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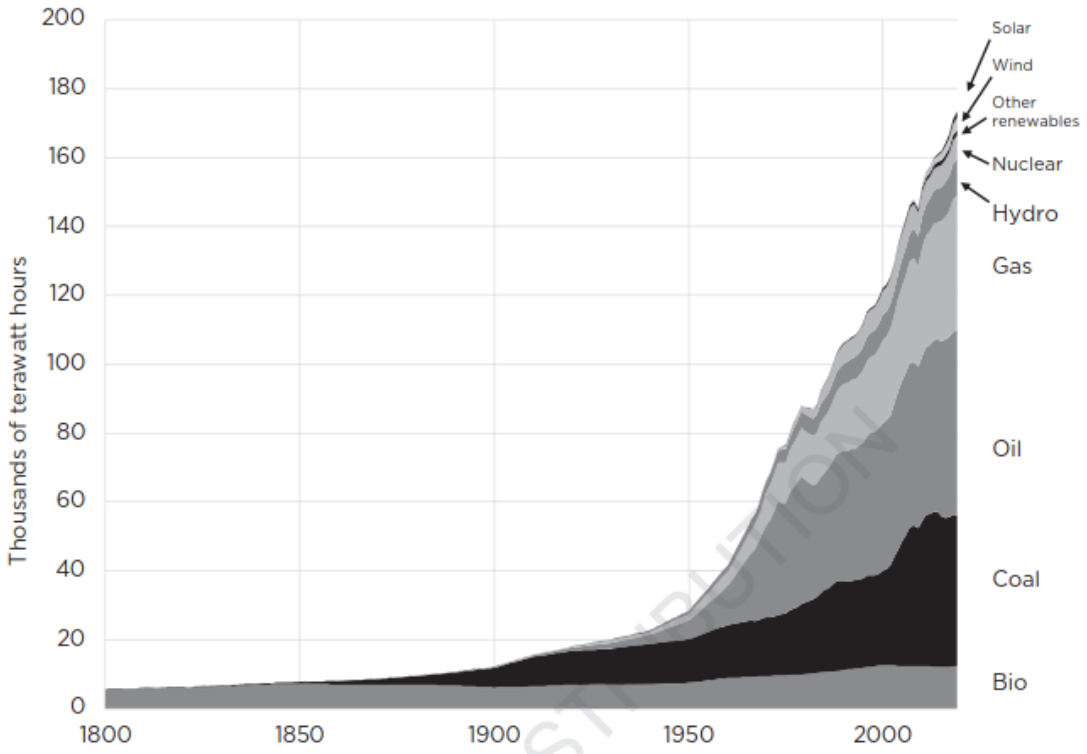
Econ 309

Week 14: Energy and Environmental Policy

I. Energy: Why We Need It, Where We Get It
   A. By itself, human labor power is pathetically weak. Even with unlimited calories, the amount of physical labor your unaided body can complete in a day is small.
   B. As a result, humans routinely augment their productivity with outside energy sources. For most of human history, these were just:
      1. Wood
      2. Dung
      3. Domesticated animals
   C. In recent centuries, however, humans figured out how to use much more advanced forms of energy. To start: coal.
   D. Later: oil, natural gas, and nuclear.
   E. Humans use energy for four main purposes:
      1. Electricity
      2. Transportation
      3. Residential heating
      4. Industrial heating
   F. Where did humanity get our energy for the last 200 years?
      1. Until 1850, virtually all still came from "bio" – wood, dung, and such.
      2. Then coal slowly took off, reaching about half of all energy by 1900.
      3. Coal kept replacing bio, but after a couple decades, oil becomes important. By 1960 or so, oil matches coal.
      4. Natural gas becomes important by 1970 or so. Now there's roughly a three-way tie globally between coal, oil, and natural gas.
      5. Around 1970, nuclear looks ready to take off, but soon plateaus at less than bio.
      6. Everything else is a rounding error. If you've seen bigger numbers, it's probably because they're only looking at electricity rather than all four energy uses.

FIGURE 1.1 **Only Fossil Fuels Provide Low-Cost, On-Demand, Versatile, Global-Scale Energy**



Source: Our World in Data; Vaclav Smil (2017); BP Statistical Review of World Energy

G. Notice that the y-axis shows *absolute* energy consumption, which has risen in step with rising population and rising living standards.

II. Why Fossil Fuels Dominate and Renewables Don't

A. Good energy sources have the following traits:
   1. Concentrated: Lots of energy by weight and volume to allow easy transportation.
   2. Reliable: Available whenever you need it.
   3. Abundant: High quantity in convenient locations.

