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# 1

## Living Energy

On the face of it, our situation seems grim. The devilish, seemingly intractable environmental, social, and political predicaments ushered in by global heating make the prospects for humanity appear gloomy. In our increasingly hot and crowded world, extreme events such as wildfires, drought, heat waves, and storms (and all the damage, landslides, and flooding that they can bring) have intensified over the past decade while the slow-burn elements of global heating—melting glaciers and ice sheets, rising sea levels, and desertification—continue along their seemingly inexorable path toward a far less hospitable planet. The year 2024 was the hottest on record, with extreme weather events devastating communities across the world—yet still with little progress on influencing the factors that will lead to further global heating, making the situation steadily worse.

That said, it would be a big mistake to assume that all hope is lost and the trajectory for humankind leads to planetary calamity sometime this century. In fact, with bold, decisive action, there is a quite reasonable likelihood for success in reversing this downward spiral, but the journey will be long, arduous, and fraught with potential pitfalls. Crucially, in order to deal with a situation

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of this complexity, it is essential to understand the nature of the core element of the problem.

The fundamental matter at issue is that of carbon.

Carbon is essential to life in our world. Touch a match to a dry leaf, and it appears that the fire produces the crumbly black carbon and ash, but this is instead an example of fire helping to reveal the core element of the plant matter. Much of life on Earth is slimy, wet, and/or quivering with fluids, so it might not always seem to be the case, but the same goes for fish, seaweed, birds, animals, and insect life. The Earth pulsates with carbon-based life. As such, the planet possesses sophisticated systems for maintaining a degree of carbon equilibrium, including familiar processes like photosynthesis and far more consequential operations such as oceanic absorption. Yet the ongoing process of global heating is at root a mismatch between the carbon of yesteryear and that of today.

Like leftover shock waves from someone else's epoch, fossil fuels represent detonations within the carbon cycle—geological improbabilities that somehow happened. Long before humans existed, oil, coal, and natural gas took form underground in a freak overlapping of necrology and geology. Oil is a mighty energy source, but it derives its power from death and decay—specifically, the decomposition of myriad plant and marine organisms from millions of years ago. Fossil fuels thus connect us to deep time in ways that remain underappreciated. During a sort of *sous vide* process of pressure cooking in the Earth's crust, under particular conditions, the more complex organic molecules of decaying plants, marine animals, and microorganisms like plankton transform into simpler hydrocarbons. Coal, oil, and natural gas each have their own rather distinctive origin stories, but all three nevertheless derive from extinction.<sup>1</sup>

Millions of years before saber-toothed cats and woolly mammoths roamed the land, parts of the world teemed with lush flora and sundry creatures, and the abundant organic matter that covered areas of the planet would flourish, die, and accumulate, such as in sea basins. Plate tectonics played a role, creating

opportunities for appropriately sheltered bodies of water. Once in progress, tectonics also moved these long-term pressure-cooking experiments across the planet. Such fossil fuel deposits in the making have meandered slowly, but incessantly, ever since. Over the course of many millions of years, these sites of dark metabolism have therefore wandered, collectively, along nearly the entire surface of the globe, meaning that the geographic origins of oil, usually associated with particular regions in our day, are far more ambiguous through time.<sup>2</sup> Oil discovered in and extracted from all well-known producing regions, such as the North Sea or Siberia, originated from organic and geological conditions far from their current locations and then slowly drifted in the interim. The so-called Persian Gulf States' dizzying oil holdings developed up to 250 million years ago out of the ancient Tethys Sea, located in Gondwanaland between what became Africa and Eurasia, in the process creating the world's largest oil reserves. Rich oil fields in Brazil (the Campos Basin) and Venezuela (the Orinoco Belt) used to be contiguous with those of West Africa, and both the continents of South America and Africa have traveled in the meantime. Alaska's most productive fields (Prudhoe Bay) used to lie further south before being pushed up above the Arctic Circle. In the sense that nearly the entire planet, land and sea, has had oil, gas, and/or coal developing or deposited underground over roughly the past 100 to 200 million years while it moved, these hydrocarbons represent our collective carbon legacy, bequeathed by planetary epochs so far back in the past that they bedevil our ability to conceive of their relationship to the present.

This process of carbon life becoming carbon death and then carbon fuel was about how organic matter encountered the conditions necessary for altering decay. Deprived of oxygen, the "remains" transformed. The weight of the water as well as the mass of all the other decaying organic matter that came later created pressure in an anaerobic environment. After all of those years of this underground "low and slow" casseroles, the carbon matter became much more concentrated. This is another way of saying

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that sequestered fossilized fuels like oil represent the combined carbon of millions of years of organic life. Fossil-fuel-derived gasoline that powers a lawn mower emits plumes of carbon from a different age; this carbon, once trapped underground, escaped the carbon cycle of the Earth's environments, at least for a time. This is why we have global heating in the present day; the carbon from the past dramatically increases the strain on climate processes that must cope with the carbon from the present as well.

Such sites that contribute to maintaining carbon equilibrium are called “sinks.” Sinks absorb carbon, like biomic sponges; they include the familiar processing of carbon in jungles, forests, and grasslands, where plant life converts carbon dioxide to oxygen. The world's oceans, furthermore, represent a far more important and capacious sink in which an intricate process involving current, water temperature, nutrients, and salinity allows the sea to absorb massive amounts of carbon from the atmosphere. At precisely the same time that we need as robust a matrix of sinks as we can manage, human industrial development, food practices, overfishing, and the effects of climate are putting sinks under a great deal of pressure. This means that humans can rely on the carbon-processing capacity of sinks—and their other linked benefits, like clean air and water for thriving wildlife and abundant flora—even less than before.

