The Return to Solar Civilizations

Narrative, Agency, and Accepting Limits

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It is no secret that the current configuration of our global energy system is leading us to the edge of the abyss. Irreversible loss of the stable interglacial climate supporting civilization as we know it looms large and although it receives substantially less attention, so does the rapid depletion of nonrenewable energy resources. The repercussions of the indispensability of fossil fuels within Modern Techno-Industrial (MTI) culture (to use Bill Rees's term) are evident in frayed communities and ecosystems around the world impacted by unprecedented stressors and rates of change. If allowed to proceed unchecked, these nonlinear and accumulating harms threaten to overwhelm us.

We will, by definition, eventually cease to rely on nonrenewable energy. But what does it really mean to change how we power our civilization? Is this simply a matter of getting the price signals right, overcoming political hurdles, and fostering innovation to bring forth the needed technological breakthroughs, as so many well-meaning green energy advocates claim? Or should we look deeper, calling modernity itself into question as a manifestation of abundant hydrocarbon energy? There is no simple answer, and as we shall see, we lack even a shared understanding of the nature of the problem we face.

As we search for pathways into the Ecozoic, we must recognize that change on this scale is unprecedented, subject to unknowable complexities, and beyond the control of any individual, community, nation, or international body. While we can tentatively probe the arc of history ahead, no one can meaningfully predict it. We would do well to begin cautiously, first discarding implausible pathways rather than simply asserting favored visions and, by extension, the existence of feasible paths arriving at them. The future, as it unfolds, will confound even the most prescient among us.

There is nothing to be gained by presenting a data-filled screed here to convince the reader of any singular view of the future. No such definitive treatment is possible. The intention here is only to offer a reflection, at the broadest scale of analysis, of the crisis of civilization—how we can contextualize it and what we realistically can and cannot expect to achieve.

To continue any further, we need to pose a central question: *What is energy transition and how should we orient ourselves toward it?* To construct an answer to this question, this article explores the stories we think with, the limits to our capacity to act, and the importance of realizing our place within a greater whole as we attempt to reinvent the energetic foundation of our culture.

The Clash of Narrative and Complexity

As we seek to understand climate change, biodiversity loss, the disruption of natural biogeochemical cycles, resource depletion, and the many other disparate aspects of ecological overshoot, we rely on stories. As humans, we have inherited an evolved propensity to think in stories, as explained by Jonathon Gottschall and Yuval Noah Harari. The creation of mental models for navigating the world and the challenges we face can be seen as an evolutionary adaptation. Stories act as fast and frugal heuristics,

facilitating the compression of complex information into simple rules and symbolisms essential for our survival. According to Gottschall, "Stories help us navigate life's complex social problems, just as flight simulators prepare pilots for difficult situations." This worked well when our natural and social environments were "mind-sized," as they were for the vast majority of our evolutionary history. However, our stories are often less helpful in the modern context of a globalized, hyper-novel world. We frequently cling to preferred or established stories at the expense of new perspectives, even in the face of a preponderance of evidence.

Powerful actors within the global community, across civil society, the private sector, and government, typically select and promote stories out of expedience and alignment with pre-existing objectives. Despite lip service paid to "trusting the science," the process of amplifying some stories over others is not in any way apolitical. Unfortunately, objective, scientific, and systematic investigation reflecting an impassionate presentation of the facts is rarely the backbone of public discourse.

There are now several well-established stories framing energy transition and the broader pursuit of sustainability. Common threads can be identified, for example:

(1) Technological innovation is coming to the rescue, characterized by falling costs and exponential improvements *a la* Moore's Law,[82] bringing solutions to any and all problems for the foreseeable future as long as regulators and naysayers stay out of the way (i.e., the Silicon Valley ethos).
(2) A socio-cultural transformation is arriving via an emerging pro-environmental consciousness aided by various social tipping points. This will unlock the spontaneous greening of lifestyles globally and usher in a new era of ecological stewardship and justice, including vacating vast tracts in favor of a new urban futurism (i.e., the bright green optimists).
(3) The failure of national and international governance to address the climate challenge is becoming increasingly apparent as emissions continue to rise year after year seemingly unaffected by a growing catalog of watered down, non-binding agreements and pledges, owing to the preferential treatment of capital over our common future (i.e., the view exemplified most clearly by a rising wave of youth activism).

