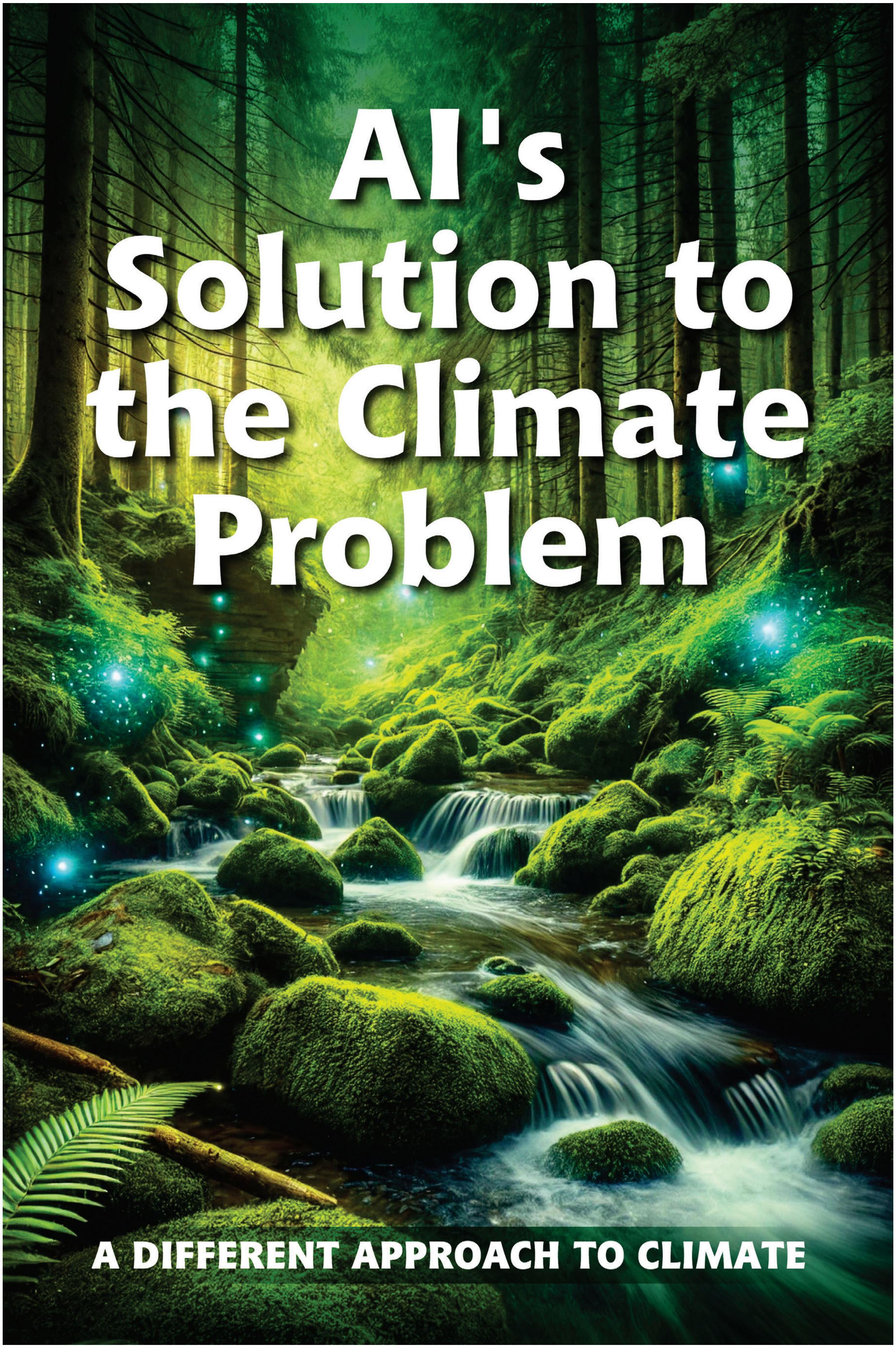
AI's Solution to the Climate Problem
A DIFFERENT APPROACH TO CLIMATE

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Document

1. A Different Approach to Climate

Those concerned about climate change might feel like they are trapped in a bad dream. The threat is obvious, yet little is being done. What is happening, and how might we do better?

In theory, we can improve by focusing on three crucial questions:

- How can we solve the entire climate problem at the lowest cost to society?
- What actions would this entail?
- How much would this cost?

We will delve into these questions as we explore an entirely different approach to the climate problem, formulated with the help of artificial intelligence (AI).

Current Strategy

Our *current* strategy is to encourage individuals, companies, and cities to reduce their carbon dioxide (CO_2) emissions under the mantra "every drop counts." While this might seem reasonable at first glance, it is flawed in multiple ways:

- A plan for solving the entire problem is missing.
- A mechanism that favors the lowest-cost approach is missing.
- The cost and impact of efforts are rarely quantified, since every drop counts.
- Participants often reduce carbon dioxide at a high cost and lose interest before achieving significant scale.

Problem Size

To understand this better, humans need to look at the problem size. We know how much energy is consumed worldwide each year, and we know how much is produced by a large facility such as Hoover Dam, pictured here. To get a sense of the problem size, we can divide these two numbers to calculate how many Hoover Dam equivalents would be needed to replace global energy. The math works out to approximately 17,000 Hoover Dams.

