

Part III: The Electric Age



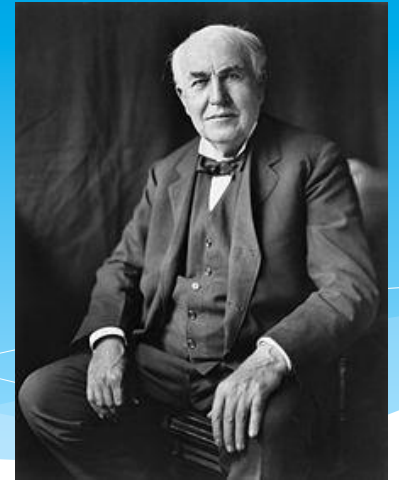
Spark notes

 Thomas Edison was a loser

 Solutions are cyclical; “know your history”

 “Only two things are infinite, the universe and human stupidity, and I’m not sure about the former.”

Thomas Edison



- Self-taught and self-centered
- Invented the telegraph and the phonograph
- 1,093 patents in total
- Wanted to subdivide current for use in private homes
- Went after system of lighting, not just a lightbulb
- Used a carbon filament
- A decade spent on Pearl Street Station

The Wizard of Menlo Park

- J.P. Morgan
- September 4th, 1882 - Thomas Edison flipped the switch to light up the office of JP Morgan
- Current was supplied from the Pearl Street Station
- Would serve one square mile of Lower Manhattan
- First electricity bill was for \$50.44 on Jan. 18th, 1883



AC vs. DC Current

- Thomas Edison
 - Proponent of DC current
 - Low voltage, not good for transport
 - Generator required per square block
- George Westinghouse
 - AC Current
 - Transformer steps up electricity to high voltage
 - Transport over long distances
- Merger formed General Electric
- World Fair in 1893



The Insull Empire

- Samuel Insull
 - Edison's Secretary
 - Imported the "meter" to Chicago – charge per usage
 - Created *holding companies*
 - Promoted the *regulatory bargain* and created atmosphere for *natural monopolies*
 - Chicago became showcase for electricity



The Insull Empire

- By the 1920s, 95% of Chicago was lit
- Insull had an empire - \$500 million
- 1928 - Created new company with stock prices at \$12
- 1929 - Stock prices had exceeded \$150
- 1929 - Market Crashed
 - Poor accounting practices and unreliable books
- 1932 - Empire Collapses
 - Fraud and embezzlement
 - FDR went after him

Ronald Reagan

- 1950s and 1960s - GI Bill
 - New homes and electric power
- Demand grew 10% per year
- Spokesperson for GE
 - "Live Better Electrically"
- Governor of CA
- President of the United States
 - Advocate for freedom and free market
 - All electric home



The Nuclear Cycle

- 1952 - Eisenhower tests hydrogen bomb
- "Atoms for Peace" - slow down arms race
- The basics: nuclear core
 - Radioactive material generates controlled chain reaction
 - Releases heat and energy
 - Coolant flows around the core
 - 90% are light water



Admiral Hyman Rickover

- Father of Nuclear Power
- Put in charge of Atomic Energy Commission
- Chose light water system
- 1954 - first nuclear submarine
- 1986 - 40% of Navy was nuclear
- 1957 - First nuclear power plant in Shippingport, PA



Nuclear Bandwagon

- GE vs. Westinghouse
 - Boiling water reactor vs. pressurized water reactor
- US, Soviet Union, Great Britain, France, and China
- 1974 - India enters market through reprocessing
- France begins a commitment to nuclear power
- Japan does too

Three Mile Island

 <http://www.youtube.com/watch?v=afdkyvSBehw>

Aftermath of Three Mile Island

- Admiral Rickover prepares report for Jimmy Carter
 - Institute of Nuclear Power Operations
- Last power plant was built in 1976
- Shoreham plant in NY sold for \$1
 - Valued at \$6 billion
- Nuclear supplies 20% of US energy

Chernobyl

 <http://www.youtube.com/watch?v=-NIP2-Sbl9w>

What now?

- Italy pledged to shut down nuclear facilities
- Great Britain, Germany, Sweden aimed to phase out as well
- Oil on its way out after 1970s crisis
- Natural Gas was banned in power plants in 1970s
- Nuclear was deemed unsafe
- Back to coal!!

