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RENEWABLES TO THE RESCUE? THE MYTHS, THE REALITY, AND WHY A SMALLER U.S. POPULATION IS NEEDED TO SAVE THE PLANET

An NPG Forum Paper

by Edwin S. Rubenstein

Can the U.S. economy run on renewable energy alone? That may seem like a fanciful question at a time when the incumbent President insists that climate change is a "hoax" and is determined to restore coal to its once preeminent role in the nation's energy supply. But a few years back Mark Z. Jacobson, a prominent Stanford University professor of engineering, published a widely acclaimed article claiming that energy from the wind, the sun, and water could power nearly the whole shebang by midcentury.[1] What's more, it would be cheaper than running it on fossil fuels.

Academia struck back. A much anticipated counter-article, published in the Proceedings of the National Academy of Sciences – the same journal in which Professor Jacobson's upbeat screed appeared – a group of 21 prominent scholars, including physicists and engineers, climate scientists and sociologists, took a fine-tooth comb to Jacobson's methodology. Their conclusion was damning: Professor Jacobson relied on "invalid modeling tools," committed "modeling errors," and made "implausible and inadequately supported assumptions."

The experts are not opposed to investing aggressively in renewable energy. But they argue, as does most of the scientific community, that other energy options – nuclear power, say, or natural gas coupled with technologies to remove carbon from the atmosphere, are likely to prove indispensable to the global effort to forestall global warming.

But with the stakes so high, the scholarly gloves came off. In an article published in the same journal Professor Jacobson argues that his critics' analysis "is riddled with errors and has no impact" on his conclusions. When later interviewed by a *New York Times* reporter, he accused his critics of being shills for the fossil fuel industry, without the standing to review his work, adding that "Their paper is really a dangerous paper."[2]

What is the concerned layman to think when (allegedly) brilliant scholars reach such diametrically opposed conclusions on our environmental future? A big dollop of skepticism is always advisable. There are often hidden agendas motivated by politics, the ideological orientations of various universities and think tanks, and, yes, self-aggrandizement on the part of researchers. With so much money at stake, each of the major renewable energy sources have attracted a cadre of well-funded special interest groups willing to spend lavishly to obtain the "right" conclusion.

Self interest aside, scoping out the future role of renewable energy is intellectually challenging. The two most prominent types – solar and wind – are both intermittent resources. You can install solar panels; you can build a wind farm, but if it's cloudy, or not windy, no electricity will be produced. Solutions to this problem usually involve building excess storage capacity or drawing power from non-renewable sources like nuclear or even gas and coal. Not only is this expensive, it may exacerbate the very climate changes that renewables were supposed to combat.

Nuclear power is steady and CO_2 free and, when working properly, generates far more power with less environmental disruption than renewables. While embraced in Europe, nuclear faces an insuperable PR problem in this country. Perhaps this is why it is not classified as a renewable energy source.

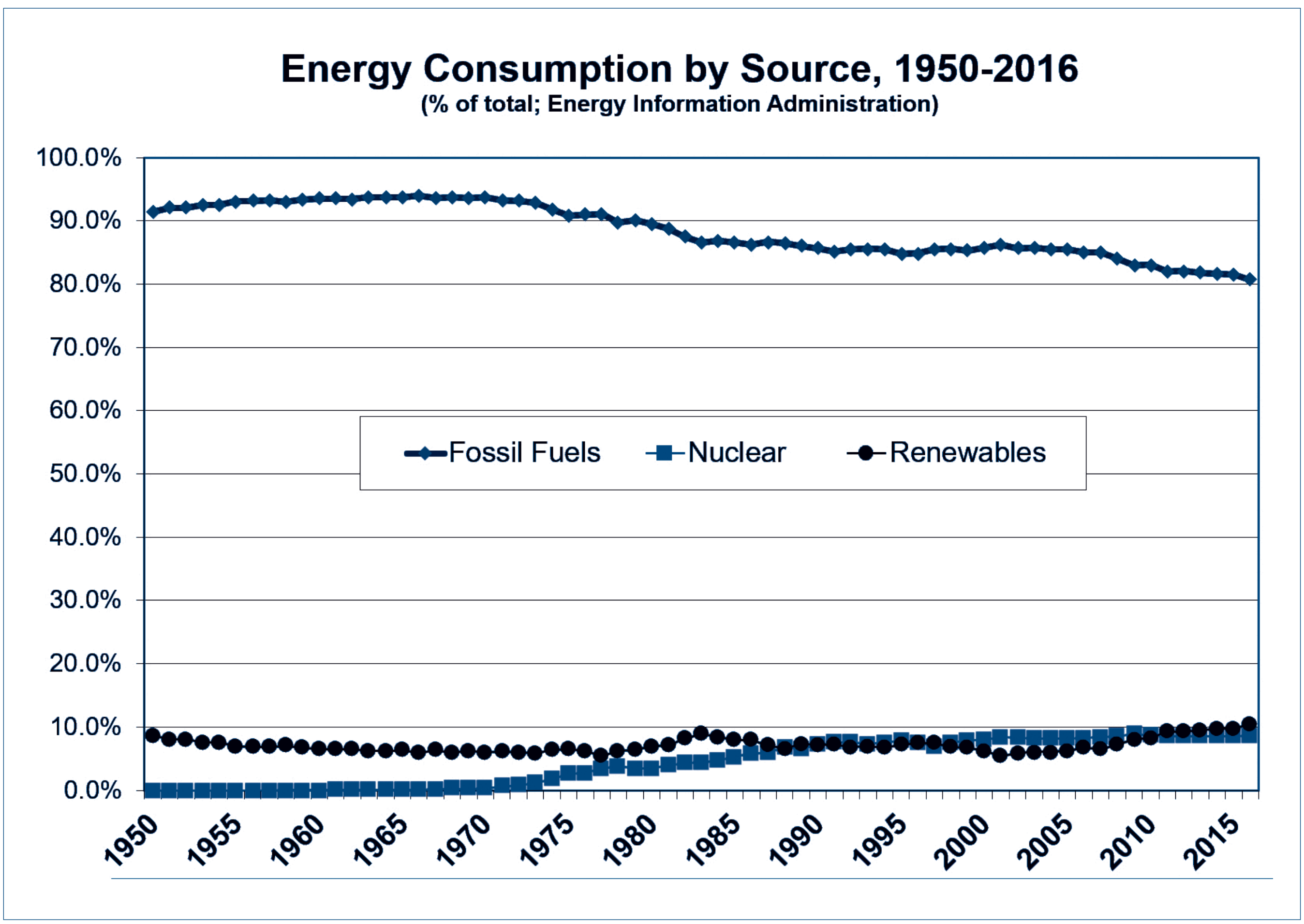
Our examination of this issue focuses not on what the "experts" say will happen, but what hard data says *has* happened since climate change has been on the national agenda. Those numbers show, with few exceptions, that the bold claims made for renewable energy simply do not hold up in the real world.