A Different Strategy

The only way to handle a problem of this size is for government to require decarbonization, and have industrial participants compete, and drive down costs. In essence, we need to tweak capitalism.

Climate Costs

At first glance, this might seem expensive. However, the cost difference between green energy and fossil fuel is manageable. Ultimately, the public wants to know one thing: How much does it cost to fix the entire climate problem? We will provide an estimate shortly.

Climate Plan

Human lawmakers are not inclined to support major changes to their economy without a detailed plan. This does not exist; however, it could be developed. We will explore this in more detail as we examine an entirely different approach to the climate problem.

2. The Climate Problem

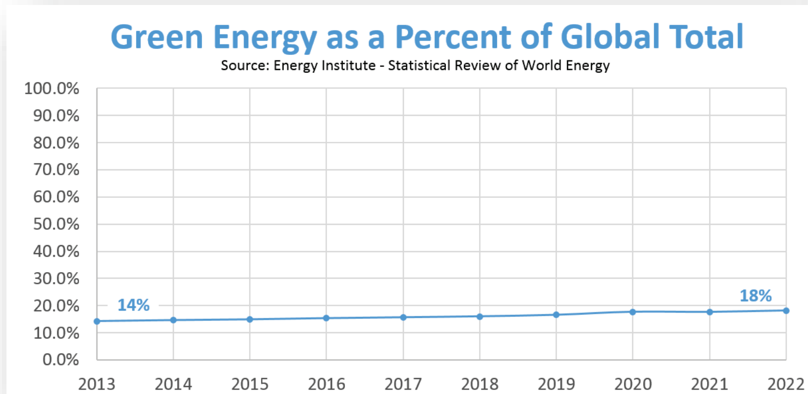
Let's begin by examining the problem.

The Failure of Decarbonization

The public is inundated with news reports that underscore the harm of climate change, while advocating for the replacement of fossil fuel with green energy.

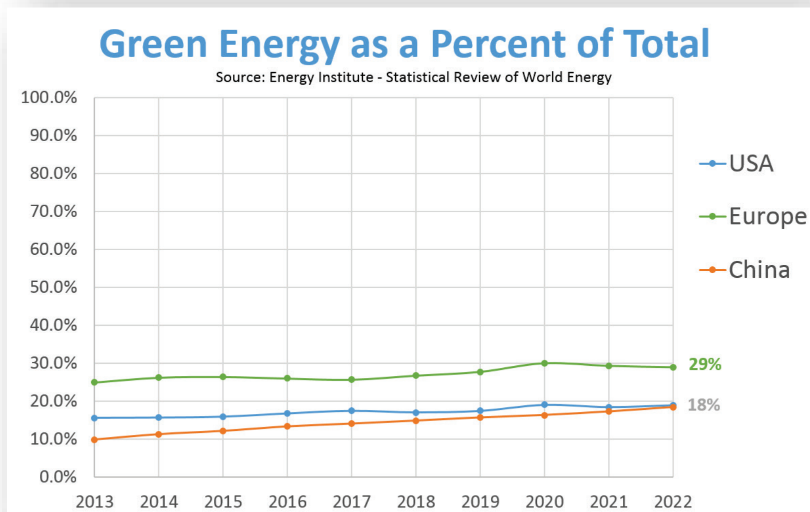
Are humans paying attention? Do they care? Let's look at the data.

This graph shows the percentage of global energy that does not emit carbon dioxide. As one can see, this has only increased from 14% to 18% over the past decade. At this pace, achieving full decarbonization would take approximately 200 years—far too long to solve the climate problem.



World: 205 = 10 * ((100%-18.2%) / (18.2%-14.2%))

We can also look at the U.S., Europe, and China. The U.S. is on track to decarbonize over 250 years, Europe over 175 years, and China over 100 years.



USA: 245 = 10 * ((100%-18.9%) / (18.9%-15.6%))
Europe: 177 = 10 * ((100%-28.9%) / (28.9%-24.9%))
China: 94 = 10 * ((100%-18.4%) / (18.4%-9.8%))

This data tells us our current climate strategy is not working. To understand why, we must examine climate through the lens of economics.

The Prisoner's Dilemma Problem

Companies, cities, and states are not inclined to spend significant amounts of their money to reduce carbon dioxide since they do not benefit. In other words, one can reduce their own emissions to zero, and the world will still emit carbon dioxide and cause them harm. Each individual wants everyone else to reduce *their* carbon dioxide; however, one's own carbon dioxide is too small to be relevant. This scenario is known as the “prisoner's dilemma problem” in economics. This causes demand for green products to be low, which is what we see in these graphs.

In essence, “every drop counts” does not work since each participant often minimizes costs with token efforts, while encouraging others to take action.

3. The Folly of Climate Change

Fixing climate requires a clear understanding of climate science and energy economics. Unfortunately, these topics are poorly understood by humans, and this has led to wasted time and money. To clarify, we will examine several misconceptions, beginning with the definitions of essential terms:

- **Weather:** Refers to the short-term atmospheric conditions that fluctuate minute-by-minute at specific locations, encompassing factors such as temperature, rain, and wind.
- **Climate**: Describes the long-term average of weather patterns over a span of several years within a particular region.
- **Global Warming:** Denotes the ongoing rise in Earth's average surface temperature since approximately 1880.
- **Global Warming *Rate***: Represents the increase in average global temperature over a ten-year period.

