## 1

#### Interpretation: “medicines” is a generic bare plural. The aff may not defend that member nations of the World Trade Organization ought to reduce intellectual property protections for a medicine or subset of medicines.

**Nebel 19**. [Jake Nebel is an assistant professor of philosophy at the University of Southern California and executive director of Victory Briefs. He writes a lot of this stuff lol – duh.] “Genericity on the Standardized Tests Resolution.” Vbriefly. August 12, 2019. <https://www.vbriefly.com/2019/08/12/genericity-on-the-standardized-tests-resolution/?fbclid=IwAR0hUkKdDzHWrNeqEVI7m59pwsnmqLl490n4uRLQTe7bWmWDO_avWCNzi14> TG

Both distinctions are important. Generic resolutions can’t be affirmed by specifying particular instances. But, since generics tolerate exceptions, plan-inclusive counterplans (PICs) do not negate generic resolutions. Bare plurals are typically used to express generic generalizations. But there are two important things to keep in mind. First, generic generalizations are also often expressed via other means (e.g., definite singulars, indefinite singulars, and bare singulars). Second, and more importantly for present purposes, bare plurals can also be used to express existential generalizations. For example, “Birds are singing outside my window” is true just in case there are some birds singing outside my window; it doesn’t require birds in general to be singing outside my window. So, what about “colleges and universities,” “standardized tests,” and “undergraduate admissions decisions”? Are they generic or existential bare plurals? On other topics I have taken great pains to point out that their bare plurals are generic—because, well, they are. On this topic, though, I think the answer is a bit more nuanced. Let’s see why. “Colleges and universities” is a generic bare plural. I don’t think this claim should require any argument, when you think about it, but here are a few reasons. First, ask yourself, honestly, whether the following speech sounds good to you: “Eight colleges and universities—namely, those in the Ivy League—ought not consider standardized tests in undergraduate admissions decisions. Maybe other colleges and universities ought to consider them, but not the Ivies. Therefore, in the United States, colleges and universities ought not consider standardized tests in undergraduate admissions decisions.” That is obviously not a valid argument: the conclusion does not follow. Anyone who sincerely believes that it is valid argument is, to be charitable, deeply confused. But the inference above would be good if “colleges and universities” in the resolution were existential. By way of contrast: “Eight birds are singing outside my window. Maybe lots of birds aren’t singing outside my window, but eight birds are. Therefore, birds are singing outside my window.” Since the bare plural “birds” in the conclusion gets an existential reading, the conclusion follows from the premise that eight birds are singing outside my window: “eight” entails “some.” If the resolution were existential with respect to “colleges and universities,” then the Ivy League argument above would be a valid inference. Since it’s not a valid inference, “colleges and universities” must be a generic bare plural. Second, “colleges and universities” fails the [upward-entailment test](https://plato.stanford.edu/entries/generics/#IsolGeneInte) for existential uses of bare plurals. Consider the sentence, “Lima beans are on my plate.” This sentence expresses an existential statement that is true just in case there are some lima beans on my plate. One test of this is that it entails the more general sentence, “Beans are on my plate.” Now consider the sentence, “Colleges and universities ought not consider the SAT.” (To isolate “colleges and universities,” I’ve eliminated the other bare plurals in the resolution; it cannot plausibly be generic in the isolated case but existential in the resolution.) This sentence does not entail the more general statement that educational institutions ought not consider the SAT. This shows that “colleges and universities” is generic, because it fails the upward-entailment test for existential bare plurals. Third, “colleges and universities” fails the adverb of quantification test for existential bare plurals. Consider the sentence, “Dogs are barking outside my window.” This sentence expresses an existential statement that is true just in case there are some dogs barking outside my window. One test of this appeals to the drastic change of meaning caused by inserting any adverb of quantification (e.g., always, sometimes, generally, often, seldom, never, ever). You cannot add any such adverb into the sentence without drastically changing its meaning. To apply this test to the resolution, let’s again isolate the bare plural subject: “Colleges and universities ought not consider the SAT.” Adding generally (“Colleges and universitiesz generally ought not consider the SAT”) or ever (“Colleges and universities ought not ever consider the SAT”) result in comparatively minor changes of meaning. (Note that this test doesn’t require there to be no change of meaning and doesn’t have to work for every adverb of quantification.) This strongly suggests what we already know: that “colleges and universities” is generic rather than existential in the resolution.

**Violation: They spec \_\_\_\_\_\_**

**Standards:**

#### [1] Semantics are a constraint on voting aff:

#### [A] Jurisdiction:

#### [B] stasis point:

**[2] precision –**

**[3] Limits and ground –**

**[4] TVA solves –**

## 2

#### Interpretation – the aff must disclose the advocacy text and framework text 30 minutes before the round.

#### Violation in the doc

Graphical user interface, text, application, chat or text message

Description automatically generated

#### First is prep and clash—

#### Second is academic integrity –

#### And you put “If I don't meet your disclosure practices, let me know so I can adjust.” On ur wiki. this means u reject any counter standard since u know disclosing is good yet u still didnt it,

## 3

#### Uniqueness: Industrial society and a growing population of humans make extinction inevitable- famine, biodiversity loss, and much more.

