The Quest: The Electric Age and Climate and Carbon

—

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EGEE 497

ALTERNATING CURRENTS

The Underpin of Modern Civilization

A commodity taken for granted, even more than oil changed the world on September 4, 1882..

- 52 light bulbs light up the offices of the New York Times

With the first coal-fired electric generating plant working, the age of electricity officially begins.

WHO WAS THOMAS EDISON?

Even with the odds against him, he managed to become a person of great achievements.

- Mainly a self-taught man
- His unusual capacity for concentration

The research Laboratory in Menlo Park, New Jersey became a source of many inventions.. “by methods which I could not explain.”

A Vision

For a time electricity was mainly used for street lightning, but Thomas Edison envisioned what he called a "subdivide" light.

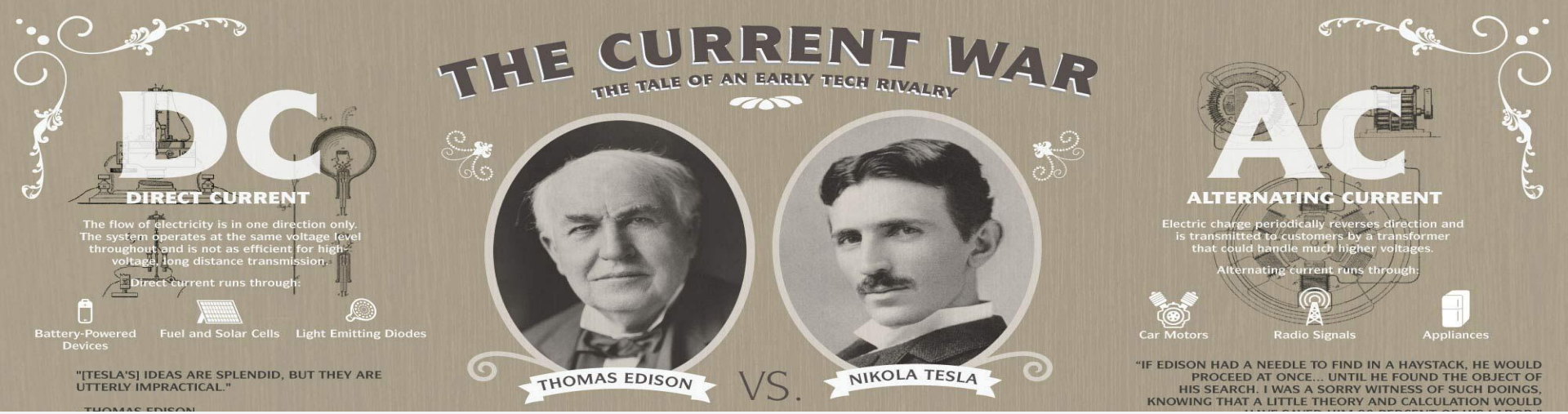
Edison had grand plans for the future with lightning. To create not only better light bulbs, or bringing electricity to homes, but to everybody on a commercial basis as soon as possible.

An Entire New System of Lightning

Years of expensive investments followed among Edison and other Inventors. After all the creation of an entire system required considerable funding.

Costs became a daily problem..

- Copper prices kept going up
- Its Direct Current method to transport electricity was not efficient in large distances.



Alternating Current was the needed alternative at the moment to create the bridge towards a commercially viable system for electricity distribution. An inevitable war had begun between a giant, and a Serbian Inventor. In the end, the higher benefits of AC were simply too big to continue to ignore.

George Westinghouse, now owner of Nikola Tesla's brilliant patent, forced the currently called Edison General Electric company to merge to become simply known as General Electric.

The Meter Man

Samuel Insull began working as a secretary in the office of the European representative of Thomas Edison. There, he made his first good impression..

In the early 1890's, electricity was still a luxury, and customers were charge by the number of light bulbs installed in the place (which was sometimes extremely expensive!)

- It was then when Insull stumbled accidentally on a new idea. A "meter" of electricity.

Natural Monopoly

There was still a lot to change in order to bring the prices of electricity down. Once again, Insull proposed to big changes:

1. To acquire all the small power plants to build bigger and more efficient ones.
2. A political innovation: A Regulatory bargain.
    - To form a Natural Monopoly

This Natural Monopoly called for the electric power business to be viewed as a public utility commission regulated by a governmental authority.

ELEKTROPOLIS

By the 1920's, 95% percent of the homes in Chicago were wired for electricity (and they payed by usage).

It was at this moment that Insull had become not only the most famous businessmen in the world, but also an icon of capitalism.

"My ambition is to hand out my name as clean as I received it."

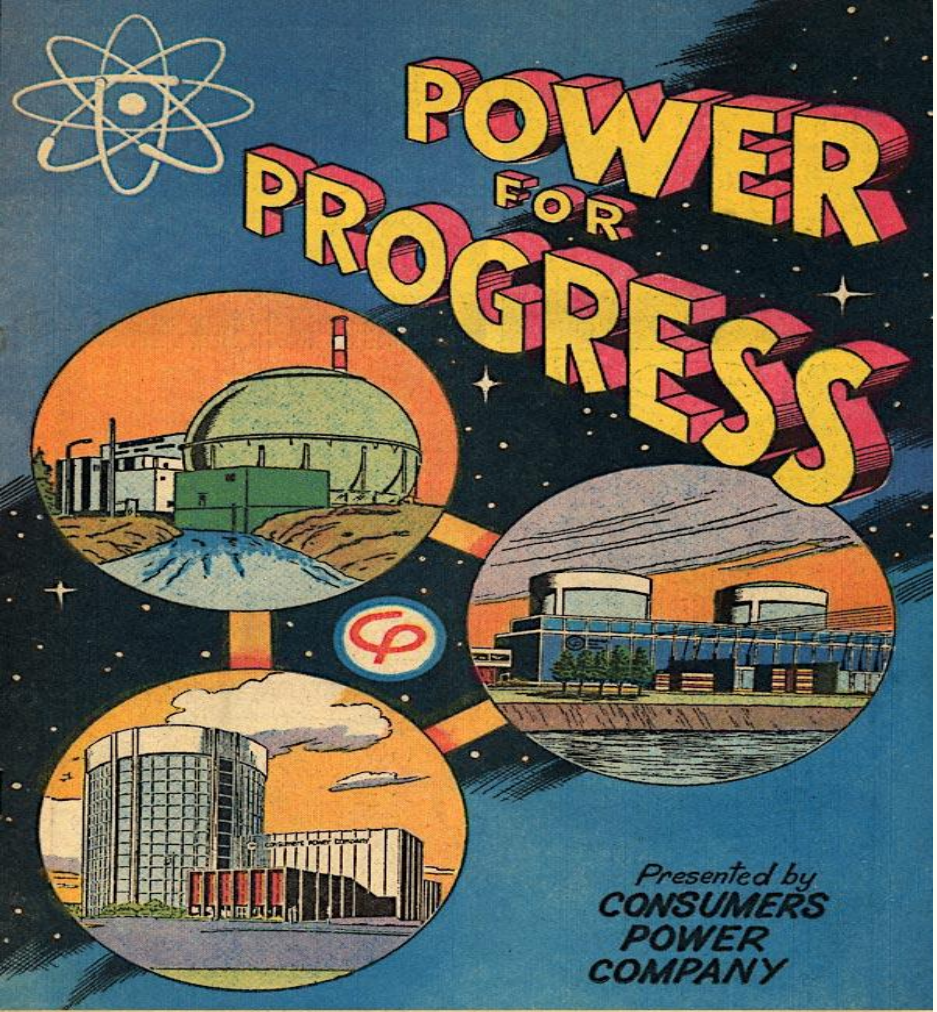
Samuel Insull

All Electric

With an unstoppable everincresing demand for electricity, the business required continually greater investments. Prices were already increasing, and problems intensified with the coming of the Great Depression..

