

Environmental physics as part of a sustainability certificate and degree.

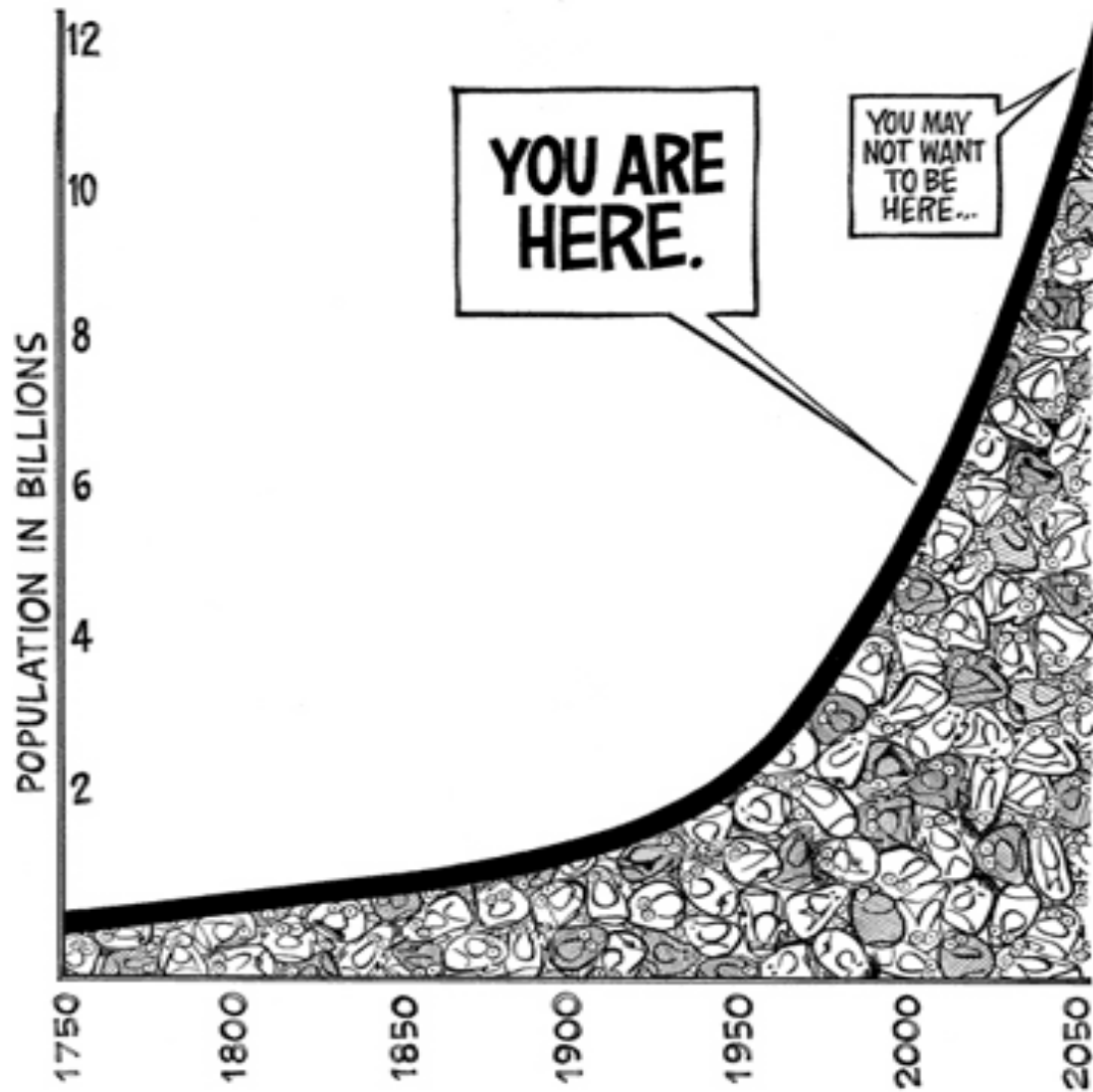


Dr. Kyle Forinash
Professor of Physics
iana University Southeast

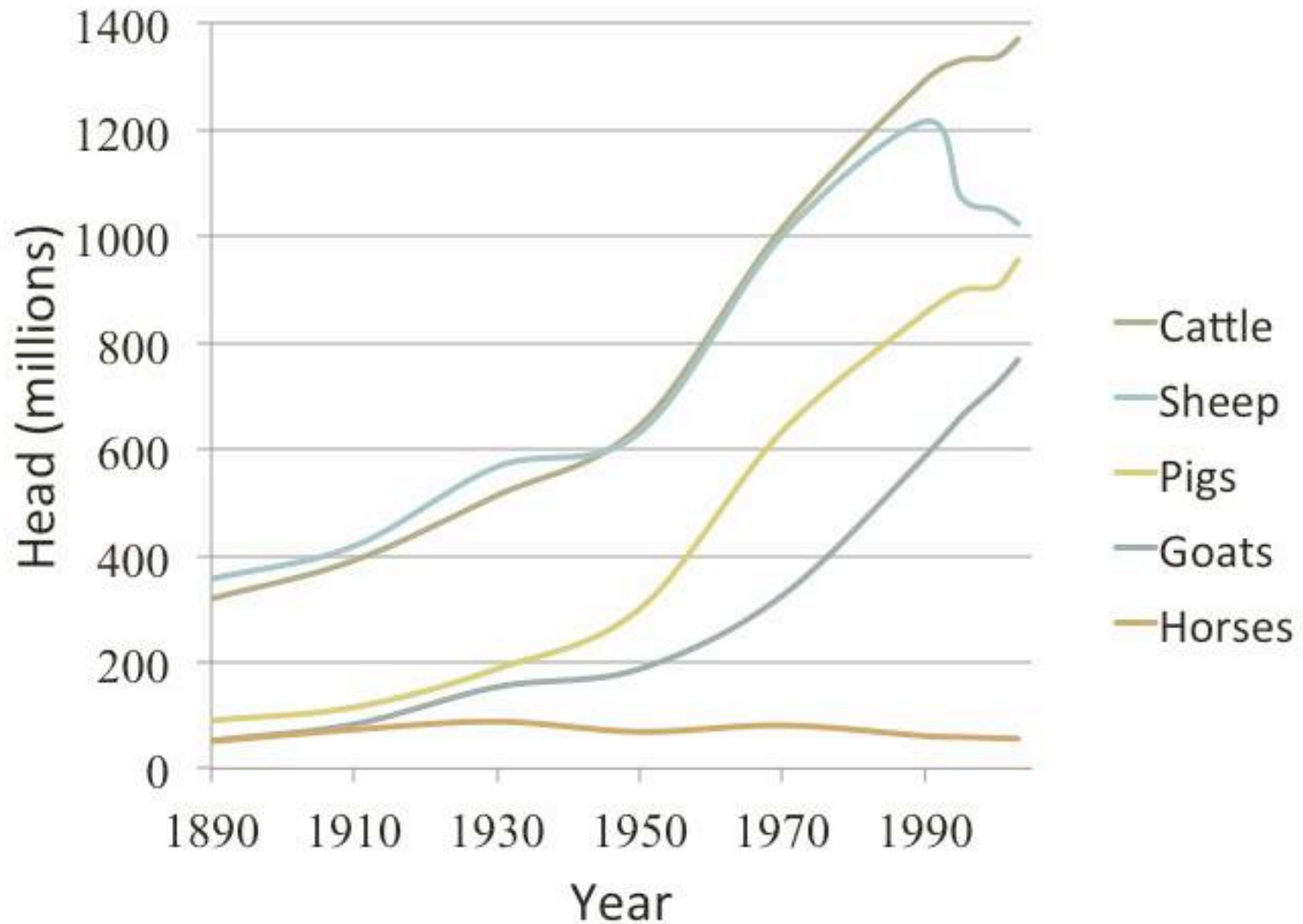
Topics in P120 and P310.

