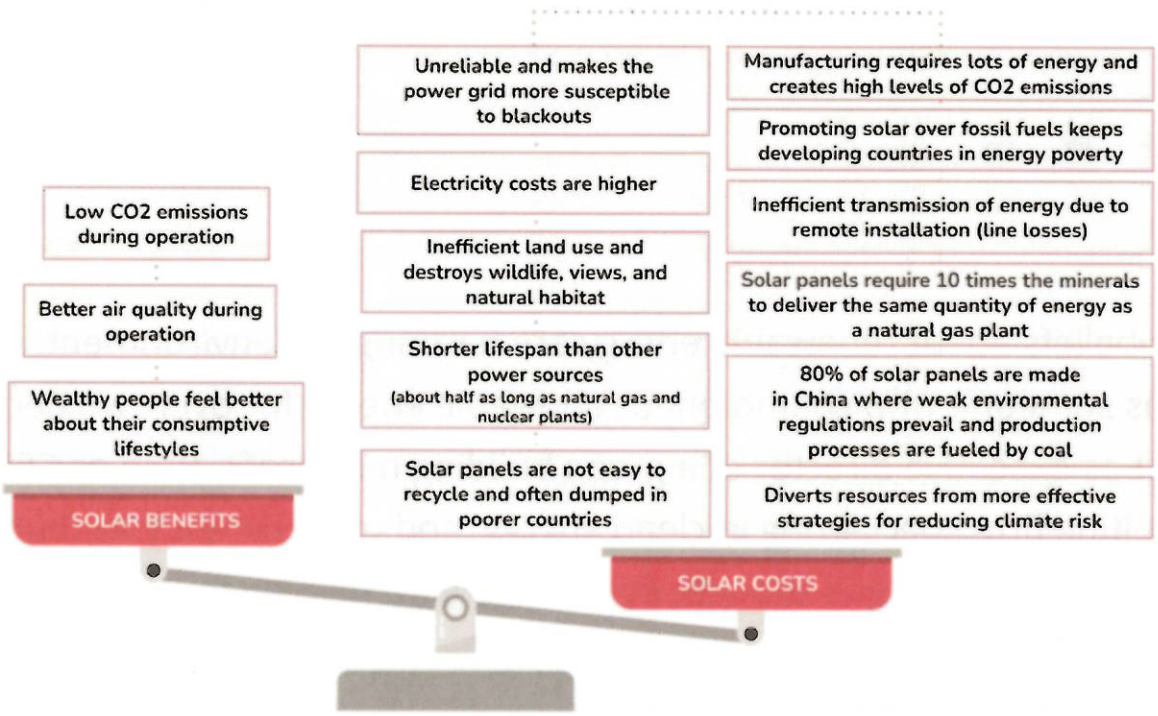
Solar's dirty secrets: How solar power hurts people and the planet

False beliefs about renewable energy are harming the environment. I say this as someone who championed renewable energy for over two decades —first as executive director of a green building non-profit, then as CEO of a consulting firm specializing in clean energy, and most recently as founder of a cleantech startup. I thought my efforts were helping to protect the environment. But I was wrong.

Like many people, I believed the worst harm to the environment came from fossil fuels—and greedy companies exploiting the land, polluting the air, and destroying ecosystems to get them. It took me many years to realize that this viewpoint is distorted and to admit that many of my beliefs about renewable energy were false. And now I'm ready to talk about what we really need to do to save the environment.

The Truth about Energy

The truth is this: every source of energy has costs and benefits that have to be carefully weighed. Wind and solar are no different. Most people are familiar with the benefits of wind and solar: reduced air pollution, reduced greenhouse gas emissions, and reduced reliance on fossil fuels. But not as many recognize the costs of wind and solar or understand how those costs hurt both the environment and people—especially people with lower incomes.



Looking at Life Cycles

To fully evaluate how solar and wind energy hurt people and the environment, we must consider the lifecycle of renewable energy systems. Every artifact has a lifecycle that includes manufacture, installation, operation, maintenance, and disposal. Every stage in that lifecycle requires energy and materials, so we need to tally up the energy and materials

used at every stage of the cycle to fully understand the environmental impact of an object.