In each of these dominant stories, the central tenet of MTI culture—*growth*—remains scarcely questioned with rare exceptions. Growth in income, living standards, and socio-technical capacities is taken as an immutable law of nature: the inevitability of progress. Policy makers target growth in the aggregate, with the distribution of associated benefits receiving scant attention. And as ecological economist Herman Daly has described in detail, the mounting social and ecological costs of growth are often excluded a priori from the discussion. Expectations of growth have become so ingrained in our stories that no other possibilities are taken seriously. Any reference to sufficiency or restraint, vital fixtures of social life before the advent of MTI culture, are systematically avoided or treated as quaint anachronisms. Given the present extent of

[82] According to "Moore's Law" the number of transistors on a microchip doubles approximately every two years. Outside the context of computing, analogous expectations may be termed "Moore's curse" and can result in unrealistic projections of what technological innovation can deliver.

overshoot, this is a frankly dangerous form of collective self-delusion. There is no available empirical evidence suggesting that the continuous growth of aggregate production and consumption can be made compatible with ecological sustainability, and we have every reason to expect the exact opposite is true. Our stories can, and frequently do, blind us to the obvious.

This is just one stark example of the epistemic limits our stories face. Philosopher Timothy Morton explains that many major societal problems can be thought of as "hyperobjects": threats of which most of us are vaguely aware but extend beyond our understanding in their totality as they are distributed across broad spatial and temporal scales, are highly complex and ecologically intertwined, and are incomprehensible via local phenomena alone and thus resist quantification. Any story involving a hyperobject collapses its complex reality into a chosen representation, each based on a necessarily incomplete set of facts. Critical information is always lost in this process of narrative simplification and, consequently, no one story can fully capture the nature of the problem. Admittedly, this article too presents just one such story, although it may differ somewhat from the majority in its chosen framing and corresponding blind spots.

Energy transition is perhaps the most pressing hyperobject we must grapple with at this juncture. What critical information is lost in the prevailing narrative simplifications? Five common and fundamental misunderstandings can be identified:

(1) *Energy is a commodity essentially like any other and, as such, can be produced via the conventional factors of production (capital and labor) alone.*
(2) *Energy stocks and flows comprising the energy system are largely interchangeable.*
(3) *The forthcoming transition to renewable energy is comparable to historical energy transitions, particularly the shift to fossil fuels observed in the 19th and 20th centuries.*
(4) *Available global material resources are sufficient for the transition to renewable energy with appropriate technological interventions.*
(5) *The transition to renewable energy will leave present-day socio-cultural forms and structures largely intact.*

The first fails because energy underpins the provision of both capital and labor. The production of energy can be seen as strongly "autocatalytic" as a significant share of the output of the energy system must be reinvested into its own operation and renewal. Conspicuously, the exploitation dynamics of primary energy resources, both renewable and nonrenewable, cause this share to trend upward over time as more energy must be reinvested to produce energy from successively lower quality resources.[83] Autocatalysis rules out simple, reductive, and ahistorical approaches to understanding the role of

[83] This occurs for nonrenewable energy due to depletion effects. For renewable energy (e.g., solar, wind, water, and geothermal flows), the more concentrated and accessible resources are generally occupied first, leaving lower qualities for later development. For example, new hydropower locations may be geographically remote, prone to reservoir silting, or drought affected, while future solar and wind projects may exhibit greater variability or simply lower power output. After technological maturity is reached, the combined monetary and energetic costs of productive capital and associated infrastructures tend to increase over time for all primary energy resources.

energy in society—an inconvenient fact sidestepped by virtually all mainstream studies and scenarios of energy transition.

The second fails because the various flows of energy across the categories of primary resources, energy carriers, and delivered energy services are, in fact, spatially, functionally, and temporally non-fungible. Significant substitutions cannot occur without major reorganizations and reconstitutions of the built capital comprising the energy system, which require significant periods of time and vast energetic investments. Even within each primary energy resource category, such as petroleum or biomass, qualities exist along non-homogeneous distributions.[84] As we have a strong proclivity to use the best and most economically valuable resources first, what remains will do less for us than many expect based on projections from past experience.

