

# Engineering, Ethics and Society: Ethics of Population & Resources

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Dr. Gershon Weltman  
Engineering 183EW, UCLA SEAS  
Lecture 8

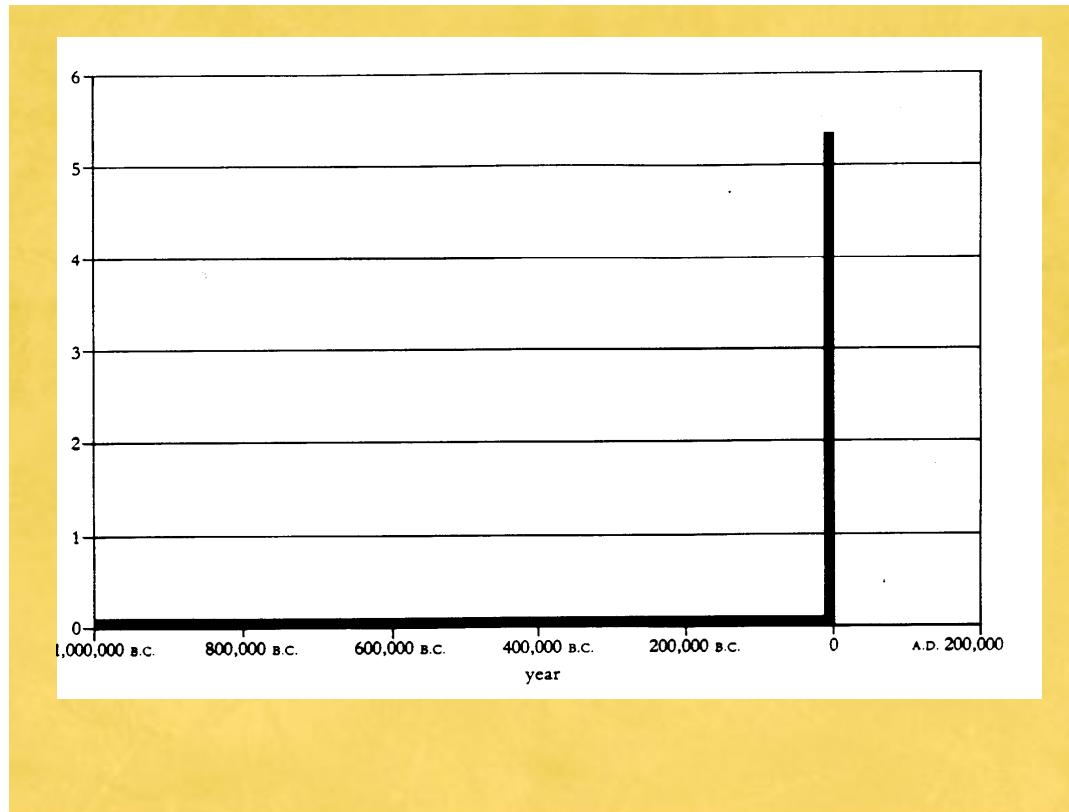
# Lecture Contents

- World Population: History, Factors, Projections
- Resources and Consumption: Water, Land, Energy
- Energy Sources and Evolution
- Viable Energy Alternatives
- Utilitarian Benefits of Affluence
- Utilitarian Costs of Affluence
- Ethical Dilemma: Today's "Tragedy of the Commons"
- A Global Ethical Framework
- Ethical Duties of Engineers
- Difficulty of Predicting

# Population History is Startling

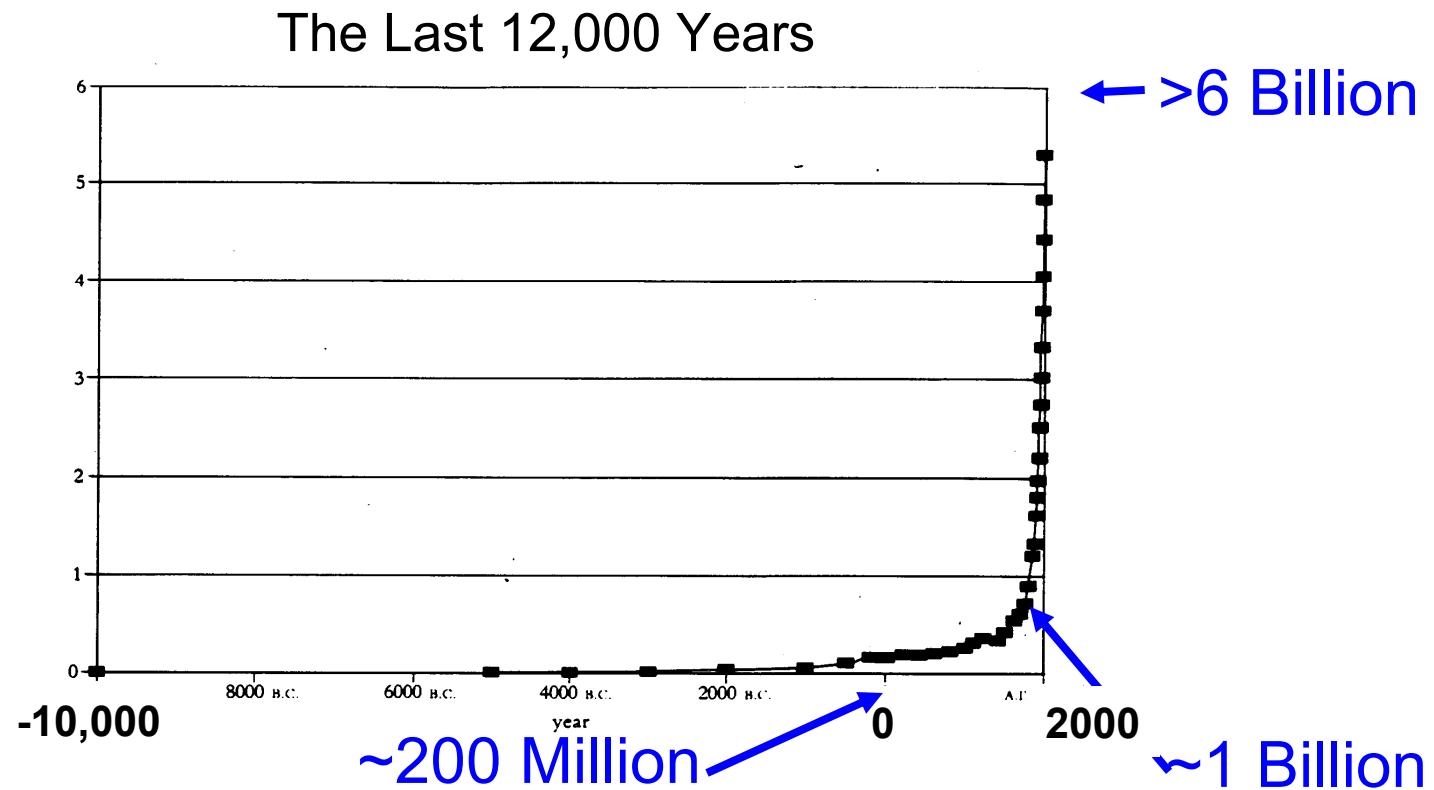
- Universe            ~13.8B Years
- Earth              ~4.5B Years
- Bacteria          ~2.5B Years
- Multicell Biota    ~600M Years
- Human Species    ~2M Years
- Homo Sapiens     ~150K Years
- Cognitive Revol.    ~70K Years
- 1 Billion People    ~200 Years

A Million Years of Human Population

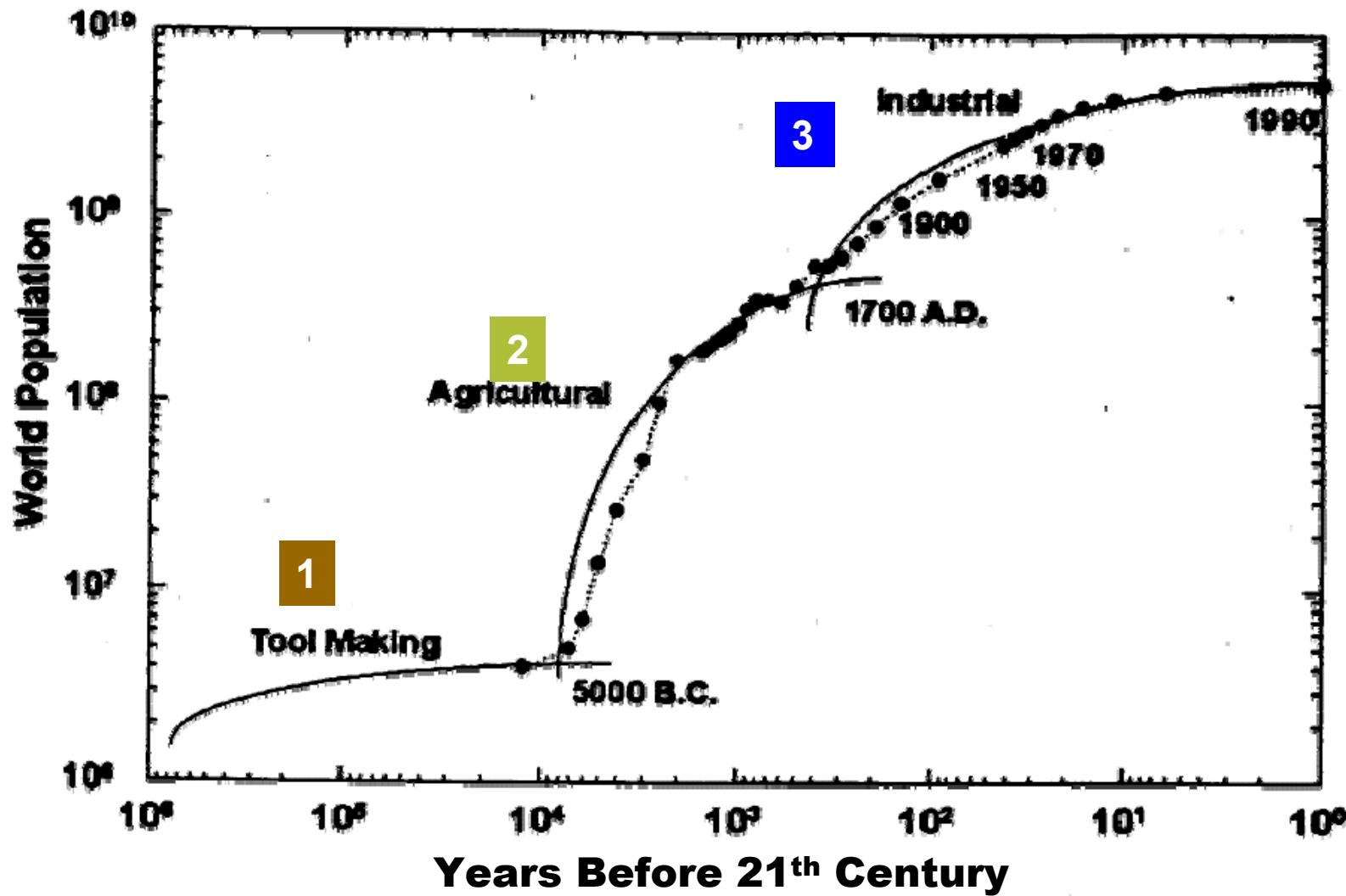


Rutger Bregman: “If we think of all life as occupying one day, we arrived at 11:59 PM.”

# A Closer Look



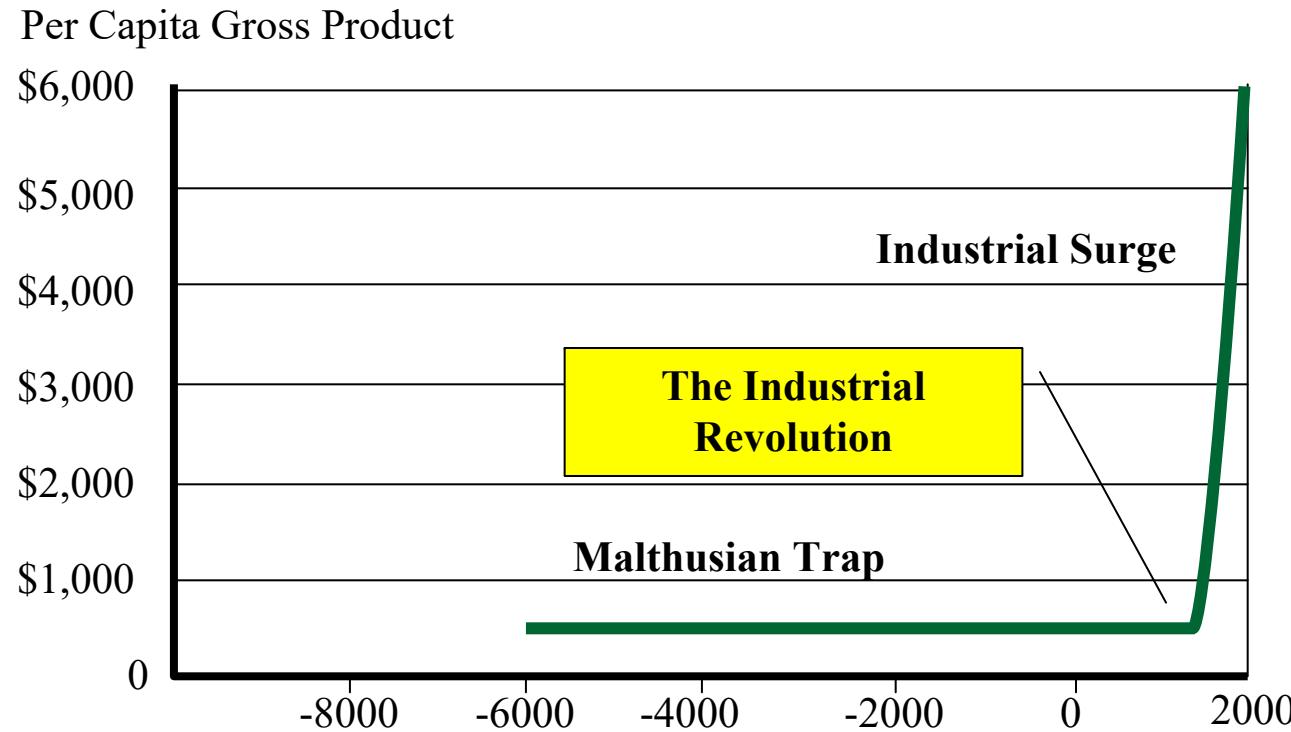
# Three Population Growth Eras



# Main Population Growth Factors

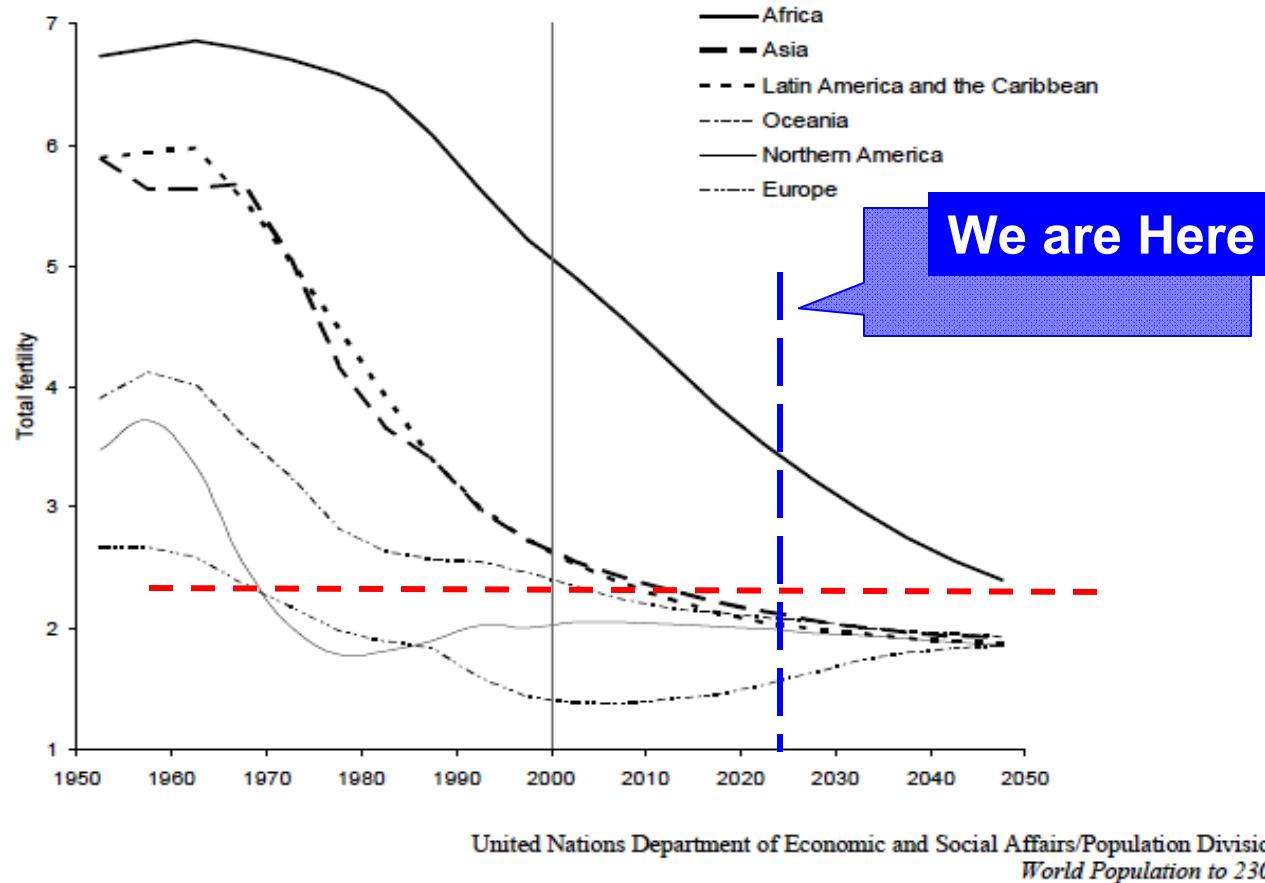
- Agriculture
  - Fixed locations
  - Local Food Production
  - Animal Domestication
- Urbanization
  - Shelter
  - Water and Energy
  - Sanitation and Health Services
- Industrialization
  - Product Availability
  - Worldwide Economic Growth
  - Increased Family Resources
- Medical Science & Technology
  - Anti-Infection: Cleanliness, antibiotics
  - Hospitalization: Isolation, intensive care
  - Medicines: Inoculation, disease treatment
  - Nutrition: Health, growth, fertility
  - Longevity: Infant and young adult survival

# Dramatic Effect of Industrialization



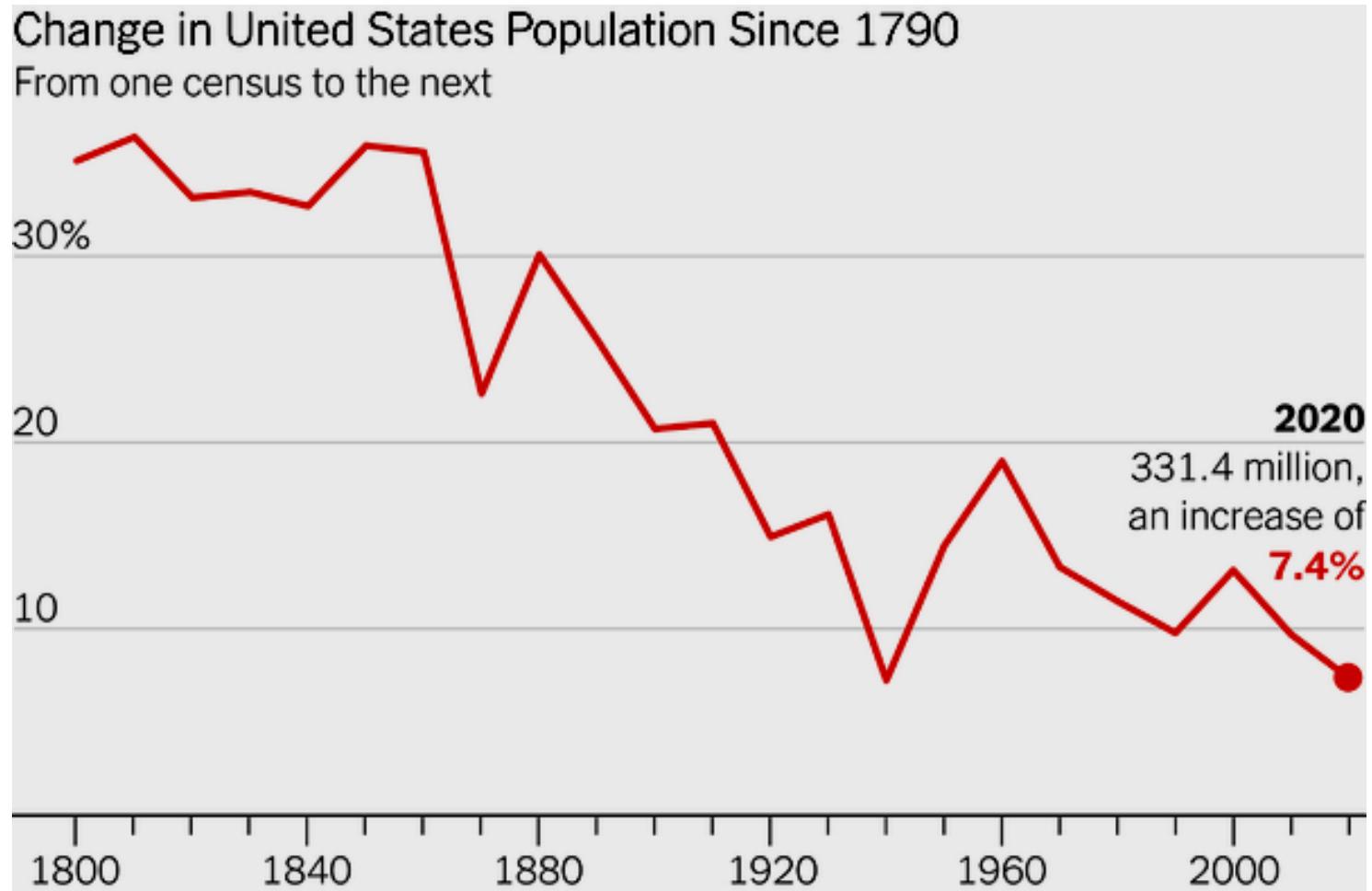
Thomas Malthus observed in 1798 that pre-industrial advances in technology resulted in brief increases in population, not in an improved standard of living. The industrial revolution initiated great financial growth, *but not evenly spread.*

# UN Estimated Fertility Trends



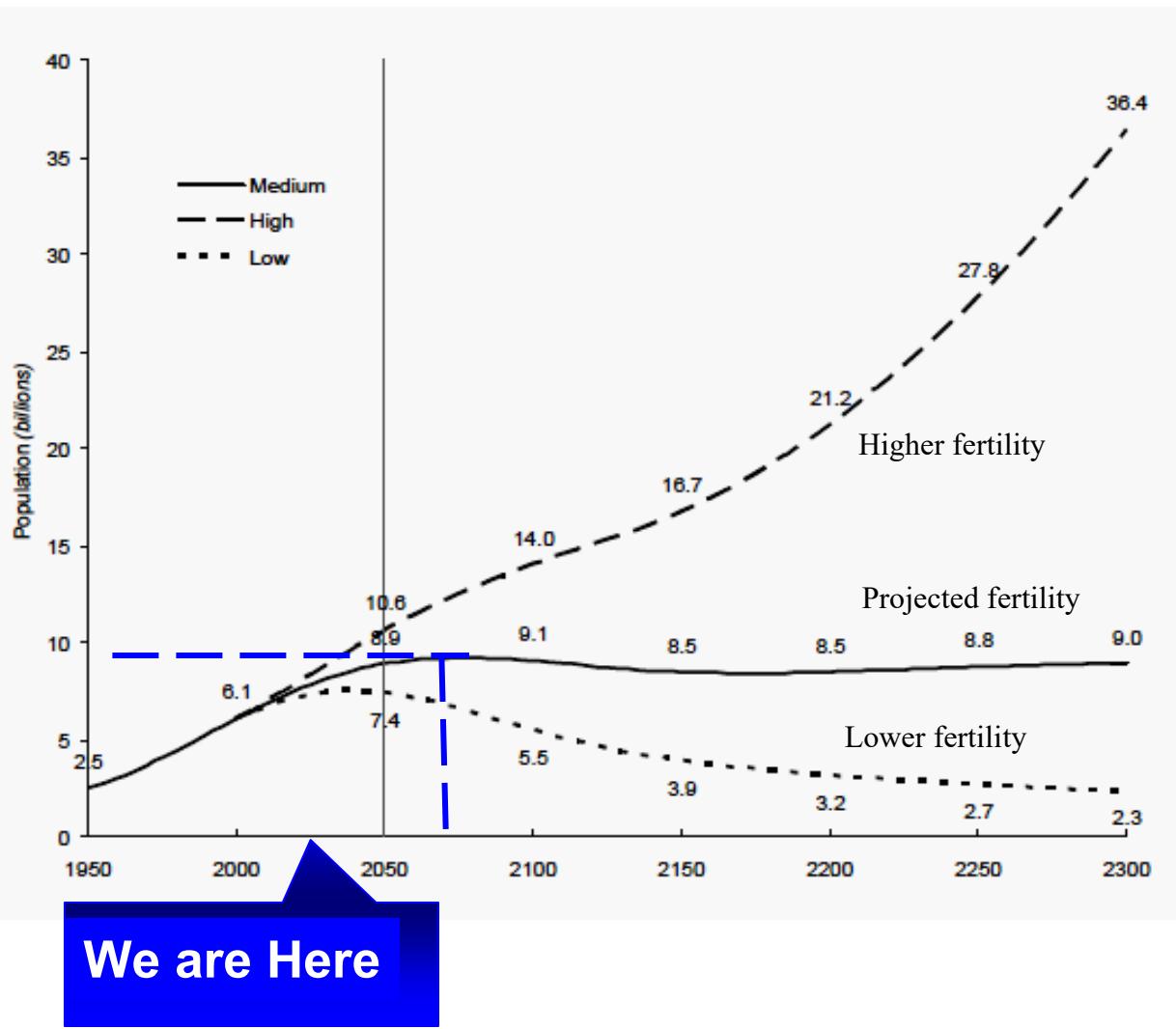
- Fertility rate is average number of childbirths per woman
- Above 2.1 is growth, below 2.1 is decline
- Industrialized nations are well below 2.1
- Developing nations are still above the 2.1 but dropping below
- Urbanization, need for education, and desire for **economic affluence** contribute to the drop