More fundamentally, the massive-scale engagement with prehistoric carbon today is a telling flirtation with extinction. The colossal endeavor of surveying, drilling for, and refining fossil fuels, not to mention transporting them far and wide, disguises the tight relationship between such fuels and the extinct life-forms of which they are constituted. Back in the eighteenth and nineteenth centuries, when fossils began to fascinate learned people mainly in industrializing countries like England, France, and the United States, the concept of the extinction of species was jarring; the notion clashed with the teachings of scripture and prevailing ideas of the origins of life on Earth.<sup>3</sup> Later, as the organic source of fossil fuels became better understood—with coal mines, for

instance, offering up numerous impressions of prehistoric plants and marine organisms visible in their tenebrous black deposits in shafts underground—the odd, unsettling provenance of oil and coal was eclipsed by the frenzy over these substances and the money and power that they afforded.<sup>4</sup> Indeed, capitalism itself is powerfully implicated in this process.<sup>5</sup>

Global heating, by itself, is more likely to be a powerful contributing factor. Humans now have abundant means to destroy the species—a radical capacity that has existed at least since 1945, when the elusive violence of the atomic bomb unleashed a new scale of warfare and produced a tense standoff between emergent nuclear powers. Like pestilential garnishes on an already overgenerous dessert, the horrific varieties of biological and chemical weaponry in the armories of the planet's powerful militaries would have little trouble finishing the job. Global heating is therefore more likely to act as an accelerant. The discord and upheaval it unleashes could trigger conflict that spirals into nuclear apocalypse.

As tempting as it is to be fatalistic in the face of these grim prospects, it is undeniable, though sometimes difficult to remember, that humankind possesses the intellect and emotional capacity to navigate its way out of this quandary. Faced with crises, many people rise to the occasion, doing extraordinarily brave things and at times taking grave risks to help strangers. However dire the daily news and social media feeds might make our fellow *Homo sapiens* seem, there is every reason to believe that lots of good people will try to sort out problems in their communities, and some of those people might indeed rise to national office or international stature to offer broader, more influential leadership. Up until now, over the decades and centuries, bright and dedicated people have regularly stepped up to make a difference in crafting inventive solutions to seemingly intractable problems. And here we find ourselves, trying to understand the true scale of the problem and its drivers even as we attempt to sort through solutions and consider outcomes so that they don't make the situation worse.

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These considerations strongly suggest that, here on the precipice of climate disaster, we embrace a radically different paradigm of energy. Instead of further destabilizing the intricate and dynamic balance of interpenetrating world systems, both human and more than human, it would behoove us to embrace *living energy*.<sup>6</sup> What do I mean by living energy? Dynamic and adaptable, living energy flows from the forces available on the planet without unduly contributing to the destruction of the planet.

Wind, solar, geothermal, and tidal—these are the sustainable energy technologies that most people associate with the climate challenge. Anyone who has glimpsed a wind farm in the distance (or on a device screen) might have thought the lazy, off-tempo symmetry of spinning turbines looked elegant, or perhaps unfamiliar, but they also probably thought, “Renewable.” “Eco.” Nuclear is more divisive, yet creating power from the fission of certain isotopes can be considered a form of living energy as well; it doesn’t derive its BTUs from extinction, but the problem is ensuring that its radiation doesn’t harm communities and ecosystems.<sup>7</sup>

Another intriguing example of living energy that likely doesn’t spring to mind for most people is the sort of Stone Age energy storage that has begun to take off via a range of inventive start-ups, despite remaining underrecognized. The burgeoning renewable storage sector indicates that some solutions to the climate crisis may well be hybrid in nature.

A clever mingling of cave dweller physics and cutting-edge tech, renewable storage strategies offer a strikingly diverse set of approaches to provisioning living energy. Imagine a boulder sitting at the top of a hill. The huge rock, which is acted on by gravity, represents a store of potential energy; this is converted to kinetic energy if pushed hard enough that it topples and rolls down the slope. This is thus a form of energy storage that can be exploited in various ingenious ways. Of course, keeping energy stored efficiently represents a key element of the new green economy that is widely overlooked because of the typical high expense of making standard batteries on an enormous scale. Yet

having substantial stores of energy would solve numerous issues, improve the functioning of the grid, and make renewables work better (e.g., smoothing out intermittency). To extend the example, what if it were possible to use green energy to push the same boulder up the hill and then generate energy from its momentum downhill whenever it was needed, on demand? What if the weight of the boulder were sitting in the freight car of rolling stock, ready to hurtle downhill along railroad tracks? Or sitting in a freight elevator? This is what the people working with renewable storage are toiling with in order to better husband energy at a time when demands for energy are on the rise.

Renewable storage makes strides toward improving some of the key shortcomings of batteries. One of the biggest challenges with using batteries is holding energy cheaply without allowing it to degrade much through use or over time. The days of buying Duracell or Energizer batteries are not completely behind us, but beyond old TV remotes and car keys, many people now rely a lot more on rechargeable lithium-ion batteries. These batteries are ubiquitous and convenient, but they are far from ideal, and not just because they deplete and require a recharge after several hours. As every smartphone and laptop user knows, device batteries peter out over time. The total capacity dwindles both through regular use and when left unused over time. External battery packs or power banks supplement this unstable, episodic capacity—useful, for instance, on a long journey—but these external power banks are difficult, heavy, and expensive to deal with, and these also deplete. Moreover, access to the materials to make lithium batteries is limited and uncertain. The war-torn Democratic Republic of the Congo provides about 70 percent of the world's cobalt—an essential ingredient in many lithium-ion batteries, along with lithium—and remains an extremely precarious source.<sup>8</sup> Not only is most of the Democratic Republic of the Congo riven by violent conflict sustained by greed-driven, plundering factions, but most of its mines are illegal, pollutant, and heavy on water use. Some mines use child labor.<sup>9</sup> Access to the mining product could shift

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at some future date without warning, leading to market chaos and product disruptions. For all of these reasons, it will be vital to create further stable sources of renewable energy storage, regardless of how the coming surge takes shape.

On top of all of this, the ongoing boom in AI development is driving a substantial increase in electricity demand, as I explore in chapter 5. I used to think that determining roughly how much energy would be required in the coming decades would be an essential part of my analysis. How else could anyone make a sound judgment on future energy choices? But the radical uncertainty of the coming years is colliding with an already unprecedented rise in demand for energy. It is reasonable to surmise that there will be so much pressure on the provision of energy, as I explain, that even the most dynamic and successful economies will struggle to maintain reliable access to energy at a price that is survivable for businesses, households, institutions, and governments. The pell-mell scramble for energy sources may make the move away from fossil fuels more difficult, particularly for countries with their own hydrocarbon resources. Even these states, though, will find it hard to ignore the astonishing cheapness of solar and wind after their cost collapse in recent years. Since these renewables can scale up so quickly, they will, in time, create clear evidence of the benefits of green energy on the balance sheet.

