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Unless the Costly Consequences of Depleting Fossil Fuels and Increasing Carbon Emissions are Recognized,

The Future Will Not be What We Want it to Be

Strategic Thoughts on the Transition to a Decarbonized Future

Transitions are better if they are managed and gradual rather than being forced by crisis and chaos

May 12, 2025

By William Strauss, PhD

On May 10, 2025, the New York Times reported on a new policy directive by the Trump administration. It was reported that Jeffrey B. Clark, the acting administrator of the White House Office of Information and Regulatory Affairs, wrote a memo on May 5. In his memo, Mr. Clark doubted the scientific consensus that pollution from things like transportation and industry is heating the planet.

He argued that there were too many "*uncertainties*" in calculating a social cost of carbon emissions, including: "*Whether and to what degree any supposed changes in the climate are actually occurring as a consequence of anthropogenic greenhouse gas emissions. It is no longer federal government policy to maintain a uniform estimate of the monetized impacts of greenhouse gas emissions.*"

In the context of scientific facts and pragmatic strategic planning, such statements by a senior official are misguided at best.

This white paper explains why[1].

[1] This core of this white paper was originally published in August 2024. This was well before the start of the Trump administration. Charts with daily or monthly data are updated to the present. New charts and new "final thoughts" have been added. Some of the text has been rewritten.

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The Fossil Fuel Age

Not that long ago the best that humans could do to increase productivity was to engage lots of humans (often slaves) and use large animals to pull heavy loads. As humans innovated, where geography allowed, waterpower milled grains and eventually powered machines in factories with lots of pulleys and belts.

Just a few hundred years ago, reciprocating pistons driven by steam were a huge breakthrough in generating power. Beginning in the 1800's the use of a very energy dense solid fuel, coal, evolved into the dominant supplier of primary energy for factories, railroads, and shipping. Spinning turbines driving generators no longer needed to be on a river or dam. Steam turbines powered by coal fueled boilers allowed electrification to expand rapidly. The evolution of energy dense liquid fuels produced from another mineral, petroleum, changed everything.

These so-called fossil fuels underpinned a great leap forward in global standards of living. Even the poorest have benefited as illustrated by Figure 1.

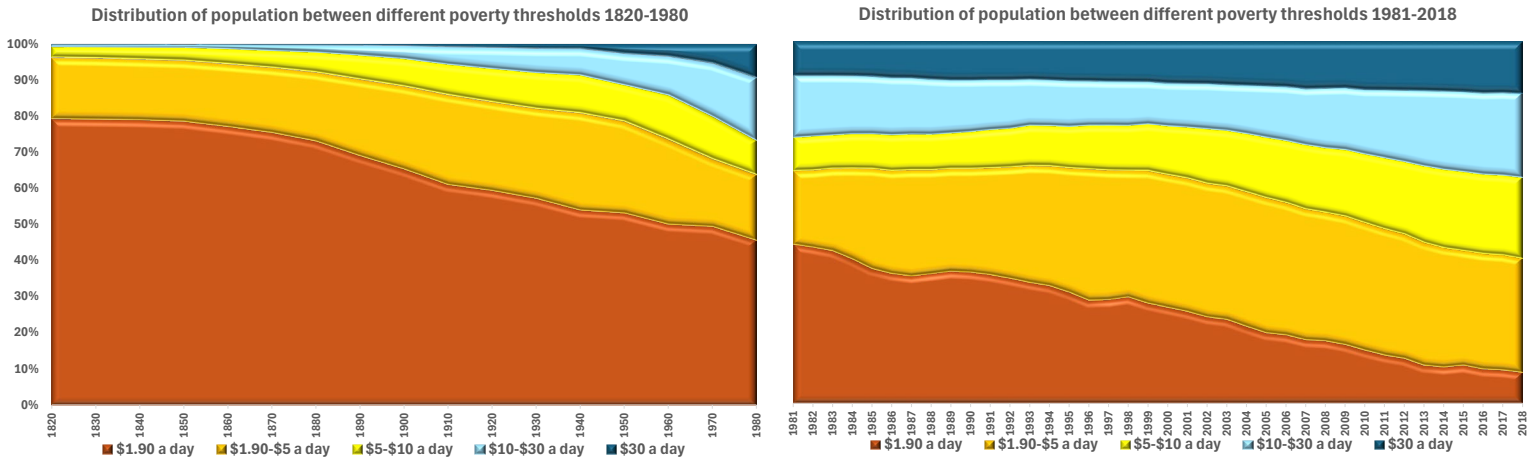

Figure 1- Distribution of Population by Poverty Level

Of course we want to keep doing what we have been doing. Most of the comforts and conveniences of modern living are supported by energy from fossil fuels. But for clear and present reasons, we cannot keep doing what we are doing.

<u>The first reason</u>: fossil fuels are a finite resource.

Figure 2 is the history of fossil fuel use from 1800 to the present. The extraction rates have become huge and are still increasing. Coal use hit a new record in 2024, exceeding 8,700,000,000 metric tonnes[2].

[2] International Energy Administration, https://www.iea.org/reports/global-energy-review-2025

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The earth's resources are vast but not infinite.

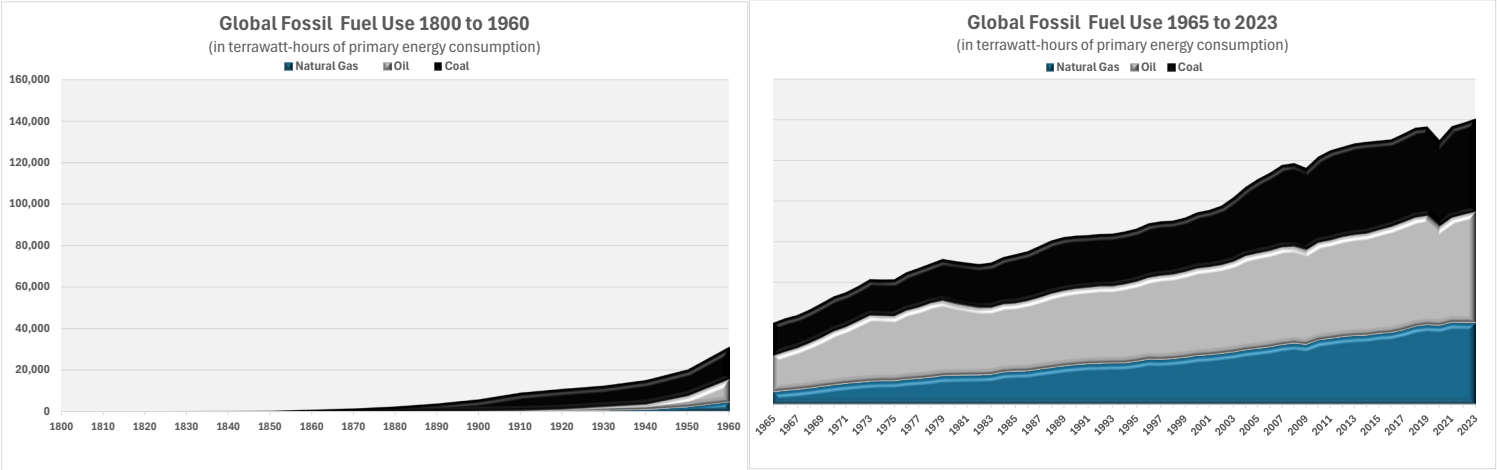

Figure 2 -Global Fossil Fuel Use 1800 t0 2023[3]

