Fossil modernity: The materiality of acceleration, slow violence, and ecological futures

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Abstract
This article seeks to materialize social theories of modern temporalities. It proposes a tempo-material analysis of carbon resources like coal, oil, and gas to illuminate how fossil materialities both underpin and undermine modern temporalities and introduce the notion of fossil modernity to evoke an understanding of the modern composed of multiple conflicting modes of material temporality. Fossil resources (fossil fuels and petrochemical substances) drive the pace and progressive perspective of modernity. The residuals of these resources (CO₂, plastic waste, and petrochemical toxins) confront societies with long-lasting ecological damage. Fossil fuels helped to produce the expectation of growth and endless possibility. Fossil residuals create a horizon of ecological liabilities in which past options have become future obligations. This renders the pretences of “modernization” understood as a process of constant renewal and innovation problematic. The article argues that modern societies cannot simply overcome their material–temporal predicaments through “decarbonization” because even after a shift to solar power, organic agriculture, and sustainable plastics, the fossil past will continue to influence, inform, and incite social operations. The article thus shows how different responses to the problems of fossil modernity need to go back to and emerge from the material residues of the past: this goes for

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bio-capitalist projects seeking to “recycle” the entropic temporality of fossil residuals as well as for environmental justice movements that decipher these residuals as indexes of social asymmetries and call for socio-ecological “redistribution.”

**Keywords**

Social theory, modernity, temporality, carbon, climate change, plastic, new materialisms, anthropocene

**Introduction**

This article seeks to materialize social theories of modern temporality by looking at modernity’s most important resources: coal, oil, and gas. Fossilized carbon resources literally fuel the tremendous dynamism and speed of modern societies. Aside from being sources of energy, they serve as raw material for petrochemical substances used in fertilizers, pesticides, cosmetics, and plastics that not only define modern ways of life but also exhibit a molecular structure unforeseen on this planet before the advent of modernity. At the same time, the mobilization of fossil matter/energies is responsible for ecological problems modern societies have to grapple with: toxification of bodies and environments, degradation of soils, loss of biodiversity, plastic waste, and, of course, climate change. These problems are associated with irreversible, long-lasting consequences that leave a “technofossil record” (Zalasiewicz et al., 2014) in the deep time of the earth system (Ginn et al., 2018). These contemporary ecological problems and the slow and long-lasting violence they exert are the effect of modernity’s future-oriented, linear, and accelerating temporality enabled and sustained by fossil resources. That is why fossil materialities are no longer just the key assets of modernity, but have become liabilities as they have turned into waste products like atmospheric CO₂, microplastic, and chemical toxins. This article argues that, in this dual guise—as asset and liability—carbon materialities both underpin and undermine the temporal operations of what I call fossil modernity. They make possible and propel the pace and progressive perspective of modern temporality and by the same token, or rather the same material substratum, confront modern societies with a particular slow time of material durability and ecological degradation.

The article draws on recent work on energy, fossil fuels (Szeman and Boyer, 2017), as well as on the products and ecological problems of petrochemicals like plastics (Gabrys et al., 2013). It also draws on historical approaches (Altvater, 2007; Huber, 2013; Malm, 2016a; Mitchell, 2011; Westermann, 2007;) that show how societies discovered, extracted, used, and ultimately began to problematize fossil resources. To account for the active role that these materialities play in modern societies, fossil resources will be analyzed as temporal operators that may
support societal time regimes but also undermine them. Inspired by, yet going beyond, new materialist approaches (Barad, 2007; Bennett, 2010), it therefore proposes a materialist analytics of time.

This materialist approach seeks to supplement canonical theories of time and modernity notoriously focused on questions of historical consciousness (Habermas, 1990: 1–23), social communication (Luhmann, 1976), and the semantics of time (Koselleck, 2004) rather than on the materiality of time. A series of now classic works have stressed that modernity goes along with—or is even defined by—a peculiar temporal order that entails a linear trajectory (Nowotny, 1989), an orientation toward the future (Luhmann, 1992), and the acceleration of social and technical operations (Rosa, 2005; Wajcman and Dodd, 2016). According to Habermas (1990: 1–23), “modernity’s consciousness of time” functions as a form of “self-reassurance.” This reassuring function, however, hinges on acts of temporal othering (Fabian, 2014) that distance modernity from the so-called societies without history and a seemingly timeless nature (Adam, 1990; Chakrabarty, 2009). By focusing on the carbon substratum of modernity, the article seeks to unsettle this self-reassuring consciousness of time. Since modern societies are confronted with the accumulated residuals of its fossil-fuelled operations, they cannot fully emancipate from the past to seize an open future of progress and possibility. For the same reason, they cannot separate themselves from nature but become implicated in the timescales of a natural history they have inadvertently created. To evoke an alternative understanding of the modern composed of multiple conflicting modes of material temporality, I will introduce the notion of fossil modernity.

As I will show in what follows, such an altered understanding of modernity and its temporality has profound implications for practices of critique. Critique has always been complicit with the modern consciousness of time (Koselleck, 1973). Instead of clinging to the “space of experience,” it relies on an open “horizon of expectations” (Koselleck, 2004: 255–276) to realize a better future (Folkers, 2016). But what happens when this horizon turns out to be clogged with the residuals of the very substance that helped to create the modernist horizon of progress in the first place? I will thus argue that critique risks “running out of steam” (Latour, 2004) because it quite literally runs out of fuel: that the temporal structures modern critique assumed relied on the use of resources that now corrode these structures. I will therefore suggest an alternative temporal grammar for critique that no longer just seeks to overcome the past but to carefully inherit it as an ongoing material condition of the present that stretches into the far future.

