Fighting Climate Change Myopia

What should our electricity future look like?

March 2021

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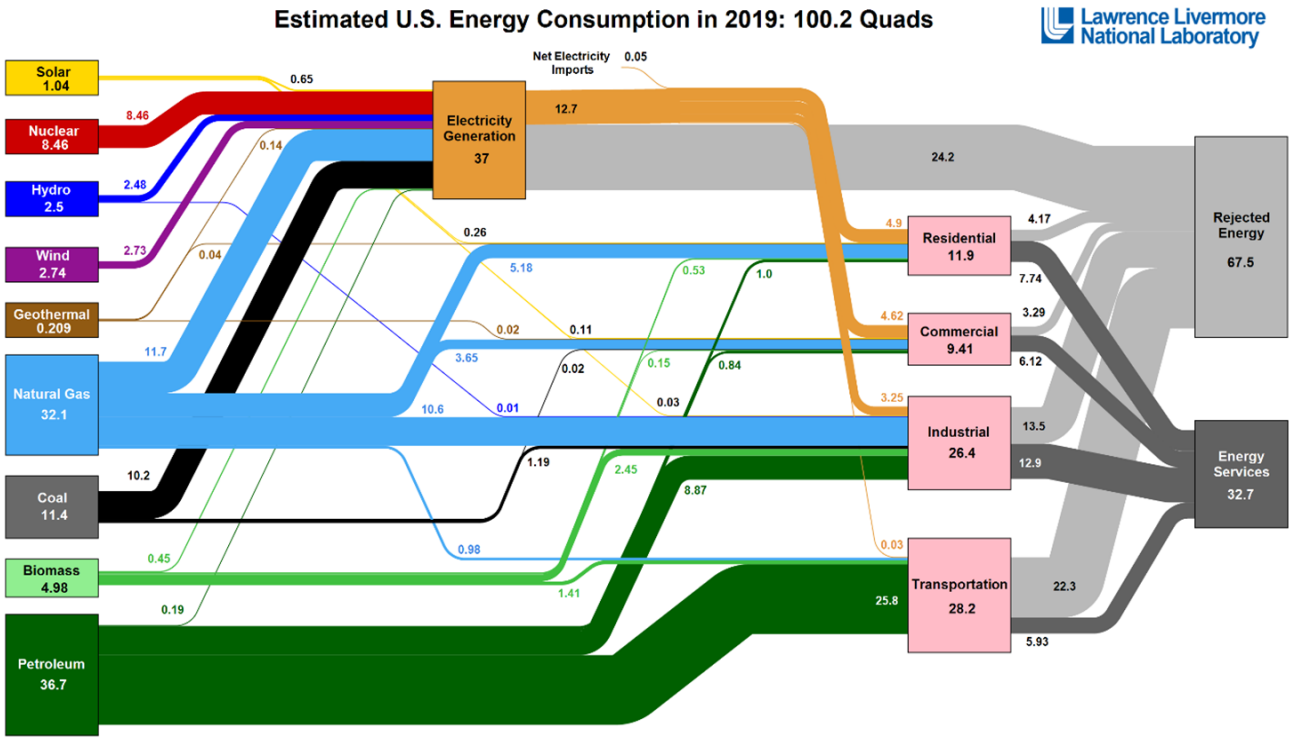
The February winter storm that devastated the State of Texas was damaging for a myriad of reasons. Not only did the storm cost hundreds of lives and left millions without water, heat, or electricity, but when the dust settles it is anticipated to be the most expensive disaster to ever hit Texas. Hurricane Harvey, which cost the state over $125 billion due to its devastation of the Houston area, will likely be eclipsed by the damage done by this one unseasonably freezing week of winter weather, with some estimates exceeding $200 billion[1].

In the early stages of the storm, the news cycle was dominated by fingers pointing blame at natural gas and wind turbines, questioning their reliability as power sources. While it was unfair to use either as a scapegoat, it called into question a larger issue: what should the future of electricity in the United States (as well as other parts of the world) look like?

Since the United States rejoined the Paris Agreement this year and will likely commit to "Net Zero by 2050," the discussion regarding various power sources and what our electricity mix should look like needs to be at the forefront of any Net Zero goal. Electricity production is responsible for 27% of greenhouse gas (GHG) emissions in the United States, and most Net Zero goals involve shifting fossil fuel energy needed by both transportation and industry onto the electrical grid, so electricity generation is the key area to address. However, any big decisions made by stakeholders (e.g., businesses and governments) will have ripple effects (both positive and negative) that will be felt across the globe. A move to the grid is further complicated by the fact that renewable energy requires storage. Finally, any measures that drastically raise prices for businesses or consumers could be quite harmful to an already fragile economy. Taking a step back and looking at the big picture will be beneficial for everyone.