The third fails due to matters of scale and pace. The transition to fossil fuels brought with it extreme energetic and economic advantage and still took the better part of two centuries to achieve today's massive scale and complexity. Additionally, historic energy transitions were additive; no significant substitution of existing fuel sources occurred in prior transitions as must characterize the shift to renewable energy. Let us be clear, this is truly a colossal undertaking which cannot be compressed into chosen timelines or be expected to deliver any pre-defined set of outcomes.

The fourth fails because the transition, as advertised, would require a Herculean expansion of mineral extraction. Available reserves of copper, nickel, lithium, cobalt, and an array of crucial rare-earth elements appear insufficient to meet the projected demand by wide margins, as noted by geoscientist Simon Michaux. Substitution alone cannot be expected to fill the gap. In addition, the proposed renewable energy build-out would need enormous amounts of steel, concrete, and other construction materials, eclipsing the quantities consumed during the historic period of fossil-fueled industrialization. Further, the expansion of mining and material processing, and the subsequent installation of continent-spanning renewable energy infrastructures, would bring unparalleled social and ecological implications and, as such, would be widely contested.

The fifth fails because the transformation of the global energy system is not simply a technical, economic, or governance challenge within a static backdrop, but rather a *complex, physically bounded, path-dependent, socio-metabolic process* which will necessarily transform the basic configuration of high-energy societies. Just as biological organisms require continuous flows of energy and nutrients, socio-cultural structures too have metabolic needs. As the quality and/or quantity of available energy supplies change, societies will reorganize, and dominant patterns will give way to new arrangements.

Overlooking these issues leads to a general misapprehension of the achievable outcomes and societal implications of energy transition. This is the unfortunate state of the discourse today, aptly described by Mario Giampietro as "a clash of reductionism against the complexity of energy transformations." Compounding this situation is an overall impression of technological mastery that has largely captured common problem framings, imparting illusions of control as we anticipate future challenges. To quote

[84] Consider, for example, the production of petroleum from the Canadian tar sands and the related energy and infrastructural requirements compared to the production of "light, sweet" crude oil in Saudi Arabia.

Nicolas Georgescu-Roegen, Romanian polymath and father of ecological economics, "Naturally, the innovations in artefacts, being more impressive, have enslaved our imagination and, *ipso facto*, our thoughts of what we can achieve."

The widely anticipated transformation is not occurring at the required pace or scale to achieve sustainability. Technology has not yet saved the day—in fact, technological innovation appears to facilitate increasing aggregate energy consumption, fossil fuel production, and mineral extraction. The resulting cognitive dissonance is beginning to push against our favored stories. There is now a growing sense that *something has got to give* resulting in rising ecological despair and apprehension of the future, particularly among younger generations. Meanwhile, we divide into tribes built around enshrined stories, increasingly seeing all others as incomprehensible and irredeemable. Our stories are failing us, and we all feel it.

Returning to Solar Civilizations in a Full World

The gravity of the ecological predicament faced by MTI culture is illustrated most profoundly by the role of fossil fuels in agriculture. The human species converts fossil fuels into food on an enormous scale via the Haber-Bosch process, using natural gas-derived ammonia for the production of nitrogen fertilizers needed to boost agricultural yields. The global human population simply could not be sustained anywhere near its current level without fossil fuels. Ecologist William Catton called this phenomenon "ghost acreage," the temporary ability to grow our numbers and our consumption levels beyond that which available ecological carrying capacity would otherwise support. We are now engaged in an attempt to increase our ghost acreage indefinitely via technological progress without regard to the historic fossil fuel abundance which underpinned this very endeavor. This abundance is coming to an end. *Can we fix nitrogen without fossil fuels?* Sure. *Can we do it in a way that is energetically and economically viable at the scale required?* Not even close.

Any species given an unconstrained food supply will expand in number and begin to overtake their environment, thereby upsetting ecological balance. Homo sapiens is no exception. However, our large brains and mastery of exosomatic energy flows confer a vastly expanded capacity to exploit ecosystems for short-term advantage, diminishing their long-term productive capacities. We are the ultimate ecological pioneers. Under the influence of MTI culture, we lack the temperament, the self-awareness, and the motivation to co-exist with the stable, mature ecosystems on which we depend. This pioneer mindset is clearly demonstrated by today's open-loop economies and the systematic dismantling of the living world through the appropriation of material and energy flows, a process which continues largely unabated. In contrast to when we set out on the path to modernity, we now find ourselves in an ecologically full world where further growth of the human sphere comes at a devastating cost to the rest of nature. Ultimately, and perhaps mercifully, the Anthropocene will be brief—a mere boundary event in the geological record. MTI culture appears uniquely ill-suited to survive the resulting biosphere-spanning ecological phase transition.