Amid this degree of anticipated market mayhem, energy storage demand may skyrocket right when novel forms are coming online. Some estimates go so far as to say that we will need several times more energy, for a start, in the coming decades, but the energy demand of an AI “arms race” is almost impossible to predict with any accuracy—and so new and reliable sources of battery or energy storage will be crucial. With electronic devices putting their own seemingly inexorable claim on relatively convenient and portable sources of batteries like lithium-ion, it seems likely that this gargantuan demand for new storage capacity, both on and off the grid, will have to be diversified. After all, lithium won’t facilitate the entire planet’s energy transition. For longer

durations—from a day to weeks or months—lithium becomes prohibitively expensive and inefficient. Added to which, lithium economics remain precarious. Instead, the most plausible path is to generate further unprecedented capacity from renewable storage to complement other strategies.

What does renewable storage mean? It means creating storage using gravity, chemistry, pressure, and geology to garner energy in a much more efficient manner. A dam generating power from a huge amount of water, according to another way of thinking, is essentially a giant battery. This “battery” is especially green if you can use low-carbon energy to put water in the reservoir; whenever you need the power, it is there to be exploited, like a battery in a flashlight yet much more long-lasting. In a sense, this is sustainable energy even beyond the key environmental concerns at issue. This is because energy storage that can be mobilized repeatedly or over long periods of time, relying on these kinds of elemental forces, becomes considerably more dependable. A key takeaway here is that renewable storage can be used in any system, not just “renewable” ones. Any network that would benefit from stored capacity—which in practice probably includes most, if not all, of the world’s electricity grids—could make good use of these kinds of durable energy storage strategies.

Some of the more interesting renewable energy storage companies making a go of it today in the market say that they are finding ways to use AI and automation in order to provide a means toward both efficiency and relative ease of scalability. Energy Vault, a venture with a test site in Switzerland and a pilot demonstration facility in China, creates massive blocks of compressed dirt in order to produce weight cheaply. These blocks, the size of a van and weighing about twenty-four tons, can then be moved around a capacious, multistory warehouse—with higher floors offering greater potential energy for the collected load. Ideally, clean energy would power the fashioning of the blocks as well as the lifting and positioning of them. With wind and solar, there are frequently times when the available power overwhelms the

grid, since there's nowhere for the power to go. This makes the price free or even negative, meaning that the grid is paying entities to absorb the electricity quickly, lest it destabilize the system. In times like this of abundant, inexpensive electricity on the grid, the "vault" could turn cheap or surplus electricity into stored potential energy. During high-demand periods, the massive weight of the stored blocks would then power turbines to send electricity to homes during peak times in the evening and/or during hot weather, for example. Over time, automation would tend more and more to the process—positioning the blocks on trolleys, guiding them onto elevators, and taking them to higher and higher stories. Then when the stored potential energy of these blocks is required, the same automated systems would unstack or extricate the blocks and bring them on trolleys to the elevator, where the descending mass converts potential energy into kinetic energy. The predictable, regular use of gravity, harvested with the help of an AI-assisted control system, turns this kind of Stone Age energy capture into a sophisticated, reliable, elemental battery. In the context of a grid powered by solar and wind, the variability of the energy available—for instance, literally how much the sun happens to be shining on an intermittently cloudy day—can be stored to offer consistency. When the sun goes down, the solar power collected by the massive warehouse battery can be harvested at a high degree of efficiency. Energy Vault claims that the round-trip efficiency of moving these blocks up and down could reach almost 80 percent. This is not quite as good as a dam hydropower project, but when was it possible to build a dam nearly anywhere—including next to a data center, in an abandoned coal mine compound, or on the outskirts of a city? Or every city? In time, these considerable advantages may well prove irresistible to investors, politicians, community leaders, and corporate strategists.

Indeed, Energy Vault loosely competes against another form of gravity-based renewable energy storage called pumped storage hydropower. Standard hydropower makes use of large, engineered water bodies, such as a dammed reservoir in a river valley. The

high pressure from the immense weight of the water drives turbines deep within the dam that generate electricity. With pumped storage hydropower, the system uses two reservoirs, one uphill from the other. Unlike a standard dam, where the “used” water flows away downstream, pumped hydro sends more or less the same water back and forth, up and down. Clean energy ideally powers the pumping of the water up to the higher-altitude reservoir, which is what makes the process so appealing. When the grid needs more energy, the uphill water drives turbines as gravity and pressure bring the water down to the lower pool. Yet this kind of hydropower is limited by geology to a certain extent. Considering the large scale that many utilities and companies desire, many of the easiest, most logical sites have already been exploited or are otherwise unavailable for all intents and purposes (e.g., due to being located on a Native American reservation). There is nothing stopping smaller-scale operations of a similar nature from springing up, however. Ponds, lakes, and water towers—using the gravity of water in this way is not technically difficult. A water tank on the roof of a building and a corresponding vessel underground could be made to serve the same purpose.

Other strange yet resourceful variations on the concept include a venture by Houston-based Quidnet, which essentially does the same thing as pumped storage hydropower, but instead of pumping the water uphill, it pumps the water underground under pressure, drawing from a small artificial pond. When needed, the pressurized water shoots forth and provides the energy to drive turbines, after which the water is returned to the pond. To have the necessary integrity and staying power, the water forced underground ideally comprises a particular horizontal, disklike volume in the geology, called a “lens” in the business.<sup>10</sup> The immense weight of the surrounding rock supplies reliable containment, by and large, and the geomechanical drilling and piping operations use highly standardized components that are widely available—ironically due to the large market share of fossil fuel–related businesses. Up on the surface, the footprint of Quidnet sites is quite modest—not

much more than a utility cabin standing next to a small pond, reached by a driveway. This kind of infrastructure could scale quite well in areas with farms or other agriculture, but Quidnet is certainly not limited to this kind of land use.

It is worth noting that renewable storage may thrive under the radar in the United States precisely because it doesn't accord with the prevalent stereotyped forms of renewables that attract the hostility of the current regime in the White House on a regular basis. In other countries, there are so many different topographies that lend themselves to the wide range of renewable storage approaches—mountains, grazing land, and so on—that it is not difficult to imagine a relatively swift implementation once their advantages become more widely known.

