The politics of technology in the Anthropocene: degrowth, ecomodernism, and the innovation trilemma[1].

Manuel Arias-Maldonado
University of Málaga (Spain)
marias@uma.es

Abstract: Whereas Ulrich Beck suggested that modern societies have become «risk societies», it has been recently proposed that we now live in the «Anthropocene», namely a historical epoch in which humanity turns into a global environmental agent. In both accounts, tehnology plays a key role. However, political theory —including environmental political theory— has overlooked the crucial subject of technological change. How does it happen? Can we control or direct it? Whereas radical environmentalism typically responds with a rejection of technology on normative grounds, aiming at reducing the number of technologies on which societies rely and mostly defending some version of degrowth, ecomodernism decidedly bets on the design and development of new technologies — those that are capable of delivering both mitigation and adaptation of climate change while not impinging on neither economic growth or nature's preservation. Nevertheless, the political dimension of technology remains unexplained. Can we have democratic monitoring and technological change? That is the subject of this paper, which will proceed by offering an overview of the subject before discussing the trilemma of technological change: efficiency, democracy, and social consensus cannot be secured at the same time.

Keywords: Technology, Climate Change, Anthropocene, Politics, Democracy, Ecomodernism.

Although they were born into different intellectual traditions, a connection can be established between the «risk society», as postulated by sociologist Ulrich Beck in the mid-eighties (see Beck 1986, 2009; Giddens, 1991; Beck, Giddens and Lash 1994), and the «Anthropocene», put forward by natural scientists in the early noughties and soon adopted by social scientists and humanists alike (see Crutzen and Stoermer 2000, Crutzen 2002, Thomas et al. 2020, Zalasiewicz 2021). They are both *descriptive* concepts that try to give meaning to several *observations* about the state of socionatural relations. In the case of the «risk society», the argument is that human societies are confronted with dangers created by their own social and technological development—from nuclear power to pollution and bioterrorism. On its part, the Anthropocene is the proposition that we now live in an epoch —be it geological or historical— in which humanity (the *anthropos*) has become a global environmental agent, such is the impact that an ongoing social activity has caused on planetary natural systems. In both cases, there is also a *normative* injunction to deal with that which is described: while risks are to be managed, the Anthropocene is to be made «good» or at least globally sustainable. What does that *exactly* mean, of course, is a different matter —different accounts of how to achieve such goals will proliferate in academia and the public sphere.

Ultimately, neither modern risks nor the Anthropocene itself can be explained without attending to the key role of technology. According to Jan Zalasiewicz, the latter has vastly diversified and become more powerful since the Industrial Revolution, so that it should now be considered «the key driver of Anthropocene change» (Zalasiewicz 2023: 43). It has even been proposed that a «technosphere» has emerged —one that is more than the sum of all our technological objects and encompasses human beings themselves, who in the meantime have become utterly dependent upon it (see Haff 2014). It is then hardly surprising that Timothy Morton (2013: 7) signals the end of the world in 1784, the year in which James Watt patented the steam engine. Together with the Industrial Revolution, so-called «fossil capitalism» would have begun back then, providing several generations of humans with abundant energy and eventually causing a warming of the planet that endangers the

[1] This paper has been written within the research project «Riesgos existenciales en el Antropoceno: tecnología y política» (PID2023-149342NB-I00).

future of civilisation (see Angus 2016). In sum: the very technology that has facilitated the material progress of human beings throughout modernity threatens now the habitability of the Earth.

The question of how to deal with sustainability in the Anthropocene is thus largely the question of how to deal with technology in the Anthropocene. There cannot be a sustainable Earth —from the viewpoint of the human species— without successfully addressing the issue of technology. If the protection of nature is also wished for, the question becomes even more pressing. It is worth recalling that the distinction between *weak* and *strong* versions of sustainability largely revolves around the amount of natural capital that can be *replaced* by human-made capital, i.e. technology (see Neumayer 2010). Admittedly, there remains the possibility —at least the theoretical possibility— that technology is successfully employed to provide sustainability *without* such replacement taking place. In other words, technology can operate *alongside* the natural world without *necessarily* adding to the harm suffered by the non-human world.

Debating what to do with technology in the quest for sustainability, however, is not just a matter of normative deliberation. Neither rejecting or embracing technology *in toto* leads us very far, since the discussion must also take into account what particular technologies do, what would happen to existing societies if we dispensed with them, which alternative technologies are needed to provide what social needs, how technological change come about and to which degree is that process amenable to political —be it democratic or not— control. They are not easy questions.

How to answer them? Unlike the *philosophy* of technology, which enjoys an excellent health and has been reinvigorated by the coming of Artificial Intelligence (see Vallor 2022), the *political theory* of technology is almost a non-existent field. As Keary (2023) has pointed out, neither liberalism (after Adam Smith) nor socialism (after Marx) have dealt systematically with technology, and neither have other schools of thought. Tellingly, there is no entry for «technology» in the *Encyclopedia of Political Thought* published by Wiley-Blackwell a decade ago (see Gibbons 2014). But political theory, let alone environmental political theory, should be able to say a lot about this topic.

In this paper, I will restrict myself to the relation between technology and sustainability at a global level — sustainability *in* and *for* the Anthropocene. The question I deal with pertains to the ability of human beings to *direct* or *control* technological change. To such end, I have organised the paper as follows. Firstly, the position of green thought on technology is presented. A particular attention is devoted to what degrowthers have to say on the topic, since current visions of sustainability among radical environmentalists (or ecologists) are mostly predicated upon the end of capitalism and indefinite economic growth. Secondly, I describe ecomodernism's bet on technology, which is a bold departure from hegemonic green thinking despite it being the last development of an old branch of environmentalism. In the last two sections, I focus on the key question of how does technological change work and whether and to which degree can it be subjected to political control and/or democratic deliberation. A brief conclusion is offered.

Technology in green (political) thought: from early environmentalism to degrowth.

Although Keary (2023) follows Dobson (1990) in distinguishing ecologists who wish to transcend liberal society from environmentalists who belief that the latter can accommodate green values and become sustainable, such opposition has arguably lost descriptive power with the passing of time. As the label «environmental political theory» has gathered consensus (see Gabrielson et al. 2016, Machin and Wissenburg 2025), it seems more apposite to make room for newer categories —such as radical environmentalism, political ecologism, degrowth theory, or ecomodernism— in order to describe the current state of green thinking. Governments all over the world, even China's, have in the meantime pivoted to environmentalism in Dobson's sense of the word, as they pursue some version of sustainability without challenging the status quo. Thus, I will refer to green thought or early environmentalism when addressing the green stance on technology, before focusing on

degrowth as the latest instalment of radical environmentalism. In the next section, ecomodernism will be dealt with as a different branch of environmental thought —one that cannot just be equated with the kind of mild reformism that Dobson categorised as «environmentalism».

