THE EFFECTS OF GLOBAL WARMING ON SOLAR

With a Focus on Commercial and Industrial (C&I) Systems

Executive Summary

Much has been said about how solar will play a huge role in combating global warming. This article reviews that role, then looks at the opposite: how solar installations will be impacted by global warming and what, if anything, to do in response.

Overview

No, the title of this article isn't backwards. Many, many people have already written about the effects of solar on global warming – more accurately, how solar energy is a critical tool in our efforts to mitigate the severity of the climate crisis that is upon us.

The Challenge

We're mostly going to discuss the opposite: how global warming will affect solar energy systems and, therefore, what we may need to consider regarding the design, installation, and maintenance of those systems. This is something that doesn't seem to get much mention, though it should.

SOLAR MITIGATES GLOBAL WARMING

Carbon Reduction

As a form of clean, renewable energy, solar (along with wind, hydropower, wave/tidal and geothermal) holds out tremendous promise in the process of transitioning away from fossil fuels. As we continue to install solar energy systems, we tap into a vast, clean renewable resource (the sun's energy), meeting more and more of our needs without producing significant amounts of greenhouse gasses. Over a typical 25-35-year service life, solar systems produce no emissions in their creation of energy, since they are using the sun as their "fuel" (i.e., rather than burning a fossil fuel like coal, diesel or natural gas). Once a solar panel has been producing electricity for about a year its embodied energy has been erased[1] making no further contribution to global warming while pumping out decades of clean electricity over its

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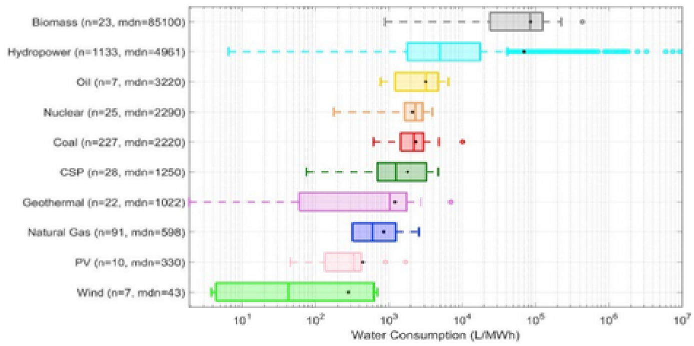
remaining service life. Thus, solar is described as having an energy payback time (EPBT) of about a year. By comparison, a coal burning power plant has an EPBT of approximately 3.3 years, and a nuclear power plant has an EPBT of about 2.5 years.[2]

Water Use

In addition to a clear win on the carbon front for electricity production (vs. fossil fuels), solar wins when it comes to water use: one lifecycle analysis suggests a median of 330 liters of water used per MWh of average energy production for solar whereas, for example, coal comes in at 2,200 liters/MWh, natural gas at 598 liters/MWh or nuclear at[3] 2,290 liters/MWh. (Note in the table below solar is referred to as "PV" – short for "photovoltaic." Also, note that the X axis is logarithmic.)



Land Use

While utility-scale solar (e.g., solar farms) uses more land per MWh than natural gas, it uses about the same amount as coal, less than wind, and far less than hydropower. However, when it comes to C&I solar energy installations, we're mostly using land that's already occupied, either by buildings (installing solar on their roofs) or by parking lots (installing solar in shade canopies above them). Some industrial solar applications are also ground mounts, but most of these use "brownfields" or other degraded land

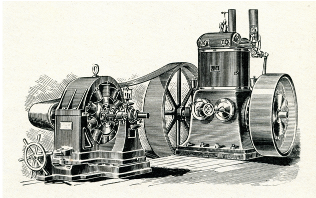
Urban Heat Island Effect

Next, several studies have shown an additional benefit of solar from the shade it creates. Installed on rooftops and over parking lots in urban areas it helps to ameliorate the "the urban heat island (UHI) effect."[4] This is where buildings and pavement soak up the sun's energy and re-radiate that energy back into the environment as heat, throughout the day and into the night. This UHI effect makes urban areas hotter than the suburbs and rural areas that surround them.

Solar helps to slightly lower urban temperatures by the shade it provides on rooftops and over parking lots – this not only provides the benefit of making the local environment more comfortable for the people in it, but it also helps reduce the demand for electricity to run air conditioning (AC) systems (so, solar in an urban setting provides a double benefit). This is especially true of solar parking lot canopies for the following reasons: pavement tends to be the most significant contributor to UHI effects because, for one, pavement is often dark in color (e.g., asphalt) and therefore converts more solar energy to heat. Secondly, pavement is more effective as "thermal mass," meaning it soaks up more heat energy and then can radiate that heat back into the air for a longer time over night. Parking lot canopies have additional benefits: not only do they produce solar energy and reduce local UHI effects (even more significantly than rooftop solar, per the above), but they also keep the cars underneath cooler. This not only makes the drivers and passengers more comfortable when they return to their vehicles on a sunny day, of course, but it also reduces the amount of gasoline needed to run the car's AC when it's first occupied (or, if that car is an EV, it reduces the amount of battery-stored electricity needed to run the AC). So, solar parking lot canopies have a triple environmental benefit (plus a human comfort benefit).