The next section presents a materialist understanding of temporality and outlines the model of historicity that structures the rest of the article. For the latter, I draw on Williams’ (1977: 121–127) argument that each historical moment is defined by three instances: the residual, the dominant, and the emergent. In the following three sections, each of these instances is associated with a particular
material mode of temporality, beginning with the dominant way of mobilizing fossil resources in modernity that contributed to a linear, accelerated, and future-oriented temporality. The following section draws attention to the residuals of fossil modernity that confront these modernist temporal regimes with the slowness and durability of accumulated waste products like CO₂ and plastic. Finally, I show how these residuals become part of emergent socio-material transformations that introduce different forms of reclaimed temporality: capitalist (bio)economies of recycling and remediation as well as environmental justice movements demanding socio-ecological redistribution.

The temporality of carbon matter

Although there are relatively few scholarly accounts so far that explicitly analyze the entanglement of time and matter (Folkers, 2019; Hawkins, 2018; Lewis and May 2020), new theoretical approaches on “materiality” and “things” have much to offer in rethinking temporality. Instead of conceptualizing matter as inert res extensa that occupies geometric space but remains identical through time, new materialist theories emphasize the processuality of the material world (Connolly, 2011; Bennett, 2010). According to the processual ontology at the heart of new materialisms, time can no longer be merely construed as an “inner sense” (Kant, 1968: 78–83), a social construct or an external parameter just tracking what takes place in the world. Rather, time is immanent to and entangled with the endless stream of material events. In this vein, Barad (2007: 180) stresses the entangled becoming of time and matter: “Becoming is not an unfolding in time but the inexhaustible dynamism of the unfolding of mattering.” Matter is not in time like beer in a can but the very “stuff of time” (Ingold, 2012: 439). Time is not a linear, extended, and empty space. Rather, matter is the intensive texture of time. This amounts to more than claiming that matter undergoes transformations, or materializes, over time. Matter changes with, or rather becomes with, time. Matter and time make up and reside in the same topological folds. Unfortunately, new materialists’ accounts often remain too abstract by focusing on matter per se and miss the Eigenzeit of particular materials (i.e., concrete things, chemical substances, or their molecular combinations) and material states (i.e., frozen, liquid, or gaseous, and ordered or entropic). A piece of coal, for example, is a tempo-material fold that stores the time of past biospheric work ready to release and unfold it in a few minutes, and thus exhibits a particular temporal profile that distinguishes it from, say, a piece of wood or iron.

In addition, new materialists often neglect the roles materials play in particular historic conjunctures. However, not only the use and importance of certain materials changed historically (think of the Stone Age, Bronze Age, atomic age). Time and again whole “new materials” came into being (thanks to the ingenuity and side effects of the chemical industries, e.g.). This, in turn, also alters the
material life of time: new resources are mobilized to speed up social life, things become more or less durable, etc. I will thus look at a particular group of materials and their role in and for a particular historical constellation. I will look at fossil matter both “in and of time” (Hawkins, 2018: 91), and combine histories of fossil resources with a focus on the temporalities of fossil materials. This will reveal how it is possible to extract different temporalities from the same material substance. This approach allows for an acknowledgment of the impact of fossil materials on modern societies while avoiding the pitfall of energy determinism that ascribes demiurgic powers to fossil fuels (Appel et al., 2015: 10–18; Huber, 2013: 3ff.). Fossil materials are not determining causal factors but receive their relative power only when associated with other socio-technical actors. In fact, they only become “resources” that contribute and catalyze modernist temporalities when they are mobilized as such: explored, extracted, combusted, cracked, transformed, etc. However, the ways the remainder of fossil resources subvert and undermine these temporalities reveal the recalcitrance of matter and material time.

Fossil modernity, as conceptualized in this article, is the encounter between conflicting, yet intersecting, strata of tempo-materialities. Accordingly, the “modern” in “fossil modernity” is no longer identical with newness but with what Rabinow (2008: 12–32) described as the “contemporary”: an intersection of old and new, and, I would add: fast and slow, natural, and social history. To account for this entanglement, I mobilize Williams’ (1977: 121–127) famous distinction among “residual,” “dominant,” and “emergent,” and adapt it for the purposes of this article. Williams used this distinction to establish a new understanding of hegemony. For him, hegemony is not a static “bloco historico.” Instead, he stressed that the dominant is always haunted by historical residuals and pulled away by the lines of light of the emergent. Residual, dominant, and emergent are therefore not simply past, present, and future, but instances of a complex and conflictual now.