Breaking the Bargain

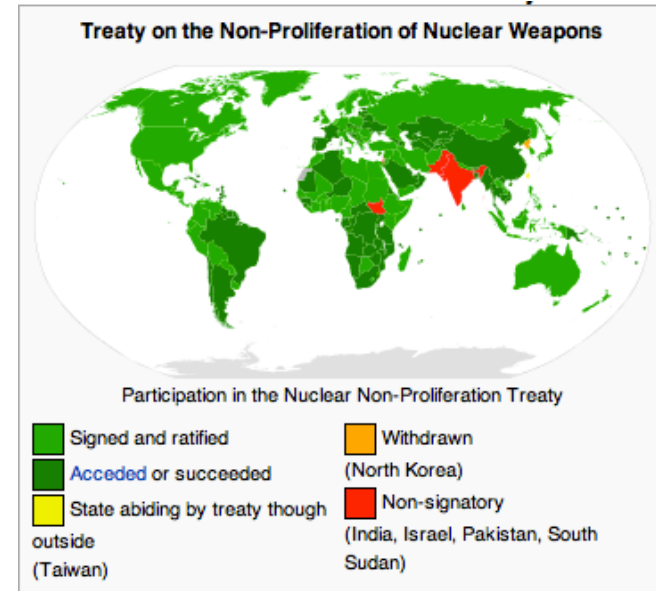
- 1980s - PURPA caused electricity rates to skyrocket
- Electric companies pushed for deregulation
- After 1970s - coal consumption doubled and accounted for 55% of electricity
- Gas plants were cheaper than nuclear or coal
- Federal Energy Policy Act of 1992
- 1998 - 2004 - Added a quarter of generating capacity, cheap nat gas disappearing

California

- 2001 - Power crisis in CA
 - Enron
 - Three Reasons
 - Partial deregulation that rejected stabilizers
 - Shift in supply and demand
 - Political culture
- Dissolution of vertically integrated companies
- Prices spiked due to drought
- Terminator becomes Governor
 - Prices finally allowed to increase

What's Up With Nuclear

- 2010 – Obama ends Yucca Mountain development
- France : reprocessed waste
- Currently waste is stored in concrete
- Proliferation
 - Two stages where civilian programs can turn into weapons
 - Nuclear Non-Proliferation Treaty



Fukushima Daiichi

- <http://www.youtube.com/watch?v=60Mp4tIpwBo>
- Germany closes all plants by 2022
- China will add 60-70 plants by 2020
- NRG - backed out of plans to build US facility

World Stats

- Electricity consumption has doubled since 1980
- Expected to double again by 2030
- China doubled electric grid between 2006 and 2010
- India's consumption is expected to grow five-fold between 2010 and 2030
- US expected to grow 1.4% per year
 - 150 nuclear reactors or 300 coal-fired plants




Question

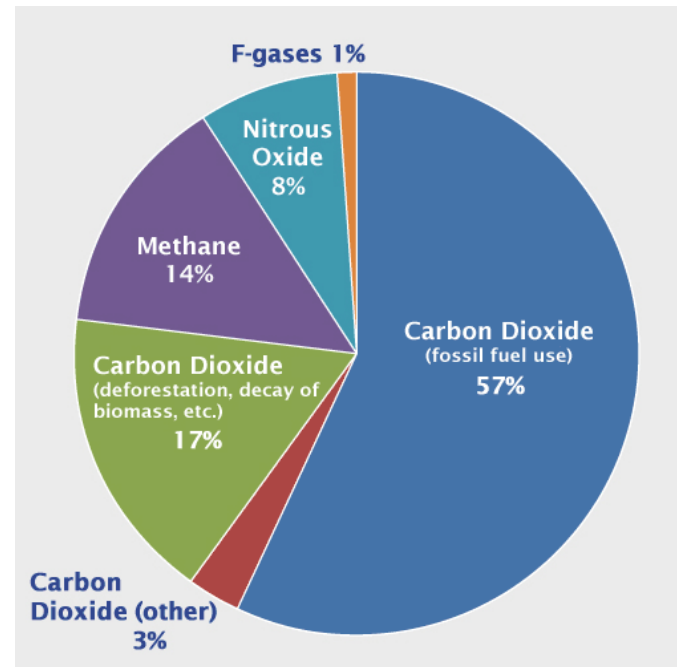
What will be the fuel of the future?