Technology has always figured as one of the main culprits of the ecological crisis —another label that seems to have lost its mobilising power— in green accounts of the latter. But it has rarely been described as an autonomous driver of environmental degradation. For environmentalists, technology is better explained as the *symptom* of an anthropocentric and rationalistic culture that has been in place for the last two millennia (see Plumwood 2002). It is because human beings are blind to ecological relations and fail to recognise the intrinsic value of nature, that they use technology in order to profit from nature. Hence the «technocentrism» denounced by ecosocialist David Pepper (1996: 124). Pepper is not alone in believing that this worldview is exclusively Western, having its roots in a Scientific Revolution that makes possible the unfolding of industrial capitalism: nature becomes «mecanised, quantified, secularised and perceived as otherness« (Westfall 1992: 65).

Other green thinkers go even further, claiming that the main goal of the Enlightenment is the manipulation and control of natural processes in order to satisfy human needs through science and technology (Katz 1997: 52). Despite the successive attempts to recruit him for the green cause (see Foster 2000, Saito 2022), socialism as defended by Marx himself also embraced the modern view that nature has to be controlled by human beings through science and technology, so that the latter can be freed from the realm of necessity and give way to a classless society (see Arias-Maldonado 2004). In fact, Marx was criticized on account of his «Prometheanism» by a number of thinkers back in the day (see Bhaskar 1994, Benton 1989, but also Giddens 1991). It should not come as a surprise that his view on the subject has been put in connection to that of ecomodernism (see Azeez and Symons 2025).

Early environmentalism amalgamated a mixture of disparate traditions of thought when developing its own view of socionatural relations, the roots of the ecological crisis, and sustainability. There is a certain conservatism that rejects modern progress and is critical towards free trade and technological disruption, while defending communal life and natural landscapes; there is Romanticism, which is opposed to rationalism and scientism and see nature as possessing a value of its own; and there is an utopian socialism that puts forward an alternative social order in which Romantic values such as creativity and the enjoyment of nature are prominent. Needless to say, the influential account of modernity provided by the Frankfurt School is also key for understanding how early environmentalism see modernity and technology — let us just mention Marcuse's assertion that the «technological society» is but a «totalitarian society» in which human true emancipation is not feasible (see Marcuse 1941). Hence the argument, almost a tenet in green thinking, that technology is not going to save us from technology.

Green political thought has not changed at all as far as modernity and technology are concerned — its current practitioners have remained faithful to this set of beliefs. And even though there was such thing as a dialogue between radical environmentalism and political liberalism in the late nineties and the early noughties, the rise of climate change as a planetary risk and the impact of the Great Recession on liberal democracy have rendered that effort almost futile. Despite the prominence of currents such as colonial theory, ecofeminism or post-humanism, green thought keeps claiming that industrial capitalism (newly dubbed as «fossil capitalism») and modern technology are the unfortunate manifestations of an anthropocentric culture that exploits nature and thus weakens the conditions of Earth's habitability.

In this connection, Stirling (2025) has suggestively claimed that control is «a constituting imagination in modernity» in which technology, insofar as it spreads the belief that humanity will dominate nature, plays a central role. Likewise, Vetlesen (2015) presents modernity as a Promethean project of domination grounded upon a false dualism that recklessly separates humans from nature and then turns the latter into a *thing* to be manipulated, transformed, and destroyed (see Vetlesen

2015). On her part, Fremaux (2019: 28) denounces how the «hypermodern narrative of control» is combined with a «postmodern narrative of hibridity» that results in a view of nature as «a fluid techno-reality mixed with the products (and waste) of technology». The argument that more technology will not solve the problems created by technology recurs as well: Hamilton et al. (2015: 9) criticize ecomodernism for *still* believing in reason and technology, thus betraying a typically «modern» worldview that ought to be deemed outmoded by now.

Such «technofix» — as the proposition to use technology to achieve sustainability is derogatorily called in most green literature — is also rejected because it would leave patterns of production and consumption untouched, hence «de-politicizing» environmental policy (Keary 2016). In the words of Dillet and Hatzisavvidou: «ambient Prometheanism, with its emphasis on technofix, leads to the economisation and depoliticisation of planetary environmental issues» (Dillet and Hatzisavvidou, 2022). A different reading of «depoliticization» is that it wrongly gives the impression that technology is «neutral» *and* a process beyond human control (Hällmark 2022). Furthermore, pursuing technological solutions to the climate crisis is perceived as leading to a technocratic regime in which experts team up with a centralised power at the expense of democratic choice (Tonder 2025: 175). Ecofeminist theory concurs: science and technology have served the needs of the powerful for centuries by sustaining existing relations of capitalism, colonialism, and patriarchy (see Thompson and MacGregor 2017). With the exception of accelerationists such as Aaron Bastani (2019), who believes in the power of technology to lead us towards a «fully automated luxuy communism», the dominant view in Critical Theory today —radical environmentalism included— is that only degrowth can solve the climate crisis and protect nature without resorting to authoritarian political solutions.

What degrowth theory says about technology is, therefore, relevant. Let us recall that degrowth stands for a reduction of society's throughput —the materials and energy extracted, processed, transported, distributed, consumed and finally turned into waste by a society must be significantly reduced (Kallis 2011: 874). Both economies and societies are to be downsized, a goal that cannot be achieved without limiting production, trade, travelling, and consumption. In a post-growth society, life is to become more local and less mobile, as well as more equitable and sustainable, while supposedly remaining democratic (see Jackson 2009). A new cultural mindset is to facilitate this transition, so that people living in post-growth societies —those which have left indefinite economic growth behind— will not feel constrained but liberated (see Demaria et al 2013, Kallis 2019). For the purpose of this paper, there is no need to make the distinction between first and second generations of degrowth, the latter being supposedly less fixed on the idea that limits to growth are natural and objective, as the ideal social arrangement supported by both is roughly the same.

According to D'Alisa and Romano (2025: 103), the growing disparity between an individual's limited capabilities and the immense power of technology pushes the former towards an indefinite accumulation of resources, which in turn compounds global unsustainability. This psychological reading of the technosphere, which the authors consider typically modern, calls for a radical shift in society's relation to technology. This is a goal that resonates with the degrowth project, which Kallis (2019) presents as a political vision shaped by collective autonomous institutions focusing on self-limitation. In other words, limits are to be *chosen* by self-conscious individuals and this would enable «the embrace of socio-natural abundance». Although the latter remains ill-defined, it is associated in the degrowth literature to communal life and a redefinition of prosperity. As Pellizzoni (2025: 17) cautions, this does not mean in itself that science and technology should be rejected, but rather that they should not become «instruments of oppression». It is thus suggested that the solutions lie in the «humble technologies» advocated by Jasanoff (2003), namely those that are «reversible or repairable, capable of responding to unforeseen events by duplicating functions and adapting to local conditions».