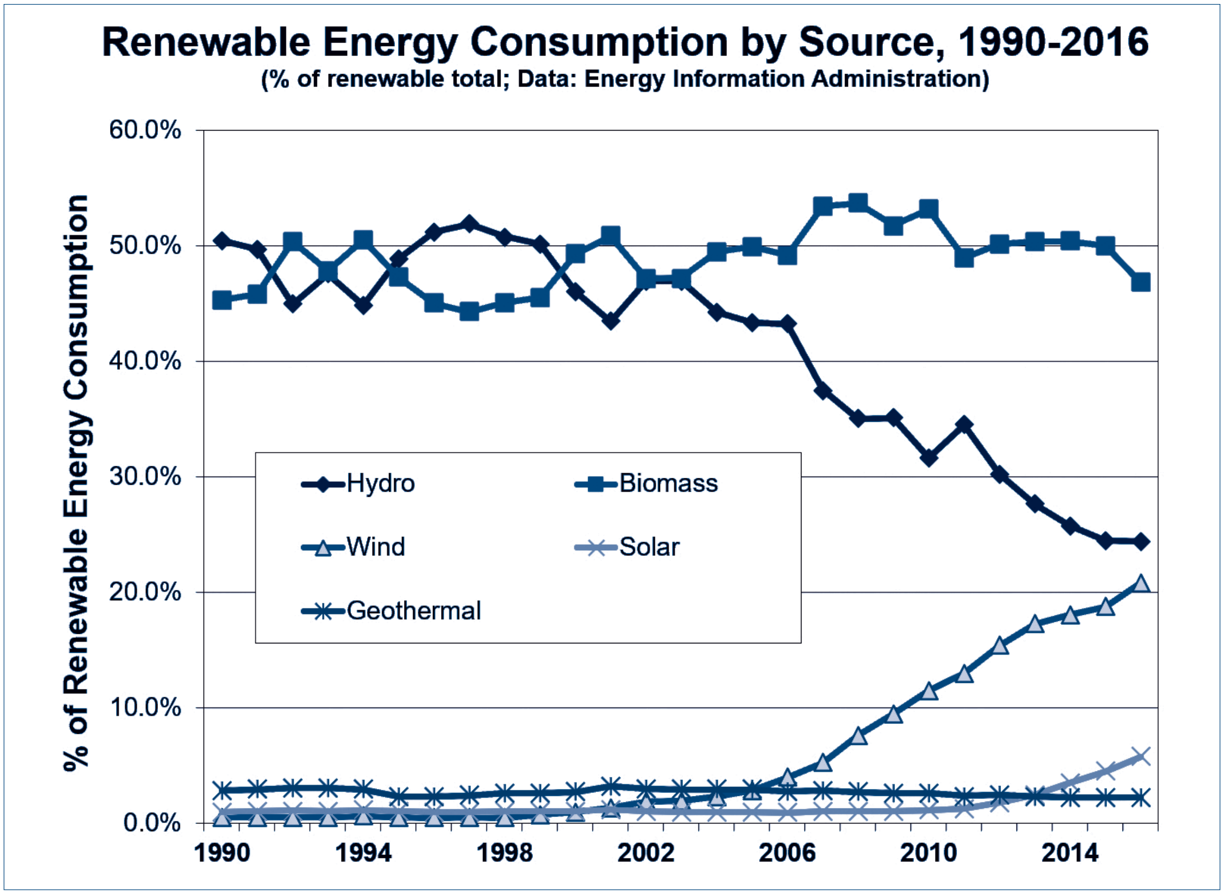
If converting to renewable energy won't save the biosphere, what can we do? The first step is to acknowledge the problem: there are no viable "supply-side" solutions to energy related CO-2 emissions in sight at this time. Technological breakthroughs in the storage and transmission of wind and solar energy are always possible, of course, but even if one were to occur tomorrow, the case for a smaller U.S. population would still be overwhelming.