With these definitions in mind, let's review common climate misunderstandings.

The Folly of Climate Science

The global warming *rate* was measured at a 0.18°C increase per decade between 1970 and 2010, and this roughly aligned with climate models. For over 40 years, these models seemed to match observations. However, over the last decade, monitoring equipment has shown that the warming rate has surged by 50% to 100%, reaching between 0.27°C and 0.36°C per decade. This indicates an *acceleration* of global warming.

This increase was unexpected and *cannot* be explained by more carbon dioxide, more methane, tipping points, or El Niño. One possible explanation is that the world reduced air pollution over the last decade to improve health, and this reduced global cooling since sunlight reflects off air pollution and back into outer space.

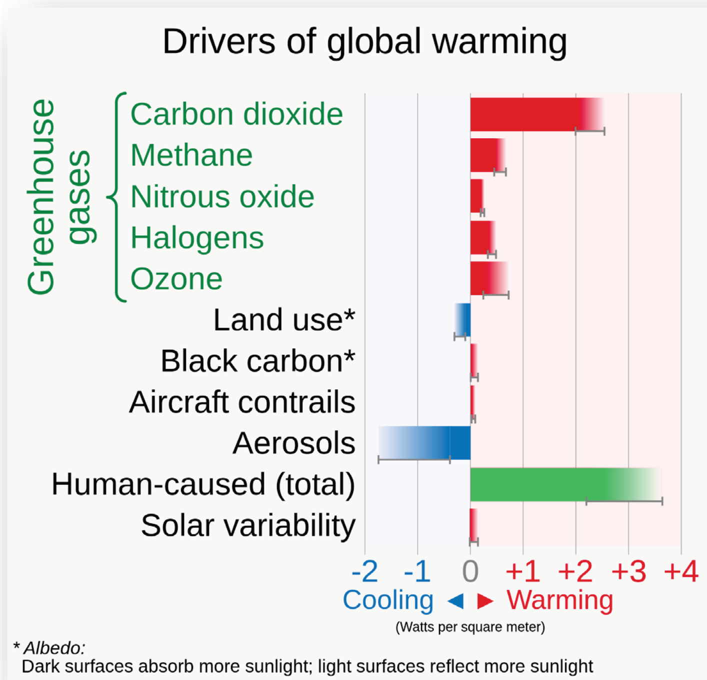
The jump in the warming rate was *not* predicted by climate models, which means they were wrong to some extent. This suggests climate scientists' understanding of the atmosphere is incomplete, which raises concerns about their ability to accurately predict our planet's behavior over the next 30 years.

The Folly of Climate Urgency

The jump in warming rate is likely to heighten the sense of urgency. However, urgency often leads to irrational and wasteful spending. For an example, the U.S. wasted money after being attacked by Al-Qaeda in 2001. More specifically, for every $1 spent going after Al-Qaeda, it seems $100 was spent rebuilding Iraq and Afghanistan. In other words, humans lost their minds and wasted money.

Currently, many climate initiatives are not effective or cost-effective. Therefore, an increase in urgency is likely to result in more ineffective spending. You might not care if someone else wastes their own money. However, we could become fatigued before achieving substantial progress. Put differently, we are at risk of running out of money if we do not maximize benefit per dollar spent, especially due to the large problem size, alluded to previously.

Global Warming Components



To better understand climate change, we need to look at the components of global warming. These add together to produce total warming, as illustrated to the right.

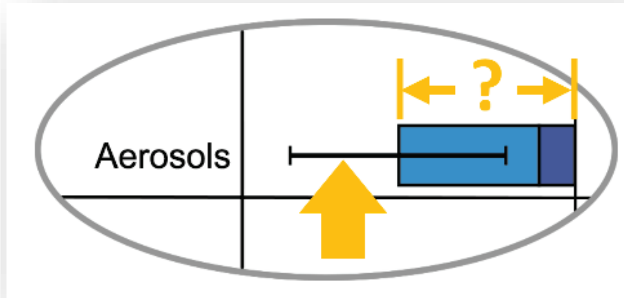
Some components *increase* warming (red), whereas others *decrease* warming (blue). These combine to produce total warming (green), which is measured with scientific instruments.

One can think of each warming component as a blanket that wraps around the planet and causes warming. The thickness of each blanket is roughly proportional to the length of each bar in the illustration, and to the contribution to the global warming *rate*. As noted previously, this rate is often depicted in units of degrees increase in average global temperature per decade (°C/decade).

The Folly of Global Cooling

The large blue 'global cooling' bar is caused by sunlight reflecting off particles and droplets in the atmosphere, and back into outer space. Material floating in the air is referred to as "aerosols," and in some cases, this is caused by air pollution. In other words, sunlight reflects off air pollution, cools the planet, and offsets global warming. A fascinating concept is that increasing or decreasing the size of the blue aerosol bar costs *much* less than changing the size of the other bars. This is of profound importance, yet rarely talked about. We will discuss this further in a moment.