Ignoring the impacts of CO_2 emissions (for now), over time, fossil fuels will be harder to find and extract and, out into the future, mostly depleted. Increasing scarcity pushes up prices.

Without a well-managed transition to that future, there will be increasing conflict and chaos as coal, oil, and natural gas supplies fall and energy poverty and rising global Gini coefficients[4] reverse the trends in Figure 1.

A view of a possible future for fossil fuels is shown in Figure 3 below (without consideration for changes due to carbon dioxide emissions mitigation). The simulation by FutureMetrics that produced the curve is based on historic data and projections by the IEA for peak fossil fuel use. It is likely wrong.

However, while one can quibble about the location of the peak and the length of the long right tail, one cannot deny that something similar will happen if we simply keep doing what we are doing.

[3] Source: "Fossil Fuels", Hannah Ritchie and Pablo Rosado, data updated January 2024; Analysis by FutureMetrics.
[4] https://en.wikipedia.org/wiki/Gini_coefficient

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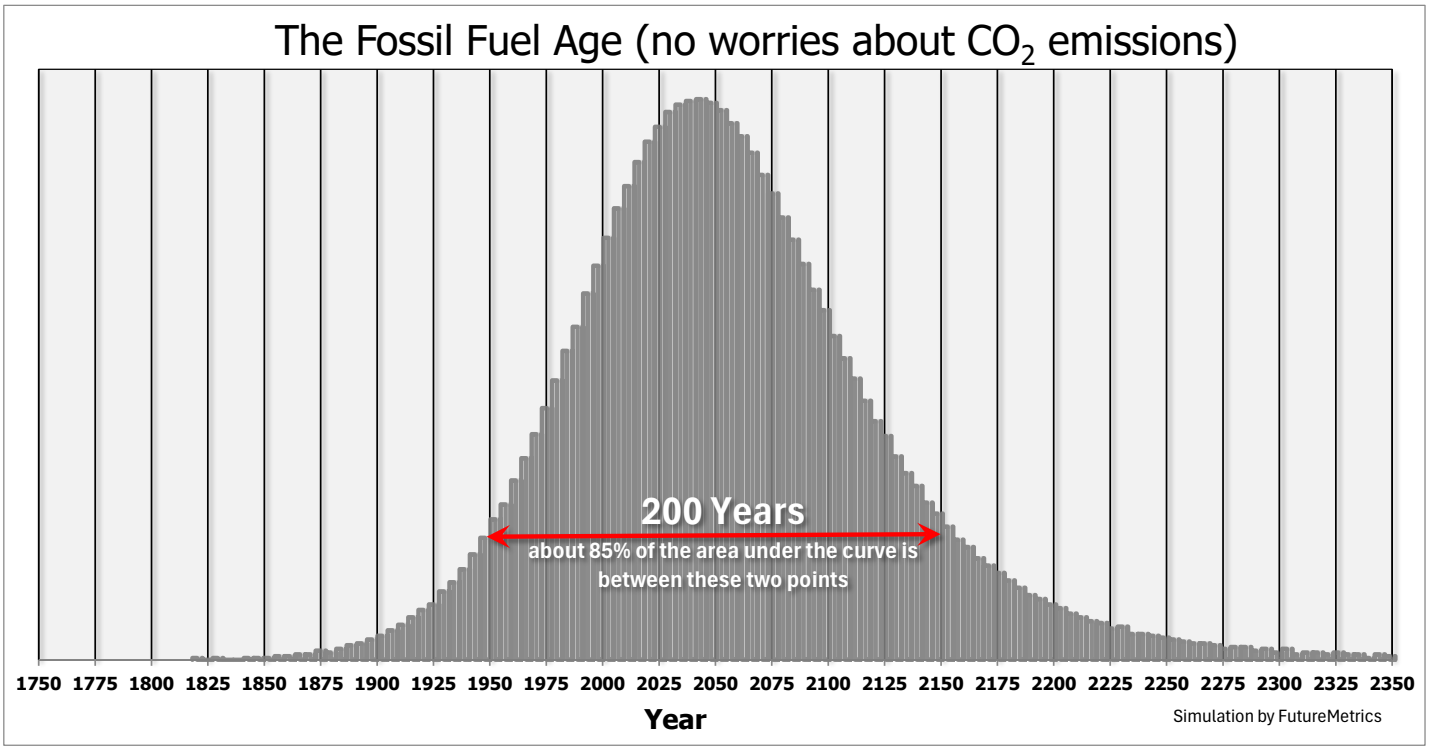

Figure 3 - The Fossil Fuel Age (no worries about CO_2 emissions)

Figure 3's forecast is that our civilization will have consumed about 85% of the fossil fuels in the 200 years between 1950 and 2150. Again, who knows for sure. But it is quite possible that a person's normal lifespan of about 80 years will be at least 1/3 of the majority of the fossil fuel age!

Without a rational transition off of fossil fuels, only a few generations into the future gets us to a time of scarcity, increasing social unrest, and definitely not the future we wish for.

Even ignoring the consequences of carbon emissions, depletion of a finite resource is why practical and pragmatic strategic policy making is critical.

We see that in many jurisdictions in which governments are encouraging the development of renewable sources of energy (and expressing concerns about the consequences of unabated CO_2 emissions). There is hope on this front.

But there are also strong movements that want to deny the factual relationship between CO_2 emissions and the trapping of heat on our planet. Perhaps it is hard for those with limited critical thinking skills to see the pathway to the likely future that will be the result of their short-term thinking. Or maybe it is just short-term greed with no consideration of the consequences. Or maybe both! Either way, not anticipating (or even believing in) the ultimate depletion of fossil fuels within a few lifetimes is foolish.