- **Population** (exponential? pollution, water)
- **Energy** (sources, fossil fuels, Hubbert's peak)
- **Conversion Efficiencies** (1st and 2nd laws)
- **Storage** (fuel, batteries, flywheels, capacitors, etc.)
- **Transportation** (well to wheel, lifecycle efficiency)
- **Nuclear** (fission, reactors, waste)
- **Climate** (blackbody radiation, absorption)
- **Risk Assessment** (meteors, driving, nuclear waste)
- **Economics** (external energy costs, standard of living)

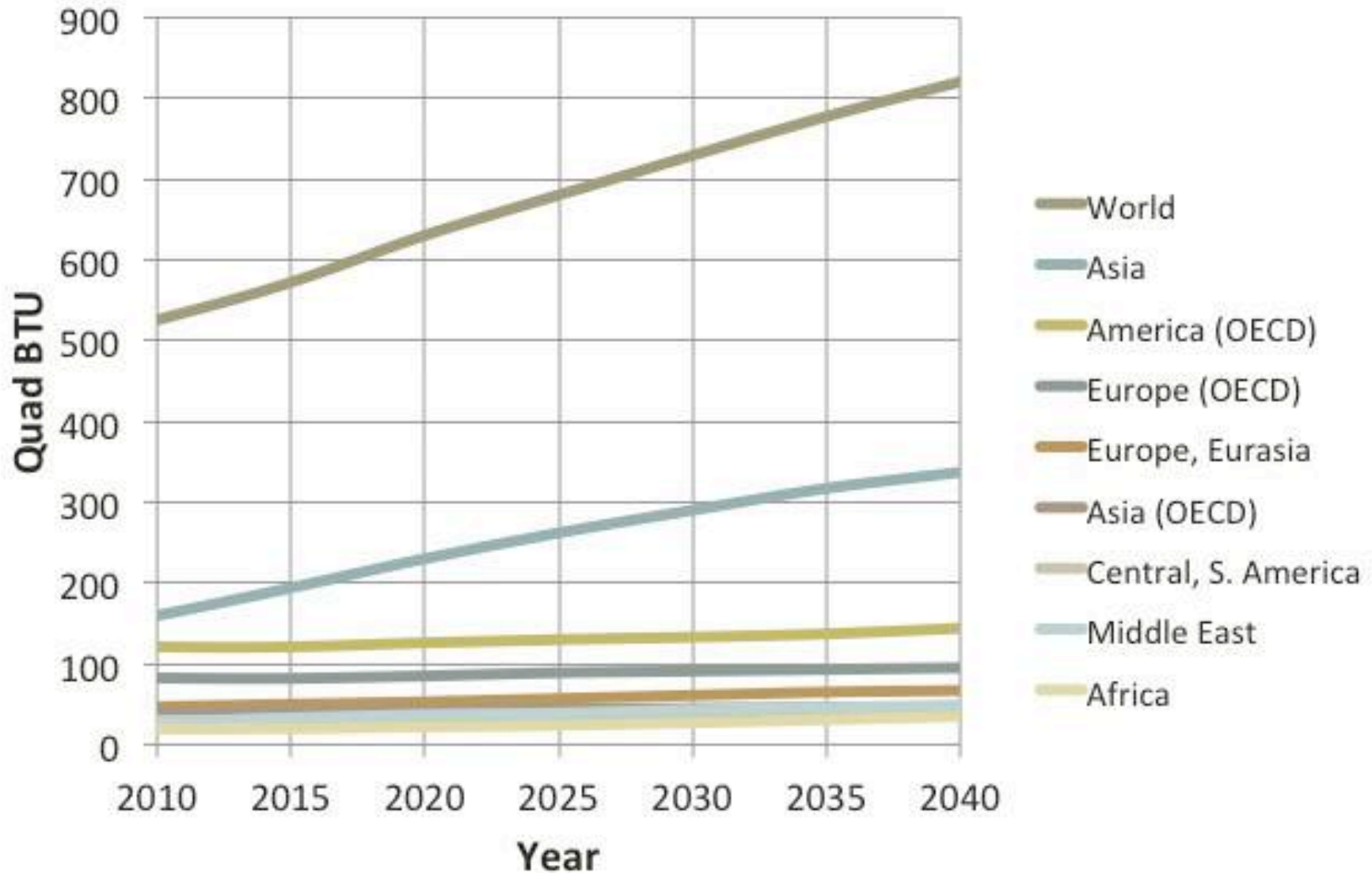
8.1 to 10.6 Billion by 2050.



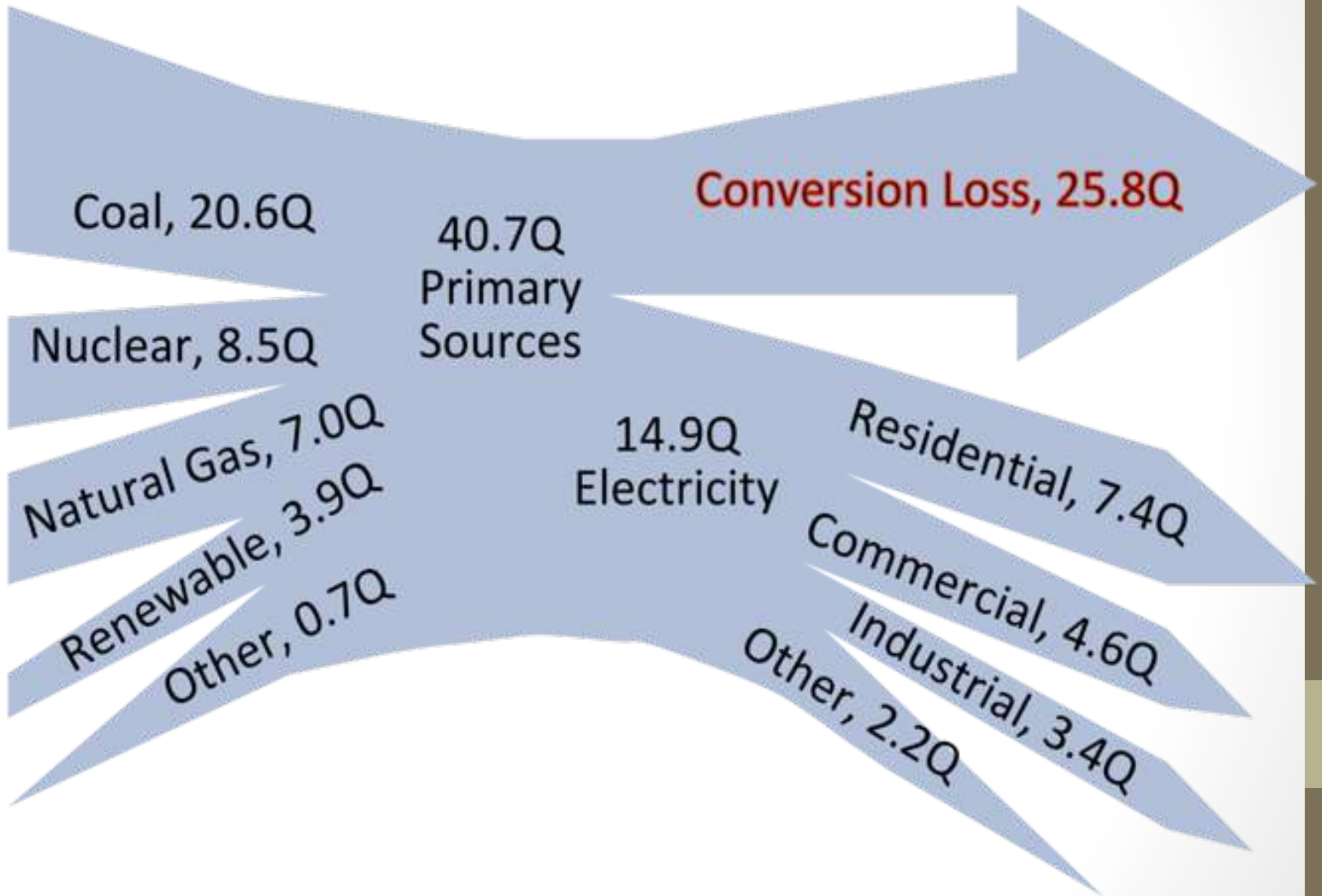
Global Livestock Production.



Energy Projections, EIA (56%!).



US Electricity Production, 2009.



The 2nd Law of Thermodynamics.