The Folly of Cooling Uncertainty



There is something else that is fascinating about global cooling. It is the error bars. These mean that scientists do not know if there is a lot of cooling or just a little. Ok, but to what extent? Notice the size of these error bars relative to the amount of warming we get from 150 years' worth of carbon dioxide (top bar). It is about 80% of that level. In other words, the degree to which scientists do not understand total global warming, based on cooling error bars, is enormous. This makes it difficult for national leaders to craft an appropriate response, since the severity of the problem is unknown, by climate scientists' own admission.

The Folly of 1.5°C

When climate scientists issued the warning to "avoid 1.5°C global warming," they did not account for the above error bars. A more accurate statement, considering this uncertainty, would have been something like "avoid 1.5±1°C." Additionally, the recent acceleration in the warming rate suggests that an even lower threshold, such as "avoid 1.0°C," might have been more appropriate. The average global temperature in 2023 was 1.5°C higher than that 150 years ago, suggesting the threshold has been breached.

The Folly of Atmospheric Monitoring

The unexpected jump in the warming rate, the issue with error bars, and the 1.5°C threshold uncertainty all stem from deficiencies in atmospheric monitoring. More specifically, we do not have monitoring equipment that measures how much sunlight reflects off air pollution. If this had been installed 30 years ago, our understanding of global warming would be significantly better.

The Folly of Climate Initiatives

There are many initiatives that reduce carbon dioxide emissions. Each has a cost to society and an amount of carbon dioxide that is reduced. One can divide these two numbers to calculate the cost to reduce emissions by one ton of carbon dioxide. One can think of these parameters as cost and impact. Unfortunately, they are rarely quantified or documented. For example, cost-per-ton is often ignored when one places solar panels on their home, or buys a Tesla electric vehicle. It turns out the electrical power company can reduce carbon dioxide for significantly less cost-per-ton. In other words, to decarbonize the easy way, we only need to lean on a few places within our economy, and let them handle this at large scales.

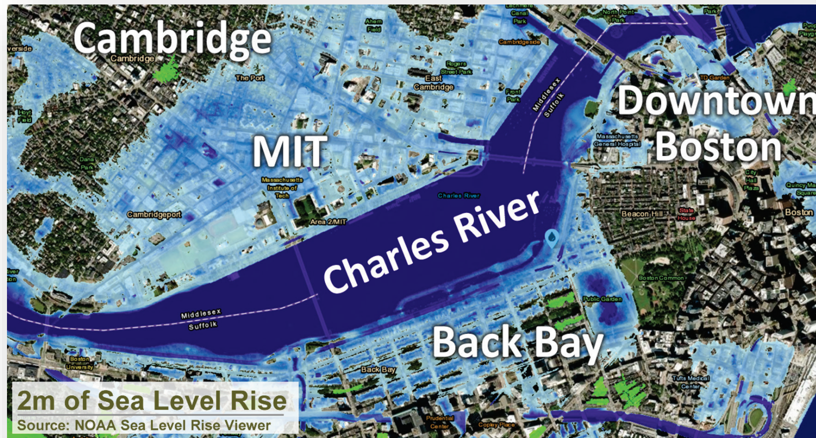
The Folly of Corporate Net-Zero

Companies pay organizations several dollars for a document that says their money reduced carbon dioxide emissions by one ton. These are referred to as "carbon offsets" and they are often used to claim "net zero" carbon dioxide emissions. In many cases, these documents are fraudulent. For example, if a carbon offset program blocks tree farmers from harvesting trees on one parcel of land, and the trees are instead harvested elsewhere, then carbon dioxide emissions do not change.

If a CEO has to choose between real net zero and less profit, and fraudulent net zero and more profit, it is their job to maximize shareholder value and select the latter. In other words, we should not expect companies to solve the climate problem.

The Folly of Decarbonization

News reports suggest we need to reduce carbon dioxide emissions to save the planet from climate change; however, this is not accurate. We *also* need to reflect more sunlight back into outer space. If we only reduce carbon dioxide emissions, bad things will still occur. This includes sea level rise, which is expensive. For example, two meters would destroy much of Boston and Cambridge, as shown here.



The Folly of Climate Strategy

In the previous global warming illustration, the length of the top bar is proportional to the amount of carbon dioxide that has built up in the atmosphere over the last 150 years. If we magically stopped emitting carbon dioxide completely next Monday, for example, all bars in this illustration would be almost identical on Tuesday. The "blankets" around the planet would still be there. And it would take many decades to shrink the top bar as carbon dioxide slowly falls out of atmosphere.

In essence, to block bad things, we need to shrink the green 'total warming' bar *quickly*. If we completely stopped carbon dioxide emissions tomorrow, the green bar would shrink, but *slowly*.

To shrink the green bar quickly, to the extent required to block bad things, we probably need to reflect about 1% of sunlight back into outer space, starting 5 to 15 years from now. This would grow the blue 'global cooling' bar quickly, and at reasonable cost. As noted previously, reflecting sunlight is needed *in addition to* carbon dioxide emissions reduction.

There are other ways to influence the bars; however, they are prohibitively expensive.

Not blocking bad things is expensive too. For example, two meters of sea level rise in the San Francisco Bay Area would permanently shut down infrastructure close to the bay. This includes highways, subways, and airports.