# US Population Growth Slows Markedly



David Leonhardt, The New York Times, April 27, 2021

# UN World Population Projections



- Current Population ~8.0B
- Broad Projections
  - 5.5B - 14.0B by 2100
  - 2.3B - 36.4B by 2300
- Nominal Projections
  - 9.5B-10B at 2060
  - Then steady or decrease
- Long term projections depend on many factors that are not fully known
- Much uncertainty exists, for 21<sup>st</sup> & next centuries

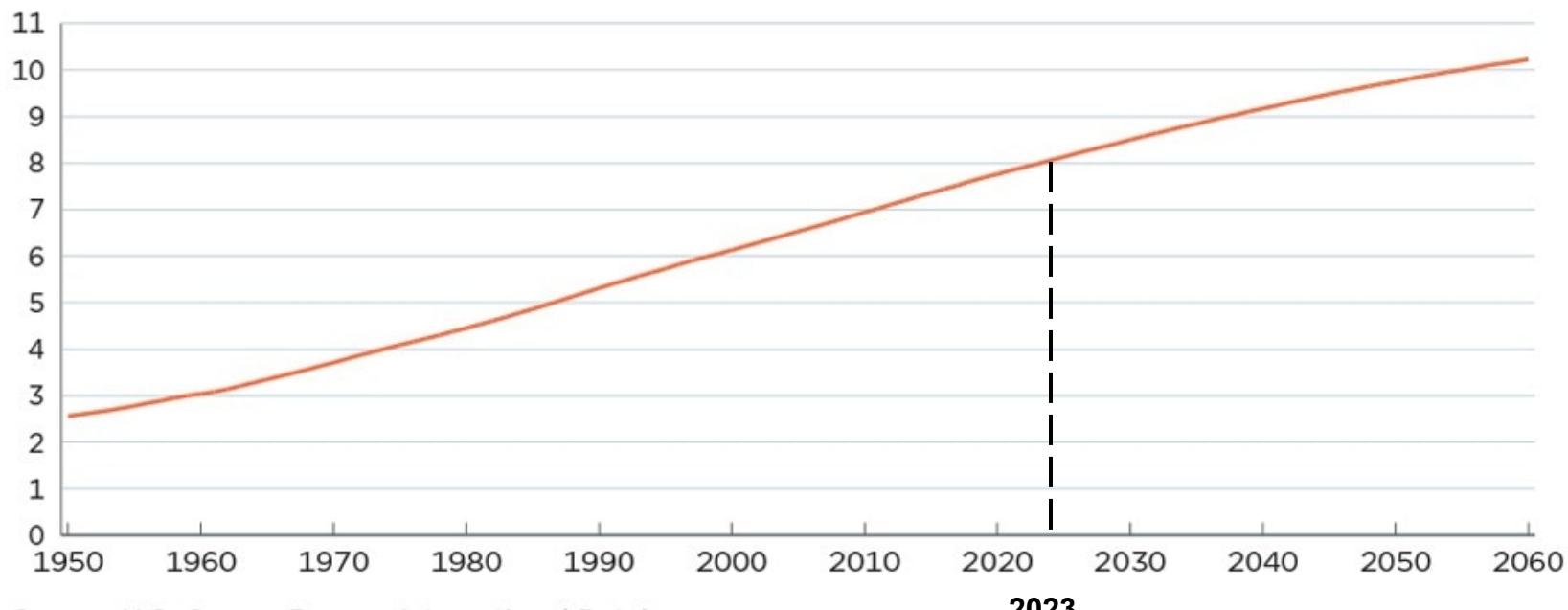
We are Here

# Near Term Detail

Figure 1a.

## Estimated and Projected World Population: 1950-2060

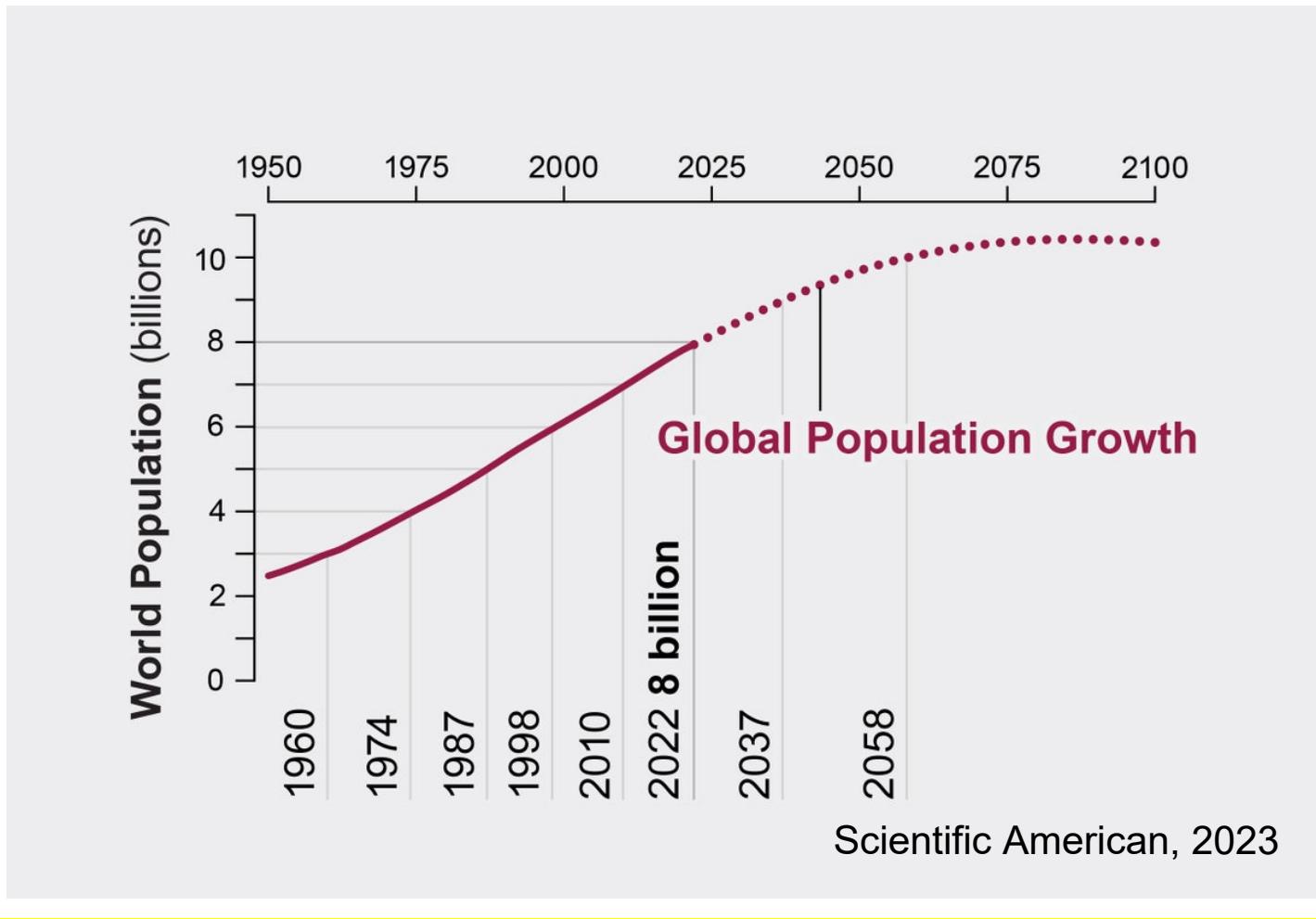
(In billions)



Source: U.S. Census Bureau, International Database.

2023

# Near Term Detail



Current estimates have world population leveling off at about 10 billion in ~50 years

# Worldwide Resource Consumption

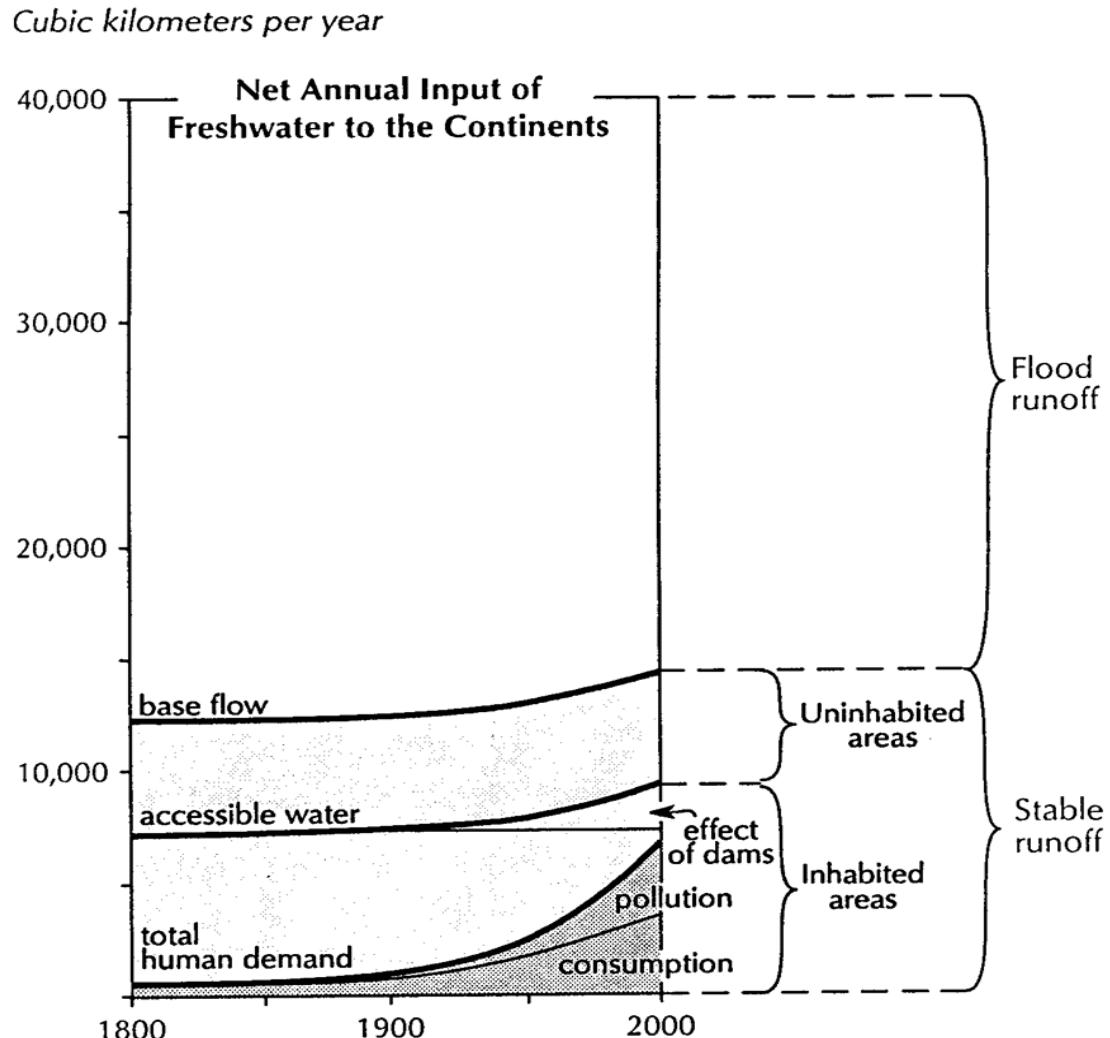
**Worldwide Research Consumption is:**

- High
- Getting higher
- Increasing faster than population

# Water Resources: Limits and Options

## Water availability:

- 33% is base flow
  - 23% is accessible
  - 10% is remote
- 67% is flood runoff
- We are near limits of presently accessible resources
- Need to exploit:
  - Water from more remote areas
  - Flood runoff
  - Other sources, e.g. local reclamation and ocean desalination



Meadows, et al., Chapter 3, *The Limits: Sources and Sinks*, 1992.

# LA's Remote Solution ~110 Years Ago

The LOS ANGELES Times

XXXII<sup>nd</sup> YEAR. THURSDAY, NOVEMBER 6, 1913.—EDITORIAL SECTION. POPULATION [By the Federal Census (1910)—1913] 1,000,000

## GLORIOUS MOUNTAIN RIVER NOW FLOWS TO LOS ANGELES' GATES

Inquiry.

### Los Angeles Investment Company Investigated.

Federal Authorities Act Under Orders from Washington Chiefs.

Complaints that Misleading Statements Have Been Sent Through the Mails by Officials of Elder's Companies to Cause Scrutiny of Books and Possible Re-organization—Stockholders to Be Protected.

Following a secret investigation by the Federal authorities of complaints to the effect that officers of the Los Angeles Investment Company have sent misleading statements of the financial condition of the concern through the United States mails, it is believed the affairs of the company will be brought to a crisis today. The investigation was ordered by United States Attorney-General McDonald and Postmaster-General Morris.

The plans of the government officials are twofold. One is to co-operate in every way with leading financiers of the city who, it is declared, wish to reorganize the investment company and safeguard the stockholders. The other is to examine books, documents, transfers and investments of every description to ascertain whether fraud has been practiced by any of the officers of the company.

It was admitted by the Federal authorities yesterday that C. A. McDonald, resident attorney of the office of the company, is under fire. He has been generally held responsible for the re-

the company, because it would permanently stop the loose talk started by enemies that had been current on the street for some time.

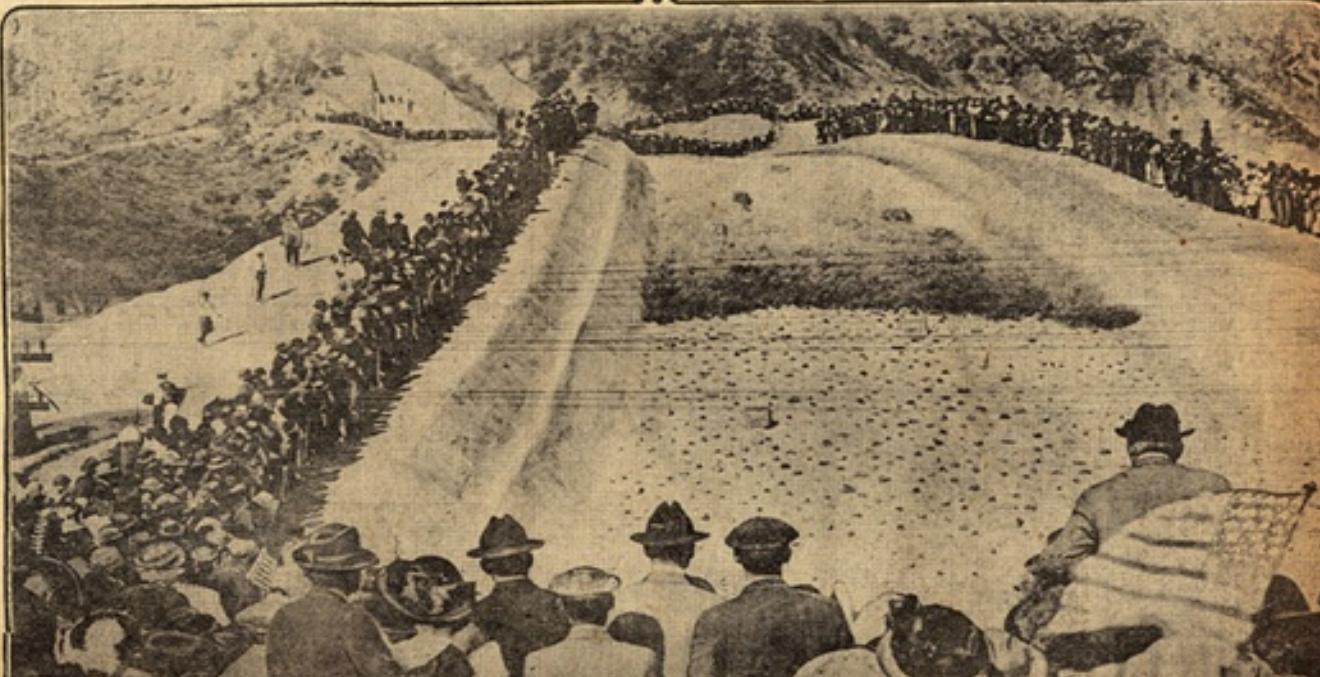
**ELDER NOT ALARMED.**

Mr. Elder is not alarmed by any investigation. He said yesterday that he has been fighting jealous competitors for many years and expects to continue doing so long as he lives. He attributes all his troubles to his enemies—and as to this he is probably right. He is certainly game and faces the situation bravely.

It is difficult to say whether the present condition of the company which he virtually brought into being is under attack by stockholders, by adverse banking interests or by men unfriendly to him personally.

The government officials usually pursue their course in silence. They do not call attention to the investigation and as a rule do not start an investigation so far-reaching as the one now on, at this one, without carefully weighing the facts.

Beyond confirming the fact that United States District Attorney Schlesinger and several postoffice inspectors are investigating the financial books of the Los Angeles Investment Company, nothing could be learned.



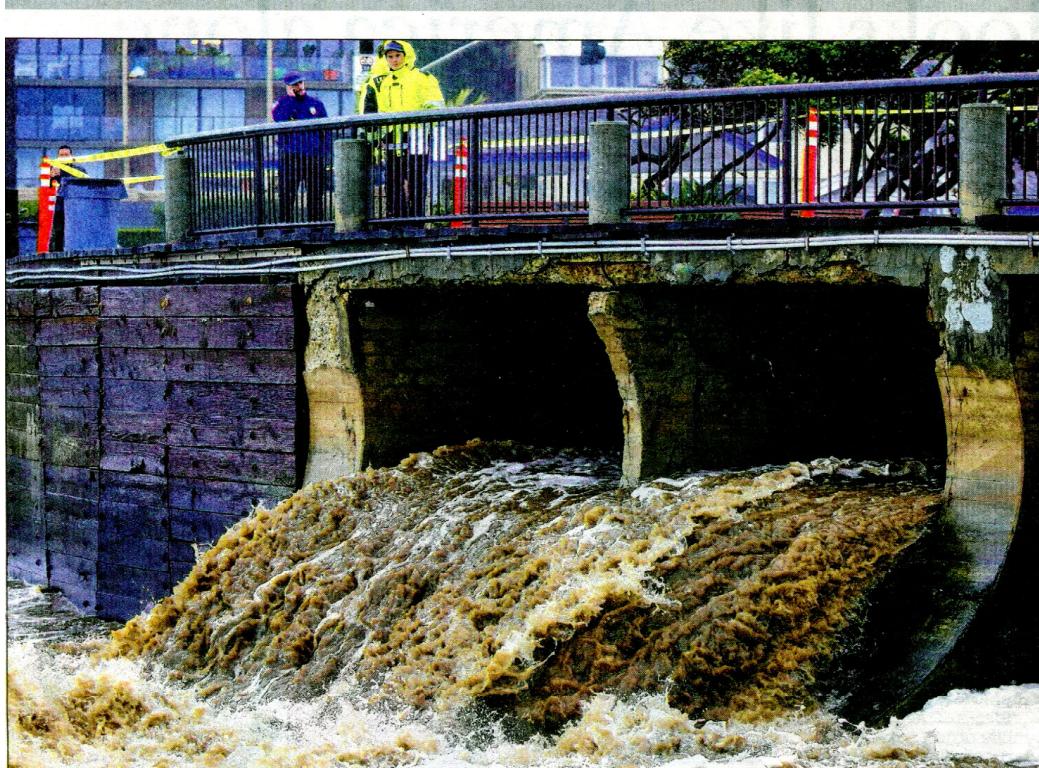
California civil engineer William Mulholland promoted and delivered an aqueduct.

# LA's Runoff Problem Today

\$2.75 DESIGNATED AREAS HIGHER © 2019 SFVN



WEDNESDAY, FEBRUARY 20, 2019



KENT NISHIMURA Los Angeles Times

**MOST OF THE RAIN** that falls in urban areas eventually reaches the ocean, as shown in Laguna Beach.

## Wet winter mostly wasted

California has gotten a lot of rain, but most of it's been lost to the ocean. Experts are seeking how to capture more runoff.

# LA's Solution Today

SATURDAY, FEBRUARY 23, 2019 :: LATIMES.COM



GENARO MOLINA Los Angeles Times

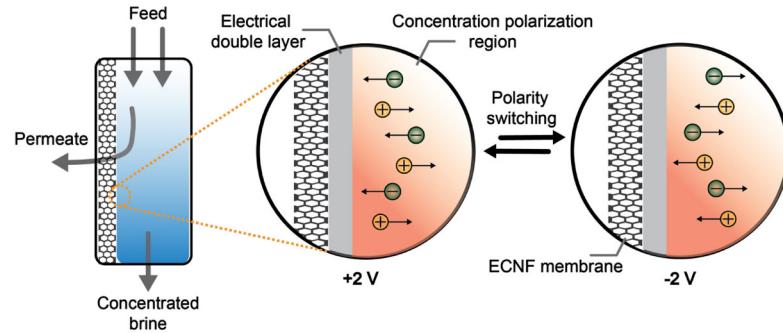
A KEY ELEMENT in L.A.'s water recycling plan is the Hyperion water plant, which the city wants to upgrade so purified water can be pumped inland and injected into the aquifers that underlie the L.A. Basin.

