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The Only Long-Range Solution to Climate Change

Climate change is often incorrectly described as an isolated pollution issue. In this flawed framing, humanity has simply made a mistake in its choice of energy sources; the solution entails switching sources and building enough carbon-sucking machines to clear the atmosphere of polluting CO_2. Only the political power of the fossil fuel companies prevents us from adopting this solution and ending our existential environmental crisis.

But techno-fixes (that is, technological solutions that circumvent the need for personal or cultural change) aren't working so far, and likely won't work in the future. That's because fossil fuels will be difficult to replace, and energy usage is central to our collective economic power.

In other words, power is the key to solving climate change—but not necessarily in the way that many pundits claim. Solutions will *not* come just from defeating fossil fuel interests and empowering green entrepreneurs; real climate progress will require the willingness of large swathes of the populace, especially in wealthy countries, to forgo forms of power they currently enjoy: comfort and convenience, the ability to travel far and fast, and the option to easily obtain a wide range of consumer products whose manufacture entails large inputs of energy and natural resources.

This is not a feel-good message, but the longer we postpone grappling with power in this larger sense, the less successful we're likely to be in coming to terms with the climate threat.

The Big Picture: Power and Consequences

Why can there be no climate techno-fix? There are two routes to this conclusion. The first one meanders through the history of humans on Earth, revealing how each new technological or social innovation empowered some people over others, while often imposing a long-term environmental cost. The adoption of agriculture was a milestone on this path: it enabled more people to subsist in any given area, and it led to cities, kings, and slavery; further, in many places, plowing tended to deplete or ruin topsoil, and city-dwellers cut down nearby forests, leading to eventual societal collapse.

But the real show-stopper came much more recently. The adoption of fossil fuels gave humans the biggest jolt of empowerment ever: in just the last two centuries, our global population has grown eight-fold, and so has per capita energy consumption. Our modern way of life—with cars, planes, supermarkets, tractors, trucks, electricity grids, and internet shopping—is the result.

Climate change is the shadow of this recent cavalcade of industriousness, since it results from the burning of fossil fuels, the main enablers of modern civilization. Nevertheless, rapidly increasing population and consumption levels are inherently unsustainable and are bringing about catastrophic environmental impacts on their own, even if we disregard the effects of carbon emissions. The accelerating depletion of resources, increasing loads of chemical pollution, and the hastening loss of wild nature are trends leading us toward ecological collapse, with economic and social collapse no doubt trailing close behind. Ditching fossil fuels will turn these trends around only if we also deal with the issues of population and consumption.

That's the big picture. However, the quest for a climate techno-fix also fails on its own terms—that is, as a painless means of averting climate change while maintaining our current industrial economy and way of life. The rest of this essay deals with this second trail of evidence and logic, which requires a more detailed presentation. So: buckle up. Here we go.

Why Solar Panels Won't Save Consumerism

Most energy analysts regard solar and wind as the best candidates to substitute for fossil fuels in electrical power generation (since nuclear is too expensive and too risky, and would require too much time for build-out; and hydro is capacity constrained). But these "renewables" are not without challenges. While sunlight and wind are themselves renewable, the technologies we use to capture them aren't: they're constructed of non-renewable materials like steel, silicon, concrete, and rare earth minerals, all of which require energy for mining, transport, and transformation. These materials are also depleting, and many will be difficult or impossible to recycle.

Sunlight and wind are intermittent: we cannot control when the sun will shine or the wind will blow. Therefore, to ensure constant availability of power, these sources require some combination of four strategies:

- Energy storage (e.g., with batteries) is useful to balance out day-to-day intermittency, but nearly useless when it comes to seasonal intermittency; also, storing energy costs energy and money.
- Source redundancy (building far more generation capacity than will actually be needed on "good" days, and then connecting far-flung solar and wind farms by way of massive super-grids), is a better solution for seasonal intermittency, but requires substantial infrastructure investment.
- Excess electricity generated at times of peak production can be used to make synthetic fuels (such as hydrogen, ammonia, or methanol),

perhaps using carbon captured from the atmosphere, as a way of storing energy; however, making large amounts of such fuels will again require substantial infrastructure investment, and the process is inherently inefficient.
- Demand management (using electricity when it's available, and curtailing usage when it isn't) is the cheapest way of dealing with intermittency, but it often implies behavioral change or economic sacrifice.