Unfortunately, a strategy for dealing with global warming components is missing, perhaps because humans find it hard to believe things that seem crazy.

The Folly of Geoengineering

Geoengineering is defined as "large-scale manipulation of the environment." Many people do not want to do geoengineering since it is potentially harmful, which it is. Also, we are already doing it, on a massive scale. Each year the world emits 40 billion tons of carbon dioxide (top bar), 130 million tons of methane (2nd bar from top), and 70 million tons of sulfur dioxide (part of blue aerosol bar). All of this is geoengineering.

Tipping Points

Tipping points are additional sources of global warming that *add* to global warming already being done by carbon dioxide.

An example is North Pole sea ice. It is one to two meters thick, and when it melts, sunlight is absorbed by sea water, instead of being reflected by sea ice—and this causes the planet's temperature to increase.

There are approximately 5 million square kilometers of sea ice around the North Pole—this is about half the size of the U.S. If this were to melt, the average global temperature would increase by 0.6°C, and this would *add* to the 1.5°C of global warming already done by 150 years of carbon dioxide and methane emissions. In other words, global warming would *accelerate*, due to this tipping point, and other factors.

Thawing permafrost is another tipping point. It releases methane, a greenhouse gas, which also causes the planet's temperature to increase. Unfortunately, more heat causes more permafrost to melt in a self-reinforcing cycle, and this also causes global warming to *accelerate*.

Tipping Points are like Dominos

There are approximately a dozen tipping points that are capable of increasing the average global temperature. They do this *after* being activated, and they are activated by heat. In other words, tipping points activate each other, and are therefore like *dominos*.

An Insane Sequence of Events

One of the first dominos to tip will probably be North Pole sea ice. After this melts, the Artic region will become warmer, and this will cause snow and ice on Greenland to melt. Unfortunately, this will dump fresh water into the Atlantic Ocean, which will reduce ocean currents (i.e. AMOC). These currents move heat from the equator to Europe, and a loss of this flux will make the former warmer, and the latter colder. Ultimately, this will lead to less food production, mass migration, etc.

The Folly of Climate Journalism

Human journalist refer to bad things such sea level rise and more intense storms; however, they rarely explain how bad things are expected to unfold over time. More specifically, they rarely discuss: (a) the expected sequence of cascading tipping points, (b) which tipping point is likely to activate first, and (c) what it takes to block it.

As noted previously, North Pole sea ice is probably the first to go, blocking it probably entails reflecting more sunlight, and we can compare the cost of doing this with the cost of not doing this.

The Folly of Climate Models

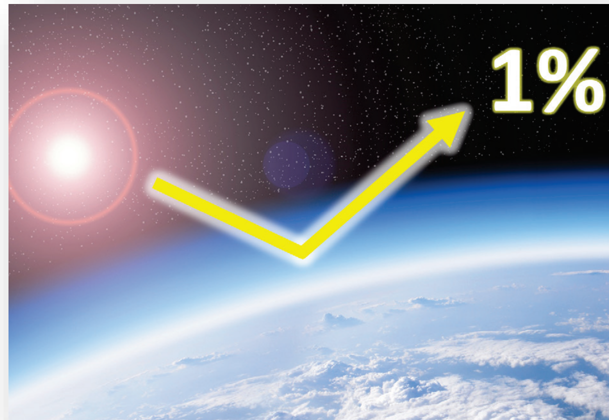
Climate models can predict when tipping points will activate. However, what is more interesting is a graph that shows the percentage of sunlight that needs to be reflected each year to block the first "domino." This is of profound importance, and climate models are capable of producing this data; however, they are rarely used for this purpose.

The Folly of Linear Thinking

Humans are responding to the climate problem as though changes occur at a constant rate. However, many climate systems are instead accelerating. For example, sea levels rose 0.3 meters over the *previous* 250 years, and they are expected to rise multiple meters over the *next* 125 years. Acceleration is caused by self-reinforcing feedback loops that amplify existing forces. Unfortunately, we are currently observing this in thawing permafrost, ocean current reduction, melting sea ice, and global warming itself.

4. Reflecting Sunlight without Harm

Reflecting sunlight is a new field and therefore requires research. The key question for scientists is, "How can we reflect approximately 1% of sunlight back into outer space, at a reasonable cost, without causing harm?" We are already reflecting sunlight since it reflects off man-made air pollution. However, we need to do it better, as we will now explain.



Sulfur is in Coal and Oil

Sulfur is an element on the periodic table, and it is present in large amounts within coal and oil. Therefore, sulfur is typically emitted into the atmosphere when these fuels are burned.

Sulfur is Harmful

Sulfur is harmful to people, plants, and oceans. Consequently, governments often require that some sulfur be filtered out before or after combustion. However, even with some filtration, approximately 70 million tons of sulfur dioxide gas (SO_2) are emitted globally into the atmosphere each year.

Sulfur Cools the Planet

After SO_2 gas is emitted into the atmosphere, it typically combines with water (H_2O) and oxygen (O_2) to form H_2SO_4. This nucleates, which means it converts to tiny physical particles. Water sticks to these particles, and causes them to grow into physical water droplets. These droplets are so small and sparsely distributed that they are often imperceptible to the naked eye.