I will neo-materialistically enrich Williams’ model to show how fossil materialities exist and persist in modernity. I will associate each of the three instances with the different temporalities of carbon materialities: the dominance of fossil capitalism with a linear temporality enabled by the use of fossil fuels, the residual with an accumulated temporality created by the waste of fossil modernity, and the emergent with a re-cyclical temporality that emerges from the ways fossil residuals incite new socio-economic and sociopolitical processes. These three layers of material temporality comprise what I call fossil modernity. Instead of assuming a break between first and second modernity (Beck, 1986), or between industrial and “ecological modernization” (Spaargaren and Mol, 1992), the concept of fossil modernity focusses on the coeval yet “multiple modernities” (Eisenstadt, 2000) that uneasily coexist in the present underpinned by the same material substratum.
Despite attempts to decarbonize society, fossil fuel consumption and CO₂ emissions are rising. This still dominant mode of fossil modernity only became possible through recourse to earth historical residuals. Modernity feeds off fossilized biomass that has become coal, oil, and gas over a period of 300 million years. The extraction of these resources not only digs holes in the ground but opens up geo-historical worm holes that bring different geological epochs into contact. This is more than just a metaphor. It is not merely a coincidence that modern geology, which began to depict the vertical strata of the earth as a geo-historical record, emerged around the same time the massive industrial use of fossil fuels started (Bowker, 1995). The ability to “read” the geological record advanced the capacities to “rewrite” the earth since geologist brought their geo-historical knowledge to bear on mining operations (Braun, 2000).

Precisely these sedimented, both geologically and historically deep, slow, and inert seams of accumulated time served as the reservoir to establish the new, accelerated, and linear time regime of capitalist modernity. The steam engine unleashed the densely folded topology of geological time and transformed it into irreversibly exhausted thermal energy and linear movement. It acted as a “steam iron” that glazed out all the temporal folds, knots, and wrinkles of geological time to create a smooth temporal surface. By releasing the stored time of fossil fuels, it established a socioeconomic temporality seemingly emancipated from natural time (Altvater, 2007), from the cycles of weather and seasons and the limited power of organic—human and nonhuman—work (Schivelbusch, 2000: 9–20). However, the success of fossil fuels cannot be reduced to technological factors. As Malm (2016a: 188) shows, coal became the most important energy source during the early days of industrialization because it was favorable to the “spatiotemporal profile” of capital. The use of coal-fired steam power allowed the factory’s accelerated time regime to be transferred to the workers in an efficient and impersonal manner. Coal became the “standing reserve army” that represented the pure essence of abstract labor devoid of the demanding nature of human workers and therefore served as an ideal weapon against the latter’s political organizations.

In fact, there is not only an affinity but also an analogy between the temporal profile of capital and fossil fuels. Both supply society with abstract goods that go along with an abstract temporality. The ability to translate the energy stored in fossil fuels into thermal and kinetic energy (and later even in electricity) made it possible to produce energy sans phrase, abstract energy. This increase in available options that characterizes modern societies (Offe, 1986) hinges on the material features of fossil fuels. Because they are easily storable, they provide abstract energy which not only serves any purposes but also does so at any moment in time. With respect to energy, the storable stockpile of fossil fuels made it possible
to experience the future in a characteristically modern way as a “storehouse of possibility” (Luhmann, 1976: 150): an open horizon of available and manageable options. Money similarly functions as a store of generic options and thereby harnesses the future as a disposable resource. Designations like “black gold” for oil, or the German “Kohle” meaning both money and coal, are not a coincidence.

Fossil fuels not only powered production but also the circulation of goods, capital, and people. The railway accelerated traffic to a hitherto unimaginable speed (Schivelbusch, 2000: 35–44). This created new temporal imperatives instigating the standardization of time and the synchronization of train station clocks (Schivelbusch, 2000: 32; Galison, 2004: 98–106). At the same time, the steamboat became a crucial “tool of empire” (Headrick, 1981: 17–42) advancing the ease, reach, and speed of colonial conquest and control (Malm, 2016b: 223–232). Yet steam and coal also increased the vulnerability of capitalist production and circulation to disruptions. The dependence of capitalist operations on fossil fuels created a critical chokepoint that could bring entire economies to a standstill when strategically mobilized by the workers’ movement (Mitchell, 2011: 12–42).

At least since the end of the Second World War, coal gave way to hydrocarbons (oil and gas) as the most important fossil resources. While some of the temporal trends of the coal age just intensified, this also brought about a series of qualitative changes. The rise of the automobile further accelerated traffic and stimulated suburbanization (Urry, 2013: 36–74; Huber, 2013: 38–43). The US-dominated automobile “product cycle” (Silver, 2003: 75–124) premised on the exploitation of the new oil frontiers superseded the British dominated textile cycle that relied on cheap cotton, labor of enslaved people, and coal (Moore, 2015: 163). Politically, this new Fordist regime of capitalism went along with Keynesian attempts to govern “the economy.” As Timothy Mitchell (2011) argues, “the economy” introduced a dematerialized conception of economic processes that ironically relied on the material infrastructure of smooth and seemingly infinite oil flows. The “economy” expressed by the new calculative infrastructure of national income accounting figures as “a system of monetary circulation […] that could expand indefinitely without any problems of physical limits” (Mitchell, 2011: 234). This introduced a new “way to bring the future into government” by introducing “a new metric of temporal change, the measurement of growth” (Mitchell, 2014: 484). Growth was no longer just the implicit trajectory of the capitalist economy but became the explicit telos of the “growth state” (Castel, 2017: 343–366).

