

Sustainable Future?

By John Benson

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1. Introduction

This will be a strange post for me. I write about technology, energy (renewables and other energy subjects), climate change, mobility, and since I'm an electrical engineer, all electric subjects. Although this post will be about some of these subjects, it will step over into politics (which I also do occasionally), and international competition.

2. The Facts

The following are the facts today as I see them.

2.1. Climate

Since I read and write much about climate and more specifically climate change, I believe the following is a safe statement: Predicting specific climate / weather more than weeks into the future is well beyond our current modeling and computation capabilities, except where we cop-out and use the most-vague statements like:

- It will be, on average, A to B degrees warmer X years from now at location Y.
- The precipitation will increase/decrease on average over X years by N percent at location Y.
- Using the following suite of models, climatologists predicted...

Furthermore, I believe it will be, at the earliest, decades in the future before we can accurately predict the climate/weather for more than a week or two into the future. This is NOT because our climatologists are incompetent or their tools are flawed, it is because earth's climate is a huge, complex system with many chaotic elements.

However, climatologists can make accurate statements based on solid science, like.

- It will be at least A degrees warmer in X years in location Y unless we reduce the greenhouse gasses in our global atmosphere verses their content today.
- If these greenhouse gasses continue to increase at the current rate the temperature will be at least A+B degrees warmer in X years in location Y than today.
- The above two estimates have a C% probability of occurring.

This is what our climatologists are telling us today. I have seen this in many books and articles, and I believe this is the truth.

On the other hand, what some politicians are telling us today is:

- Climate change is a hoax.
- Renewables are a bad investment.
- Drill baby, drill.

Those are not only illusions, they are harmful-illusions.

The rational leaders in the world believe what the climatologists are telling us (see above), and will act on this.

3. The Future

The following is an excerpt from a short “Opinion and analysis” piece from my February Scientific American.

Incoming President Donald Trump and his administration have called warnings about climate change “alarmist,” and have pledged to expand oil and natural gas production. But there are important reasons for the U.S. to expand its use of clean energy technologies as well. Renewable energy not only cuts carbon emissions, it is an economic juggernaut.¹

Renewable energy is growing faster than any other electricity source in the U.S., according to the U.S. Energy Information Administration. Globally, the market for these technologies is projected to rise from \$700 billion in 2023 to more than \$2 trillion by 2035.

China dominates the worldwide markets for solar panels, electric vehicles, and batteries able to store energy when the sun or wind is down. If the U.S. does not support domestic renewable-energy industries, China's dominance will only grow, with the European Union and India poised to also rise. If the Trump administration stops federal support for renewables or, worse, discourages them, the nation will both continue to degrade its environment and miss a profound economic opportunity. “This is ceding the future,” says Steven Cohen, director of Columbia University's master's program in sustainability management.

More renewables also mean greater U.S. energy independence, and right now it means more support for domestic industries. According to an August 2024 report by the Rhodium Group and partners, the five states receiving the most clean-energy and clean-technology dollars from the Inflation Reduction Act, relative to the size of their economy, are all red or “swing” states: Nevada, Wyoming, Arizona, Tennessee and Montana. There is plenty more cash from the Inflation Reduction Act to hand out-unless the Trump administration dismantles the legislation.

That would be a mistake. A rise in renewable energy does not mean a fall in oil or natural gas. U.S. production is growing there, too, and overall power demand is increasing. We're not proposing a future free of fossil fuels. Major energy transitions take time. But as numerous studies have shown, more fossil-fuel consumption makes climate change, air and water pollution, and public health worse. Ultimately renewable energy costs less, and the cheaper technology always wins. Some U.S. states have gotten this message: Texas, the oil center of the country, now produces more wind power than any other state and ranks second in the nation for solar power production (after California)². The market for clean technologies is “increasingly catching up with the market for fossil fuels,” Fatih Birol, executive director of the International Energy Agency noted in an October 2024 release of the agency's latest study.

¹ Board of Editors, Scientific American, February Issue, Page 68, “Renew Support for Renewable Energy,” To Order a Copy of a Scientific American Issue: Call (800) 333-1199.

² The words “...and ranks second in the nation for solar power production (after California).” Were added by your author (John) after researching this. See <https://environmentamerica.org/texas/center/media-center/clean-energy-continues-meteoric-rise-in-texas/>

A common refrain from critics is that U.S. renewable energy industries depend on subsidies. Truth is, that's how canals, roads, trains, steel, aluminum, corn, soy, beans, and space rockets developed, too. And even though the U.S. oil and gas industries are more than a century old, they still get huge subsidies as well.