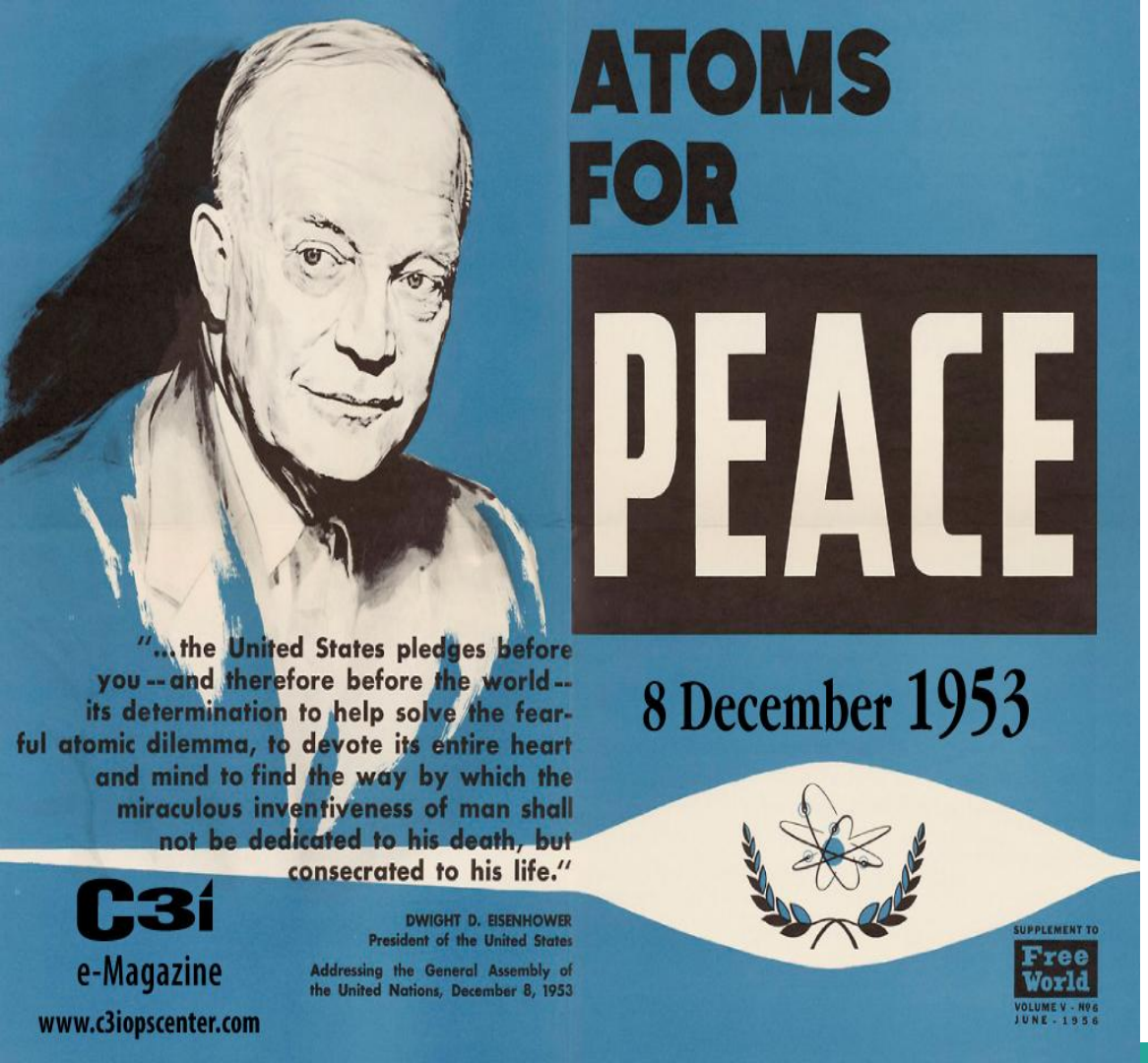
- Now "too broke to be broke" Insull had lost his Empire.

With the footprints left by Insull, the creation of an All Electric Society was no longer a dream, but how to generate electricity to meet the ever increasing demand?



POWER FOR PROGRESS - 1970s Nuclear Power Plant Comic Book - Distributed in 1971 to visitors of the Big Rock Point Power Plant, Charlevoix County, Michigan USA - Ethan Persoff, http://www.ep.tc
full text of this 16 page comic found at http://www.ep.tc

The Nuclear Cycle



November morning in 1952..

It was time to take Nuclear Power down a different path: The generation of electricity with Nuclear Power

The Admiral

Hyman Rickover, a 6 years old Polish boy immigrated to America in early 1900's. During high school he would work the night shifts since his family was so poor.

It was thanks to this work that later his chances will change for the good..

- The Naval Academy at Annapolis

The Nuclear Navy Engineer

Rickover served in two submarines with some entry jobs he got after graduation. He was assigned as the head of the Electrical Section in the Bureau of Ships. It was here when his talents first became notorious.

> *"An organizer & leader of outstanding ability"*

After World War II was without a doubt on his abilities to a secret atomic research in Oak Ridge, Tennessee, where his was sent to learn about the mysteries of nuclear energy.

The Nuclear Navy Engineer

Rickover understood the potential behind Nuclear Energy. His goal was nothing short from a challenge, but his methods worked..