B. Fossil fuels have the whole package.
   1. Concentration: Gasoline, for instance, has 31,000 calories per gallon. If humans could digest gasoline, you'd only need two gallons per month!
   2. Reliable: You can burn them anywhere and anytime you want energy.
   3. Abundant: Despite recurring fears of "running out," known sources are large, and finding new sources is pretty easy.

C. Added bonus: Humans have been figuring out ways to harness fossil fuels for about 200 years, so we've gotten really good at it.

D. By the first three measures – concentration, reliability, abundance – nuclear energy is even better than fossil fuels. Uranium has 18 billion calories per gram!
E. At least for now, however, we have much less experience figuring out ways to harness nuclear.
F. More importantly, regulation of nuclear power is extraordinarily strict. The last American nuclear plant to be built opened 2016; the previous plant opened in 1996.
    1. Nuclear energy is simultaneously subsidized and penalized, but the penalties far outweigh the subsidies. The 2016 plant took 43 years to complete.
    2. Just to replace existing fossil fuels with nuclear would require us to scale up construction of nuclear by a factor of over 500x.

III. The Problems of Renewable Energy
A. The leading renewables, in contrast, lack all three traits of good energy sources. Wind and solar are:
    1. Diffuse: You have to collect low levels over a large area.
    2. Unreliable: After you drain your batteries, they don't work unless the wind is blowing or the sun the shining.
    3. Not naturally abundant: They've been subsidized for decades but still provide little energy.
B. What would it take to solve the unreliability problem? Vastly better batteries, or a massive global grid far beyond anything that now exists.
C. Optimists usually focus on wind and solar electricity, but electricity is only one of the four main categories of energy. Using wind and solar for heavy transportation (like planes or container ships) or industrial heating (like steel mills) are still fantasies.
D. How do we manufacture windmills and solar panels? Fossil fuels.
E. Aren't wind and solar quickly becoming more competitive? Even now, wind and solar are only widely-used where they are heavily subsidized.
F. Rich countries that use a lot of wind and solar have a full fossil fuel backup system – and pay the fixed costs to maintain both systems.
G. Could all of this suddenly change? Anything's possible, but the best predictor of the future is the past.
    1. Who wants to bet on it?
H. What about hydro? It works well in areas with abundant water sources, but it is also heavily regulated.

IV. CBA, Externalities, and the Value of Nature
A. Despite their incredible performance as energy, fossil fuels also have notorious problems.
B. Classic problem: air and water pollution. Early coal burning turned whole cities black with soot. Modern fossil fuels are much cleaner,

but many researchers still find that air pollution does serious damage.

C. Modern problem: climate change. Burning fossil fuels releases carbon dioxide. At the levels that humans now use fossil fuels, this is enough to measurably warm the entire planet.

D. Many people fear that this warming will, in turn, cause numerous other severe environmental problems: storms, flooding, ocean acidification, and much more.

E. More extreme environmentalists also have a per se objection to humans tampering with nature:

"In the late 1980s, inaccurate reports that fusion was close to commercial reality caused some of our designated experts to be asked what they thought about the prospect of an incredibly low-cost and clean form of energy. What did they say?

"Paul Ehrlich: Developing fusion for human beings would be 'like giving a machine gun to an idiot child.' Jeremy Rifkin, another designated environmental expert: 'It's the worst thing that could happen to our planet.' Amory Lovins was already on record as saying, 'It would be little short of disastrous for us to discover a source of clean, cheap, abundant energy, because of what we might do with it.'"

F. Just a few extremists? Explain the strict regulation of hydro and nuclear, which emit no air pollution or carbon dioxide.

G. There are even notable environmental objections to wind and solar, because they require filling large regions with windmills and solar panels.

H. If people really value unspoiled nature, CBA counts their willingness to pay. Due to severe SDB, however, it's unlikely that true willingness to pay is high.

1. How much can people *really* care about an oil spill in an uninhabited area of Alaska?

I. Remember how Pigovian remedies work: Add a tax the matches the negative externalities, then let people do what they want.