To understand the United States' electricity future, considering how we currently use energy is important. With technology, we can transfer energy from other sources onto the electrical grid. Doing so will not be without challenges but has the potential to severely reduce GHG emissions.



Source: Lawrence Livermore National Laboratory

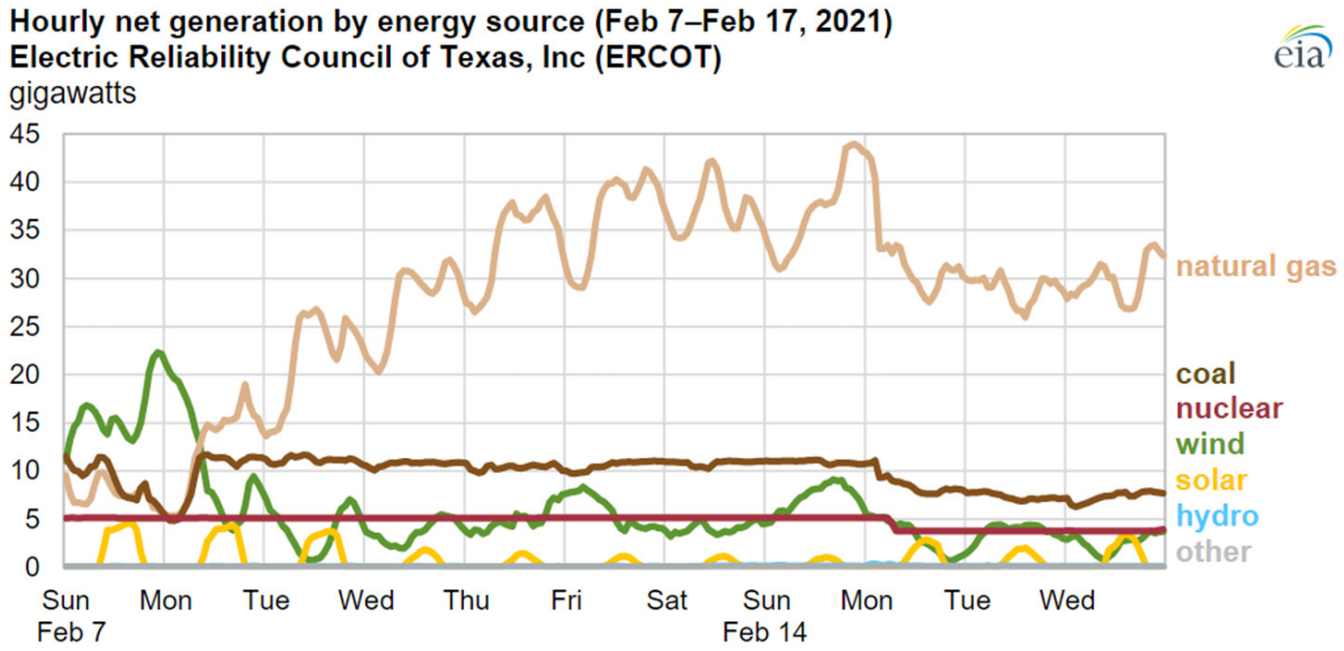
The Big Debate: The Future Mix of U.S. Electricity

The misguided debate on the inferiority of various power sources has provided a great opening to a larger discussion about what the U.S. energy mix should look like. Any climate change pledge by the Biden Administration will clearly lean heavily on the reduction of fossil fuel usage and rely on wind and solar power to pick up the load. The Biden campaign team promised a 100% carbon-free economy by 2035[2]. With essentially carbon-free sources like nuclear power on the decline in the United States, we will have to see rapid employment of wind and solar nationwide to meet that objective. While it sounds like a great promise, have all stakeholders come together and really assessed the viability of this goal?

We have established that renewables were not the primary culprit during the Texas blackouts, but we would argue that they would have made matters worse if they had represented a greater portion of the energy mix. Anytime there are widespread blackouts, everyone argues for ways to make the electrical grid more reliable, but it should seem obvious that an intermittent power source, such as wind, solar, and hydropower, only adds to the challenge of meeting demand. Wind and solar power have their own unique challenges, but the big problem is their variability in power generation, not only based on the time of day or the season, but also from a year-to-year perspective. Capacity factor, which measures the output of an energy source relative to hypothetical continuous operation, is a great way to highlight this point.