Process	Conversion Type	Efficiency, %
Large Electric Generator	Mechanical to Electrical	98-99
Large Electric Motor	Electrical to Mechanical	90-97
Home Gas Furnace	Chemical to Thermal	90-96
Small Electric Motor	Electrical to Mechanical	60-75
Fuel Cell	Chemical to Electrical	50-60
Large Steam Turbine	Thermal to Mechanical	40-45
Diesel IC	Thermal to Mechanical	30-35
Gasoline IC	Thermal to Mechanical	15-25
Florescent Light	Electrical to Radiative	15-25
Incandescent Light	Electrical to Radiative	2-5
Plant Photosynthesis	Radiative to Chemical	1

Where Does Your \$1 of Gas Go?

4% idling **loss**

3% transmission **loss**

74% heat **loss**



3% acceleration

3% accessories

6% rolling friction

7% air drag

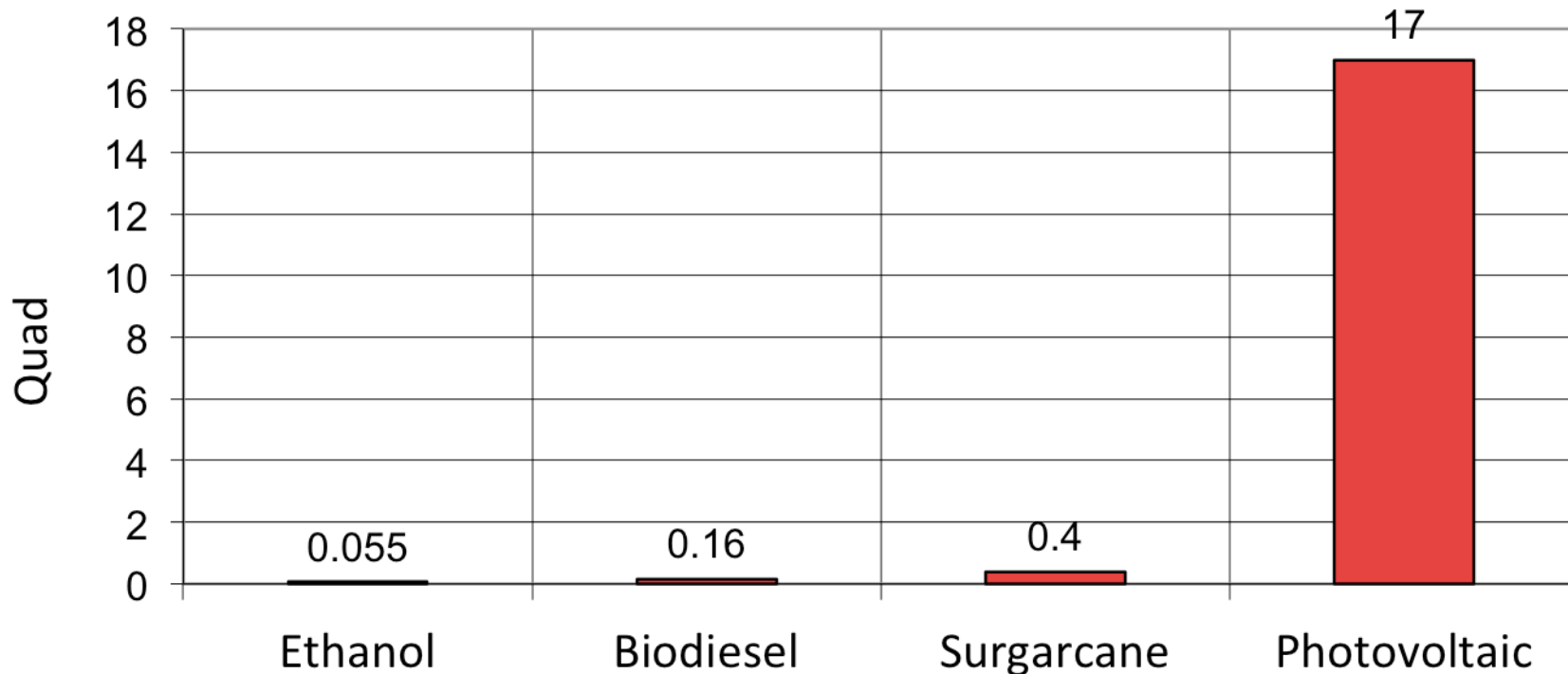
Gasoline Will be Hard to Replace.

Fuel	Energy per Weight (MJ/kg)
Hydrogen	114 (10 liquid, 5 compressed gas)
Gasoline	48
Plant Oil (bio Diesel)	38
Ethanol	28
Common Coal	22
Natural Gas (STP)	20
Air Dried Wood	15
Potatoes	4
Carbon Fiber Flywheel	0.8
Fruits and Vegetables	0.6-1.8
Lithium Batteries (400C)	0.2
Lead Batteries	0.1

Plant Oil as a Fuel?

- Energy production, all arable land in the US cultivated with soybeans (bio-diesel): 25.6 Quad
- US transportation consumption (2004): 27.8 Quad

