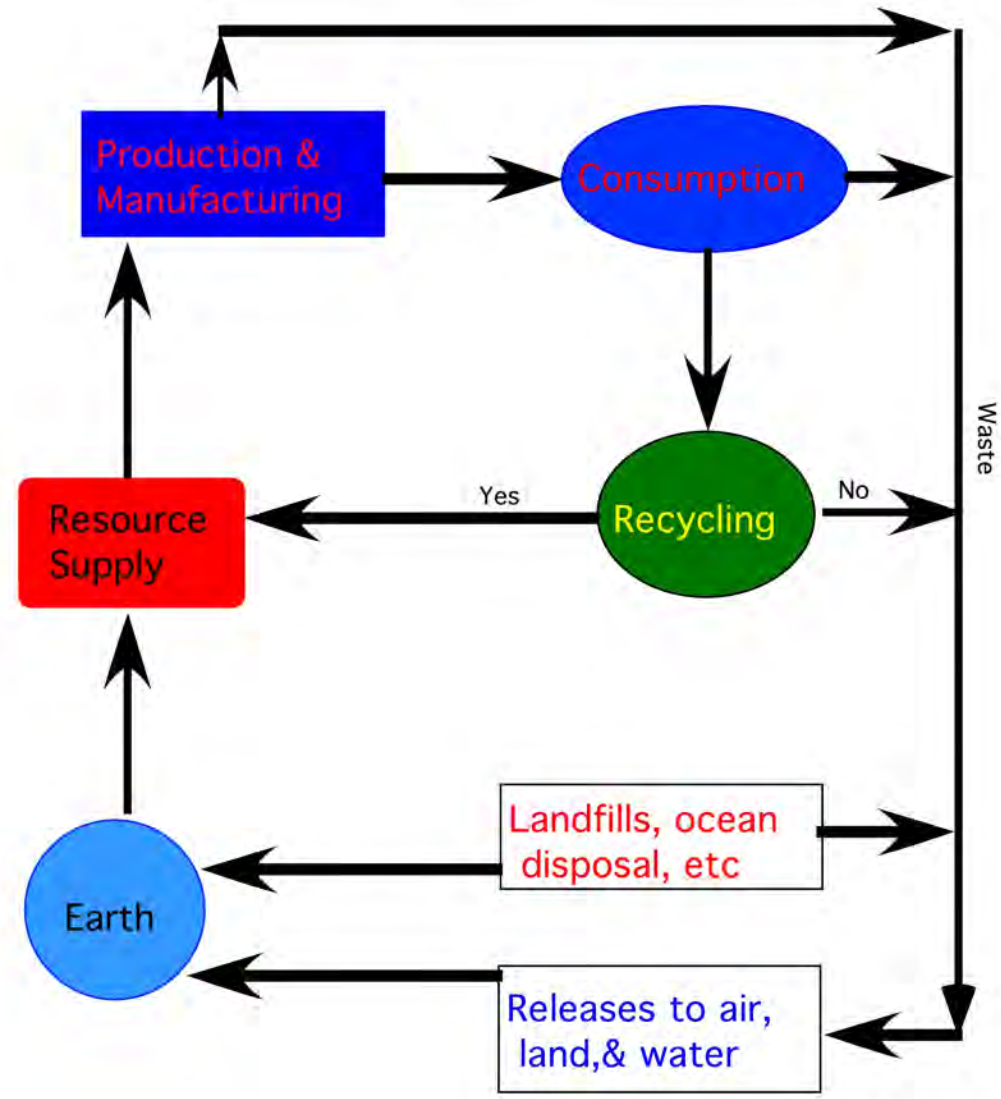
Summary

- No consensus has developed among economists regarding changes in the present economic system that will remedy these problems. Technological innovation, pricing mechanics, and moral persuasion are the principle suggestions for effecting change.