Importantly, renewable storage could be used for a variety of energy sources, not just renewables themselves. Maybe nuclear strategists or government planners will decide, based on the fundamentals, that every nuclear reactor should have an “energy vault” nearby in order to offer another means of managing variable flow and disruption. Maybe utilities will learn in time that the grid should have vast Quidnet “lenses” of compressed air, sitting underground, distributed around regions to balance out a diversity of energy input sources (including all the plugged-in electric cars able to contribute during high-peak periods, solar panels, and any number of large power generators like wind turbines, geothermal plants, and tidal energy operations). At this nascent stage in the sector, though, the marketplace for renewable storage has not matured, with numerous ventures rushing to demonstrate proof of concept and viability while attracting major capital investment in order to grow past the crowded stage of early incubation. This makes it unclear which strategies will take hold first, at scale, and gain the advantages of early adoption in a sector with promise.

These forms of energy storage using elemental forces, geography, pressure, gravity, and chemistry, and facilitated sometimes by robots, computers, and AI to streamline the logistics, might seem the antithesis of wholesome, organic approaches. Nevertheless, this

is living energy. Human systems engaged in moving matter around, adapting to forces, assessing conditions, and husbanding energy—such a dynamic set of processes is distinct from fossil fuels, which derive their BTUs from death, decay, and extinction. Necrotic energy along these lines has helped to create an overheated greenhouse that is increasingly unpleasant, dangerous, and unsustainable as a set of habitats for many species, including our own. Stone Age storage thus makes for a sustainable buffer that complements well the more familiar living energy strategies of solar and wind, not to mention a range of other energy-generation methods like geothermal, tidal, and so on. Nuclear proponents would also be quick to add nuclear power stations and (as yet untested) small modular reactors to the suite of methods that can produce living energy as well as provide a lower-carbon alternative to noxious fossil fuels.

But first, most of humanity needs to wake up to the building crisis.

## **Total Disaster**

Disasters have long been regarded as swift, unwelcome, typically isolated affairs. While some of the most devastating events in history have been protracted, such as the Black Death, which ravaged Eurasia between 1346 and 1353—with an estimated twenty-five to fifty million deaths, sacrificing as much as perhaps half of Europe’s population and maybe a third of the population of the Middle East at the time—most disasters are a finite, relatively contained suspension of “normal” existence. In a sense, this is partly a product of human sensibilities. Humans want to be able to signal that the disaster is over. Victims want to be able to turn a page and know that predictable, humdrum life and reliable services have returned. In reality, many disasters endure, sometimes for many months or years. It takes time for communities to repair the damage to hospitals and schools, rehouse victims, and rebuild infrastructure in order to allow transportation and commerce. Areas of so-called Tornado Alley in the United States can get hit by a twister out of

the blue and then spend days, weeks, and sometimes months or years cleaning up debris, making repairs, rebuilding hospitals and schools, and trying to return to normalcy. For people like this in harm's way, it can be comforting to be able to speak of the calamity in the past tense and believe that their world is getting a reset. Arguably, the human mind is not well suited to operating otherwise. Sometimes improbable hope sustains human lives.

In our greenhouse-warming world, however, scientists, policy experts, and political leaders are exhorting people to get their heads around a disaster that is so diffuse and widespread that its true scope can frequently only be understood through recourse to cumbersome computer models and big data. Regardless of their tribal political affiliations, keen skiers and residents of communities that depend on ski tourism are much more likely to notice the more recent fluctuations in the weather that turn potential powder snow into rain and transform ground snow into slush and mud. For people like this who are often acutely attuned to variations in weather along with the difference between current patterns and those from decades ago, climate issues are rarely so abstract. Even skiers whose politics are conservative probably contend, at least sometimes, with the cognitive dissonance that would come from concrete experience with climate weirding.

Global heating has been validated by an overwhelming majority of the world's cleverest, hardest-working, and most highly trained scientists, policy mandarins, and environmental specialists. Nevertheless, it remains contested by political opponents, antielite agitators, culture warriors, and a wide range of conservatives, from billionaires to bartenders, who just simply don't like being told what to do, particularly if it's by know-it-alls who went to fancy schools. This makes for a lot of performative or knee-jerk disagreement over core meteorologic and geographic conclusions that are plainly all but beyond challenge due to the immense weight of empirical as well as scientific proof that backs them up. The world of scholarly peer review, with its inevitable shortcomings, can be as withering toward unproven claims as a seasoned judge presiding

over a criminal trial. The peer review system is far from perfect, but flimsy assertions are refuted with great regularity. Fabricated research is frequently, though of course not always, discovered, revised, retracted, and/or otherwise addressed. The notion that thousands of climate scientists, academics, technicians, policymakers, and other experts in numerous different nations are conspiring to hoodwink the world's population with regard to global heating is patently ludicrous, especially against the backdrop of record heat, brutal wildfires, sharpening storm systems, and horrific flooding. But countries generally get the mediaspheres that they deserve, one way or another, and rival claims that are skeptical of global heating remain in play in many influential nations. The tribal political affiliations of rival perspectives can be enough to sour conservatives on the sometimes straightforward-seeming climate issues at hand.

In terms of climate Armageddon, it has therefore been difficult to get a clear picture of what failure looks like and the consequences of delay—particularly regarding a topic that in some circles has become virtually off-limits in public and/or official discourse. This is not hyperbole; recall that during the first Trump administration, the White House forbade federal agencies to even mention climate change, and in the febrile political climate at the time, accusations of bias became national news. The ongoing second Trump administration has picked up where it left off, with a vengeance.

At root, stories motivate people. Age-old mythologies and contemporary memes alike, including so-called urban myths, help organize our understanding of the world around us and make sense of complexity and change. Compelling narratives help build momentum to drive political transformation. Consider the success of the highly effective (and highly deceptive and even underhanded) “take back control” campaign that helped turn the United Kingdom away from the European Union in the contest over the Brexit referendum in 2016. Across the pond, former senator and vice presidential nominee John Edwards gained substantial political purchase—before his scandalous fall from grace—when he spoke of the “two Americas”—one composed of a wealthy elite

and the other of people living paycheck to paycheck and juggling debts—as well as his lifelong fight as an attorney for the latter forged by his humble upbringing. These stories seduce adherents partly because gregarious humans appear to be attuned to compelling narratives and even programmed to believe them.