Part Four

Climate & Carbon

Greenhouse Gas Background

-  Greenhouse gases make up 62 miles of atmosphere
-  Sky would freeze without this blanket
-  Trap heat in form of infrared rays



Causes & Problems



Causes



Population tripled since 1950



Deforestation with burning of trees



Global poverty



Livestock



Problems



Melted ice caps



Coastlines under water






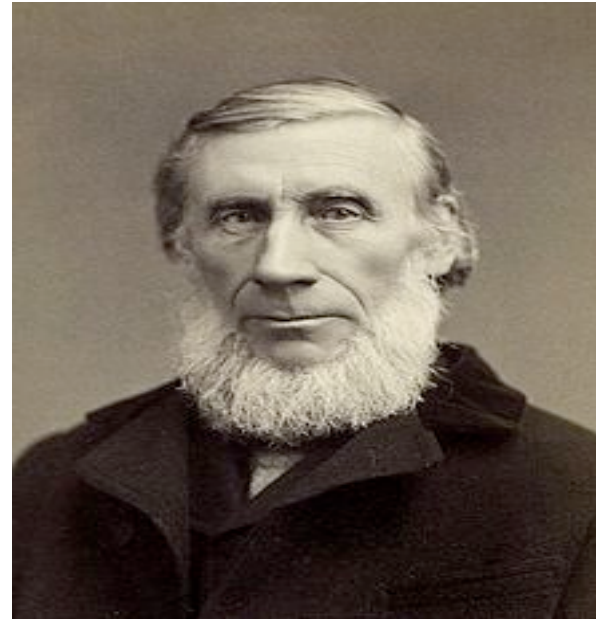
Fertile areas to deserts



Obliterating species

Glacial Change

-  Tyndall-originally in England
-  Graduate studies in Germany with Robert Bunsen
-  Observed changes in glaciers







http://en.wikipedia.org/wiki/John_Tyndall

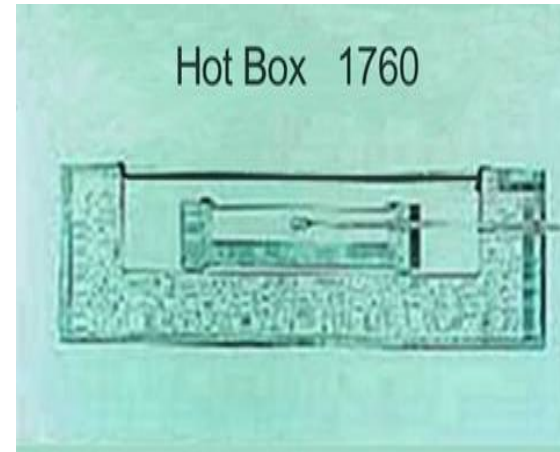
2 Important Questions

 What could have made the climate change?

 Could glaciers ever return?




“Hot Box”

-  Horace Saussure
-  Questioned why heat did not leave the Earth at night
-  Creation of “Hot Box”
1760s
-  Trapped gas increased temperature



<http://www.jc-solarhomes.com>

Joseph Fourier

-  French mathematician
-  Convinced Saussure was right
-  Tried to prove the hot box theory but failed








Louis Agassiz

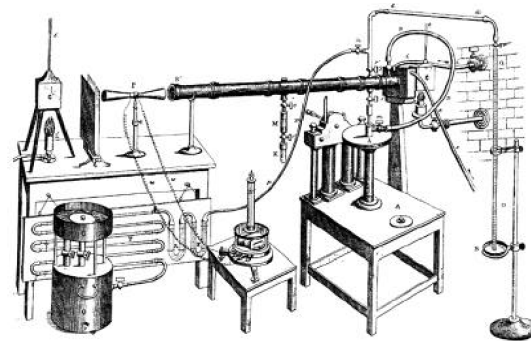
-  Swiss scientist
-  Time before present- ice age
-  Glaciers retreated to form mountains & rivers
-  Became a professor at Harvard
-  Great Lakes research



http://de.wikipedia.org/wiki/Datei:Louis_Agassiz-2.jpg

Spectrophotometer, 1859

-  Tyndall wanted answers
-  Device measuring trapped gas
-  First- N & O
-  Next- coal gas
-  Finally- CO₂ and H₂O








theresilientearth.com



biology.clc.uc.edu

Svanta Arrhenius Calculations

-  Tyndall died 1894
-  Cutting CO₂ in ½, decrease temperature 4-5 degC
-  Doubling CO₂, increases temperature 5-6 degC
-  3000 years
-  Prevent another ice age

About Revelle

 Awarded National Science Medal in 1990

 US Navy's chief oceanographer






 Scripps Institution of oceanography

 60x more CO₂ in ocean



<http://www.modernsandiego.com/>

Revelle & Suess' Findings

-  Revelle thought ocean absorbs all CO₂
-  After WW2, studied effects of nuclear weapons
-  Water temperatures differ with depth
-  Revelle & Suess collaborate
-  CO₂ rose into atmosphere, not the ocean