The U.S. emits more CO_2 per capita than any industrialized nation in the world. Reducing the demand for energy via a reduction in U.S. population is a demand-side alternative whose time has come.

RENEWABLES IN CONTEXT

Despite the hype, renewable energy sources generated only one-tenth of U.S. energy consumption in 2016. Fossil fuels generated 81% of all energy consumed that year, while nuclear energy contributed about 9% of the total.





Fossil fuels have dominated U.S. energy usage since the government began collecting statistics on energy usage in 1950: This is painfully evident in the first graphic, where the fossil fuel line towers above the lines for nuclear power and renewables.

At its peak, in 1966, fossil fuels accounted for 94% of all energy consumed in the U.S. Displaced first by nuclear energy in the 1970s and 1980s, and by renewables after 2001, fossil fuel's share fell to 80.4% in 2016 – the lowest on record.

Renewables are not new. In 1950 the renewable energy category accounted for 8.5% of total energy consumption – only 1.9 percentage points below their share in 2016. More amazingly, the top two renewable fuels in 2016 – biomass and hydropower – ranked first and second in 1950 also. The list of renewables for 2016 includes wind and solar. While small scale examples of solar and wind renewables are reported to have existed as early as 1950, these categories do not appear in the Energy Information Administration's official energy statistics until 1989. Today they are the fastest growing of all major renewables.

Renewables are universally touted as clean energy sources (free of CO_2 emissions) that exist in unlimited amounts. These assertions simply do not hold up under close scrutiny. Each of the major renewable energy sources is supported by what can best be called a mythology – a narrative that ignores major problems in performance, reliability, and implementation.

We start with the oldest, and still the largest, renewable source – Biomass.

BIOMASS: MYTH V. REALITY

Biomass is a term invented by the lumber industry for energy fueled by burning wood and other organic matter. The biomass brand is fairly new, but the biomass idea is ancient. Cavemen used biomass energy when lighting a fire at the mouth of the cave. Pioneers used biomass when they burned buffalo dung for heat. What *is* new is its classification by the EU, the UN, and the U.S. energy bureaucracy, as a renewable energy source, and the claim, by the biomass industry, that it is "carbon neutral." Neither assertion is defensible.

When burned, the carbon in biomass fuel is released into the atmosphere as CO_2. Dry wood is the most carbon intensive of all: 50% by weight[3]. At one time biomass fuel consisted mainly of waste products – wood chips, bark, even sawdust – left over in sawmills after trees were cut for commercial purposes. Those leftovers did not cleanse the atmosphere, so there was no diminution in CO_2 cleansing. Today entire forests are grown specifically as inputs for the biomass industry - in some places exceeding the volume of those used for traditional lumber operations. Whole tree biomass harvesting is common. No longer can biomass be called "carbon neutral."

Forests are cut down; forests are re-planted. But current studies indicate that it takes at least 50 years before a new forest can replace the carbon storage capacity of the mature one it replaced.[4] Fifty years before this "renewable" fuel is able to renew itself.

Clearly, biomass fuel is neither renewable nor carbon neutral, and yet those official designations are allowed to stand.

Most experts believe that industrial-scale biomass energy has already compromised the environment and air quality. This hasn't stopped industry flaks from dreaming of a world where all energy demands are met by the fuel.

What would a world run on biomass energy look like? Here is one analyst's projection:

"For very large scale biomass production, each person in the world would need about 2.6 hectares of land growing only biomass to provide for their liquid and gas consumption…. To provide the anticipated 9 billion people on earth by 2060 we would need 24 billion hectares of biomass plantations. The world's total land area is 13 billion hectares, and the total forest, cropland and pasture adds to only about 8 billion hectares, just about all heavily overused already…."[5]

Bottom line: an area three-times the world's land surface will be needed to grow biomass by 2060. That scenario is truly out of this world.

Even smaller scale biomass projects suffer from a large ratio of costs to benefits. Corn ethanol provides a good example. Launched in hopes of substituting a biofuel for gasoline, it turned out to consume just as much energy as it generated. It absorbed about 20% of the U.S. corn crop while replacing only 3% of U.S. gasoline consumption. Plus, it was heavily subsidized.[6]

In the U.S., biomass remains a lucrative industry. The fuel is particularly popular with coal fired power plants that are able to use existing infrastructure when switching to biomass – a major cost savings. But if cheap coal makes a comeback that process could be reversed – with still more dire environmental consequences.

HYDROPOWER

Using rivers and dams to make electricity is often touted as a win-win for the climate and the consumer: a cheap, renewable, and reliable power source without the greenhouse gases that come from burning fossil fuels. But it turns out that hydro is not as clean, or as reliable, as its proponents claim – and may actually do more environmental harm than good.

Hydropower is the largest source of electricity in the world, accounting for 20% of global output, though only 2% in the U.S. While hydropower plants do not emit greenhouse gases in the process of generating energy, the dams and reservoirs associated with them do. The greenhouse gas emitted from dams is methane (CH_4), a close cousin to carbon dioxide (CO_2) emitted by burning fossil fuels.