The emergence of the petrochemical industry marks another threshold of fossil modernity. While a couple of petrochemical inventions date back to the first part of the 20 century and especially to the search for synthetic substitute materials (Westermann, 2007: 60–80) and chemical weapons (Carson, 1962: 14) during the World Wars, the petrochemical industry only gained its current importance after the Second World War. The petrochemical industry cracks the molecular structure
of hydrocarbons to reassemble them into entirely new synthetic substances, which come to use in cosmetics, foods, fertilizers, pesticides, and all kinds of plastics. It exploits what Rachel Carson called the “wonder world of the carbon atom” (Carson, 1962: 15) with its “almost infinite capacity for uniting with each other […] and for becoming linked with atoms of other substances” (Carson, 1962: 15–16). Petrochemistry no longer just molds and forms existing materials but “informs matter with intelligence and intentionality” (Vincent, 2013: 22). These new informed materials have become critical for a series of socio-technical processes. Fertilizers made with the use of natural gas and pesticides derived from oil are among the most crucial elements of the green revolution in agriculture that massively increased and accelerated food production. Fossil fuels made it possible to transcend the energetic limits of agricultural production set by the limited rate of solar energy flow so that we today “eat fossil fuels” (Pfeiffer, 2006: 1–11).

The most visible effect of the petrochemical industry in everyday life is the invention of an entirely new set of materials: plastics. While fossil fuels introduced new forms of abstract energy, the synthetization of plastics from oil introduced a new kind of abstract materiality: a kind of matter that might become almost any kind of concrete stuff. Already in the 1950s, Barthes (1991: 97) remarked that: “[M]ore than a substance, plastic is the very idea of its infinite transformation, […] it is less a thing than a trace of a movement.” Just like fossil fuels, plastic acts as a temporal operator that underpins the temporal rhythms and horizons of modernity (Davis, 2015: 349). In contemporary consumerism, plastic introduced a certain type of seemingly timeless presentism (Hawkins, 2018). It is always shiny and new since it is not subject to decay. At the same time, it is made to be used and consumed as quickly as it is thrown away. As has been frequently emphasized (Bergmann, 2019; Davis, 2015; Gabrys et al., 2013), this short-term nature of plastic consumption contrasts sharply with the enormous material persistence of plastic waste.

**Residuals: The “recumulated” time of fossil remainders**

Plastic is modernity made durable. According to some estimates, it takes up to 100,000 years for plastic to be gone for good (Weisman, 2008: 127f.). Plastic accumulates as waste and sooner or later ends up in landfills or the ocean. This constitutes the similarity between plastics and its energetic siblings. The rapid combustion of fossil fuels contrasts sharply with the longevity of its waste products. After 1000 years, the atmosphere still retains half of the CO₂ once emitted into it (WBGU, 2009: 15). Carbon does not dissolve into proverbial air but accumulates in literal atmospheric strata. The toxic residues of the petrochemical industry similarly sediment in the environment. Carson (1962: 38–83) already in the 1960s forcefully showed how pesticide runoff pollutes the soil, surface, and underground water and the earth’s biosphere. The production sites of
the petrochemical industry often suffer from even harsher chemical pollution (Misrach and Orff, 2012; Davies, 2018; Mah and Wang, 2019). Air, water, and earth: fossil modernity has saturated environmental spaces with its residuals. And these “environments” stretch into the human body (Bond, 2013: 695) since organs similarly act as repositories of fossil modernity. The exhaust gases of cars and fossil industries find their way into lungs (Choy, 2011), petrochemical toxins end up in fatty tissue, bone marrow, the liver, etc. In vicious “chains of poisoning” (Carson, 1962: 49), toxins bioaccumulate in certain tissues and over the food chain so that seemingly harmless levels of toxic exposure aggravate until they become severe hazards that are often passed on to the next generation. Making available a stock of fossil energy and transforming it into a linear energetic flow is sometimes referred to as decumulation (Georgescu-Roegen, 1974: 303). The threatening piling up of fossil residuals represents a reversion of this process, a recumulation if you will: linear tempo-materiality sediments into accumulated time.

Rosa et al. (2017) introduced the concept of “dynamic stabilization” to account for the predicament of modern societies that only maintain their status quo by constantly growing and accelerating. I argue that fossil fuels and materials underpin dynamic stabilization by making possible economic growth and the acceleration of social life. Yet, fossil residuals undermine the dynamic stabilization of modern societies by contributing to phenomena of thermodynamic destabilization: the dissipation of matter and energy, pollution understood as entropy. Thermodynamic destabilization, the accumulation of chaotic, disruptive and often toxic fossil residuals, introduces a new experience of temporality. While the worldview of dynamics and dynamic stabilization abstracts from irreversible, historical time and locks societies into a “frantic standstill” (Rosa, 2005), thermodynamics and thermodynamic destabilization introduce the “arrow of time” (Prigogine and Stengers, 1984: 257–290) and expose societies to the experience of irreversible ecological change. The dialectic of fossil modernity is that the way it stabilizes through speed produces destabilizing heat.