In Texas, the average capacity factor for wind power in 2019 was 38%, making it the sixth-best state from that perspective[3]. Pretty impressive, but when looking at the variability, one can start to see the difficulties. During a good hour, wind can provide power to most of the Texas grid; in May 2020, it was able to set a record and provide 59% of Texas' power demand in the middle of the night. However, there are times when the wind is so calm that almost no power is produced, meaning that Texas saw swings of hourly wind power output varying from 0.2 GW to 21.2 GW over 2020, according to the U.S Energy Information Administration (EIA)[4]. Interestingly, a week before Winter Storm Uri hit Texas, the state's wind power experienced a significant and unseasonable drop in output (and it stayed that way throughout the blackouts), further highlighting this problem of variable wind power output[5].

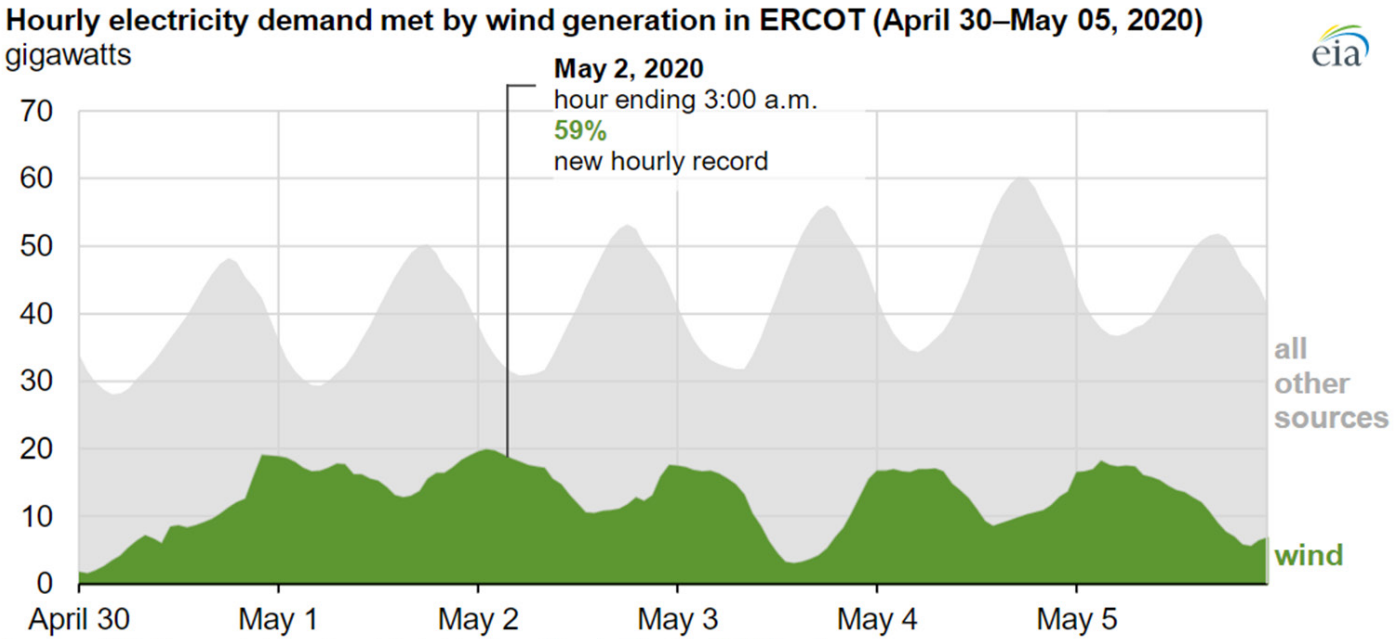
February is usually a good month for wind power in Texas, but not this year (note: Winter Storm Uri hit Texas on February 13).