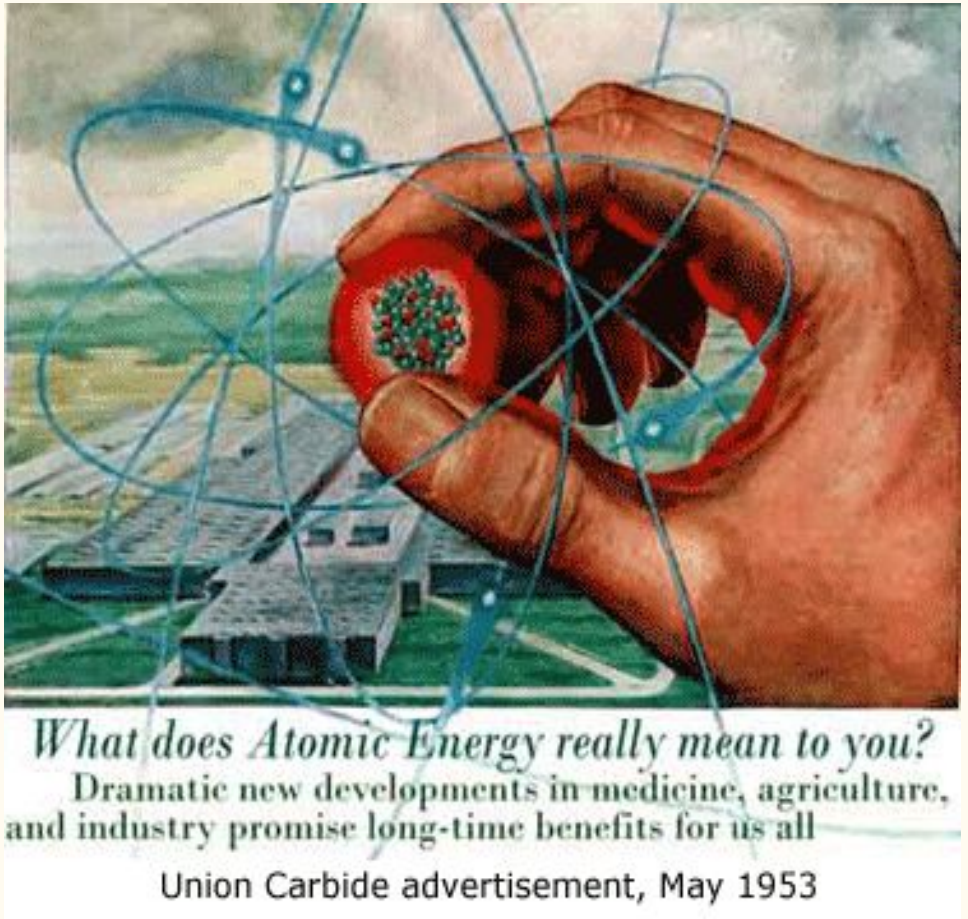
- The light-water reactor

By the end of his career in 1986, more than 40% percent of the navy's major ships would be nuclear propelled.

A "First" in Soviet Science

It was in the summer of 1954 when a Soviet radio announced that the first civilian reactor had gone into operation just south of Moscow in the "science city" of Obninsk.

The news went to Britain and the United States with a new push toward the development of nuclear technology.



Union Carbide advertisement, May 1953

New Phase

The Atomic Energy Commision made the announcement in 1954 that called the Civilian Program, with the optimistic view that electricity will become so cheap it will become "too cheap to meter."

Rickover based the design of the new nuclear reactor on his already nuclear reactors used on submarines. The results were exceptional.

The Great Nuclear Bandwagon

Once again, Thomas Edison, and George Westinghouse were battling for a market share of the new technology. In just the next few years, more that 50 nuclear power plants were ordered.

The best things never come free..

- Unprecedented prices
- How safe is safe enough?

1. Minor Malfunctions
2. Unprepared Staff
3. Lack of Standardization

Three factors that called the attention of the world.

Solution: The creation of the Institute of Nuclear Power Operations. From now on, everything was going to work under Rickover standards.

The Nuclear Accident

Radiation Continues To Leak From Crippled Plant

HARRISBURG, Pa. (AP) — Radiation leaks from the Three Mile Island nuclear power plant continued today, authorities said, as a debate grew over what was described as one of this most serious such incidents in this country's history.

"The vapor that is now going into the atmosphere is from a sump pump and is only mildly radioactive within accepted limits," said Don Curry, a spokesman for the Metropolitan Edison Co., owner of the plant. The pump is designed to remove water after it has cooled the reactor.

"We concede that it's not just a little thing," Curry said. "In terms of publicity it will probably surpass the Browns Ferry incident."

Until now, a March 1975 fire in the control room of the Browns Ferry nuclear plant in Alabama has generally been considered this nation's most dangerous incident involving a nuclear reactor.

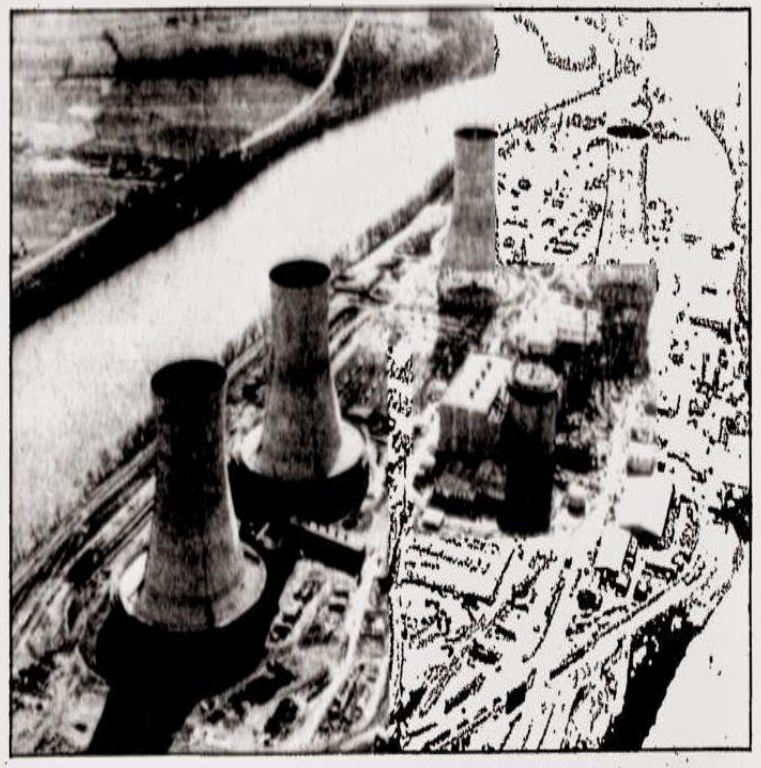
Low level radiation was detected in the air as far as 16 miles away after an apparent valve failure Wednesday morning resulted in excessive pressure being built up in the water used to cool the reactor core at Three Mile Island.

"Some of the water vapor, through the venting system, went into the atmosphere," Curry said.

Curry said the latest radiation measurements outside the plant were at two to three millirems. Individuals are exposed to up to 30-millirems in a single X-ray examination.

Walter Creitz, president of Metropolitan Edison, said on ABC-TV's *Good Morning America* show this morning that the plant shut down safely and that the level of radiation released "would not endanger or injure any people."

Creitz said his company did not know what equipment had been disabled or what precisely caused the accident.



An aerial view of the Three Mile Island nuclear power plant.

AP Photo

Don't move Forward

Despite the alarming events of Three Mile Island accident, the Soviets continued to move ahead in nuclear power.