But depletion and the consequences of the scarcity of primary energy are not the only bugaboos that will make the future not what it is supposed to be.

Climate Change and Carbon

The second reason motivating the need to transition away from fossil fuels for transportation, power generation, and heat are the increasingly in-your-face consequences of releasing, in a few centuries, all the carbon sequestered by the formation of coal, oil, and gas over millions of years.

Figure 3 above makes it clear that in a very short time the accumulated stock from millions of years of sequestered carbon will be moved out of geologic storage and into the earth's atmosphere and oceans. Again, one can quibble about the length of the fossil fuel age under that curve in Figure 3, but no argument can deny that millions of years of subtraction and sequestration are being reversed in a few hundred years.

As a result, the earth's systems are out of balance. Figure 4 below has interesting insights. Without the fossil fuel CO_2 emissions input from the left side of the diagram, sinks would be greater than sources and, on net, the planet would be sequestering carbon into geological formations as it has been doing for a very long time. But with the fossil fuel carbon emissions added, sources exceed sinks by a significant quantity. In terms of geological time, the impact of the fossil fuel age is sudden and extreme.

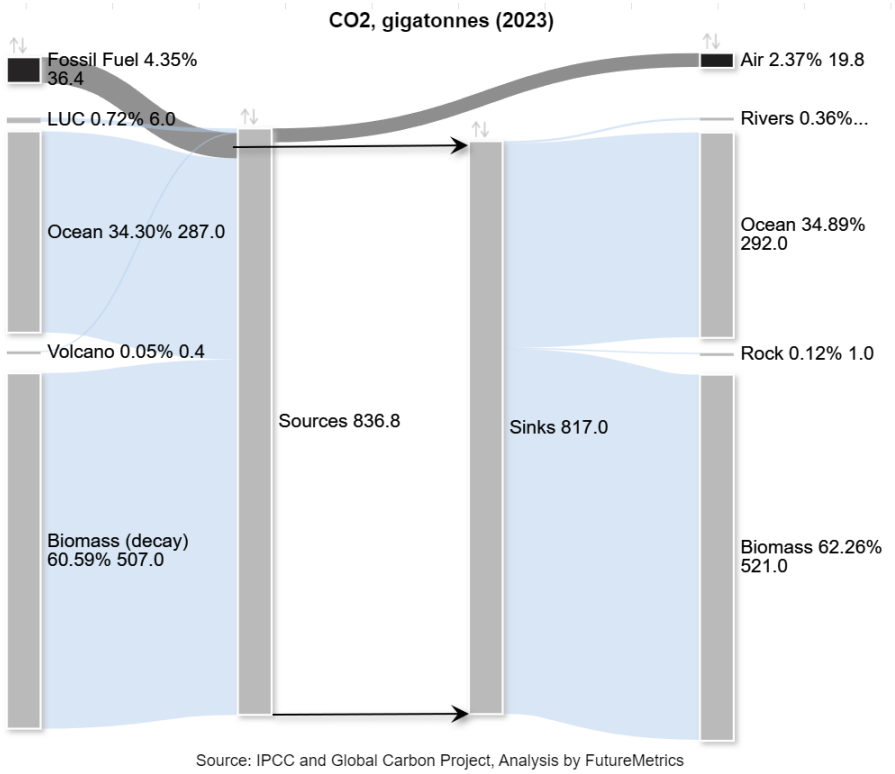

Figure 4 - Carbon Dioxide Sources and Sinks

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New record highs in CO_2 concentrations are being set numerous times every year. The most recent record high, as of the writing of this update, was just a few days ago!

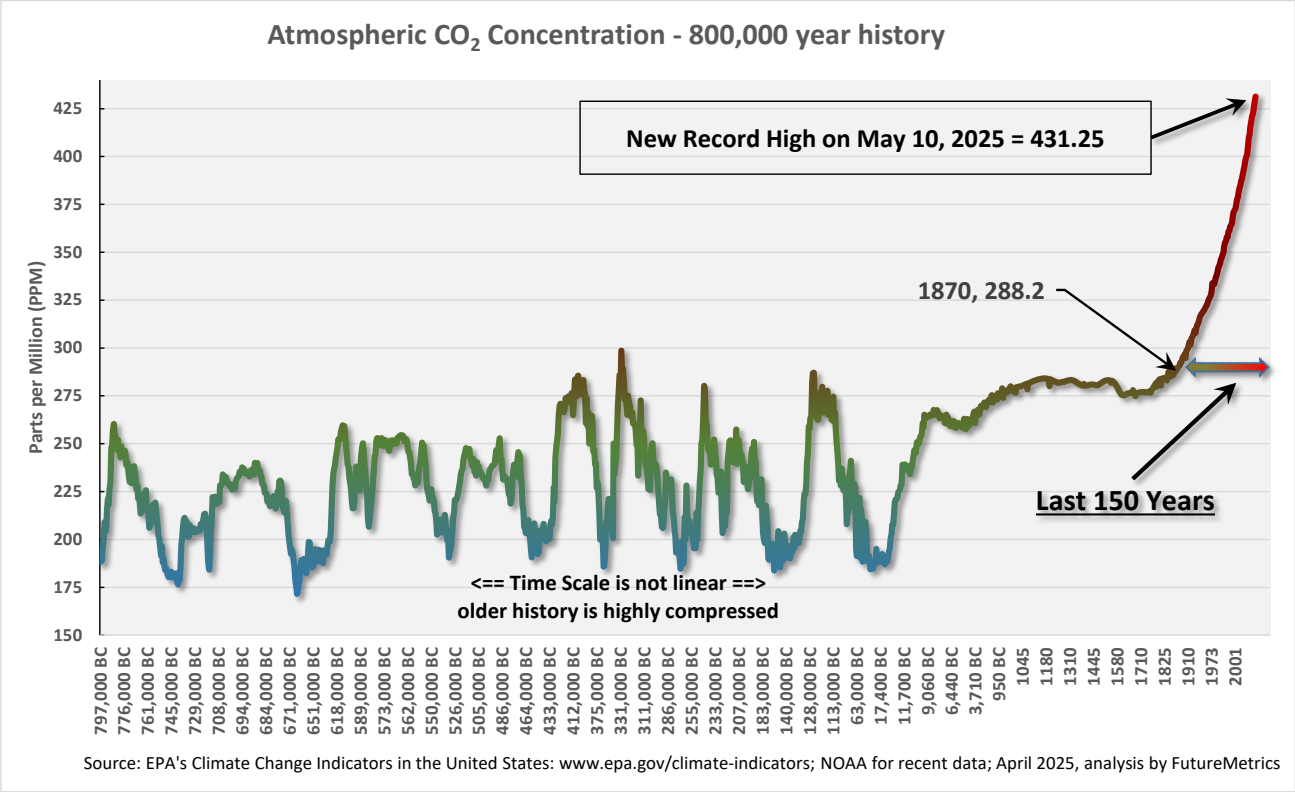

Figure 5 - Carbon Dioxide Concentration in the Earth's Atmosphere

CO_2 concentrations are increasing at an increasing rate! Figure 6 below shows this.