In her new materialist theory, Bennett (2010) has emphasized the vitality of matter to stress the intrinsic force of things. In contrast to Bennett, I argue that entropy, while clearly a propensity immanent to matter, is not a vital force but rather represents the death drive of the material world. The necro-materialism of entropy should, however, not be confused with an utter loss or disappearance of matter–energy because this would contradict the first law of thermodynamics. Rather, the second law states that there is an inevitable transition of matter–energy from an ordered and readily available to a chaotic, wasteful, and unavailable state (Stengers, 2010: 174). This becomes especially obvious with regard to the molecularization of matter in the form of CO₂ molecules and microplastics. These “new immortals” (Bastian and Van Dooren, 2017) are still materially present but can no longer be used and are often not even visible let alone tangible.
Nevertheless, the many repositories for these dispersed and unavailable waste products—the atmosphere, the ocean, the soil, human, and nonhuman organs etc.—are living archives that record them as ghostly traces of the past and also establish a connection to the future through their threatening latency (Murphy, 2015: 106). They have become “agents of death” (Carson, 1962: 14) and bear a potential to do harm that has often not yet manifested itself. Global warming caused by rising CO2 levels in the atmosphere only sets in with a delay. Because of the “long memory of the climate system” (Schaeffer et al., 2012: 869) that retains CO2 for centuries, climate change is a sort of “archive fever” (Derrida, 1996) where the temperature is rising with the fossil records piling up. Every measurable temperature rise refers metonymically to the fossil traces of the past. The threatening climate future actualizes the virtual potential of the past. The modernist future horizon of growth, endless possibility, and epic conquest creates an accumulated past that remains present in the degraded “second nature” of the Anthropocene and goes along with the threatening horizon of not yet fully manifested and known, but nevertheless certain harm. The future is no longer a “storehouse of possibilities” but becomes a repository of liabilities in which past options have become future obligations.

The promises of the fossil fuelled past have turned into future ecological threats that confront societies with two different temporal trajectories, which both in their own ways subvert the accelerationist tendency of modernity. On the one hand, ecological threats called forth by the long-lasting fossil residuals represent forms of what Nixon (2011: 2) famously called “slow violence,” a form of “violence that occurs gradually and out of sight, a violence of delayed destruction”: sea levels rising over decades, yet violently washing away human and nonhuman life-worlds, chronic diseases that slowly drag down the body, etc. On the other hand, there is a growing concern that the violence of climate change might be more sudden than we tend to think. Some climate scientists argue that beyond certain tipping points, the regulative mechanisms of the Earth System might flip giving way to an abrupt and self-reinforcing climate change (Clark, 2010). The prospect of slow violence suggests that acceleration engenders creeping devastations imperceptible by social observations adapted to high speeds. The abrupt climate change scenario implies that social acceleration catalyzes an uncontrollable acceleration of nature which happens too fast for a society locked into speed to react. Modern societies, this suggests, suffer from a “carbon lock-in” (Unruh, 2000) since the material weight of existing fossil infrastructures (extraction, transportation, energy) and vested capital interests drags it toward a disastrous pathway of ever more fossil fuel consumption. Yet, it is also plagued by the carbon locked into the atmosphere which might lock society into the heat of a fast and self-sustaining climate change.

Thermodynamic destabilization affects societies in highly unequal ways. The benefits of modernist progress for some are not only made possible by the
exploitation of others, but also go along with ecological harms mostly affecting marginalized regions and people. Climate change disproportionately affects the global south. African and Southeast Asian countries have become the recipients for plastic waste from the industrialized countries in the global north because of their place in capitalist value chains (Gregson and Crang, 2015). And the sites of petrochemical production—like the infamous “cancer ally” in Louisiana (Davies, 2018; Misrach and Orff, 2012)—have become paradigmatic cases of environmental racism. In this respect, the residuals of fossil modernity represent “imperial debris” (Stoler, 2013: 5): “durabilities of duress that imperial formations produce as ongoing, persistent features of their ontologies.” Enjoying the benefits of fossil modernity only becomes possible through the systematic externalization (Lessenich, 2016) of its harms, through the “unequal exchange” between useful and entropic fossil matter/energy (Lawrence, 2009). It is therefore important to stress that in fossil modernity “residual” and “dominant” are “coeval” (Fabian, 2014). They are moments of a singular formation that is both socially and materially stratified.

**Emergent: The temporality of reclaimed residuals**

As fossil materials turn from resource into waste, they confront modern societies with a persistent and threatening temporality. Societies will have to cope with these afterlives of modernist progress. This complicates the notion of “modernization.” Social transformations can no longer be solely understood as bringing forth the new. Transformations will have to come back to and emerge from the residual. It is of course still important to analyze and promote forms of “ecological modernization” (Spaargaren and Mol, 1992) that overcome the fossil fuel dependence of modern societies. However, even a decarbonized society that shifted to solar power, organic agriculture, and sustainable plastics will continue to be influenced, informed, and incited by its fossil past. This calls for an analysis of digestive rather than disruptive forms of social change. Indeed, the social transformations already underway entail more than a transition from high-carbon to decarbonized societies. They also encompass new ways of processing and making sense of the carbon traces left behind. In the remaining part of the article, I will sketch two possible ways of going back to and reclaiming the residuals of the past to make a liveable future.

**Reconciling recycling and return**

Some scientists argue that it will take 100,000 years for plastics to (bio)degrade because it needs a new organism to metabolize and therefore remove plastic on a large scale (Weisman, 2008: 128). Such projections invoke two distinct biocultural temporalities: the cyclical time of metabolism and the temporality of
evolutionary becoming. As biologists emphasize, there is no rubbish in a well-functioning ecosystem because the waste products of one organism serve as feedstock for another (Margulis, 1999: 119). The excessive accumulation of fossil residuals is thus an outcome of a “metabolic rift” (Marx, 1968). From using up finite energy stocks to the “take-make-dispose” of plastic cultures, the fossil economy is premised on a linear metabolism that uses up resources and accumulates waste products. It is cold comfort that new life forms and ecological cycles will emerge eventually and metabolize plastic, absorb excessive CO2, or at least be able to exist in the hothouse earth, because in such an evolutionary long run, too many human and nonhuman lives will be lost.1