It was the RBMK nuclear reactor design that, due to its cheap costs and a bad set a political decisions, was chosen to be installed in the Pripyat near the town of Chernobyl.

Soon enough, the sum of impulsive decisions would lead to one of the greatest disasters in the history of nuclear power. generation

Fuel for the Future

Chernobyl's impact was immense. By solidifying the opposition to nuclear power brought the nuclear power market to a stop in the U.S. as in most of the members of the "nuclear club" (U.S., Soviet Union, Britain, France and China).

Th exceptions: Japan & France.

If not nuclear energy, then what??

BREAKING THE BARGAIN

Rate Shock

Up until the 1970's, the electric power prices were established not in the marketplace, but rather by a state's public utility commission (PUC).

It worked. Since 1934, the price of electricity had went down by 86%. In 1970, the prices abruptly turned up rising an alert that something in the system was not right.

- There was too much control!

Deregulation

Easier said than done, but the timing seemed perfect. Increased confidence in the markets grew..

- Communism collapsed in the Soviet Union
- China and India opened up to the world economy
- Britain's industry was privatized

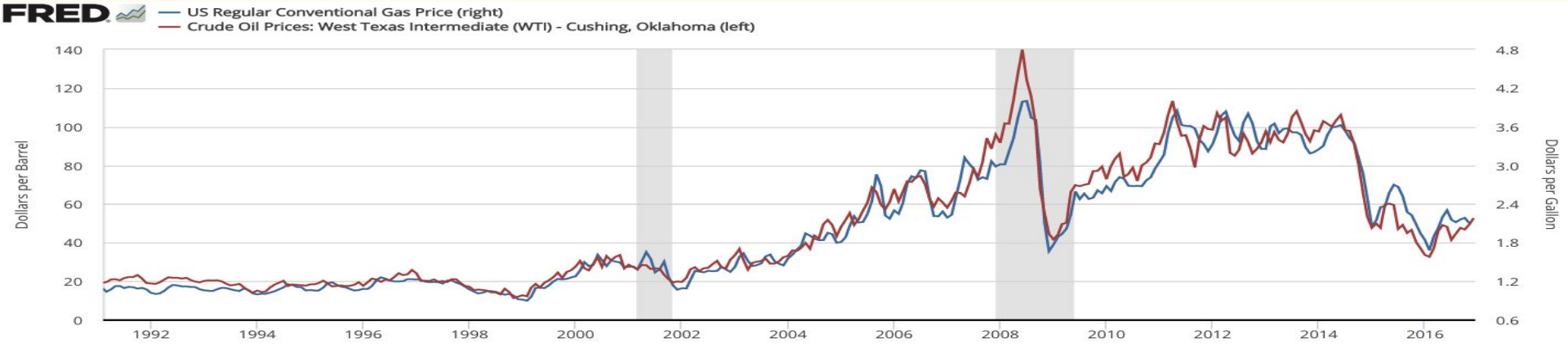
The goal: To drive prices down with through competition.

Save California!

The power crisis was throughout the country, but California went into disarray. California enacted deregulation in 1994, but this was not the way it was supposed to be..

- Unworkable form of deregulation
- Adverse turn Supply & Demand
- Erroneous Political Culture

It was time to end with the "Natural Monopoly" once envisioned by Samuel Insull.



The Iron Curtain

Wholesale markets were deregulated. Prices in those markets would be free to fluctuate with supply and demand. But the traditional retail markets were not. This is what is called the Iron Curtain.

The new system was implemented in 1998.

Madness

California kept making mistakes.. A state heavily dependent on hydropower, was once again affected by the drought that passed by in the year 2000.

- Scared, the agency that managed the state's power grid, frantically look for new power supplies.

Prices in electricity spiked bringing down even the giants of the state.

Governor Gray Davis, finally putting his ego aside, let the retail prices rise. By the end of the year 2001 the crisis was finally easing.

Crisis by Design

"The California crisis was not a failure of markets. It was a failure of regulation"

The California energy crisis left an important lesson in the energy market. It proved that a well-designed power market can work.

This new market will now reflect the true cost of electricity. The major question today is not what market design works better, but something of much more importance, and that is the fuel of choice.