The current narrative turmoil over climate change is hardly surprising; the issue lacks direction and focus precisely because the stories are so disjointed and incoherent. This is partly due to active disinformation and interference from groups opposed to carbon revisionism. But it is also due to a poverty of imagination, not to mention relatability gaps. Amid vituperative contemporary political theater in Washington, DC, some left-of-center politicians who crave a pathway to higher office have seemed reluctant to stake out a clear climate position that might alienate independent voters. Such is the hyperpartisan political landscape in the United States that even when the stakes are so high, the corresponding handful of more moderate Republicans are reluctant to whisper support for ecofriendly policies, even when those initiatives were originally conceived and implemented by Republicans and accord with conservative doctrine. A fine example of this kind of policy flip-flop would be contemporary opposition to a marketplace for carbon, which people in the United States used to call “cap and trade,” even though this is an example of a plan crafted carefully by conservative players and think tanks and promoted by Republican powerbrokers in the 1980s and 1990s. Originally conceived to fix the devastating problem of “acid rain” caused by power plant emissions of sulfur dioxide, this kind of emissions trading proved to be a successful means of using human nature and the market to achieve environmental goals. It is worth noting that carbon trading works pretty well, though sometimes with flaws, in other parts of the world like the European Union, although most see such a plan as dead on arrival on the fractious US political stage. From the vantage of the mid-2020s, sensible energy policy seems to need to be garbed in the raiments of trillion-dollar patriotic AI investment to get anywhere in contemporary Washington.

As a result, mainstream representations of global heating seem remarkably impoverished and unconvincing given the prominence of the issue, even taking into account how embattled work on climate change and coverage of climate weirding has become. It is worth mentioning that the US political system is unusually complex: a decentralized locus of power and decision-making composed of overlapping jurisdictions along with a dense lattice of checks and balances. While senators and representatives wrangle in Congress—and horse trade continuously with the executive branch—each state runs its own parallel rodeo, with state legislators maneuvering in the legislature and cutting deals with the governor. Certain mayors, especially those in media-saturated cities like New York, command national attention, and states such as California exercise outsized influence by virtue of their scale or history of effective policymaking. In this pitched arena, many ambitious political hopefuls jostle for visibility, staking claims on lurid, symbolic, or otherwise “hot” issues (or nonissues) in an attempt to seize a slice of the national limelight. Yet few politicians have successfully communicated the peculiar horror of some climate outcomes, perhaps because it is so difficult to link labile present conditions to uncertain future outcomes convincingly in the minds of the electorate. By contrast, in the United States, Republicans are generally more successful at creating successful political narratives and positioning campaign rhetoric, partly because they have, historically, probably been more organized and ruthless as a party and more willing to say nearly anything to win. In recent years with the rise of the “America First!”-style MAGA movement, Republicanism has perhaps never been less disciplined, but Republicans have far less reason to characterize (or even mention) global heating in their messaging due to their more typical, denial-oriented modus operandi. Take for example the Republican approach to border security. Illegal immigration, trafficking, and smuggling across the southern border with Mexico have been serious and legitimate policy concerns for decades, though wildly exaggerated by and large, especially on the Right.

In recent years, Republican politicians of all stripes have made extensive efforts to portray the border as an existential “crisis” for the United States even as they play down or ignore the looming climate crisis, which in the eyes of many experts and policy specialists is far more consequential. Regardless of where one sits politically, it is impossible to ignore that these competing narratives lie at the heart of successful politicking.

Perhaps the most striking words spoken by a politician came from a diplomat, UN secretary-general António Guterres at the 2022 COP27 meeting. He declared, “We are in the fight of our lives, and we are losing. . . . We are on a highway to climate hell with our foot still on the accelerator.” Guterres added, “Humanity has a choice. Cooperate or perish. It is either a Climate Solidarity Pact, or a Collective Suicide Pact.” But these words had little lasting impact. One reason for this was that Guterres has helped preside over the precipitous irrelevance of the United Nations in terms of a core facet of its long-standing role: meaningful influence on major nations, distilled out of a robust forum of all nations. Guterres, by instinct a tough, backstage, consensus operator, has been reluctant to assert himself publicly in international affairs or put himself on the firing line for most of his time at the helm of the United Nations. This meant that when he had perhaps the most important message of his career to impart, he has seemed to lack the profile to make it stick. This was not charismatic former UN secretary-general Kofi Annan or even his affable predecessor, Boutros Boutros-Ghali, giving a wake-up call to humanity. This was Guterres, whose name is unfamiliar to many. Guterres has been a solid and effective UN leader but has not established a track record of risking his position or the United Nations’ role in order to speak truth to power. He does not land blows on the world’s mightiest and/or most intractable leaders, like China’s Xi Jinping and Russia’s Vladimir Putin, not least compulsive political grenade throwers like President Donald Trump. Guterres instead attempts to achieve progress and build bridges behind the scenes, and it shows. It is hardly fair, of course, but his positive results and

legitimate wins along the way remain underrecognized by different publics and even sometimes by world leaders.

Outside the political sphere, the most memorable attack on fossil fuels and the energy status quo came from fifteen-year-old Swedish high schooler Greta Thunberg. Like a nonpetroleum Molotov cocktail, Thunberg exploded onto the scene in 2019; her dogged protest against Swedish inaction on climate issues struck a chord with many, particularly young people who felt voiceless in contemporary political affairs and upset or terrified at the prospect of spending most of their lives on a hot, sweaty, perilous, and unpredictable planet.

Thunberg's statements make for discomfiting consumption because they lay bare the extent to which young people can or will blame these problems on their elders. ("Adults keep saying: 'We owe it to the young people to give them hope.' But I don't want your hope. I don't want you to be hopeful. I want you to panic. I want you to feel the fear I feel every day. And then I want you to act. I want you to act as you would in a crisis. I want you to act as if the house is on fire. Because it is.") When the panic of the COVID pandemic gripped most of the world's population in 2020, however, people tended to worry about their own lives and the health of those closest to them during a pestilence of historic proportions rather than abstract climate issues, which by contrast seemed to slump, losing prominence and relevance. After a couple years of coronaplague hangover, Thunberg retained much of her name recognition, but the urgency of her message and her ability to penetrate the media noise seemed to have diminished. Indeed, she is perhaps best well-known, of late, for inadvertently helping to expose virulent misogynist and sex trafficker Andrew Tate. It remains to be seen whether Thunberg will find a way to harness her global fame in the service of a coherent protest campaign with specific, achievable goals.