Humble technologies for a low-impact humanity organised around small communities in which social and environmental harmony is achieved with the help of a radical value change — the vision is clear, albeit short in details. Moreover, it has not been explained yet how this brave new world is

supposed to come about. And while it has been suggested that we should let nature be and release ourselves from technology (see Mathews 1999, Coeckelbergh 2023), these ideas remain unpopular outside academia —much as degrowth itself. These normative fantasies do have a place in the ongoing conversation about the good society, but it should be reminded that they do not play any role whatsoever in in electoral competition or international relations.

Ecomodernism and the pursuit of breakthrough technological innovation

In contrast to classical environmentalism's mistrust of technology, ecomodernism believes it to be the only solution to global unsustainability. It openly rejects the widespread belief that technology is a path to dystopia and bets on innovation as the path towards a «good Anthropocene», a state of socionatural relations in which sustainability is made compatible with material wealth, liberal values, and nature's conservation. In the good Anthropocene «humans use their growing social, economic, and technological powers to make life better for people, stabilize the climate, and protect the natural world» (see Asafu-Adjaye et al. 2015). The goal is not to radically change modern societies on account of their spiritual crisis, as classical environmentalism has it, but to reorient them towards sustainability by deliberately applying the modern tools — rom rationality and freedom to technological innovation and state power— to stabilise the Earth system *and* protect nature. Instead of assuming that a completely new mindset will eventually spread itself across the globe, as degrowth theory does, ecomodernists attend to what actual people across the globe wish for. As Bazilian and Pielke puts it:

«The course of development followed by virtually all nations demonstrates that people around the world desire a high-energy future. Our plea is that we begin to recognize that fact, and focus more attention and resources on positively planning for, and indeed bringing about, that future» (Bazilian and Pielke 2013:79).

This is what Karlsson calls a «high-energy planet», a vision grounded on principles of justice: «Unlike post development theories, ecomodernism imagines a future of global economic convergence in which people everywhere will be able to enjoy the fruits of modernity» (Karlsson 2018: 80). Most people in most places do want to have access to abundant energy and material comfort, which in turn make societies more peaceful —while not eradicating conflict— and in fact more concerned by the protection of the natural world. Admittedly, the demand for cheap energy is not necessarily accompanied by an embrace of green values, the latter being perceived as a luxury by those who struggle with poverty or inequality within developed societies or outside them. As Karlsson himself cautions,

«the ecomodernist belief that cheaper and cleaner technologies will displace more expensive and polluting ones seems to depend on the existence of biophilic norms in society and a universalist ethic that considers the global implications of otherwise seemingly 'sustainable' local practices» (Karlsson 2025: 122).

It seems that ecomodernism also need a mindset of its own, after all. And yet what Karlsson points out is but the unavoidable weak spot of sustainability theory, namely that the latter will only be pursued if people consent to it or the state imposes it on them. But the same goes for democracy: it only works if people belief in it and behaves accordingly. That said, the ecomodernist vision appears to be closer to what people across the world seem to prefer when they can choose or have a say — they want access to material goods and being able to decide how they are going to live their lives. In that regard, ecomodernism seems to have a better chance than degrowth to be realised —the environmental strategy of most states is already closer to ecomodernism than to degrowth. However, ecomodernism is an *eco* and it remains unclear whether it will gather enough support to be fully embraced by states and policy makers.

Ecomodernists assume that the technologies that can make the Anthropocene «good» do not exist yet. For that reason, they advocate «breakthrough technological innovation to move forward our technological frontiers» (Lara-De la Fuente 2024). As forerunner Stewart Brand put it: «Human nature doesn't change much; science does, and the change accrues, altering the world irreversibly» (Brand 2009: 216). It should be noted that the orientation of human endeavor toward the production of sustainable technologies is still very recent. That is why philosopher Peter Sloterdijk (2017: 38) claims that technology has not said its last word and points towards a new relationship between technology and the environment based on biomimicry, i.e. the design and production of materials, structures and systems modeled after biological entities and processes. Leaving that prospect aside, ecomodernist hopes can be dashed by cultural prejudice —not all potentially sustainable technologies will be accepted by society. For instance, genetically modified foods have been systematically rejected by the public, even though we have never stopped manipulating the food we eat. In this case, the social perception of risk has been influenced by campaigns from the environmental movement, which has successfully presented GMOs as a dangerous distortion — Frankenstein Food— likely to contaminate our «natural» bodies.

But how is such breakthrough technological innovation to be achieved? Unlike ecological modernisation, which is the strand of environmental thought of which ecomodernism comes from, ecomodernism believes that the state should play an active economic role shaping the trajectory of technological and economic change (Symons 2019: 59). As Nordhaus and Shellenberg (2011) argued some time ago, transformative technologies over the last century were made possible because government invested in them at a scale that private firms just cannot replicate. The role of the state in ecological modernisation is to set and enforce proper regulations, standards and incentives to encourage market actors and entrepreneurs to engage in eco-innovation (see Mol 1995, Jänicke 2008). For ecomodernists, this not enough. As Lara points out:

«ecomodernism highlights the inability of markets to cope with climate change due to incentives, as well as the lack of a long-term vision. This means that states are the only institutions capable of dealing with the uncertainties and risks involved in the creation and diffusion of technologies to replace, for example, fossil fuels and conventional farming products» (Lara-De la Fuente 2024: 7).

The *Ecomodernist Manifesto* is explicit about this, expressing a preference for «a strong public role in addressing environmental problems and accelerating technological innovation, including research to develop better technologies, subsidies, and other measures» (Asafu Adjaye et. al. 2015). Symons (2019: 115) has explicitly grounded this view in Mazzucato's «entrepreneurial state», namely a state that acts as an entrepreneur, creating and shaping markets to solve certain missions (see Mazzucato 2017). The rationale behind this idea, which is popular among political representatives and policy makers across the globe, is that the state can create markets (not only regulating or mending them) and diffuse technology (as opposed to just funding basic research); they can do that because, unlike markets, they can be mission-oriented.

Assigning a strong role to the state in matters of technological innovation goes hand in hand with a bold conception of technological innovation itself. Whereas ecological modernisation theories defended a *precautionary* market-driven innovation regulated by governments, ecomodernism bets on innovation based on the *proactionary* principle and asks for a more flexible and open risk assessment (see Lara-De la Fuente 2024). This approach was latent in Brand's call for a precautionary process managed in a way that «the freedom to try things» is encouraged (see Brand 2009: 164). In More's (2013) account of the proactionay principle, so-called «freedom to innovate» plays a key role, as the burden of proof belongs to those who propose restrictive measures. In a warming planet that demands an effective social response, the undesired effects of new technology cannot become an obstacle for innovation — he proactionary principle allows for handling mixed effects through compensation and remediation instead of prohibition (see More 2013). Such stance on risk-taking should not come as a surprise, since it might very well be considered a natural response to the rhetoric of impending catastrophe spread by environmentalists during the last decades.