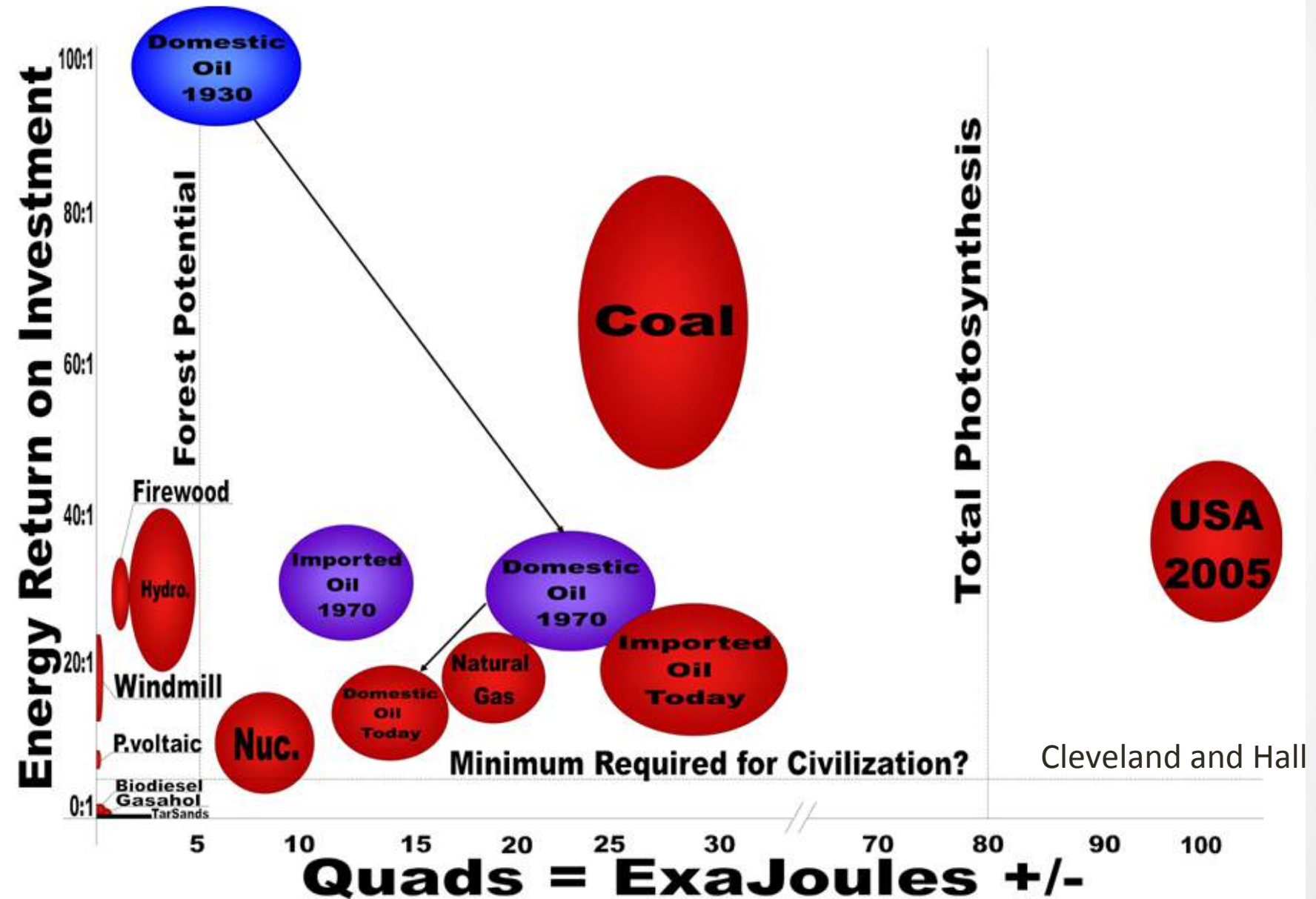
Energy Recovered per 10,000 km²



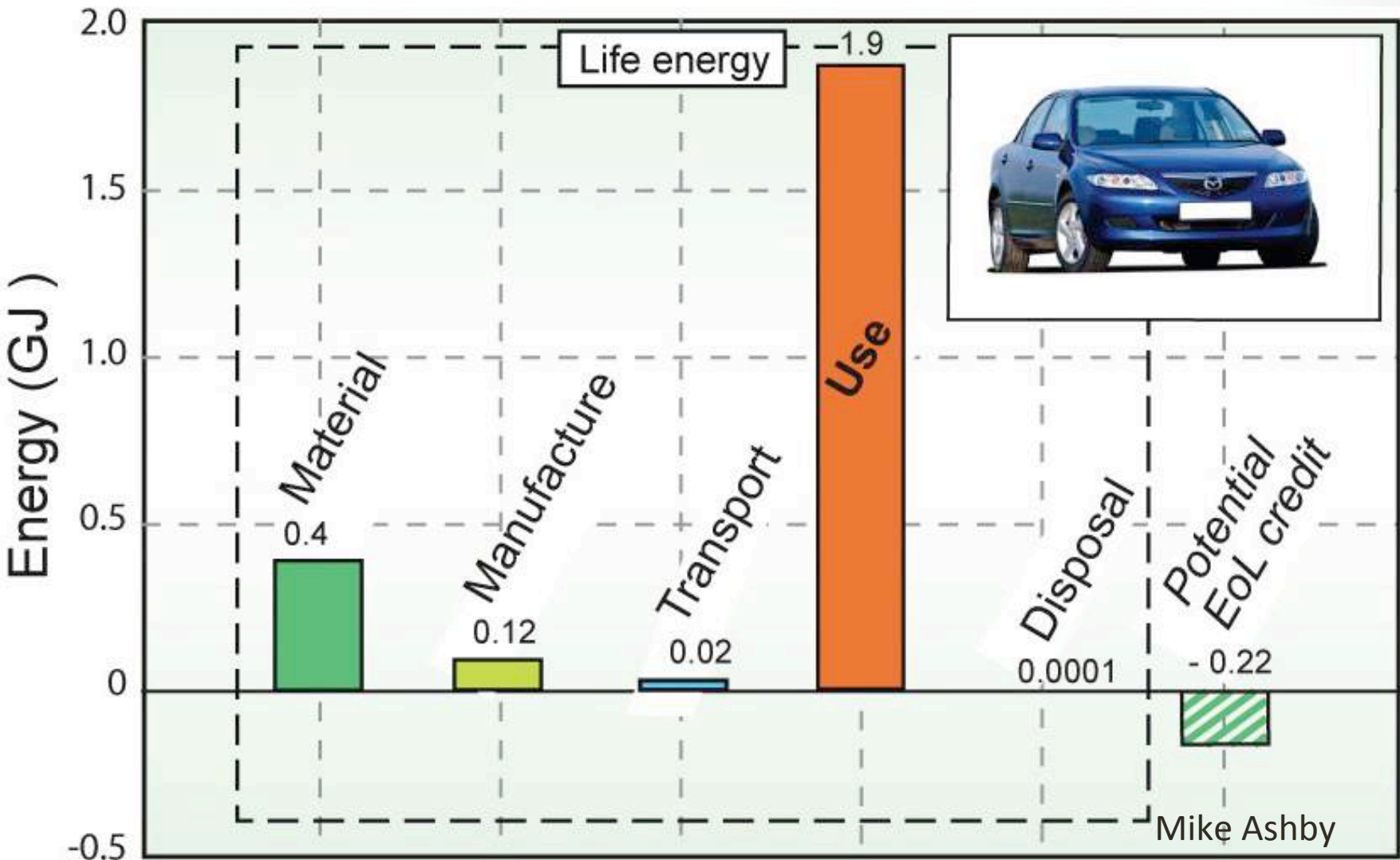
How Many New Power Plants to Convert to Electric Vehicles?

- Annual US transportation needs (primary energy): **27.8 Quad**.
- Assuming a 50% efficient electric car we need **10.8 Quad** of fuel energy to replace our 20% efficient gasoline cars.
- For a 1,000 MW power plant (coal, gas or nuclear) operating at 80% capacity this is **450 new plants** (current US total is 950 plants).
- For a 2MW windmill operating at 40% capacity this is about **452,000 windmills**.
- For 20% efficient solar panels this is **21,400 km²** (the size of New Hampshire).

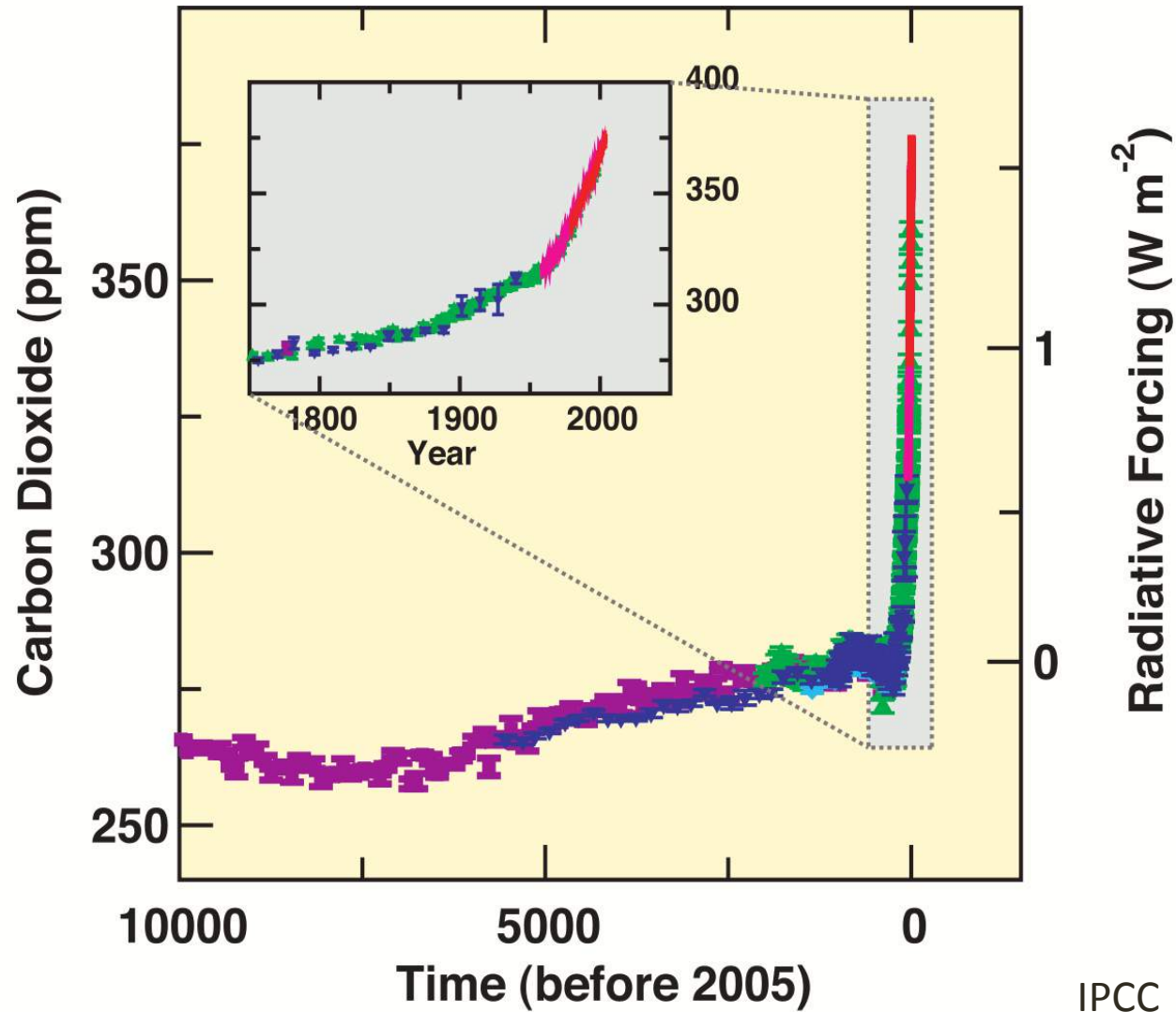
EROEI.