Today the world uses only about 20 percent of its final energy in the form of electricity. The other 80 percent of energy is used in the forms of solid, liquid, and gaseous fuels. A transition away from fossil fuels will entail the electrification of much of that other 80 percent of energy usage, which includes most transportation and key industrial processes. However, many uses of energy, such as aviation and the making of cement for concrete, will be difficult or especially costly to electrify. In principle, the electrification conundrum could be overcome by powering aviation and high-heat industrial processes with synfuels. However, doing this at scale would require a massive infrastructure of pipelines, storage tanks, carbon capture devices, and chemical synthesis plants that would essentially replicate much of our current natural gas and oil supply system.

Machine-based carbon removal and sequestration methods work in the laboratory, but would need staggering levels of investment in order to be deployed at a meaningful scale, and it's unclear who would pay for them. These methods also use a lot of energy, and, when full lifecycle emissions are calculated, it appears that more emissions are often generated than are captured.[1] The best carbon capture-and-sequestration responses appear instead to consist of various methods of ecosystem restoration and soil regeneration. These strategies would also reduce methane and nitrous oxide emissions. But they would require a near-complete rethinking of food systems and land management.

Not long ago I collaborated with a colleague, David Fridley, of the Energy Analysis Program at Lawrence Berkeley National Laboratory, to look closely at what a full transition to a solar-wind economy would mean (our efforts resulted in the book *Our Renewable Future*).[2] We concluded that it will constitute an enormous job, requiring tens of trillions of dollars in investment. In fact, the task may be next to impossible—*if* we attempt to keep the overall level of societal energy use the same, or expand it to fuel further economic growth.[3] David and I concluded:

> We citizens of industrialized nations will have to change our consumption patterns. We will have to use less overall and adapt our use of energy to times and processes that take advantage of intermittent abundance. Mobility will suffer, so we will have to localize aspects of production and consumption. And we may ultimately forgo some things altogether. If some new processes (e.g., solar or hydrogen-sourced chemical plants) are too expensive, they simply won't happen. Our growth-based, globalized, consumption-oriented economy will require significant overhaul.[4]

The essence of the problem with a climate techno-fix is this: nearly everything we need to do to solve global warming (including building new low-emissions electrical generation capacity, and electrifying energy usage) requires energy and money. But society is already using all the energy and money it can muster in order to do the things that society wants and needs to do (extract resources, manufacture products, transport people and materials, provide health care and education, and so on). If we take energy and money away from those activities in order to fund a rapid energy transition on an unprecedented scale, then the economy will contract, people will be thrown out of work, and many folks will be miserable. On the other hand, if we keep doing all those things at the current scale while also rapidly building a massive alternative infrastructure of solar panels, wind turbines, battery banks, super grids, electric cars and trucks, electrified industrial equipment, and synthetic fuel factories, the result will be a big pulse of energy usage that will significantly increase carbon emissions over the short term (10 to 20 years), since the great majority of the energy currently available for the project must be derived from fossil fuels.

It takes energy to make solar panels, wind turbines, electric cars, and new generations of industrial equipment of all kinds. For a car with an internal combustion engine (ICE), 10 percent of lifetime energy usage occurs in the manufacturing stage. For an electric car, roughly 40 percent of energy usage occurs in manufacturing, and emissions during this stage are 15 percent greater than for an ICE car (over the entire lifetime of the e-car, emissions are about half those of the gasoline guzzler). With solar panels and wind turbines, energy inputs and carbon emissions are similarly front-loaded to the manufacturing phase; energy output and emissions reduction (from offsetting other electricity generation) come later. Replacing a very high percentage of our industrial infrastructure and equipment quickly would therefore entail a historically large burst of energy usage and carbon emissions. By undertaking a rapid energy transition, while also maintaining or even expanding current levels of energy usage for the “normal” purpose of economic growth, we would be defeating our goal of reducing emissions now—even though we would be working toward the goal of reducing emissions later.