International Geophysical Year

 IGY

 1957-1958


 Tests on the Earth to
calculate CO₂



<http://www.nas.edu/>

Keeling & His Curve

 Began to study CO₂ levels
in CA

 Revelle gave him money to
do research at Scripps

 Mauna Loa volcanic peak

 Antarctica

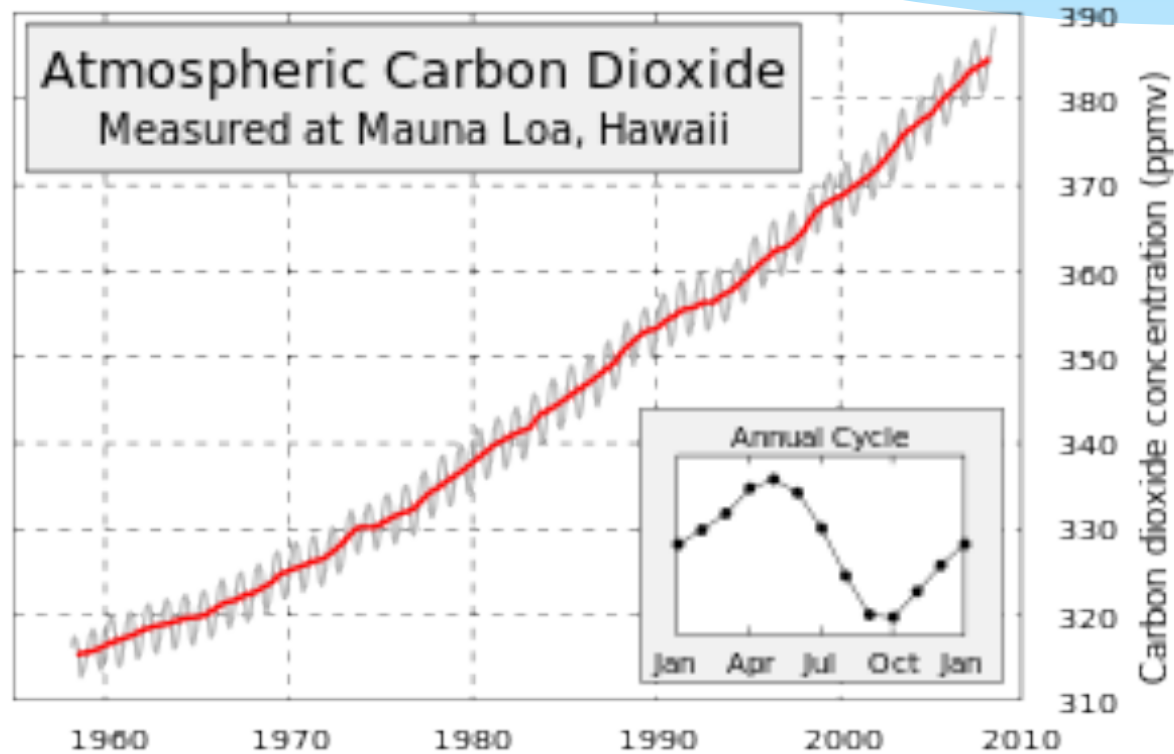
 1959-316 ppm

 1970- 325 ppm

 1990- 354 ppm




 prediction in 1969: we are
going to be in great danger

Keeling Curve



Cooling or Warming?





Warming

-  Nixon's advisor, Daniel Moynihan did research
-  By 2000 an increase of 7 deg
-  Seal levels increase 10 ft





Cooling

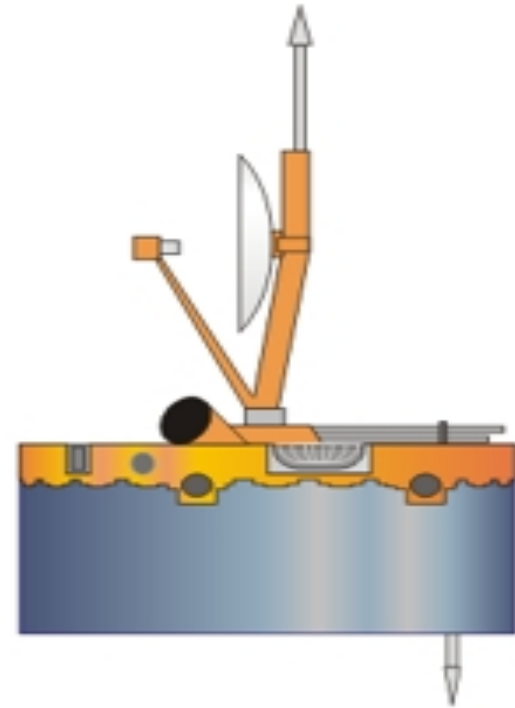
-  Defense Department, CIA & US National Science Board reported a cooling trend