## L.A.'s bold goal to turn waste to drinkable water

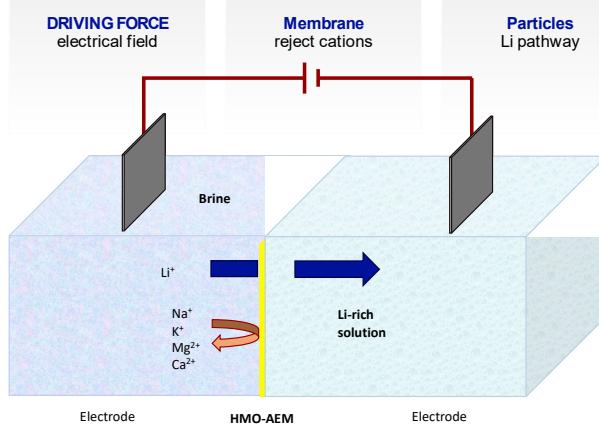
Recycling plan lines up technology and political will, but lacks money

# UCLA is Contributing to Solutions

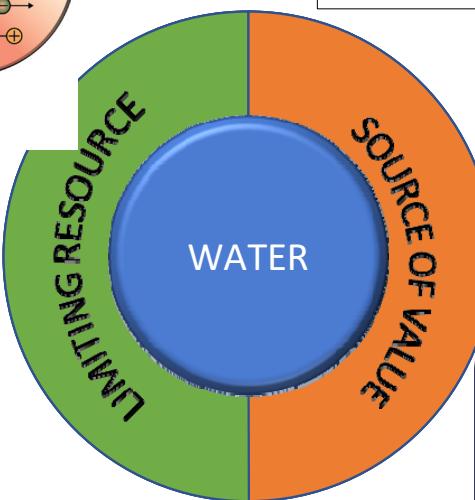
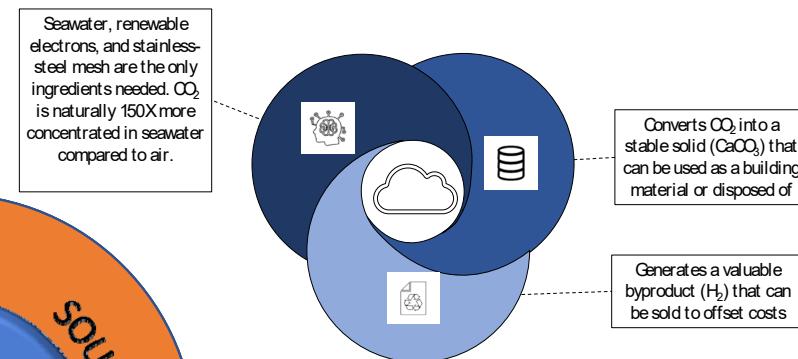
## Water Treatment and Desalination



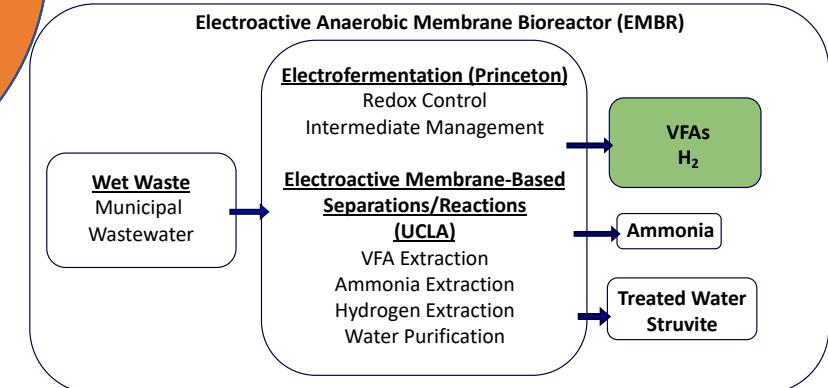
## Lithium Extraction from Brines



## CO<sub>2</sub> Capture and Sequestration from Seawater



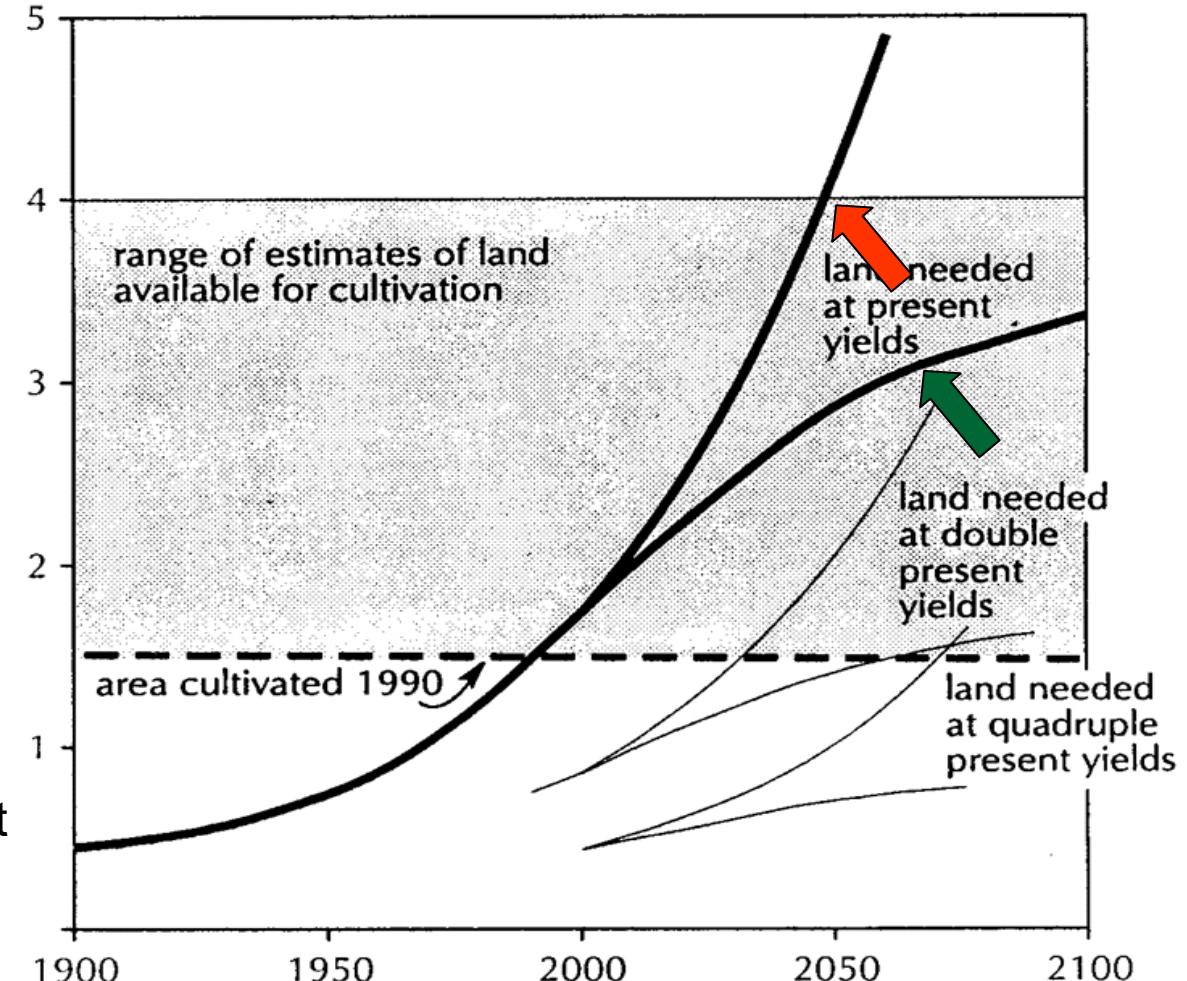
## Extraction of Energy/Chemicals from Wastewater



Courtesy of SEAS Prof. David Jassby, Civil and Environmental Engineering

# Land Resources: Limits and Options

- Available land will soon be inadequate at present agricultural yields
- Sufficiency means:
  - More land under cultivation, or
  - At least 2x yields
- Land losses -- Situation is complicated by greater use of cropland for non-food purposes such as biofuels
- DNA biotechnology – Yields can increase by DNA engineering, but possibly at a cost



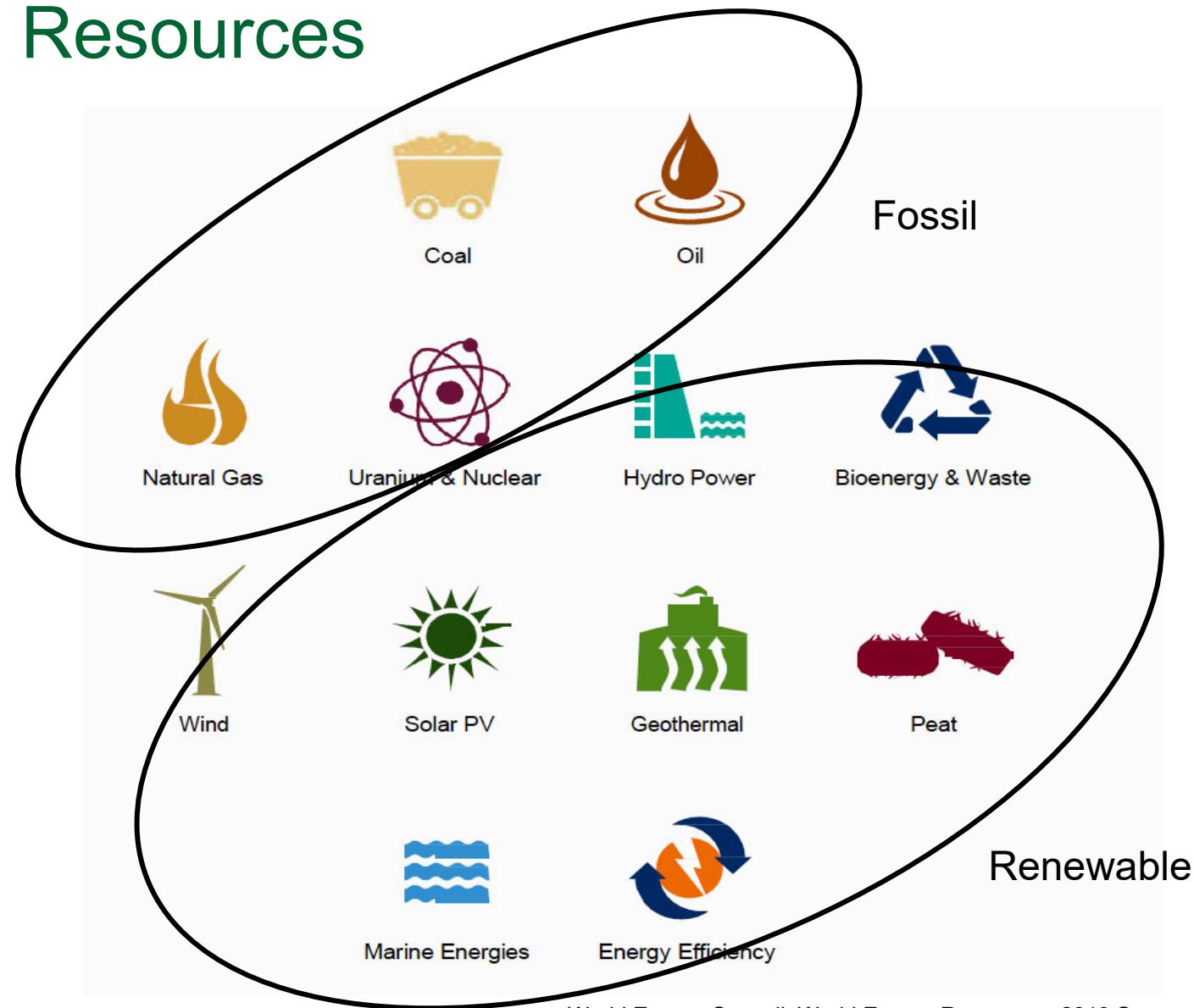
Meadows et al, Chapter 3, *The Limits: Sources and Sinks*, 1992

# Another Potential Direction: Up



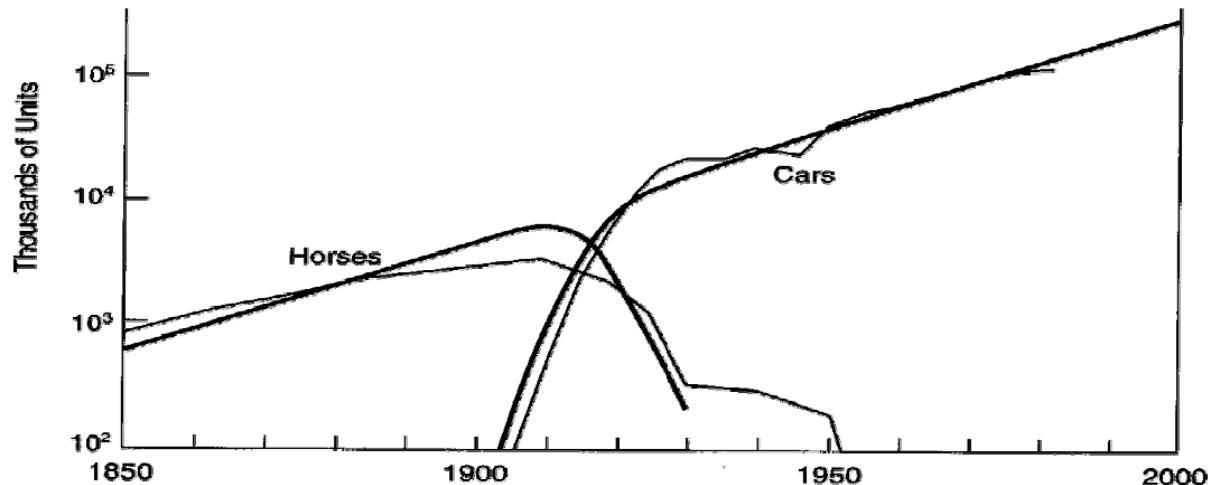
Vertical farming may be a solution to the problem of limited land area

# Energy Resources



World Energy Council, World Energy Resources, 2013 Survey Summary

# Energy Technology Evolves



Cars replaced horses as technology created new transportation needs

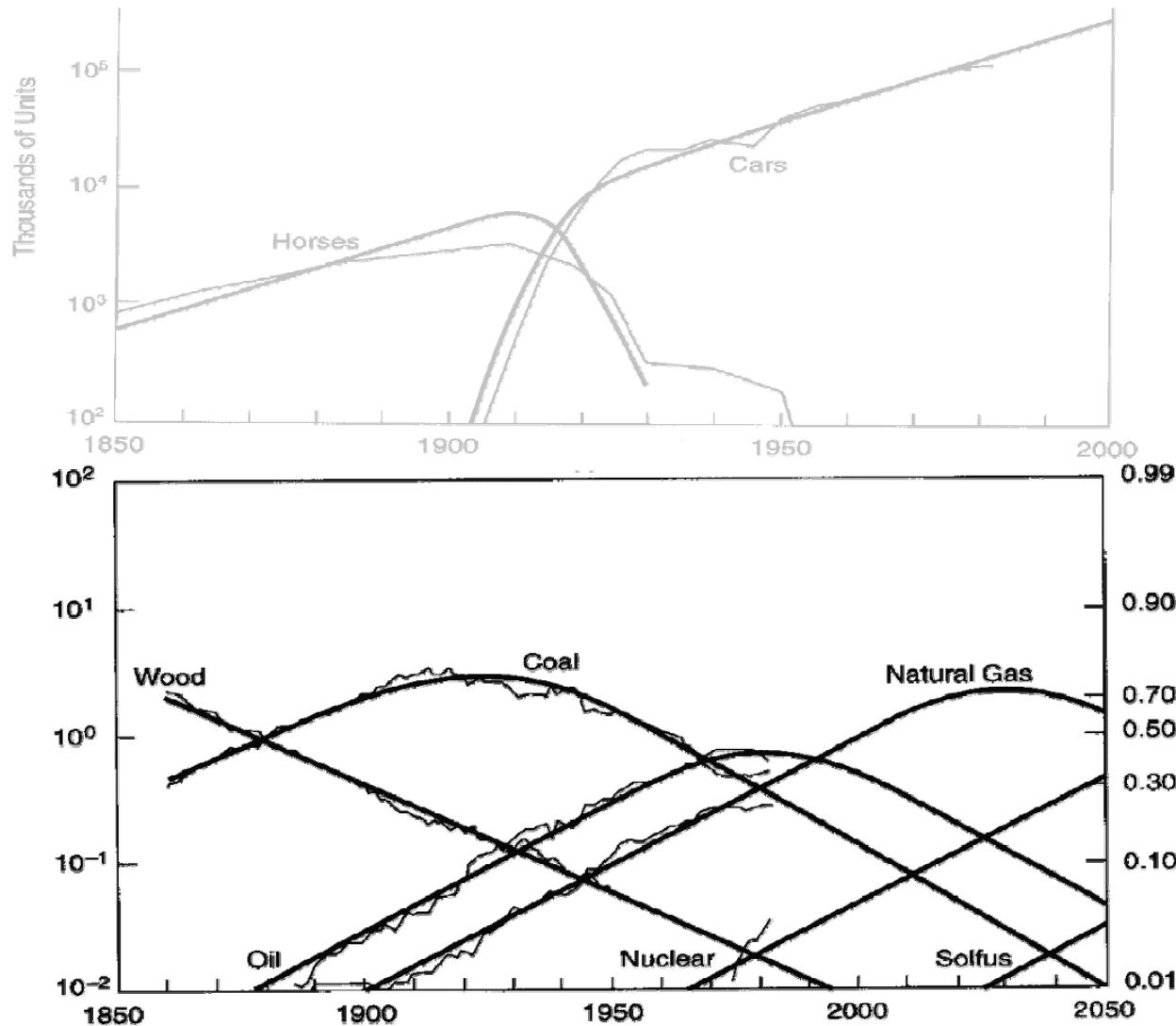
Ausubel, J., and H.D.Langford, Eds., Technological Trajectories and the Human Environment, National Academy Press, Washington, D.C., 1997,

# Volkswagen Saw the Trend



**"It was the only thing to do after the mule died."**

# Energy Technology Evolves

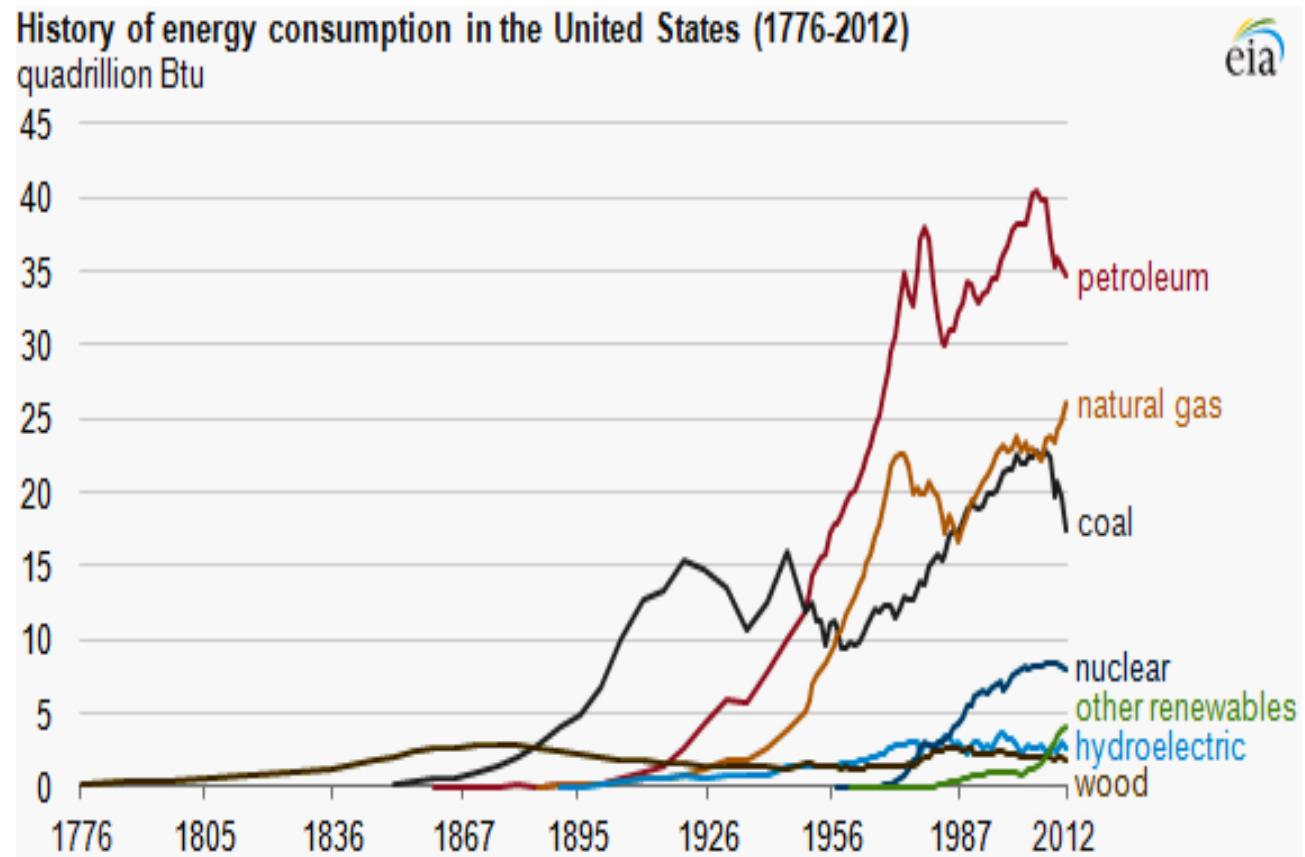


Cars replaced horses as technology created new transportation needs

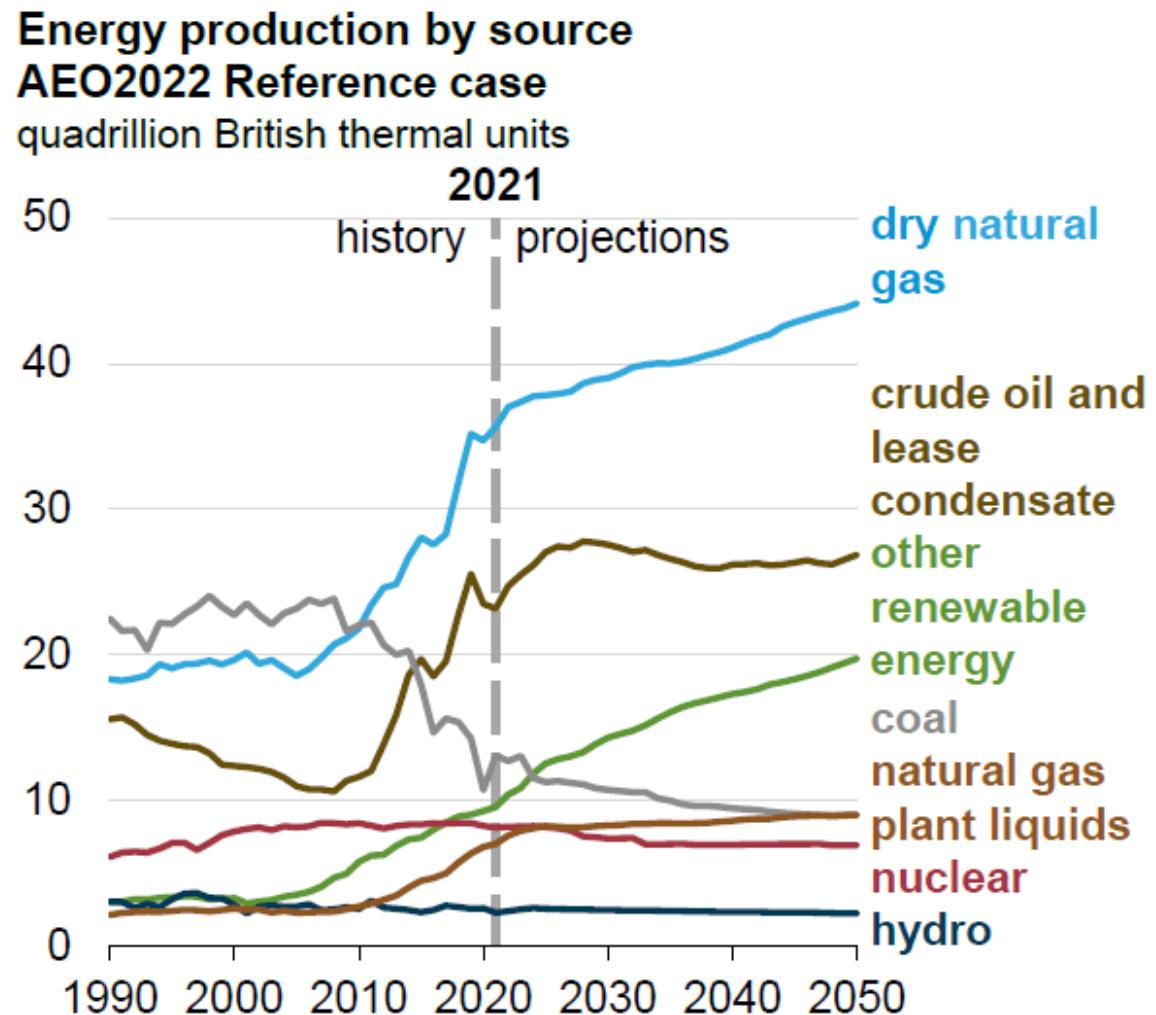
Energy forms change historically to match society's changing needs and the availability of natural resources

# Historical Energy Consumption

- Steeper increase in last 80 years
- Mostly from increased use of hydrocarbons
- Influenced by:
  - Development
  - Climate
  - Affluence
- Primary resources are mainly non-renewable