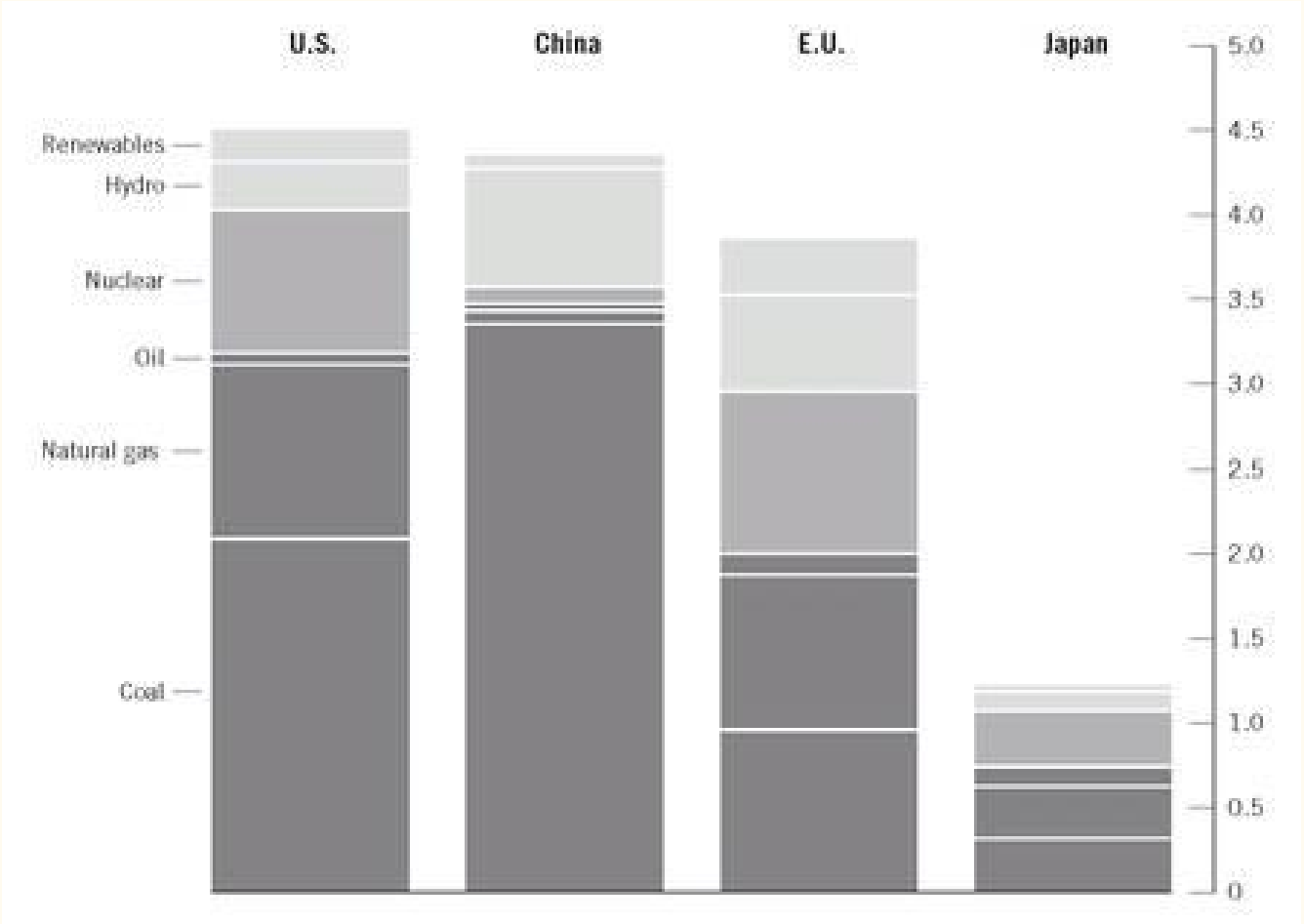
Fuel Choice

Electricity consumption doubled in 1980, expected double again by 2030

- China and India need power supply to keep up economic growth,
- US-all-electric-home

Power choice

- The choices on fuel mix determined by the constraints and endowments of region and geography
- Technology, economics, availability, and the three Ps—policy, politics, and public opinion
- Coal, nuclear and natural gas remain dominant


U.S.
China
E.U.
Japan
Renewables
Hydro
Nuclear
Oil
Natural gas
Coal
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0

Coal and Carbon

- 40% of world's electricity from coal
- Produce more than twice CO_2 compares to natural gas
- In US, Global warming-political and regulatory opposition to coal environmental groups and concerns with water usage
- Increase the cost of coal plant, accelerate retirement of coal plant

CCS(Carbon Capture and sequestration)

- Expensive and complex in terms of technology, politics and regulation

“Big Carbon”

- A new energy industry work in reverse
- Uncertainties with large-scale adoption of CCS: responsibility, liability, monitoring, management
- Rise coal-fire electricity by 80% to 100%
- Nothing close to a large-scale system for managing carbon
- Large amount money and time needed until it becomes commercial
- Provide incentives for clean coal

The Return of Nuclear

- Large capacity: 20% of electricity in US from 1980s to 2010 without new plant
- NRC's license extension-leads to update the safety system
- 2010, Obama administration announced loan guarantees to Southern Company to build two new plants under the Energy Policy Act of 2005
- Nuclear waste-easy to store, time duration is too long
- Nuclear proliferation-A. Q. Khan helped Iran and North Korea
- Nuclear renaissance continues despite the incidence of Fukushima Daiichi
- Cheap unconventional natural gas poses the challenge to nuclear

Glacial Change

Glacial Change

- Rise of carbon, humanity is generating an increasing proportion of carbon for two reason: population and rising income
- Increasing of greenhouse gases might change climate in potentially apocalyptic ways:melting ice caps, transforming fertile areas into dying deserts, etc
- The balance of greenhouse gases keeps the temperature hospitable to life, not too cold or too hot
- Atmosphere traps heat: first discovered by Horace Bénédict de Saussure and Joseph Fourier

Glacial change

- 1837, Louis Agassiz introduced the concept of ice age.
- John Tyndall discovered coal gas, water and carbon dioxide tapped infrared light-approval of greenhouse effect
- Svante Arrhenius predicted the effect of CO_2 concentration on climate
- 1938, Stewart Callendar further describe the role of CO_2 in climate change-Callendar Effect
- Both Arrhenius and Callendar thought increasing in CO_2 would prevent ice age and be beneficial to mankind

The Age of Discovery

Roger Revelle

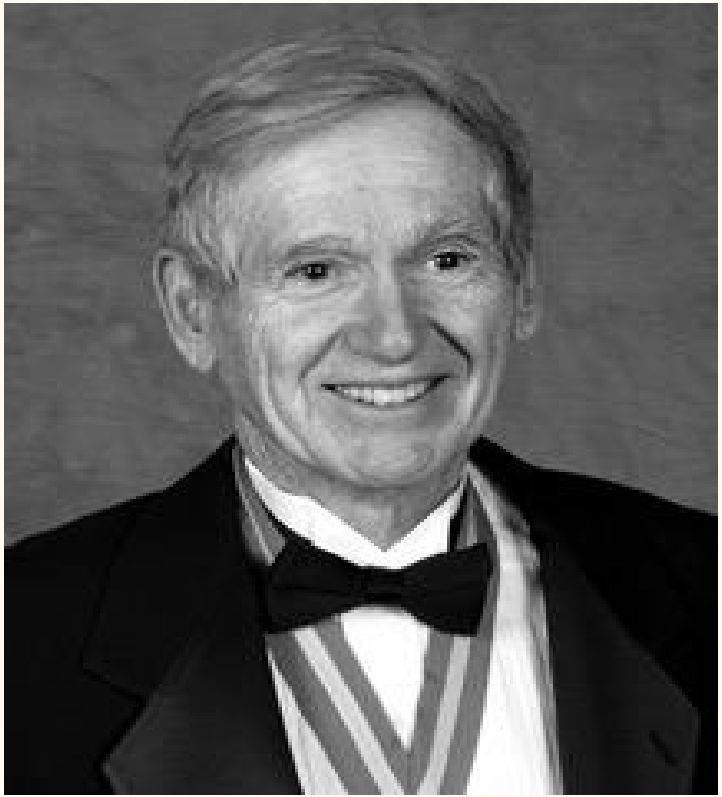
- Invoked Arrhenius and Callendar with ambiguity, 1950s
- Ocean absorb most of carbon, but most of the absorption was only on a temporary basis due to the lack of interchange between warmer and colder level in the ocean