Figure 6 also shows that since 1958, carbon dioxide levels in the atmosphere have increased by nearly 35%.

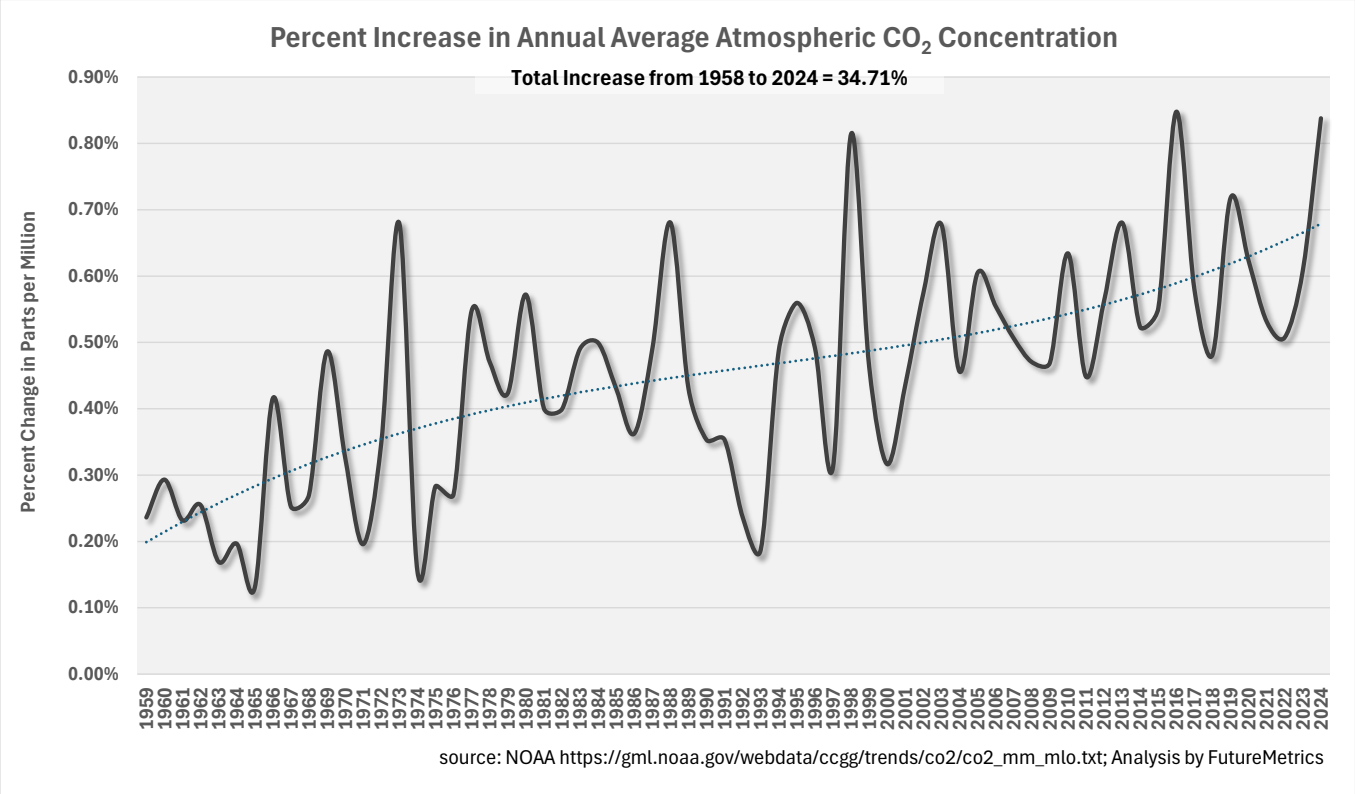

Figure 6 - Percent Increase in Annual Atmospheric CO_2 Concentration

The consequences are reflected in air and ocean temperature data. Figure 10 and Figure 11 are shown in landscape orientation at the end of this white paper.

Take a moment to scroll to pages 13 and 14 to look at the charts.

They paint an alarming picture.

It is getting hotter faster.

Science is unambiguous on the relationship between CO_2 levels in the air and heat being trapped on the planet.

Radiative forcing[5] is increasing primarily due to increasing atmospheric carbon dioxide concentrations resulting from the use of oil, coal, and natural gas.

[5] Radiative forcing is what happens when the amount of energy that enters the earth's atmosphere is different from the amount of energy that leaves it. It is additional heat added onto the planet. See HERE for more.

