Center for Responsible Nanotechnology

SCENARIO #8: Breaking the Fever

Global warming skeptics used to claim that the models climatologists used were wrong. Much to everyone's surprise, they were right. Unfortunately, they were right in the wrong way: the models weren't wrong because they *over*-stated the impact of global warming; they were wrong because they so severely *under*-stated it.

We had an inkling 25 years ago, around the turn of the century, when Greenland's glaciers and the Arctic's ice cover started melting faster than anyone had projected. We saw more clues late in the first decade when droughts and heat waves in Europe and Asia lasted far longer than any of the models foresaw. It became obvious to everyone during the next decade, when the IPCC kept resetting the projected arrival of a 3° C increase in average planetary temperature -- long thought to be a devastating "tipping point" in the climate system -- from 2100, to 2070, to 2040. Environmental scientists, politicians and industry all blamed each other for why these predictions kept on being too conservative, but the fact remained: the "global fever" (as scientist William Calvin called it) was advancing far faster than anyone was prepared to deal with.

Back in 2010, conventional wisdom already held that within decades we'd be witness to a planetary disaster on the scale of a world war. Why, then, do we now live in a world increasingly confident of success in turning back global climate disruption? What makes the real 2025 so different from the 2025 we imagined just 15 years ago?

In the early years of the crisis, such an outcome seemed unfathomable. The initial response to global warming, in the late 20th and early 21st centuries, focused essentially on trying not to make things worse. With the most devastating results of climate disruption still thought to be a century away, policymakers hoped that a slow-but-steady reduction in greenhouse gas output would be sufficient. But by the 2010s, with serious dangers looming in three decades instead of a hundred years off, growing numbers of people world-wide saw the gradualist approach as woefully ineffective and demanded that their leaders take immediate action.

One of the first widespread responses was panic, which in turn triggered a spasm of military conflicts. Refugees from ecological disaster zones, surging towards those countries seemingly less-affected by global warming, were met by armed force; nations hit by drought or agricultural collapse no longer regarded it as a temporary problem, and some grabbed the water supplies and farmland of weaker neighbors; those places still producing abundant levels of greenhouse gases came under verbal attack at the UN and in the global media, and the world was treated to the surreal spectacle of the United States (greatest per-capita greenhouse output) and China (greatest total greenhouse output) on the verge of coming to blows over which one was the worst carbon offender.

Those tensions came to a boil in 2015 when coordinated acts of sabotage took nearly a hundred Chinese coal-fired power plants offline. The Chinese government blamed the U.S. and put its military on high alert; the American government responded in kind. Fortunately, before either side could launch a preemptive attack, a rural Chinese movement took credit for the sabotage. Beijing was taken by surprise when the resulting crackdown backfired, with some regiments refusing to attack Chinese citizens and others actively joining the movement. A smuggled camphone clip of renegade Chinese military aircraft bombing the nation's largest coal-fired power plant was the top-rated video on YouTube that year.

The United States fared slightly better. The Presidency was up for grabs in 2016, with no clear favorite, and while neither of the two major-party nominees denied the extent or source of global warming, each considered the problem less of a priority than issues like health care and terrorism. But the standoff with China, coupled with the onset of the "Second Dust Bowl" in the Midwest and the final abandonment of New Orleans after another in a series of massively destructive hurricanes, led to the surprise victory in the November election of a third-party candidate operating under the "Carbon-Free America" banner. In early 2017, Congress began calling in the CEOs of energy companies for what were soon labeled "carbon trials," and the new President -- a person long in the national spotlight, with a reputation as a bit of a technology wonk -- arranged a series of high-level Carbon Crisis Summits with leading technologists, scientists, and environmental activists around the world.

It was at the first of these summits, held in October 2017 at the Rocky Mountain Institute in Colorado, that the President revealed that the Pentagon's research arm, DARPA, had been working on molecular manufacturing technologies for more than five years, and would have a functional prototype of an early generation nanofactory by 2019. This stunning announcement had not been cleared through the Defense Department, however, and the Secretary of Defense along with the entire Joint Chiefs of Staff resigned in protest. Pundits and leaders from both major parties excoriated the President for revealing high-level military secrets, some going so far as to warn that terrorists would use molecular fabrication tools in a devastating attack upon the United States.

The President stood his ground, calling upon the leaders he had assembled for his summits to focus on ways to use this "transformative technology" to halt -- and even reverse -- global warming. In public, the President seemed calm and resolute; in interviews after his health-related retirement in 2022, he acknowledged that this was the riskiest decision any President had ever made, and that the dangers of failure were enormous. At the same time, he believed that the speed of the onrushing crisis required widespread, parallel development of potential solutions, and keeping this technology secret would have guaranteed a disastrous outcome.