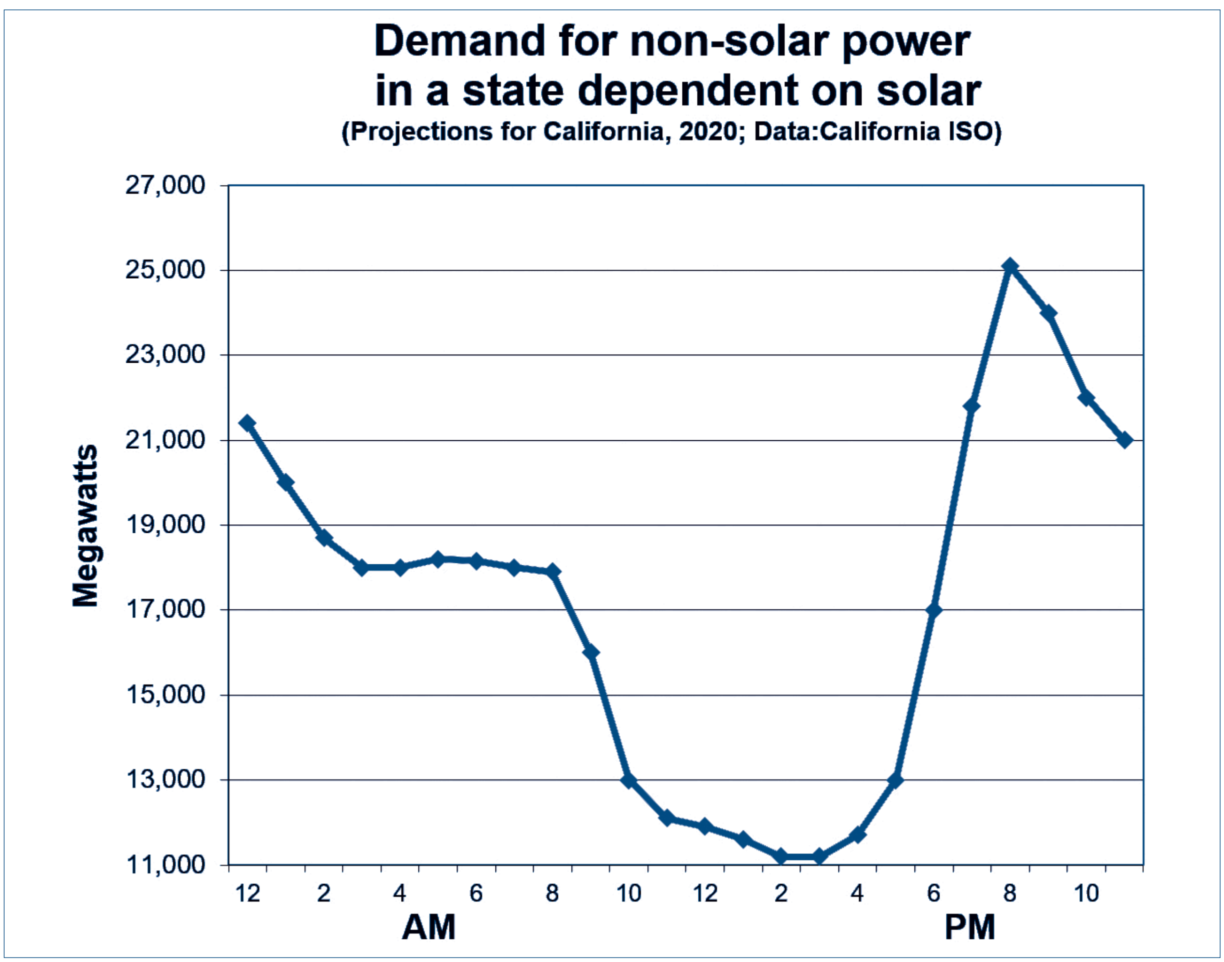
Most reservoirs – here and around the world – are in rural, agricultural areas. They emit methane because bacteria that feed on underwater agricultural runoff breathe out methane.

Climate scientists have long believed that 20% of all manmade methane emissions are generated from reservoirs. It may be far more. When the EPA studied methane emissions from Harsha Lake near Cincinnati, they found more CH_4 emissions than had ever been recorded at any reservoir in the country. Amy Townsend-Small, one of the study's authors, may have understated the peril when she said: **"It could be that these agricultural reservoirs are a larger source of atmospheric methane than we had thought in the past."**[7]

This raises the prospect of a vicious cycle, where increased reliance on hydropower feeds global warming, which in turn reduces the capacity of hydro to produce energy. Hoover Dam is a case in point. In the space of a year the Hoover power plant essentially shrunk in half, from about 2,100 megawatts of generation in early 2014 to 1,200 megawatts in spring 2015, all because of the impact of the drought.[8] As energy supply fell, energy prices rose dramatically.

Although drought has given way to floods and mudslides, the long-term prognosis for California and the U.S. Southwest is for a much drier future. The U.S. Bureau of Reclamation, which oversees the Hoover Dam, is reconfiguring some of the power plant's turbines to keep them running in a drier world.[9] Likewise, countries in Latin America, Africa, and Asia are planning for lower river flows, less hydroelectric output, and unavoidably, an increase in fossil fuel usage.

At least one "expert" in this field has not read the memo. Professor Jacobson blithely proposes deploying hydropower systems on an unprecedented scale and speed. His goal: 25% more hydro power in 2060 than is produced by *all*



U.S. energy sources today. Achieving that would require power equivalent to 600 Hoover Dams, and water to be discharged from the nation's rivers at about 100 times the flow of the Mississippi River.[10]

All this to back up renewables that, by his reckoning, would rarely need help.