The United States being a place where business is viewed as a valid and (sometimes) edifying alternative power source to politics, corporate leaders also occasionally cultivate a public profile that can convey climate information. Major corporations have



**FIGURE 3.** Swedish high schooler and global climate activist phenomenon Greta Thunberg delivering a fiery speech to a spirited crowd in Lower Manhattan on September 20, 2019, a few days before the UN Climate Action Summit, where she pointedly addressed world leaders, proclaiming, “How dare you!”  
Photo: Peter Wynn Kirby.

made green energy commitments, discussed below, and corporate sustainability innovation leads to useful reporting standards, investor-led pressure to maintain momentum and, naturally, gains in efficiency and risk management. Yet even though global corporations must still comply with stricter European standards, US programs, subsidies, and incentives have withered under the current administration, and corporations have often strategically played down their sustainability efforts. Prominent corporate leaders, wary of provoking Trump, are even less likely to take a stand on climate issues or push messaging related to global heating.

In the absence of compelling political narratives that could bring immediacy and relevance to global heating, most people in industrialized countries (and others) become exposed to climate

fables by way of Hollywood and related culture industries with global reach. Many hundreds of millions of people, and probably billions, feed on a regular diet of calamity and action, with an increasing focus on arid worlds, dysfunctional governance, and feral conflict over scarce resources.<sup>11</sup>

The most successful climate disaster films tend to be sparing with the details. Take *Mad Max: Fury Road* (2015, dir. George Miller), an electrifying, multi-award-winning sequel to the gritty, post-apocalyptic road movie franchise. When scrappy, lone-wolf Max is imprisoned by a warlord, he manages to join the escape of five beautiful concubines from the warlord's Citadel, speeding away in an armored semi, or "War Rig." They venture into a desiccated landscape almost completely bereft of vegetation, animals, and people. What the film conveys is a world where much has gone wrong and where the survivors must be tough, clever, and extremely lucky to survive. Indeed, the escaping women realize that their only chance is to turn the War Rig around and storm the Citadel while their former captors are out searching for them; this would allow them access to the large store of water that the fortress controls, and its crops. In the world that the film inhabits, the planet is already far gone and the prospects for humanity seem exceedingly dim.

In the case of *Interstellar* (2014, dir. Christopher Nolan), the film goes heavy on the details of astrophysics, wormholes, space travel, and relativity—rather surprising, considering its status as a mainstream blockbuster Hollywood product—while the dire condition of the planet and its population remains largely in the background. Nevertheless, the worsening climate crisis is a source of slow boil tension and sets a clock of sorts on the action. The beginning of the film crafts a bleak setting: a world beset by famine, with drone-managed agriculture attempting to squeeze crops out of nearly barren ground. A dedicated NASA team working in a hidden, bare-bones space facility manages to build a rocket intended to explore settlement on one of three potentially habitable planets, all accessible through a wormhole discovered near Saturn, or in other words, a portal to another galaxy. If this last-ditch

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attempt at off-world settlement becomes impossible, humanity seems doomed to face extinction. Nolan's signature attention to spatiotemporal complexity that drives the film's plot offsets and leavens the on-screen bleakness of Earth's crisis and the depressing prospects for humanity, as does the spaceship pilot's ability to communicate with his tragically aging, much-beloved daughter back on Earth via a sort of spatiotemporal window between dimensions (also known as a tesseract). Despite these powerful cinematic sources of energy in the plot, *Interstellar* furnishes a desolate glimpse of the aftermath of planetary ecocide as industrialization manages to destroy humanity's hopes for survival.

*Elysium* (2013, dir. Neill Blomkamp) pulls fewer punches and pays closer attention to the anticipated human chaos of climate shift, even though it is clearly the weaker film here. While a large human population remains on the Earth's surface in dusty, slum-like cities, the privileged elite dwells inside a gleaming space station in terrestrial orbit. Called Elysium, the space polity has the real estate aesthetic of a country club crossed with a posh gated community, complete with manicured grounds, homes ringed by lawns and pools, and extensive mall-style shopping and leisure opportunities nearby. Service droids offer a compliant and subservient workforce. Inevitably, a brawny subaltern troublemaker/hero manages to enter Elysium and create pandemonium that exposes criminal wrongdoing among its management, but what is memorable is how the film makes the divide between haves and have-nots starkly lurid and convincing in a time of global catastrophe—the sort of tableau that could contribute to a volatile mix amid contemporary reports of billionaires holding luxurious boltholes on Pacific islands and hidden bunkers elsewhere.

The sublimeness of these celluloid visions, however, frequently detracts from the true horror of the disasters portrayed. Talented film directors and cinematographers can, on occasion, make global heating look like an Insta-friendly mountain getaway or Saharan vlogging excursion.

Filmic narratives of climate disaster also bring unhelpful distortions. For instance, hyperreal portrayals of fictional planets and intergalactic travel can, in the most fleeting of moments, almost make absurd-sounding ideas seem real. Immersed in a rollicking, rip-roaring tale on-screen, it can almost seem possible that far-fetched scenarios like ferrying climate refugees to other survivable worlds could actually happen, offering a chance to save most or all of the human race. Bewilderingly immersive computer-generated images take us to seemingly plausible and even inviting new exoplanets, complete with oceans, flora, and sometimes even breathable air. The global heating predicament outside the cinema doors is far from hopeless, but this deluded, even woolgathering sense of mass space deliverance on film is probably encouraging an unhelpful sense of vague efficacy and possibility in the service of storytelling—important in its own way, of course, yet prone to la-la land self-referentiality. In the the process, though, it demonstrates some of the problems of tacitly farming out the publicity related to climate policy to Hollywood and other culture industries.

Most similar productions fall into the rather vague, bleak vision of the future mold, including the big-budget *Edge of Tomorrow* (2014, dir. Doug Liman), but also more obscure shows like the particularly grim *Tides*, aka *The Colony* (2021, dir. Tim Fehlbaum) and even *Bacurau* (2019, dir. Kleber Mendonça Filho and Juliano Dornelles), the last a Brazilian near future sci-fi Western fable about a small community with an unusual past that finds itself battling drought and murderous tech-wielding elites on a struggling planet that seems to have forgotten their whole community. Another strand of film/television plots portrays humans exploring future worlds—in a less desperate version of *Interstellar*—with humanity's need to find a new outland settlement left more implicit in the filmic vision. For instance, *Alien: Covenant* (2017, dir. Ridley Scott) depicts a colonization ship whose crew members visit a seemingly habitable planet en route to its destination and find a lot more than they bargained for. In discovering, to their delight and awe, a beautiful, if austere, planet with a breathable

atmosphere, they learn in horror that the world is claimed by an all-but-indomitable settler that already has the run of the place.