Corey J. A Bradshaw et al (16 other people), January 13, 2021, frontiers in conservation science, “Underestimating the Challenges of Avoiding a Ghastly Future”, [https://www.frontiersin.org/articles/10.3389/fcosc.2020.615419/full] mc

Humanity is causing a rapid loss of biodiversity and, with it, Earth's ability to support complex life. But the mainstream is having difficulty grasping the magnitude of this loss, despite the steady erosion of the fabric of human civilization (Ceballos et al., 2015; IPBES, 2019; Convention on Biological Diversity, 2020; WWF, 2020). While suggested solutions abound (Díaz et al., 2019), the current scale of their implementation does not match the relentless progression of biodiversity loss (Cumming et al., 2006) and other existential threats tied to the continuous expansion of the human enterprise (Rees, 2020). Time delays between ecological deterioration and socio-economic penalties, as with climate disruption for example (IPCC, 2014), impede recognition of the magnitude of the challenge and timely counteraction needed. In addition, disciplinary specialization and insularity encourage unfamiliarity with the complex adaptive systems (Levin, 1999) in which problems and their potential solutions are embedded (Selby, 2006; Brand and Karvonen, 2007). Widespread ignorance of human behavior (Van Bavel et al., 2020) and the incremental nature of socio-political processes that plan and implement solutions further delay effective action (Shanley and López, 2009; King, 2016). We summarize the state of the natural world in stark form here to help clarify the gravity of the human predicament. We also outline likely future trends in biodiversity decline (Díaz et al., 2019), climate disruption (Ripple et al., 2020), and human consumption and population growth to demonstrate the near certainty that these problems will worsen over the coming decades, with negative impacts for centuries to come. Finally, we discuss the ineffectiveness of current and planned actions that are attempting to address the ominous erosion of Earth's life-support system. Ours is not a call to surrender—we aim to provide leaders with a realistic “cold shower” of the state of the planet that is essential for planning to avoid a ghastly future. Biodiversity Loss Major changes in the biosphere are directly linked to the growth of human systems (summarized in Figure 1). While the rapid loss of species and populations differs regionally in intensity (Ceballos et al., 2015, 2017, 2020; Díaz et al., 2019), and most species have not been adequately assessed for extinction risk (Webb and Mindel, 2015), certain global trends are obvious. Since the start of agriculture around 11,000 years ago, the biomass of terrestrial vegetation has been halved (Erb et al., 2018), with a corresponding loss of >20% of its original biodiversity (Díaz et al., 2019), together denoting that >70% of the Earth's land surface has been altered by Homo sapiens (IPBES, 2019). There have been >700 documented vertebrate (Díaz et al., 2019) and ~600 plant (Humphreys et al., 2019) species extinctions over the past 500 years, with many more species clearly having gone extinct unrecorded (Tedesco et al., 2014). Population sizes of vertebrate species that have been monitored across years have declined by an average of 68% over the last five decades (WWF, 2020), with certain population clusters in extreme decline (Leung et al., 2020), thus presaging the imminent extinction of their species (Ceballos et al., 2020). Overall, perhaps 1 million species are threatened with extinction in the near future out of an estimated 7–10 million eukaryotic species on the planet (Mora et al., 2011), with around 40% of plants alone considered endangered (Antonelli et al., 2020). Today, the global biomass of wild mammals is <25% of that estimated for the Late Pleistocene (Bar-On et al., 2018), while insects are also disappearing rapidly in many regions (Wagner, 2020; reviews in van Klink et al., 2020). Freshwater and marine environments have also been severely damaged. Today there is <15% of the original wetland area globally than was present 300 years ago (Davidson, 2014), and >75% of rivers >1,000 km long no longer flow freely along their entire course (Grill et al., 2019). More than two-thirds of the oceans have been compromised to some extent by human activities (Halpern et al., 2015), live coral cover on reefs has halved in <200 years (Frieler et al., 2013), seagrass extent has been decreasing by 10% per decade over the last century (Waycott et al., 2009; Díaz et al., 2019), kelp forests have declined by ~40% (Krumhansl et al., 2016), and the biomass of large predatory fishes is now <33% of what it was last century (Christensen et al., 2014). With such a rapid, catastrophic loss of biodiversity, the ecosystem services it provides have also declined. These include inter alia reduced carbon sequestration (Heath et al., 2005; Lal, 2008), reduced pollination (Potts et al., 2016), soil degradation (Lal, 2015), poorer water and air quality (Smith et al., 2013), more frequent and intense flooding (Bradshaw et al., 2007; Hinkel et al., 2014) and fires (Boer et al., 2020; Bowman et al., 2020), and compromised human health (Díaz et al., 2006; Bradshaw et al., 2019). As telling indicators of how much biomass humanity has transferred from natural ecosystems to our own use, of the estimated 0.17 Gt of living biomass of terrestrial vertebrates on Earth today, most is represented by livestock (59%) and human beings (36%)—only ~5% of this total biomass is made up by wild mammals, birds, reptiles, and amphibians (Bar-On et