China subsidizes its renewable-technology industries – and for the rest of the world, that's positive. Inexpensive Chinese solar panels, electric cars and wind turbines help to accelerate the energy transition world-wide. Energy transitions are costly, notes Jeffrey Frankel, professor of capital formation and growth at Harvard University and a research associate at the U.S. National Bureau of Economic Research. So, he asks, why not let Chinese taxpayers foot a subsidy bill that helps to spread renewable energy everywhere?

Author's comment: Although I believe the U.S. needs to do it's share, and also provide technology leadership for renewable and zero-carbon energy, as long as we share an atmosphere with the other nations of the world, China's role in production leadership and international commerce described in the prior paragraph is critical in reducing climate change. **If you don't have time to read and digest the text in this section, just read the highlighted text on the prior page** and below.

*Capitol Hill's view of the renewable energy industry may be influenced by the strong fossil-fuel industry lobby. But the big users of renewable energy have strong influence, too. More than 70 percent of the U.S. gross domestic product now comes from the service sector, according to the U.S. Bureau of Economic Analysis, and it is gaining in political power. Meta is the largest buyer of solar panels in the country. The service sector consumes gobs of energy; witness the meteoric rise in energy demand from artificial-intelligence data centers. **These companies want the cheapest power prices, and renewables offer them. "Money tends to dominate over ideology,"** Cohen says.³*

Most people recognize that climate change is real and a result of our own actions, notably, burning fossil fuels, which they increasingly see as harmful. According to a large 2023 survey by the Pew Research Center, "59 percent [of Americans] think that air and water quality would get better if the U.S. greatly reduced fossil fuel energy production and increased production from renewable sources." The survey also found that "67 percent of Americans say the U.S. should prioritize developing alternative energy sources, such as wind, solar and hydrogen technology, while 32 percent say the priority should be expanding the exploration and production of oil, coal and natural gas."

A cultural shift is underway, in part because many more people in the U.S. are experiencing extreme weather: most recently, unprecedented flooding in North Carolina from Hurricane Helene and record- breaking drought killing crops across many states. Homeowners in some coastal states cannot get flood insurance. These experiences put millions of Americans at great risk of death, injury or financial ruin. People can see that the scientific predictions have been correct all along. They are increasingly worried about their health and their children's well-being. They are feeling the human impact.

³ Steven Cohen, director of Columbia University's master's program in sustainability management, see fourth paragraph on page 2.

Supporting renewable energy is not asking anyone to do without—we won't have to give up our trucks or air conditioners. It provides an opportunity to reduce the threats we all face and to lead in a rapidly expanding, thriving economy.

4. Data on Recent Growth of Renewables

I thought the above was a reasonable paper, I thought it was a bit short on solid data, so I found an article from reputable source (referenced below) and inserted some excerpts below.

Solar deployment and electric vehicle (EV) sales broke records in 2023 and 2024. Renewables now dominate new power generation capacity, while new domestic clean energy manufacturing facilities are popping up around the nation.⁴

However, headwinds are also getting stronger. Several challenges persist that are slowing deployment, including lack of sufficient grid capacity and large interconnection queues, permitting and siting challenges, high interest rates, and lingering supply chain issues. These factors have been holding clean power development back at a time when it needs to be surging ahead.

Meanwhile, the need for increased clean energy development has become even more urgent in recent years, as skyrocketing demand from data centers and more is leading to significant electricity load growth in the U.S. for the first time in decades. And with a new federal administration creating roadblocks for leasing and permitting wind energy, freezing funding, and threatening to upend policies like the Inflation Reduction Act and Bipartisan Infrastructure Law, it may become even harder to make progress...

Following the record-breaking outcomes of 2023, 2024 was another impressive year for clean energy deployment in the United States. These upward trends signal that clean electricity sources are an increasingly vital part of the U.S. economy and power system, with renewable sources and battery storage making up the vast majority of new additions to the grid.

Solar surpassed 2023's record installations in 2024, adding an estimated 39.6 gigawatts (GW) of capacity, compared to 27.4GW in 2023. Installed solar capacity in the U.S. now totals about 220 GW, enough to provide over 7% of the nation's electricity. This continues a decade-long trend of rapid growth in solar power.