Think of a car. To understand its full impact on the environment, we must consider more than simply how many miles it gets per gallon of gas. Gas consumption measures only the cost of operating the car, but it doesn't measure all the energy and materials that go into manufacturing, transporting, maintaining, and ultimately disposing of the car. Tally up the costs at each stage of the car's lifecycle to get a more complete picture of its environmental impact.

The same is true of solar panels. To fully understand the environmental impact of solar panels, we need to consider more than simply how much energy and emissions the panels produce during operation. We also need to tally up the expenditure of energy and materials that go into manufacturing, transporting, installing, maintaining, and ultimately disposing of the panels. Once we tally up those costs, we see that solar power leaves a larger ecological footprint than advocates like to admit.

The Environmental Costs of Manufacturing and Installing Solar

Solar advocates often gloss over the solar-panel manufacturing process. They just say, "We turn sand, glass, and metal into solar panels." This oversimplification masks the real environmental costs of the manufacturing process.

Solar panels are manufactured using minerals, toxic chemicals, and fossil fuels. In fact, solar panels require 10 times the minerals to deliver the same quantity of energy as a natural gas plant.[1] Quartz, copper, silver, zinc, aluminum, and other rare earth minerals are mined with heavy

diesel-powered machinery. In fact, 38% of the world's industrial energy and 11% of total energy currently go into mining operations.[2]

Once the materials are mined, the quartz and other materials get melted down in electric-arc furnaces at temperatures over 3,450°F (1,900°C) to make silicon—the key ingredient in solar cells. The furnaces take an enormous amount of energy to operate, and that energy typically comes from fossil fuels.[3] Nearly 80% of solar cells are manufactured in China, for instance, where weak environmental regulations prevail and lower production costs are fueled by coal.[4]

There are also environmental costs to installing the panels. Solar panels are primarily installed in two ways: in solar farms and on rooftops. Most U.S. solar farms are sited in the southwestern U.S. where sunshine is abundant. The now-canceled Mormon Mesa project, for instance, was proposed for a site about 70 miles northeast of Las Vegas. It was slated to cover 14 square miles (the equivalent of 7,000 football fields) with upwards of a million solar panels, each 10-20 feet tall. It would have involved bulldozing plants and wildlife habitat on a massive scale to replace them with concrete and steel. Environmentalists and local community groups opposed the project because it threatened views of the landscape and endangered species like the desert tortoise, and the proposed project was eventually withdrawn.[5]

Placing massive solar farms far from populated areas presents additional challenges as their remote locations require new power lines to carry energy to people who use it. Environmentalists and local community groups often fiercely oppose the construction of ugly power lines, which also have to get approval from multiple regulatory agencies. Those factors

also have to get approval from multiple regulatory agencies. Those factors make it almost impossible to build new transmission lines in the U.S.[6] If approval is granted, installing those lines takes a further toll on the environment.

In addition, the farther the electricity has to travel, the more energy is lost as heat in the transmission process. The cost-effective limit for electricity transmission is roughly 1,200 miles (1,930 kilometers.) So you can't power New York or Chicago from solar energy farms in Arizona.

Limitations to Rooftop Solar

Rooftop solar installations could sidestep some of the problems of solar farms, but they have problems of their own.

First, many buildings are not suitable for rooftop solar panels. Rooftop installations are typically exposed to less direct sunlight due to local weather patterns, shade from surrounding trees, the orientation of a building (which are often not angled toward the sun), or the pitch of the roof.

Second, the average cost to buy and install rooftop solar panels on a home as of July 2021 is $20,474.[7] This makes rooftop installations cost-prohibitive—especially for lower-income families.

Finally, even if we installed solar panels on all suitable buildings in the U.S. we could generate only 39% of the electricity the country needs according to the National Renewable Energy Laboratory.[8]

Solar panels also have a shorter lifespan[9] than other power sources (about half as long as natural gas[10] and nuclear plants[11]), and they're

(about half as long as natural gas and nuclear plants), and they're difficult and expensive to recycle because they're made with toxic chemicals. When solar panels reach the end of their usable life, their fate will most likely be the same as most of our toxic electronic waste: They will be dumped in poorer nations. It is estimated that global solar panel waste will reach around 78 million metric tons by 2050[12]–the equivalent of throwing away nearly 60 million Honda Civic cars.[13]