Modeling the Climate






-  1960, first US weather satellite
-  John von Neumann came to Princeton
-  1945 Neumann built a new prototype computer
-  1948- Numerical Meteorology Project

James Hansen

-  Book on atmosphere of Venus
-  Venus orbiter vehicle, 1976
-  Shows atmospheric effect
-  Mars and Venus became best proof of greenhouse gases



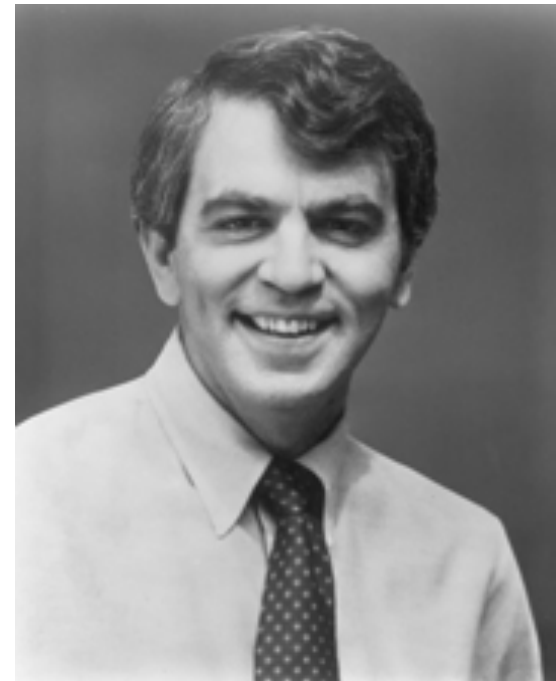
Rafe Pomerance

-  Friends of the Earth, President
-  Increasing coal use could warm the Earth
-  1978- met up with MacDonald to determine the truth
-  Carney, president of National Academy of Science declared risk is real
-  1980- Senate met to discuss consequences

Senator Paul Tsongas



“It means good-bye Miami.. Good-bye Boston, good-bye New Orleans, good-bye Charleston.. On the bright side, it means we can enjoy boating at the foot of the capitol and fishing on the south lawn”



<http://en.wikipedia.org/>

4 Point Program

○ Keeling, Revelle, Woodwell, MacDonald

 1) Acknowledgement of the problem





 2) Energy conservation

 3) Reforestation






 4) Lower carbon fuels

 More natural gas, less coal

Problems..






-  Carter administration reeling from second oil shock
-  Iranian Revolution
-  Natural gas shortages, restricted
-  1980- Reagan came into office & cut money

Breakthrough, 1980




-  Study of ice cores
-  Tiny holes in ice samples
-  Pre-industrial age: 275-280 ppm
-  1970- 325 ppm
-  1990- 354 ppm

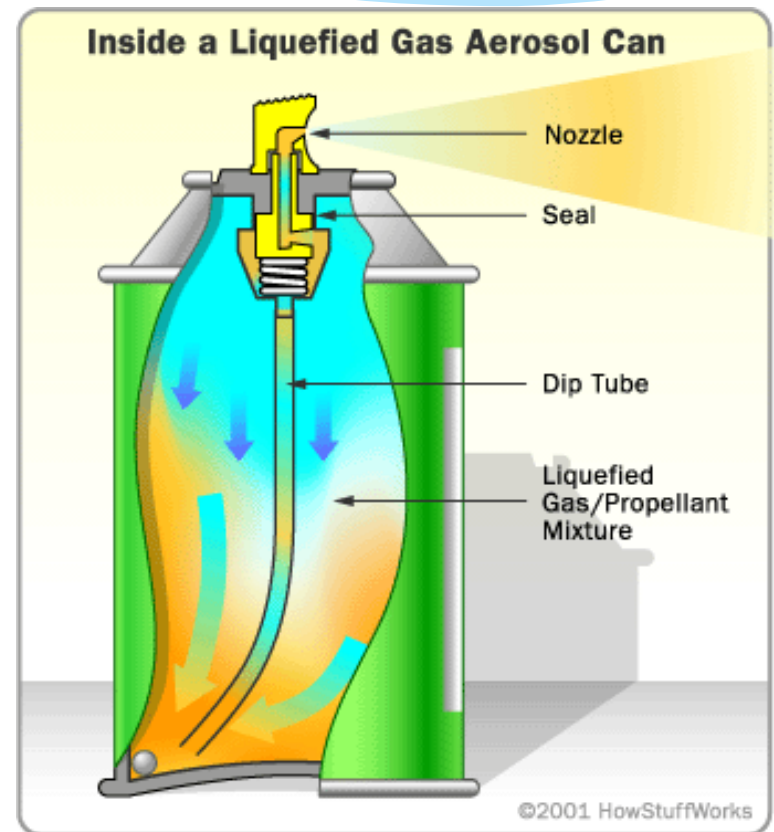


Revelle's Exile

-  New UC campus being built
-  Revelle wanted to be chancellor, blocked out
-  Went into “exile” & taught at Harvard
-  Student, Al Gore, took great interest in his class
-  20 years later, make climate change a political issue