In that regard, Fuller (2013) emphasizes that *proactionaries* actually believe that *precautionaries* place humanity at greater risk by preventing scientists «from making the sort of radical experiments that in the past had resulted in major leaps in knowledge that enabled us to overcome our natural limits». It is from this perspective that the advocacy for GMOs, nuclear fission energy or solar engineering should be understood —the assumption being that their potential benefits outweigh the environmental and social costs of current climate inaction (Lara-De la Fuente 2024). Interestingly, Symons (2019: 119) make a similar point when discussing the potential shortcomings of the entrepreneurial state as advocated by Mazzucato: in response to critics that question the efficiency of the latter, he argues that the debate over the inefficiency of government is of limited relevance provided that our interest is in accelerating the pace of low-carbon innovation. Failure and inefficiency, he contends, may be a necessary cost to be managed (Symons 2019: 120). It is a kind of political realism that recalls Deng Xiaoping's cat: it doesn't matter whether a is black or white, if it catches mice it is a good cat.

Degrowth and ecomodernism, in sum, provide accounts of what the role of technology in the quest for sustainability in the Anthropocene should be. Both are tied to wider visions of the good society —and the good Anthropocene. And both are utopians, insofar as they do suggest that socionatural relations will be pacified if their proposals are implemented. In the case of degrowth, it is all about size: human societies are to be replaced by local communities in which «humble technologies» will help to satisfy the basic needs of their inhabitants, who are supposed to live happily and democratically after having escaped from modernity's *cul-de-sac*. As for ecomodernism, it stands for the ecological reform of liberal capitalism through breakthrough technological innovation, as fostered by a strong state in a world where abundant energy is employed to liberate humans from necessity and nature from human exploitation. Thus it makes sense to conceptualise ecomodernist technologies as *bold technologies* that try to respond to the urgent dangers created by anthropogenic global warming.

But how plausible are these accounts? How does technological change work? Is it possible to direct it? If that is indeed possible, can we do it democratically? In sum, can we have our cake and eat it? Such are the questions that the next section address.

Directing technological change?

Technology should be widely understood as a technique grounded on science, linked to the industrial production system and developed through design. And while human beings have used it to shape the world, technology itself has shaped human beings: even though we tend to think that technologies are *neutral* regarding our use of them, the opposite is the case, as each technology favors some values at the expense of others (Diéguez 2024). As a result, the technological choices made in the past have brought us —for good or worse— to the situation in which we find ourselves. To get out, however, we must first understand how we got in.

What does *choosing* mean in this context? Who chooses? And how? Can innovations be chosen that immediately reveal their usefulness? Can we avoid negative side-effects in advance? Were the wheel, the combustion engine, or the telegraph really chosen? The notion that we consciously «choose» which technologies to keep and which to discard can be misleading. It is only with the passing of time that their side-effects become clear —and that is the moment in which alternatives are picked up in hindsight. But this retrospective exercise may put in the past something that was never there, obscuring for us the real reasons why some technologies were successful, and others were never adopted. Take the case of fossil fuel technologies, which, according to critics such as Andreas Malm (see 2016), were preferred by capital over those others involving the use of clean energy, such as hydropower, because it offered more profits —as if the ease of extracting, refining, transporting, and using coal or oil hadn't influenced their rapid dissemination.

Arguably, the state may ban technological innovations that cause undeniable social harm; just as it can require manufacturers of a particular product to adopt measures that guarantee the safety of consumers. But that is not the same as *controlling* technological change. Controlling technological change involves determining what type of innovation is being pursued and selecting the outcomes of that process before specific technologies are introduced into society through the market or public action. If this is unfeasible, then technological change will not be «controllable» but merely «manageable», since we will be reacting to its unintended effects rather than foreseeing them ourselves. To top it all off, it remains to be seen what it means to decide «democratically» about the goodness or badness of different technologies: do experts decide, do our representatives decide on the advice of experts, or do citizens decide through a referendum?

Note that no one could have *decided* that digital communication technologies were inadvisable due to their effects on public debate *before* those effects became apparent; nor is it at all clear that those effects are what they are routinely claimed to be. Moreover, if the complex process of technological innovation were subject to strict political control, technological innovation could barely take place. In other words, the conditions for the emergence and diffusion of new technologies seem poorly suited to political control, let alone the kind of control that democratic politics demands. The problem is compounded if the latter is to be inclusive, participatory, and deliberative.

In Joseph Schumpeter's theory, the entrepreneur is the key driver of technological change — he is the one who introduces a novelty that disrupt a given equilibrium and hence contributes to the kind of «creative destruction» that defines capitalism (see Schumpeter 1942). Even though modern societies orient themselves towards innovation in a systematic manner, the great inventions of the past —from powder to the print— were truly revolutionary despite the lack of free markets. Those who brought them about were innovators rather than entrepreneurs, but then again, the boundaries between them are not easy to identify. In a dynamic economy, the assumption is that there is a force that can account for change and development, which in Schumpeter's view is none other than the entrepreneur. The latter is driven by factors such as competition to improve their organization, incorporate technology, and even take advantage of financial opportunities . He writes that

«in capitalist reality as distinguished from its textbook picture, it is not [textbook]... competition which counts but the competition from the new commodity, the new technology, the new source of supply, the new type of organization (the largest-scale unit of control for instance) —competition which commands a decisive cost or quality advantage and which strikes not at the margins of the profits and the outputs of the existing firms but at their foundations and their very lives» (Schumpeter 1942: 82).

Moreover, he understood that diffusion of innovation was key for technological change to take place. As much as there is no diffusion without innovation, innovation without diffusion is but an isolated event that is not communicated to society. Successive ways of innovation cause existing stock of ideas, skills, technologies, and equipment to become obsolete. His was a theory of endogenous innovation in which technological change is one of the potential novelties brought about by the entrepreneur —among the latter there are also changes in corporate organisation, skill management, or marketing strategy. However, it is obvious that technological innovation plays a large part in the kind of disruption caused by private economic actors in capitalist economies.

In his paper, Keary (2023) rightly distinguishes between exogenous theories of technology, in which the latter is described as outside human control, and endogenous theories, i.e. those that present technological change as «controllable». But a clarification is in order: on the one hand, there is the question as to whether innovation and technological change happen *because* human actors drive them purposefully; on the other, there is the question of whether such occurrence can be *controlled* by those very human actors. And it seems to me that the first question can be answered affirmatively, while the answer to the second remains unclear. The relevant question is thus the one that Keay makes next: «can the pace and direction of technological change fall under the will of a political programme?» (Keary 2023). Or rather: can the pace and direction of technological change *successfully* fall under the will of a political programme?

The idea that technological change can fall under the will of a political programme is called «directed technological change» and has become hegemonic in government and policy (see Acemoglu 2002, 2015, Keary 2016, Van Vuuren et al. 2004). It is telling that Acemoglu (2002) does not wonder about the *occurrence* of technological change, but about the «direction and bias» of the latter. In his framework, the relative profitability of innovation depends on two competing forces, namely the price effect and the market size effect —either technologies are developed that provide larger profits or those that have a larger market. When the two factors are more substitutable, the market size effect is stronger and endogenous technical change is more likely to favor the more abundant factor. But then he goes on to show that in addition to those factors there is also «the degree of state dependence in the innovation possibilities frontier», which relates to «how future relative costs of innovation are affected by the current composition of R&D» (Acemoglu 2002: 791).