Strategies soon developed by the newly-formed CCRO ("Climate Crisis Response Organization") covered two broad approaches: 1) rapid replacement of greenhouse gas-emitting technologies with clean technologies; and 2) large-scale reversal of global warming processes. What neither the President nor the CCRO anticipated was that the information released by the White House about DARPA’s molecular manufacturing research would enable non-governmental groups to make a giant leap ahead in the design of commercial nanofactories.

People around the world were worried, but not terribly shocked, when the White House acknowledged in late 2019 that the first government-developed molecular fabricator would be delayed until 2022; the same people were surprised and elated when, just a month later, a group called the "Nanofactory Alliance" announced that their first *working* nanofabrication system would soon be ready to replicate working nanofactories for all of the CCRO working groups, and would be available at a significant discount to any industry or academic group working on reversing climate disruption. Not long after, a UK project (spun off from the landmark 2006 "IDEAS Factory" research effort) announced its own functional prototype nanofab. By the time the DARPA work finally came to fruition, more than a year behind schedule, a dozen different global commercial and academic teams had come up with their own alternative systems.

During the time between the first Carbon Crisis Summit, in 2017, and the roll-out of early molecular manufacturing systems four years later, the global climate continued to degrade. It became obvious that a third approach beyond the carbon reduction and greenhouse reversal endeavors was needed, and that strategy -- effects mitigation -- soon became the dominant effort. While zero carbon teams worked to drive down the cost of nanopolymer photovoltaic materials (used today on nearly every product that needs power, and quite a few that don't) and greenhouse reversal teams experimented with ways to pull carbon dioxide and methane out of the atmosphere without causing unanticipated problems, the mitigation groups became a new kind of "first responders" to climate-related disasters. From the rapid fabrication of sea walls and

flood barriers to the overnight construction of housing and infrastructure for millions of environmental refugees, effects mitigation teams had the closest relationship with the everyday victims of global warming; correspondingly, they soon had the greatest popularity, and even became the subject of a top-ten holovision show.

As popular as the effect mitigation efforts had become, some movements saw the teams as threats. Because the regions hardest-hit by global warming also tended to be in the least-stable parts of the world, by 2022 most effects mitigation groups went out accompanied by counter-insurgency military units. It was soon realized that techniques employed by the CCRO effects mitigation teams on climate impacts could be quite effectively deployed in response to insurgent attacks as well. By 2024, these efforts had morphed into what strategist Tom Barnett had identified more than 20 years earlier as a "SysAdmin Force," focused not simply on defeating insurgencies, but stabilizing and improving physical, economic and political conditions of unstable regions.

The other two CCRO fronts progressed better than feared, but more slowly than hoped. The low costs associated with molecular manufacturing meant that it was far easier to shift productive industries to a zero-carbon footprint than some pundits had predicted. All new vehicles from the globe's major carmakers were solar-shell electrics, and the building refit business was booming. The economic hit from rapid conversion to low-carbon techniques was milder than anticipated, and the public was now generally ready to accept once-taboo policies such as carbon taxes. At the same time, coal power remained a problem, even though the remaining number of coal-fired plants world-wide was far below even the wildest dreams of turn-of-the-century environmentalists. And some economically-critical industries, such as air travel, remained dependent upon greenhouse-gas-emitting fuels. Nevertheless, all reliable measurements indicate that global output of greenhouse gases is now on a strong downward trajectory.

Greenhouse reversal teams have had a more moderate level of success. Carbon removal and solar shield projects demonstrated partial effectiveness, but as of yet all greenhouse reversal efforts have been forced to stop prematurely due to unanticipated effects. The climate is a damnably complex system, and geoengineering remains in its infancy. Nobody wants to make the problems worse, so reversal efforts have been cautious. More ambitious projects, such as seeding the atmosphere with semi-autonomous "swarms" of nanoscale devices that can offer transient regional shading and carbon management, remain relegated to simulations (increasingly complex ones, of course, given the mushrooming of computational capability enabled by nanomanufacturing).

Still, the world of 2025 is daring to hope that we'll make it through the global warming disaster intact. We're developing a far better understanding of how our geophysical systems work, so as to better manage them; we're moving aggressively away from industrial processes likely to become environmental threats and certain to leave us vulnerable to political and economic instability; and -- perhaps most importantly -- we're learning to see the connection between environmental fragility and social fragility. Much to everyone's surprise, we may well get through this crisis with a better world than we had at the outset.

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