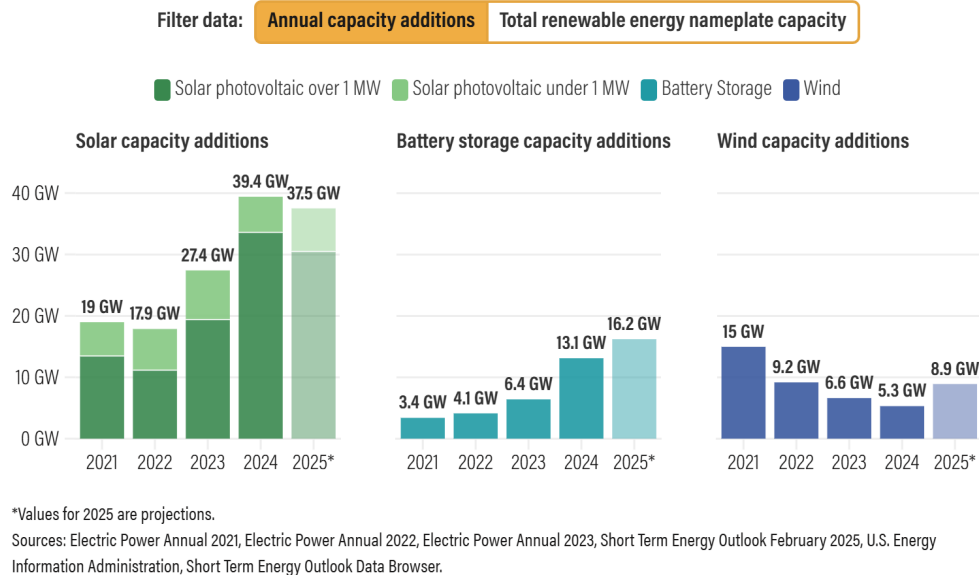
Battery storage nearly doubled in 2024, with total installed capacity reaching almost 29 GW — and projected to grow another 47% in 2025. This growth in capacity will help support the grid when variable renewable energy technologies, such as solar and wind, are unavailable, making the U.S. power system more stable and secure.

At the same time, onshore wind capacity growth has tapered off, with only 5.3 GW of new generation added in 2024, significantly less than wind installation levels in previous years. According to the Energy Information Administration (EIA), installed wind capacity totaled 153 GW at the end of 2024. Limited growth of wind power resulted in part from a focus on repowering older facilities as well as continued challenges related to supply chains, financing, interconnection and permitting.

⁴ Lori Bird, Andrew Light and Ian Goldsmith, World Resources Institute, "US Clean Power Development Sees Record Progress, As Well As Stronger Headwinds," February 21, 2025, <https://www.wri.org/insights/clean-energy-progress-united-states>

See the graphic below.

U.S. renewable energy annual capacity additions and total generating capacity by source



4.1. Geothermal and Nuclear see Renewed Interest

Carbon-free energy sources that can operate around the clock, such as geothermal and nuclear, are quickly gaining attention. Despite generating only 0.4% of the total U.S. utility-scale electricity mix, geothermal technologies are seeing interest from large energy buyers and utilities. For example, Fervo Energy recently announced the execution of two power purchase agreements (PPAs) with Southern California Edison that would add 320 MW of geothermal to the grid. New geothermal technologies can provide 24/7 power, have dropped in cost, and can be sited in a wide range of geographies.

Over the last decade, nuclear power plants have been decommissioned at a faster rate than they have been built, with nuclear accounting for 18.6% of all U.S. generation through 2023. But it's now seeing renewed interest from corporate purchasers. For example, in 2024, Microsoft signed a 20-year power purchase agreement with Constellation for nuclear energy from a previously shuttered unit at the Three Mile Island plant; Amazon said it would invest \$500 million in small modular nuclear reactors (SMRs); and Google announced plans to purchase power from SMRs by Kairos Power.

4.2. Is the Grid Decarbonizing Fast Enough?

Taken all together, renewables vastly outpaced other generation sources and collectively accounted for around 90% of the United States' new installed capacity in 2024. With the new projects online, renewables (including wind, solar, geothermal and hydropower) and battery storage now make up 30% of the country's large-scale power generating capacity. In 2024, all carbon free electricity sources, including nuclear, supplied nearly 44% of electricity, while renewables, including small-scale solar, supplied nearly 25%.

So where does this put us in terms of achieving a carbon free grid? Studies show that reaching 90% or more carbon-free electricity by 2035 — a key element of achieving a clean energy economy — would require 60-70 GW of new renewables per year over the next decade, as well as other forms of carbon-free power. Last year (2024), the U.S. saw additions of about 45 GW of solar and wind combined. This increase from 2023 shows robust progress, but we still need more growth in carbon free generation to meet grid decarbonization targets.