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Materialized ideology and environmental problems: The cases of solar geoengineering and agricultural biotechnology

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Abstract

This article expands upon the notion of ideology as a material phenomenon, usually in the form of institutionalized, taken-for-granted practices. It draws on Herbert Marcuse and related thinkers to conceptualize technological solutions to environmental problems as materialized ideological responses to social-ecological contradictions, which, by concealing these contradictions, reproduce existing social conditions. This article outlines a method of technology assessment as ideology critique that draws attention to: (1) the social determinants of the given technology; (2) whether the technology conceals or masks social-ecological contradictions; (3) whether the technology reproduces existing social conditions; and (4) whether the technology may be used for more rational or emancipatory ends in different social conditions. The examples of solar geoengineering and agricultural biotechnology are examined and it is found that, in each case, these technological solutions conceal social-ecological contradictions and support the current economic system and those benefiting from it, while precluding other alternatives.

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We typically think of ideology as subjectively held ideas, beliefs, values, or other immaterial phenomena that are part of a personal or shared worldview. Some thinkers have questioned this assumption. For example, the French Marxist Louis Althusser (1971: 165ff) makes the case that ideology is not false consciousness or immaterial, subjective beliefs, but has an actual material existence in 'un-reflected, merely lived practical activity' (Jay, 1984: 404), activities governed by rituals within specific institutions, or, 'Ideological State Apparatuses' (see also Žižek, 1994: 12ff). For Althusser, although ideology in material form is not material like a rifle or a rock, it has a physical, actual existence in the world as structured human practices. Similarly, in the final chapter of his masterpiece, *Society of the Spectacle* (1983), Guy Debord also theorizes institutions as 'ideology materialized'. More specifically, he argues that, in late capitalist societies, the *spectacle*, or, 'the vast institutional and technical apparatus of contemporary capitalism, to all the methods power employs, outside direct force, to relegate subjects to passivity and to obscure the nature and effects of capitalism's power and deprivations' (Best and Kellner, 1999: 132), allows ideology to 'disappear'. We *live* ideology passively through material practices structured by institutions – the standardized rules, behaviors, and relationships that permeate society. As we are 'subjected to the spectacle', ideology is now 'imposed during every hour of daily life' (Debord 1983: Thesis 217).

If Althusser and Debord theorize ideology as 'material' in the sense of material practices embedded in institutions, DeMarrais et al. (1996: 16) discuss the 'materialization of ideology' in the sense of ideology becoming institutions *and* material *things*. The materialization of ideology refers to 'the transformation of ideas, values, stories, myths, and the like, into a physical reality', specifically monuments, texts, symbolic objects, and ceremonies. They argue that ideology is both symbolic and material: '[w]e believe that ideology is as much the material means to communicate and manipulate ideas as it is the ideas themselves' (DeMarrais et al., 1996: 16). Rather than (only) being fragmented immaterial and subjective ideas and values, materialization is actively created in everyday life by making ideology physical and tangible.

Also working within the Marxist tradition, DeMarrais et al. argue that those with social power use resources to reproduce and bolster the social order through their legitimation. Elites materialize ideology to out-compete other ideologies. Materialization makes legitimations of the social order more persuasive because they are physical and tangible. Based on three archeological case studies, they show that ideology is materialized to establish or deepen social power, or, to increase the elite's ability to control the activities and labors of others. In other words, the materialization of ideology is a *power strategy* to maintain or expand existing hierarchies and relations of domination. Sometimes technological artifacts are used as examples of materialized ideology, but these are interpreted as status symbols (e.g., daggers) or ceremonial objects (e.g., ceramics).

This article extends the concept of materialized ideology in three ways. First, drawing from Herbert Marcuse and related scholars, we argue that some technological artifacts[1] that are typically (in commonsensical experience) considered neutral techniques are modes of materialized ideology. Second, we argue that, in addition to legitimating power relations, technologies as materialized ideology *mask* or *conceal* social-ecological contradictions, a conception of ideology rooted in Marx. Third, we bring together ideology critique and technology criticism in a way that allows for assessments of technology based on whether the technology conceals contradictions and reproduces the social order, or whether the technology could be used for more rational aims in different social conditions.