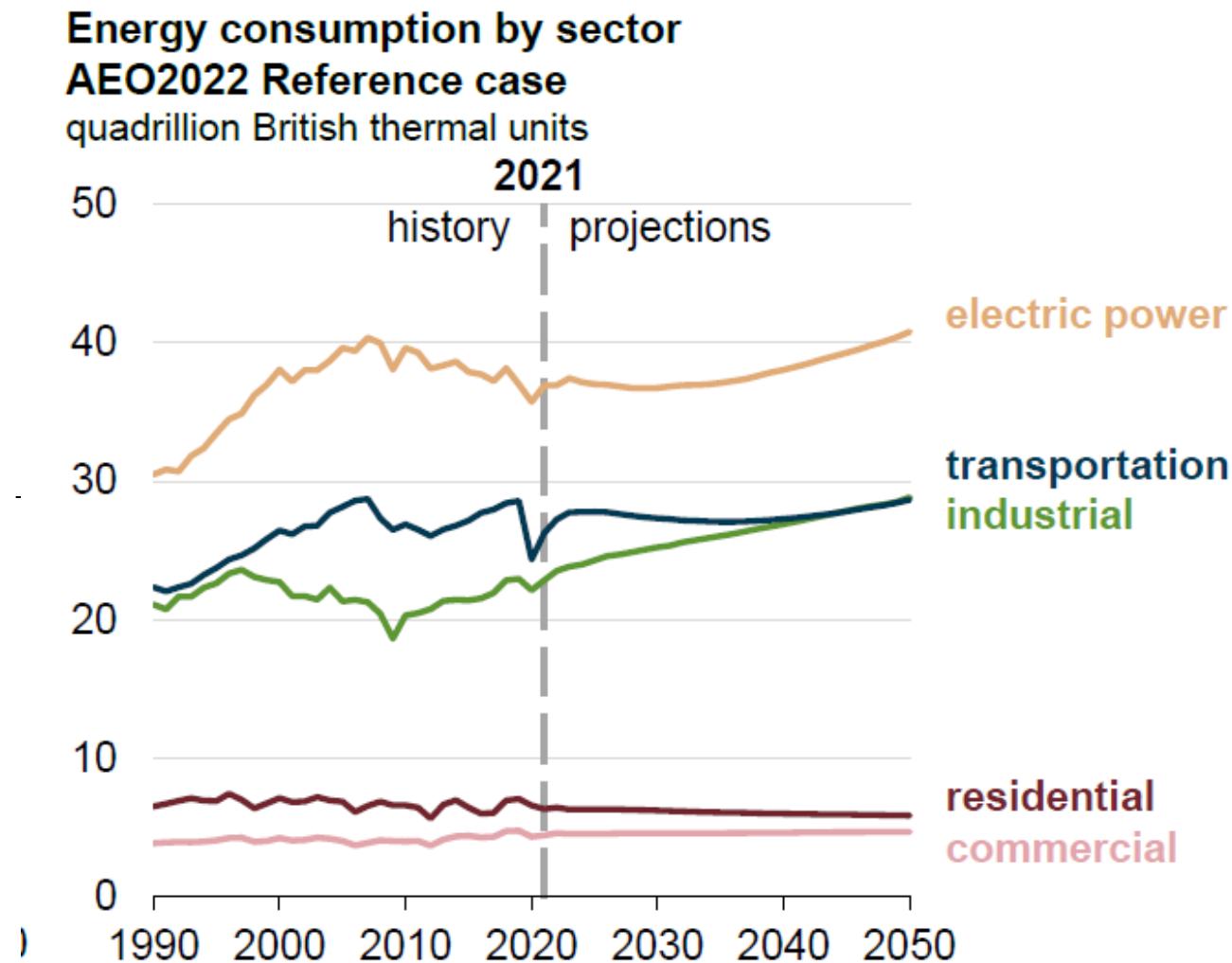


# Projected Energy Consumption by Source



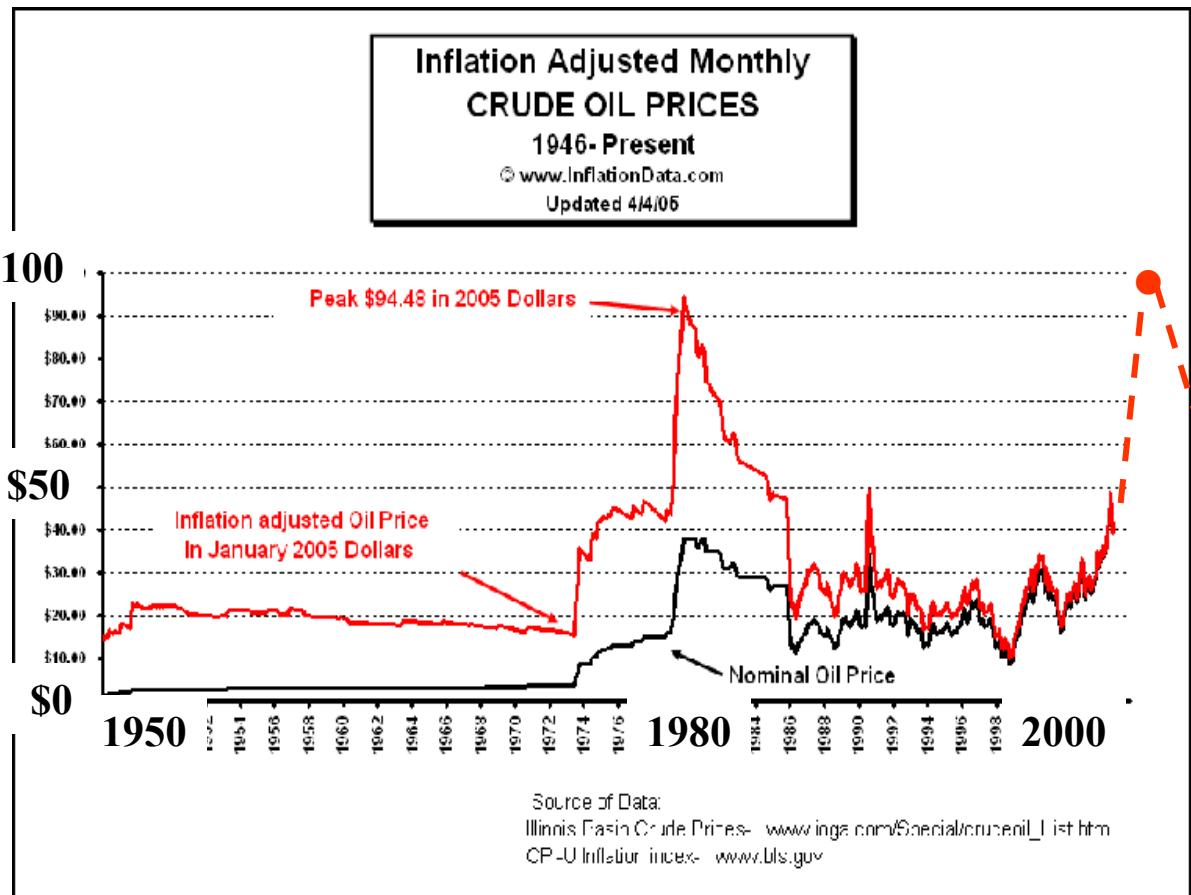
U.S. Energy Information Administration, *Annual Energy Outlook 2022* (AEO2022)

# Projected Energy Consumption by Sector



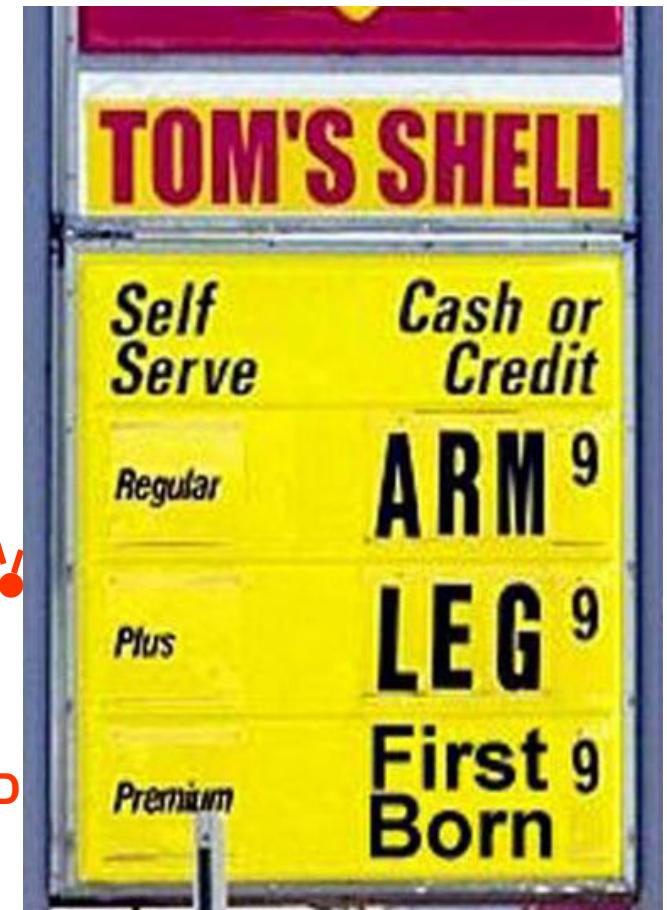
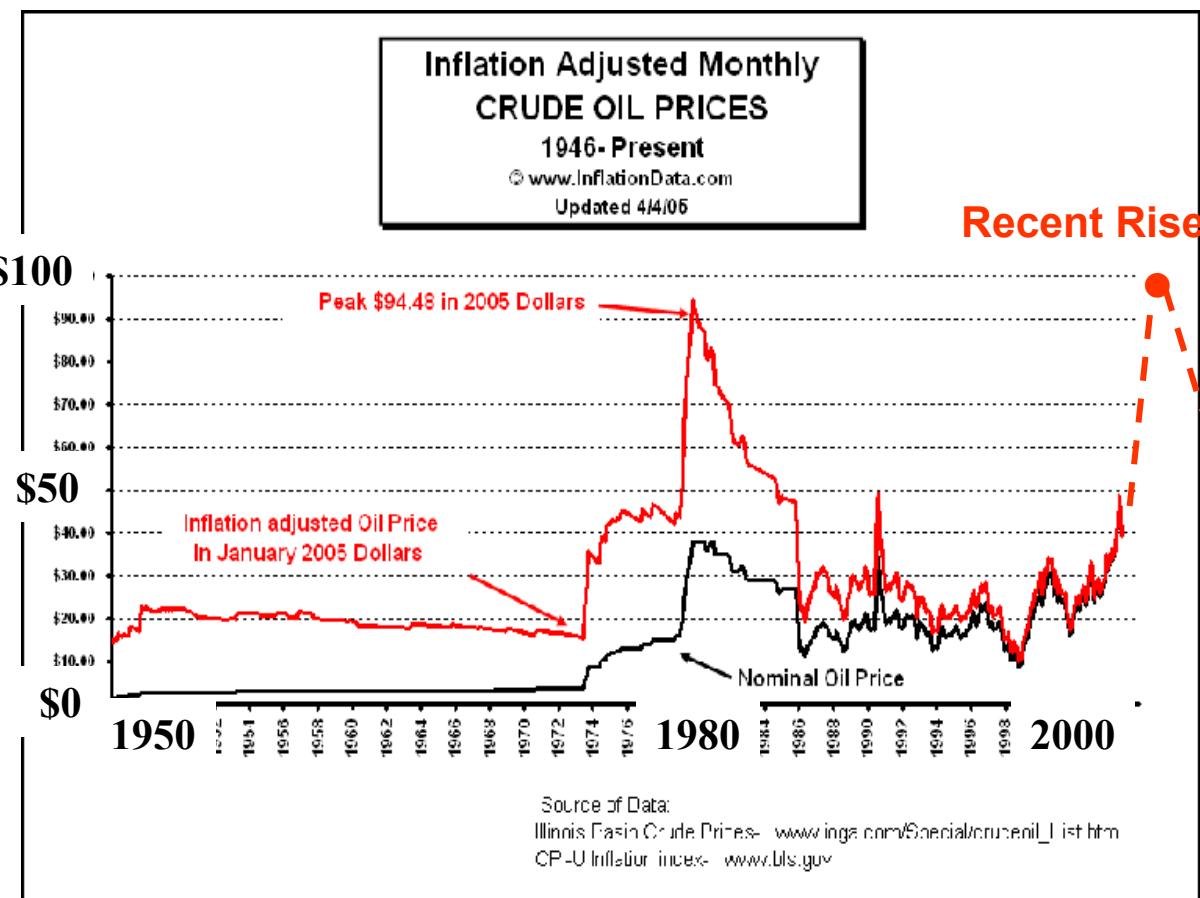
U.S. Energy Information Administration, *Annual Energy Outlook 2022 (AEO2022)*

# Emotions Oscillate with the Price of Oil



Recent  
Dip & Rise

# Emotions Oscillate with the Price of Oil



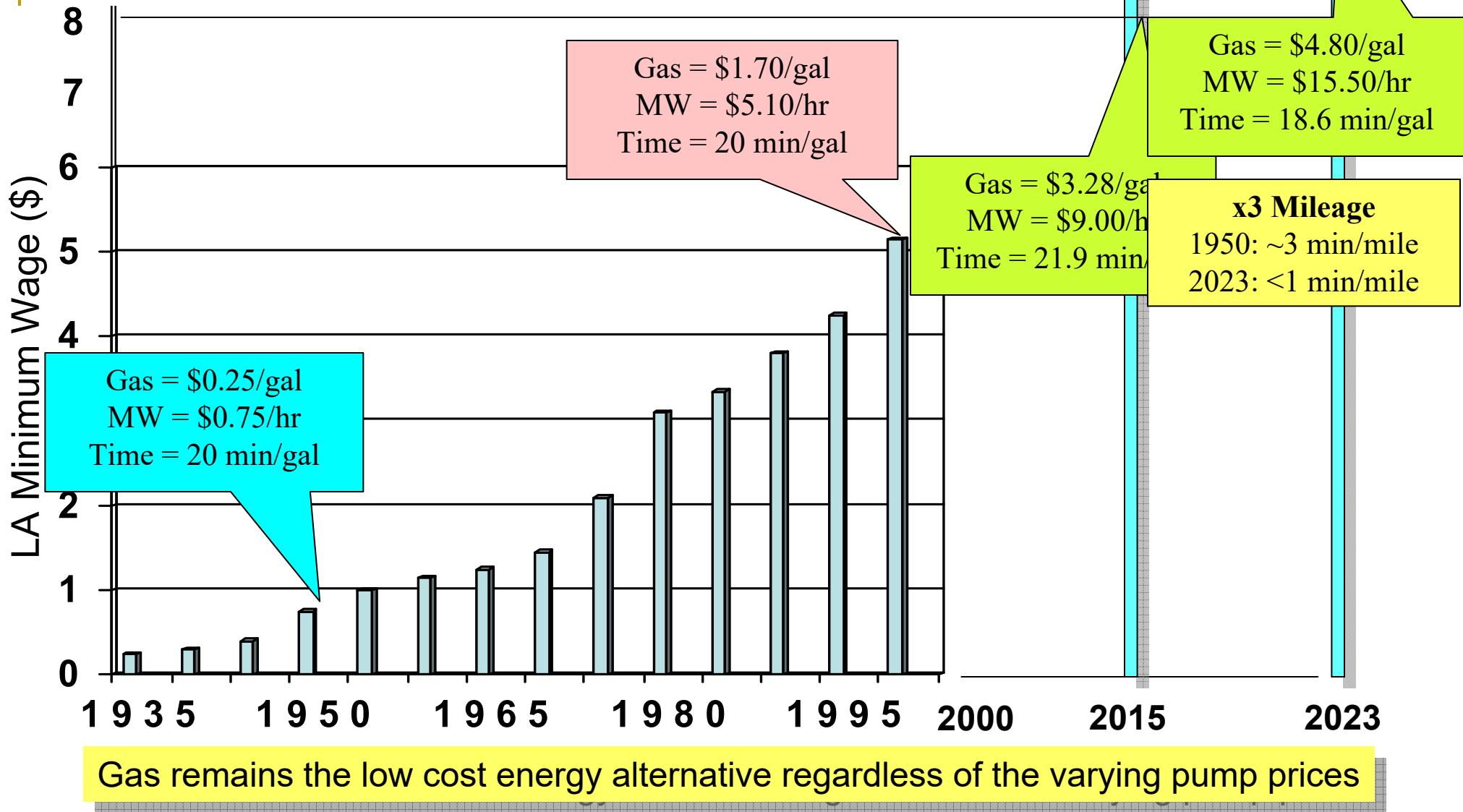
People panic when prices rise

# And You Hear This All the Time...

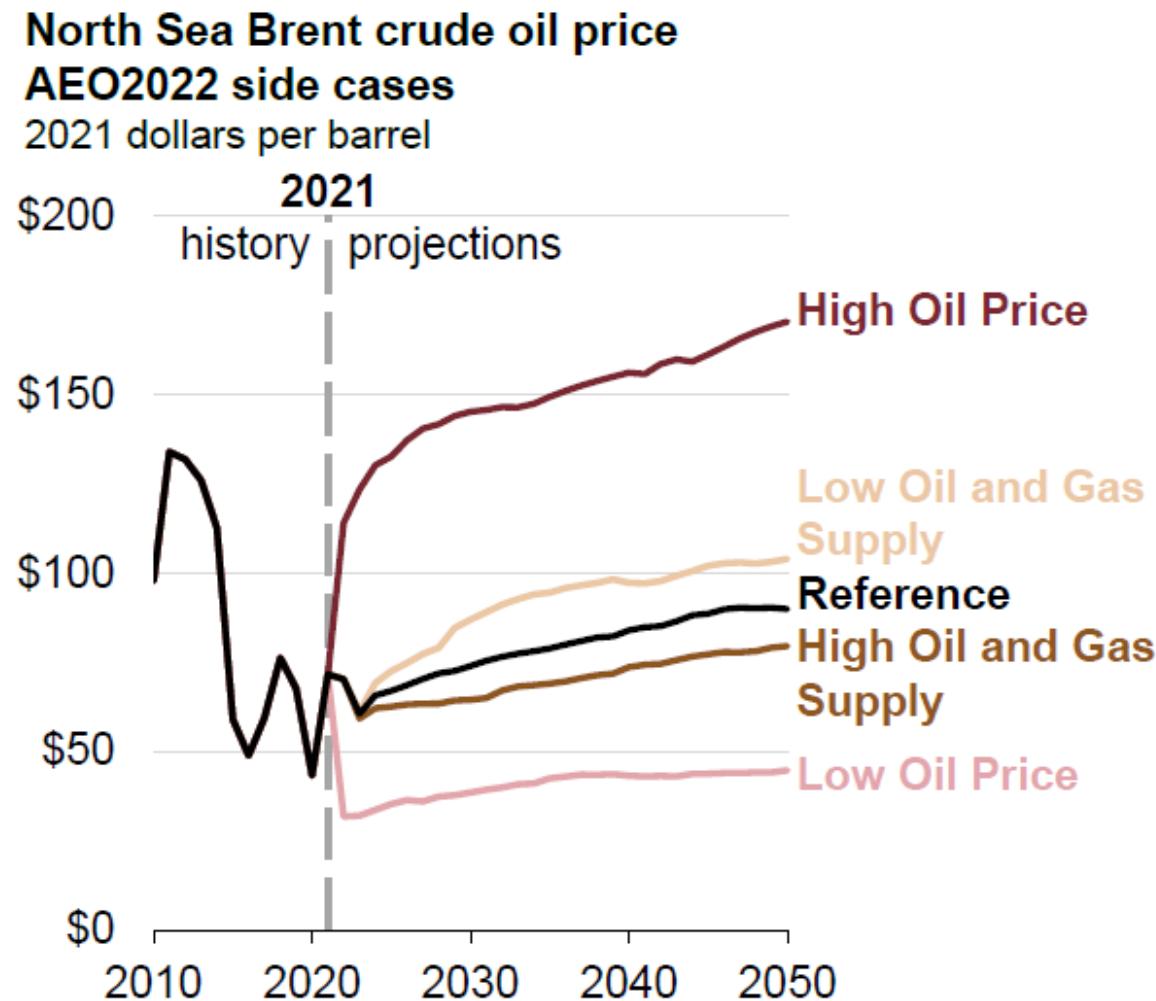
I remember  
when gas was  
25¢  
a gallon!



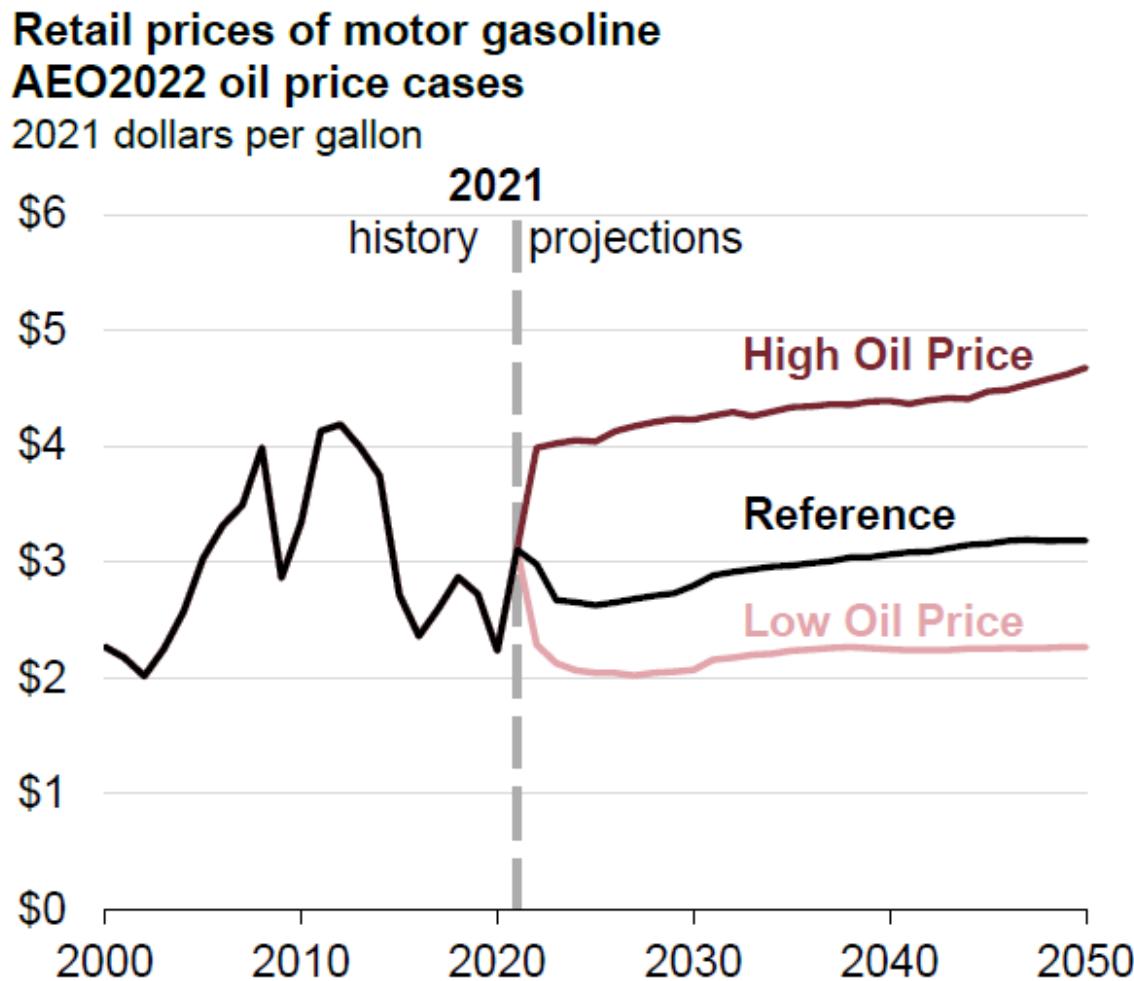
# ...but Gas is Still a Bargain



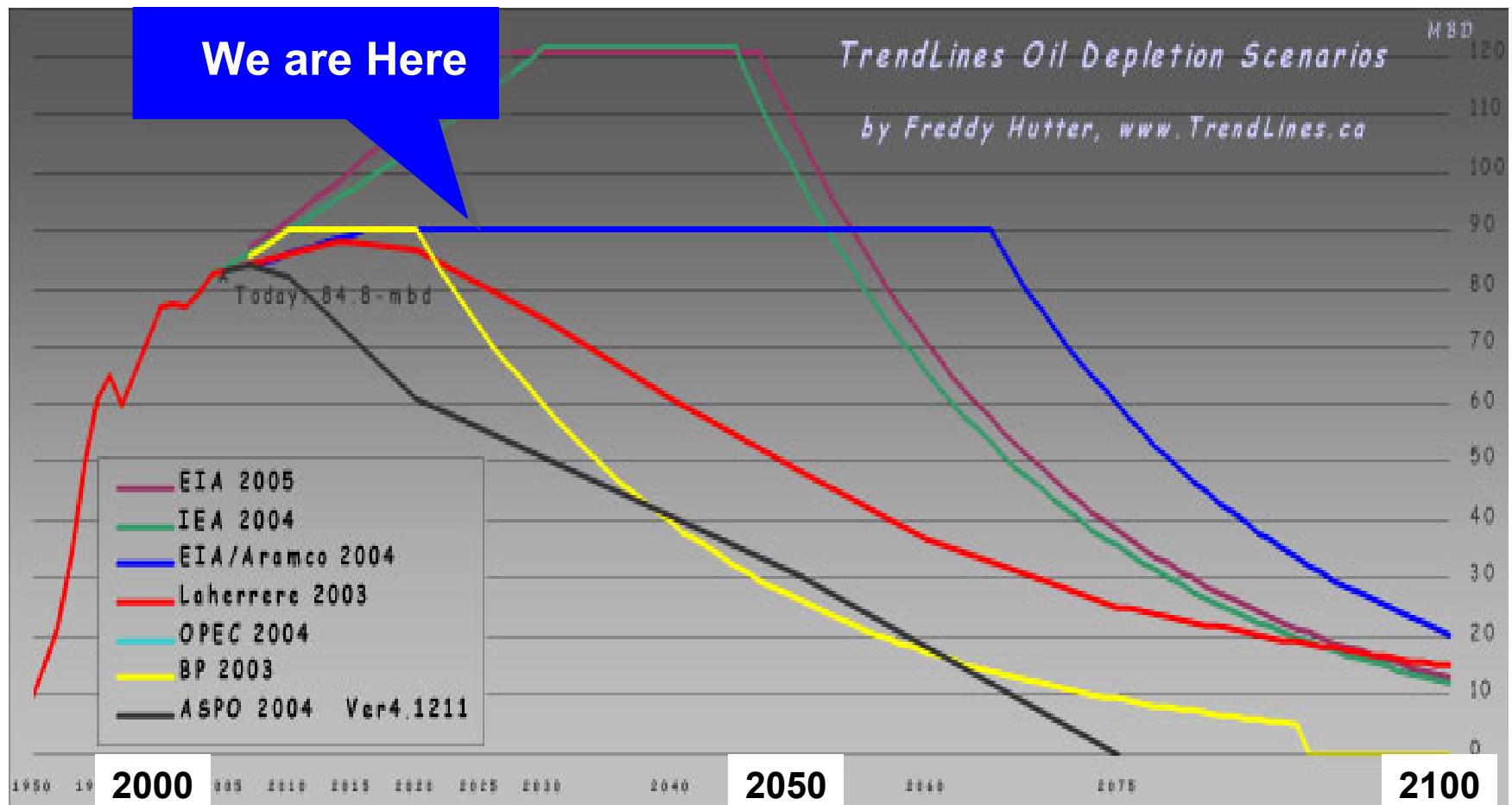
# Projected Oil Price



# Projected Gas Price



# Varying Predictions of Oil Depletion...



Regardless of prediction accuracy, or of new discoveries, oil and gas are still finite.