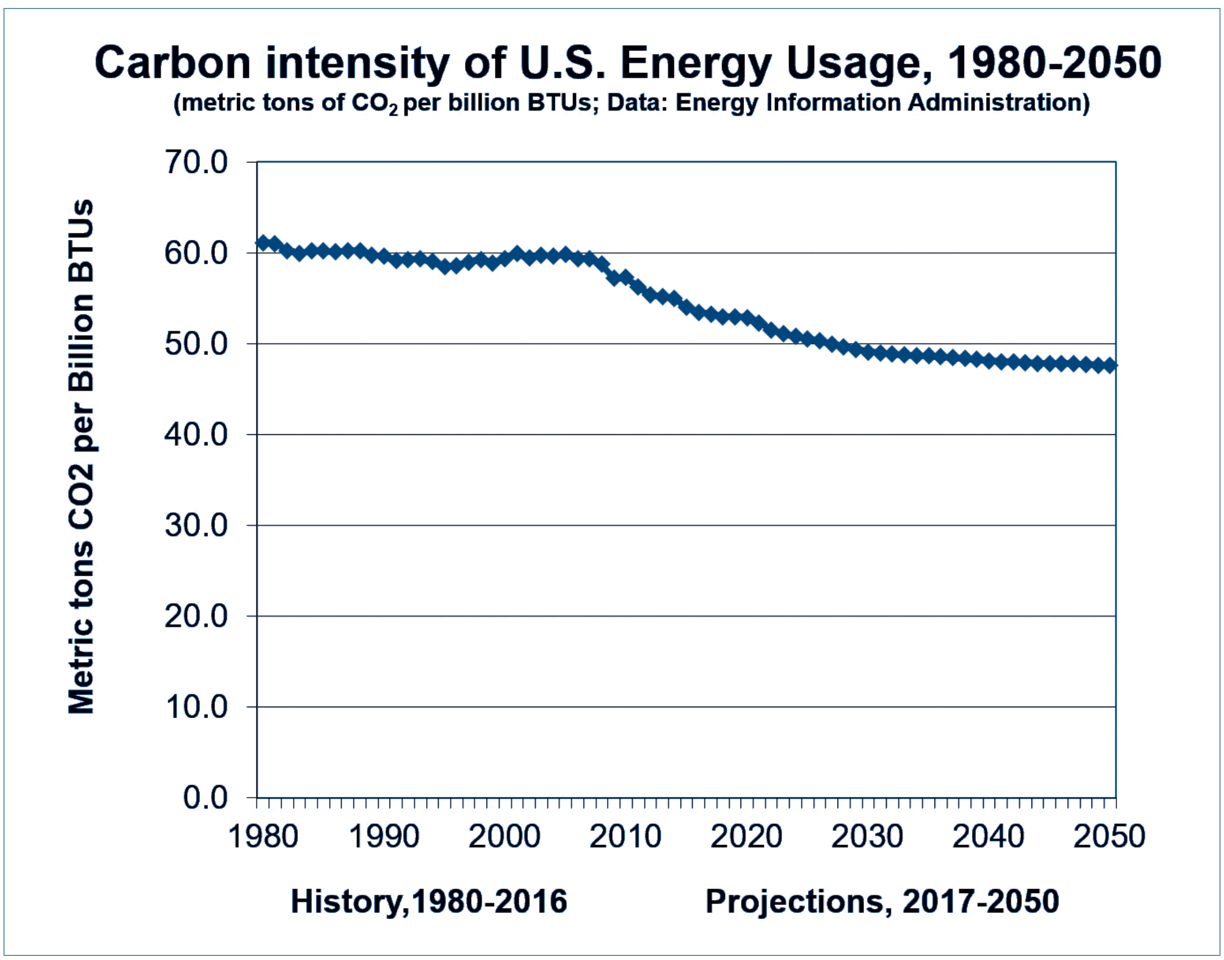
SUN AND WIND

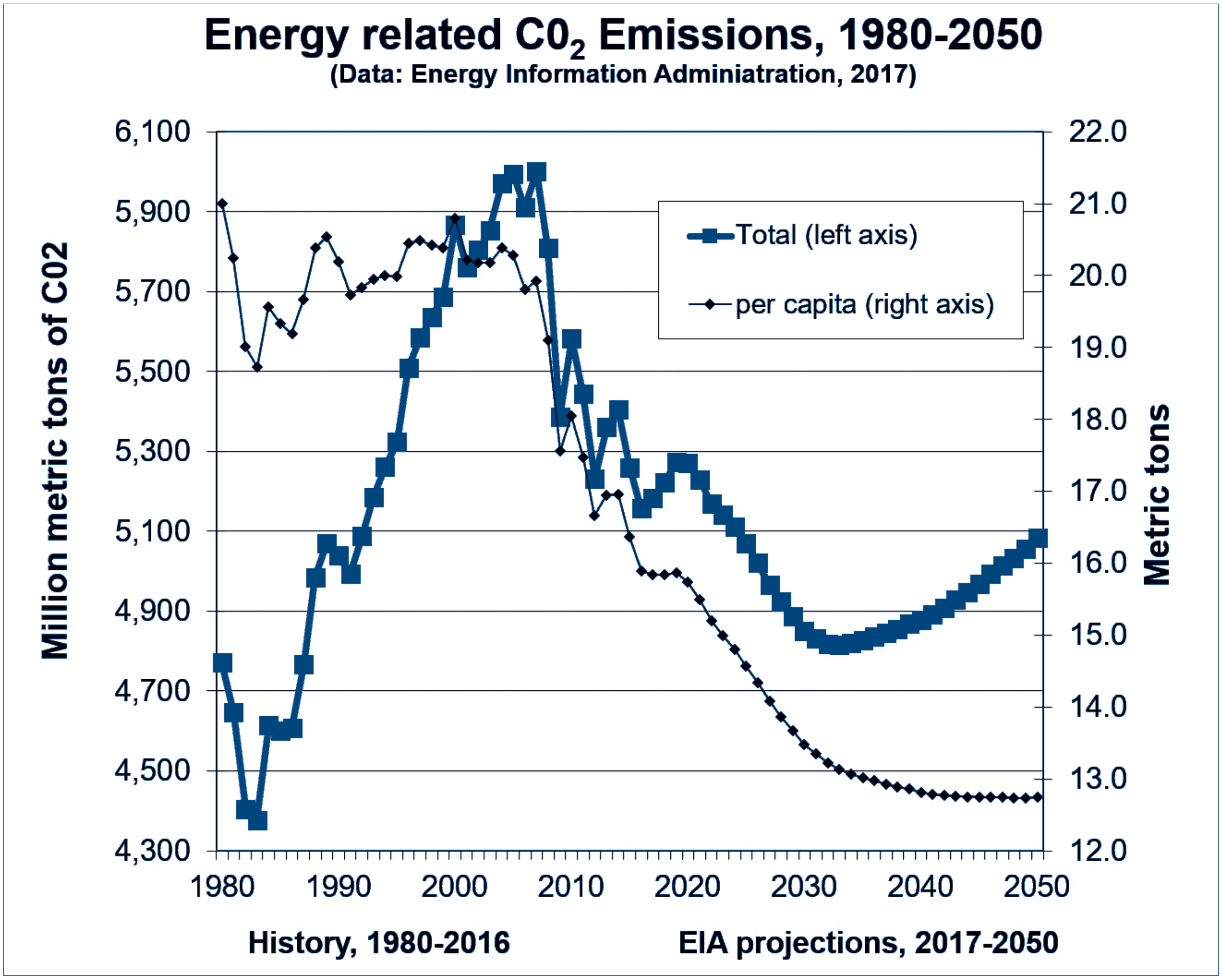
"There's no shortage of renewable energy from the sun, wind and water... The sunlight ... in one day contains more than twice the energy we consume in an entire year. ... Clean energy sources can be harnessed to produce electricity, process heat, fuel and valuable chemicals with less impact on the environment." (California Energy Commission 2006)

Solar and wind power are the great green hopes of renewable energy fans. It's hard to find a more taken for granted, unquestioned assumption than that it will be possible to substitute these two sources for fossil fuels, reduce greenhouse gases, and still grow the economy. But objective analysis shows these assumptions are without merit.

Millions of homeowners have installed rooftop solar panels with great success. They enjoy cheaper and cleaner power while remaining on the grid. No sun? No problem: the system switches seamlessly to the electric grid. Solar is just a backup power source for most residences.

But using solar (or wind) to run a commercial size powerplant is another thing entirely. It requires overcoming logistical problems unknown to the happy, solar paneled homeowner. The intermittency issue, so easily sloughed off by homeowners, is the Achilles Heel of large scale





power – and it's a larger problem than you might think.

Solar fueled plants operate at only 10% of their capacity over the course of a day. Wind is slightly more reliable, operating at 17%. By comparison, fossil fueled plants achieve capacity factors in the eighty percent range, and nuclear in the nineties.[11] This implies that replacing conventional power with solar or wind will require enormous increases in renewable capacity. This creates new problems.