Energy and Complexity

As observed by anthropologists Leslie White, Marvin Harris, and Joseph Tainter, societal complexity—defined variously in terms of the number of people living in a given society, material living standards, extant socio-technical capacities, and varieties of social organization—is closely connected to available energy supplies. Put simply, culture rests on an energetic foundation. However, as discussed above, primary energy resources and the flows derived from them are not equivalent. Quality varies by temporal availability, spatial concentration, power level, transportability, storability, and ease of transformation to name only a few pertinent attributes. Ecologist H.T. Odum highlighted the use of high-quality energy flows to develop lower qualities as a common feature of complex systems. MTI societies are now inescapably dependent on the higher grades of energy quality delivered by fossil fuels for their essential processes—think steel, cement, silicon, ammonia, plastics, and global logistics. Reduced access to higher-quality energy supplies will sharply curtail the level of complexity which can be supported.

Humans have always been a highly inventive species, but without sufficient flows of energy of the requisite qualities, we are incapable of bringing ideas to life in ways that shape culture. Da Vinci's drawings of flying machines remained just that without the motive force to propel them and the extraordinary inventiveness exhibited by the Antikythera mechanism could not progress beyond a rare curiosity to become a fixture of daily life in ancient Greece. Energy can be seen as the capacity to give tangible form to concept. Knowledge alone does not move the world.

Basic socio-metabolic patterns have changed only twice in human history. Once in the transition from hunter-gatherer lifestyles to settled, agrarian communities, and again (and still unfolding) following the dawn of industrialization through vast profusions of exosomatic fossil energy. We are now tasked with a third transition involving a retreat to flow-based, place-bound, primarily solar societies once more. This new world will be as different from the first three stages (hunter-gatherer, agricultural, and industrial) as the second was from the first, or the third was from the second. The transition away from a high-energy MTI culture brings with it many opportunities for cultural renewal fostering greater sustainability and resilience. However, it also entails an inevitable loss of economic surplus, societal complexity, and many present-day socio-technical capacities. Future societies will not likely support advanced medicine, global tourism, or higher education at current scales. In light of this, the evolving context for Thomas Berry's Great Work can be expected to be fundamentally unlike the present, with most of us enjoying much less personal power, comfort, and access to information.

The Problem with Renewables

Earth is bathed in natural energies originating from the Sun, natural nuclear decay, and gravitational interactions between the Earth and Moon, none of which can be depleted. However, the return to solar civilizations will be frustrated by the lower quality of these renewable energy flows relative to their conventional, nonrenewable counterparts. Renewable resources with the potential to become major players in the global supply mix include solar energy and its derivative, wind. While abundant, these flows are diffuse, variable, and difficult (read: *monetarily and energetically expensive*)

to convert into the storable, transportable fuels required by industrial economies. Geothermal, hydro, and biomass resources typically have greater utility but are constrained by limited geographic availability and often outsized ecological demands. All renewable options except large-scale hydroelectricity are limited by their own considerable energetic requirements when full system integration requirements are considered, and thus yield comparatively less net energy to be used by society for productive purposes. As such, any significant renewable energy buildout attempting to displace fossil fuels will run into massive capital requirements and a consequent re-materialization of the global economy, with far-reaching implications.

Vaclav Smil explains that renewable energy flows cannot easily replace hydrocarbons powering the central technological and industrial pillars supporting modern society. Variable, "non-dispatchable" electricity[85] from wind and solar does not substitute well for the energy flows on which the MTI system has come to rely, such as transportation fuels and high-temperature heat. And it is not just the motive or thermal energy we need to consider, but also deeply embedded dependencies on a global petrochemicals industry for everything from plastics to life-saving medicines. Reforming our methods of industry may be theoretically possible, but would require rebuilding critical infrastructures, redistributing populations, and retraining workforces at a minimum. It would also produce less surplus, meaning that we would have to simultaneously rein in overconsumption and give up our love affairs with economic growth and personal mobility. In short, we would need to change everything. And this is to say nothing of the dynamic, path-dependent feasibility of such a socio-metabolic transformation. This is open-heart surgery for civilization, and the slated replacements will not likely satisfy the gargantuan demands placed upon them.