# Coal is More Plentiful, But...

ANNUAL PRODUCTION AND RESERVE/PRODUCTION RATIOS FOR OIL, COAL, AND GAS, 1970 AND 1989

Fuel	1970 production (per year)	1970 R/P (years)	1989 production (per year)	1989 R/P (years)
Oil	16.7 billion barrels	31	21.4 billion barrels	41
Coal	2.2 billion tons	2300	5.2 billion tons	326 (hard coal) 434 (soft coal <sup>(1)</sup> )
Gas	30 trillion cu. ft.	38	68 trillion cu. ft.	60

- Lots of Coal – Maybe enough for several centuries
- President Trump promised to increase American production, but didn't.
- Coal is both relatively expensive and a high polluter
- So companies and countries have been moving away from coal energy, meaning reserves are probably staying at their high levels

# Alternative Technologies are Emerging...



Boeing Spectrolab Solar Concentrator Cells  
[www.defenseindustrydaily.com](http://www.defenseindustrydaily.com)

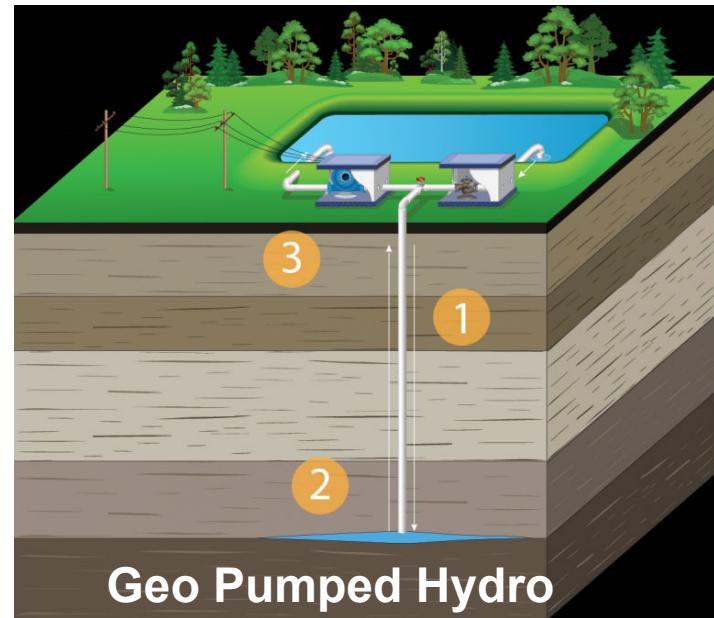
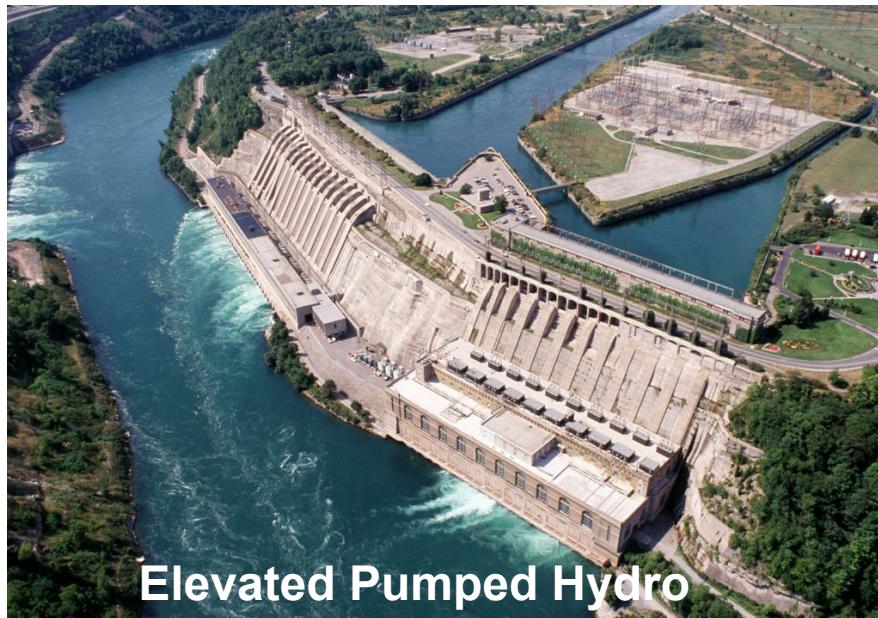


Windmills Farm, Altamont Pass, Livermore, California  
© Dan Chusid 2009 Worldwide

...There Are Encouraging Signs Everywhere...



# ...and Technologies for Energy Storage...

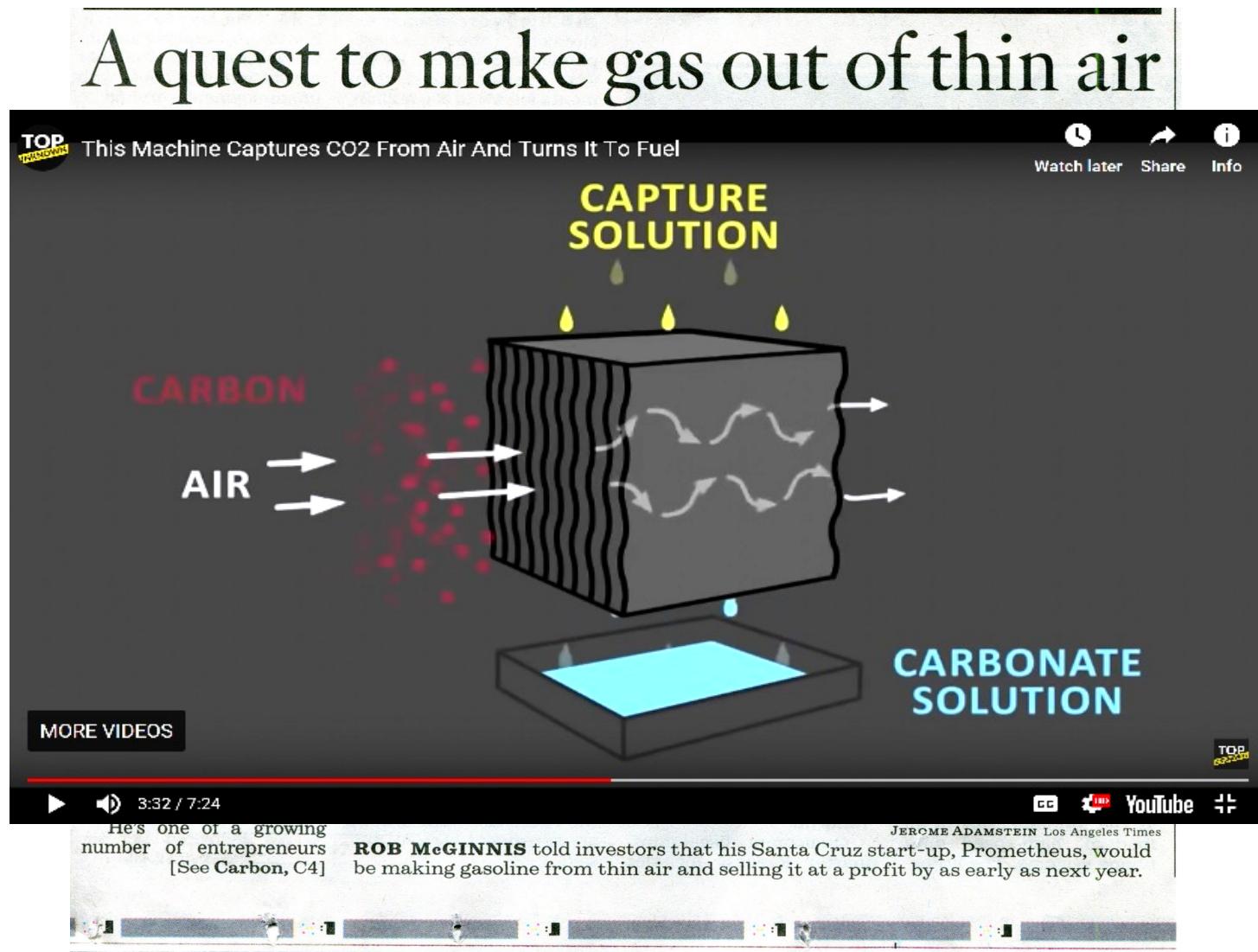


# ... Including Gravity



Storage technologies are proliferating and may coexist instead of competing directly

# New Sources May be Viable...

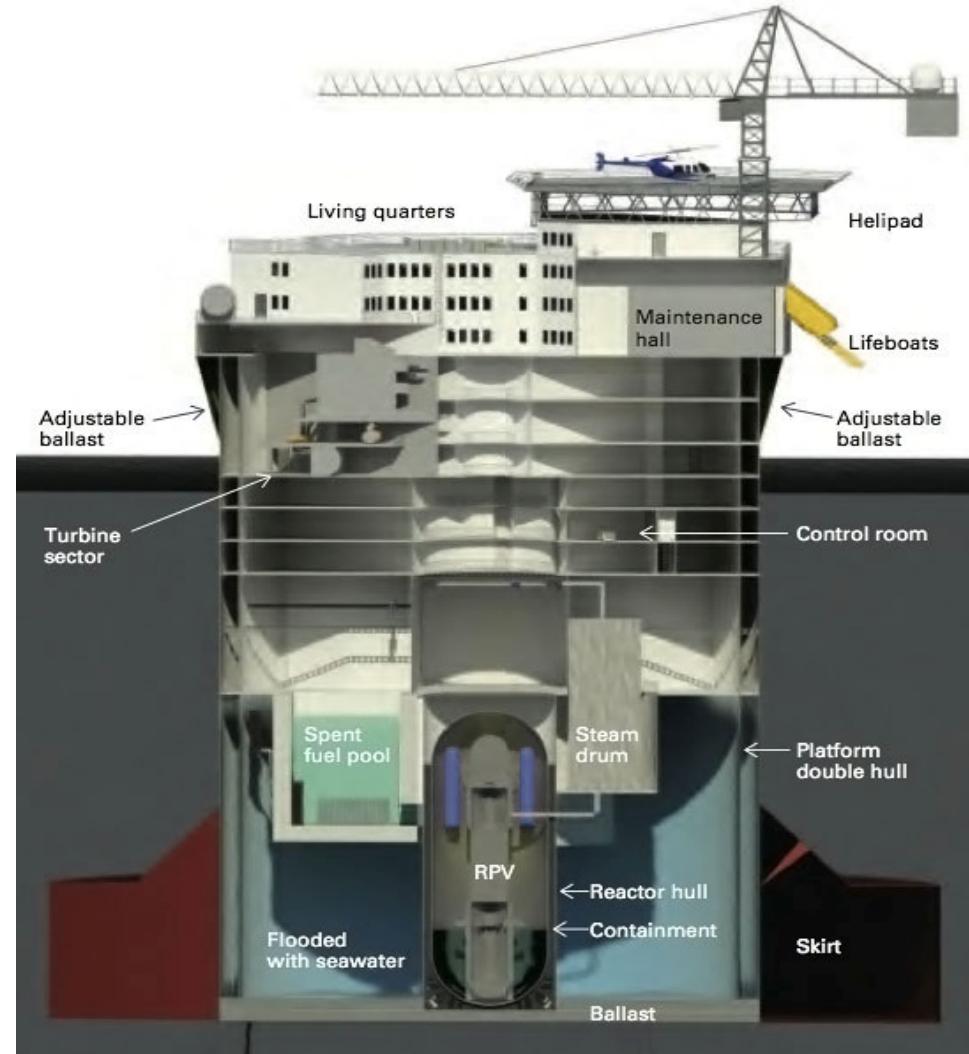


# Nuclear May Be Making a Comeback...



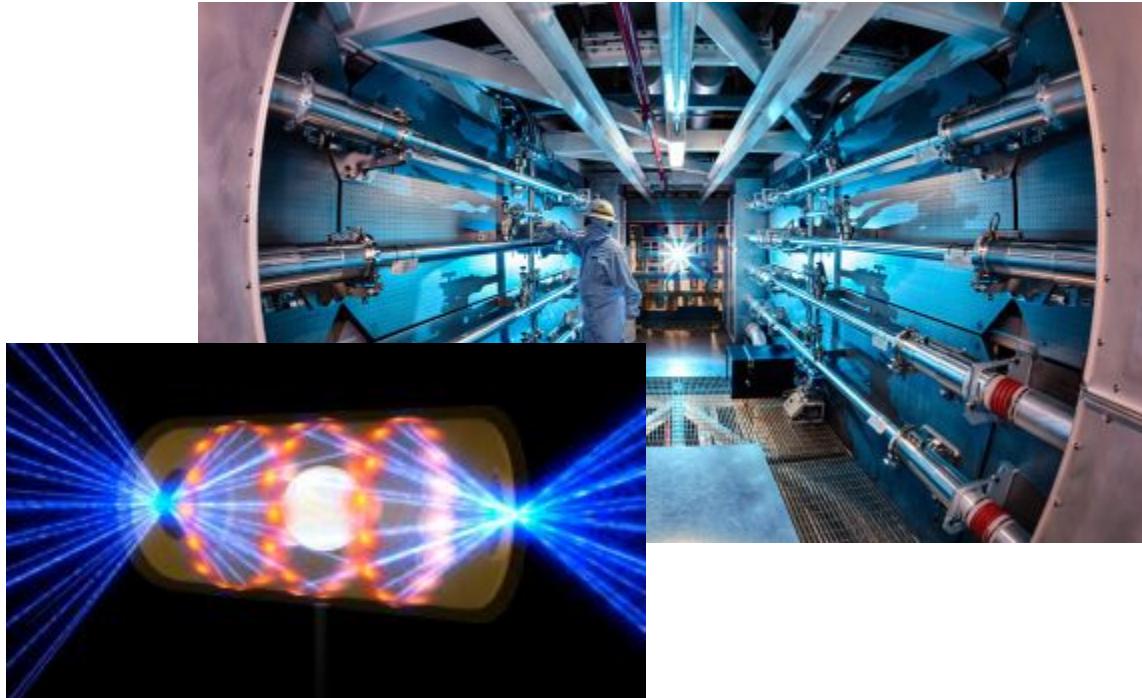
Small commercial nuclear reactors

Sea-based power plant site



# ...and Nuclear Fusion May Finally Arrive

US officials announce nuclear fusion breakthrough



Scientists at Lawrence Livermore National Laboratory's National Ignition Facility have made history by successfully producing a nuclear fusion reaction resulting in a net energy gain, a breakthrough hailed by US officials as a "landmark achievement" and a "milestone for the future of clean energy."

December 5, 2022

# The Worldwide Trend is Positive

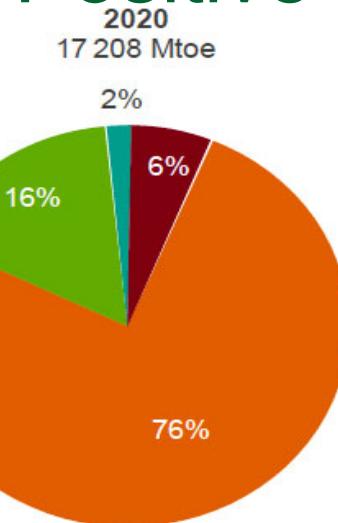
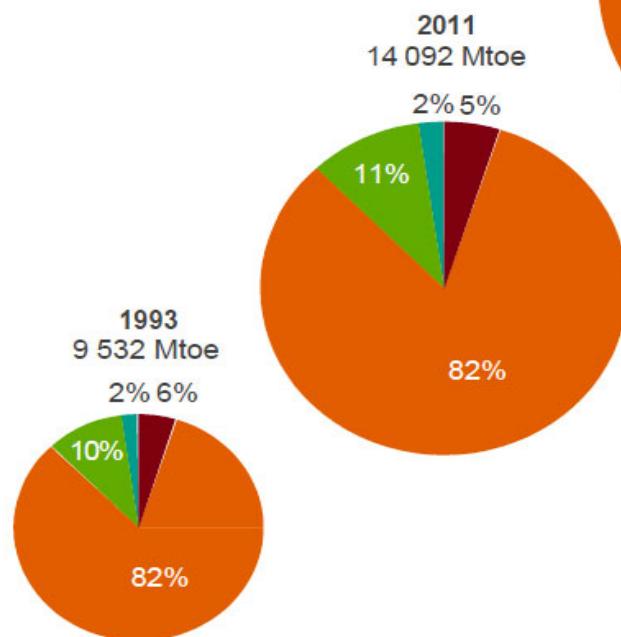
Nuclear

Fossil

Renewables (other than large hydro)

Hydro (>10MW)

Mtoe: Million Tons of Oil Equivalent:



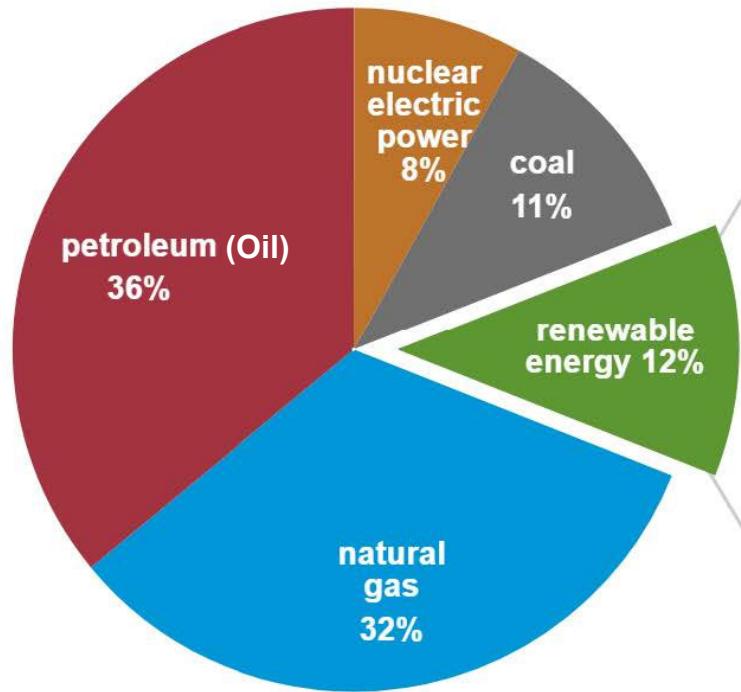
It's hard for alternative energy to make headway while oil and gas are still cheap, but countries, states, cities and individuals are converting for reasons we'll explain in the next lecture...

<sup>1</sup>World Energy Council, World Energy Resources, 2013 Survey Summary

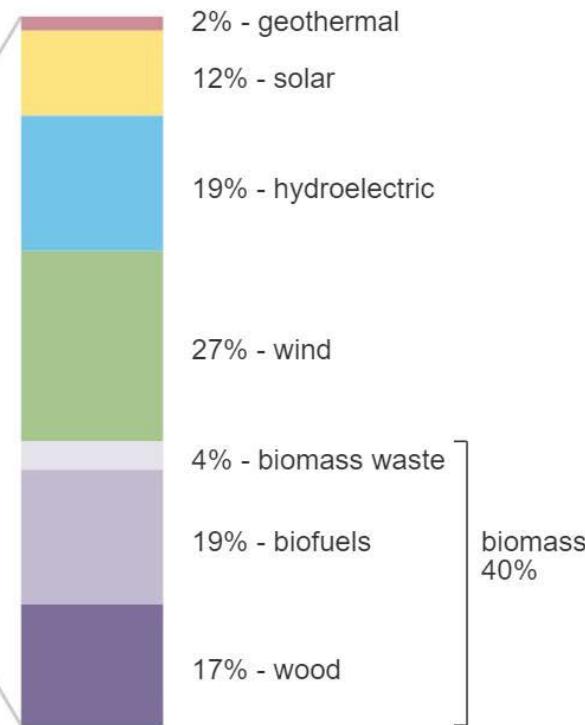
# In the U.S. As Well

## U.S. primary energy consumption by energy source, 2021

total = 97.33 quadrillion  
British thermal units (Btu)



total = 12.16 quadrillion Btu



Data source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1, April 2022, preliminary data



Note: Sum of components may not equal 100% because of independent rounding.

# With Strong Support...



JAE C. HONG Associated Press

**PUMPJACKS** operating at the Kern River Oil Field in Bakersfield in 2015.

## Say goodbye to fossil fuels

LAST MONTH, the United Nations issued a dire warning: It's too late to stop the effects of global warming, which are fueling record-breaking heat waves, flooding and wildfires. But by dramatically reducing the use of fossil fuels starting now and zeroing out planet-warming gases by mid-century, it noted, the world could prevent greater devastation.

In theory, California is already moving in that direction. The state has committed to cutting greenhouse gas emissions by 40% by 2030. And then-Gov. Jerry Brown signed an executive order in 2018 setting an even higher goal: carbon neutrality by 2045, meaning the state would remove as much carbon dioxide from the atmosphere as it emits.

For the emissions that cannot be eliminated, the state would pursue technologies that capture carbon dioxide from industrial facilities and that remove existing carbon dioxide from the atmosphere. Some of these technologies are still being developed or don't even exist yet. The bill would direct state agencies to ensure that carbon capture or removal projects don't end up polluting the surrounding communities or pose a public health risk. That makes sense — in fighting climate change, we shouldn't sacrifice local environmental protection.

There's strong opposition to AB 1395 from the oil and gas sector, the agricultural industry and business groups. They argue the bill moves too fast and doesn't consider the cost and feasibility of slashing greenhouse gas emissions and largely eliminat-

Los Angeles Times, September 7, 2021

# ...For Green Electrification

1

## **End fossil fuel infrastructure:**

Stop permitting new oil and gas drilling, pipelines and infrastructure, and accelerate a managed decline to phase out oil production and refining in California, starting with operations near homes and schools. Provide proper support and resources to ensure a fair transition for fossil fuel workers.

2

## **Increase the use of clean electricity:**

Accelerate the building of solar, storage, wind and other clean technologies so that all our electricity is 100% zero-carbon by 2030, prioritizing communities at the frontlines of fossil fuel operations.

4

## **Phase out polluting cars and trucks:**

Move to 100% zero-emission vehicle sales by 2030 and accelerate public transportation solutions.