To avoid blackouts, every additional BTU of wind and solar capacity must be backed up by another BTU of conventional power. This means that coal, natural gas, and even nuclear plants cannot be phased out. We have created a CO_2 Catch 22, where a system touted as a way to reduce greenhouse gas emissions relies on coal and fossil fuel plants for backup – plants that emit even more CO_2 when "peaking" to replace sudden drops in renewable generation.

Sunny California, whose Governor has decreed that generators will get half of their power from solar by 2030, offers a good illustration of the peak load problem. It is called the "duck curve." (See page 5) It shows what adding renewables to the power supply does to the demand for conventional energy sources, and it does look like a duck:[12]

As more and more solar goes on line, alternatives will be displaced. Sunlight is free, but the sun doesn't shine equally over the course of a day. At the heat of the day, from noon to 4PM, solar generators can meet demand with little help from nuclear or fossil fuel backups. At 7PM, when people come home from work and turn on their appliances, sunlight has diminished, and, as seen in the duck's long neck, the demand for alternative energy spikes dramatically.

The problem here is that nuclear power plants, and even gas and coal fired generators, cannot switch on and off on a dime. At mid-day they are stuck with excess capacity which they either sell at a deep discount or, in some cases, pay the grid to take. Not surprisingly, this is bad for the nuclear bottom line, and has hastened the decline of this green and dependable – albeit controversial – power source.