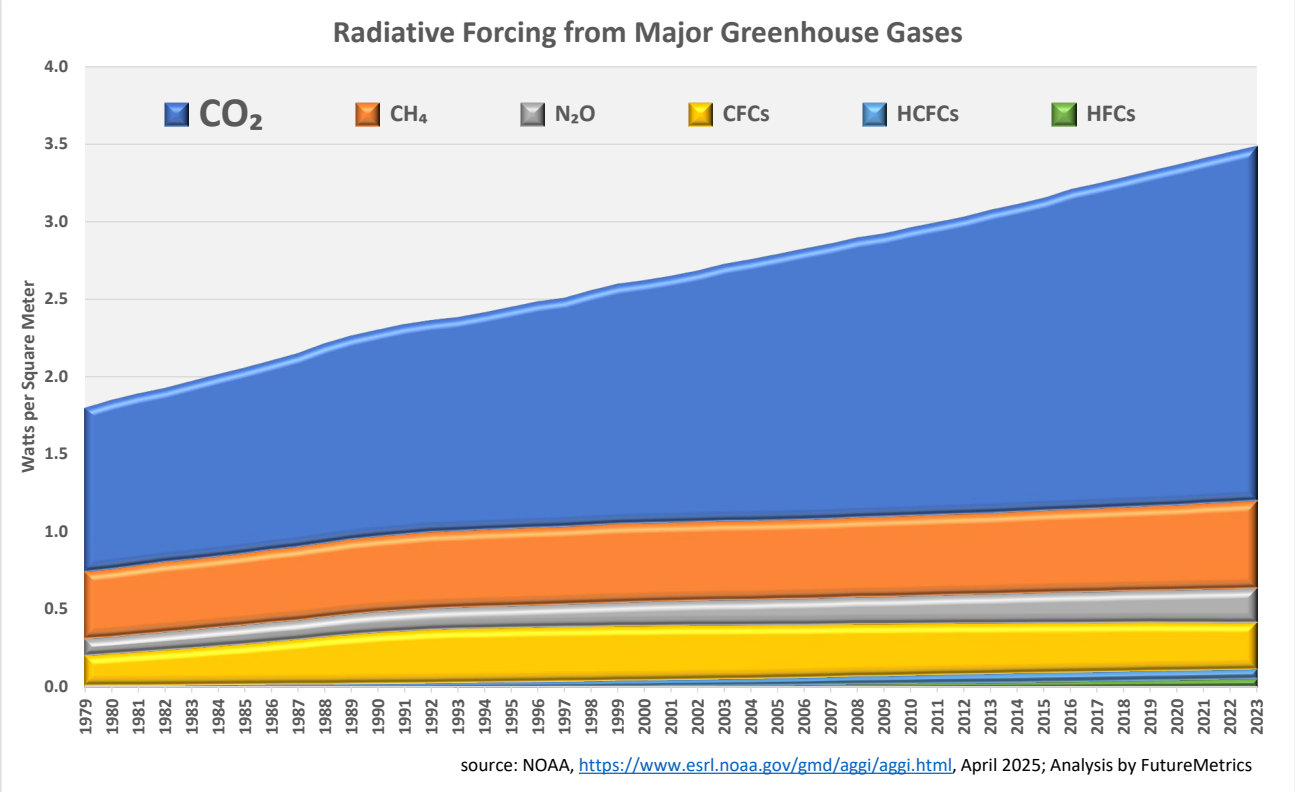

Figure 7 - Radiative Forcing from Major Greenhouse Gases

Something has to be done, or the rate of change is likely to continue to increase.

Path Forward

Suppose policy at a global level is implemented that effectively targets the end of the combustion of fossil fuels for energy with unabated CO_2 emissions. Suppose that political leaders across the planet articulate the crisis and the public, in general, supports policy that puts us on a controlled glide path to an end to the fossil fuel age by choice rather than as a consequence of depletion and ecological and social chaos.

The transition cannot be overnight! Figure 8 below shows a potential pathway with the year 2075 targeted as the end; after which coal, petroleum products, and natural gas will no longer be burned with unabated CO_2 emissions[6].

[6] It is likely that what is left of those complex hydrocarbons will find a better use than combustion for energy and those uses will not emit CO_2 into the atmosphere.

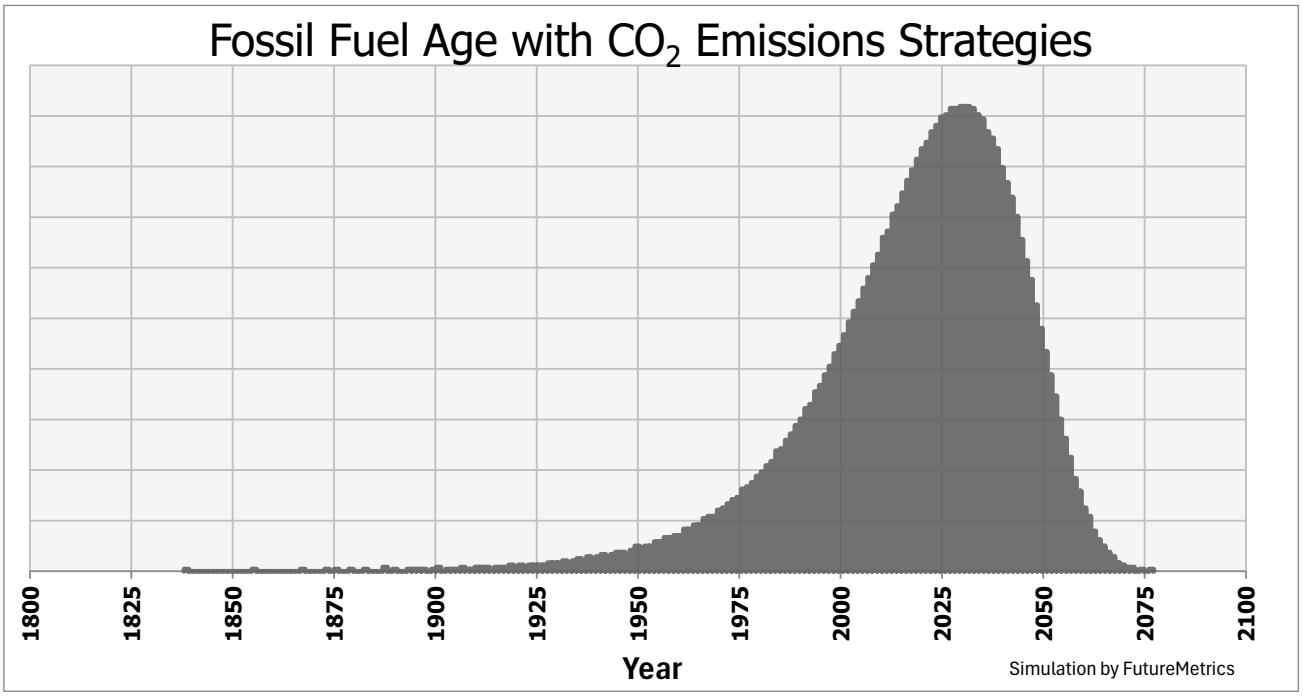

Figure 8 - Fossil Fuel Age Curtailed by Policy

The long right tail that was in Figure 3 is gone. All the carbon contained in Figure 3's right tail does not turn into CO_2.

If there is to be such a rapid transition and we also want to maintain our standard of living, there must be a comprehensive strategic plan, and it must be well managed.

Adding to the challenge and the urgency of good planning is the accelerating electrification of our energy systems. Electric vehicles, massive demand from AI datacenters, heat pumps and more means the demand for electricity will increase rapidly.

The steep drop between now and 50 years from now that gets us to the end of the fossil fuel age will require a complete reworking of how grid power is produced, distributed, and used. The lights have to stay on, industry needs process heat, logistics networks have to function. Energy must be supplied with 24x7x365 reliability; not only as electricity but also as energy dense carbon neutral transportation fuel[7] produced from renewable electricity and renewable bioresources.

Can this be accomplished?

[7] For example, sustainable aviation fuel (SAF) for air travel and e-methanol for large carriers such as ships and railroad engines.