Embodied Energy. (per 1000km)



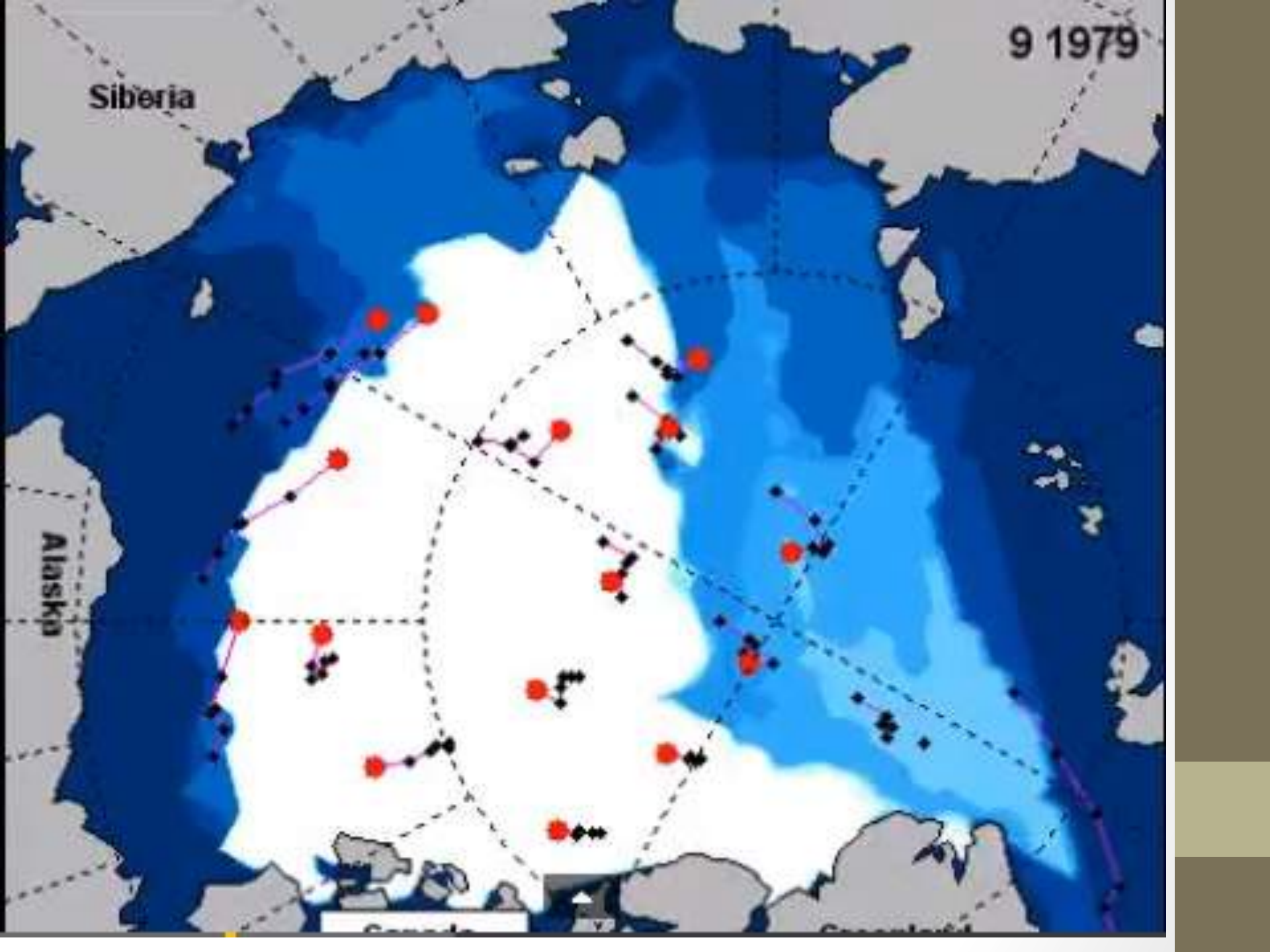
CHANGES IN GREENHOUSE GASES FROM ICE CORE AND MODERN DATA



9 1979

Siberia

Alaska



The Earth is Warming.

Alaska:
Face of
Glacier in
2001



Alaska:
Face of
Glacier in
1951

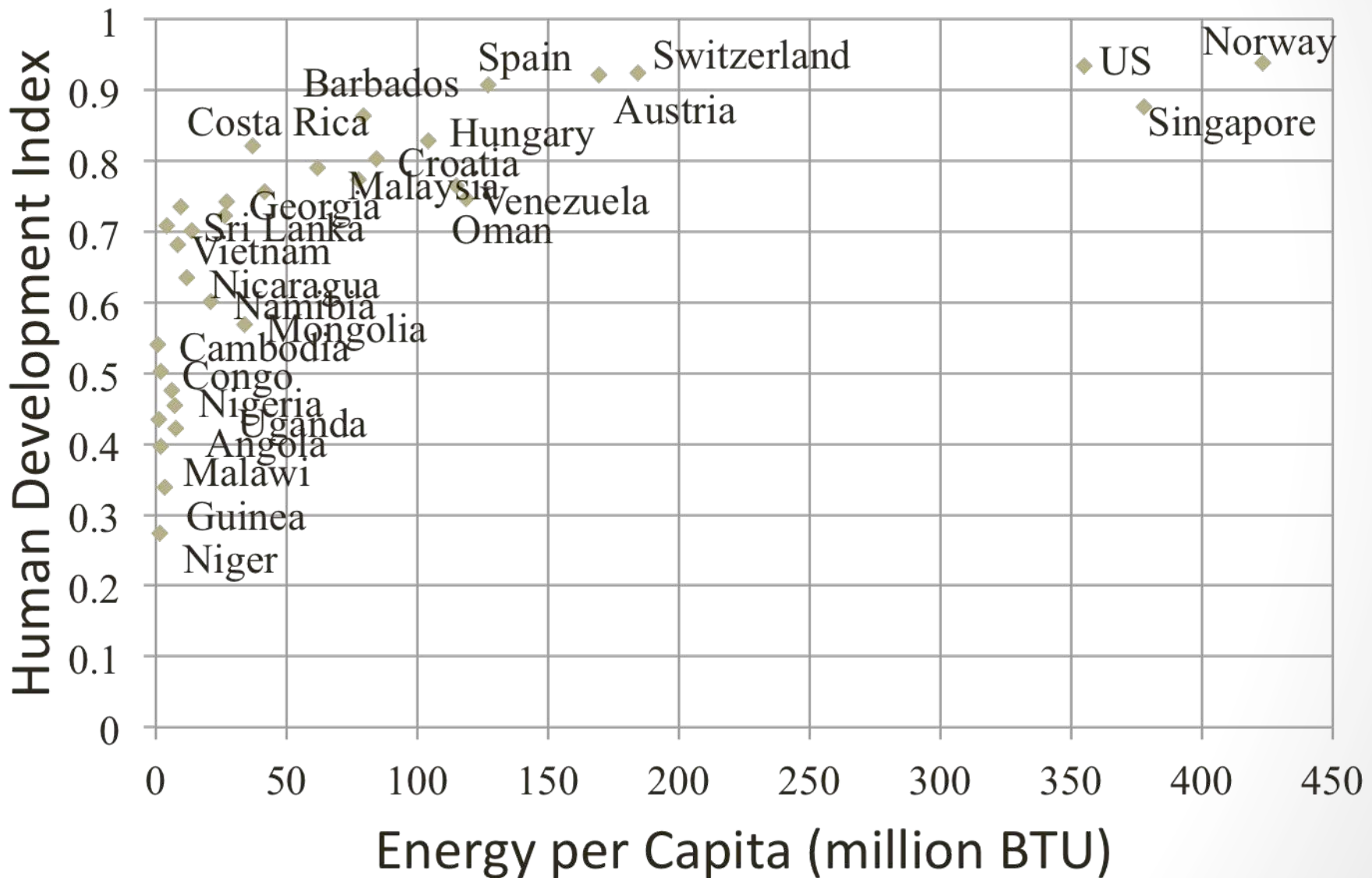
Dollar per *MWh* for Electricity.