That is why there are more and more attempts to consciously design solutions to society’s fossil waste problems instead of relying on disastrous evolutionary adaptations. Policy-makers, capitalists, and scientists are busy coming up with alternatives to the fossil economy that are not premised on the exploitation of finite resources and the accumulation of infinite waste heaps. The bio-economy in which renewable biological materials are supposed to replace fossil resources—ranging from all kinds of biofuels to biodegradable plastics—has become a crucial policy framework and capitalist venture in recent years (Birch, 2018). In addition, bio-capitalist strategies seek to remove fossil residuals by reinserting them into productive circuits. Currently, these projects go under names such as the “circular economy” (Hobson, 2016) and, of course, “recycling.” Scientist and biotech companies are trying to engineer efficient metabolic pathways where fossil residuals become feedstock for biological processes. In experiments, scientists have synthetized the enzymes of plastic eating bacteria for the large-scale biodegradation of plastics (Laux, 2018), while other microbiologists mobilize the unique metabolic capacities of extremophile bacteria for remediating toxic wastes from the petrochemical industry (Anton, 2017).

Contemporary climate politics similarly represents a strategy for the planetary management of the waste products of and repositories for fossil capitalism (Lohmann, 2005). The climate regime has introduced new metrics to estimate how much atmospheric dumb space is still available for fossil modernity’s pollution. One of these metrics is the so-called carbon budget that indicates the amount of CO2 that can still be emitted without global warming exceeding 2°C or, reps., 1.5°C Celsius (WBGU, 2009). To achieve the climate change mitigation targets, the date when society (say in 2050) may have achieved net-zero-emissions does not really matter. Instead, the cumulative emissions since the beginning of industrialization decide over the climate future. Climate scientists and environmental activists thus frequently represent the carbon budget as a kind of doomsday clock that runs faster when CO2 emissions rise.2 The CO2 molecule, or rather the concentration of CO2 molecules in the atmosphere measured in parts per million, becomes the fundamental temporal unit for measuring the ticking time of irreversible climate change. Carbon budgeting tracks the Eigenzeit of the
looming climate crisis. Just like national income accounting, it indexes the “great acceleration” (Steffen et al., 2015) of fossil modernity, but not in terms of the circulation of money but of flows of CO₂. Climate change mitigation thus amounts to slowing down and eventual stopping the carbon clock by limiting CO₂ emission before it is too late.

In addition, the climate regime also establishes mechanisms to offset or compensate carbon emissions through the creation of carbon sinks, thus introducing an alternative tempo-material pathway to combat global heating. For example, instead of closing down a coal plant (presumably in the industrial north), it may be cheaper to grow trees (most likely in the Global South) (Fogel, 2004). This amounts to an extension and recalibration of the carbon waste economy. It is no longer just about flows of CO₂ accumulating in the atmosphere but about the whole carbon cycle (Dahan, 2010) that involves all kinds of biological agents from methane-producing bacteria in a cow’s digestive tract to CO₂ fixing rain forests. The hegemonic climate regime thus enrols the carbon cycle to meddle with the unforgiving carbon clock and to overcome the limitations of the linear metabolism of fossil modernity. Negative emission solutions even promise to turn back the time of the climate system. One of the most discussed negative emissions technologies is Bioenergy and Carbon Capture and Storage (BECCS) where the burning of biomass provides energy while the resulting carbon emissions are captured and stored. BECCS is not only supposed to provide an alternative to fossil fuels by making use of fossil residuals (CO₂) as a feedstock for biomass, it also extracts carbon from the atmosphere and stores it underground to reverse the process of fossil fuel extraction and combustion.

Similar to the economy of recycling and remediation, life processes metabolizing, fixing, and storing carbon promise to slow down, stop, or even reverse the irreversible temporality of thermodynamic destabilization. The goal is to render the linear trajectory of fossil modernity more circular and thus introduce a new form of tempo-materiality, a recyclical time (Nowotny, 1989: 75). However, the temporality in play also goes along with a rather traditional capitalist horizon. As capitalism starts to conquer the garbage frontier, recycling is aligned with economic return.

**Redistribution and reparative critique**

Following Williams (1977: 123), it is easy to depict the recycling economy as a form of “the emergent” that is just “new phase of the dominant.” It salvages the capitalist horizon of growth by supplementing it with a commitment to equally future-oriented environmental rationalities like sustainability, often purposefully designed to reconcile capitalist “yield” with environmental protection (Bonneuil and Fressoz, 2016: 215). The current climate regime and green capitalism only turn back to the residuals in order to recycle, reuse, and thereby erase the traces of
the fossil past. In contrast, environmental justice movements challenge these responses to ecological problems (Dawson, 2010) and—at least implicitly—also their temporal orientation. What sets climate justice apart from the hegemonic climate regime most clearly is that it has put “historical justice” on the agenda of international climate summits by calling for fairly sharing mitigation efforts (Holz et al., 2018) and for compensations for present and future loss and damages (Agarwal and Narain, 1991: 15f.; Friman and Linnér, 2008; Holz et al., 2018).