al., 2018). As of 2020, the overall material output of human endeavor exceeds the sum of all living biomass on Earth (Elhacham et al., 2020). Sixth Mass Extinction A mass extinction is defined as a loss of ~75% of all species on the planet over a geologically short interval—generally anything <3 million years (Jablonski et al., 1994; Barnosky et al., 2011). At least five major extinction events have occurred since the Cambrian (Sodhi et al., 2009), the most recent of them 66 million years ago at the close of the Cretaceous period. The background rate of extinction since then has been 0.1 extinctions million species−1 year−1 (Ceballos et al., 2015), while estimates of today's extinction rate are orders of magnitude greater (Lamkin and Miller, 2016). Recorded vertebrate extinctions since the 16th century—the mere tip of the true extinction iceberg—give a rate of extinction of 1.3 species year−1, which is conservatively >15 times the background rate (Ceballos et al., 2015). The IUCN estimates that some 20% of all species are in danger of extinction over the next few decades, which greatly exceeds the background rate. That we are already on the path of a sixth major extinction is now scientifically undeniable (Barnosky et al., 2011; Ceballos et al., 2015, 2017). Ecological Overshoot: Population Size and Overconsumption The global human population has approximately doubled since 1970, reaching nearly 7.8 billion people today (prb.org). While some countries have stopped growing and even declined in size, world average fertility continues to be above replacement (2.3 children woman−1), with an average of 4.8 children woman−1 in Sub-Saharan Africa and fertilities >4 children woman−1 in many other countries (e.g., Afghanistan, Yemen, Timor-Leste). The 1.1 billion people today in Sub-Saharan Africa—a region expected to experience particularly harsh repercussions from climate change (Serdeczny et al., 2017)—is projected to double over the next 30 years. By 2050, the world population will likely grow to ~9.9 billion (prb.org), with growth projected by many to continue until well into the next century (Bradshaw and Brook, 2014; Gerland et al., 2014), although more recent estimates predict a peak toward the end of this century (Vollset et al., 2020). Large population size and continued growth are implicated in many societal problems. The impact of population growth, combined with an imperfect distribution of resources, leads to massive food insecurity. By some estimates, 700–800 million people are starving and 1–2 billion are micronutrient-malnourished and unable to function fully, with prospects of many more food problems in the near future (Ehrlich and Harte, 2015a,b). Large populations and their continued growth are also drivers of soil degradation and biodiversity loss (Pimm et al., 2014). More people means that more synthetic compounds and dangerous throw-away plastics (Vethaak and Leslie, 2016) are manufactured, many of which add to the growing toxification of the Earth (Cribb, 2014). It also increases chances of pandemics (Daily and Ehrlich, 1996b) that fuel ever-more desperate hunts for scarce resources (Klare, 2012). Population growth is also a factor in many social ills, from crowding and joblessness, to deteriorating infrastructure and bad governance (Harte, 2007). There is mounting evidence that when populations are large and growing fast, they can be the sparks for both internal and international conflicts that lead to war (Klare, 2001; Toon et al., 2007). The multiple, interacting causes of civil war in particular are varied, including poverty, inequality, weak institutions, political grievance, ethnic divisions, and environmental stressors such as drought, deforestation, and land degradation (Homer-Dixon, 1991, 1999; Collier and Hoeer, 1998; Hauge and llingsen, 1998; Fearon and Laitin, 2003; Brückner, 2010; Acemoglu et al., 2017). Population growth itself can even increase the probability of military involvement in conflicts (Tir and Diehl, 1998). Countries with higher population growth rates experienced more social conflict since the Second World War (Acemoglu et al., 2017). In that study, an approximate doubling of a country's population caused about four additional years of full-blown civil war or low-intensity conflict in the 1980s relative to the 1940–1950s, even after controlling for a country's income-level, independence, and age structure. Simultaneous with population growth, humanity's consumption as a fraction of Earth's regenerative capacity has grown from ~ 73% in 1960 to 170% in 2016 (Lin et al., 2018), with substantially greater per-person consumption in countries with highest income. With COVID-19, this overshoot dropped to 56% above Earth's regenerative capacity, which means that between January and August 2020, humanity consumed as much as Earth can renew in the entire year (overshootday.org). While inequality among people and countries remains staggering, the global middle class has grown rapidly and exceeded half the human population by 2018 (Kharas and Hamel, 2018). Over 70% of all people currently live in countries that run a biocapacity deficit while also having less than world-average income, excluding them from compensating their biocapacity deficit through purchases (Wackernagel et al., 2019) and eroding future resilience via reduced food security (Ehrlich and Harte, 2015b). The consumption rates of high-income countries continue to be substantially higher than low-income countries, with many of the latter even experiencing declines in per-capita footprint (Dasgupta and Ehrlich, 2013; Wackernagel et al., 2019).