Grid Resilience

When electrification began at around the turn of the 20th century, electric generation came in the form of dynamos (generating direct current, a/k/a DC) and then alternators (generating alternating current, a/k/a AC). These generators were driven by piston steam engines which were, in turn, powered by large boilers (mostly burning coal). They were expensive and mildly dangerous (lots of exposed, rapidly spinning parts in addition to the coal-fired boilers supplying pressurized steam). Even the earliest generators were the size of large washing machines and, including the boilers, etc., took up a good-sized room (or two) of space. Subsequently, they just kept getting larger until we got to the size of modern power plants: large complexes of multistory buildings on acres of land, requiring access to lakes or rivers for the large quantities of water they need for cooling. The bottom line is that even the earliest electric generation systems were not something a home or business owner was going to install in their basement. So, a grid system based on centralized power generation made the most sense back then.



Now, with today's highly efficient solar panels, and changes in regulations allowing for "gridtied" solar, it's possible for little solar "power plants" to be installed on homes and businesses scattered around communities and regions – what is referred to as "distributed generation" (DG). DG makes the grid more resilient as, for one, it helps to relieve "bottle necks" where the grid is struggling to transmit the amount of energy needed through a given section. Moreover, with more and more weather events blacking out parts of the grid, homes and businesses can be more resilient individually by having solar, in combination with batteries, providing backup power. Fossil fuel-powered generators can also provide backup power, but there are considerable tradeoffs between the two approaches – a lengthy discussion that deserves its own treatment at another time.

Microgrids, which include the ability to maintain electric power within a local geography (like a town, campus or corporate park) even when the larger electric grid is offline, can extend that local resilience even further than individual homes and businesses – also a discussion for another time.

Global Warming's Effects on Solar

Unless you haven't been paying attention for the last several years you already know what global warming's effects are, and will be, on the world. Warmer temperatures, of course, starts the list. (To be clear, that's warmer temperatures on average, across global regions, over time – i.e., a colder-than average couple of winter months during one or two years in any given region of the world is not evidence against global warming.) Along with warming temperatures we get rising sea levels, mass coral bleaching, infestations of new/invasive species, die-offs of other species, local ecosystems degrading (even collapsing). Plus, as we've come to understand, global warming means greater weather extremes, including stronger storms (like hurricanes and tornados), greater rainfall in some areas, more severe drought in other areas, more extreme heat waves (with the droughts and heat waves giving rise to more frequent, and more consequential, wildfires), looming issues of food and water scarcity in various world regions, etc.

So, how is any of this going to affect solar?
Not surprisingly, it comes down to the weather….

Warmer Weather

Solar PV panels produce less energy as they are heated by the sun. The spec sheet for a solar panel always includes something called the "Temperature Coefficient of P" which tells you how much power (and, ultimately, energy over time) you will lose when the panel gets hot. For every degree Celsius increase a typical solar panel will lose about 0.35-0.40% of power output.[5] This is why solar panels on pitched (sloped) roofs are typically mounted with a 2-3" air space beneath them – this gap allows airflow to help keep the panels cooler, so they'll produce more energy. Solar panels on flat roofs, as in most commercial and industrial systems, are usually tilted up off the roof (for several different reasons) and get plenty of cooling airflow.

Somewhat ironically, the heating up of solar panels is probably one of the least significant effects global warming will have on solar energy production. Most predictions are that over the coming decades average global temperatures will rise another degree Celcius or so. Therefore, based solely on average air temperatures we might be looking at something less than a 1% decrease in average solar production as a result of panel heating. In practice, it's much more complex than that: things like cloudy versus sunny weather, or strong breezes versus calm winds, can have more profound effects on solar panel temperatures than just ambient temperature, and there's no reliable way to predict what weather conditions will be (e.g., cloudy/sunny or windy/calm), over the long term, especially at a local level. However, whatever the effects of warming panels, they will likely not be all that significant in terms of solar energy production. While solar panel manufacturers are always looking at ways to increase panel production, improving temperature coefficients is probably not an issue that needs to be prioritized (or at least not specifically in response to global warming concerns). And we certainly don't have any specific recommendations for our customers beyond sticking to current best practices for panel installation that allow for air flow.