Climate justice activists are concerned with the fundamental socio-temporal injustice that the industrialized countries from the Global North are largely responsible for past and present emissions, while countries from the Global South will face the largest burdens from climate change. Climate justice draws on the feverish carbon archive as an index of present and future social asymmetries. This shifts the attention from the efficient allocation of atmospheric assets to the distribution of carbon liabilities. In the context of climate justice, calling for a “balancing of the earth’s budget” (Bonneuil, 2015) not only means to balance the accounts between industrial carbon emissions and biospheric carbon fixation. It is instead a call to settle the “climate debt” (Klein, 2015: 389–418) among past, present, and future, rich and poor, and north and south. Here, climate politics will no longer just be a politics of recycling, but becomes a politics of redistribution and reparation (Folkers, 2020: 621–623). As in recycling, this means coming back to the residuals of fossil modernity, but not in order to erase their traces but to decipher them as thick tempo-material traces of the inequalities and injustices that structure fossil modernity. The thermodynamically chaotic traces of the fossil past are rich sources of information that—it turns out—can not only serve as a “far-future signal of the Anthropocene” (Zalasiewicz et al., 2014) or be translated into a price signal on carbon markets but can also make visible geo-social injustices and guide the politics of temporal and socio-ecological redistribution.

Environmental justice movements thus promote a politics that seeks to come to terms with a past that has never ended. This temporal orientation sets them apart from the emancipatory imaginary of modernity. In his 18th Brumaire, Marx (2003: 14) famously derided the French revolutionaries that looked back to antiquity and proclaimed that the proletarian revolution would have to “draw its poetry […] from the future” and let the “dead bury their dead.” What to do with this sentiment today when it has become clear that the residuals of fossil modernity do not bury themselves but will keep on haunting the future? This is not just a problem for emancipatory politics, since the changing relation among past, present, and future also affects the temporal grammar of critical theories.

Critique always questions the present in the name of a different and better future and therefore relies on an open “horizon of expectations” (Koselleck, 2004). This is not only the case for normative, teleological, or utopian varieties of critical theory but also for all the postmodernist, constructivist, and even ANTish (Latour, 2004) styles of critique showing that “it can be otherwise” and thereby
excavating hitherto untapped horizons of possibility. Even when critique becomes historical, as in critical genealogy, it mostly only goes back to the past to cut loose from it. Genealogy seeks to “separate out, from the contingency that has made us what we are, the possibility of no longer being, doing, or thinking what we are, do, or think” (Foucault, 1984: 46). To be clear, these forms of possibilistic critique remain indispensable to overcome the fossil fuel dependence of modern societies. However, when it is true that fossil resources enabled and shaped the modern experience of the future as a “storehouse of possibility,” such a “possibilism” risks running out of steam together with “fossilism,” when not adapted to the contemporary situation. Critical histories of the present can no longer just illuminate how that which is came to be and how it can be otherwise, but also how it materially persists. While it remains crucial to cut loose from the past, critique also needs to figure out ways to inherit the past in the right way and to stay with the “consuming fever of history” (Nietzsche, 1997: 60) fossil modernity brought about.

It is no coincidence that a series of social theorists grappling with ecological problems (Coronil, 1997; Gabrys, 2013) have turned to Benjamin’s (2007: 258) critique of modernist progress as a storm that “irresistibly propels [society] into the future […] while the pile of debris […] grows skyward.” Benjamin is one of the few critical theorists who rejected the modern grammar of temporality. For him, the past is not only a chain of events from which one has to cut loose but a reservoir of unredeemed obligations. Yet, for him, these obligations provide potentials to break with the ongoing catastrophe of the present because they represent the demands of the damned of history. Social movements, Benjamin (2007: 260) argues, are “nourished by the image of enslaved ancestors rather than that of liberated grandchildren.” This is a productive provocation for contemporary conceptions of intergenerational environmental justice that usually just focus on the relation between present and future generations. In addition, it suggests a new temporal orientation for critique after its prime source of “nourishment”—the open future facilitated by fossil fuels—has been exhausted. By deciphering the material residuals of fossil modernity as indexes of past and ongoing injustices to be addressed, critique taps into a resource that will prevent it from running out of steam any time soon. Habermas (1979) characterized Benjamin’s approach as a form of “redemptive critique.” However, when dealing with the residuals of fossil modernity, the prospect of a messianic redemption is rather misplaced. After all, the residuals of fossil modernity will continue to cause harm. It might be more apt to speak of “reparative critique” since the critical task is to reckon with lasting ecological destruction, to repair what can be fixed, and to care and grieve for the socio-ecological relations irreversibly severed. In other words, practicing critique in fossil modernity means staying with the rubble.
Conclusion

In the face of looming ecological disasters, modernity seems ever more outdated. Bruno Latour has therefore recommended that, if we were ever modern at all, we better leave it behind and start to “ecologize” instead of “modernize” (Latour, 2013: 99). However, tempting it may be to say farewell to modernity and set out toward a greener future, one cannot and should not deny the “complicated fact that [...] we still have a modernist mess on our hands” (Fortun, 2014: 312). The heroic and all too modern gesture of throwing modernity on the proverbial dustbin of history neglects the literal garbage heaps modernity leaves behind. Modernity is an “unfinished project,” but not—as Habermas (1990) believed—as an indispensable normative horizon. Rather, modernity is materially unfinished because it persists in the form of fossil residuals like CO2 in the atmosphere, pesticides in the soil, and plastic in the ocean. To capture this sense of modernity and the peculiar temporality that goes along with it, this article introduced the notion of fossil modernity. The concept emphasizes the entanglement between fossil materialities and modern temporalities. It stresses how modernity depends on something altogether unmodern, prehistoric even, that makes it tick, that creates and sustains its temporality, but utterly undermines it. By “modernizing” fossil resources through industrial technologies, modernity eventually became fossil: outdated and untimely without simply going away. Weber (1988: 203) famously predicted that modern capitalism would continue until the last ton of fossil fuel was burned. It is worse than that. Even after the spirit of fossil capitalism is exhausted, its ghosts will continue to haunt future life on this planet. “We” have always been and will always be fossil.