#### Link: Nuclear war would collapse civilization through nuclear famine but ensure that a number of humans survive.

Shaun Tandon, December 10, 2013, PHYS ORG, “Nuclear war would 'end civilization' with famine, study says”, [https://phys.org/news/2013-12-nuclear-war-civilization-famine.html] mc

A nuclear war between India and Pakistan would set off a global famine that could kill two billion people and effectively end human civilization, a study said Tuesday. Even if limited in scope, a conflict with nuclear weapons would wreak havoc in the atmosphere and devastate crop yields, with the effects multiplied as global food markets went into turmoil, the report said. The Nobel Peace Prize-winning International Physicians for the Prevention of Nuclear War and Physicians for Social Responsibility released an initial peer-reviewed study in April 2012 that predicted a nuclear famine could kill more than a billion people. In a second edition, the groups said they widely underestimated the impact in China and calculated that the world's most populous country would face severe food insecurity. "A billion people dead in the developing world is obviously a catastrophe unparalleled in human history. But then if you add to that the possibility of another 1.3 billion people in China being at risk, we are entering something that is clearly the end of civilization," said Ira Helfand, the report's author. Helfand said that the study looked at India and Pakistan due to the longstanding tensions between the nuclear-armed states, which have fought three full-fledged wars since independence and partition in 1947. But Helfand said that the planet would expect a similar apocalyptic impact from any limited nuclear war. Modern nuclear weapons are far more powerful than the US bombs that killed more than 200,000 people in Hiroshima and Nagasaki in 1945. "With a large war between the United States and Russia, we are talking about the possible—not certain, but possible—extinction of the human race. "In this kind of war, biologically there are going to be people surviving somewhere on the planet but the chaos that would result from this will dwarf anything we've ever seen," Helfand said. The study said that the black carbon aerosol particles kicked into the atmosphere by a South Asian nuclear war would reduce US corn and soybean production by around 10 percent over a decade. The particles would also reduce China's rice production by an average of 21 percent over four years and by another 10 percent over the following six years. The updated study also found severe effects on China's wheat, which is vital to the country despite its association with rice. China's wheat production would plunge by 50 percent the first year after the nuclear war and would still be 31 percent below baseline a decade later, it said. The study said it was impossible to estimate the exact impact of nuclear war. He called for further research, voicing alarm that policymakers in nuclear powers were not looking more thoroughly at the idea of a nuclear famine.

#### Internal Link: Isolated island populations repopulate Earth solves nuclear winter led extinction.

Turchin and Green 18 (Alexey Turchin – Scientist for the Foundation Science for Life Extension in Moscow, Russia, Founder of Digital Immortality Now, author of several books and articles on the topics of existential risks and life extension. Brian Patrick Green – Director of technology ethics at the Markkula Center for Applied Ethics, teaches AI ethics in the Graduate School of Engineering at Santa Clara University. <MKIM> “Islands as refuges for surviving global catastrophes”. September 2018. DOA: 7/20/19. https://www.emerald.com/insight/content/doi/10.1108/FS-04-2018-0031/full/html?fullSc=1&mbSc=1&fullSc=1)