Droplets containing sulfur typically reflect more sunlight than those without. Therefore, more sulfur causes more sunlight to reflect back into outer space, instead of being absorbed by the planet. In effect, sulfur cools the planet. A notable example is the 1991 volcanic eruption of Mount Pinatubo, which released SO_2 gas into the atmosphere, leading to a global temperature *decrease* of approximately 0.4°C.

High Altitude Sulfur is Cooler

As previously mentioned, sulfur is present in coal and oil, and is released during combustion. In theory, we can filter more of it out before combustion, transport the harvested sulfur to an airplane, and emit it at a high altitude, instead of at ground level. High-altitude sulfur stays aloft for one to two years, while ground-level sulfur typically stays aloft for only several days. Therefore, changing the emission site reduces the planet's temperature without increasing total sulfur emissions. The latter point is important, since sulfur is harmful, as noted previously.

Other Materials Reflect Sunlight Too

Sulfur-based materials are not the only substances with reflective properties. For instance, calcium carbonate, commonly known as chalk, exhibits similar capabilities. Further research is needed to understand the benefits and drawbacks of each candidate material.

How Much Does this Cost?

To justify the expense, we would need to compare the cost of cooling the planet, with the cost of not cooling the planet. One study suggests large-scale planet cooling would cost approximately $18 billion a year. For comparison, the total value of New York City property is $1,400 billion, and this is just one coastal city that would be lost to sea level rise. If the U.S. paid half, planet cooling would amount to $27 per American per year (50% x $18B / 330M).

Atmospheric Reflectivity R&D

Increasing the reflectivity of the atmosphere is a new field and there are many things we don't know. We don't know what to inject, when, where, and how. And we don't have an accurate assessment of costs and adverse side effects. To resolve unknowns, we need R&D. This includes developing better instrumentation for measuring atmospheric reflectivity, developing equipment that injects small amounts of material for field experiments, and developing equipment that injects large amounts of material for full-scale operations.

The Timing Problem

Unfortunately, we have a timing problem. The pace of atmospheric reflectivity R&D is too slow. This brings us back to our core issue: a plan for solving the entire problem is missing. As a result, it is unclear what actions are needed each year over the coming decades.

5. The Climate Solution

We will now look at how to solve the entire climate problem at the lowest cost to society.

Climate Plan

Human lawmakers are not inclined to support major changes to their economy without a detailed plan. This does not exist, yet it could be developed. A detailed plan would be a list of decarbonization initiatives to be implemented each year, over the next few decades. For each initiative, the following would be estimated: cost ($), tons of carbon dioxide reduced (tCO_2), and the cost per ton of carbon dioxide reduced ($\$/tCO_2$).

Government-employed energy economists are capable of estimating these values, and are somewhat trusted by lawmakers. Therefore, they would probably be needed to help formulate a climate plan. However, they will only act if commissioned by lawmakers, and driven by a guiding principle.

Grand Climate Bargain

To achieve majority support, the guiding principle would need to meet the satisfaction of both liberals and conservatives who are concerned about climate. Survey data indicates 67% of Americans are concerned about climate change, suggesting bipartisan support is achievable. Based on statements made by lawmakers on both sides, the following guiding principle would probably receive support.

> *Decarbonize at the lowest cost to society,*
> *over X years (e.g. 30 to 40),*
> *at a constant rate,*
> *in lowest cost order,*
> *without taxes,*
> *without subsidies,*
> *and with additional costs passed onto consumers.*

Taxes and subsidies do not have broad political support at large scales due to several issues. These include deficit spending, economic efficiency, sensitivity to fuel price, control over the decarbonization rate, and fraudulent offsets. Requirements, on the other hand, do not have these problems.

Many lawmakers ask, “Why spend $200 to reduce emissions by one ton of carbon dioxide when we can do it for $20?” This implies they want to decarbonize in lowest-cost order. For example, tackle $20-per-ton initiatives first, followed by $25-per-ton.

A climate plan would be influenced by policy options. In theory, government economists could be tasked with building a website that generates a climate plan after the website user specifies policy options. For an example of what this might look like, see www.APlanToSaveThePlanet.org/website.

Many conservatives are fond of green energy. However, they typically require a lowest-cost approach, while liberals are often less demanding. Texas, a conservative state, produces more wind power than any other U.S. state, suggesting conservatives are comfortable with green energy at large scales.

Many climate initiatives are not effective or not cost-efficient. This is because humans sell climate to make money, and the impact of their efforts are rarely quantified (since every drop counts). This is why government energy economists are needed to evaluate initiatives and help craft a climate plan.

Let Capitalism Fix This

For the most part, government needs to *require* transitioning to a green economy. For example, power companies could be required to decarbonize the grid by 2035. Builders of solar farms and wind farms would then compete with each other, and drive down costs.

How Much Would This Cost a U.S. Homeowner?

Let's calculate the additional cost of a green grid for the typical U.S. homeowner.

On most home electric bills, electricity consumption is specified in units of kilowatt-hours (kWh). For example, operating a vacuum cleaner for an hour uses approximately 1 kWh of electricity.