But then again he cautions that profit-motivated R&D does not explain all scientific discoveries — non-profit motives may drive «macro-innovations» (Mokyr 1990), or «general-purpose technologies» (Bresnahan and Trajtenberg 1995). However, the profit motives determine how these macro-innovations are developed for commercial use, opening up the possibility that the profit motive actually shapes the direction of technological change insofar as it determines its social diffusion. Paul Romer (1990), one of the pioneers of endogenous technological change theory, concedes that much: although technological change arises because of intentional actions taken by people who respond to market incentives, not everyone involved in the process is motivated by market incentives. Schumpeter would agree: the motivations of the entrepreneur are complex and not solely based on the search for profit. But Romer argues that market incentives play an essential role in technological change —in their absence, new knowledge would not be translated into goods with practical value.

At the same time, as Acemoglu (2015) cautions in a paper that draws upon Atkinson and Stiglitz (1969), the diffusion of frontier technology to less developed economies can actually inflict harm on the latter —the reason being that technological change is by definition «localised and biased» (Acemoglu 2015: 451). The key role of diffusion is also highlihted by Smil (2023), who carefully distinguishes between invention and innovation, the latter being the process of introducing, adopting, and mastering new materials, products, processes, and ideas. For instance, we know what should be done to avoid water leaks in the pipes of countries where drought is common, but this task is rarely undertaken — public action is ineffective, resources are nor properly allocated, the subject does not appeal to the public. Still, he adds a cautionary note that is relevant for our discussion:

«Undoubtedly, technical advances are not autonomous and are strongly influenced by social conditions and contexts —but, all too obviously, major influences go in the other direction, and it is often not in the power of open societies (or even the rulers in dictatorial states) to decide what innovation to embrace or to reject» (Smil 2023: 12).

This is because some innovations just *happen* and cannot be stopped because of its usefulness, its popularity among the public, or its efficiency. Conversely, Smil himself shows that innovation can and often do fail: some technologies are eventually rejected (as DDT or leaded gasoline), others do not fulfill their promises (like airships), and still there are those that do not meet expectations (as hihg-speed travel in a vacuum). Failure is to be expected, since the image of the innovation process that emerges from the literature is hard to reconcile with the idea that technological change can be politically controlled. Admittedly, it may to some extent be *directed*, but not exactly *controlled* —if it is to happen at all.

Technological change, democracy, and control: confronting the trilemma of innovation.

How does technological change happen then? According to Clarke et al. (2008), the main sources of technological change in our time are R&D (both publicly and privately funded, be it devoted to basic

science or applied research), learning by doing (including the process through which organisations cope with new technologies), and spillovers (coming from activities undertaken in largely unrelated sectors). But there is also the question of whether the driving cause of innovation is exploitation of new technological opportunities (technology push) or perceived market demand (market pull). Yet most authors concede that differentiating them is often difficult:

«In many cases one cannot say with confidence that either breakthroughs in research "cause" commercial success or that the generation of successful products or processes was a predictable "effect" of having the capability to read user demands or other market signals accurately» (Rycroft and Kash 1999).

The authors conclude that «no single source dominates the process of technological change», acknowledging that technological change responds to market forces as much as new markets can be created in response to new (unpredictable) technological opportunities (Clarke et al. 2008). Public action must be taken into the picture, too, but caution is in order. After all, as Merton (1973) pointed out long ago, scientific discovery is often the product of an intellectual climate at a particular place in which scientific foundations are in place —which means a spirit of free enterprise, as well as an institutional and corporate ecosystem that facilitates research and diffusion. To put it bluntly, a breakthrough scientific discovery is more likely to come from Palo Alto than from Afghanistan.

But the state can also try to *induce* technological change by other, more straightforward, means. Among the mechanisms employed by them for inducing and supporting innovation are economic and policy incentives, which can be of three main types: (i) reliance on market forces, shaped by public policy; (ii) traditional public sector R&D support; and (iii) exceptional investment in research and development (see Wilbanks 2011). In the latter case, government define ambitious multi-year goals and allocate large quantities of funds and management emphasis. The number of cases of sustained investment over many decades is still limited, but some extraordinarily focused efforts have been successful —such as the Manhattan and Apollo projects, both reflecting a broad national sense of threat. And whereas decarbonizing an energy system is too diffuse a goal, Wilbanks and his colleagues contend, a national commitment of unlimited resources to make carbon capture and storage economically and socially acceptable in a decade could very well work... provided that a national consensus is reached based on an existential threat to society. In this case, however, the relevant technologies are already available and the public action would basically be a diffusion effort. It makes sense: any transformational new technology must be followed by a second period in which an appropriate socio-institutional framework develops, usually meaning a time lag of two to three decades before the technology is fully implemented (Perez, 2002).

For those who support the assumption that technological change can be «directed», the allure of the «entrepreneurial state» is uderstandable. What lies behind the latter, of course, is a matter of detail: saying that the state must actively participate in the quest for sustainable technologies may be relatively uncontroversial, but it remains to be explained *what* exactly is the state to do and *how* efficient is it when doing it. Moreover, it must be proven that the entreprenurial state can do what is expected to do without politics or parties or lobbies interfering with its task —witness the tariffs that the EU has imposed on electric vehicles coming from China, the purpose of which is to shelter the European automobile sector from competition. In the same vein, the electric vehicle in the Western world does not seel well because it is still expensive and because states have so far been unable to provide a public system of chargers that can be easily accessed. On the other hand, Schou (2024) argues that the growing reports of mission-oriented policy failures are due to the disregard of the role of private entrepreneurship, the fact that policy makers are encouraged to ignore limits to government action, and the extrapolation of grand policies from limited results. The paradigm, therefore, is at fault: policy makers should move away from it and focus instead on «the enabling role of the state».

And yet the appeal of the entrepreneurial state lies in its ability to legitimise the strengthening and expansion of the state —that is why policy makers and environmentalists alike are attracted to it. But the former is just another version of the *dirigisme* that dominated Western economies in the

post-war period with mixed results. Instead of embracing the view that technological change can and should be *directed* with the aid of an entrepreneurial state, it seems more realistic to keep a nuanced view of innovation in which the state plays an important but not exclusive role in inducing the invention, while facilitating the diffusion of, new technologies. As the technologies for the energy transition show, the state is never alone nor can do it as it pleases: decreeing that all cars will be electric as of tomorrow would just wreak havoc. But the state can help less well-to-do consumers, build up new infrastructures, and create incentives for all kind of firms while continuing to fund basic research. Taxation is a particularly powerful tool, as it pushes firms to look for more sustainable technologies. To say that the pace and direction of technological change can *successfully* fall under the will of a political programme, however, is not warranted. And neither it is to claim that technological change can henceforth be «controlled» by political means —even though it can surely be watched and acted upon if necessary.