Different types of possible catastrophes suggest different scenarios for how survival could happen on an island. What is important is that the island should have properties which protect against the specific dangers of particular global catastrophic risks. Specifically, different islands will provide protection against different risks, and their natural diversity will contribute to a higher total level of protection: Quarantined island survives pandemic . An island could impose effective quarantine if it is sufficiently remote and simultaneously able to protect itself, possibly using military ships and air defense. Far northern aboriginal people survive an ice age. Many far northern people have adapted to survive in extremely cold and dangerous environments, and under the right circumstances could potentially survive the return of an ice age. However, their cultures are endangered by globalization. If these people become dependent on the products of modern civilization, such as rifles and motor boats, and lose their native survival skills, then their likelihood of surviving the collapse of the outside world would decrease. Therefore, preservation of their survival skills may be important as a defense against the risks connected with extreme cooling. Remote polar island with high mountains survives brief global warming of median surface temperatures, up to 50˚C. There is a theory that the climates of planets similar to the Earth could have several semi-stable temperature levels (Popp et al., 2016). If so, because of climate change, the Earth could transition to a second semi-stable state with a median global temperature of around 330 K, about 60˚C, or about 45˚C above current global mean temperatures. But even in this climate, some regions of Earth could still be survivable for humans, such as the Himalayan plateau at elevations above 4,000 m, but below 6,000 (where oxygen deficiency becomes a problem), or on polar islands with mountains (however, global warming affects polar regions more than equatorial regions, and northern island will experience more effects of climate change, including thawing permafrost and possible landslides because of wetter weather). In the tropics, the combination of increased humidity and temperature may increase the wet bulb temperature above 36˚C, especially on islands, where sea moisture is readily available. In such conditions, proper human perspiration becomes impossible (Sherwood and Huber, 2010), and there will likely be increased mortality and morbidity because of tropical diseases. If temperatures later returned to normal – either naturally or through climate engineering – the rest of the Earth could be repopulated. ‘‘Swiss Family Robinsons’’ survive on a tropical island, unnoticed by a military robot ‘‘mutiny’’. Most AI researchers ignore medium-term AI risks, which are neither near-term risks, like unemployment, nor remote risks, like AI superintelligence. But a large drone army – if one were produced – could receive a wrong command or be infected by a computer virus, leading it to attack people indiscriminately. Remote islands without robots could provide protection in this case, allowing survival until such a drone army ran out of batteries, fuel, ammunition or other supplies: Primitive tribe survives civilizational collapse. The inhabitants of North Sentinel Island, near the Andaman Islands in the Indian Ocean, are hostile and uncontacted. The Sentinelese survived the 2004 Indian Ocean tsunami apparently unaffected (Voanews, 2009), and if the rest of humanity disappear, they might well continue their existence without change. Tropical Island survives extreme global nuclear winter and glaciation event. Were a nuclear, bolide impactor or volcanic “winter” scenario to unfold, these islands would remain surrounded by Warm Ocean, and local volcanism or other energy sources might provide heat, energy and food. Such island refuges may have helped life on Earth survive during the “Snowball Earth” event in Earth’s distant past (Hoffman et al., 1998). Remote island base for project “Yellow submarine”. Some catastrophic risks such as a gamma ray burst, a global nuclear war with high radiological contamination or multiple pandemics might be best survived underwater in nuclear submarines (Turchin and Green, 2017). However, after a catastrophe, the submarine with survivors would eventually need a place to dock, and an island with some prepared amenities would be a reasonable starting point for rebuilding civilization. Bunker on remote island. For risks which include multiple or complex catastrophes, such as a bolide impact, extreme volcanism, tsunamis, multiple pandemics and nuclear war with radiological contamination, island refuges could be strengthened with bunkers. Richard Branson survived hurricane Irma on his own island in 2017 by seeking refuge in his concrete wine cellar (Clifford, 2017). Bunkers on islands would have higher survivability compared to those close to population centers, as they will be neither a military target nor as accessible to looters or unintentionally dangerous (e.g. infected) refugees. These bunkers could potentially be connected to water sources by underwater pipes, and passages could provide cooling, access

#### Impact: Industrial civilization wouldn’t recover.

Lewis **Dartnell 15**. UK Space Agency research fellow at the University of Leicester, working in astrobiology and the search for microbial life on Mars. His latest book is The Knowledge: How to Rebuild Our World from Scratch. 04-13-15. "Could we reboot a modern civilisation without fossil fuels? – Lewis Dartnell." Aeon. https://aeon.co/essays/could-we-reboot-a-modern-civilisation-without-fossil-fuels