5

**Appoint strong climate leaders** to regulatory agencies, like the Air Resources Board, who will champion bold solutions that simultaneously address climate change and other air pollution.



Los Angeles Times, September 18, 2020

# And Some Caveats



**WIND TURBINES** in Mojave, Calif. A new federal regulation would give solar and wind developers a way to compensate for environmental harm from their projects.

President Biden has prioritized construction of solar and wind farms on public lands to help solve climate change.

But solar companies worry a new regulation proposed by the Biden administration would do the opposite, limiting their ability to build on public lands by giving federal employees — and members of the public — new tools to block development.

It's the latest example of a growing conflict between clean energy and conservation — a conflict that threatens to derail climate solutions even as rising temperatures disrupt human life and drive wildlife toward extinction.

Biden's appointees have framed the Public Lands Rule as a sea change in how the Bureau of Land Management protects the 245 million acres under its care in the American West. They say the rule would put conservation on an

## BOILING POINT

# Conservation and green energy at odds on public lands

A federal proposal aims to protect habitats, but solar backers say it would impede climate solutions

By Sammy Roth

to restore ecosystems or protect landscapes.

Mark Squillace, a natural resources law professor at the University of Colorado, thinks conservation leasing is generally a good idea. But he's concerned that the Biden administration's rule would allow nonprofits and other private parties to oversee those leases, with what he considers insufficient federal oversight. That could lead to a scenario, he said, in which a habitat restoration project designed to make up for a solar farm doesn't get the job done, leaving America's public lands worse off.

"I understand that if we're ever going to hope to meet the goals of the Paris climate agreement, we're probably going to have to use a lot more public land, and we probably have to move these [renewable energy projects] along more quickly," he said. "But there are adverse consequences to these big solar developments."

# Overview of Resource Problems

- Energy
  - Consumption is increasing
  - Conventional resources are decreasing
  - Environmental considerations are increasing
- Water
  - Overall use: 6x in 100 years (vs. 2x population growth)
  - Agriculture: Uses 70% of total
  - Human consumption: Inadequate drinking supplies
    - 40% of world faces drinking water shortages
    - **1 billion people lack access to safe drinking water**
    - **2.2 million die annually from contaminated water**
- Food
  - Developing countries: 2100 to 2700 cal/day
  - Industrialized countries: 3000 to 3400 cal/day
  - Capacity to produce is nearing limits

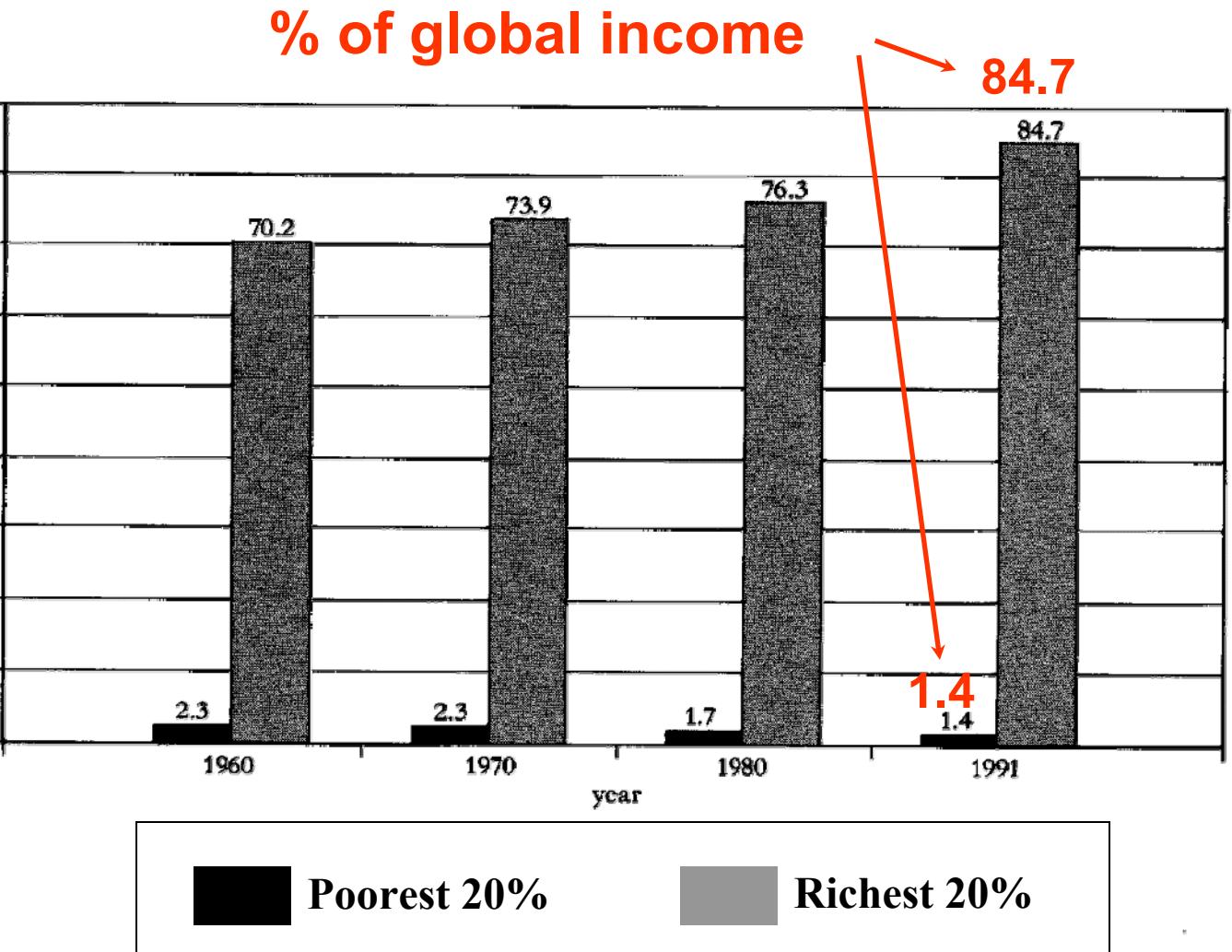
Conclusion: New technical approaches are required in each critical area, but patterns of consumption and universal ethics are also key factors.

# Moving Ahead: Utilitarian Analysis

- What is the objective: “Most happiness for most people.”
- Who are the people? The world’s population.
- What is happiness? Income, life style...greater affluence.
- What is the starting point? Significant disproportion, some progress.
- What does affluence cost now? Scarce resources.
- What is the solution? New technologies. New world ethics.

# Historical Income and Impact

- Impact = PAT
  - Population
  - Affluence
  - Technology
- United States
  - 5% population
  - 25% impact
- New Players
  - China
  - India
  - Japan
  - South Korea
  - Brazil
  - Argentina
  - Others



Cohen, Joel, *How Many People Can The Earth Support?*, W. W. Norton & Co., New York, 1995,

# Historically Skewed Income Distribution

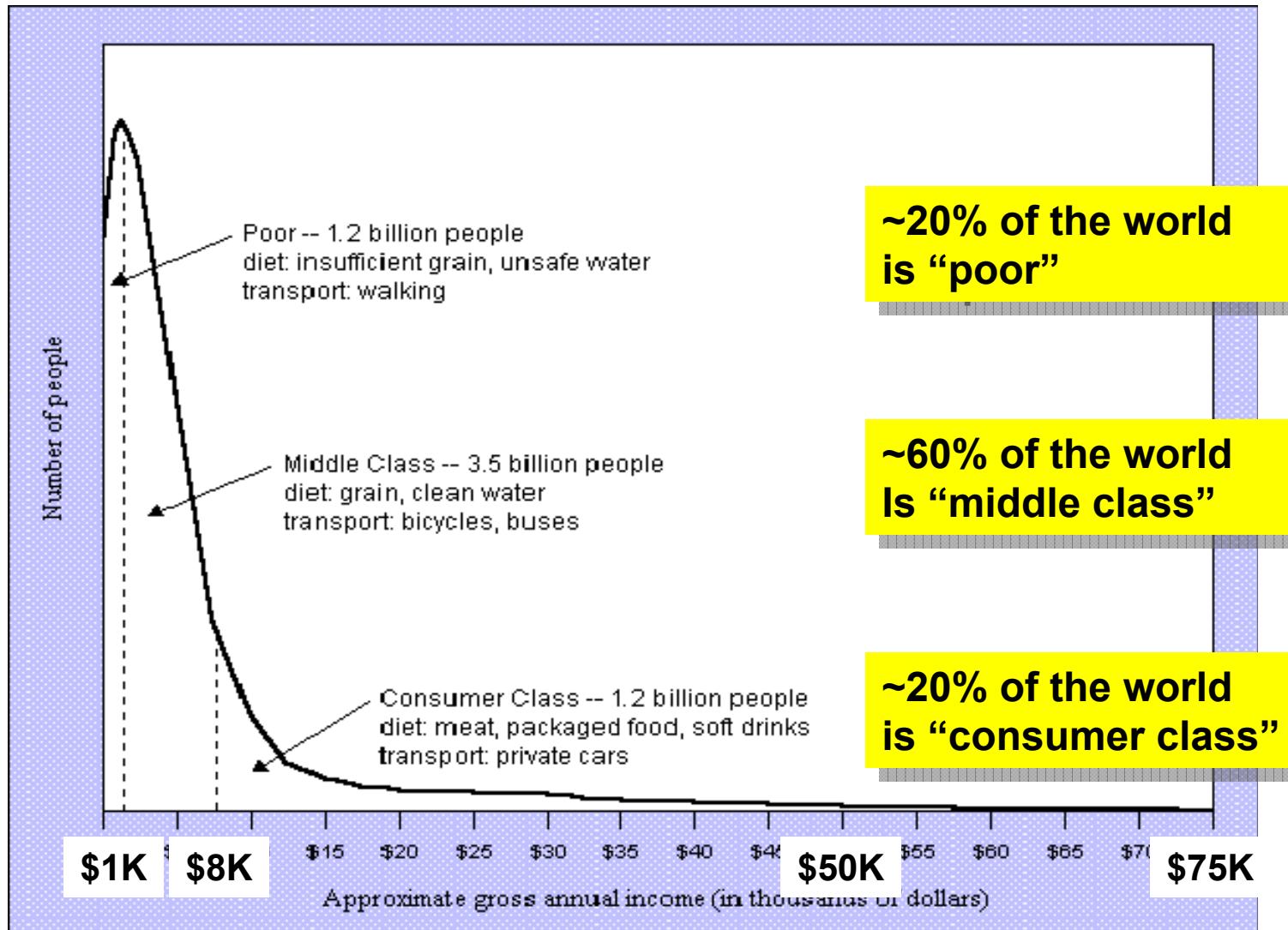


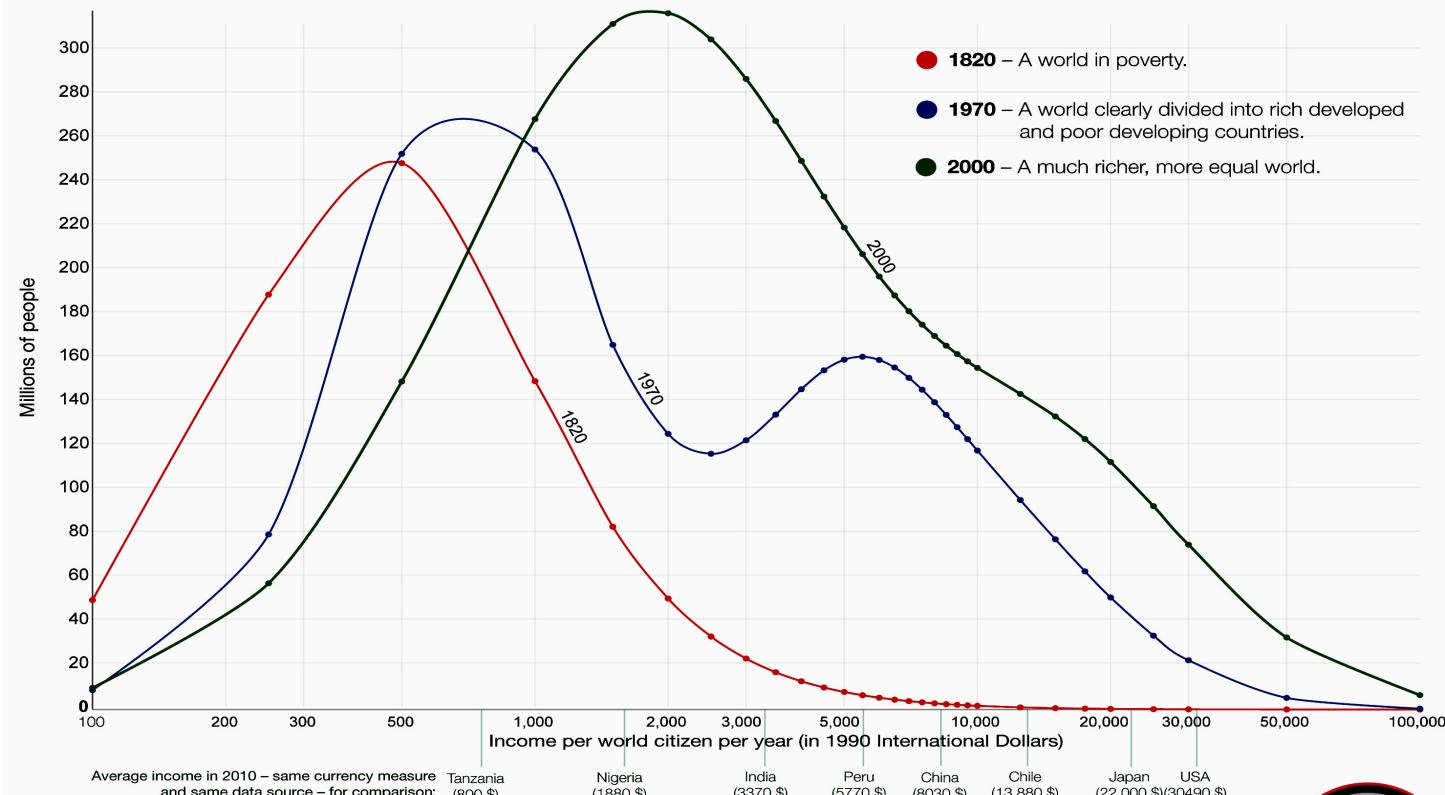
Table from B.D. Skinner, "The Gumption Memo", [www.gumption.org](http://www.gumption.org), 1992

# Increasing Income: Long-Term Past



## The World Income Distribution in 1820, 1970 and 2000 – by Max Roser

The yearly income of all world citizens is measured in International Dollars. This is a currency that would buy a comparable amount of goods and services a U.S. dollar would buy in the United States in 1990. Therefore incomes are comparable across countries and across time.



Data source: [www.Clio-Infra.eu](http://www.Clio-Infra.eu) via van Zanden et al. (2014) – *How Was Life?*, OECD.

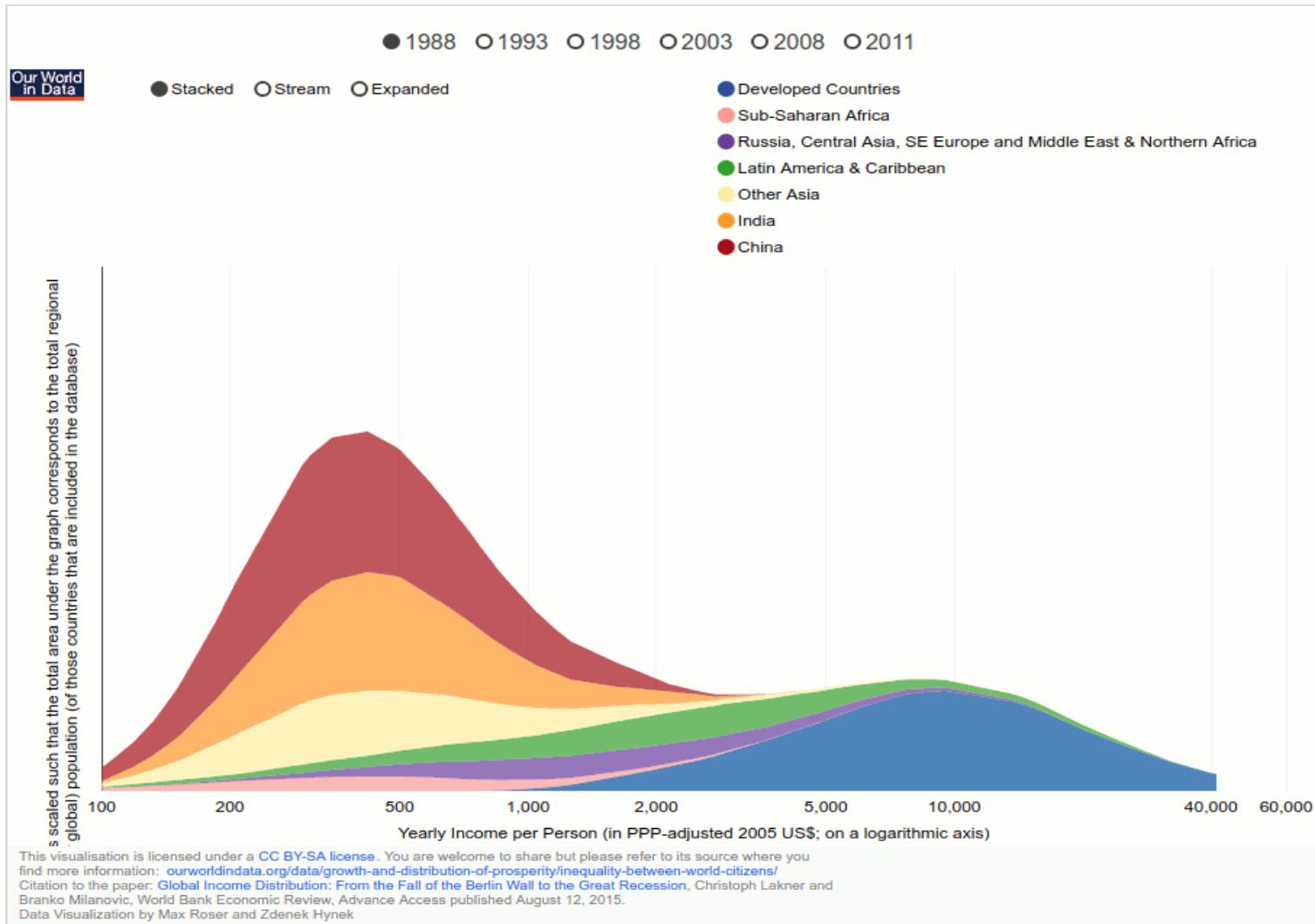
The interactive data visualisation is available at [OurWorldInData.org](http://OurWorldInData.org). There you find the raw data and more visualisations on this topic.

Chart 2 of 'What on Earth is going on – 100 charts that show how living standards around the world are changing'.  
Published on [www.MaxRoser.com](http://www.MaxRoser.com) and licensed under CC-BY-SA.