Despite the risks of distorting the climate problem and downplaying the difficulties of resolving it, these regular depictions of global heating, over time, nevertheless allow people—especially in industrialized countries—to visualize and conceive of the eventual large-scale implications of climate change. This is not trivial across a probable viewership of billions of people. Yet the hitch with effectively delegating the production of climate narratives to Hollywood is that studios are not known for long-term policy strategy. They are, however, dab hands at protecting their bottom line. Culture industry shotcallers may well decide to safeguard their substantial investments by not alienating the sizable portion of the population that believes global heating is a “hoax.” Anyone who doesn’t believe studios make these kinds of adjustments to plots and/or messages can reflect on the long-standing imperiousness of China in its de facto censorship of foreign content. In recent years, if Beijing found itself displeased by specific plot elements—for example, James Bond’s quarry casually murdering a Shanghai building lobby security guard in *Skyfall* (2012, dir. Sam Mendes) or the prospect of Chinese soldiers invading the United States in the remake of *Red Dawn* (2012, dir. Dan Bradley), making China look either weak or menacing—Chinese censors made their concerns known, and timorous studio chiefs made changes to curry favor. (The *Skyfall* assassination scene never made it to the screen in China; as for the reworked latter film, rather than the Chinese, it showcased North Korea’s deeply unlikely invasion of the US heartland instead, even though the film was never released in China.) Studios frequently attempt to maintain a balance between liberal and conservative themes as well—despite being reliably more progressive in general—and sometimes balance or offset elite portrayals with storylines focused on working-class characters and their communities. With climate themes more or less left at the mercy of the fickle calculations of film studios, societies risk having powerful narratives (of planetary threat/collapse or communities

working together for positive change) diluted or even bowdlerized into oblivion. Telling signs of such stealth pandering appear in the blockbuster film *Mission: Impossible—Dead Reckoning Part One* (2023, dir. Christopher McQuarrie). The most obvious giveaway is actor Tom Cruise’s striking change of hairstyle, the latest iteration of which resembles that of a Trent Lott era conservative US politician. But the film’s tone, villain (technology in the form of a faceless, anonymous AI), and the different, more frenetic plot and scene progression indicate that the franchise caretakers hope to make the movie attract a wider cultural/political viewership. If the successful *Mission: Impossible* franchise can, on the face of it, suddenly be recalibrated to appeal more to conservative audiences, then it is certainly conceivable that Hollywood shotcallers could find themselves self-censoring, if they felt obliged to do so, in order to avoid angering parts of the population that, say, believe that climate change is a conspiracy perpetrated by bicoastal liberal media elites and their fellow travelers. Who doesn’t believe, by 2026, that President Trump, for instance, is capable of lashing out at Hollywood or streaming studios as he has at certain law firms and top universities, or corporations outsourcing labor?

This is a long way of saying that thoughtful, engaging, mainstream explanations of the energy challenges that humanity faces are unlikely to come from contemporary politicians and other public figures—or avaricious culture industries, including Hollywood, Bollywood, Nollywood, Instagram, TikTok, or wherever else. Yet a colossal energy transition is already upon us. The title of this section, “Total Disaster,” is a play on words but also calls to mind how fascist states once invoked the phrase “total war” to signal a mobilization of all aspects of society in service to a cause. Many of the wealthiest, most influential and powerful nations in the world right now are not fascist (or authoritarian), and their populations generally have no desire to live in an autocratic state that tramples on their accustomed rights and freedoms. Still, it is difficult to imagine that global heating can be vanquished by “total” fragmentation either. Somehow, institutions dedicated to

confronting climate change are going to have to find ways to craft coherent narratives that can begin to convince and empower different publics critical to the effort.

When it comes to the climate challenge, the prospect of a desperate surge of expenditure and effort to find solutions to global heating is a real one, and the recent example of the pandemic does give pause. Any effective solution will require integrated responses, extensive cooperation over time, temporary as well as lasting sacrifices of one kind or another, and colossal investment—though the investment could certainly be regarded as effectively paying for itself in many respects. Can the messy, exuberant, pell-mell throng of humanity coping with crisis make such medium- and long-term commitments, take on sacrifices, and shell out these substantial monies? The arc of the COVID pandemic suggests that less organized attempts will end up throwing money at climate problems in inefficient ways. Nations will duplicate efforts. Factionalized politics will undermine more coherent, problem-oriented thinking. Some nations will distrust other nations and/or try to gain advantage in key ways. But even if the fight against global heating becomes a sort of coalition of the willing that includes prosperous nations and groupings like the core Anglosphere nations (Australia, Canada, Ireland, New Zealand, the United States, and the United Kingdom), the European Union, neoliberal Asia (notably Japan, South Korea, and Taiwan), and cooperative parts of Africa (maybe including South Africa) and Latin America, this would be a considerable alliance of partners. Would it be more effective to include nations like China, India, Russia, and the Gulf States? If they were demonstrably interested in working toward solutions, then maybe. Nevertheless, the narrower potential climate alliance would still be able to achieve a great deal in advance of what might become greater cooperation with others over time, with rolling participation. Perhaps the final lesson of COVID is that when the carnage becomes palpable and affects large constituencies, populations demand action.