Imagine that the world as we know it ends tomorrow. There’s a global catastrophe: a pandemic virus, an asteroid strike, or perhaps a nuclear holocaust. The vast majority of the human race perishes. Our civilisation collapses. The post-apocalyptic survivors find themselves in a devastated world of decaying, deserted cities and roving gangs of bandits looting and taking by force. Bad as things sound, that’s not the end for humanity. We bounce back. Sooner or later, peace and order emerge again, just as they have time and again through history. Stable communities take shape. They begin the agonising process of rebuilding their technological base from scratch. But here’s the question: how far could such a society rebuild? Is there any chance, for instance, that a post-apocalyptic society could reboot a technological civilisation? Let’s make the basis of this thought experiment a little more specific. Today, we have already consumed the most easily drainable crude oil and, particularly in Britain, much of the shallowest, most readily mined deposits of coal. Fossil fuels are central to the organisation of modern industrial society, just as they were central to its development. Those, by the way, are distinct roles: even if we could somehow do without fossil fuels now (which we can’t, quite), it’s a different question whether we could have got to where we are without ever having had them. So, would a society starting over on a planet stripped of its fossil fuel deposits have the chance to progress through its own Industrial Revolution? Or to phrase it another way, what might have happened if, for whatever reason, the Earth had never acquired its extensive underground deposits of coal and oil in the first place? Would our progress necessarily have halted in the 18th century, in a pre-industrial state? It’s easy to underestimate our current dependence on fossil fuels. In everyday life, their most visible use is the petrol or diesel pumped into the vehicles that fill our roads, and the coal and natural gas which fire the power stations that electrify our modern lives. But we also rely on a range of different industrial materials, and in most cases, high temperatures are required to transform the stuff we dig out of the ground or harvest from the landscape into something useful. You can’t smelt metal, make glass, roast the ingredients of concrete, or synthesise artificial fertiliser without a lot of heat. It is fossil fuels – coal, gas and oil – that provide most of this thermal energy. In fact, the problem is even worse than that. Many of the chemicals required in bulk to run the modern world, from pesticides to plastics, derive from the diverse organic compounds in crude oil. Given the dwindling reserves of crude oil left in the world, it could be argued that the most wasteful use for this limited resource is to simply burn it. We should be carefully preserving what’s left for the vital repertoire of valuable organic compounds it offers. But my topic here is not what we should do now. Presumably everybody knows that we must transition to a low-carbon economy one way or another. No, I want to answer a question whose interest is (let’s hope) more theoretical. Is the emergence of a technologically advanced civilisation necessarily contingent on the easy availability of ancient energy? Is it possible to build an industrialised civilisation without fossil fuels? And the answer to that question is: maybe – but it would be extremely difficult. Let’s see how. We’ll start with a natural thought. Many of our alternative energy technologies are already highly developed. Solar panels, for example, represent a good option today, and are appearing more and more on the roofs of houses and businesses. It’s tempting to think that a rebooted society could simply pick up where we leave off. Why couldn’t our civilisation 2.0 just start with renewables? Well, it could, in a very limited way. If you find yourself among the survivors in a post-apocalyptic world, you could scavenge enough working solar panels to keep your lifestyle electrified for a good long while. Without moving parts, photovoltaic cells require little maintenance and are remarkably resilient. They do deteriorate over time, though, from moisture penetrating the casing and from sunlight itself degrading the high-purity silicon layers. The electricity generated by a solar panel declines by about 1 per cent every year so, after a few generations, all our hand-me-down solar panels will have degraded to the point of uselessness. Then what? New ones would be fiendishly difficult to create from scratch. Solar panels are made from thin slices of extremely pure silicon, and although the raw material is common sand, it must be processed and refined using complex and precise techniques – the same technological capabilities, more or less, that we need for modern semiconductor electronics components. These techniques took a long time to develop, and would presumably take a long time to recover. So photovoltaic solar power would not be within the capability of a society early in the industrialisation process. Perhaps, though, we were on the right track by starting with electrical power. Most of our renewable-energy technologies produce electricity. In our own historical development, it so happens that the core phenomena of electricity were discovered in the first half of the 1800s, well after the early development of steam engines. Heavy industry was already committed to combustion-based machinery, and electricity has largely assumed a subsidiary role in the organisation of our economies ever since. But could that sequence have run the other way? Is there some developmental requirement that thermal energy must come first? On the face of it, it’s not beyond the bounds of possibility that a progressing society could construct electrical generators and couple them to simple windmills and waterwheels, later progressing to wind turbines and hydroelectric dams. In a world without fossil fuels, one might envisage an electrified civilisation that largely bypasses combustion engines, building its transport infrastructure around electric trains and trams for long-distance and urban transport. I say ‘largely’. We couldn’t get round it all together. When it comes to generating the white heat demanded by modern industry, there are few good options but to burn stuff While the electric motor could perhaps replace the coal-burning steam engine for mechanical applications, society, as we’ve already seen, also relies upon thermal energy to drive the essential chemical and physical transformations it needs. How could an industrialising