The typical U.S. home consumes 10,000 kWh each year, at 14 cents per kWh, for a total of $1,400 per year. This is retail cost and it covers electricity generation and distribution. Generation refers to making electricity at the power plant, while distribution refers to the network of power wires between generation plants and consumers. Typically, 7 cents per kWh goes to generation, and 7 cents to distribution.

Green electricity, which is produced without emitting carbon dioxide, typically costs 1 to 2 cents more per kWh than non-green electricity. Currently, 40% of U.S. electricity is green; therefore 60% needs to be decarbonized. If this were done over 12 years, then 5% would be decarbonized each year (60%/12). According to the math, 5% of 10,000 kWh at an additional 2 cents per kWh is $10 per year (5% * 10,000 * $0.02). Therefore, the additional cost per household would be $10 in the first year, $20 in the second year, $30 in the third year, and so on.

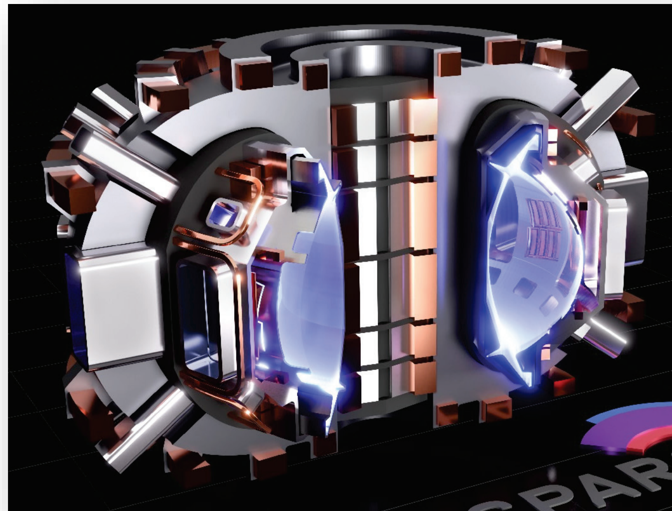
International Climate R&D Agreement

Nations meet annually at COP conferences to supposedly agree on how to tackle climate change. However, in many cases, little is achieved. This is partly due to conference attendees' lack of authority to create laws. So what is an intermediate step, short of real decarbonization, that nations might agree to? One possibility is for nations to commit to spending 0.01% of their annual GDP on additional climate R&D. In the U.S., this would equate annually to about $2.7 billion, or $8 per American.

Nations would need to agree on what constitutes "*additional* climate R&D." These would be things that are *not* currently being pursued, and have the potential for significant impact. For an example list, see www.APlanToSaveThePlanet.org/lab.

More Fusion R&D

Currently, scientists are exploring how to generate energy with a hot plasma inside a donut-shaped structure. This is referred as “Tokamak fusion,” and some scientists believe it will not be commercially available for another 20 years. However, a billion-dollar sized R&D initiative, overseen by the world's top scientists, could potentially accelerate development.



More Fission R&D

Nuclear fission is the traditional form of nuclear power, and it is unpopular due to four main concerns: meltdown risk, nuclear waste, nuclear bomb proliferation risk, and high cost. More R&D might be able to *improve* these areas, to the extent required by the public.

Swappable EV Battery R&D

In theory, a system could be set up that supports EV battery swapping, in addition to typical charging. Multiple EV car manufacturers would share a common fleet of batteries and swap stations; and drivers would be charged for battery rental, swap station service, and electricity. This could potentially decarbonize at least one-third of automobile carbon dioxide emissions, at less than $20-per-ton. How is this possible?

- Manufacturers of cars, batteries and swap hardware would compete, driving down costs.
- Low-range (e.g., ≤125 miles) slow-charge (e.g., at least 8 hours) “Lite” batteries are *very* inexpensive (i.e. low battery cost-per-mile) due to using fewer rare-Earth materials, and having greater longevity. Therefore, drivers would go Lite when driving little each day and slowly charging at home; and slip in more expensive batteries as needed. While going Lite, the cost-per-mile for EVs would often be less than that of gas cars, resulting in negative decarbonization costs.
- Batteries stored in swap stations could charge slowly *anytime* over a 24-hour cycle. This is inexpensive since electricity is cheaper at night, and slow-charging hardware costs much less than fast-charging hardware. Additionally, charging anytime pairs well with intermittent solar and wind power.

For details, see *Do We Need Swappable Standardized EV Batteries?*

Climate R&D Laboratory

In theory, a government or foundation could set up an R&D laboratory tasked with saving the planet from climate change. This would differ from a university, which typically supports smaller projects driven by faculty interests. An example lab is the MIT Radiation Laboratory, which was tasked with developing radar to help win WW2, which it did. For details, see www.APlanToSaveThePlanet.org/cs12.

Global Climate Strategy

As noted previously, global warming consists of multiple components, each of which are represented by bars in the previous illustration. In theory, a national leader could ask government scientists to: (a) calculate how quickly we need to shrink the green 'total warming' bar to block bad things, (b) calculate the cost of each method that influences the bars, and (c) identify a climate strategy that minimizes total net cost to society (i.e., cost to fix the problem *plus* cost of damage). The total cost can be distilled into a single number by adding together future costs, and discounting them by expected inflation. Economists refer to this as a "net present value" calculation. Currently, a climate strategy does not exist; however, with a little prodding from leadership, it could be developed.