Source: U.S. Energy Information Administration

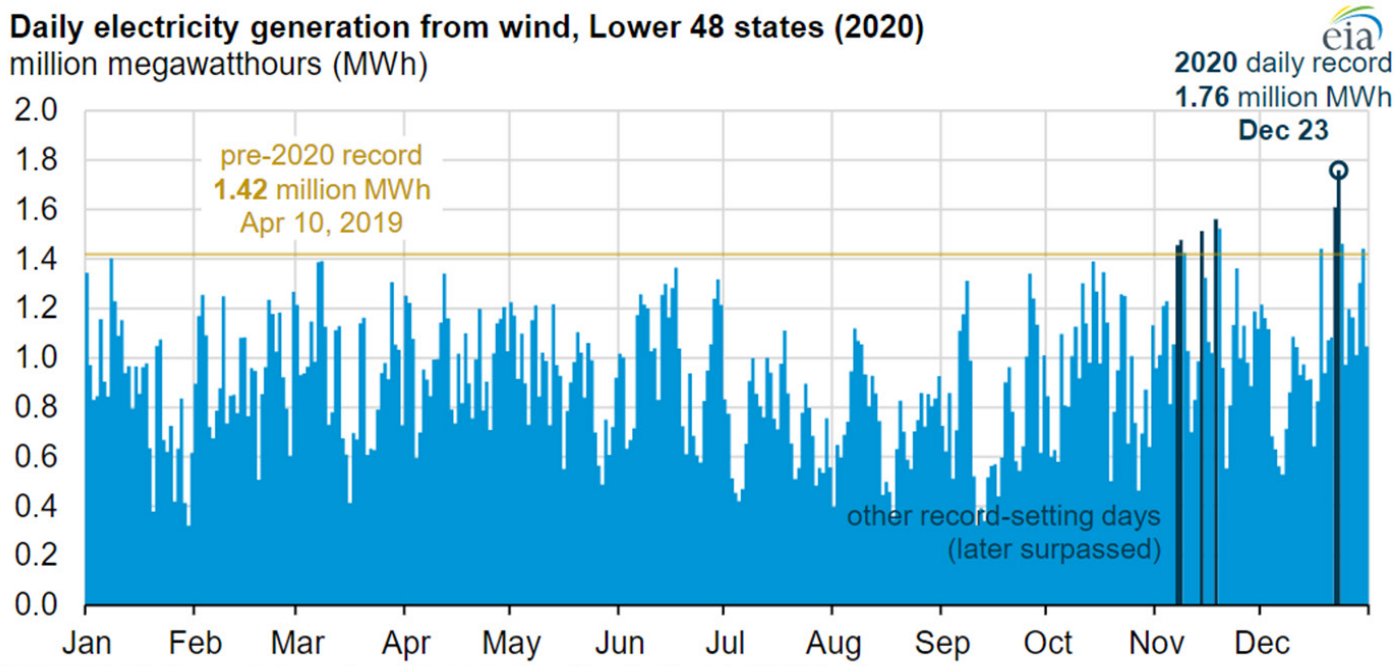
This variability makes it apparent that wind cannot be a standalone power source and needs complementary large-scale and long-term energy storage (or a reliable conventional power source with significant backup capacity) to be a viable primary source of energy.

Peak wind power generation usually does not meet peak demand (quite the opposite). Even during a good week there are wide swings in power generation.



Source: U.S. Energy Information Administration

With the variation in wind power output, it is going to be hard for Texas and other states to plan for more renewables.



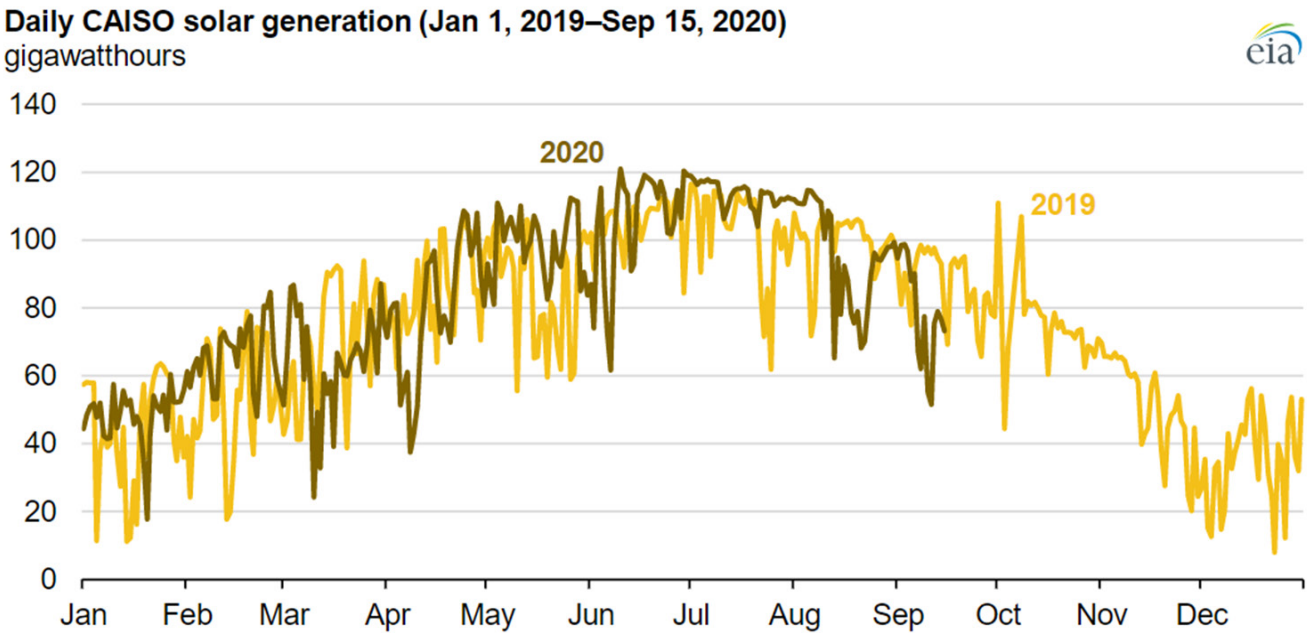
Source: U.S. Energy Information Administration