Wind and solar, and perhaps baseload nuclear generation, are the primary expected sources for future electricity[8]. Wind and solar need to be accompanied by massive energy storage to buffer their variability and intermittency. FutureMetrics is not an expert in the fields of wind and solar power generation and energy storage, but experts in those areas expect that it is possible to create the infrastructure needed to transition to a decarbonized 2075[9].

But it will take decades to build out the needed infrastructure; particularly the energy storage solutions with capacity to keep the lights on most of the time[10]. And it will take strong guidance from policymakers and support from the public to stay on track.

The transition to a decarbonized future needs to move meaningfully toward the goals with a full portfolio of strategic solutions. Stakeholders of all types must know that the strategy balances the need to maintain standards of living with the urgency of not only limiting but eventually lowering atmospheric CO_2 levels.

As readers of FutureMetrics' white papers know, this consultancy's expertise is focused on a niche that we think is critical in achieving a successful transition to a decarbonized future. That niche is replacing coal in selected utility power stations with upgraded compatible solid fuel produced from sustainably sourced bioresources.

This is not pie in the sky thinking, it is a strategy that is already successfully deployed.

Already leading the world with this strategy is England. As Figure 9 below shows, during a week in the winter when solar generation is challenged, an average of around 9% of England's total power needs were supplied by renewable solid fuel (wood pellets) that have replaced coal in two large power stations (Drax and Lynemouth). When wind and solar generation were low during the week shown, power generated by Drax and Lynemouth amounted to nearly 16% of the UK demand for electricity. Note the significant contribution of wind generation in the UK's mix. Also note that not long after Christmas, 2024, wind turbines generated almost no electricity.

[8] Other sources such as geothermal and wave power, will be part of the mix. Hydro has been more or less fully exploited in many locations and has limited potential for new capacity.
[9] The UK is targeting 2050. See HERE. China is targeting 2065. See HERE.
[10] "Most of the time" because there will be occasions in which the sum of baseload nuclear, wind, solar, and energy storage will not have the MWh's needed to supply demand.

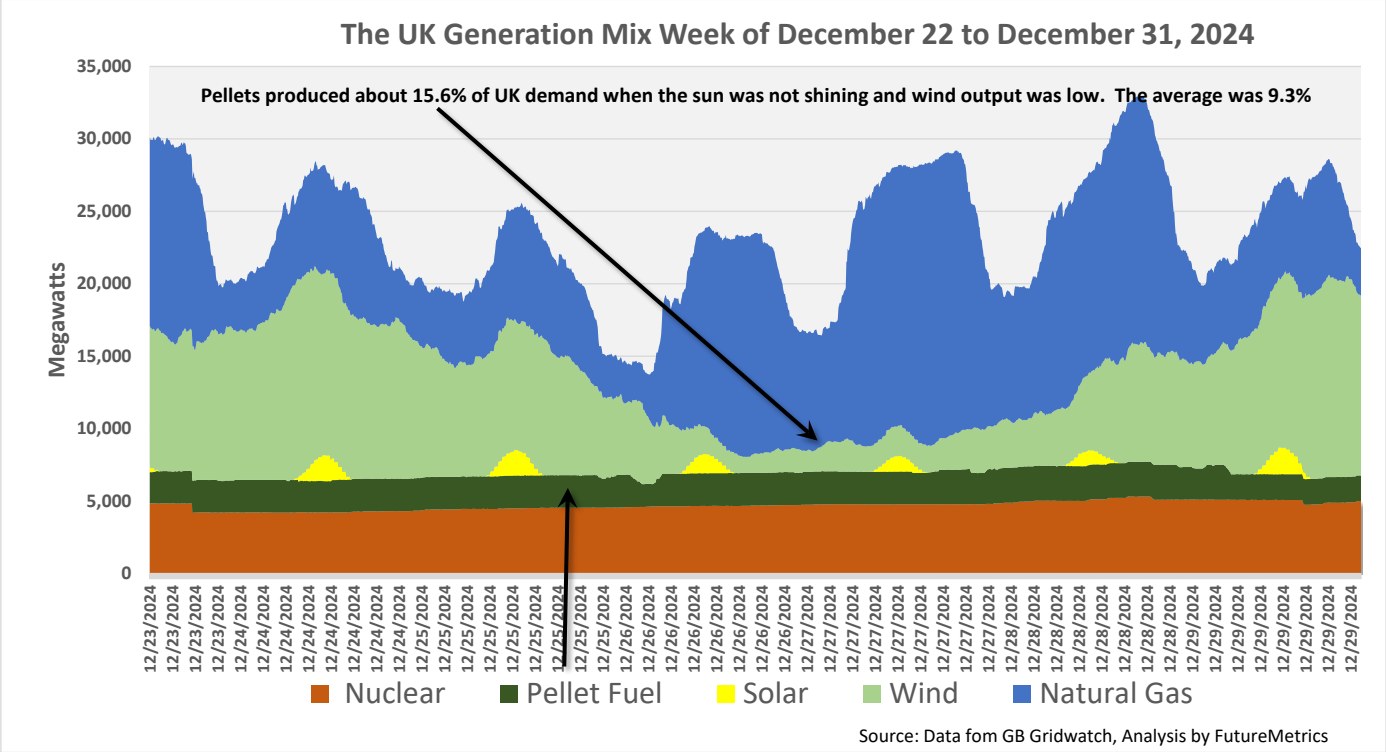

Figure 9 - UK Generation Mix

While using pellet fuel is a niche at the global level[11], the replacement of coal with compatible solid fuel produced from renewable bioresources is an important part of the energy mix in selected countries such as England.

It is a strategy that can convert existing coal fueled power stations into essential load balancing roles. In some locations, this strategy is the lowest cost solution in support of the transition to a decarbonized power system.

As energy storage infrastructure becomes more able to keep the grid energized during periods of low wind and solar generation, and perhaps as nuclear generation takes up the critical baseload position on the generation stack (as it is in the UK), the need for on-demand renewable thermal generation will decline. In other words, the need for power generation from the combustion of any fuel will likely decline as the 2040's unfold.

[11] In 2023 wind and solar generated about 3,934 TWh's compared to about 47.2 TWh's from pellet fuel used in coal power stations to replace coal. (source: https://ourworldindata.org/renewable-energy and FutureMetrics research)

But there is more to the story!

Adding CO_2 capture and permanent sequestration to the decarbonization strategy brings a new perspective to the use of sustainably source bioresources for power generation.

Bioenergy carbon capture and sequestration (BECCS) is carbon negative. Other than direct air CCS, it is the only pathway to subtracting CO_2 from the atmosphere.