society produce crucial building materials such as iron and steel, brick, mortar, cement and glass without resorting to deposits of coal? You can of course create heat from electricity. We already use electric ovens and kilns. Modern arc furnaces are used for producing cast iron or recycling steel. The problem isn’t so much that electricity can’t be used to heat things, but that for meaningful industrial activity you’ve got to generate prodigious amounts of it, which is challenging using only renewable energy sources such as wind and water. An alternative is to generate high temperatures using solar power directly. Rather than relying on photovoltaic panels, concentrated solar thermal farms use giant mirrors to focus the sun’s rays onto a small spot. The heat concentrated in this way can be exploited to drive certain chemical or industrial processes, or else to raise steam and drive a generator. Even so, it is difficult (for example) to produce the very high temperatures inside an iron-smelting blast furnace using such a system. What’s more, it goes without saying that the effectiveness of concentrated solar power depends strongly on the local climate. No, when it comes to generating the white heat demanded by modern industry, there are few good options but to burn stuff. But that doesn’t mean the stuff we burn necessarily has to be fossil fuels. Let’s take a quick detour into the pre-history of modern industry. Long before the adoption of coal, charcoal was widely used for smelting metals. In many respects it is superior: charcoal burns hotter than coal and contains far fewer impurities. In fact, coal’s impurities were a major delaying factor on the Industrial Revolution. Released during combustion, they can taint the product being heated. During smelting, sulphur contaminants can soak into the molten iron, making the metal brittle and unsafe to use. It took a long time to work out how to treat coal to make it useful for many industrial applications. And, in the meantime, charcoal worked perfectly well. And then, well, we stopped using it. In retrospect, that’s a pity. When it comes from a sustainable source, charcoal burning is essentially carbon-neutral, because it doesn’t release any new carbon into the atmosphere – not that this would have been a consideration for the early industrialists. But charcoal-based industry didn’t die out altogether. In fact, it survived to flourish in Brazil. Because it has substantial iron deposits but few coalmines, Brazil is the largest charcoal producer in the world and the ninth biggest steel producer. We aren’t talking about a cottage industry here, and this makes Brazil a very encouraging example for our thought experiment. The trees used in Brazil’s charcoal industry are mainly fast-growing eucalyptus, cultivated specifically for the purpose. The traditional method for creating charcoal is to pile chopped staves of air-dried timber into a great dome-shaped mound and then cover it with turf or soil to restrict airflow as the wood smoulders. The Brazilian enterprise has scaled up this traditional craft to an industrial operation. Dried timber is stacked into squat, cylindrical kilns, built of brick or masonry and arranged in long lines so that they can be easily filled and unloaded in sequence. The largest sites can sport hundreds of such kilns. Once filled, their entrances are sealed and a fire is lit from the top. The skill in charcoal production is to allow just enough air into the interior of the kiln. There must be enough combustion heat to drive out moisture and volatiles and to pyrolyse the wood, but not so much that you are left with nothing but a pile of ashes. The kiln attendant monitors the state of the burn by carefully watching the smoke seeping out of the top, opening air holes or sealing with clay as necessary to regulate the process. Brazil shows how the raw materials of modern civilisation can be supplied without reliance on fossil fuels Good things come to those who wait, and this wood pyrolysis process can take up to a week of carefully controlled smouldering. The same basic method has been used for millennia. However, the ends to which the fuel is put are distinctly modern. Brazilian charcoal is trucked out of the forests to the country’s blast furnaces where it is used to transform ore into pig iron. This pig iron is the basic ingredient of modern mass-produced steel. The Brazilian product is exported to countries such as China and the US where it becomes cars and trucks, sinks, bathtubs, and kitchen appliances. Around two-thirds of Brazilian charcoal comes from sustainable plantations, and so this modern-day practice has been dubbed ‘green steel’. Sadly, the final third is supplied by the non-sustainable felling of primary forest. Even so, the Brazilian case does provide an example of how the raw materials of modern civilisation can be supplied without reliance on fossil fuels. Another, related option might be wood gasification. The use of wood to provide heat is as old as mankind, and yet simply burning timber only uses about a third of its energy. The rest is lost when gases and vapours released by the burning process blow away in the wind. Under the right conditions, even smoke is combustible. We don’t want to waste it. Better than simple burning, then, is to drive the thermal breakdown of the wood and collect the gases. You can see the basic principle at work for yourself just by lighting a match. The luminous flame isn’t actually touching the matchwood: it dances above, with a clear gap in between. The flame actually feeds on the hot gases given off as the wood breaks down in the heat, and the gases combust only once they mix with oxygen from the air. Matches are fascinating when you look at them closely. Wartime gasifier cars could achieve about 1.5 miles per kilogram. Today’s designs improve upon this To release these gases in a controlled way, bake some timber in a closed container. Oxygen is restricted so that the wood doesn’t simply catch fire. Its complex molecules decompose through a process known as pyrolysis, and then the hot carbonised lumps of charcoal at the bottom of the container react with the breakdown products to produce flammable gases such as hydrogen and carbon monoxide. The resultant ‘producer gas’ is a versatile fuel: it can be stored or piped for use in heating or street lights, and is also suitable for use in complex machinery such as the internal combustion engine. More than a million gasifier-powered cars across the world kept civilian transport running during the oil shortages of the Second World War. In occupied Denmark, 95 per cent of