V. Negative *and* Positive Externalities of Energy

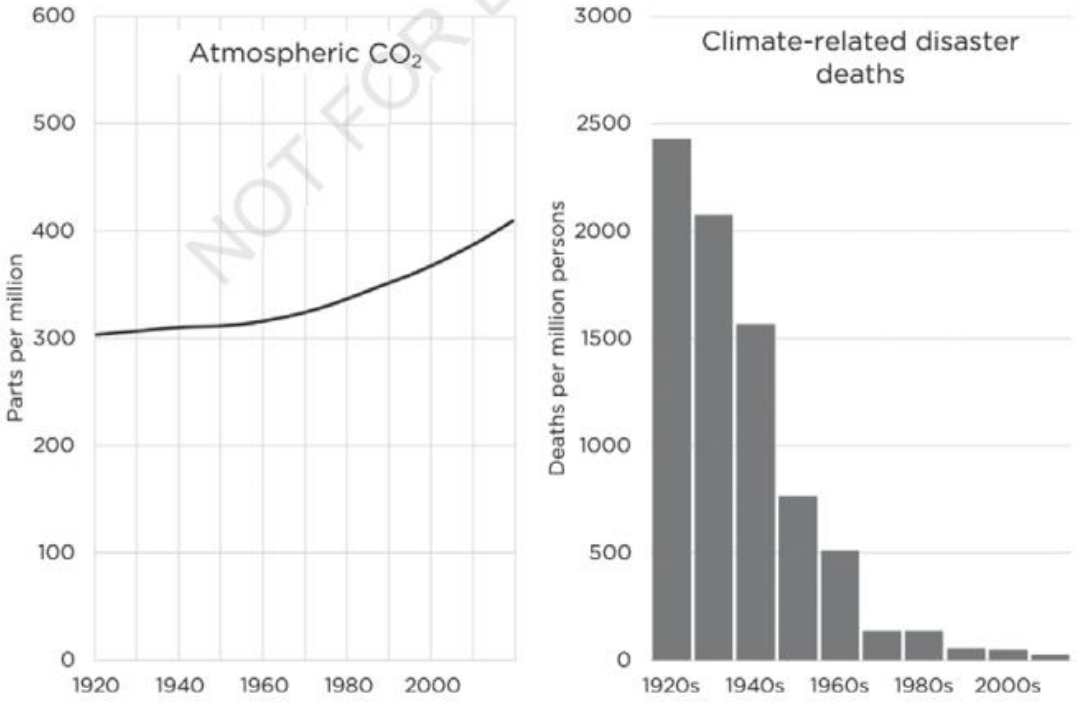
A. Energy, like population, has greatly neglected positive externalities.

1. Effect of carbon dioxide on plant growth.

B. In at least some important cases, the positive externalities clearly outweigh the negatives.

C. Most notable example: climate deaths.

FIGURE 2.2 **More Fossil Fuel Use, Plummeting Climate-Related Disaster Deaths**



Sources: Scripps Institution of Oceanography; EM-DAT; World Bank Data; Maddison Project Database

D. Carbon emissions are definitely warming the planet, so how is this possible? Because fossil fuels power the modern economy, which (a) shelters humans from harm, and (b) rescues them from harm that still occurs.

E. Other positive externalities? Fossil fuels power the modern economy, which makes humans rich, which creates surplus resources for innovation.

F. Epstein points out that even coal has clear positive externalities… when it replaces dung and wood.

G. Published estimates of the effect of carbon emissions on GDP are doing a thought experiment where we *costlessly* find a perfect replacement for fossil fuels.

H. Is this likely? Humanity discovered nuclear power, a fantastic replacement for fossil fuels, almost a century ago. It would be miraculous if we found something better, but we barely use the replacement we have.

VI. Climate Change and Climate Mastery

A. Realists who write about climate change usually admit that part of the solution is “adaptation.” Low-lying coastal areas, for example, will find that building seawalls is their least-bad option.

B. From this perspective, however, adaptation sounds very risky. When disaster strikes, what makes us so sure that we can readily "adapt"?

C. Epstein's central lesson: We should stop thinking of adaptation as a new, untested process. The reality is that Earth is *naturally* a dangerous place for humans – and we've been "adapting" to it for thousands of years.

1. Imagine the Virginia winter with only wood and dung for heating.

D. Historically, this adaptation was spotty at best; just look at climate deaths in 1920.

E. In the last century, however, humans' adaptation has become amazingly good. So good, in fact, that Epstein proposes a replacement phrase: "climate mastery."

F. We don't just use fossil fuels, then struggle to "adapt" to the world we've ruined.

G. Instead, fossil fuels change Earth from one dangerous place to a different kind of dangerous place. We already used fossil fuels to practically eliminate all the familiar dangers.

H. The only question is whether the new dangers are outside the range of what we've already been able to handle – and we already handle a *huge* range of dangers – every climate from equatorial to Arctic.

VII. The Problem of Tail Risk

A. Isn't there at least some small probability that continuing fossil fuel usage will lead to total disaster? A disaster that exceeds our climate mastery?

B. Sure, but we face multiple disaster scenarios. Most obviously, what if the world's governments disallow fossil fuels before we have any cost-effective replacement?

C. More likely: What if energy regulations force the Third World to stay in poverty for a few extra decades? Taking away energy from rich countries will probably be much harder than preventing poor countries from getting energy in the first place.