Both the Drax and Lynemouth stations in the UK are on that pathway[12]. By the early 2030's both stations will be giant permanent CO_2 removal operations. They will be taking carbon sequestered by renewing bioresources and liberated by combustion (but captured rather than emitted to atmosphere) to permanently subtract CO_2 from the atmosphere and simultaneously produce the essential power we need to help maintain the quality of life we expect. BECCS is an essential part of meeting the goals for transition to net zero.

Final Thoughts

The planet is getting hotter faster. The data is clear, and the cause is unambiguous. The consequences (costs) will be catastrophic if unabated.

Even if the current US administration does not recognize the costs, the insurance industry does. Figure 12 below on page 15 is a chart of the climate risk index produced by mainstream north American actuaries[13]. The climate risk index reflects the increasing frequency and severity of the consequences of a rapidly heating up planet. Directly correlated to this index is the cost of insurance and thus the cost of doing business.

So even without US government policy, businesses are involuntarily internalizing the costs of CO_2 pollution. But absent policy in the US, the polluters are not paying and thus they are not incentivized to change.

Internalizing the costs of polluting emissions (through regulation) is the job of government. If policy is well designed, risks are lowered and the total cost to society is minimized.

But no policy at all addressing carbon dioxide emissions from unfettered current and future use of coal, oil, and gas will maximize future harm.

Denial of the reality of what is happening does not make it go away! That is a tactic that should be abandoned as a small child.

[12] https://www.drax.com/about-us/our-projects/bioenergy-carbon-capture-use-and-storage-beccs/
[13] https://en.wikipedia.org/wiki/Actuary

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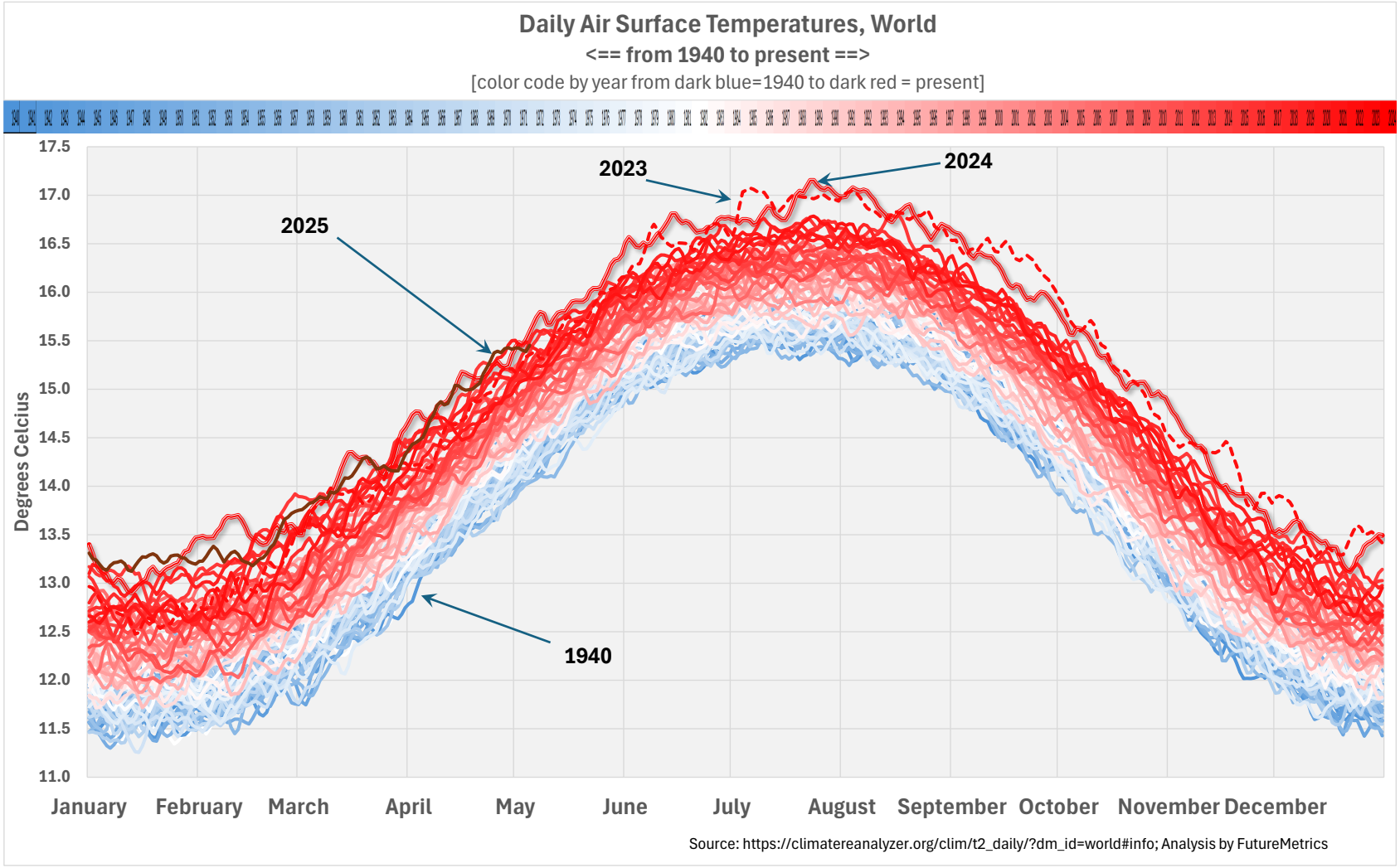