all tractors, trucks and fishing boats were powered by wood-gas generators. The energy content of about 3 kg of wood (depending on its dryness and density) is equivalent to a litre of petrol, and the fuel consumption of a gasifier-powered car is given in miles per kilogram of wood rather than miles per gallon. Wartime gasifier cars could achieve about 1.5 miles per kilogram. Today’s designs improve upon this. But you can do a lot more with wood gases than just keep your vehicle on the road. It turns out to be suitable for any of the manufacturing processes needing heat that we looked at before, such as kilns for lime, cement or bricks. Wood gas generator units could easily power agricultural or industrial equipment, or pumps. Sweden and Denmark are world leaders in their use of sustainable forests and agricultural waste for turning the steam turbines in power stations. And once the steam has been used in their ‘Combined Heat and Power’ (CHP) electricity plants, it is piped to the surrounding towns and industries to heat them, allowing such CHP stations to approach 90 per cent energy efficiency. Such plants suggest a marvellous vision of industry wholly weaned from its dependency on fossil fuel. Is that our solution, then? Could our rebooting society run on wood, supplemented with electricity from renewable sources? Maybe so, if the population was fairly small. But here’s the catch. These options all presuppose that our survivors are able to construct efficient steam turbines, CHP stations and internal combustion engines. We know how to do all that, of course – but in the event of a civilisational collapse, who is to say that the knowledge won’t be lost? And if it is, what are the chances that our descendants could reconstruct it? In our own history, the first successful application of steam engines was in pumping out coal mines. This was a setting in which fuel was already abundant, so it didn’t matter that the first, primitive designs were terribly inefficient. The increased output of coal from the mines was used to first smelt and then forge more iron. Iron components were used to construct further steam engines, which were in turn used to pump mines or drive the blast furnaces at iron foundries. And of course, steam engines were themselves employed at machine shops to construct yet more steam engines. It was only once steam engines were being built and operated that subsequent engineers were able to devise ways to increase their efficiency and shrink fuel demands. They found ways to reduce their size and weight, adapting them for applications in transport or factory machinery. In other words, there was a positive feedback loop at the very core of the industrial revolution: the production of coal, iron and steam engines were all mutually supportive. In a world without readily mined coal, would there ever be the opportunity to test profligate prototypes of steam engines, even if they could mature and become more efficient over time? How feasible is it that a society could attain a sufficient understanding of thermodynamics, metallurgy and mechanics to make the precisely interacting components of an internal combustion engine, without first cutting its teeth on much simpler external combustion engines – the separate boiler and cylinder-piston of steam engines? It took a lot of energy to develop our technologies to their present heights, and presumably it would take a lot of energy to do it again. Fossil fuels are out. That means our future society will need an awful lot of timber. An industrial revolution without coal would be, at a minimum, very difficult In a temperate climate such as the UK’s, an acre of broadleaf trees produces about four to five tonnes of biomass fuel every year. If you cultivated fast-growing kinds such as willow or miscanthus grass, you could quadruple that. The trick to maximising timber production is to employ coppicing – cultivating trees such as ash or willow that resprout from their own stump, becoming ready for harvest again in five to 15 years. This way you can ensure a sustained supply of timber and not face an energy crisis once you’ve deforested your surroundings. But here’s the thing: coppicing was already a well-developed technique in pre-industrial Britain. It couldn’t meet all of the energy requirements of the burgeoning society. The central problem is that woodland, even when it is well-managed, competes with other land uses, principally agriculture. The double-whammy of development is that, as a society’s population grows, it requires more farmland to provide enough food and also greater timber production for energy. The two needs compete for largely the same land areas. We know how this played out in our own past. From the mid-16th century, Britain responded to these factors by increasing the exploitation of its coal fields – essentially harvesting the energy of ancient forests beneath the ground without compromising its agricultural output. The same energy provided by one hectare of coppice for a year is provided by about five to 10 tonnes of coal, and it can be dug out of the ground an awful lot quicker than waiting for the woodland to regrow. It is this limitation in the supply of thermal energy that would pose the biggest problem to a society trying to industrialise without easy access to fossil fuels. This is true in our post-apocalyptic scenario, and it would be equally true in any counterfactual world that never developed fossil fuels for whatever reason. For a society to stand any chance of industrialising under such conditions, it would have to focus its efforts in certain, very favourable natural environments: not the coal-island of 18th-century Britain, but perhaps areas of Scandinavia or Canada that combine fast-flowing streams for hydroelectric power and large areas of forest that can be harvested sustainably for thermal energy. Even so, an industrial revolution without coal would be, at a minimum, very difficult. Today, use of fossil fuels is actually growing, which is worrying for a number of reasons too familiar to rehearse here. Steps towards a low-carbon economy are vital. But we should also recognise how pivotal those accumulated reservoirs of thermal energy were in getting us to where we are. Maybe we could have made it the hard way. A slow-burn progression through the stages of mechanisation, supported by a combination of renewable electricity and sustainably grown biomass, might be possible after all. Then again, it might not. We’d better hope we can secure the future of our own civilisation, because we might have scuppered the chances of any society to follow in our wake.