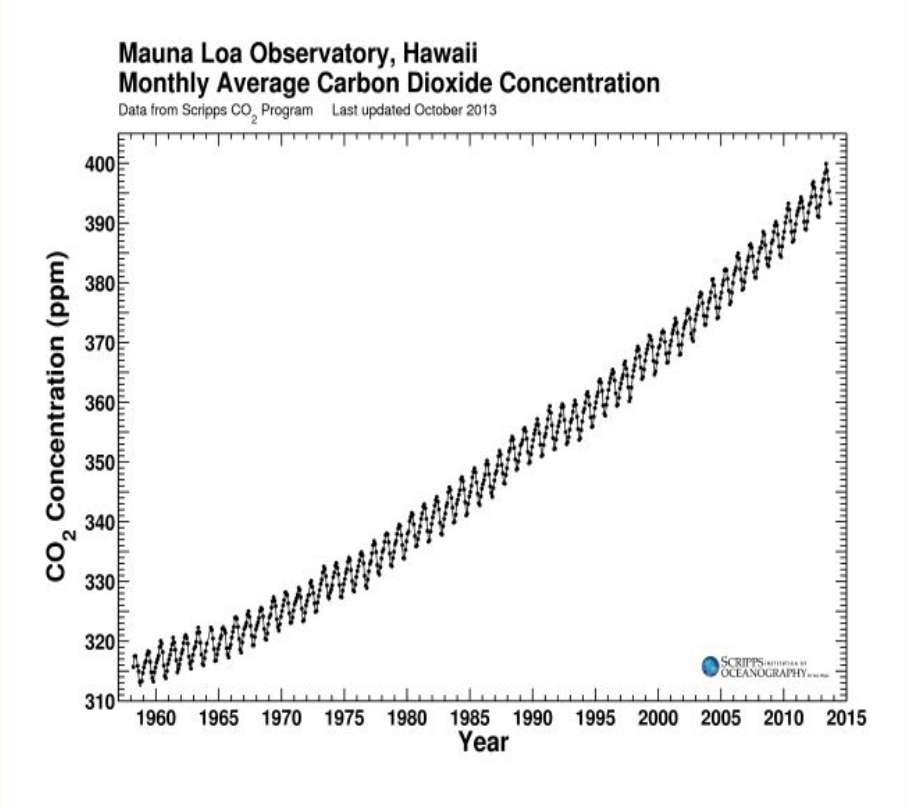
The Age of Discovery

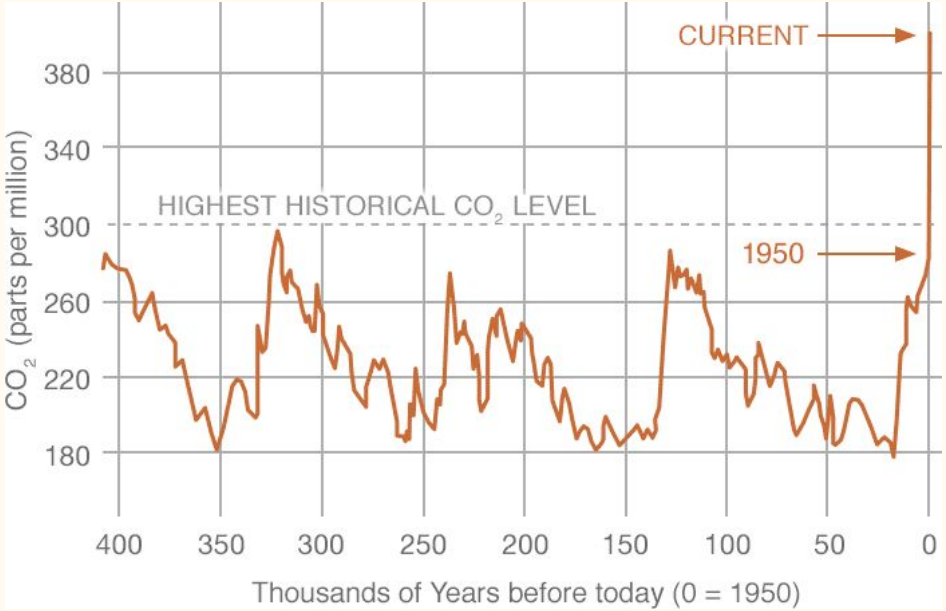
- Weather played key role in WWII, ex The D-DAY
- Eisenhower initialed the IGY
- IGY(international geophysical year)brought many scientists to understanding of weather and climate

Charles David Keeling

- Proved Callendar Effect
- Measured the concentration of CO_2 known as Keeling Curve-central icon of the greenhouse effect
- 1969, realized the risk of rising carbon




Mauna Loa Observatory, Hawaii
Monthly Average Carbon Dioxide Concentration
Data from Scripps CO2 Program Last updated October 2013
CO2 Concentration (ppm)
400
390
380
370
360
350
340
330
320
310
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015
Year
SCRIPPS INSTITUTION OF OCEANOGRAPHY


CURRENT
HIGHEST HISTORICAL CO2 LEVEL
1950
CO2 (parts per million)
380
340
300
260
220
180
400 350 300 250 200 150 100 50 0
Thousands of Years before today (0 = 1950)

The Age of Discovery

- 1972, *Science* magazine-“the present cooling is especially demonstrable”
- By 1980s, “Nuclear Winter”-nuclear war
- Satellites and development in computer to model climate

John Von Neumann

- Recognized the importance of computer to model the climate

The Age of discovery

- JASON committee led to Senate hearing in 1980

"It means good-bye Miami, Corpus Christi...good-bye Boston, good-bye New Orleans, good-bye Charleston.... "

- Gus Speth with other author came up four-point program: "acknowledgment of the problem, energy conservation, reforestation—and lower carbon fuels"

The Age of Discovery

- Key breakthrough: recovery of ice core

"Carbon concentrations had been lower in the preindustrial age—275 to 280 parts per million compared with 325 parts in 1970 and 354 parts in 1990"

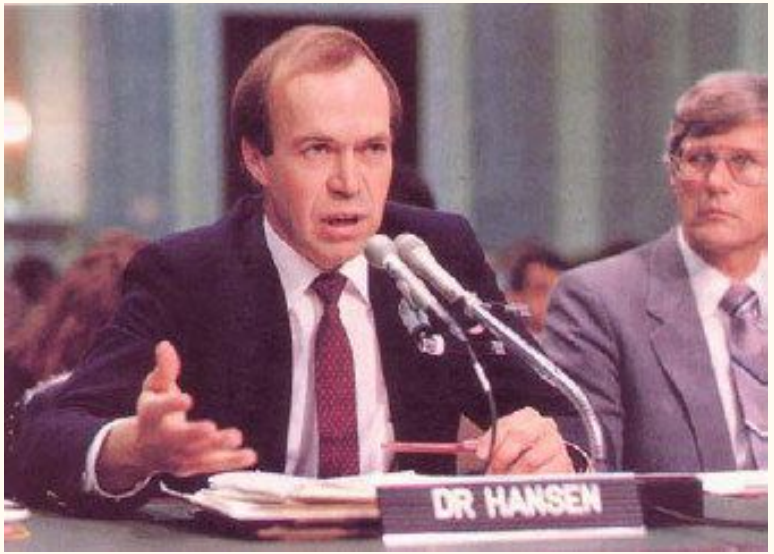
- Al Gore (inspired by Revelle) and other 7 senators is concerned with climate change

The Road to Rio

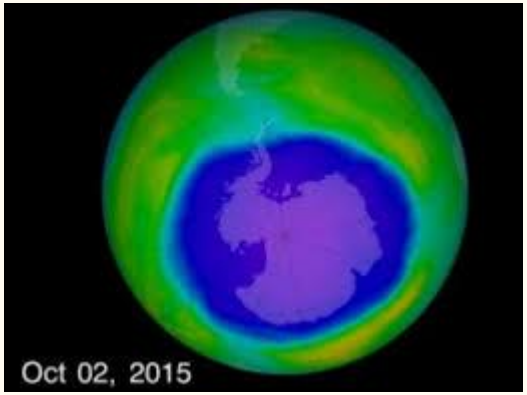
A Hot and Muggy Afternoon in DC

June 23, 1988 - Washington DC Senate hearing on global warming set up by Chairman Senator Tim Wirth

“We can ascribe with a high degree of confidence a cause-and-effect relationship between the greenhouse effect and observed warming.” - James Hansen



1987 Montreal Protocol



Researchers in 1985 from the British Antarctic Survey used NASA satellites to find a hole in the ozone over Antarctica. Found source of hole to be chlorofluorocarbons (CFCs).