Still, the problems and pitfalls of standard modernity theory are too serious to ignore. And it does not suffice to add matter to modernity to make them go away. To avoid the homogenizing and universalizing tendencies in modernity theory, the article has focused on three different tempo-material strata that all in their own way characterize the contemporary condition defined by the “simultaneity of the unsimultaneous” (Koselleck, 2000; Pottage, 2019: 155–158). The still dominant mode of fossil modernity resorts to coal, oil, and gas as sources of energy and raw material and enables a linear and accelerated temporality as well as a future horizon of seemingly endless growth and opportunities. This linear and future oriented tempo-material order conjures up an accumulated time composed out of the residual waste products of fossil modernity. “Dynamic stabilization”—the maintenance of the socio-economic status quo through speed and growth—evokes thermodynamic destabilization—the degradation of the environment through heat and chaotic dissipation. The open horizon of infinite options turns into the sinister prospect of ecological obligations. Faced with this conundrum, the emergent can no longer take the form of the new, but can only rise from the
residuals of the fossil past. The article first sketched an emergent response in which these residuals become the feedstock for an emerging bio-economy. A different, counter-hegemonic response breaks with this horizon and instead deciphers fossil modernity’s residuals as indexes and operators of social asymmetries.

This perspective deepens the understanding of the entanglement of time and matter, and thus supplements traditional social theories of temporality that all too often just focus on communication and social expectations (Luhmann, 1976). The tempo-material approach explored in this article shows how social temporalities go along with, and are facilitated or thwarted by particular modes of material existence. It emphasizes that the modification of matter releases different temporal trajectories and potentialities. Matter lets time be. Time matters because matter temporalizes. A tempo-material approach can thus evoke an alternative experience of time, a time that can be more flexible than clock time and much stickier and more durable than the time of social action and communication. That is why this approach can account for a strange temporal topology in which past, present, and future do not follow each other in a sequence of instances but are part of the same tempo-material plane composed of dominant, residual, and emergent modes of fossil modernity. This can further debates in new materialism. Even though Barad (2007) has prominently acknowledged the topological unfoldings of time and matter in the abstract, there is still very little scholarly work that investigates the temporality of more concrete substances and the temporalities they go along with. Yet, the different modes of tempo-material existence the article elucidated—the temporality of stored time, the irreversible trajectory of entropic matter, the cyclical and evolutionary time of life processes, etc.—might help in thinking through the entanglement of matter and time beyond the specific substrate it engaged with.

In addition, this approach upsets two of the most fundamental assumptions of the “modern consciousness of time” (Habermas, 1990). First, modern social history cannot be understood independently from natural history. Rather, this article has shown how through the medium of fossil materialities they become inherently intertwined. Second, modern society can no longer simply leave its past behind in favor of an orientation toward the future. The past materially persists, insists, and thus occupies the horizon of expectations. However, unlike traditional societies, it cannot wish to preserve the past and continue its tradition because it imperils the present and threatens to keep on erupting in the future. It nevertheless has to attend to the past to adapt to the ecological challenges it faces.

Last but not least, this article has shown how fossil modernity is not only temporally and materially but also socially stratified. It thus emphasized that the experience of modernist progress for some comes at the expense of “accumulated injuries” (Mah and Wang, 2019)—exploitation and poverty, ecological
degradation, toxification, and illness—for others. Instead of assuming a break between first and second modernity (Beck, 1986), the fossil modernity framework emphasizes the coevalness (Fabian, 2014) of dominant, residual, and emergent tempo-material layers of time and social positionings. Taken together, the social and temporal dimension of stratification produces complex international and intergenerational inequalities. This calls for a new understanding of intergenerational environmental justice and styles of critique that not only speak for a better future (for “our” grandchildren), but are able to inherit a complicated past that will not likely go away any time soon.

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Notes
1. Like other Gaia theorists, Margulis (1999) has frequently stressed that the proliferation of oxygen emitted as the waste product of the photosynthetic activity of cyanobacteria acted as poison for most living species but eventually gave rise to oxygen breathing life forms. Such an evolutionary transformation seems to be particularly slow. However, work in microbiology and symbiosis theory by Margulis and others suggests that evolution can be quicker than biologists have usually expected. Lateral gene transfer among bacteria and symbiotic mergers can radically speed up evolution. In fact, some bacteria are already able to metabolize plastic (unfortunately not on a scale large enough to have a significant impact). As fascinating as these biological findings are, their focus on the time of evolution tends to neglect the temporality of finite lives and life forms suffering from the ecological devastations of the present.

2. See for example: https://www.theguardian.com/environment/datablog/2017/jan/19/carbon-countdown-clock-how-much-of-the-worlds-carbon-budget-have-we-spent
3. Luhmann’s (1984) elaborate theory of social temporality as well as his theory of communication hinge on the idea that a communication, the fundamental social operation in his systems theory, is an event that vanishes as soon as it occurs. If social theory wants to take materiality into account, it has to change its theory of temporality, because matter does not simply vanish. Even if it dissipates, it does not disappear but changes its material and temporal mode of existence.

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