Source	Capital Cost	Fixed O&M	Fuel Cost	Transmission Cost	Total Cost
Coal	57	3.7	23	3.5	87
Gas	20	1.6	55	3.8	80
Nuclear	82	10	9	4	105
Biomass Landfill	64	9	25	4	102
Geothermal	77	22	0	5	104
Hydropower	57	7	0	5	69
Wind, onshore	73	10	0	8	91
Wind offshore	171	29	0	9	210
Solar Thermal	220	21	0	10.6	252
Photovoltaic	342	6.2	0	13	362
Conservation					-60

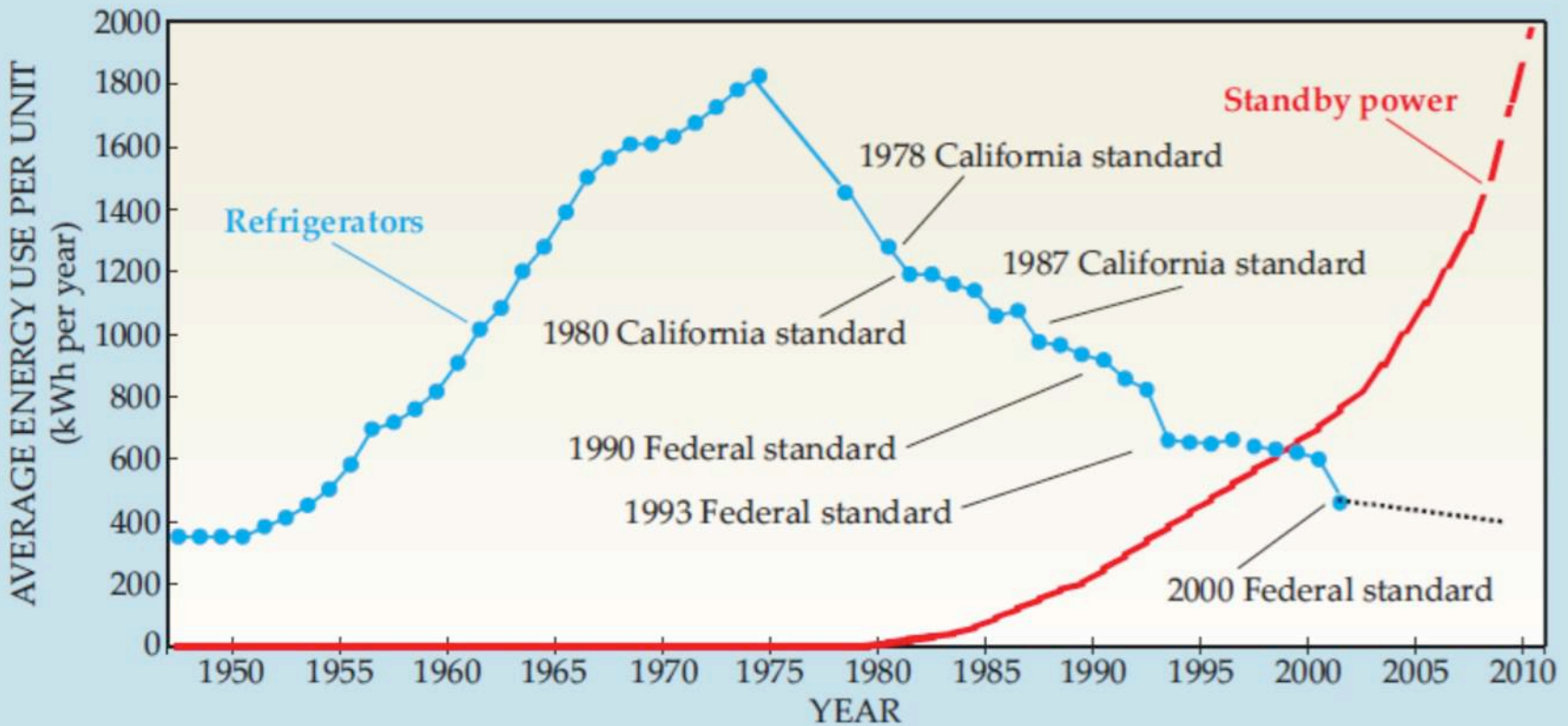
Risk.

Risk	Loss of Life Expectancy, Days
Alcoholic	4000
Smoker	2500
Cancer	1300
20% Overweight	1100
Grade School Dropout	950
Motor Vehicle Accidents	210
Air Pollution	75
AIDs	55
Spouse Smoking	53
Radon	45
Fire	25
Poison	25
Nuclear Power	2

Energy versus Living Conditions.

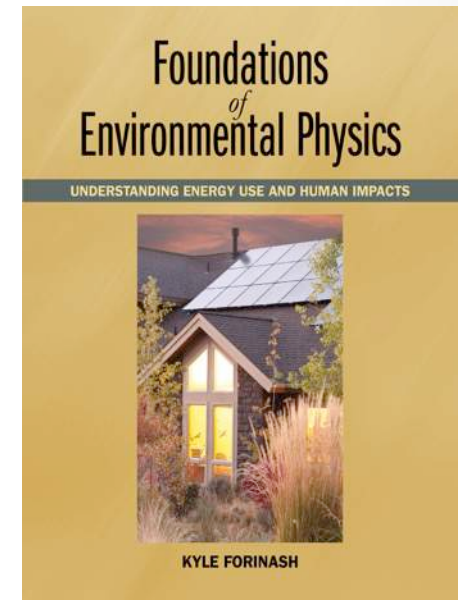


Refrigerators vs Personal Electronics.



Interesting Resources.