More Precipitation

Certain regions will get more rain (more frequent storms and/or heavier rainfall). This is a double-edged sword when it comes to solar: on the one hand, rain helps keep solar panels clean, washing away "panel soiling" (dust, soot, pollen, bird droppings, blown leaves, etc.) – that's one edge of the sword. The other is that more rain probably means more clouds/less sunshine. Whether more rain means more, or less, solar energy production remains to be seen. Moreover, it will probably be both a very localized and a very variable phenomenon. There is nothing that we, or our customers, should be doing specifically to prepare for this.

Drier

Other regions will get less rain – also a double-edged sword, but for reasons that are the converse of the above. Less rain will mean less washing away of panel soiling, which could become a new maintenance issue. For context, here in the NYC-area panel soiling today might cost you about 2-3% of your annual production, whereas in a drought-stricken region it could amount to more significant production losses if the panels are not proactively cleaned. On the other hand, less rain probably means fewer clouds/more sunshine – implying greater solar energy production, though it remains to be seen how those opposing factors will balance each other out.

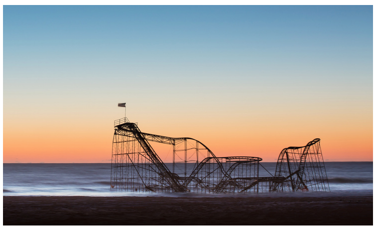
All that said, we'd note that we have not yet needed to clean any of our utility scale "solar farms" in the western US due to excessive soiling, even with the severe drought that's been plaguing that region for a few years. Other considerations, such as soil types, amount of local dust-raising activity (e.g., farming, surface mining), etc. are all part of the mix when it comes to whether panel soiling will become an issue for any given solar installation.

Whatever conditions you encounter, panel washing is always an option if the economics warrant it (e.g., the cost of lost energy production is greater than the cost of washing your solar panels). If anything, the expectation of longer rain-free periods may suggest an additional benefit to 10 degree panel tilt on flat roofs, which allows panels to shed dirt more readily when it rains than with a 5 degree tilt.

Windier

Solar panels are flat sheets of material that act like sails in how they can catch the wind, and the forces acting upon them from a strong gust can be considerable. The panels themselves, with their rigid extruded aluminum frames and tempered safety glass top sheet ("glazing"), are designed, tested, and certified to withstand almost anything mother nature wants to throw at them, including not only the forces of wind, but also the weight of snow and the impact of hail. Solar panel specifications typically show how much "load" a panel can tolerate (pushing and pulling forces) as measured in Pascals. Most quality solar panels show very similar ratings.

Then, there's the engineering involved with how they're mounted to the roof (or the ground or the parking lot canopy). Obviously, solar arrays need to meet or exceed local building code for wind and snow loading. When it comes to wind in particular, most jurisdictions require the solar installation be designed and installed to withstand a sustained (e.g., 3-second) wind gust of at least 90 mph. Along coastlines and river valleys those requirements are often higher (e.g., 100-120 mph). Ditto for installations on roofs that are more than a couple/few stories up. So, as storms become more frequent and/or stronger, it might be worth designing for higher gusts than what code presently requires. For example, one of the "racking systems" we use (the hardware that holds all the solar panels down) can be engineered to withstand wind gusts as high as 190 mph.

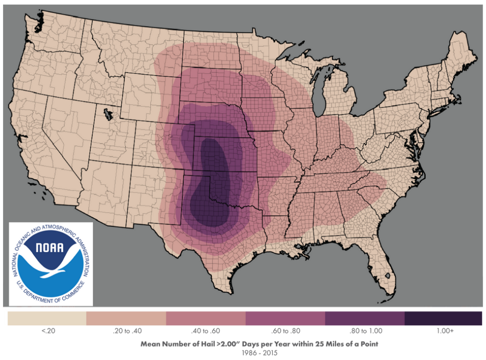


A couple of notes about that, however: for one, it should be mentioned that the strongest measured gust of wind on the East Coast from "superstorm" Hurricane Sandy was 89 mph (along the Jersey Shore). More importantly, I'd point out that typically roofs are built to just meet, or slightly exceed, the very same code. So, engineering solar arrays to withstand, say, a 150-mph gust gives you no great benefit when the roof has left the building during a 120-mph gust. Going forward, "futureproofing" your solar in anticipation of higher wind speeds than current code requires is likely a good idea, assuming the roof structure is also designed accordingly, or an existing roof is reinforced if appropriate.

All that said, in extreme storms a significant danger to the solar panels is not so much the solar panels leaving the roof, or the roof leaving the building, but rather blowing debris. There's really nothing practical we can recommend to protect your panels from that possibility (beyond insurance coverage, as discussed further on). Then, you might ask, what if that "blowing debris" is in the form of little balls of ice?