Montreal Conference, 1987

-  Greenhouse gases: carbon dioxide, methane, nitrous acid, chlorofluorocarbons (CFC)
-  CFC is ten thousand times more potent than CO₂
-  From propellants in aerosol cans and coolant in refrigerators



Montreal Conference, 1987

 Researchers from British Antarctic saw “hole”

 CFCs

 24 countries signed the Montreal protocol

 Montreal protocol:





 Direct impact on climate-change movement

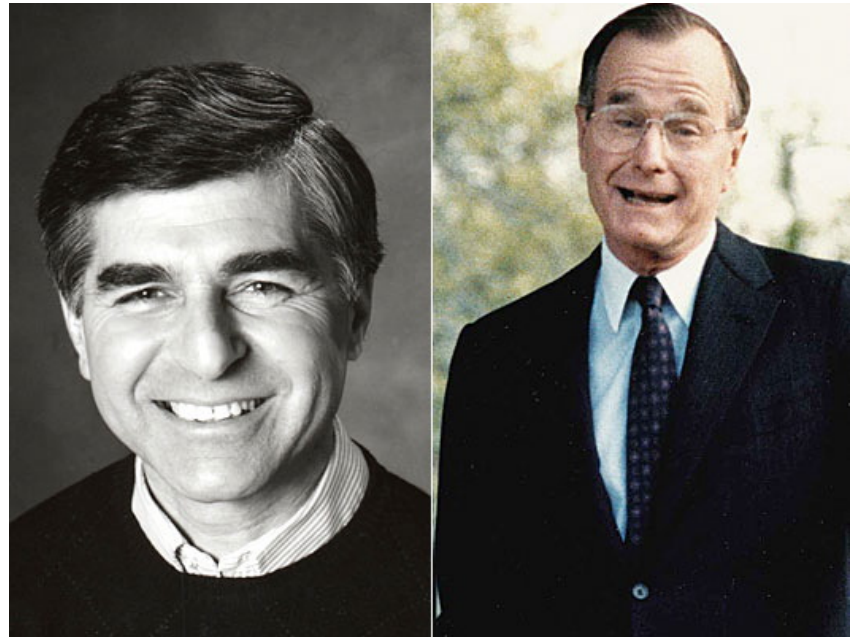
 Increased levels of CO₂ are dangerous

 Human activity imposes

 Countries need to come together

Michael Dukakis vs. George H. W. Bush

-  Election time, 1988
-  Dukakis-
environmentalist, governor
of Massachusetts
-  Bush inspects Boston
harbor
-  Dukakis blames Reagan
administration
-  “White house effect”








Over in Britain..

-  Thatcher, prime minister
-  Coal miners union cut off supply
-  North Sea- natural gas supply
-  Thatcher delivered address, no television media




Intergovernmental Panel on Climate Change, IPCC


-  1988 scientists met to inaugurate IPCC
-  Self-regulating, self-governing organization gathering scientists
-  Bert Bolin, coordinator
 -  Worked with Carney & Neumann on computerized weather predictions
-  Days of individual research was over

Shoot-out at Sundsvall

- ❑ August 1990, UN General Assembly approaching
- ❑ Agreement finally reached:
 - ❑ The Earth was warming but it was too soon to say whether man was causing the warming
- ❑ Agreement to limit greenhouse gases
- ❑ Developing countries did not want limits
 - ❑ Thought developed nations should pay the price

To go or not to go

 Would Bush go to Rio conference on climate change?