A global energy transition will be a protracted process. Arnulf Grübler notes that energy transitions on the scale required, involving changing "systems of systems," are subject to slow processes of technological diffusion affecting extensive, long-lived infrastructures, taking many decades or even centuries to complete. And this time around, we must replace established energy sources rather than simply adding to the total as we have in the past. This reveals energy transition as a multi-generational process. Given this timeline, and considering both the degree of climate destabilization already manifesting around the world and the inexorability of nonrenewable resource depletion, should we continue to base our plans around an 11th hour technological salvation? Absolutely not. To do so is tantamount to denial of reality, putting the real, achievable prospects we do possess at great risk.

Leverage Points and Paths Forward

If technological responses to our energy predicament are insufficient to maintain our present course, behavioral adaptation will become increasingly unavoidable. This means a reduction in the consumption of energy services back toward alignment with our vital needs, or in other words, prioritizing sufficiency over affluence. But this response is inimical to growth, the principle by which MTI culture has organized itself and

[85] A dispatchable electric power generator can supply electrical power to the grid on demand. In contrast, variable power generators, such as those based on most renewable energy resources, are subject to supply variations due to diurnal and seasonal patterns and short-term changes in local weather conditions.

maintained its dynamic coherence since the dawn of industrialization. The growth mantra demands the creation and satisfaction of new desires, building more, using more, earning more, and spending more. Everywhere growth has taken hold, superfluous demands eclipse basic needs at an ever-accelerating rate while being counted in the same category of general economic "value." Working in the reverse direction, contraction will be deeply destabilizing and fiercely resisted. However, barring a highly unlikely sequence of technological breakthroughs, the MTI paradigm will inevitably give way in a tumultuous readjustment to new circumstances. This is the landscape in front of us.

Group Behavior and Agency

As agents form larger groups, functional intelligence—defined as the sum capability to respond effectively to novel challenges—initially rises markedly. However, after group size reaches a relatively modest level, an inescapable decline in functional intelligence begins. Educator and systems thinker Nate Hagens argues that at the scale of a global society encompassing billions of agents, we collectively act as an energy-hungry superorganism. It doesn't feel this way because we each see the world from our individual perspectives and think in terms of agency manifesting at this level, but our intuition fails to grasp the dilution of influence across the many hierarchical levels of organization present in a globalized society—conditions we as a species have never before encountered during our evolutionary history. For example, as ecozoans, we form an imperceptibly small group of actors among the enormous networks of contested influence comprising the human socio-ecological system. Furthermore, we live in webs of social power which are self-reinforcing by nature, amplifying conformity while detecting and isolating deviancy. Only a limited and non-threatening diversity of thought is tolerated. Anyone who has attempted to raise the topic of ecological overshoot in polite conversation, or in a professional setting, has experienced this firsthand. After an initial pointed silence, the topic is swiftly redirected back to safe territory. Depending on the severity of the perceived offense, the culprit may suffer diminished standing or be excluded entirely from future interactions.

Socio-ecological systems, including all human societies, are examples of "complex adaptive systems." Such systems evolve as their environments change via processes of self-organization and feedback, subject to decentralized networks of interaction. That is, societies and their respective cultures are not primarily designed or controlled in a top-down manner, but instead organically become what they will to survive or perish where they fail. Complex adaptive systems follow their own internal drivers (often the maximization of power in practice, as observed by mathematician and chemist Alfred Lotka) and do not follow our commands or respect our stories. Unfortunately, research and policy circles alike remain beholden to technocratic reductionism, approaching societal interventions like fixing a broken machine where one part can be swapped out for another while changing little else. *Ceteris paribus*, the assumption that we can make major changes to one aspect of a system while holding all others constant, is no longer appropriate as the basis of our collective problem solving. We are now in an era of radical emergence.