Signed Montreal Protocol to eliminate CFC production. Protocol acknowledged that increasing concentrations of greenhouse gases were dangerous.

Successful because it was easy to enforce - only 40 companies manufactured CFC’s

James Hansen - Celebrity of Climate Change

His peers thought he was too categoric - “ Fails to hedge his conclusions with appropriate qualifiers that reflect the imprecise science of climate modeling.”

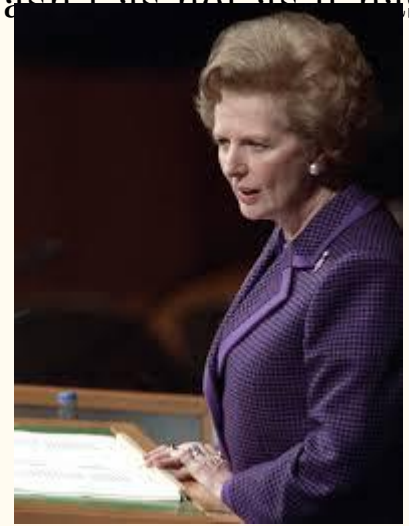
Hansen developed the “Venus Syndrome” - runaway greenhouse effect in which the Earth would become like Venus if nothing is done (hot and full of CO2)

Changing Opinions of Climate Change

1988 Presidential Election- George H.W. Bush promised to make it a priority in office

Urgency fell after the summer - even though it was hot - it wasn't as hot as it has been (Dust Bowl in 1934)

Margaret Thatcher - Did not receive any media attention



Public was not worried about climate change.

Bert Bolin and the IPCC

IPCC - Intergovernmental Panel on Climate Change - made up from UN development program and World Meteorological Organization - a coordinated network of scientists who worked across borders, facilitated by cheaper and better communications.

Bert Bolin - head of the IPCC - had experience from a geochemist to a policy maker to a mathematician. He did not want to get ahead of the science - wanted to wait on policy.

IPCC First Climate Change Report

Sundsvall, Sweden (1990): No consensus on the final report to the United Nations General Assembly

After much turmoil and a language barrier, IPCC was rescued and final report was approved by all.

“Unsure that it is man made or not but there is warming.”

To Rio?

UN called for a convention and international agreement to limit greenhouse gases (particularly CO2)

Limits on carbon use = constrain economic development and energy use

Developed nations were split - Europeans sought specific timetables to reduce emissions. US was worried about the economic impacts.

Bush’s Decision

William Reilly

- Head of the EPA
- Proponent for Bush’s trip
- Wanted Targets for US

John Sununu

- White House Chief of Staff
- Opponent for Bush’s trip
- Questioned the Models

Bush did not really had not done much related to climate change - busy with the fall of the Soviet Union and Gulf War.

Bush's Decision

Bush decided to go because of pressures from the campaign and a need to seem in touch with the world amid falling poll popularity.

In Rio - 160 heads of state, governments, international organizations, 10,000 government officials, 25,000 businessmen, NGOs, journalists, activists

Rio Summit Takeaways

UN Framework Convention on Climate Change was signed first by US and also the first nation to ratify it.

The goal “the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent **dangerous anthropogenic interference** with the climate system.”

Developed countries took commitments to control emissions while developing countries only had to monitor. Developed countries had to provide funding for developing nations to help reduce their emissions.

Making a Market

Cap and Trade vs. Nixon Regulation

Cap and Trade: Using the market to buy and sell pollution like a commodity. Hated by environmental groups - takes away the moral stigma that is properly associated.

Ronald Coase - wrote on externalities. Government regulation is not necessarily the best option - leave it to the market forces.

Compared to Nixon's EPA in the 60s and 70s - intense environmental regulation, command and control regulation

Market Forces in Action

Lead became known as toxic - during the Reagan presidency, refiners were allowed to trade lead permits which gave an economic incentive to those who could get rid of lead more quickly. In only 5 years, lead was phased out of gasoline.

A Possibility For Market Forces: Acid Rain

George H.W. Bush invited Richard Stavins to talk about how to apply the market forces theory to acid rain.

Hard fight through Congress - but it was a bipartisan issue. Bush signed the Clean Air Act in 1990 which established an emissions trading system to reduce acid rain. Shrinking the allowed permits every year would increase incentive to reduce emissions. “The Grand Policy Experiment.”

Provided credibility for cap and trade.

Second IPCC Report and the Problems With It

“The balance of evidence suggests that these is a discernable human influence on global climate.” “Newly perceived fingerprint of human-induced climate change.”

Became much more controversial -

1. Developed vs. Developing Nations: Ahead of Kyoto, Angela Merkel hosted Berlin meeting of national delegations. Berlin Mandate said that developed countries would have targets but developing countries did not need to have targets.
2. Divisions between scientists/business and IPCC. Biased vs. Ignorance.

The Kyoto Meeting (1997)

“The most complex, difficult, and draining” negotiation he had ever encountered - Stuart Eizenstat, Undersecretary of State for Economic, Business, and Agricultural Affairs.

First Problem in Kyoto - the EU vs. the USA

EU wanted Americans to make deeper cuts. America did not want to. It was easier for the EU to meet targets.

Al Gore electrified the conference and the US, Europe, and Japan all signed for 6-8% lower CO2 emissions by 2008 compared to 1990 levels.

Second Problem of Kyoto - Developing Countries

US signed “Byrd-Hagel Resolution” before Kyoto that said US would not ratify treaty where developing countries would not have to meet targets. Congressmen were worried that it would put the United States at economic competitive disadvantage.

Developing countries were not required to meet targets.

Third Problem of Kyoto - Implementation

“Cost of mitigating climate change without a market system would be far too expensive for any economy to bear.” - Stuart Eizenstat

Was Kyoto realistic?

Bolin - “At the time of its adoption it was already politically unrealistic.”

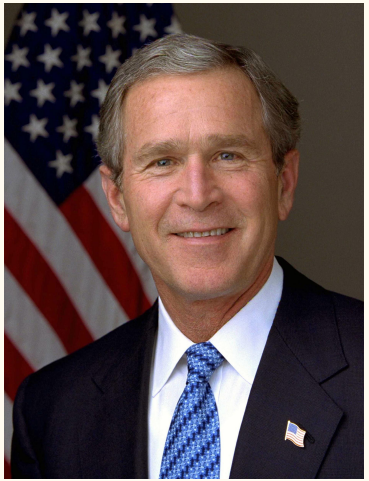
US never voted on ratification of the treaty or implemented it. Did not follow it.