Solar Power

Solar is the other energy source that will likely see huge growth in places like Texas. The Energy Information Administration (EIA) predicts that 28% of the U.S. solar capacity added in 2021 will be in Texas[6]. Solar has its benefits, mainly that barring any sort of cloud cover, it is easy to calculate the hypothetical maximum power output for every minute of the year. Solar power ultimately provides a large quantity of electricity in the summer months and in the middle of the day. This variability can be complementary to wind power to some extent; winds tend to die down during solar's peak hours, and air conditioning usage is a big draw of power in the summer months when solar is working at its best.

But even as predictable as solar might be, all it takes is one cloudy period (or a layer of snow or frost) to limit the effectiveness of solar panels. Estimates vary, but on an overcast day, solar panels will generate about 10% to 25% of the power that they would on a sunny day[7]. When we look at Winter Storm Uri and the Texas blackouts, we can clearly see that the combination of heavy cloud ceilings and snow and ice accumulation on solar panels led to a significant decrease in output. Increasing reliance on solar power will aggravate certain situations like the Texas blackouts, which means that solar power also needs to be coupled with a large amount of long-term energy storage to be a viable solution.

California is arguably one of the best places for solar power, but variability (daily/hourly/yearly) is still significant. (Note: The August/September 2020 drop due to wildfire particulate matter was a contributing factor to the blackouts the state faced.)



Source: U.S. Energy Information Administration. *The California Independent System Operator (CAISO) is a non-profit Independent System Operator serving California.*

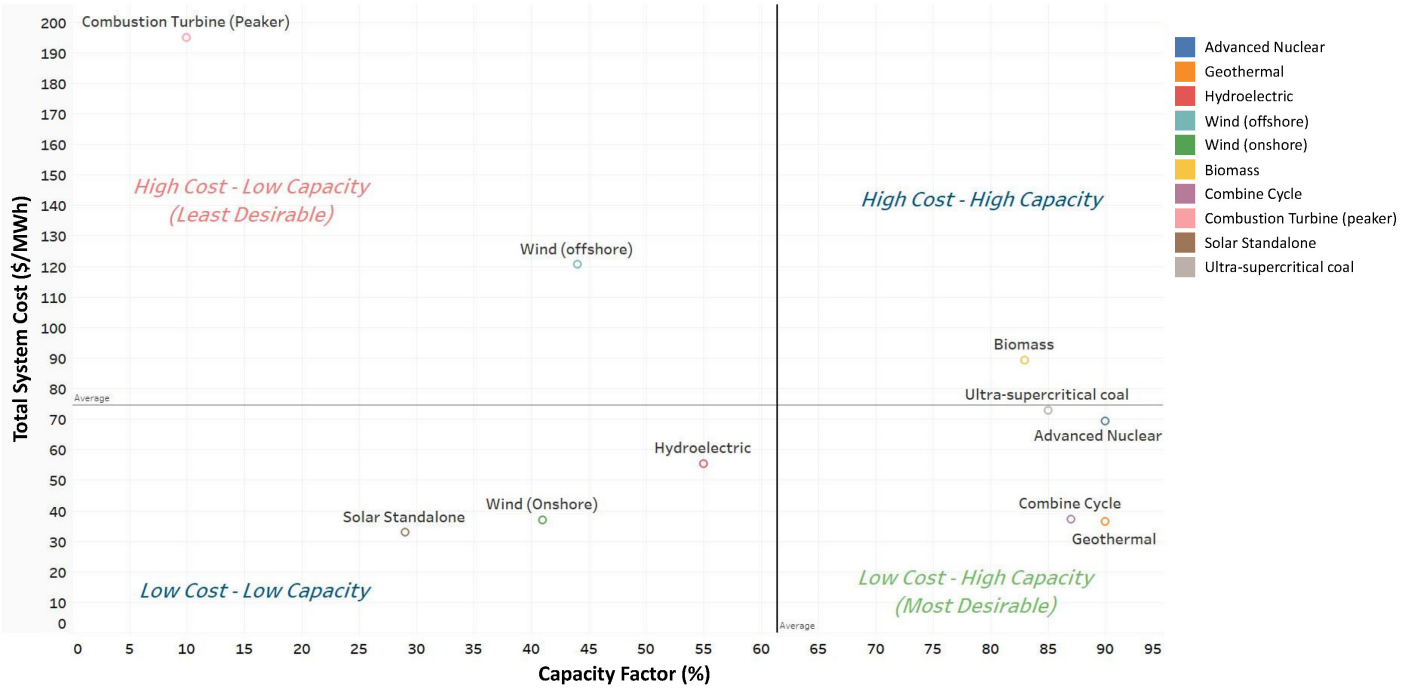
Energy Storage is the Answer, But it is Still Expensive