What about the *democratic* control of technological change? A participatory democracy in which citizens engage in deliberative decision-making has belonged to the green agenda from the beginning (see Dobson 1990). Although the flaws in the latter argument have been put forward time and again (see Goodin 1992), environmentalism has remained adamant and the notion of self-government is central to depictions of the post-growth society, as associated to the green republican ideal (see Cannavò 2016, Barry 2021). What is to be democratically decided in a small community devoted to the task of being sustainable under the constraints of a warming world is unclear —a potential contradiction acknowledged by some authors (see Cannavò 2016: 83). But the democratisation of sustainability also requires giving voice to «communities of risk», i.e. to those affected by particular technologies or industrial impacts (see Eckersley 2000), as well as enlarging representation so as to make possible that the interests of other species or future generations are taken into consideration (see Saward 2000).

On the other hand, the Anthropocene demands a democracy that embraces «reflexivity» as a core value embedded in its institutional design: public inquiries, independent review bodies, procedural environmental rights and deliberative settings in which citizens and experts can work together are elements of reflexivity (Dryzek and Pickering 2019). Relevant to our subject is also «epistemic pluralism», as manifested in the efforts to democratise scientific knowledge production by negotiating and bridging the gap between local communities, indigenous peoples, technoscientific knowledge hubs, and the humanities and the social sciences (Mert 2025, Beck et al. 2014, Pickering et al. 2023). Whereas technology is «depoliticized» by those who present it as a neutral tool, ecomodernists among them, the opposite is required:

«Without making politics a public matter, one cannot speak of democracy. Depoliticization offsets the politically legitimate opposition that is so important for democracy, and reduces politics to consensus reached through rational argumentation of experts. Politicization, by contrast, offers the opportunity to address issues democratically, in both private, social and more formal institutional governmental settings» (Hällmark 2022).

It should be noted that ecomodernists see «depoliticization» as a benefit insofar as it might help to prevent the kind of polarisation around the climate issue that hampers *any* kind of progress. Such view is predicated upon the assumption that a majority of people wish to enjoy abundant energy and material comfort. If one is to contest this assumption, by arguing that degrowth is preferable or unavoidable, a majority of the population must be persuaded.

By no means does this entail that the energy transition is emptied out of political content. This cannot possibly happen, as we see in the protest by European farmers or in the opposition to the side-effects of wind parks. But democratising the energy transition does not seem possible if the latter means popular control of, or binding citizen deliberation about, technological innovation and/or diffusion. The reason is simple and has been outlined above: neither technological innovation nor its diffusion actually work like that. Technological change can of course be induced: states can prioritise certain goals and cultural change itself may open up new markets that incentivise private entrepreneurship.

However, success is not guaranteed —let alone a rapid success— and neither can it be prevented that trade-offs and conflicts present themselves once particular technologies are diffused throughout society.

Moreover, the sources of technological change are too manifold and unpredictable to allow for a successful pre-emptive political control. What states do is to monitor the appearance of new technologies, making sure that they fulfill some basic requirements, proceeding then to watch their implementation and contributing to its social diffusion when the latter is desirable and needs to be helped out. Going beyond this, for instance subjecting innovation to popular monitoring or citizen deliberation, would hamper the innovation process. It is in the stage in which the impacts of new technologies are assessed that democratic participation makes more sense —civic associations and deliberative settings may help to ensure that innovation retains social acceptance.

Therefore, a dilemma appears to emerge: we cannot simultaneously have technological change and democratic control. If we reinforce the latter, the capacity for innovation will be significantly reduced; if we focus on promoting technological change outside of democratic control, the rate of innovation will increase —provided the institutional, economic, and cultural conditions for it are in place— while our ability to limit in advance its undesirable effects will decrease. And given that there are countless controversial technologies, as well as different ways of viewing technology's place within a human community, democratic control need not necessarily go hand in hand with social consensus —the dilemma becomes a trilemma. This means that you cannot have innovation, political control, and social consensus at the same time. Either you weaken the process of innovation by increasing political control (which may or may not bring about greater social consensus) or you loosen the political control of technological change (which may or may not bring about greater social consensus). When urgency is added to the picture, as is the case with the energy transition, the trade-offs become even stronger.

If we come back to the contrasting positions of degrowth and ecomodernism on technological change, it would appear as if the latter is better placed to confront the trilemma. Whereas degrowth seeks a complete revamping of society that can only happen when a complete new cultural mindset is adopted, ecomodernism takes a pragmatic stance and gives up democratic control of innovation, placing its hopes instead on a proactionary approach to technology and simply expecting that the «high-energy planet» resulting from this kind of energy transition will generate enough social consensus to legitimise its outcomes.

Conclusion

Although technological change and democratic politics seem to speak different languages, truly existing democracies choose a middle path between them. On the one hand, it is assumed that technology is indispensable for producing material well-being, its development being thus encouraged through various means: promotion of basic science, financial aid, funding of targeted projects based on predetermined objectives, and the like. On the other hand, technological change is subject to regulation —informed by experts— that seeks to minimize its negative effects and maximize its positive ones, while establishing certain moral limitations on it (animal treatment or genetic experimentation). It is a pragmatic approach that does not solve the trilemma described above but manages to navigate its conflicts and contradictions.

In the case of climate change and decarbonisation, technological change is happening thanks to a combination of factors —from public action to private entrepreneurship and cultural change. To deem the whole process as a failure is unwarranted. The problem lies in the unrealistic expectation that the energy transition could be completed overnight; on the contrary, it takes time. But the required technologies are in place, even though most of them must gain efficiency and still others are on their way. As a matter of fact, trying to achieve a rapid decarbonisation has created major problems of legitimacy, resulting in a social and political backlash against climate policies. Ironically,

a section of the democratic public now firmly opposes the latter —so much for the democratisation of technological change.

If we accept the view that the energy transition is mostly about technology and innovation (Overland 2019), then ecomodernism seems well suited to provide a realistic path towards global sustainability —or the «good Anthropocene»— through breakthrough technological innovation. To be sure, there are utopians elements in its account (see Arias-Maldonado 2023) and the emphasis on breakthrough innovation may lead us to forget how decisive the diffusion of plain innovation really is. On the other hand, the hopes ecomodernists place in the entrepreneurial role of the state is not consistent with how innovation actually works and should be best reformulated as a reasonable bet on the enabling role of the state.

As for degrowth, it has a view of technology that is consistent with the green intellectual tradition. Most environmentalists —ecomodernists excepted— firmly reject the view that the problems created by technology can be solved by technology and hence the pejorative view of what they see as an unfeasible «technofix». Obviously, they reject the view that the energy transition is mostly about technology and innovation. For them, it is about changing how we feel, think, and live. It is a legitimate position, but one which seems far away from the real world in which climate policies are being devised and implemented by a complex set of public and private actors.

References

Acemoglu D (2002) Directed Technical Change. *The Review of Economic Studies* 69(4): 781-809.