Many folks nurture the happy illusion that we can do it all—continue to grow the economy while also funding the energy transition—by assuming that the problem is only money (if we find a way to pay for it, then the transition can be undertaken with no sacrifice). This illusion can be maintained only by refusing to acknowledge the stubborn fact that all activity, including building alternative energy generators and carbon capture machinery, requires energy.

The only way out of the dilemma arising from the energy and emissions cost of the transition is to reduce substantially the amount of energy we are using for “normal” economic purposes—for resource extraction, manufacturing, transportation, heating, cooling, and industrial processes—both so that we can use that energy for the transition (building solar panels and electric vehicles), and so that we won’t have to build as much new infrastructure. Increased energy efficiency can help reduce energy usage without giving up energy services, but many machines (LED lights, electric motors) and industrial processes are already highly efficient, and further large efficiency gains in those areas are unlikely. We would achieve an efficiency boost by substituting direct electricity generators (solar and wind) for inherently inefficient heat-to-electricity generators (natural gas and coal power plants); but we would also be introducing new inefficiencies into the system via battery-based electricity storage and hydrogen or synfuels production. In the end, the conclusion is inescapable: actual reductions in energy services would be required in order to transition away from fossil fuels without creating a significant short-term burst of emissions. Some energy and climate analysts other than David Fridley and myself—such as Kevin Anderson, Professor of Energy and Climate Change at the University of Manchester—have reached this same conclusion independently.[5]

Energy is inextricably related to power. Thus, if society voluntarily reduces its energy usage by a significant amount in order to minimize climate impacts, large numbers of people will likely experience this as giving up power in some form—whether physical, social, or economic.

It can't be emphasized too much: energy is essential to all economic activity. An economy can grow continuously only by employing more energy (unless energy efficiency can be increased substantially, and further gains in efficiency can continue to be realized in each succeeding year—a near-impossibility over the long run, since investments in making processes more efficient typically see diminishing returns over time). World leaders demand more economic growth in order to fend off unemployment and other social ills. Thus, in effect, everyone is counting on having more energy in the future, not less.

A few well-meaning analysts and pundits try to avoid the climate-energy-economy dilemma by creating scenarios in which renewable energy saves the day simply by becoming dramatically cheaper than energy from fossil fuels; or by ignoring the real costs of dealing with energy intermittency in solar and wind power generation. Some argue that we have to fight climate change by becoming even more powerful than we already are—by geoengineering the atmosphere and oceans and thus taking full control of the planet, thereby acting like gods.[6] And some business and political leaders simply deny that climate change is a problem; therefore, no action is required. I would argue that all of these people are deluding themselves and others.

Do the Right Thing—Even if It's Hard

Problems ignored usually don't go away. And not all problems can be solved without sacrifice. If minimizing climate change really does require substantially reducing world energy usage, then policy makers should be discussing how to do this fairly and with as little negative impact as possible. The longer we delay that discussion, the fewer palatable options will be left.

The stakes could hardly be higher. If emissions continue, the result will be the failure of ecosystems, massive impacts on economies, widespread human misery and migration, and unpredictable disruptions to political systems. The return of famine as a familiar feature of human existence is a very real likelihood.[7]

It's easy to see why people would wish to avoid giving up social, political, economic, and physical power to the degree that's necessary in order to deal with climate change. Fighting entrenched power is a contentious activity, often a dangerous one. People with power don't like threats to it, and they often fight back.

That's why environmentalists like to choose their battles. The fossil fuel industry is wealthy and formidable, but at least it's an enemy that's easy to identify, and a lot of people already feel critical of the oil and gas companies for a variety of reasons (gasoline is too expensive, oil pipelines cause pollution, and so on).