 “White house effect” caused battle within administration

 Go:

 1988 promise

 European’s mad at Bush

 Don’t go:

 Carbon restrictions would affect the already recession

 Not a big issue; fall of communism in Europe, Iraq’s invasion of Kuwait & Gulf War

Road to Rio

Decision

- ❖ Bush went to Rio
 - ❖ Called himself an environmentalist
 - ❖ Did not want to let other countries down
- ❖ White House chief in staff John Sununu left

Rio Conference

- ❖ 12 days long
- ❖ 160 heads of states, governments & international organizations
- ❖ 10,000 government officials
- ❖ 25,000 other people
- ❖ UN framework convention on climate change signed, 153 countries

Framework Set in Motion

Goal

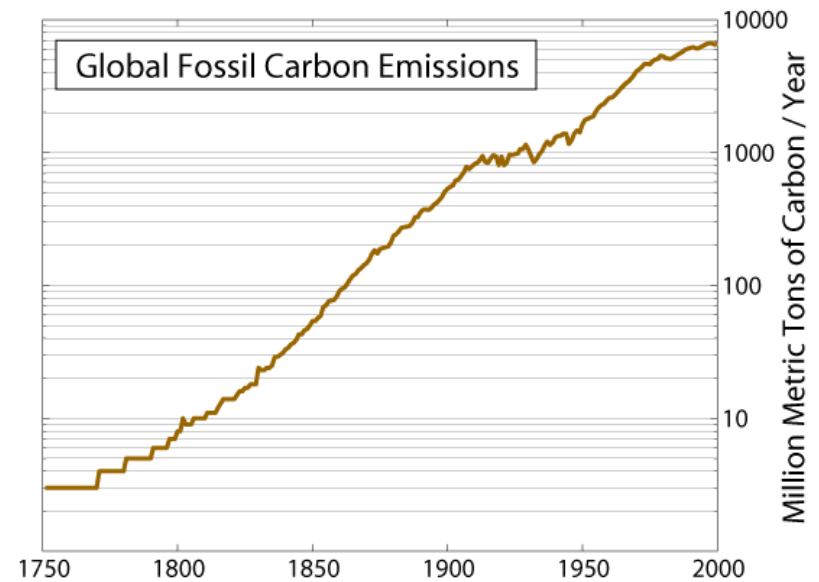
- ☒ Stabilization of greenhouse gas concentrations in the atmosphere at appropriate levels

Developed vs. Developing Countries

- ☒ Developed:
 - ☒ Control emissions
 - ☒ Provide financial resources to developing countries
- ☒ Developing:
 - ☒ Monitor emissions
 - ☒ No other obligations

Result





 Emissions actually grew 11
% due to economic growth



<http://en.wikipedia.org/>


Making A Market

Create a market in pollution

-  Use market place mechanisms of buying and selling to solve environmental problems
-  Meet resistance in late 1980s into 1990s
-  Small group of “policy entrepreneurs” seized upon the idea- economists, environmental activists and officials
-  Eventually to be called cap and trade

The “Scribbler in Chief”

 Ronald Coase

 From education track for the physically and mentally disabled, to earner of a Ph.D and Nobel Prize winner in economics

 Nobel Prize for two enormously influential articles







“The Problem of Social Costs”

- Published in *The Journal of Law and Economics*
- One of the most cited articles in the history of economics
- Became the foundation for the idea of using markets to solve environmental problems
- Thinking influenced by his studies of state-owned industries and regulation
 - Markets and pricing systems better
 - Issues of property rights and relative values
 - More easily solved by the market
 - The idea was trading pollution rights as currency or stocks would be (although never explicitly said by Coase)






“The War on Pollution”

- ❏ Pollution rising on the political agenda (late 60s early 70s)
- ❏ President Richard Nixon established the EPA in 1970
 - ❏ Marked the opening of an era of much more intense environmental regulation
 - ❏ Administrative control and micromanagement
 - ❏ “Command and control” regulation
- ❏ Later 1970s experimentation with more market-based approaches began in the US




Cap the Lead

-  “Knocking” in automobile engines leads to tetraethyl lead additives to gasoline
-  Threat to human health-HAS TO GO
-  Refiners allowed to trade lead “permits”
 -  Very successful
 -  Within 5 years all lead gone from gasoline
 -  Something to this?

Project 88

-  Election year of 1988
-  Organized by senators Tim Wirth and John Heinz
 -  Hired Harvard economist Robert Stavins
 -  Identified a range of environmental and energy problems which “harnessing market forces” would be a major step forward
 -  “Economic incentive systems” would deliver quicker, better results for much less money than the “dictated technological solutions” of command-and-control

Acid Rain

-  Acid rain huge issue in the black forests of Germany, the northeast US and Eastern Canada
-  By the end of Reagan's term, >70 different acid rain bills introduced in congress, none became law
-  During the 1980 campaign, Michael Dukakis and George H.W. Bush pledged to reduce SO₂



C. Boyden Gray, the president's White House counsel invited Robert Stavins to help implement a market based-approach to acid rain

“Least Cost Solutions”