Acemoglu D (2015) Localised and biased technologies. *The Economic Journal* 125(583): 443–463.

Angus I (2016) *Facing the Anthropocene: Fossil Capitalism and the Crisis of the Earth System*. New York: Monthly Review Press.

Arias-Maldonado M (2004) Prometeo desencadenado. Sobre la concepción marxista de la naturaleza RIPS. *Revista de Investigaciones Políticas y Sociológicas* 3(2): 61-83.

Arias-Maldonado M (2019) Blooming landscapes? The paradox of utopian thinking in the Anthropocene. *Environmental Politics* 29(6): 1024–1041. https://doi.org/10.1080/09644016.2019.1703384

Asafu-Adjaye J et al. (2015) *An Ecomodernist Manifesto*. Available at: http://www.ecomodernism.org/

Atkinson AB Stiglitz JE (1969) A New View of Technological Change. *Economic Journal*, 79: 573-578.

Azeez GK and Symons J (2025) Seizing the means of innovation: On the relationship between Marxism and ecomodernism, *Political Geography*, 122: 103388. https://doi.org/10.1016/j.polgeo.2025.103388.

Barry, J. (2021). Green republicanism and a 'Just Transition' from the tyranny of economic growth. *Critical Review of International Social and Political Philosophy* 24(5): 725-742. DOI: 10.1080/13698230.2019.1698134

Bastani A (2019) Fully Automated Luxury Communism: A Manifesto. London: Verso.

Bazilian M Pielke R (2013) Making energy access meaningful. *Issues in science and technology* 29 (4): 74-78.

Bhaskar R (1991) Materialism. In: T. Bottomore (ed.), *A Dictionary of Marxist Thought* (p. 369). Oxford: Blackwell.

Beck S et al. (2014) Towards a reflexive turn in the governance of global environmental expertise: The cases of the IPCC and the IPBES. *GAIA-Ecological Perspectives for Science and Society* 23(2): 80–87. https://doi .org /10 .14512 /gaia .23 .2 .4.

Beck U (1986) *Risikogesellschaft. Auf dem weg in eine andere Moderne*. Frankfurt: Suhrkamp.

Beck U (2009) *World at Risk*. Cambridge: Polity Press.

Beck U, Giddens, A and Lash S (1994) *Reflexive Modernization. Politics, Tradition, and Aesthetics in the Modern Social Order*. Cambridge: Polity Press.

Benton T (1989) *Marxism and Natural Limits: An Ecological Critique and Reconstruction*, *New Left Review*, 178: 51-86.

Brand S (2009) *Whole Earth Discipline*. New York: Viking Press.

Breshanan TF Trajtenberg M (1995) General Purpose Technologies: "Engines of Growth"? *Journal of Econometrics* 65(1): 83-108.
Cannavò P (2016) Environmental Political Theory and Republicanism. In: T. Gabrielson et al. (eds.), *The Oxford Handbook of Environmental Political Theory* (pp. 72-88). Oxford: Oxford University Press.
Clarke L Weyant J Edmonds J (2008) On the sources of technological change: What do the models assume? *Energy Economics* (30) 2: 409-424 https://doi.org/10.1016/j.eneco.2006.05.023.
Coeckelbergh M (2023) Green Leviathan or the Poetics of Political Liberty. Navigating Freedom in the Age of Climate Change and Artificial Intelligence. London and New York: Routledge.
Crutzen P (2002) Geology of mankind. *Nature* 415(6867): 23. DOI: https://doi.org/10.1038/415023a
Crutzen P and Stoermer E (2000) The Anthropocene. *IGBO Global Change Newsletter*, 41: 17–18.
D'Alisa G Romano O (2025) Degrowth and Limits. In: A. Machin and M. Wissenburg (eds.), *Handbook of Environmental Political Theory in the Anthropocene* (pp. 99-108). Cheltenham and Northampton: Edward Elgar.
Demaria F, Schneider F, Sekulova F and Martínez-Alier J (2013) What is degrowth? From an activist slogan to a social movement. *Environmental Values* 22: 191–215.
Diéguez A (2024) *Pensar la tecnología*. Barcelona: Shackelton Books.
Dillet B Hatzisavvidou S (2022) Beyond technofix: Thinking with Epimetheus in the anthropocene. *Contempary Political Theory* 21: 351–372. https://doi.org/10.1057/s41296-021-00521-w
Dobson A (1990) *Green Political Thought*. Oxford: Oxford University Press.
Dryzek J and Pickering J (2019) *The Politics of the Anthropocene*. Oxford: Oxford University Press.
Eckersley R (2000) Deliberative democracy, ecological representation and risk: towards a democracy of the affected. In: M Saward (ed.), *Democratic Innovation. Deliberation, representation y association* (pp. 117-132). London: Routledge.
Foster JB (2000) *Marx's Ecology*. New York: Monthly Review Press.
Fremaux A (2019) *After the Anthropocene: Green Republicanism in a Post-Capitalist World*. London: Palgrave.
Fuller S (2013) The Proactionary Principle: Between No Caution and Precaution. *The Breakthrough Institute*, August 8th.
Gabrielson T Hall C Meyer J Schlosberg D (2016) *The Oxford Handbook of Environmental Political Theory*. Oxford: Oxford University Press.
Giddens A (1991) *The Consequences of Modernity*. Cambridge: Polity.
Gibbon E (ed.) (2014) *The Encyclopedia of Political Thought*. Malden: Wiley-Blackwell.
Goodin R (1992) *Green Political Theory*. London: Polity.
Haff P.K. (2014) Technology as a geological phenomenon: implications for human wellbeing. In: C. N. Waters, J. Zalasiewicz, and M. Williams (eds.), *A Stratigraphical Basis for the Anthropocene* (pp. 301-309). London: Geological Society of London, Special Publication 395.
Hällmark K (2022) Politicization after the 'end of nature': The prospect of ecomodernism. *European Journal of Social Theory*, *26*(1), 48-66. https://doi.org/10.1177/13684310221103759.
Hamilton C Bonneuil C Gemenne F (2015) Thinking the Anthropocene. In: C Hamilton, C Bonneuil F Gemenne (eds.) *The Anthropocene and the Global Environmental Crisis* (pp. 1-13). London & New York: Routledge.
Jackson T (2009) *Prosperity Without Growth. Economics for a Finite Planet*. London: Earthscan.
Jänicke M (2008) Ecological modernisation: new perspectives. *Journal of Cleaner Production*, 16 (5): 557-565. doi:10.1016/j.jclepro.2007.02.011
Jasanoff S (2003) Technologies of Humility: Citizen Participation in Governing Science. *Minerva* 41: 223-244. https://doi .org /10 .1007 /978 -3 -322 -80692 -5 _17.
Kallis G (2011) In defense of degrowth. *Ecological Economics*, 70, 873-880.
Kallis G (2019) *Limits: Why Malthus Was Wrong and Why Environmentalists Should Care*. Stanford: Stanford University Press.
Karlsson R (2018) The high-energy planet. *Global Change, Peace & Security*, 30(1), 77-84. DOI: 10.1080/14781158.2018.1428946
Karlsson R (2025) Ecomodernism. In: A. Machin and M. Wissenburg (eds.), *Handbook of Environmental Political Theory in the Anthropocene* (pp. 120-128). Cheltenham and Northampton: Edward Elgar.
Katz E (1997) *Nature as subject. Human obligation and natural community*. Lanham: Rowan & Littlefield Publishers.
Keary M (2016) The new Prometheans: Technological optimism in climate change mitigation modelling.