"Post-Normal Science"[86] and a recent surge of research efforts operating outside of traditional disciplinary boundaries are much needed responses for this new era, as is the rising awareness of the ethical responsibility engendered by our fundamental dependence on the web of life. Even so, the scientific establishment and accepted moral wisdom both appear to be more epiphenomenal than causative, following culture rather than leading it. High-minded principles are simply not the major force guiding our collective action (although our stories may claim otherwise), constrained as it is by more immediately individual and group impulses for near-term status, reward, and loss aversion. As a damning example, numerous studies now have revealed that those who self-identify as environmentalists tend to have larger environmental footprints than those who do not. Wealth trumps ideals, implying that the "greening" of society will only come as wealth is destroyed and MTI culture is forced to release its stranglehold on the natural world. Notably, and not incidentally, many Indigenous cultures which have persisted for many thousands of years have traditionally practiced forms of wealth destruction and redistribution through ritual and gift economies.

Social groups, from households all the way up to nation-states, behave as all other nested, complex adaptive systems do—with agents exhibiting both integrative and self-assertive tendencies within their larger wholes. Bringing the pro-social, integrative tendencies to bear on the problem of overshoot requires the personal and collective curtailment of consumption with attendant losses of convenience, power, and advantage. This is the mother of all collective action problems. Any solution would necessitate elevating long-term, widely distributed, and holistically defined benefits over private, proximate, and immediate sacrifices on a monumental scale. It is the author's humble opinion that, unfortunately, this is *simply not going to happen*. There is too much self-interest at work and not enough assurance of reciprocity. If you doubt this assessment, ask yourself whether the members of your own community would all voluntarily cut their incomes in half with no guarantee that those living on the other side of the world, or even the next neighborhood over, will do the same. Further, ask yourself how social tensions emerging from public health measures designed to combat the SARS-CoV-2 pandemic bode for such prodigious aspirations. Indeed, what capabilities for coordinated collective responses to novel challenges are apparent at the global level? Historically, grand mobilizations have occurred to neutralize immediate threats, true, but how about diffuse, slow-moving challenges that are no less existential in nature?

What effect have the many climate conferences and agreements over recent decades, from Kyoto to Paris and beyond, had in bringing about reductions in global greenhouse

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[86] Jerome Ravetz gives the following description of Post-Normal Science:

> In response to the new conditions of science in its social context, with increasing turbulence and uncertainty, the idea of 'Post-Normal Science' has been developed. Going beyond the traditional assumptions that science is both certain and value-free, it makes systems uncertainties and 'decision stakes' the essential elements of its analysis. It distinguishes between 'applied science' where both dimensions are low, 'professional consultancy' where at least one is salient, and Post-Normal Science where at least one is severe. In the latter case, science derived from textbooks must be supplemented by other ways of knowing. Its theoretical core is the task of quality assurance; it argues the need for new methods, involving 'extended peer communities', who deploy 'extended facts' and take an active part in the solution of their problems.

Ravetz, J. R., "What Is Post-Normal Science." *Futures* 31, no. 7 (1999).

gas emissions? How about biodiversity loss? While there have been successes in regulating the production of specific ozone depleting and acid rain causing pollutants, these occurred only in the presence of relatively simple technological fixes lacking serious economic impacts. Where deeper changes to the metabolic pattern of society are required we appear to be largely powerless to bring them about. Therefore, contraction will likely be unplanned, initiated instead by biophysical processes.

System Inertia

The basin of attraction for the prevailing MTI culture is deep and wide. Existing structures have not yet released in such a way that would allow reorganization on the scale required to achieve ecological sustainability. At the present time, the Great Work remains a profoundly Sisyphean task. Perhaps our humbler role is to pass the necessary knowledge and care to future generations so that they, in time, can bring about changes we cannot.

We know more or less what needs to be done: A systems-cognizant perspective on the crisis of civilization allows leverage points to be identified. These are actions we could theoretically employ to improve outcomes, at least for chosen metrics. Some work synergistically bringing improvements on multiple dimensions, such as reducing emissions while improving public health, while some come at the expense of others and require careful consideration of relevant priorities and consequences. Leverage points indicated by research in this area include the abandonment of economic growth as the overriding policy objective, the curtailment of wasteful and unnecessary forms of consumption, humane population reduction (with responsibilities falling first and foremost on the overconsuming nations), and redesigning and reconstructing our built environment to favor efficiency, sufficiency, and slowness over raw power. We can and should take positive actions to implement such changes within the limits of the basic collective action problem. However, given the present extent of global ecological overshoot, we cannot avoid hitting the wall. *Disruptive socio-ecological phase change is now likely unavoidable.*

Under such conditions, we cannot take even the ostensibly essential elements of our culture for granted. Modern political and institutional forms, including our liberal ideals and democratic institutions, may not survive the end of the energetic basis that gave rise to them. William Ophuls[87] argues that the loss of fossil-fueled abundance will force political change, warning "democracy as we have known it is entering a perfect storm that threatens to obliterate politics as usual." Worryingly, history is replete with examples of the human tendency to become strongly illiberal in the face of chronic scarcity.