Boyden Gray built a team of advisers



Robert Grady (Office of Management and Budget)



Robert Hahn (Economist on the Council of Economic Advisers)



Determination to design a lower-cost system by creating a market-based system in which utilities could trade emissions



“One quarter of US regulating costs were from the Clean Air Act. The best way to lower costs to the American people was by lowering compliance costs”

Opposition

 Gray recruited Fred Krupp, president of the Environmental Defense Fund

 Have the EDF draft a market based approach to acid rain

 Opposition from:

 congressional delegations representing Appalachia & the Middle West, and the West

 Just about every environmental organization

 EPA

 Gray and his team convinced a market based solution was the way

 **Command-and-control approach:**

 Ordain specific technologies and processes

 **Proposed legislation:**


 Would allow much wider latitude for innovation by specifying instead performance and outcomes

 All this struggle before a bill could even work its way through congress!

The Grand Policy Experiment

 Clean Air Act signed into law

 Nov. 15 1990 under Bush

 Title IV: reducing the total number of allowances or permits year by year would have the effect of making the permits scarcer and therefore more expensive, increasing the incentive to reduce emissions



 Buying and selling of allowances became standard practice among utilities


 By 2008, emissions had fallen from the 1980 level by almost 60%

 Allowance trading = cap and trade

 SO₂ program was a “demonstration model” for the issue of climate change


 Provided credibility for cap and trade for climate change

 As the SO₂ market was getting going..

 The IPCC was preparing its next every-half-decade “assessment” of where the science was on climate change

 “Bulk reports” totaled 2,000 pages that referenced 10,000 scientific papers

 The second IPCC report in 1995 declared “The balance of evidence suggests that there is a discernable human influence on global climate.” this became famous

 As well as the reports “best estimated” judgment that, on current tracks, global temperatures would rise 2° C by 2100

Developed VS Developing

North-South face-off

 75% of total accumulated emissions of CO₂ between 1860 & 1990 from industrialized nations

 Only 20% of the world's population

 Developing nations greatly opposed to restrictions on their use of hydrocarbons.

Berlin Meeting 1995

 National delegations to follow up on Rio that would serve as the basis for conference in Tokyo








 Angela Merkel, chairman of the Berlin meeting opens with the remark stressing the importance of the industrialized countries being

“The first to prove that we are bearing our responsibility in protecting the global climate”




 Developing nations were spared the obligations of developed nations

 “Differentiated responsibility”





More contention...

-  Polarization over the IPCC process itself
 -  Radical changes
 -  Impacts on economic growth and well being
 -  Uncertainty about science behind climate change
-  The second assessment set the framework for the international conference to be held in Kyoto
 -  How to implement pledges made at Rio?
 -  This summit would come to represent the transition of climate change into a global political issue!




Battles at Kyoto


-  Stuart Eizenstat (led the us delegation at the summit) described it as
 - “the most complex, difficult and draining” negotiation he had ever encountered
-  Binding targets for greenhouse gas reductions and on the mechanisms to implement it
-  Mandatory, binding targets (unlike Rio)

Europe VS the United States

-  Europeans wanted the US to make deeper cuts, we refused
-  Europeans would have an easier time beating 1990 targets
-  The arrival of Al-Gore broke the deadlock with is “electric effect” on the conference
-  Result : The US, Europe and Japan ended up with roughly the same binding targets- CO₂ emissions between 6 & 8% lower by 2008

Developed VS Developing Nations (Again)

-  Should developing nations also make binding agreements?
-  There response was NO, especially because two years earlier the Berlin mandate exempted them
-  During the Asian financial crisis

- 
- ❏ Without binding targets for developing countries there was little chance the US senate would approve the treaty
 - ❏ Fear of bringing harm to US economy
 - ❏ The senate also thought the protocol was doomed by the inability to bind these developing nations whose emissions were growing on a fast-track.


Cost, Cost, and Cost


How to implement reductions?

 European Union wanted mandates and direct intervention

 They called it policies and measures, but they meant command-and-control

 US committed to a trading system

 Europeans opposed, they were suspicious of markets, they dismissed the idea of selling emission rights as “hot air”

 Eizenstat put it “ There were three issues- cost, cost, and cost.” The cost of mitigating climate change without a market system would be far too expensive for any economy to bear

 The conference was over and still no agreement was made

 The chairman had Eizenstat and the chief European negotiator John Prescott go into an adjacent green room to work something out

 Prescott realized that Eizenstat would not budge and reluctantly agreed to the central role of trading



The agreement at Kyoto marked the “first steps toward actually creating a political regime for preventing a human-induced climate change.”