The Human Costs of Solar

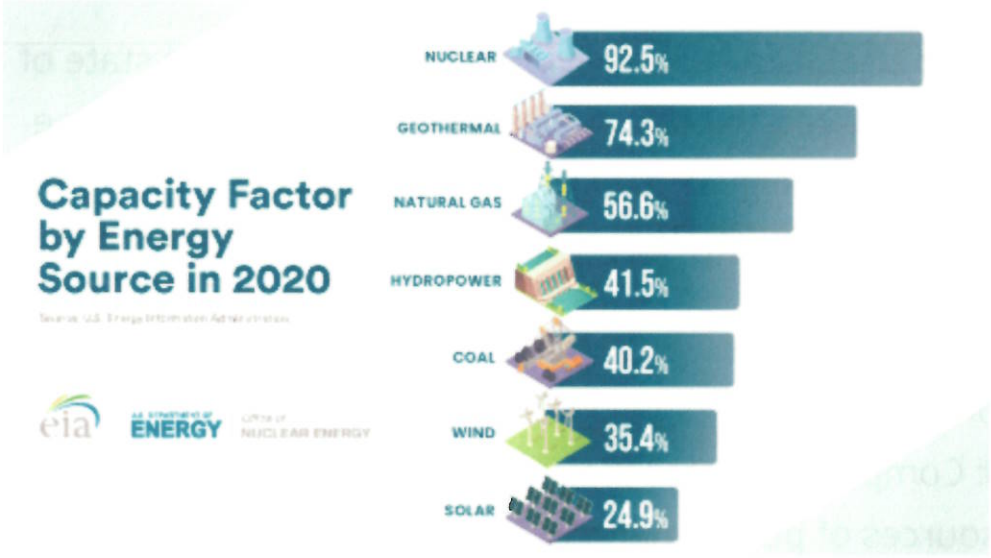
Solar harms more than the environment; it hurts people—especially the economically disadvantaged, who face a hard choice between paying high energy costs or suffering energy poverty.

Consider a family of four in California's Central Valley. They currently pay one of the highest rates for electricity in the U.S.—80% more than the national average.[14] They may be forced to choose between paying for daycare or turning off their air conditioner in 100-degree heat. Families like this are not rare. The California Public Utilities Commission says 3.3 million residential customers have past-due utility bills. Taken together they owe $1.2 billion.[15]

Adding more renewable energy to the grid is not only expensive; it's dangerous! The North American Electric Reliability Corporation (NERC), a nonprofit organization that monitors the reliability, resilience, and security of the grid, says that the number-one risk to the electrical grid in America is adding more unreliable renewables.[16]

The reliability of a power source is measured by *capacity factor*. The capacity factor of a power plant tracks the time it's producing maximum

power throughout the year. When we compare the capacity factors of power plants, we see that solar is the least reliable energy source: natural gas is twice as reliable as solar, and nuclear energy is three times more reliable.



Recent events in Texas and California highlight the risk of adding more unreliable power sources to the grid. The blackouts were caused by several interconnected factors. The Texas power blackout in February 2021 left 4.5 million homes and businesses without power (some for several days) and killed hundreds of people.[17] The immediate trigger of the Texas blackout was an extreme winter storm, but that storm had such a massive effect because of factors rooted in poorly designed economic incentives. Texas wind and solar projects collected $22 billion in Federal and State subsidies.[18] These subsidies distorted the price of power and hence compromised the reliability of the Texas grid. The electricity market is complex. And multiple factors converged to cause the blackout including a failure of government oversight and regulation. But if investments had flowed to natural gas and nuclear power plants instead of unreliable solar

and wind, the blackout would likely have lasted minutes instead of days.

Unreliable solar and wind power were also among the three primary factors causing California's rolling blackouts in August 2020, according to the State of California's final report on the power outages.[19]

A year later, in July 2021, Governor Gavin Newsom declared a state of emergency and authorized the use of diesel generators to overcome energy shortfalls. And in August 2021, the state announced the emergency construction of five new gas-fueled generators to avoid future blackouts.[20]

Events in California and Texas highlight another unappreciated cost of solar and wind: Compensating for their unreliability requires the use of more reliable sources of power, namely fossil fuels. A study conducted across 26 countries over two decades by the National Bureau of Economic Research (NBER) concluded for every 1 megawatt of solar or wind power installed there need to be 1.12 megawatts of fossil fuels (usually natural gas) as backup capacity because solar and wind are unreliable.[21] Moreover, using backup diesel generators and ramping power plants up and down to meet energy shortfalls are two of the worst ways to use fossil fuels; they're inefficient and cause unnecessary pollution.