Accepting Limits

Whatever happens, we can be assured that humanity *will* be brought back into a coherent relationship with the biosphere. All that is unsustainable, in time, ceases to be so. Ecozoans must carry a terrible awareness: the knowledge that our civilization, our

[87] The pen name of political scientist Patrick Ophuls.

culture, is likely self-terminating. The pain of holding this knowledge is not unlike accepting one's own mortality following a terminal diagnosis.

What is our ecological destiny? Stabilization and maturity, or collapse? It is too early to say definitively, but signs point to the latter. We collectively exhibit no obvious ability to exercise restraint in our quest for more growth and more power. Species capable of making the leap to a mature ecosystem acquired this hard-won ability only via eons of selective pressure and realize it only in the presence of a rich and fragile symbiosis. We are new arrivals. This cumulative learning does not exist in our genetic endowment; if it is to occur, we need to develop this capacity via culture. It may take many more attempts and the collapse of many future societies to finally find maturity.

New Stories Will Come

Is it fruitful to attempt to control long-term ecological outcomes? Do pioneer species question their role in ecological succession? Perhaps it is more instructive to ask how we can, and how we want to, influence the aspects of the transition that matter most to us on relevant timescales. Do we want to minimize human suffering, slow biodiversity loss, or maintain as much scientific knowledge and socio-cultural complexity as possible? These goals are not necessarily compatible. Optimizing for one will detract from others we hold to be important.

We often fail to ask: What do we really want? What is our fundamental axiology? Let's start with the ultimate bad, say a Chicxulub-like asteroid impact, a massive solar flare, or the eventual expansion of the Sun engulfing Earth. Annihilation. We should first stop to consider that MTI culture is now a force possessing the same magnitude of destructive potential to the biosphere. Why is this fact not central to our stories of what we have become?

One way forward is to acknowledge our outsized impact, accept the reality of overshoot, and embrace limits, then carefully weave this new consciousness into our stories. This would represent a Socratic dialogue at the societal scale—an iterative refutation of old stories in light of either foresight, promoting adaptation, or more realistically hindsight following difficult times, creating a synthesis of new narratives needed for the long journey toward renewed solar civilizations. As simplifications of a hyperobject, these narratives will never arrive at a final truth and will need to be as revisited time and time again. Radical uncertainty will always be with us.

What will these new stories look like? It is impossible to know as our stories too are emergent phenomena. However, we may be able to glean a few essential details of incipient stories. Firstly, we can expect that they will stop assuming that nature owes us the way of life to which many of us raised within MTI culture have become accustomed. Secondly, they will abandon technocratic delusions and become reacquainted with our ecological and energetic realities. Thirdly, they will no longer appeal to limitless growth and will instead reclaim the vital principles of sufficiency and resilience. Finally, they will embrace working with humility and purpose within our small spheres of influence, never expecting to change the world at large. The main obstacle preventing the creation of these new stories is the modern ego screaming *we are the ones who know better,* the *ones who can fix* things, if only others *would listen*. We don't, we can't, and they won't. And this is okay.

And New Hope Will Follow

It is no longer reasonable to expect an ever more elaborate and precarious set of technological interventions to sustain modernity in perpetuity. Instead, one must ask how a life of purpose can be lived in the midst of a dying culture. Current structures of meaning may be difficult to maintain as the societal stability begins to give way and phase change looms. One must ask, why continue to invest in a system which is going away anyway? For many, daily life is already burdened with this apprehension of the future.