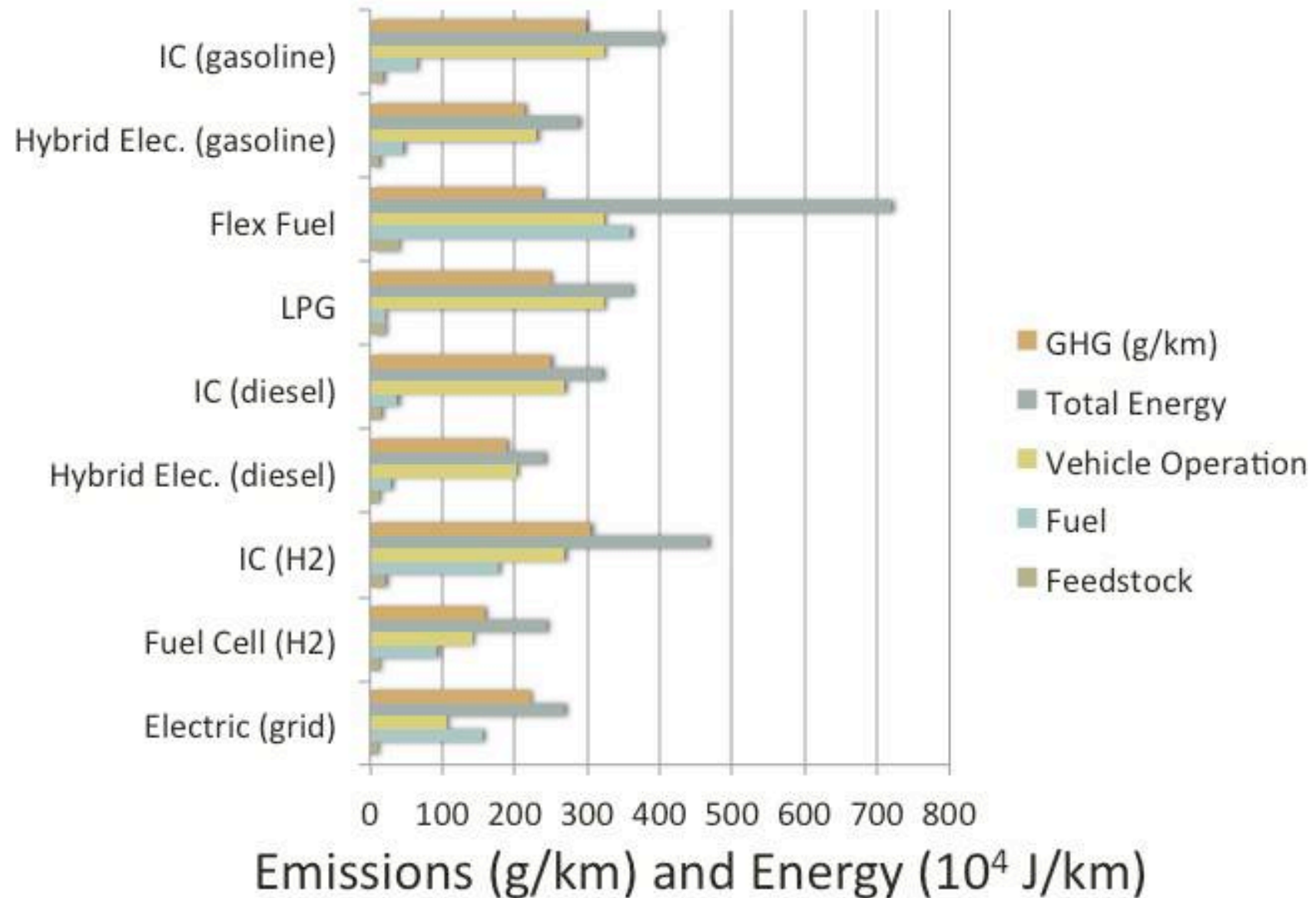
- EIA web site Energy Data <http://www.eia.doe.gov/>
- Oak Ridge Climate Data (CDIAC) <http://cdiac.ornl.gov/>
- Gapminder (Google) <http://www.gapminder.org/>
- Argonne Nat. Lab well to wheels Energy Spreadsheet <https://greet.es.anl.gov/>
- Educational Climate Model; EdGCM <http://edgcm.columbia.edu/>
- My Book (!) and web pages.
<http://homepages.ius.edu/kforinas/ClassRefs/EnviroRefs.html>



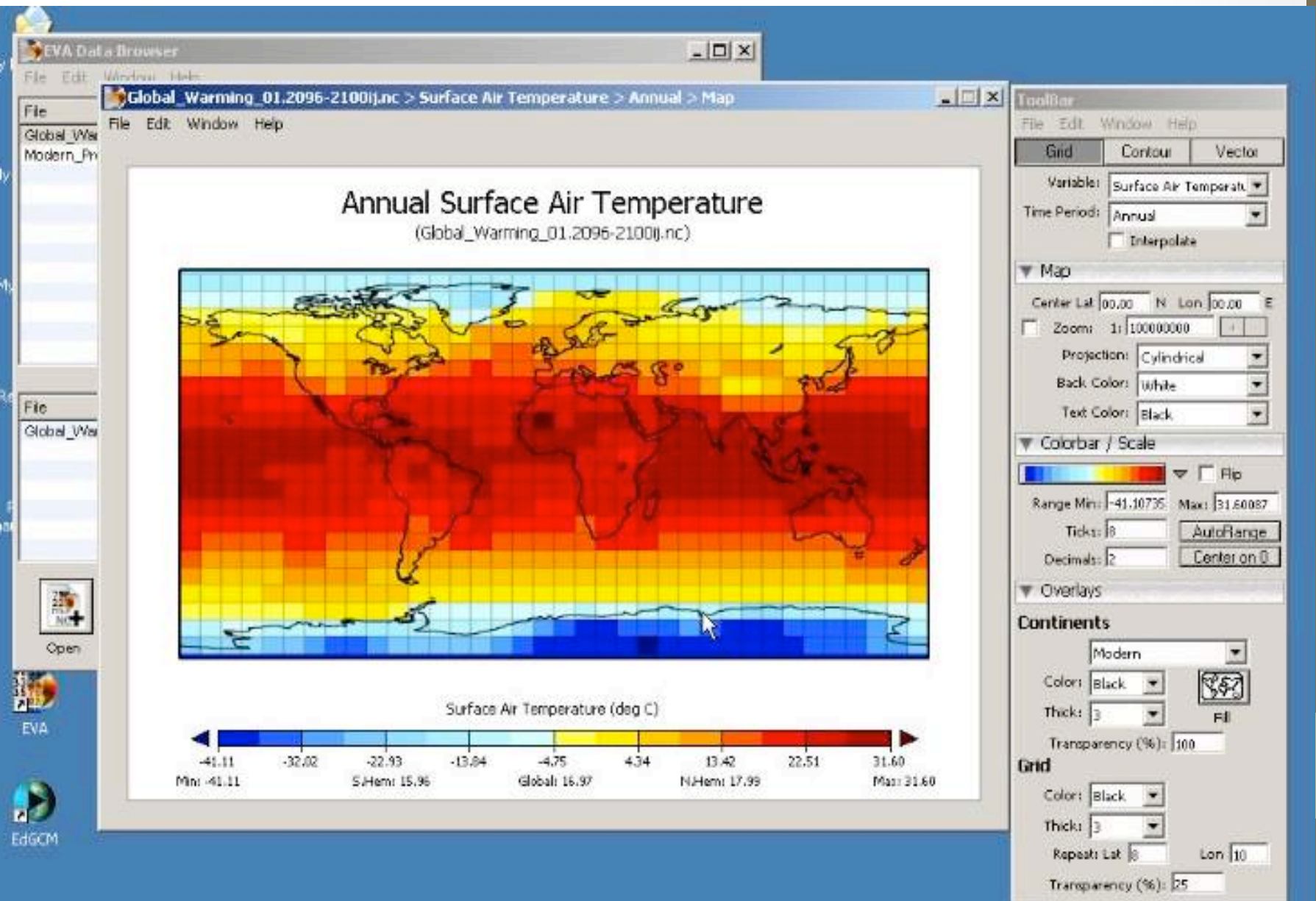
GapMinder.



Argonne NL Greet Model.