Hail

If you read through spec sheets for solar panels, you'll generally find that they are tested and certified to withstand being hit by 1″ hail at 50 mph – this covers hail as we know it in much of the country (see map below). In fact, one homeowner with solar on Long Island, NY got hit with 3-4″ hail (I've seen the pictures) – these hefty hailstones cracked the front and rear windshields of their car and put visible dents in the hood, trunk, and roof, but there wasn't a scratch on the nearby solar panels. I wouldn't have predicted that positive outcome with hail of that size, nor would I bet most panels would survive that unscathed, but it does illustrate the toughness of the glazing on most solar panels.



As global warming causes storms – and thunderstorms, in particular – to get more frequent and more violent, we will not only see more instances of hail, but larger hail striking with more force (i.e., the map above will change). So, should manufacturers be looking to make their panels more resistant to hail strikes (or blowing debris, as previously mentioned)? Well, only if they can do so without adding much to the cost or reducing the efficiency. For example, one solution might be thicker glazing. However, if using today's glass that would mean more cost and weight, and less light getting through that glass to the solar cells themselves. This is not a solution we'd recommend today – while there are certainly solar panels that have been damaged by hail, it's still a relatively rare phenomenon and it's still not clear what the future of storms will be for any given location.

Make Sure You Are Covered

Some customers choose to install solar systems with some sort of third-party ownership arrangement, such as an operating lease or a power purchase agreement (PPA). Not only do these arrangements allow those customers to install without having to come up with the funds for the initial capital expenditure, but that third-party owner typically assumes the liability for storm damage, etc., for the term of the contract (e.g., seven years for an operating lease, 15-20 years for a PPA).

Other customers might choose to purchase the system outright. As owners of the solar, they need to come up with the investment capital, and they assume the liabilities, but they get a higher return on investment for their trouble.

Whether there's concern about wind damage, or hail or blown debris from more powerful storms in the future, or concern about fire, theft, or flood (etc.) in the present, insurance coverage is really the most appropriate solution. Just as the third-party owners of leased or PPA solar make sure their systems are covered, we highly recommend that your solar is insured in all cases of self-ownership, regardless of whether global warming ultimately brings a higher risk of storm damage – there's still enough risk today. Importantly, it should be noted that when your panels are first installed, typically over half the cost is subsidized through a combination of federal (and, in some cases, state) subsidies. However, if you are replacing damaged panels, you don't get to enjoy any such subsidization. So, if you own the solar make sure your insurance covers it against any kind of risk or damage.

Batteries

The pros and cons of combining solar and batteries, versus generators, for backup power is a topic for another time (ditto for the concept of microgrids). However, the bottom line is that given the more frequent/more severe storm activity that has come with global warming, with worse predicted for the future, the market's interest in battery backup systems has been increasing and will certainly continue to do so.

Note that aside from backup power, battery systems are also being installed to help smooth out the peaks and valleys of grid demand (peak shaving), for both practical (grid resilience) and economic reasons.

While pricey upfront when compared to other means of peak shaving (e.g., natural gas-fired "peaking plants"), de minimis operating costs allow battery systems to pay for themselves reasonably quickly and their long-term payback economics are quite favorable – for example, that's one of the reasons why 174 Power Global was recently awarded the contract to install a 100MW battery system in Astoria (Queens), NY for local utility Con Edison. When compared to other types of backup systems for local/on-site emergency power (e.g., gas or diesel generators), solar with batteries is also more expensive up front. However, there are some significant pros and cons to each approach – as mentioned, this will be covered in a future article.

CONCLUSION

Global warming is bringing a complex combination of more extreme weather trends that are difficult to predict at the local level, making specific design accommodations for solar a low probability exercise. Higher average temperatures, although generally associated with sunnier conditions, may counterintuitively reduce solar production (although not by much). More intense storms and the potential for damage they represent seem to be global warming's most likely impact on solar energy systems. If anything, the solar owners best prepared for global warming will most likely be those with appropriate insurance coverage.

About 174 Power Global

174 Power Global is a leading solar and energy storage project developer focused on North America's utility and C&I energy markets. The company is wholly owned by the Hanwha Group, and has offices in Houston, Irvine, California and New York City. With deep expertise across the full spectrum of the project development cycle, 174 Power Global works closely with utilities, landowners, local communities, financial investors, and other partners to build highly productive, utility-scale and commercial and industrial (C&I) solar power plants throughout North America. Since its formation in 2016, 174 Power Global has signed more than three gigawatts of power purchase agreements. 174 Power Global's pipeline includes more than eight gigawatts of solar projects and ten gigawatt hours or energy storage projects. 174 Power Global is uniquely positioned to become a leader in green energy development. 174 Power Global's affiliate brand, Chariot Energy, is a retail energy provider that provides 100% clean, renewable solar energy to homes and businesses. Chariot Energy and 174 Power Global are modernizing and simplifying the way solar energy is sold and delivered to the grid.

174 Power Global's name was inspired by the 174 petawatts (PW) of power the earth receives from the sun at any moment.

Sources

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