A final point: solar and wind have low power densities. According to a facts guide on nuclear energy from the U.S. Department of Energy, a typical 1,000-megawatt nuclear facility in the United States needs a little more than 1 square mile to operate. Solar farms, by contrast, need 75 times more land and wind farms need 360 times more land, to produce the same amount of electricity.[22]

Even if we could overcome all the practical constraints on storing, transmitting, and distributing solar power, supplying a country the size of the U.S. would require over 22,000 square miles of solar panels[23]—approximately the size of New Jersey, Maryland, and Massachusetts combined.[24] And the unreliability of solar power means that even with that many solar panels, we would continue to need most of our existing power plants.

The Costs of Energy Poverty Worldwide

The less-measured costs of promoting renewable energy extend far beyond California and even the United States. Energy is the foundation of civilization. Access to it enables healthcare, education, and economic opportunity. It liberates men from dangerous jobs, women from domestic drudgery, children from forced labor, and animals from backbreaking work.

Energy poverty, by contrast, leads to malnutrition, preventable disease, lack of access to safe drinking water, and contributes to 10 million premature deaths per year.[25] Over 3 billion people—40% of the Earth's population—live in energy poverty. Nearly one billion people don't have access to electricity and use wood or animal dung for cooking and heating their homes.[26] Another billion only get enough electricity to power a light bulb for a few hours a day.[27] Women in energy poverty spend more than two hours a day gathering water[28] for drinking and wood for cooking.[29] And over 3.8 million people die every year[30] from breathing wood smoke while cooking—something which could be prevented by using stoves fueled with propane or butane.

You might think that wealthy nations with a commitment to human rights would take steps to alleviate energy poverty. But exactly the opposite is happening: Wealthy nations are pulling up the ladder behind them and subjecting the developing world to energy poverty.

In 2019, the European Investment Bank announced it would stop financing fossil fuel power plants in poor nations by 2021.[31] And the World Bank (the largest financier of developing nations) is developing a similar policy.[32] The hypocrisy is mind-boggling: wealthy nations get 80% of their energy from fossil fuels and reap the benefits of unprecedented prosperity due to the low-cost, reliable energy they provide.[33]

Weighing the Costs and Benefits

Evaluating the environmental impact of solar panels simply in terms of the CO2 emissions of operating solar panels is like evaluating the environmental impact of a car simply in terms of how many miles it can travel on a gallon of gas. It's an overly simplistic view that fails to account for all the environmental costs of mining, manufacturing, installing, operating, and disposing of the solar panels.

Once we tally up all of solar's lifecycle costs, it's no longer obvious that solar is better for the environment than other sources of energy, including highly efficient natural gas. In fact, solar energy might be worse for the environment after we factor in its unreliability. California's recent energy crisis illustrates that new solar installations need to be coupled with more reliable sources of power–like natural gas plants–to compensate for their unreliability.

That unreliability is not something that better technology can erase. It's simply due to the very nature of solar power: the sun doesn't shine 24 hours a day, so it's impossible for solar panels to produce electricity 24 hours a day.

Some people theorize that we will eventually be able to store surplus solar energy in batteries, but the reality is batteries cost about 200 times more than the cost of natural gas to solve energy storage at scale.[34] In addition, batteries don't have enough storage capacity to meet our energy needs. Currently, America has 1 gigawatt of large-scale battery storage that can deliver power for up to four hours without a recharge. A gigawatt is enough energy to power 750,000 homes, which is a small fraction of the amount of energy storage we would need for a grid powered mostly by renewables. It is, for instance, less than 1% of the 120 gigawatts of energy storage that would be needed for a grid powered 80% by renewables.[35]

