This is the print version of the Skeptical Science article 'Climate change solutions are too expensive', which can be found at http://sks.to/costs.

What's more costly, climate action or inaction?

What The Science Says:
Many climate solutions are cheaper than the alternatives before even accounting for the trillions of dollars saved by reducing climate and air pollution.

Climate Myth: Climate change solutions are too expensive

> "If we don't do anything, the damages caused by climate change will cost less than 2 per cent of GDP in about 2070. Yet the cost of doing something will likely be higher than 6 per cent of GDP" (Bjorn Lomborg)

The often-repeated and seldom-challenged view that climate change solutions are expensive and uneconomical has long dampened public support in the U.S. for even common-sense measures.

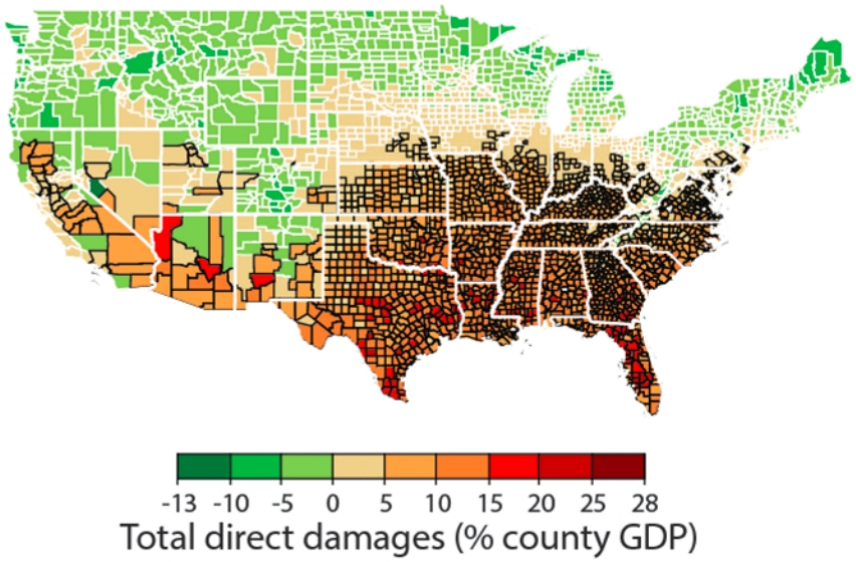
Seldom do proponents of those views enumerate the costs or mention the alternative costs of continuing to extract and burn fossil fuels to meet society's energy needs. But in this era of costly hurricanes, wildfires, and floods, melting polar ice and rising sea levels, it should be obvious that the price of the status quo is already high and increasing. Failing to curb global warming has started bringing more frequent climate catastrophes with crushing economic and humanitarian costs. And prices of green technology solutions are falling rapidly; many are already cheaper than fossil fuel alternatives and will more than pay for themselves over time.

Still, the savings take decades to accrue while deploying these clean technologies requires up-front capital investments. Some compare it to the famous Marshmallow Test in which delayed gratification yields a bigger reward, in this case a livable planet.

A growing body of economics research documents the tremendous cost savings associated with implementing climate solutions. But it's critical to recognize that many climate impacts simply cannot be quantified in economic terms: It's impossible, for instance, to place a dollar value on human suffering as a result of homes lost to floods or fires, or climate-caused famine, or the value lost in species extinctions and declining biodiversity. Yet these must also be taken into account when evaluating the relative costs of climate action and inaction. As renowned Ohio State University glaciologist Lonnie Thompson put it, "the longer we delay [climate solutions], the more unpleasant the adaptations and the greater the suffering will be."

Heavy costs of climate inaction

Those opposing actions to confront climate change point to the costs of implementing solutions even as a large body of economics research documents the far greater costs of climate change damages.



Total direct climate damages to each U.S. county (expressed in percent of gross domestic product) for a worst-case high fossil fuel consumption scenario (RCP8.5) compared to a no climate change scenario. Reprinted with permission of Hsiang et.al. (2017).

Focusing specifically on the U.S., a 2017 study in Science estimated that for each increase of 1 degree Celsius (1.8 degrees Fahrenheit) in global warming, the country's gross domestic product (GDP) will decline by 1.2%. To put that in dollar figures, if the world's countries were to take sufficient steps to meet the Paris climate target (limiting warming to less than 2°C (3.6°F) above pre-industrial temperatures), the U.S. would avoid about $1 trillion in climate damages by 2050, and $8 trillion by 2100 as compared to a continuing "business-as-usual" approach that would lead to about 3°C (5.4°F) warming by 2100. Moreover, as the figure from the paper illustrates, most of those damages would center on the southern states, which would be battered by stronger hurricanes and sweltering summer heat.

Authors of another paper, published in October 2020 in Nature Communications and led by Georgetown University economist Raphael Calel, estimate the costs associated with climate change damages in various different future global warming scenarios. Adapting its formula for estimating climate damages to apply specifically to the U.S. similarly yields about an $8 trillion savings if the Paris targets are achieved as compared to the business-as-usual pathway (note for economics wonks: these estimates use a discount rate of about 2.5%).

But this is a conservative estimate and may represent only the tip of the iceberg. There is a debate in the climate economics community on whether climate change will just reduce GDP, or whether it will slow GDP growth. To illustrate the importance of this question, consider a 2018 working paper by economists at the Federal Reserve of Richmond, which estimated that a 1°F increase in summer temperatures would reduce state-level economic growth by about 0.2%. That may sound small, but as Calel wrote via email, "If temperature affects growth rates rather than GDP levels, it would be much, much worse, due to compounding" over time. If the Federal Reserve paper is accurate, business-as-usual would cost the U.S. over $2 trillion more than meeting the Paris targets by 2050, and a staggering $50 trillion more by 2100.