On the Global Agenda

Communication but No Action

Tony Blair, British Prime Minister, and the leaders of the G8 convened in Scotland to discuss many topics in which climate change took a role. Nicholas Stern, noted the lack of urgency and interest in the climate change discussion.

Bush “Governor of Wind” from Texas said he would address climate in his election. Called for the reduction of 4 main greenhouse pollutants.



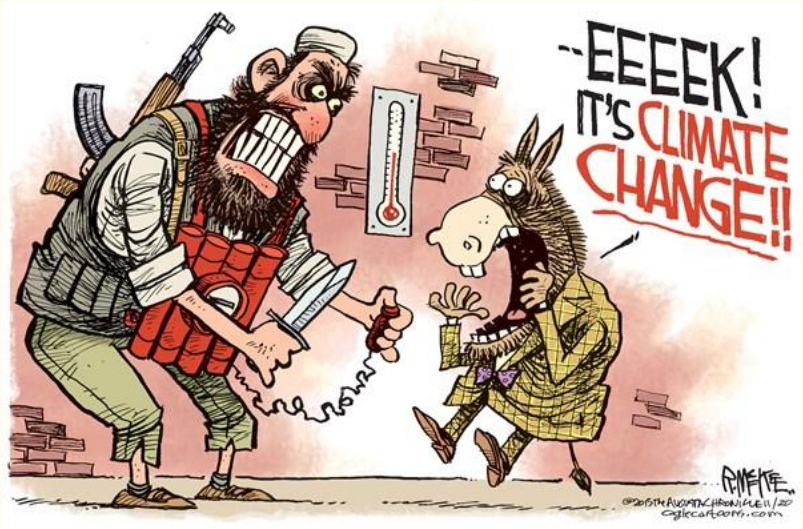
Research and Spending

Deep divisions in the research:

1. We need to get the science right
2. How long will it take us to really understand the science right.

David King, Cambridge professor, criticized Bush administration for their inaction and Bush administration was not happy - they were fighting terrorists.

What's more important: terrorism or climate change?



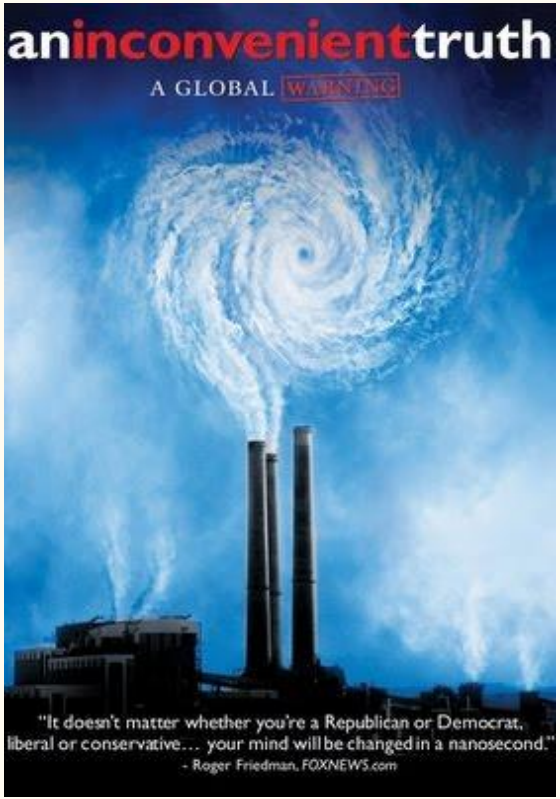
The Sandor Experiment on Cap and Trade

Richard Sandor - economist from Northwestern, experimented with a carbon market in which he involved 14 companies and the city of Chicago (Chicago Climate Exchange). It was successful - he created a sister venture in Europe called the European Climate Exchange.

“Carbon is the biggest market in the world - carbon is released from coal, oil, natural gas, and other processes.”

More Signs of Climate Change

- Katrina and Rita hit the gulf coast - major signs of the super storms that may be to come without action
- *An Inconvenient Truth*
- Fourth IPCC report - 90% certain the man contributed to climate change. Stated the 2 - 4.5 degrees C rise in global temperatures
- The Stern Review of the Economics of Climate Change - climate change would be the largest market failure of all time. More money to fix later than to mitigate now.



Green Credentials

John Browne of BP

GE - Eco-Imagination Conference

Global Climate Coalition: lobbied against the climate change initiatives: would result in “severe unemployment, decreased competitiveness for US goods and grave economic disruptions.”

GE and BP and other companies formed to create the US Climate Action Partnership. GCC disbanded later.

Changing Attitudes to Climate

Al Gore and the IPCC jointly won the Nobel Peace Prize. Showed the importance of the subject around the world and in developing countries.

US States adopted state-wide emission targets, cap and trade programs. Massachusetts sued EPA for not regulated car exhaust CO2 emissions - won court case due to the possibility of storms and loss of coastline to Massachusetts. CO2 is a pollutant that should fall under the Clean Air Act.

Bush had to respond to this ruling - he decided to form a group called the Major Economies that were the world's biggest emitters. Included developing countries so that it was less contentious.

In Search of Consensus

US

Ed Markey and Henry Waxman were in charge of developing a cap and trade program for carbon during Obama administration.

1. Hand out allowances for free to specific industries
2. Regulation by the EPA

Took ideas from the SO2 acid rain reductions. Huge goals 85% reductions in CO2 by 2050. Passed the congress but was still stuck in the Senate.

China

Criticized for its carbon use. They responded:

1. Much lower per capita based on US levels.
2. China is still a relatively poor nation - unlike US, Europe, and Japan
3. US and Europe have outsourced a significant portion of their energy use and emissions to China.

China decided to make a change and started their own green revolution due to major droughts, poor air quality and threats to water and food for their people.

India

Much more impoverished than China, very vulnerable to climate change - monsoons, storms, glaciers.

“India has not caused the problem of global warming. But try and make sure that India is part of the solution.”

“Hopenhagen”

Obama heard of the dysfunctions and somehow found and sat down with the leaders of China, Brazil, South Africa, and India and drafted an agreement to adopt parallel nonbinding pledges to reduce emissions.

This agreement was not adopted by the rest of the conference delegation.

Result of COP 15 - UN was too large to get a full climate change plan passed.

US bill on Climate Change never passed through the Senate.

IPCC comes into Question

Emails leaked that said scientist used tricks to get the results that they wanted.

Different findings from the IPCC pointed to bad sources and poor studies.

Resulted in decline in interest for global warming.

Climate Change Today

Seen in increased results of global warming (more severe weather, more melting of the ice caps, more animal species in danger).

Obama moved away from legislation and more toward regulation installing many EPA regulations on greenhouse gas emissions. However - it was met with controversy from the Congress.

“The outcome of the battle over CO2 regulation will depend on the makeup of the US Congress over the next half decade and the disposition of the courts.”