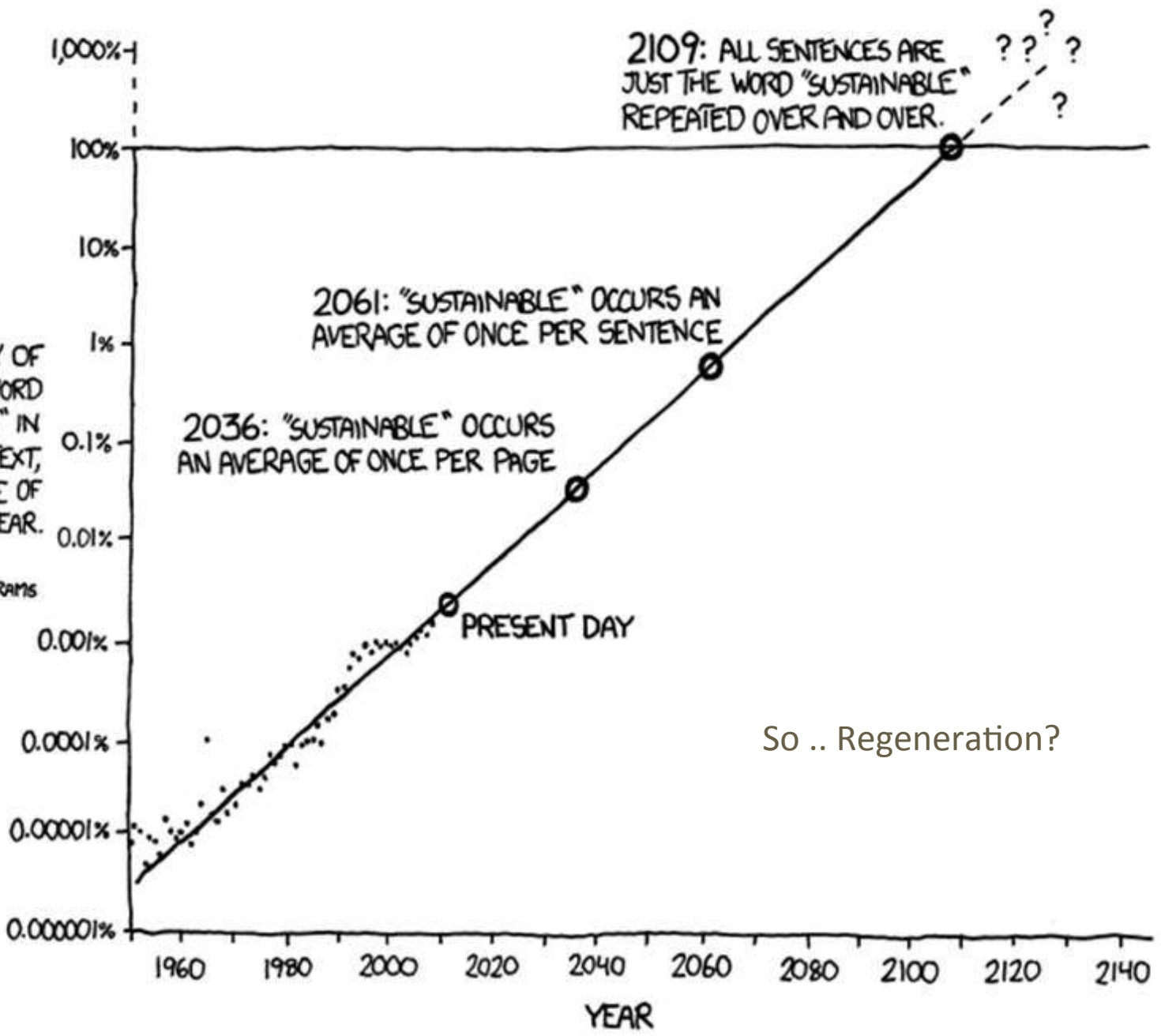


EdGCM.



FREQUENCY OF USE OF THE WORD "SUSTAINABLE" IN US ENGLISH TEXT, AS A PERCENTAGE OF ALL WORDS, BY YEAR.

SOURCE: GOOGLE NGRAMS



So .. Regeneration?

THE WORD "SUSTAINABLE" IS UNSUSTAINABLE.

Sustainability Certificate.

- Offers a holistic interdisciplinary approach.
- Engages students in relevant civic engagement opportunities in the Southern Indiana - Louisville metropolitan region.
- Provides an alternative program for students interested in environmental issues but less interested in scientific occupations.
- Enhances the liberal arts experience with courses in the social sciences, humanities, natural sciences, and business.
- More: Science Education Resource Center at Carleton College: http://serc.carleton.edu/sisl/sustain_in_physics.html

Requirements. (28 Credit Hrs.)

Primary:

PHYS-P 120 Energy and Technology

PHIL-P 237 Environmental Ethics

SOC-S 309 The Community

Secondary (select one from each):

Environmental Sustainability:

EDUC- Q 450/550 Science Technology and Society in a Changing World

BIOL-L 200 Environmental Biology

Social Sustainability:

SOC- S 305 Populations and Human Ecology

SOC-S 308 Global Society

Economic Sustainability:

ECON- E 363 Environmental and Natural Resources

POLS-Y 376 International Political Economy

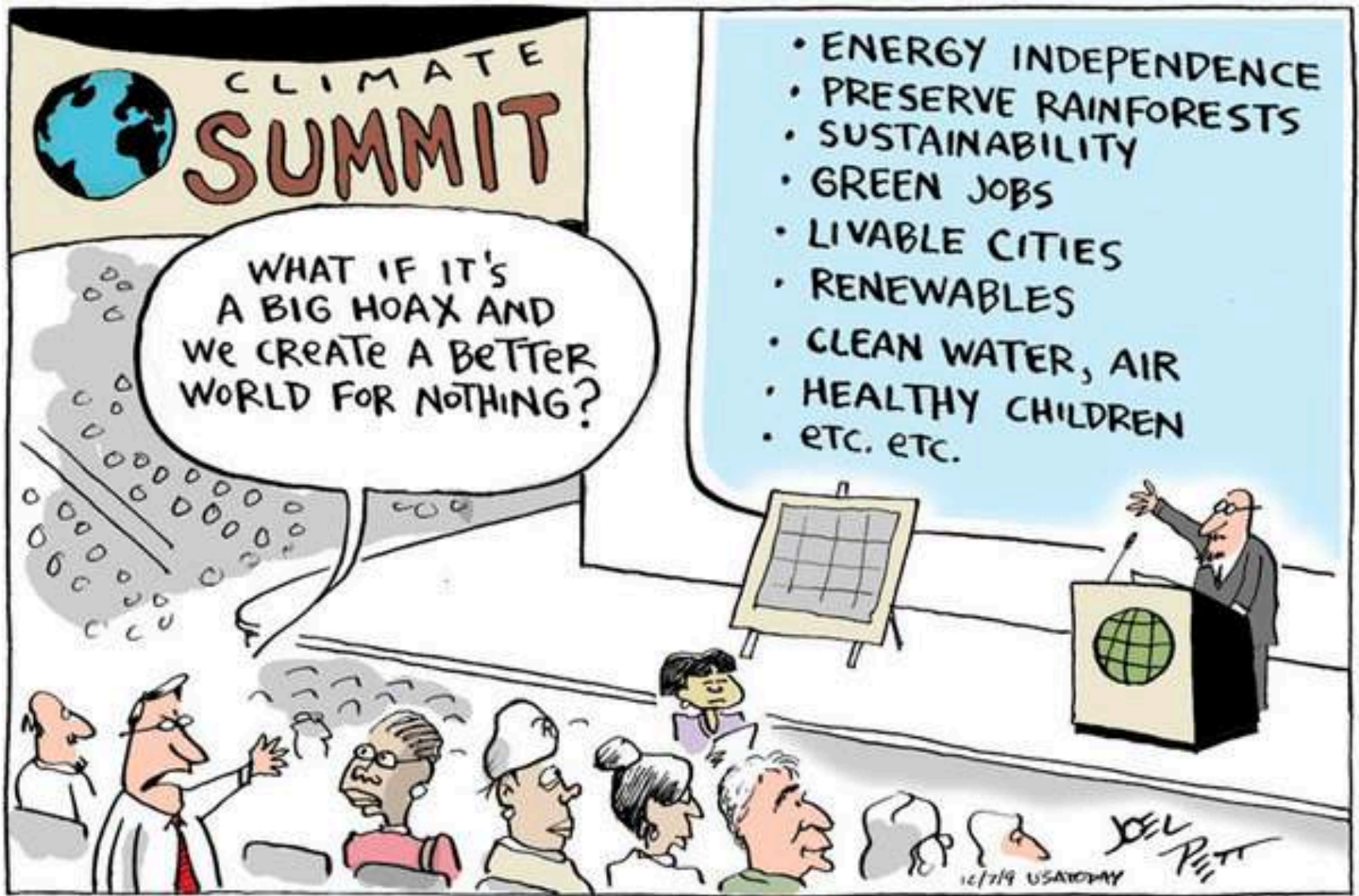
Specialization areas of 8-9 semester credits addressing:

environmental, economic, and social impact.

List of 26 possible courses in BIO, PHYS, CHEM, SOC, ECON, POLS, PSY

Career Opportunities.

- The US Environmental Protection Agency (EPA), and similar such departments in other countries.
- The Department of the Interior, the National Parks System.
- City and state departments of natural resources and environmental management.
- Private agricultural and resource management firms.
- Policy advocacy and grassroots organizations at all levels.
- Major non-profit organizations such as World Resources International, World Watch, World Wildlife Fund.
- International organizations, such as the World Bank or United Nations (focusing on water, agriculture, resources, food, energy).
- Financial markets focusing on carbon permits, other pollutants.



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