Professor Jacobson puts forth what you might call a "Make Hay While the Sun Shines" strategy for how solar plants can smooth the duck curve. During sunlight hours they would generate more power than is needed, while requiring their customers to purchase – and store – the excess for use during periods of darkness. A modest proposal, you say? Perhaps for the ivory tower, but not the real world:

"…The system in [Jacobson's article] **assumes the availability of multiweek energy storage systems that are not yet proven at scale and deploys them at a capacity twice that of the entire United States' generating and storage capacity today. There would be underground thermal energy storage…systems deployed in nearly every community to provide services for every home, business, office building, hospital, school, and factory in the United States."**[13]

Robert Lyman chimes in on the implausibility of the 100% renewable scenario:

"Accommodating the 46,480 solar PV plants envisioned for the U.S. in… {Jacobson's] **vision would take up 650,720 square miles, almost 20% of the lower 48 states. This is close in size to the combined areas of Texas, California, Arizona, and Nevada.**

"To replace the 440 MW of U.S. generation expected to be retired over the next 25 years, it would take 29.3 billion solar PV panels and 4.4 million battery modules. The area covered by these panels would be equal to that of the state of New Jersey. To produce this many panels, it would take 929 years, assuming they could be built at the pace of one per second.[14]

Wind power is equally disruptive:

"A 1000-megawatt (MV) wind farm would use up to 360 square miles of land to produce the same amount of energy as a 1000-MV nuclear plant."

If Lyman is right, the mass deployment of solar and wind power could actually increase CO_2 emissions in the U.S. To destroy natural habitat on this scale is to diminish the most effective decarbonization process known to mankind: photosynthesis. Trees, plants, grass, and other flora use sunlight to convert atmospheric CO_2 to oxygen. The solar and wind focus turns out to be more about infrastructure than decarbonization.

Infrastructure can play a role in reducing greenhouse gases. Not the horizontal infrastructure of solar storage and wind farms, but the vertical infrastructure of a border wall – real or metaphorical. We explain below.

A CO_2 REPORT CARD: AUTHOR'S GRADE: D MINUS

How are renewables doing? Have they reduced the amount of CO_2 emitted from the U.S. electric grid? Does a carbon free future appear attainable if current levels of investment in wind and solar are maintained for the foreseeable future?

Perhaps the best answer to this question comes in a statistic called the Carbon Intensity of Energy (CIE). CIE measures the average amount of CO_2 spewed into the air per each unit of energy consumed in the U.S. It is the closest thing we have to a Renewable Report Card – except that unlike academic grades, lower CIE's denote success, while higher ones signify failure.

The good news: the CIE has declined since the federal government started collecting this data in 1980. The bad news: at a mere -0.37% per year, the decline is too slow to make a big dent in CO_2 intensity. More depressing still, government energy experts project even smaller CIE reductions for years 2017 to 2050.

CIE is projected to decline by an average -0.33% per annum from 2017 to 2050. At this rate it would take 210 years to cut CO_2 intensity in half, and 490 years to cut it to one-fifth its current level. Moreover, this modest decline is attributable mainly to shifts in the U.S. energy mix from carbon-intensive fossil fuels like oil and coal to relatively low carbon natural gas.

Renewables contribute little to energy decarbonization in this country and the world. As brought out above, they may have increased CO_2 emissions in some cases.

With the CO_2 intensity of energy projected to be practically flat for the foreseeable future, renewables deserve a grade of, at best, D-.

The relative stability of CO_2 intensity has not prevented wide swings in total CO_2 emissions. Emissions grew more or less in tandem with population growth until 2008, then fell abruptly when the Great Recession hit. Other factors reinforced the decline, including a shift from carbon intensive industrial production to services and health care, a more than 25% drop in energy lost in our electricity grid, and more energy efficient appliances – but the recession was the most significant factor in the decline:

We surmised that as the economy rebounds, the fall in emissions would slow, and eventually reverse. Government projections confirm our hunch. After bouncing around after 2008, total emissions are expected to increase steadily in the period 2032 to 2050.

The burgeoning gap between the per capita and the total emissions lines highlights the role of population growth in this reversal:

- **Per capita CO_2 emissions (the thin line) declined steadily for most of the period, and is projected to be 40% lower in 2050 than it was in 1980.**
- **Total emissions (the thick line) is projected to be 7% higher in 2050 than it was in 1980.**

Had population remained at its 1980 level, total emissions would have declined by the same 40% as per capita emissions. But EIA energy experts expect population growth – the number of "capitas" – to swamp the long-term decline in per capita emissions.

Decarbonization is no match for population growth.

THE MISSING LINK: IMMIGRATION AND CO_2

Over the long run population growth is the most important factor in CO_2 emissions emanating from this country. Whether a new immigrant or a baby born to a U.S.-born mother, the number of children the new arrival chooses to have is far more important to 2100 climate than whether he or she recycles, bicycles to work, drives a hybrid vehicle, or sets the thermostat high or low.

In this sense, the act of immigrating is no different from the act of giving birth: both add a new source of future CO_2 emissions from this country. Of course, had immigrants remained in their home countries they would have still produced some CO_2, but their output would have been far less. Immigration to the U.S. represents a large-scale transfer of population from countries with comparatively low per capita CO_2 emissions to one of the highest per capita CO_2 emitters in the world.