These limitations of wind and solar power highlight the fact that energy storage is clearly the missing link here. Although energy storage costs have come down considerably, they are still prohibitively expensive. The National Renewable Energy Laboratory predicts in its mid-cost assumption that a 4-hour lithium-ion system, which is estimated at $380/kWh, could fall to $208/kWh by 2030[8]. Unfortunately, when energy storage costs are added to the power mix equation, it makes it difficult to justify switching solely to wind and solar. To replace a conventional power source, not only is battery storage technology needed, but additional power sources are necessary to charge the battery.

Oftentimes “cheap” costs are marketed for wind and solar energy, but they only tell part of the story. Levelized cost of energy (LCOE) is used to estimate the cost of a unit of energy across the entire lifecycle of a project, but one does not get to choose when the energy is available. The problem with LCOE is that it does not factor the capital and operational costs associated with a backup power source (conventional power or energy storage) that is still needed to subsidize renewable energy’s variability in energy output.

Wind and solar power have dropped considerably in price from a cost perspective over the years, but their low capacity factors mean that they need complementary power sources or battery storage to be reliable sources of electricity.

Unweighted Levelized Cost of Energy (LCOE) for Projects Entering Service in 2026
(Assumes No Tax Credits)



Source: EIA 2021 Annual Energy Outlook

So, if we are using a metric like this for key decisions, we are missing a huge part of the equation. Ultimately, what really matters to all stakeholders, in addition to environmental and reliability considerations, is the cost associated with the entire system. If the addition of wind power, solar power, or energy storage is affordably able to lower costs by increasing energy output or enabling the retirement of other systems, those decisions are easy to make. Unfortunately, in practice we know it ends up being more complicated than that, especially as the share of power generation from renewables gets larger. Variability in both demand and output means that large amounts of excess conventional power capacity or energy storage will always be needed to complement wind and solar power. And if energy storage is chosen it will need to be for a lot longer periods than just the 4-hour capability that most utility-scale projects are today.