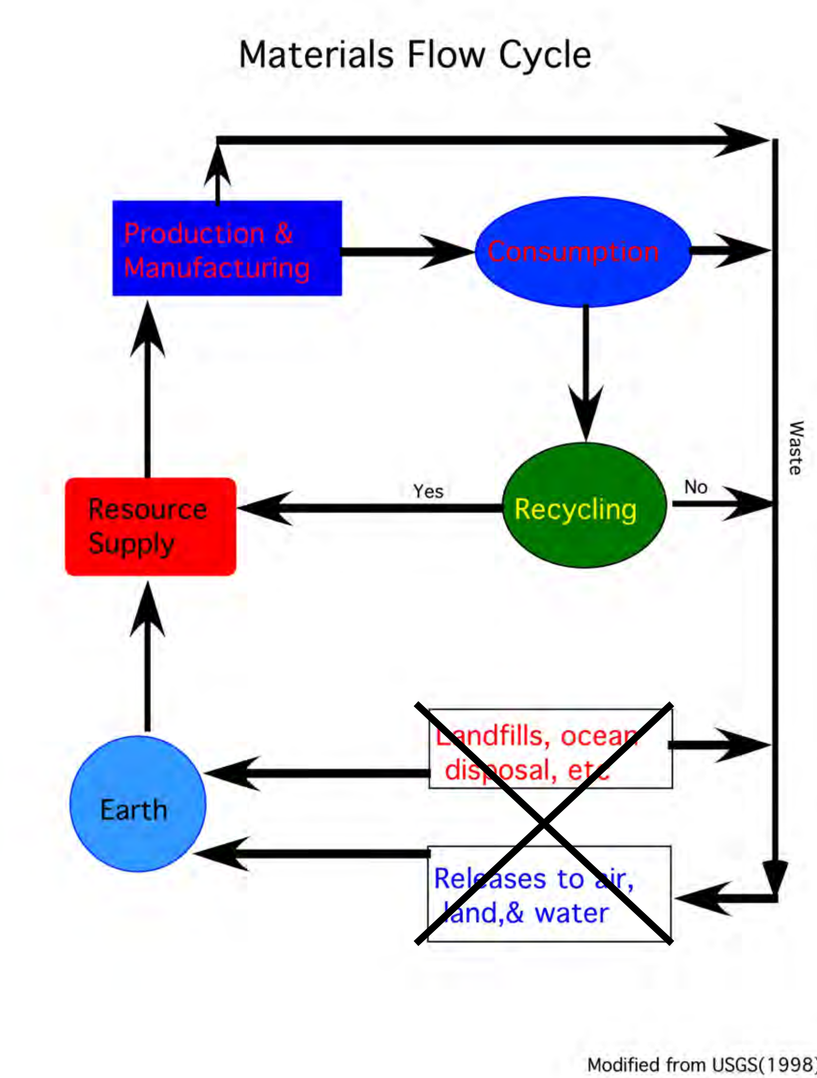
Summary

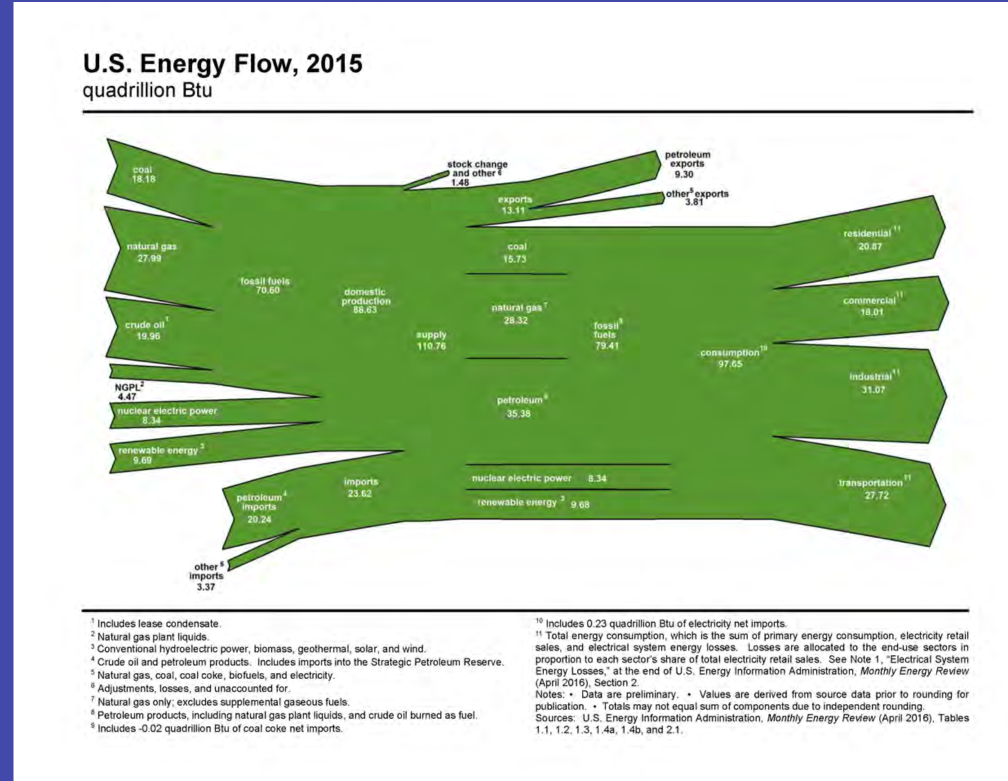
- Political leaders and their advisors are preoccupied by short term, regional governance issues that obscure important large-scale issues such resource availability, pollution, or consumption patterns.
- Drucker (1999): using external information in an organization’s decisions is a major management challenge.

Materials Flow Cycle



Modified from USGS(1998)





"The Stone Age came to an end but not for a lack of stones and the oil age will end not for a lack of oil"
Ahmed Zaki Yamani

Sun Yuan and Peng Yu
Saatchi Gallery, London
December 2008