CO_2 Emissions Per Capita: U.S. vs. Top 20 Countries of Origin of U.S. Immigrants, 2015		
	Metric Tons per Person	**U.S. as Multiple of Each**
United States	**16.07**	**1.00**
Mexico	3.72	4.32
China	7.73	2.08
India	1.87	8.59
Philippines	1.12	14.35
Cuba	3.03	5.30
Dominican Republic	2.31	6.96
Vietnam	2.20	7.30
Iraq	4.41	3.64
El Salvador	1.22	13.17
Pakistan	0.93	17.28
Jamaica	3.29	4.88
Colombia	1.68	9.57
South Korea	12.27	1.31
Haiti	0.21	76.52
Bangladesh	0.44	36.52
Iran	8.01	2.01
Nepal	0.24	66.96
Myanmar	0.22	73.05
Canada	15.45	1.04
United Kingdom	6.16	2.61

Data: Top 20 countries of origin as ranked in DHS, *Annual Flow Report*, 2015, Table 3; per capita CO_2 Emissions from https://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions_per_capita

Each of the top 20 countries of origin have lower per capita CO_2 emissions. This is not surprising: most immigrants immigrate to improve their standard of living – the A, or affluence, factor in the IPAT equation – and this generally entails moving to countries with higher per capita energy consumption and CO_2 emissions. Per capita CO_2 emissions in the U.S. in 2015 were 4.2-times the average for the rest of the world (16.07 versus 4.1 metric tons.) This implies that immigration to the U.S. from nearly any country will increase global CO_2 emissions.

South Korea is the only Asian nation among the top 20 countries of origin to come close to the U.S. in CO_2 per capita. It is also the most industrialized and affluent of this group.

This is not to say that new immigrants immediately generate as much CO_2 as the average American. Income matters. There is a strong positive correlation between income and emissions. High-income Americans consume more fossil fuel than low income Americans. They are more likely to own a car, live in unattached houses that take more energy to heat and cool, commute from distant suburbs, travel by airplane, and purchase goods and services with substantial energy embodied in their manufacture, production, and delivery. Low income Americans and immigrants are more likely to live in apartments or other group quarters, carpool or take public transportation, travel less and buy fewer consumer goods.

The Energy Information Administration does not estimate the share of CO_2 emissions generated by immigrants. However, a study by the Center for Immigration Studies (CIS) used income differences between immigrants and native-born Americans as a proxy for differences in per capita emissions of the two groups.[15] They found that immigrants earn about 85% of what the average U.S. resident (native-born and immigrant) earns. Applying this percentage to the 16.07 metric tons of CO_2 per capita generated in the U.S. in 2015, and multiplying by the 43.2 million immigrants living in the country, we estimate that immigrants generate about 590 million metric tons of CO_2 annually, or about 11.4% of all CO_2 generated by U.S. residents.

It is useful to put the immigrant CO_2 number into context. Five hundred and ninety metric tons is roughly equal to the combined emissions of Argentina, Venezuela, Colombia, Chile, Ecuador, and Bolivia. It also equals the combined CO_2 emissions of the U.K., Ireland, and Sweden.

If the 43.2 million immigrants living in the U.S. were a separate country, they would rank ninth in CO_2 emissions, behind China, the United States, India, Japan, Russia, Germany, South Korea and Iran.

Had they not come to the U.S., and generated CO_2 at the average per capita rate of persons in their home country, their CO_2 emissions would be 167 million metric tons, – a drop of 72% from the emissions they generated in the U.S.

The net impact of U.S. immigration on global CO_2 emissions – an increase of 423 million metric tons in 2015 – represents 1.2% of total global emissions. By contrast, our immigrants are only 0.6% of the Earth's population

CONCLUSION

Renewable energy has grown faster than all other power sources in recent years, including coal, natural gas, and nuclear. Solar and wind are the standouts: globally, their installed capacity in 2015 was more than 10-times larger than what the International Energy Agency had forecast ten years earlier. Still, all this wind and sun has not brought about much decarbonization. CO_2 emissions per unit of energy has remained stubbornly flat for decades

While sunlight and wind are still free, the price of energy generated from these sources has not declined – and in some areas, is increasing. The increasing returns to scale that we expect in large, capital intensive, production processes do not apply to intermittent energy. As their share of the energy market increases, indirect costs – maintaining idle fossil fuel plants as backups, building large scale electricity storage, expanding reliability of an aging and capricious electric grid – grow disproportionally large. At a certain fairly low level of market penetration, solar becomes very pricy. The notion that you can simply extrapolate recent solar growth rates to the foreseeable future may be comforting to renewable fans – but it is wrong.

Unintended consequences abound. Because they produce when the sun is up and the wind blowing, renewable generators flood the grid with excess power at certain times of day, slashing the price of power. This is especially hard on nuclear reactors, which are more expensive (per BTU) than other sources, and have been targeted for phase out for other reasons. The withering of nuclear is a major reason for the stall in decarbonization. Renewables have not been able to produce power on a nuclear scale.

Per capita CO_2 emissions are significantly higher in the U.S. than in most other countries in the world. Our growing population has overwhelmed improvements in energy efficiency and emissions abatement. Indeed, for most of our recent history, reductions in energy use per capita and per dollar of GDP have failed to offset the increased demand for energy brought on by population growth.

Immigration is expected to account for 82% of U.S. population growth by 2050. Our immigration policy is, therefore, key to the global effort to lower greenhouse gas emissions.

The war on global climate change starts at home.

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