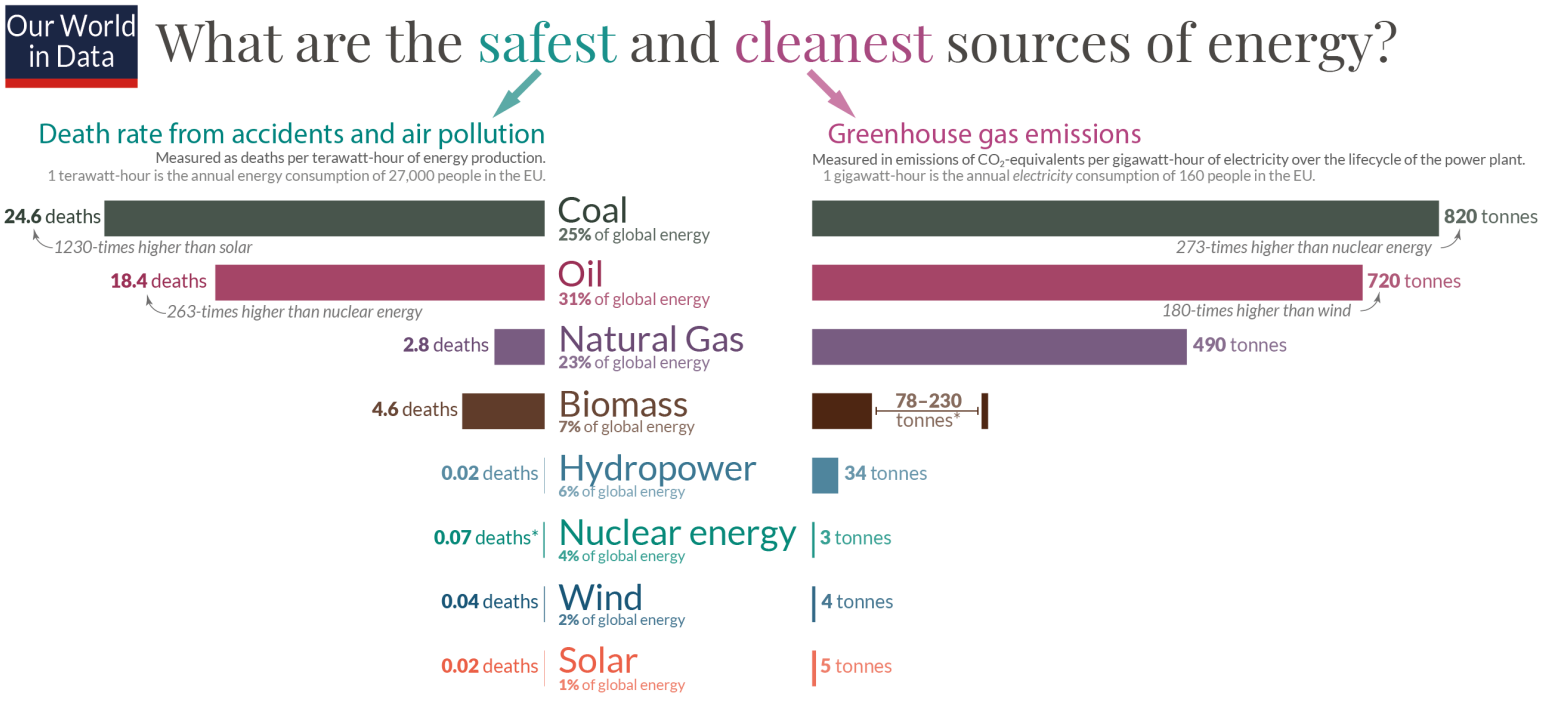
Without the ability to store large amounts of energy for a long period of time, there will be extreme challenges to greater renewable production. The United Kingdom, Australia, California, and now Texas, have all had problematic blackouts recently, arguably all exacerbated by their sizeable renewable energy mix. Reliable energy needs to be a focus just as much as clean energy, which is why the process of achieving any climate change goal is just as important as the end state.

In the United States, we have reliability challenges when it comes to renewable energy. We have identified locations that are great for producing renewable energy, but what about states that are not very sunny or windy? As problematic as it might be for a place like Texas to consider increasing its renewable energy, it is a far easier discussion than elsewhere. These reliability challenges will only be further strained by the push to get all our transportation energy onto the grid as more electric vehicles (EVs) are added to the road. And since heat pump technology, which could be critical in cutting down GHG emissions, has become a cost-effective, viable option that can replace traditional fossil fuel-powered furnaces (to include natural gas), it will require even more energy from the United States power grid in the winter months.

What About Natural Gas?

Right now, the climate change debate should not be about whether renewables will be the primary, standalone power sources at some point in the future. As the timeline of when that could be possible is anyone's guess, the real debate should be how we effectively move forward in the near term of ridding the world of coal power while also increasing our overall capacity to provide available power for more EVs, which are on the horizon. The Biden Administration appears to be on a mission to severely constrain natural gas extraction and consumption within the United States, which could have both domestic and international consequences. Natural gas is a necessary commodity that will be a requirement for many years to come, whether we like it or not.

Coal power is not only bad for the environment, but it is also deadly. Natural gas is much better from both perspectives.



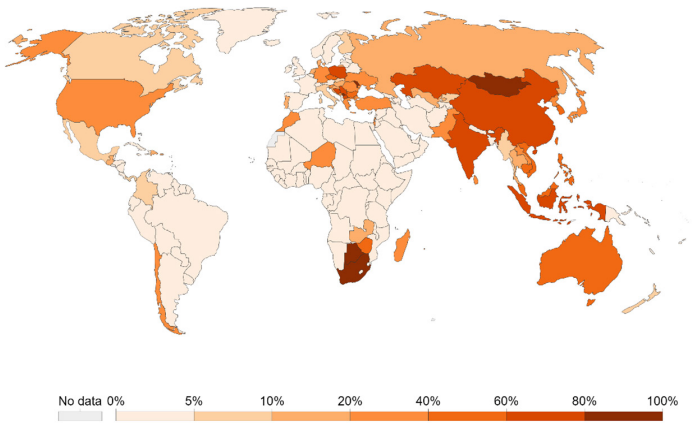
Source: Our World in Data

When considering natural gas versus its main alternative, coal, the world still stands to benefit from using natural gas. Not only are lifecycle GHG emissions lower (estimates vary, but 50% to 60% relative to coal is a fair estimate)[9], but the air pollution due to coal is a huge health problem, resulting in nearly a million premature deaths worldwide and causing many chronic health problems[10]. Referred to many as a "bridge" energy source (though it may be a bridge we keep on lengthening), natural gas will be imperative until we either solve the energy storage problem, or pivot to other technologies (e.g., nuclear power).