The modern collapse of meaning is a paradox. On one hand, our collective inability to do much to shift the inertia of MTI culture is palpable. On the other, our capacity to affect the future has never been greater in human history and may never be so great again. This imparts overwhelming meaning to our choices. That the overall arc of history in the late Anthropocene is more constrained than we may have hoped does not change this. We will see new social pathologies and rising conflict brought on by the end of economic abundance, yes, but also a rare period of cultural malleability in which new forms will arise. Ecozoic ideas can take hold during such a contraction offering a path to mutualistic human-nature flourishing, but so can avarice, authoritarianism, and outright barbarism which would then exacerbate the decline. The future holds all of these. Each region will experience its own pathway of societal reorganization and simplification picking up on unique natural and cultural elements. There will be many experiments and many failures. Hopefully, the process will be slow and orderly enough in most regions to maintain sufficient levels of social cohesion and ecosystem integrity, and fast enough to preserve the climate stability needed for the eventual rise of local cultures that thrive under new conditions. Solar civilizations of the future may scarcely resemble anything we might expect or wish for as they evolve under uniquely contingent and unpredictable circumstances. This too is okay.

Embracing Ecocentrism

Crucially, there is hope to be found, but of a different kind than most of us have been taught to expect. We can find some measure of peace in the knowledge that, at the very least, life will go on. The immense damage the human species, and MTI culture in particular, has inflicted on the biosphere is dwarfed by the creative, regenerative potential of the natural world, which will in time bring diverse new forms into being to fill the ecological niches we have emptied. This reflection offers freedom from the vanity of anthropocentrism.

The bulk of the myriad forces that shape our future lie far beyond our control—evolutionary legacies, physical laws, the fragility of our host ecosystems, and finite endowments of fossil energy. We cannot "fix" these things. Embracing ecocentrism means giving up our view of ourselves as the primary protagonists in Earth's story. It is not incumbent upon us to *bring about* the transition to the Ecozoic. Only nature has the power to do this. But we do possess the capacity to make things immeasurably worse. We should give heed to Thomas Berry's observation that "our power of creativity in the natural life systems is minimal, while our power of negating is immense."

The tasks ahead are to *embrace the terms* of the coming transition and then to *live within them*. To the extent we exercise options available to us and make wise decisions,

the transition may be rendered more benign than it would otherwise be, but it will not be made painless. We must accept that much of what we care about—facets of high-energy modernity—will be lost. Our numbers will fall. Biodiversity loss and ecosystem degradation will continue along the trajectories we have set, for a time. Eventually, Earth will breathe again, and a resurgence of life will follow in direct proportion to the severity of the presently unfolding mass extinction. As for our species, we will find the humility to acknowledge the finiteness we share with all life. To quote Georgescu-Roegen again,

> *Perhaps, the destiny of man is to have a short, but fiery, exciting, and extravagant life rather than a long, uneventful and vegetative existence. Let other species—the amoebas, for example—which have no social ambitions whatever inherit an Earth still bathed in plenty of sunshine.*

Meaning can be untangled from outcomes beyond our control and reconnected to a direct experience of the here and now. This means revelling in wild places rather than despairing what may become of them, enjoying the richness of life and connections to place, family, friends, and music, knowing that in the deep abundance of geological time lies a world beyond our machinations, our deprivations, and our conceits. We are social primates both fortunate and unfortunate enough to stumble upon a vast cache of fossil energy, an eventuality for which our genetic heritage did not equip us. Even in these unprecedented times, we can look to the wisdom of the past. In the words of Roman statesman and Stoic philosopher, Lucius Annaeus Seneca,

> *The greatest obstacle to living is expectancy, which hangs upon tomorrow, and loses today. You are arranging what lies in Fortune's control and abandoning what lies in yours. What are you looking at? To what goal are you straining? The whole future lies in uncertainty: live immediately.*

To return to our original question: *What is energy transition and how should we orient ourselves toward it?* Energy transition will be no less than a multi-generational, evolutionary process that will transform our basic socio-metabolic pattern, profoundly reshaping societies and rewriting culture. This will not be easy, predictable, or even fully comprehensible to anyone living through it. The sense of foreboding many of us feel facing this prospect is understandable. However, this is a limbic response to threats we could, in times past, either manage or evade. The crisis of civilization is simply not such a threat. Stories of certainty and human omnipotence may soothe us, but as Oswald Spengler famously remarked, *optimism is cowardice*. Now is the time to be brave, to tell new stories, and to re-learn how to lead lives with much less power, control, and material abundance—lives that will allow us to one day rediscover our rightful place within the community of life.