Part III: The Electric Age
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!!
• 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
• 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=60MptIpwB0](http://www.youtube.com/watch?v=60MptIpwB0)
- Germany closes all plants by 2022
- China will add 60-70 plants by 2020
- NRG - backed out of plans to build US facility
• 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
  o 150 nuclear reactors or 300 coal-fired plants
What will be the fuel of the future?
Part Four

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

http://www.epa.gov
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

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

Swiss scientist

Time before present- ice age

Glaciers retreated to form mountains & rivers

Became a professor at Harvard

Great Lakes research

Spectrophotometer, 1859

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

http://en.wikipedia.org/
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
1960, first US weather satellite
John von Neumann came to Princeton
1945 Neumann built a new prototype computer
1948- Numerical Meteorology Project
Book on atmosphere of Venus
Venus orbiter vehicle, 1976
Shows atmospheric effect
Mars and Venus became best proof of greenhouse gases

http://historicspacecraft.com/
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
“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”
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
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

http://oceanworld.tamu.edu/
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
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”

http://images.businessweek.com/
Over in Britain..

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

http://www.guardian.co.uk/
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
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
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

<table>
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<th>Goal</th>
<th>Developed vs. Developing Countries</th>
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| ▶️ Stabilization of greenhouse gas concentrations in the atmosphere at appropriate levels | ▶️ Developed:  
- ▶️ Control emissions  
- ▶️ Provide financial resources to developing countries  
▶️ Developing:  
- ▶️ Monitor emissions  
- ▶️ No other obligations |
Emissions actually grew 11% due to economic growth.
Making A Market
Create a market in pollution

- Use marketplace 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
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 Problem of Social Costs*”
“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
“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?
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 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 $\text{SO}_2$. 
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”
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!
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

SO$_2$ 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!
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 has 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 his “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.
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.
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.”