## The Energy Challenge

The term “fossil fuel” is something of a misnomer. “Fossil” refers to a relic or remnant of life from a previous geological age.<sup>12</sup> But most people think of fossils as traces, usually embedded in stone, of elements from the Earth’s past that are familiar in our present—footprints of hominids, dinosaur skeletons (familiar from museum visits and cartoons, at least), seashells, and so on. (Fossil derives from the Latin term *fossilis*, for digging in the ground.) Oil is an imperfect record in this regard, not readily allowing those who engage with it to learn, visibly, from remnants of past life on Earth. (Coal has offered more; from the nineteenth century on, miners regularly came across impressions of fernlike plants, or prehistoric organisms, embedded in the coal they stripped from mines deep in the ground.) Nonetheless, just as the fossil record has helped teach humanity about the myriad species that preceded it, we can benefit from the experience of fossil fuels in unexpected ways. Yes, these hydrocarbons connect us with the deep past, helping us to understand the traces of carbon-based life that lie amid planetary geology, remnants of vastly different habitats and meteorologic conditions (e.g., ice ages). The best way we can learn from fossil fuels, however, is mainly by moving on from them. The accumulated energy of oil, gas, and coal has shown humanity what can be achieved with immense power, ably directed on demand. Numerous technological, cultural, and political innovations have been made possible by levels of energy production that previous societies could only have dreamed of. Yet this carbon binge has helped create an odd, secular geological version of impending apocalypse. Somehow there needs to be a surge of extremely low-carbon energy infrastructure, decoupled from the carbon gyre, in order to keep the planet from experiencing an inconvenient climate Armageddon.

The broad contours of the challenge are clear, but this moment arrives at a time of mind-bending difficulty and complexity. Is it possible to come together as a species and reorient the thermodynamic profile of our industrious economic systems at a time of

such geopolitical turmoil and updated Great Game-style competition? How can policymakers re-create a sustainable system of energy use, production, consumption, and exchange during at least one war in Europe, another in the Middle East, ritualistic tit-for-tat strikes exchanged between longtime enemies and nuclear weapons states India and Pakistan, and the ongoing pull of devastating conflict over the continued independence of Taiwan?

Despite the apparent lack of urgency in public life in the industrialized world, societies will probably arrive at a tipping point within about a decade. Much of the United States remains distracted or in denial about the titanic, though slow-burn threat of global heating. In this context, it is intriguing to note that the Pentagon's focus, by contrast, has been unwavering for nearly two decades, depicted in author Michael Klare's (2019) *All Hell Breaking Loose: The Pentagon's Perspective on Climate Change*. Although initially slow to recognize the enormity of the implications domestically and internationally, the Pentagon's military leadership has been focused on climate threats since 2007.<sup>13</sup> Ever since, the military's upper echelons have recognized climate change as not only imperiling US communities and undermining the military's own ability to respond to as well as complete its missions; the top brass sees global heating as a threat multiplier—one that is able to help trigger regional conflicts and then worsen the prospect of resolving those conflicts. Competition over scarce water resources in the Middle East is a prime illustration, offering a fine, though regrettable example of how global heating could help start shooting wars and then make them much more difficult to snuff out. A 2006–10 drought in Syria devastated agricultural production—with massive crop failure, up to 75 percent in some areas, and losses of about 85 percent of livestock for some herders—and this not only impacted food provision while exacerbating social and political tensions but also led to the displacement of 1–1.5 million rural Syrians to cities like Aleppo and Damascus.<sup>14</sup> Global heating was not the sole cause of tensions in Syria. The draconian Assad regime and its corruption-ridden control via the Alawite minority, not to

mention Damascus's decision to offer little relief or climate adaptation to affected citizens, were unpopular with many Syrians; there was a contagion effect from the wider Arab Spring unrest as well.<sup>15</sup> But the drought, worsened by global heating, acted as either a primary stressor or accelerator; the tensions that flared from 2010 on and led to a brutal civil war influenced the Assad regime's collapse in public support, along with a rebel-led coup in 2024 that installed an interim government eager to distinguish itself from the Assads.<sup>16</sup> Water is a necessity, of course, not a luxury or choice, and in a warming world this precious resource will be put under much greater pressure.

At any rate, the contrast between the armed service top brass's persistent frankness about climate change and the hostile, doctrinaire stance of Republican politicians, notably during the first Trump administration, provides a telling portrayal of the dysfunction of the contemporary US system regarding climate heating and the environment while helping to demonstrate the absurdity of denialism.<sup>17</sup> Recall that during the period depicted, the Pentagon leadership was openly contradicting its own commander in chief, a stark message in itself. A top general would only take this kind of step if they believed that it was a mission critical issue, a strategic imperative, and that they were duty bound to speak unvarnished truth to power in order to avoid degrading the nation's ability to defend itself in the face of such challenges. The book's title, *All Hell Breaking Loose*, refers to a war game that depicts a nation hobbled by cascading climate damage at home, with bases mired in damage and competing domestic priorities, but compelled at the same time to launch missions overseas to rectify escalating situations created by global heating.<sup>18</sup> Be that as it may, Klare's portrayal of the awkward, sniping debates over these issues provides a sense of how difficult it might be to have evidence-based discussions and analyses over the threats of climate heating in the short and medium term. If so much of the Beltway—that is, Washington, DC—and US political life have been captured by an ideological stance that clashes with and contradicts clear evidence of such

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impending difficulty, the same evidence that has prompted the Pentagon to engage in extensive worst-case scenario planning for planetary chaos, then it will be diabolically hard to navigate the political badlands to find workable solutions, both inside a country and internationally.

It is intriguing to note that throughout this curious period after the pandemic and during the war on Ukraine, when much of the world's attention seems directed away from climate issues even as their concrete effects become more discernible, nuclear has been making progress. The nuclear lobby, which benefits from a great deal of establishment access and elite credibility in many G20 nations, is adept at “talking the talk” and adapting its message. Nuclear boosters regularly make the argument that nuclear power is, unlike its competition, “emissions free” and reliable.<sup>19</sup> Yet to many people in industrialized nations, nuclear had become a fringe part of the climate conversation; much more attention is directed at solar panels and offshore wind turbines, with some sporadic interest in renewable innovations like pumped storage hydropower, tidal power, various forms of heat pumps, and so on. Most climate-related news stories include developments regarding renewables, not nuclear. Nevertheless, in elite circles such as high-profile international meetings (e.g., Davos) and multiparty negotiations, nuclear's promoted climate-mitigating attributes have been and will continue to be persuasive to technocrats and others.

In a stunning development at the COP28 meetings in December 2023, the nuclear lobby and its allies were able to secure a pledge for a staggering 200 percent increase in nuclear by 2050. This was not a one-off. By March 2024, the Biden administration announced an initiative to boost nuclear production and streamline the regulatory process. The plan included a simplified regulatory process and pathway toward swifter approvals of new nuclear power station designs. This was the biggest shift in promoting nuclear in the United States in more than a generation, but the news hardly made a ripple and did not noticeably impact public consciousness of climate policy.<sup>20</sup> Amid the seesaw-like

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