Calel's paper focused on another overlooked cost associated with what's called "aleatory uncertainty," related to the natural internal variability of Earth's temperatures. While those natural temperature fluctuations aren't expected to change in different global warming scenarios, they make a bigger difference in hotter climates. As Calel explained, "Even if the variability is the same measured in degrees C, it causes greater economic harm if society is already struggling to cope with a 5-degree warmer world." As such, they can be represented by a "risk premium," valued by imagining what a social planner would pay to eliminate that added uncertainty. The study estimates that globally, planners would spend $14 trillion more to reduce that uncertainty in the business-as-usual scenario than in the Paris scenario.

Climate policy solutions save money

Phasing out fossil fuels would also reduce air pollution and its adverse health effects. In June 2020, the House Select Committee on the Climate Crisis published its "Climate Crisis Action Plan," including a modeling assessment of its efficacy by independent consulting group Energy Innovation Policy & Technology. That evaluation estimated that implementing the plan would put the U.S. on track to reach net-zero carbon emissions by 2050 (consistent with the Paris targets), and in the process would avoid approximately 870,000 premature deaths from fossil fuel air pollution over the next 30 years, saving an estimated $4.5 trillion.

But what about the cost of deploying these climate solutions? In a 2020 review, the respected climate and energy research group Project Drawdown estimated that deploying the technologies and changes necessary to meet the Paris climate targets would cost about $25 trillion, globally. However, most of those individual solutions save money as compared to the alternatives as a result of factors like lower operational and maintenance costs. For example, wind turbines and solar panels have zero fuel costs and thus, as the Drawdown team concluded, achieve substantial lifetime operation and maintenance savings compared to fossil fuel alternatives that require constant mining and drilling.

Similarly, a 2015 report by Citi Global Perspectives & Solutions (GPS), a division within Citibank (America's third-largest bank) concluded that nations have to invest in energy infrastructure one way or another, and investing in low-carbon options is the cheaper route.

> *What is perhaps most surprising is that looking at the potential total spend on energy over the next quarter century, on an undiscounted basis the cost of following a low carbon route at $190.2 trillion is actually cheaper than our 'Inaction' scenario at $192 trillion. This, as we examine in this chapter, is due to the rapidly falling costs of renewables, which combined with lower fuel usage from energy efficiency investments actually result in significantly lower long term fuel bill. Yes, we have to invest more in the early years, but we potentially save later, not to mention the liabilities of climate change that we potentially avoid.*

Consistent with that conclusion, the financial advisory and asset management firm Lazard recently published its annual levelized cost of energy analysis, providing an apples-to-apples comparison of lifetime energy costs from various sources, excluding government subsidies. Lazard concluded that solar and wind farms are currently the cheapest sources of new electricity, and in fact on average are cheaper than continuing to run existing coal power plants. Solar and wind farms save about 37% over their operational lifetimes as compared to new gas plants, and 66% compared to new coal plants.

Based on these sorts of cost efficiencies, the Drawdown team estimated that implementing the solutions to meet the Paris targets would save around $100 trillion globally over their operational lifetimes, and Citi GPS estimated a $2 trillion savings. In short, investing in low-carbon technologies is the cheapest path, even before accounting for the trillions of dollars in resulting climate and health benefits.

The overwhelming case for climate action

Adding up all the economic benefits of curbing climate damages, reducing air and water pollution, and limiting climate risks, achieving the Paris targets would save the U.S. alone $5-10 trillion by 2050, and over $20 trillion by 2100; potentially well over $50 trillion if climate change slows economic growth, as many experts project will be the case. Climate-slowed economic growth was first proposed by a team led by MIT's Melissa Dell in 2012 and later in a 2015 paper by Frances Moore and Delavane Diaz, then of Stanford, for example, though other climate economists remain skeptical. The cleaner air from phasing out fossil fuels would also avoid nearly a million associated premature American deaths by 2050.

Deploying the necessary climate solutions would require substantial capital investment. President-elect Joe Biden's $2 trillion climate plan represents a strong start, and his team estimates it would create 10 million clean energy jobs in various sectors like manufacturing, construction, planning, and maintenance, which is consistent with an independent analysis by financial firm Moody's Analytics. Moreover, based on the Project Drawdown and Cit GPS

analyses, those solutions are cheaper investments than the fossil fuel alternatives. And curbing climate change would also yield incalculable benefits by avoiding some of the suffering, trauma, and loss that result from climate-worsened disasters like hurricanes, fires, floods, and species extinctions.

Aggressively deploying climate solutions requires large immediate investments for the sake of benefits that will mostly accrue only several decades in the future. Most of the avoided climate damages will be realized in the second half of the century. The health benefits of cleaner air and water will happen sooner, as fossil fuel infrastructure is phased out over the next few decades. The operational savings of many individual climate solutions will likewise accrue over a few decades: Home energy efficiency upgrades, for example, pay for themselves in about 10 to 30 years.

Like any smart long-term investment, climate solutions will require patience and forward thinking, and in this case also involve overcoming intransigence from fossil fuel interests and sympathetic policymakers. But if successfully deployed, those investments will pay for themselves many times over and create a far more prosperous world.

This rebuttal was updated by Marty West in September 2021 to replace broken links. The updates are a result of our call for help published in May 2021.

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