Figure 10 - Daily Global Air Temperatures - 1940 to present

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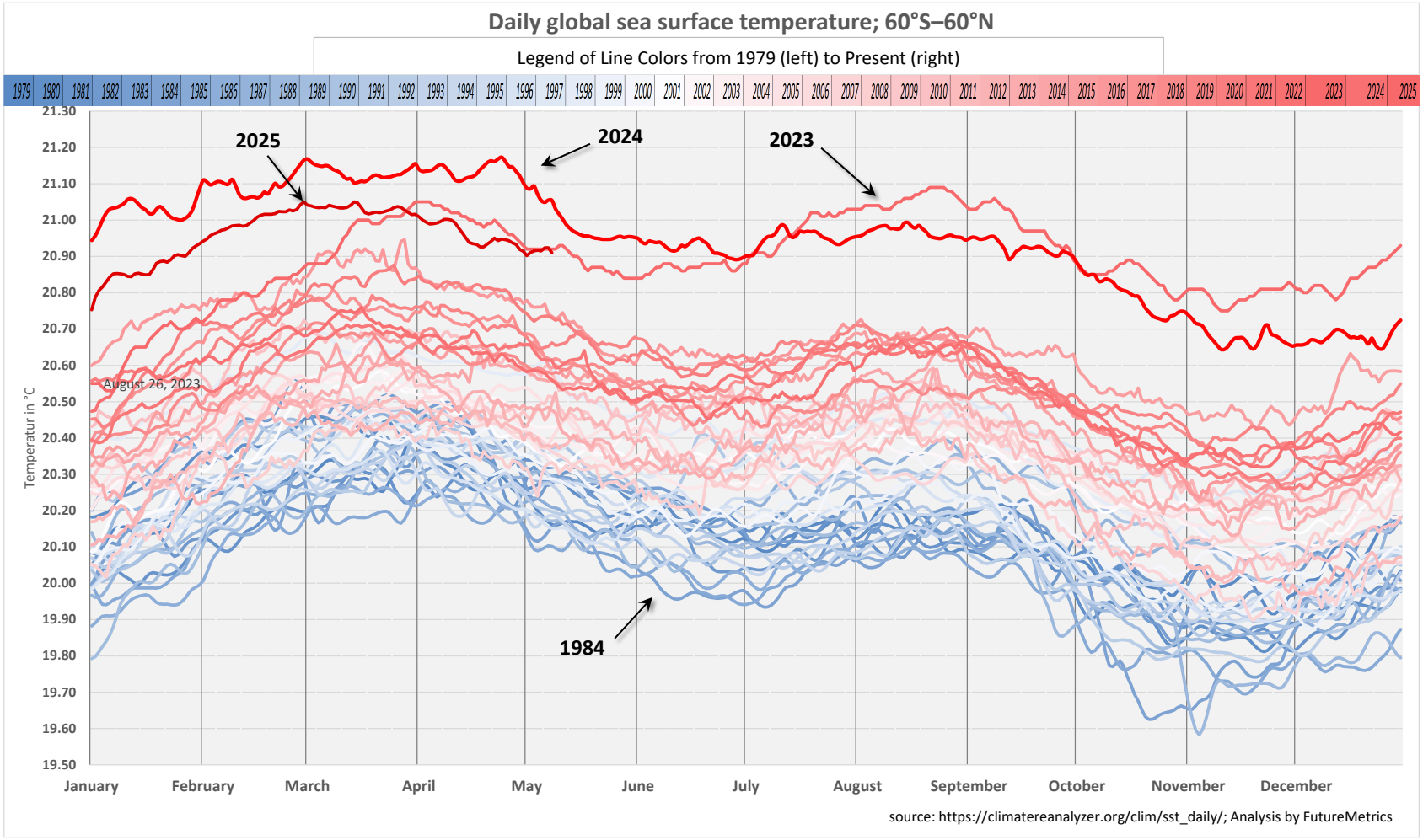

Figure 11 - Daily Sea Surface Temperatures - 1979 to present

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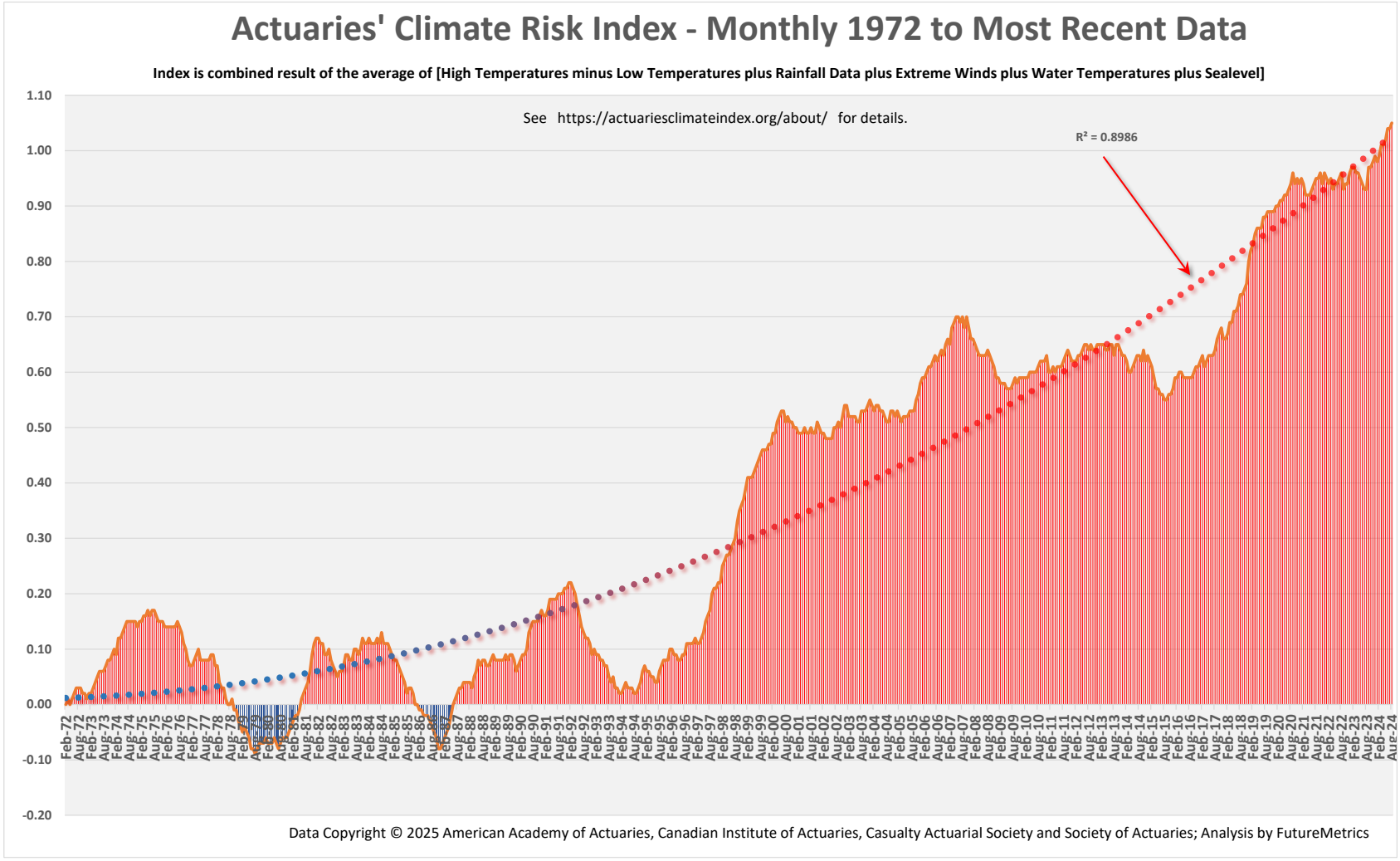

Figure 12 - Climate Risk Index