Environmental Values 25(1): 7–28.
Keary M (2023) The political theory of technological change: Lessons from the liberalism-ecologism debate. *Politics*, 44(1): 155-172. https://doi.org/10.1177/02633957231173371
Lara-De la Fuente, D. (2024). Making sense of ecomodernism: normative implications and rational consumption. *Environmental Politics*, 1–21. https://doi.org/10.1080/09644016.2024.2437879
Machin A Wissenburg M (eds.) (2025) *Handbook of Environmental Political Theory in the Anthropocene*. Cheltenham and Northampton: Edward Elgar.
Malm A (2016) Fossil Capital: The Rise of Steam Power and the Roots of Global Warming. London: Verso.
Marcuse H (1941) Some Social Implications of Modern Technology. *Zeitschrift für Sozialforschung* 9(3): 414-439.
Mathews F (1999) Letting the world grow old: An ethos of countermodernity. *Worldviews: Global Religions, Culture, and Ecology* 3(2): 119–137.
Mazzucato M (2017) *The entrepreneurial state*. New York: Penguin Books.
Mert A (2025) Democracy. In: A. Machin and M. Wissenburg (eds.), *Handbook of Environmental Political Theory in the Anthropocene* (pp. 48-57). Cheltenham and Northampton: Edward Elgar.
Merton RK (1973) *The Sociology of Science: Theoretical and Empirical Investigations*. Chicago and London: University of Chicago Press.
Mokyr J (1990) *The Levers of Riches: Technological Creativity and Economic Progress*. New York: Oxford University Press.
Mol A (1995) *The refinement of production: ecological modernization theory and the chemical industry*. Utrech: International Books.
More M (2013) The Proactionary Principle. In: M More and Vita-More N (eds.), *The Transhumanist Reader: Classical and Contemporary Essays on the Science, Technology, and Philosophy of the Human Future* (pp. 258-267). Chichester: Wiley-Blackwell.
Morton T (2013) *Hyperobjects. Philosophy and Ecology after the End of the World*. Minneapolis & London: University of Minnesota Press.
Neumayer E (2010) *Weak versus Strong Sustainability. Exploring the Limits of Two Opposing Paradigms*, 3rd edition. Cheltenham: Edward Elgar.
Nordhaus T Shellenberger M (2011) The long death of environmentalism. *The Breakthrough Institute*. Available from: https://thebreakthrough.org/issues/ energy/the-long-death-of-environmentalism
Overland I (2019) The geopolitics of renewable energy: debunking four emerging myths. *Energ Res Soc Sci* 49(2019): 37–40.
Pellizzoni L (2025) nature. In: A. Machin and M. Wissenburg (eds.), *Handbook of Environmental Political Theory in the Anthropocene* (pp. 10-18). Cheltenham and Northampton: Edward Elgar.
Perez C (2002) *Technological Revolutions and Financial Capital*. Cheltenham: Edward Elgar.
Pepper D (1996) *Modern Environmentalism. An introduction*. London: Routledge.
Pickering J et al. (2022). Pluralizing Debates on the Anthropocene Requires Engaging with the Diversity of Existing Scholarship. *Annals of the American Association of Geographers*, *113*(2), e-i-e-vi. https://doi.org/10.1080/24694452.2022.2105296
Plumwood V (2002) *Environmental Culture. The ecological crisis of reason*. London: Routledge.
Romer P (1990). Endogenous Technological Change. *Journal of Political Economy*, *98*(5), S71–S102. http://www.jstor.org/stable/2937632
Saito K (2022) *Marx in the Anthropocene*: *Towards the Idea of Degrowth Communism.* Cambridge: Cambridge University Press.
Saward M (ed.) (2000) *Democratic Innovation. Deliberation, representation and association*. London: Routledge.
Schou P (2024) Unpacking the myth of the entrepreneurial state. *Journal of Business Venturing Insights*, 21: e00454. https://doi.org/10.1016/j.jbvi.2024.e00454.
Schumpeter JA (1942) *Capitalism, Socialism and Democracy*. New York: Harper and Brothers.
Sloterdijk P (2017) *Was geschah im 20 Jahrhundert?* Berlin: Suhrkamp.
Smil V (2023). *Invention and Innovation: A Brief History of Hype and Failure*. Cambridge and London: The MIT Press.
Stirling A (2025) Colonial modernity in the anthroposalon. In: A. Machin and M. Wissenburg (eds.), *Handbook of Environmental Political Theory in the Anthropocene* (pp. 77-88). Cheltenham and Northampton: Edward Elgar.
Symons J (2019) *Ecomodernism: Technology, Politics, and the Climate Crisis*. Cambridge: Polity Press.

Thomas J, Williams M and Zalasiewicz J (2020) *The Anthropocene: A Multidisciplinary Approach*. Polity, Cambridge.

Thompson C MacGregor S (2017). The Death of Nature: Foundations of ecological feminist thought. In: S. MacGregor (ed.), *The Routledge Handbook of Gender and Environment* (pp. 43-53). London: Routledge.

Tonder L (2025) *Power in the Anthropocene*. Edinbugh: Edinburg University Press.

Vetlesen A (2015) *The Denial of Nature: Environmental Philosophy in the Era of Global Capitalism*. London: Routledge.

Vallor S (2022) *The Oxford Handbook of Philosophy of Technology*. Oxford: Oxford University Press.

Van Vuuren DP De Vries B Eickhout B Kram T (2004) Responses to technology and taxes in a simulated world. *Energy Economics* 26(4): 579–601.

Westfall R (1992) The scientific revolution of the seventeenth century: the construction of a new world view. In: J. Torrance (ed.), *The Concept of Nature* (pp. 63-93). Oxford: Clarendon Press.

Wilbanks, T (2011) Inducing transformational energy technological change. *Energy Economics*, 33: 699-708.

Zalasiewicz J et al. (2021) The Anthropocene: Comparing Its Meaning in Geology (Chronostratigraphy) with Conceptual Approaches Arising in Other Disciplines. *Earth's Future* 9(3): e2020EF001896. DOI: https://doi.org/10.1029/2020EF001896

Zalasiewicz J (2023) Science: Old and New Patterns of the Anthropocene. In: J. A. Thomas (ed.), *Altered Earth: Getting the Anthropocene Right* (pp. 21-50). Cambridge: Cambridge University Press.