The domestic national gas boom has led to the United States being the largest producer of natural gas worldwide[11]. It has also jumpstarted the process of the United States weening itself off coal, while also providing American residents and businesses with affordable electricity. If the Biden Administration wants to make a dent in worldwide GHG emissions (and help support American jobs), it needs to create a landscape that accepts the pragmatic view that not all fossil fuels are created equal (i.e., natural gas is better for the environment than coal and can also provide affordable and continuous power). Countries globally have a significant appetite for natural gas, which can be exported via liquified natural gas (LNG), and yet coal power is still abundant in developed and developing countries nationwide (e.g., Japan, South Korea, Australia, and China, to name a few).

Coal power is a worldwide problem, not just in emerging markets.

Share of Electricity Production from Coal, 2019



Source: Our World in Data based on BP Statistical Review of World Energy & Ember (2021)

This brings us to probably the most important climate change issue that needs to be addressed, and that is coal use within emerging markets. China alone increased its coal power capacity by 38.4 GW (a net increase of 29.8 GW when factoring in decommissions), and has 88.1 GW under construction[12], which is more power generation capacity than the entire country of Mexico[13]. In fact, China's current coal capacity could essentially power all of Russia. Since the capital has already been spent on these new coal plants (securing GHG emissions for decades) and China is likely wary of any overreliance on U.S. energy, the U.S.'s LNG export business with China probably does not have much room for growth.

Other countries, however, could clearly benefit if the success of China's Belt and Road Initiative is any indication. According to Boston University's Global Development Policy Center, from 2000 to 2018 Chinese companies and policy banks have invested in 777 power plants in 83 countries, with 40% of the overall power capacity coming in the form of coal power[14]. This demand from other countries is a clear signal that the United States should also be looking strongly at the benefits of international power generation as a strategic policy tool, both to build partnerships and as a way to help fight climate change.

Think of a country like Vietnam, whose people have a strong appetite for cleaner energy but also want energy security and are wary of their ties to China. Encouraging a combination of natural gas and clean energy projects (while also not creating regulatory hurdles that would limit exports) would be a perfect way to build geopolitical capital while also helping the Vietnamese people and U.S. businesses. Many companies like AES Corporation and Exxon Mobil are already taking advantage of these opportunities, and our hope is that the Biden Administration will send a clear signal that natural gas is needed as part of the world's energy future. Thousands of well-paying jobs are at stake nationwide, and a *worldwide* path to Net Zero by 2050 is as well. The sooner the Biden Administration recognizes that a U.S. pathway to Net Zero means nothing unless the rest of the world comes along, the better.

Conclusion

Clearly, our society is not ready to make the bold changes needed to alter our energy future. Reductions of GHGs from current levels by any means will help society on an eventual path to Net Zero, so we should view it as a victory when a coal power plant shuts down, even if its replacement is natural gas.

As important as solving the energy mix is, so too is the affordability of that energy. Our economy is still very fragile as we recover from the Covid-19 pandemic, and consumers cannot afford higher electric bills. In 2020, California consumers owed approximately $1.15 billion in debt to utilities, and high fixed costs for energy means some pay nearly twice the national average[15]. If renewable energy can affordably retire outdated conventional power sources without sacrificing reliability, then it is a sound decision. But if renewable energy cannot displace other power sources, then spending the additional capital could lead to higher energy costs, which will need to be weighed against the environmental benefits.

Because of this difficult dilemma, we should be considering multiple energy sources. This could mean exploring larger usage of nuclear power, to include “advanced nuclear” options, such as small modular reactors or the holy grail of clean energy, nuclear fusion. Hydrogen is also likely to have a role at some point in the future, and although costs are still prohibitively high, it merits being part of the big picture energy discussion. Hopefully, those that are still convinced that we can place the majority of our Net Zero ambitions into wind and solar power will look at their plans with a little more skepticism and realize there needs to be an ongoing discussion about the future of electricity.

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