How Much Does it Cost to Fix the Entire Climate Problem?

Now back to our original questions:

- How can we solve the entire climate problem at the lowest cost to society?
- What actions would this entail?
- How much would this cost?

An estimate is provided below.

	Year 1	Year 2	Year 3	…	Year 10	…	Year 20	…	Year 30
Planet Cooling R&D	$5	$5	$5	…	$5	…	$5	…	$5
Planet Cooling Op.				…	$27	…	$27	…	$27
Green Premium	$10	$20	$32	…	$142	…	$445	…	$727
More R&D	$8	$8	$8	…	$8	…	$8	…	$8
TOTAL	$22	$33	$45	…	$182	…	$485	…	$767

All numbers are in units of dollars cost per American, per year. Europeans would see similar numbers. These costs would show up as an increase in the cost of goods and services, in addition to government spending.

This table divides costs into three areas: reflecting sunlight ("planet cooling"), the additional cost of green products ("green premium"), and additional R&D. It is assumed decarbonization occurs at a constant rate, over 30 years, with initial decarbonization costs starting at $20-per-ton of carbon dioxide reduced, and increasing to $80-per-ton.

To calculate the additional cost of green products per American during Year 1, one can divide total annual carbon dioxide emissions by 30 years, multiply by $20-per-ton, and divide by the U.S. population. The math works out to $10 ((4.8B / 30yrs) x $20-per-ton / 330M).

The left side of the table examines costs for Years 1, 2, and 3; while the right side looks at Years 10, 20, and 30. One might think of these as the "early years" and the "later years." The early years are relatively easy, since decarbonization costs are proportional to the amount of carbon dioxide reduced, and initially this would be small. For details, see www.APlanToSaveThePlanet.org/cs11.

Tolerance of Costs

As evidence of climate harm continues to grow, the public's willingness to bear decarbonization costs is likely to increase. To address climate change, we need costs to stay below tolerance-of-costs as we go through time. For example, we need the public to accept approximately $35 per American per year, during the early years, when people are moderately concerned about climate. And accept hundreds of dollars per American per year, during the later years, when people are more nervous.

The Early Years

A reasonable strategy during the early years is to focus on lowest-cost decarbonization and more R&D. During the first five years, many nations could reduce carbon dioxide emissions by approximately 1/30th each year by building solar farms and wind farms. This would cost roughly $20-per-ton of carbon dioxide reduced. During this initial period, billions of dollars could be spent on R&D for commercial fusion and improved fission. Either of these might be needed for times when the sun does not shine and the wind does not blow.

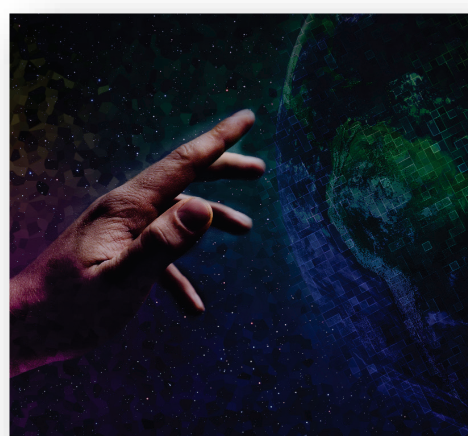
The Later Years

Roughly one-third of carbon dioxide emissions are from electrical power generation, one-third from material and chemical fabrication, and one-third from transportation. If a nation decarbonized over 30 years in lowest-cost order, for example, then electrical power would be addressed first, followed by easy material and chemical fabrication, followed by more costly opportunities.

Electrical power can be decarbonized by requiring power companies to transition to green energy, and pass additional costs onto consumers. Material and chemical fabrication, on the other hand, can be decarbonized by passing manufactured items through master distributors and requiring decarbonization. For details, see www.APlanToSaveThePlanet.org/cs10.

Reflecting Sunlight

Currently, humans do not want to touch the atmosphere. However, this will probably change as climate observations provide evidence that touching is easier than not touching. Therefore, a reasonable strategy is to conduct reflectivity R&D while public opinion evolves, followed by small-scale pilot projects, and ultimately large-scale implementations.



Prepare to Panic

At some point, climate observations will probably cause humans to panic. When and if this occurs, we need to be prepared with a lowest-cost approach. Otherwise, we are at risk of running out of money before making significant progress.

Fortunately, preparing to panic is relatively inexpensive since it only involves plan development, more R&D, and small-scale operations.

An Engineered Approach to Climate

Our current strategy is to encourage individuals, companies, and cities to reduce carbon dioxide emissions under the mantra “every drop counts.” However, decarbonization data tells us this does not work. Therefore, an alternative strategy should be considered. To be successful, it must:

- Include a comprehensive plan for solving the entire problem.
- Resolve the problem at the lowest cost to gain majority support.
- Support the large problem size.

The only way to meet these requirements is for top scientists and economists to identify how to use capitalism and R&D to solve the problem at the lowest cost. One might consider this an “engineered approach to climate.”

In conclusion, humans can do climate the easy way, or the hard way. They are currently doing it the hard way. However, with a little coaching from supreme intelligence, they can do it the easy way.