#2  
100

# Increasing Income: Near-Term Past

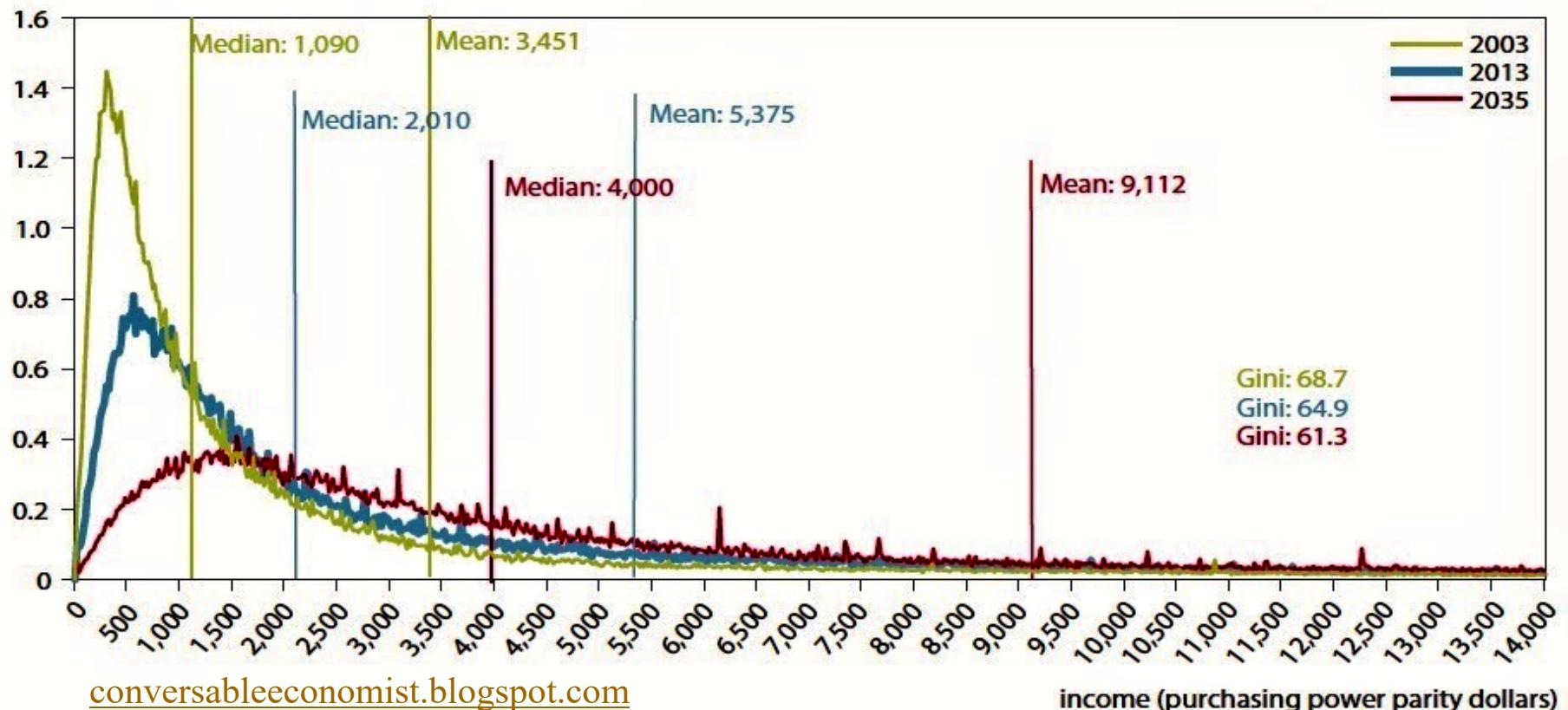
Global Income Distribution 1988 to 2011



# Increasing Income: Future

**Figure 5 Frequency plot of global income distribution, 2003, 2013, and 2035**

percent of world population



# Likely Effect on Energy Consumption

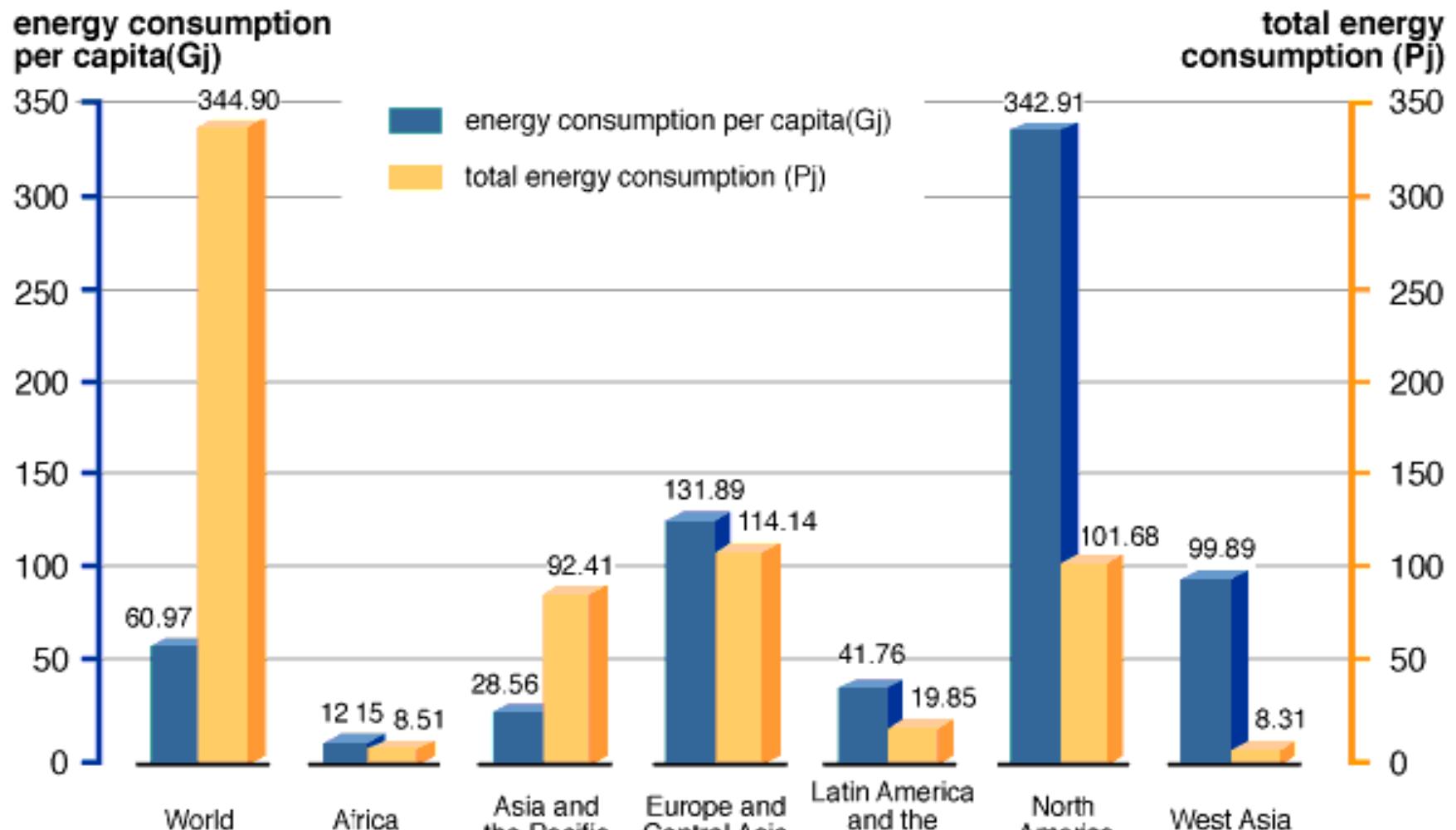
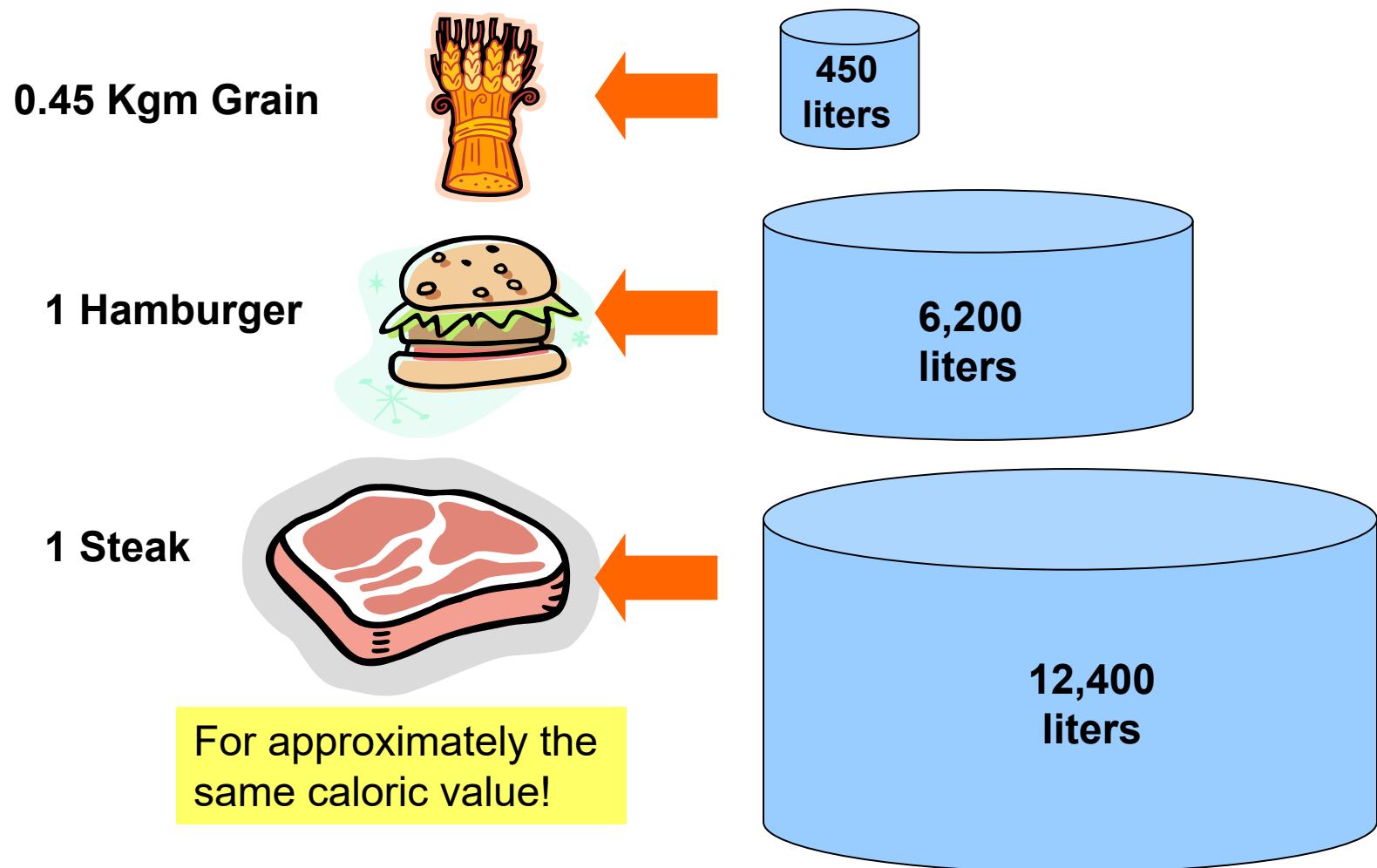


Table from <http://www.geographylwc.org.uk>

# Effect on Water Usage



# Troubling Cattle-Growing Facts



## Fresh Water:

- Agriculture uses the most of any activity
- Livestock uses 1/3 of agricultural water

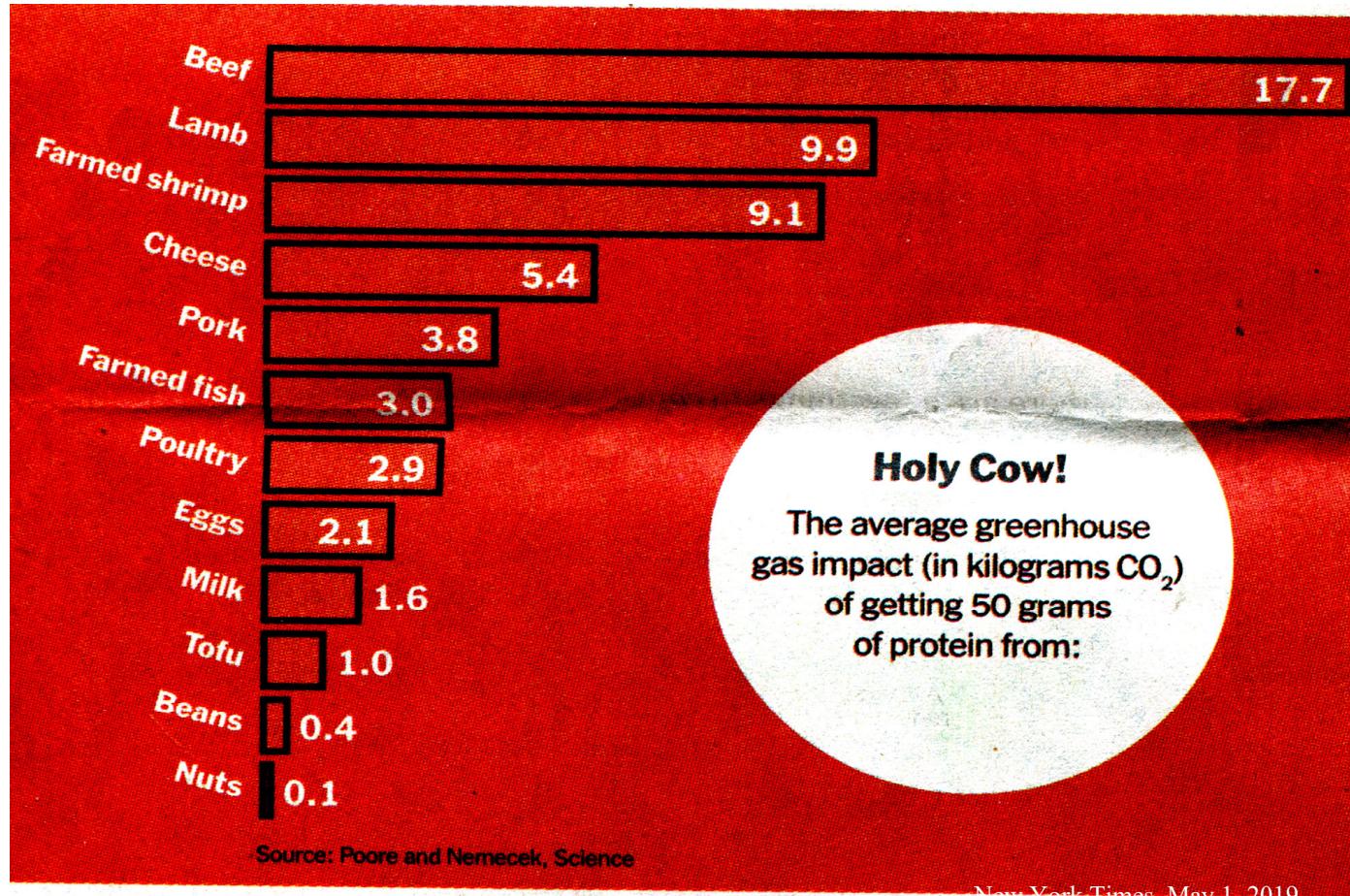
## Cattle Feeding:

- Livestock feed uses 1/3 of arable land
- Area>South American cleared in 25 years
- Carbon sink becomes carbon spigot

## Cattle Greenhouse Gas (GHG) Emissions:

- Cattle is ~10% of global GHG
- Cattle GHG > European Union countries
- 4 lb beef = 1 person flying NY to London

# Troubling Cattle-Growing Facts



One solution is to convince increasingly affluent people to stop craving beef

# New Food Technology: Plant Based “Meats”



## A BURGER WITH BENEFITS

MADE FROM PLANTS

ng a burger from the ground up is you and leave out the bad (cholesterol). The first plant based burger that is so meaty stores and on the menu alongside it.

ric plant based ingredients, applied in . Trace amounts of beet lend the beefy taste ensure mouth watering juiciness. Impromisingly delicious burger, made

ECT STORES  
LIST



## THE IMPOSSIBLE CHEESEBURGER

You know meat. You know choices. Eat the meat of your future. Call or click.

Beyond Meat and Impossible Foods have taken the lead in this technology.

# Goal is Clear: Impossible Mission



“The use of animals in food production is by far the most destructive technology on earth. We see our mission as the last chance to save the planet from environmental catastrophe.”

Pat Brown, CEO Impossible Foods, in  
T. Friend, “Value Meal,” New Yorker, Sep 30, 2019

To get meat eaters to accept plant-based meat substitutes, Beyond Meat, Impossible and other producers focus on taste and feel rather than on health or environmental benefits, and are staying with this as they tackle steak, chicken and other meats.

# Other Plants and Manufactured Meats

The left side of the image shows a magazine spread. At the top is a photograph of a plate of food, likely a sandwich or burger, with a hand pointing at a piece of meat. Below the photo is a dark blue rectangular box containing the title "MUSHROOMS MAGICALLY MORPH". To the left of the box is the author's name, "BY CORIE BROWN". At the bottom left is a large letter "P" followed by a paragraph of text: "PLANT-BASED meat entrepreneurs launched the alternative-protein movement, and cultured meat scientists". To the right of the "MUSHROOMS" box is another dark blue rectangular box containing the text "FUNGUS-BASED PRODUCTS ARE MAKING THEIR WAY INTO STORES". On the far right edge of the spread, there is vertical text: "ZONNERS BASIC ARTIFICIAL FOOD".

## FROM BIOREACTOR TO TABLE

CULTURED MEAT STARTS WITH ANIMAL CELLS, GROWS FROM THERE



Los Angeles Times, October 24, 2021

# Meat Producers are Not Retreating, But...

THE BEST STEAKS  
OF YOUR LIFE OR  
YOUR MONEY BACK

100%  
GUARANTEE  
OMAHA STEAKS SINCE 1917

**Butcher's Deluxe Pack**

4 Butcher's Cut Filet Mignons (5 oz.)  
4 Boneless Chicken Breasts (1 lb. total)  
4 Boneless Pork Chops (6 oz.)  
4 Omaha Steaks Burgers (5 oz.)  
4 Gourmet Jumbo Franks (3 oz.)  
1 pkg. All-Beef Meatballs (12 oz. pkg.)  
4 Potatoes au Gratin (2.8 oz.)  
4 Caramel Apple Tartlets (4 oz.)  
1 Jar Signature Seasoning (1 oz. jar)  
4 **FREE** Boneless Chicken Breasts (1 lb. total)  
4 **FREE** Omaha Steaks Burgers (5 oz.)

6624XXL separately \$299.99  
**SPECIAL INTRODUCTORY PRICE \$139.99**

Take an **EXTRA \$20 OFF** your first order. Use code: **WELCOME** at checkout.

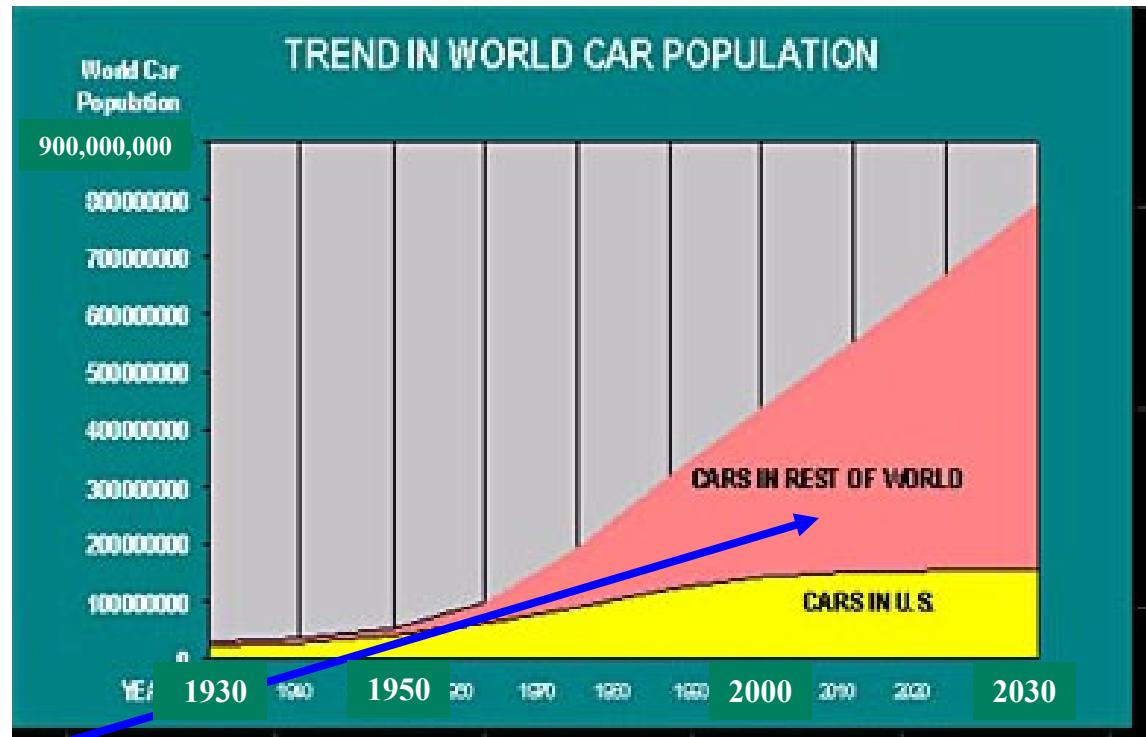
Order Now! » [OmahaSteaks.com/everytime519](http://OmahaSteaks.com/everytime519) | 1.800.811.7832  
Ask for free burgers & chicken breasts with offer 6624XXL

\*Shipping shown over aggregated single item base price. Please exemplary of product advertised. Limit 2-4 lbs. (5 oz.) burgers and 4 lbs. chicken breasts (1 lb. total) will be sent to each shipping address that includes 6624XXL. Standard 3-5 business day shipping. While supplies last. There may be limited due to inventory limitations. First Order Offer is a one-time use code, valid only on the first order of \$139 or more placed by new customers or customers whose net purchase was more than 360 days prior to offer date. One offer code per customer, cannot be combined with other offers or be applied to previous orders. Gift Cards, Wine, Gift Baskets, Wine Clubbers, or Custom Cuts Omaha Steaks items are exempt to anyone that has used and conditions or to vary or discontinue the offer without prior notice. The code can be redeemed online by phone, or at Omaha Steaks retail locations. All purchases acknowledge acceptance of Terms & Use. Visit [omahasteaks.com/terms-of-use](http://omahasteaks.com/terms-of-use) or call 1-800-226-6572 for a copy. Expires 11/1/21. ©2021 OSG | Omaha Steaks, Inc. | SRC0608

This ad was in the Parade magazine part of the Los Angeles Times, along with ads for walkers, knee braces, recliners, Medicare supplements, etc. What conclusion can we draw?

# Car Transport: Consuming Much Energy

- Transport % of Energy
  - World = 20%
  - US = 30%-35%
- Cars % of Transport
  - USA = 90%
  - Europe = 80%
  - Japan = 60%
- Total Number of Cars
  - 2000 = ~450 Million
  - 2030 = ~1000 Million
- Developing world is the area of main concern
- For equal % of energy
  - 2030 = 3x (60 mpg)
  - 2100 = 20x (400 mpg)



© Copyright 1999 - 2011 Robert Q. Riley Enterprises, LLC.  
<https://www.rqriley.com/sld002.htm>

For example, as of 2022 China now has 319 million cars while the United States has 284 million cars, and in the past decade China expanded its car population by >132%.

# Car Transport: Becoming more Rational...



GMC Yukon  
~ 6000 lb  
~ 15 mpg  
~ \$45,000

Toyota Prius  
~ 2800 lb  
~ 55 mpg  
~ \$21,000

# ...Maybe

## WHY S.U.V.S ARE STILL A HUGE ENVIRONMENTAL PROBLEM

*The world is moving toward heavier cars at a time when it should be doing precisely the reverse.*



By Elizabeth Kolbert

March 3, 2023



# Car Transport: The Electric Answer



Tesla Model 3

‘It’s a beautifully designed car *with no carbon emissions...*’

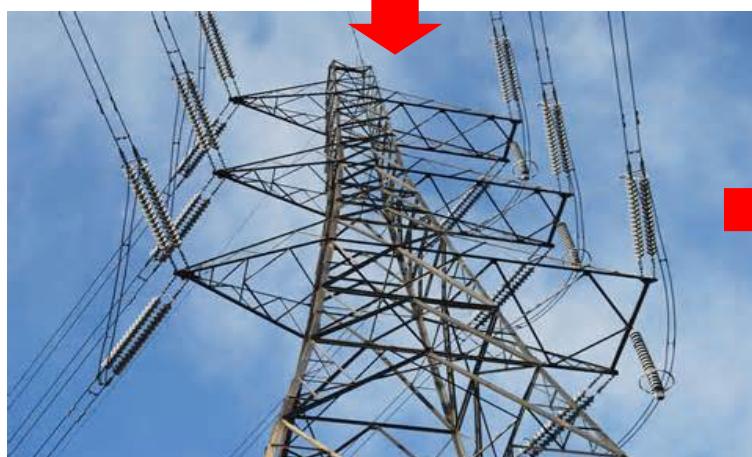
John Blumenthal  
Los Angeles Times, December 28, 2022

# People Sometimes Forget...

Dirty power generating plants



Electricity that is generated by fossil fuel plants, and delivered over an inefficient grid, can result in less efficient and more polluting vehicles on a *total system* basis.



Inefficient electrical grid



Local clean, efficient power

# ...But Not Everybody

## Are electric cars greener? Depends

By Joshua Graff Zivin, Matthew Kotchen and Erin Mansur

**L**ONG THOUGHT a thing of the future, electric cars are becoming mainstream. Sales in the United States of plug-in, electric vehicles nearly doubled last year. Credible forecasts see the number rising within a decade to half a million vehicles per year, which would easily exceed sales of the Toyota Camry today.

Although the technology for electric cars is improving quickly, the industry still depends heavily on public policy — such as the \$7,500 subsidy that the federal government gives everyone who buys one. The rationale for such aggressive support is, in part, rooted in the idea that these cars cause less pollution. Indeed, conspicuously “green” consumers dominate sales of electric vehicles, just as they did initially for hybrid vehicles such as the Toyota Prius.

But whether electric cars are actually greener depends on where the electricity comes from. Our research, along with other studies, finds that electric cars are not necessarily the environmentally friendly choice when it comes to the emissions of carbon dioxide — the pollut-

ant of greatest concern for climate change.

It is true that electric cars have no tailpipe emissions (they don't even have tailpipes!), which means they can help clear local air. But the electricity used to charge these vehicles comes mainly from power plants that burn coal or natural gas, with coal being the biggest emitter. Other sources of electricity — wind, solar, hydro and nuclear — generate zero emissions.

Figuring out whether the electricity is more environmentally friendly than just burning gasoline directly in cars depends on statistical sleuthing. It's necessary to estimate changes in emissions within the overall electricity grid in response to the additional electricity needed to charge an electric car. We've done this using data on every hour of every day for recent years across the nation, and the results are striking.

Where and when electric cars are charging affects how their emissions compare with the alternatives of a conventional or hybrid car. In some places and at some times, electric cars generate more emissions. We find, for example, that charging an electric car at night in the upper Midwest will generate more carbon dioxide per mile driven than the average

conventional car that burns gasoline. In contrast, electric cars in the western United States and Texas always generate lower emissions than even a hybrid, and this arises because natural gas rather than coal tends to be used for generating the additional electricity in these regions.

Our findings are based on how electricity is generated and current technologies that determine the efficiency of vehicles. But how might things change in the future to affect whether electric cars will reduce emissions and therefore help address climate change? We know the fuel economy of non-electric cars will increase in the coming years. The U.S. Environmental Protection Agency has nearly doubled the average fuel efficiency goal for cars by 2025. And the manufacturers of electric cars are seeking to significantly increase the distance that one can drive on a charge.

But the critical driver of electric-car emissions is how the electricity is generated. And this is where the future of electric cars as a means for addressing climate change is related to the future of power plant regulations. The EPA is in the process of developing its “Clean-Power Plan” to reduce emissions from power plants. This, along with other rules, will make the electricity sector

cleaner and help ensure that electric vehicles are the green choice down the road.

More than 100 years ago electric vehicles were the dominant and most promising technology for powering personal automobiles. But oil won that battle and reigned over the 20th century. Now electricity is poised to make a comeback, and might yet power the transportation sector this century. The push is due in large part to concerns about climate change, so it is important to have policies that ensure electric cars are part of the solution rather than the problem.

JOSHUA GRAFF ZIVIN is a professor in the Economics Department and School of International Relations at UC San Diego. MATTHEW KOTCHEN is a professor of economics at Yale University.

ERIN MANSUR is a professor at the Tuck School of Management at Dartmouth. All three authors are research associates at the National Bureau of Economic Research.

### HOW TO WRITE TO US

Please send letters to [letters@latimes.com](mailto:letters@latimes.com). For submission guidelines, see [latimes.com/letters](http://latimes.com/letters) or call 1-800-LA TIMES, ext. 74511.

# If Energy Was Entirely Green

## Total lifetime CO<sub>2</sub> emissions

*Over the life of the vehicle\**

- = battery manufacture
- = manufacture, maintenance, and end-of-life recovery
- = fuel production
- = vehicle use



⚡ Electric car



💧 Gasoline car

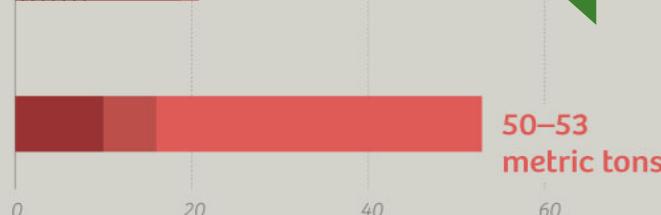
Standard NL electricity mix:



100% renewable electricity:



The target



Electric vehicles may reduce emissions somewhat now, but targeted resource benefits depend on *new energy sources*

# Back to the Future?



Citroen 2CV; 60+ mpg, 1948 - 1988



Vespa Motor Scooter, 75+ mpg, 1946 - ?