But not all roadblocks to climate solutions are attributable to the oil companies. The rest of us are also implicated, though to greatly varying degrees depending on where we live and how much we consume. Our whole modern consumerist way of life, the essence of our economic system, is at fault. Unless we're willing to give up some of our power over nature—our power to extract and transform resources and deliver the goods that we have come to rely on—then we're destined to careen from one disaster to the next until our worst fears are realized.

It's understandable why most environmentalists frame global warming the way they do. It makes solutions seem easier to achieve. But if we're just soothing ourselves while failing to actually stave off disaster, or even to understand our problems properly, what's the point?

The only real long-range solution to climate change centers on reining in human physical, social, and economic power dramatically, but in ways that preserve human dignity, autonomy, and solidarity. That's more daunting than any techno-fix. But this route has the singular advantage that, if we follow it intelligently and persistently, we will address a gamut of social and environmental problems at once. In the end, it's the only path to a better, safer future.

[1] June Sekera and Andreas Lichtenberger, "Assessing Carbon Capture: Public Policy, Science, and Societal Need." *Biophysical Economics and Sustainability* volume 5, Article number: 14 (2020); https://link.springer.com/article/10.1007/s41247-020-00080-5

[2] Richard Heinberg and David Fridley, *Our Renewable Future: Laying the Path for 100 Percent Clean Energy.* Washington D.C.: Island Press, 2016. Full text available at www.ourrenewablefuture.org. Accessed September 2, 2020.

[3] Other researchers have come to similar conclusions. For example, Tim Morgan (former head of research at Tullett Prebon) argues that it is surplus energy—the energy left over once energy required for energy-producing activities—that has driven economic expansion, and that a transition to renewables will necessarily result in declining surplus energy (see Tim Morgan, *Surplus Energy Economics* website https://surplusenergyeconomics.wordpress.com/ Accessed September 2, 2020.) In a recent paper, Carey King of the Energy Institute at the University of Texas, Austin, shows the inadequacy of current growth-based economic modeling of the renewable energy transition and proposes a new model that incorporates data-derived relationships between energy use, resource extraction, and economic growth. His conclusion is that the renewable energy transition will entail trade-offs with consumption, population, and wages; these trade-offs will depend on the path taken (whether high or low rate of investment). Carey King, "An Integrated Biophysical and Economic Modeling Framework for Long-Term Sustainability Analysis: The

HARMONY Model." *Ecological Economics,* Vol. 169, March 2020. https://doi.org/10.1016/j.ecolecon.2019.106464 Accessed September 2, 2020.

[4] Heinberg and Fridley, *Our Renewable Future,* p. 140

[5] Kevin Anderson and Alice Bows-Larkin, "Avoiding Dangerous Climate Change Demands De-Growth Strategies from Wealthier Nations." *KevinAnderson.Info,* November 2013. https://kevinanderson.info/blog/avoiding-dangerous-climate-change-demands-de-growth-strategies-from-wealthier-nations/. Accessed September 2, 2020. See also Patrick Moriarty and Damon Honnery, "Can Renewable Energy Power the Future?" *Energy Policy* Vol. 93, June 2016, pp. 3-7. www.sciencedirect.com/science/article/pii/S030142151630088X. Accessed September 2, 2020.

[6] Rachel Kaufman, "The Risks, Rewards and Possible Ramifications of Geoengineering Earth's Climate." *Smithsonian,* March 11, 2019. https://www.smithsonianmag.com/science-nature/risks-rewards-possible-ramifications-geoengineering-earths-climate-180971666/. Accessed September 3, 2020.

[7] Christopher Flavelle, "Climate Change Threatens the World's Food Supply, United Nations Warns." *New York Times,* August 8, 2019. https://www.nytimes.com/2019/08/08/climate/climate-change-food-supply.html Accessed September 3, 2020.