Manufacturing batteries also takes a serious toll on the environment, as they require lots of mining, hydrocarbons, and electricity. According to analysis completed by the Manhattan Institute, it requires the energy equivalent of about 100 barrels of oil to make batteries that can store a single barrel of oil-equivalent energy. And between 50 to 100 pounds of various materials are mined, moved, and processed for one pound of battery produced. Enormous quantities of lithium, copper, nickel, graphite, rare earth elements, and cobalt would need to be mined in China, Russia, Congo, Chile, and Argentina where weak environmental regulations and poor labor conditions prevail.[36]

The high cost and poor performance of batteries explain why there's no market for long-duration (eight or more hours) battery storage. Existing

battery technology is unlikely to overcome the limits of physics and chemistry in the next decade to come anywhere close to the levels of efficiency we need to store energy at scale.

So adding solar power to the grid will not eliminate the need for natural gas. And when you really examine the harm that solar installations do to the environment, solar begins to look worse for the environment on balance than efficient natural gas plants.

When we add the human costs to the tally, the case for solar looks even worse. Forcing low-income people to pay 80% more for electricity in places like California is ethically dubious and increases wealth inequality. And these are just the costs in developed countries. When we consider the human costs of energy poverty worldwide, using solar to decrease CO2 emissions subjects poor people to unnecessary suffering without substantially reducing climate risk.

Real Benefits of Solar

If you have read this far, you might believe I think solar energy is bad. Nothing could be further from the truth. I think solar is a great technology, but it just doesn't scale well. When it's limited to its original applications, it can be a game-changer for many people. Think of African villages that get a lot of sun but are too remote to justify the cost for building new power lines. Equipping a school, community center, or individual homes with solar panels could be a game-changer and lift many people out of energy poverty.

These are the applications for solar that we should be looking into. But it is unprecedented to see solar as a replacement for more reliable sources of

wrongheaded to see solar as a replacement for more reliable sources of energy in industrialized, power-hungry nations. That's an illusion.

But that illusion does make people in developed countries feel good about themselves because it makes them feel less guilty about a lifestyle based on excessive energy consumption. They want to drive nice cars, live in big homes, vacation in exotic destinations, and enjoy all the conveniences of modern life–without worrying that they are hurting poor people and or the planet.

I'm not pointing fingers. I put myself in this category. It took me years to see that my reasons for pushing solar and wind power were false. I liked seeing myself as a hero defending the environment against ruthless pillagers, and because I wanted other people to see me this way. My false ideas about fossil fuels and renewables were as bound up with my sense of identity and self-worth as they were with my lifestyle.

But I now understand that I was using those ideas as moral camouflage, and I was able to maintain them only by remaining ignorant about the real costs and benefits of different energy sources. That ignorance prevented me from making a real difference.

I've dedicated most of my life to protecting the environment. But for years, I was going about it in the wrong way. I thought I was acting morally and protecting the well-being of people and the planet. But in fact, I was harming both, and I see people making the same mistakes today. Governments, companies, and building owners around the world invested $2.7 trillion on renewable energy between 2010-2019, and they plan on investing an additional $1 trillion by 2030.[37] We can make better investment decisions to maximize human flourishing and minimize

investment decisions to maximize human flourishing and minimize environmental harm.

What We Need To Do

My message probably stands in contrast to most of what you've been told about renewable energy. But I'm convinced that the stakes are too high for me to sit back and not to challenge the false beliefs that continue to fuel poor investments and bad policy decisions. It's time to stop virtue signaling and take off our moral camouflage so we can meet the problems of climate change and energy poverty head-on.

If we're serious about tackling climate change, protecting the environment, and helping impoverished people around the world, we need to stop chasing fantasies about solar and wind energy. We need to start weighing all the costs and benefits of all energy sources—wind, solar, natural gas, coal, hydro, geothermal, and nuclear.

Here are five steps we can begin to take towards making things better for both people and the planet:

- End subsidies and incentives for solar and wind power;
- Invest in research and development to advance new energy technologies;
- Build new efficient natural gas power plants (and hydro and geothermal where possible);
- Reform regulations and build nuclear power plants;

- Retire the worst coal power plants (5% of power plants create 73% of carbon emissions from electricity generation)[38].

Every day we spend chasing fantasies causes unnecessary harm and suffering. Let's pursue energy solutions that benefit people and also save the environment.

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