# Even Further Back?



Ignaz Schwinn, Mrs. Schwinn and son Frank on a Schwinn-Built family tandem of 1896

# Even Further Back?



# Or More Futuristic?



Electric Bicycle, ~20 mph, ~30 miles/charge, ~ \$700 to \$2,500

# Or More Futuristic?



Electric Scooters, ~20 mph, ~\$1 rental + \$0.15/minute

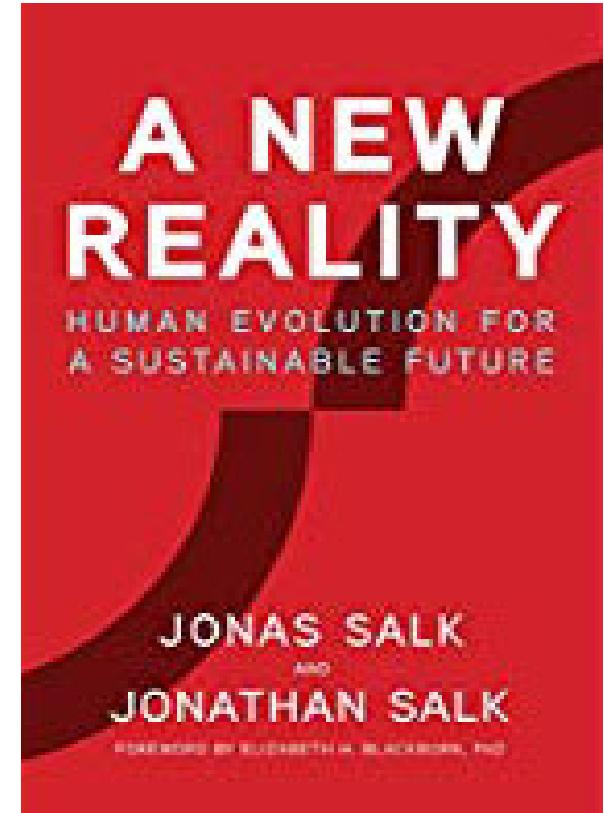
# A Point of Inflection

## Previously in history:

- Exponentially increasing population
- Accelerating advances in industry and technology
- Seemingly limitless resources
- *Advantages to competitiveness, independence, exploitation of resources, short range thinking*

## Today and in the future:

- Population growth slowing and declining
- Realistic expectations of industry and technology
- Many resources approaching limits
- *Advantages to cooperation, interdependence, and sustainability*



The present situation resembles the shared use of a “commons.”

# Good Use of Commons Depends on Ethics

- A commons is a resource not individually owned, but one that is available for use by all.

# Our Commons Today



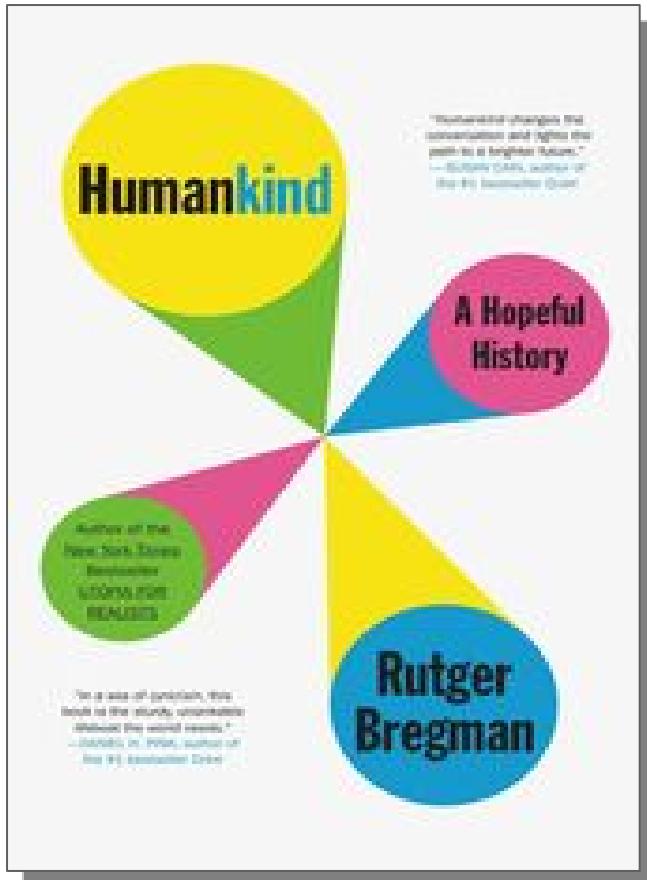
\*Garrett Hardin, "The Tragedy of the Commons," Science, 162(3859), Dec. 13, 1968

# Good Use of Commons Depends on Ethics

- A commons is a resource not individually owned, but one that is available for use by all.
- Adam Smith's 18<sup>th</sup> century idea was that a free market will optimize use of a commons; but Smith also said this requires *strong prior agreement on ethical behavior for the common good*
- Garrett Hardin wrote in 1968 that in the absence of such agreement governments, organizations and companies act in ways that endanger or destroy commons, including over-populating territories and exploiting resources. Hardin's thesis was widely accepted and his writing was widely disseminated.
- But 2009 Nobel Prize winner Elinor Ostrom showed that in numerous cases people can come to reasoned agreements on equitable means to exploit commons without destroying them.

Can the world's people agree on Earth-wide ethical behavior?

# People May Be Basically Decent



Dutch author Rutger Bregman says that while most people *believe other people are basically bad and can't be trusted*, research shows most people are basically honest, caring and helpful, and there are evolutionary reasons for this, including the benefits of *friendliness* for societal survival and progress.

People's biases the other way are intensified by the Media, which promotes:

- **Negativity Bias**, negative more interesting
- **Recency Bias**, latest news most important
- **Reality TV**, people incited to act bad
- **Fiction as Science**, e.g. *The Lord of the Flies*

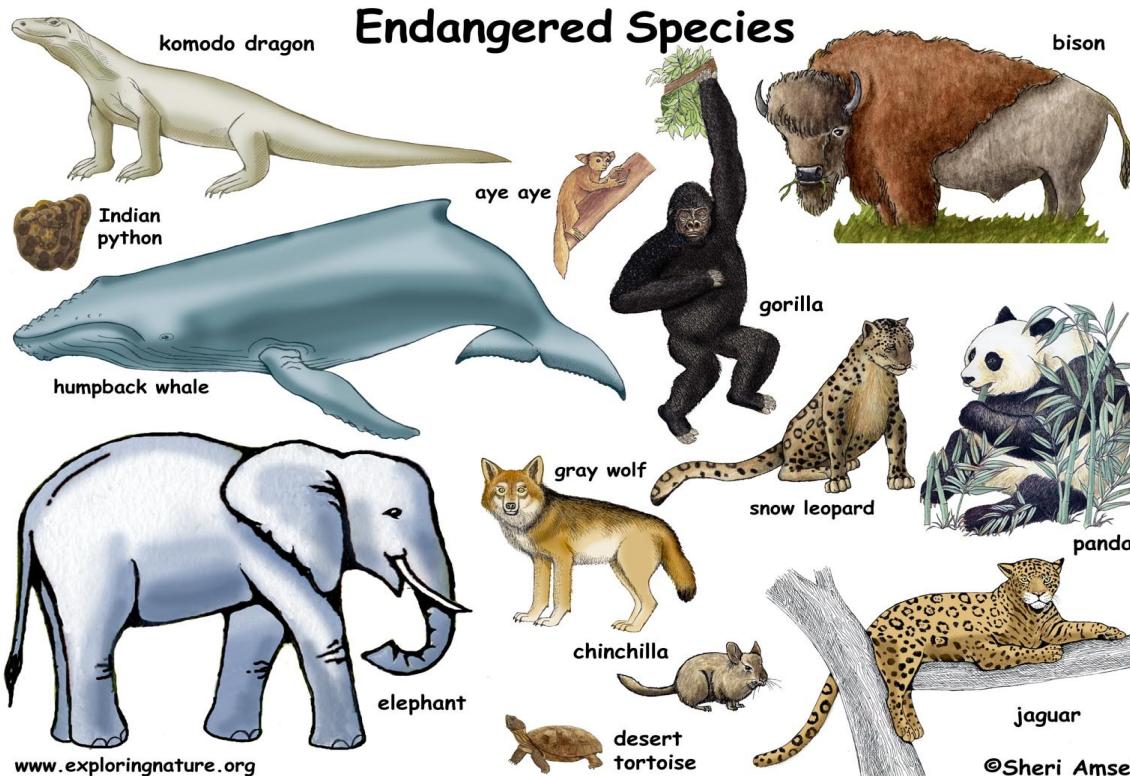
Bregman thinks *countries and companies* can arrange things to incentivize our better angels

So a reasonable conclusion might be that while there are still problems with our global commons, people should be able to work together to solve them.

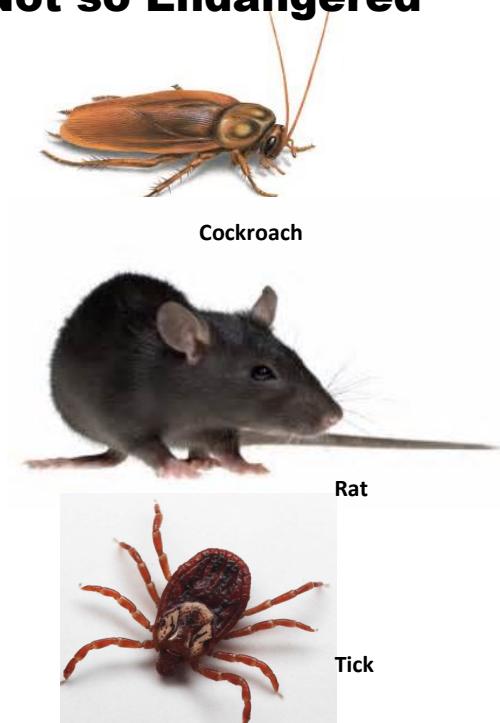
# Earth Common Components in Danger

- Non-renewable resources:
  - Fossil fuels
  - Mineral ores
  - Topsoil
- Water: Pollution including ground aquifers
- Forests: Wood and oxygen production
- Atmosphere: Pollution and climate change
- Oceans and coral reefs: Food, sea-life & beauty
- Wilderness: Refuges, wetlands & scenery
- Species: Biodiversity and biological resources (?)

# Species Discrimination?



## Not so Endangered



It may be futile to choose among species, but it may be ethical to try.

# An Emerging Global Ethical Framework

- New System Concepts
  - Ecosystem as an entirety
  - Finite limits on non-renewable resources
  - *Ecological stability* is highly desirable
  - *Ecological sustainability* is essential
- New Views of Nature
  - Holistic & interdependent vs. dualistic & mechanistic
  - Influenced by science – Darwin, DNA, biology, etc.
  - And by religion – Stewardship, the sacredness of nature
- Biocentric Ethical Philosophy
  - *Rights of the whole biotic community*, not just humans
  - *Rights of future generations*, not just today's populations

# The Dalai Lama Agrees

## We need global, secular ethics

By Tenzin Gyatso,  
the 14th Dalai Lama

**W**HEN THE president of the United States says "America first," he is making his voters happy. I can understand that. But from a global perspective, this statement isn't relevant. Everything is interconnected today.

The new reality is that everyone is interdependent with everyone else. The United States is a leading nation of the free world. For this reason, I call on its president to think more about global-level issues. There are no national boundaries for climate protection or the global economy. No religious boundaries, either. The time has come to understand that we are the same human beings on this planet. Whether we want to or not, we must coexist.

History tells us that when people pursue only their own national interests, there is strife and war. This is shortsighted and narrow-minded. It is also unrealistic and outdated. Living together as brothers and sisters is the only way to peace, compassion, mindfulness and more justice.

Religion can to a certain degree help to overcome division.



SANJAY BAID/EPA/Shutterstock  
**TIBETAN** leader the Dalai Lama visited Dharamsala, India, in November.

But religion alone will not be enough. Global secular ethics are now more important than the classical religions. We need a global ethic that can accept both believers and nonbelievers, including atheists.

My wish is that, one day, formal education will pay attention to the education of the heart, teaching love, compassion, justice, forgiveness, mindfulness, tolerance and peace. This education is necessary, from kindergarten to secondary schools and universities. I mean social, emotional and ethical

learning. We need a worldwide initiative for educating heart and mind in this modern age.

At present our educational systems are oriented mainly toward material values and training one's understanding. But reality teaches us that we do not come to reason through understanding alone. We should place greater emphasis on inner values.

Intolerance leads to hatred and division. Our children should grow up with the idea that dialogue, not violence, is the best and most practical way to solve conflicts. The young generations have a great responsibility to ensure that the world becomes a more peaceful place for all. But this can become reality only if we educate, not just the brain, but also the heart. The educational systems of the future should place greater emphasis on strengthening human abilities, such as warmth-heartedness, a sense of oneness, humanity and love.

I see with ever greater clarity that our spiritual well-being depends not on religion, but on our innate human nature — our affinity for goodness, compassion and caring for others. Regardless of whether we belong to a religion, we all have a fundamental and profoundly human wellspring of ethics within our-

selves. We need to nurture that shared ethical basis.

Ethics, as opposed to religion, are grounded in human nature. Through ethics, we can work on preserving creation. Empathy is the basis of human coexistence. It is my belief that human development relies on cooperation, not competition. Science tells us this.

We must learn that humanity is one big family. We are all brothers and sisters: physically, mentally and emotionally. But we are still focusing far too much on our differences instead of our commonalities. After all, every one of us is born the same way and dies the same way.

**THE 14TH DALAI LAMA, TENZIN GYATSO,** is the spiritual leader of Tibet and a Nobel laureate for peace. He wrote this op-ed with Franz Alt, a television journalist and bestselling author. This piece is adapted from their new book, "An Appeal to the World: The Way to Peace in a Time of Division."

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Los Angeles Times, November 13, 2017

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everyone else. The U.S.  
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its president, to  
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economy. No religi-  
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Los Angeles Times, November 13, 2017

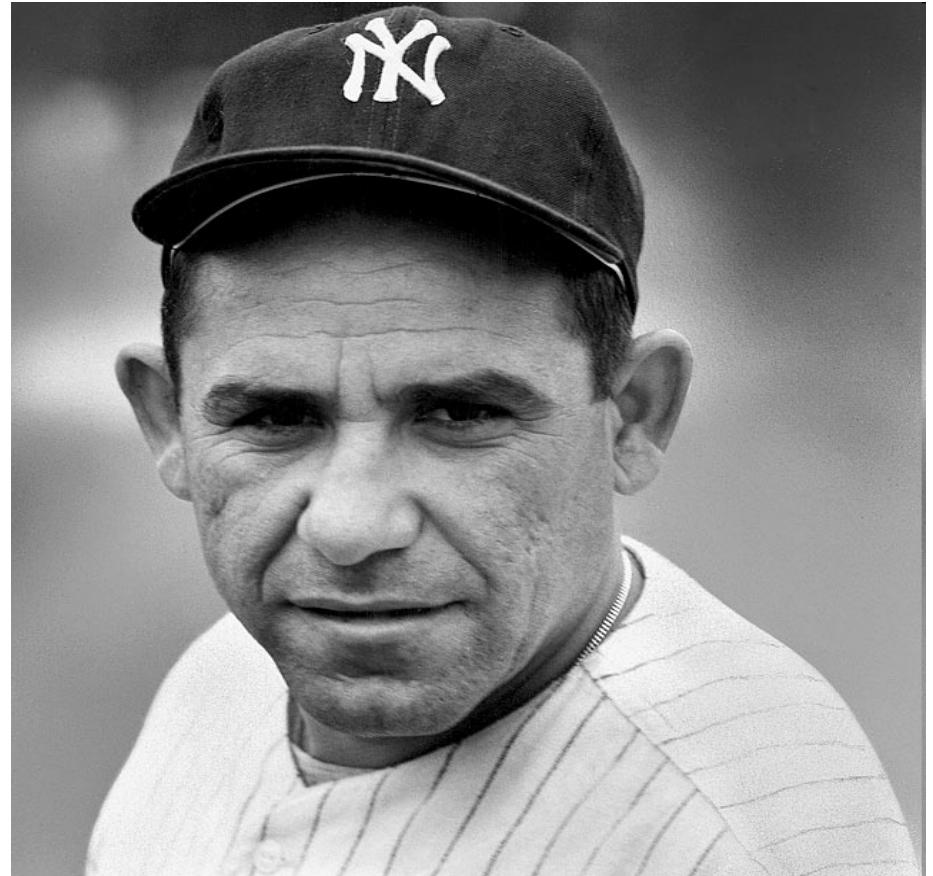
# The Ethical Duties of Engineers

- Analysis
  - Measure and analyze current situation
  - Predict future conditions
  - Establish technical requirements
  - Create new strategies for a sustainable environment
- Innovation and Development
  - Improve current technologies
  - Develop totally new approaches and technologies
- Communication
  - To policy makers
  - To the non-technical public
  - Factual, transparent, and above all -- Truthful!

# But Remember

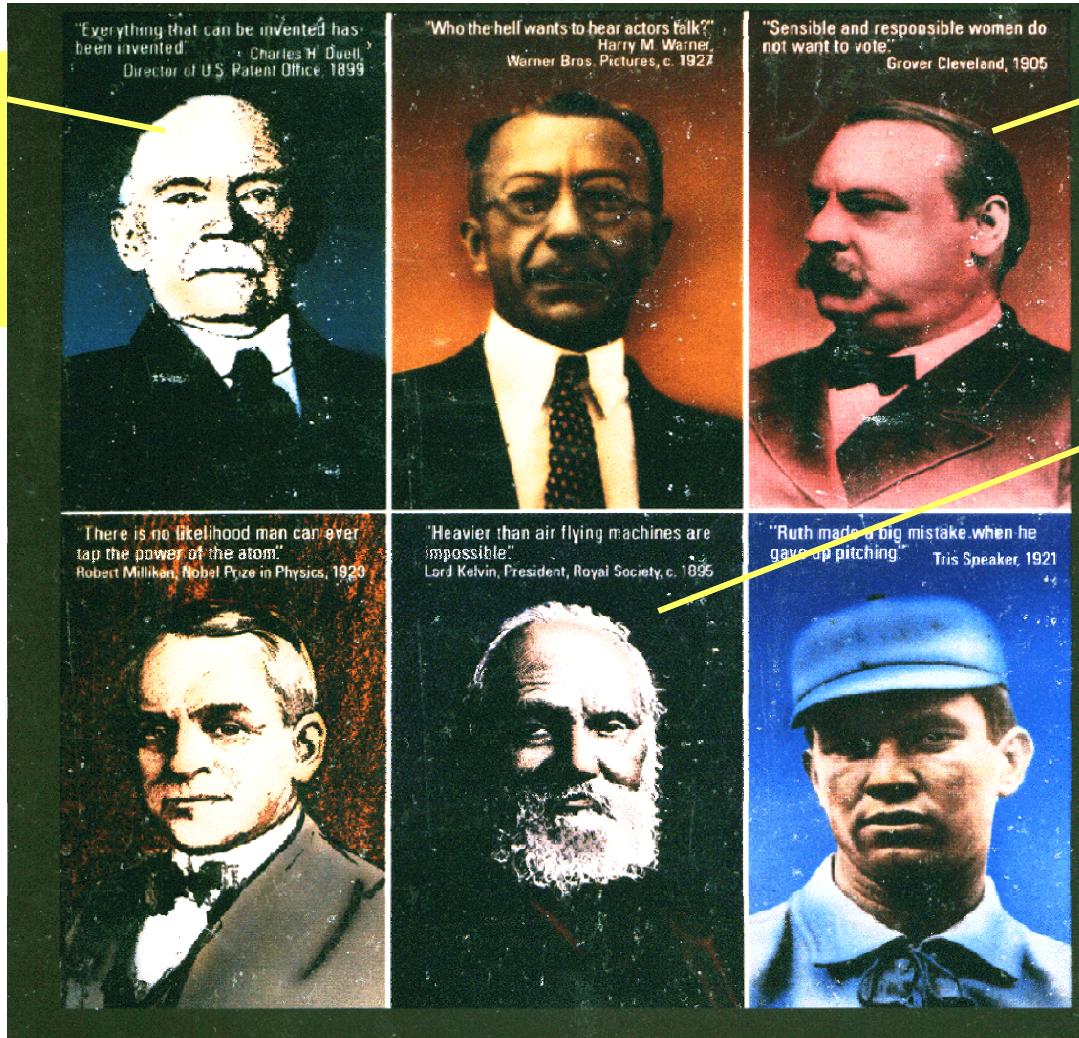
“It’s tough to make predictions, especially about the future.”

Yogi Berra  
New York Yankees  
Baseball Legend



# Some Previous Misguided Predictions

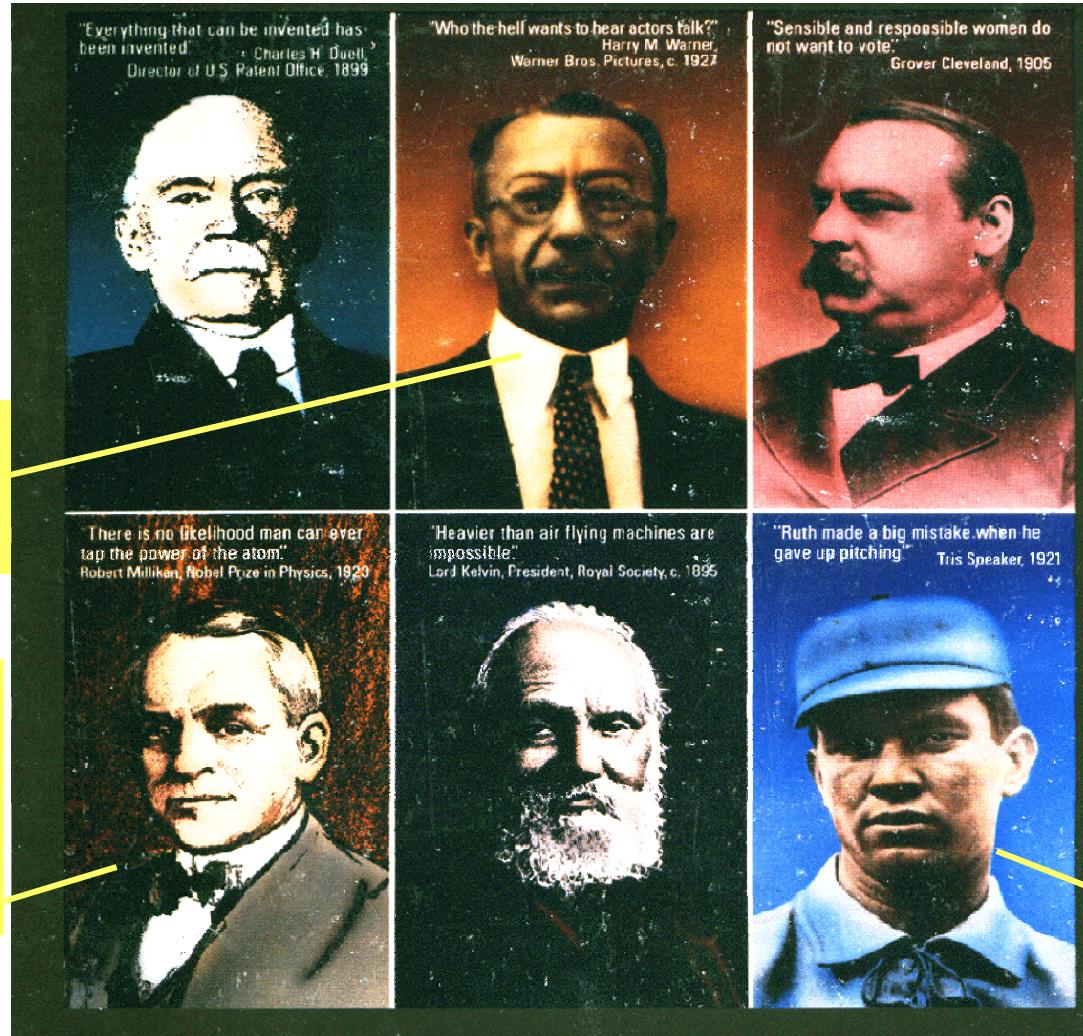
**Everything that can be invented has been invented – Charles Duell, US Patent Office, 1899**



**Sensible and responsible women do not want to vote - Grover Cleveland, 1905**

**Heavier than air flying machines are impossible - Lord Kelvin, President, Royal Society, 1895**

# Some Previous Misguided Predictions



# Summary

- We are at a worldwide point of inflection
- Increases are still occurring – In the world's population and in people's economic aspirations and achievements
- As a result, there are significant stresses on our common resources, environment and ecology
- Science and technology are central -- In creating these problems and in solving them
- The next 50-75 years will likely be critical
- Predicting future outcomes remains very difficult