Our theory draws almost exclusively from the critical or Marxist tradition. We are aware of key thinkers and ideas in science and technology studies (STS), including theories in posthumanist STS that relate to the human-nature-technology interface. Although these approaches can be rendered useful when transformed to take account of political-economic conditions (e.g., Stuart, 2011), we think critical theory is better positioned to study the materialization of ideology – the masking of social-environmental contradictions through the development and use of technologies – because it draws attention to how the imperatives of capitalism shape technology design and use. In comparison, contemporary STS has not developed a viable theory of capitalism – indeed, some hyper-empiricists reject the existence of capitalism – and tends to knowingly fetishize, in the Marxist sense of the term (see below), technological artifacts (for overview and critique, see Hornborg, 2017). For these reasons and others, we draw from critical theories of technology in our analysis.

There are many scholars in the critical tradition who cannot be revisited in depth here. Most notable is Braverman's *Labor and Monopoly Capital* (1974: 184), which examines 'technology in its connections with humanity and defines the machine in relation to human labor, and as a social artifact', along with the subsequent development and debates in labor process studies (e.g., Hales, 1980; Levidow and Young, 1981; Noble, 1984). A unifying theme in the critical tradition is attention to how technology develops out of unequal productive (class) relations and serves capitalist imperatives, namely, the drive for capital to self-accumulate (for a brief review, see Malm, 2018: 177ff). Put in more conventional language, '[t]echnology is the embodiment of values in artifacts' (Young, 2014: 293), specifically the historically particular 'value' of capital accumulation (see below). Levidow's (1998: 213) study shows how 'a technology "works" by reifying social relations and thus technologizing society'. A technology can enforce the power relations that birth it. Although Winner's (1980: 123) approach draws from far more intellectual traditions than Marxism to categorize it as 'Marxist', his classic argument that technological artifacts 'contain political properties' is in line with the critical approach. This is not inconsistent with Marx's own theory of technology, especially the late Marx (see Malm, 2018), whose framework is far more dynamic and sociological than it is technological-determinist (e.g., MacKenzie, 1984; Roth, 2010). While we cannot review this entire tradition, we think Herbert Marcuse, Andrew Feenberg, Alf Hornborg, and Adam Greenfield exemplify important themes most relevant to this project.

In what follows, we first review the literature on the negative conception of ideology as contradiction-concealment and technology as ideology. Subsequently, we outline a method of technology assessment as a form of ideology critique. Then two illustrations of technologies that conceal social-ecological contradictions are discussed: solar geoengineering and agriculture biotechnology, respectively. We conclude that approaching technology as materialized ideology allows for assessments of the social and ecological impacts of technology that are not restricted to romantic technology criticism or utilitarian cost-benefit analysis.

Ideology, technology, and the environment

The French rationalist Destutt de Tracy coined the term 'ideology' to label an emerging discipline that investigated the genesis of ideas (for histories of the development of the concept of ideology, see Barth, 1976; Larrain, 1979; Lichtheim, 1965; Mannheim, 1936). The place of ideology in human-nature relations has been examined by environmental social scientists, who, like Mannheim (1936), typically either employ a neutral notion of ideology as a general worldview or, as the term is often used in everyday life, political beliefs (e.g., Best, 2009; Cutler, 2016; McCright et al., 2016; Sunderlin, 2003).

This article draws from the 'negative' (Larrain, 1979) or 'critical' (Thompson, 1984) conception of ideology, or ideology as *contradiction-concealing ideas and practices* (for overlapping conceptualizations of ideology in environmental studies, even when the term is not explicitly used, see Bell and York, 2010; Foster, 2010; Hornborg, 2001a; 2001b; Melathopoulos and Stoner, 2015; Norgaard, 2011; Wright and Nyberg, 2015). This conception of ideology is rooted in Marx. The Marxist tradition examines ideologies that *reproduce* contradictions through their concealment. The first section summarizes the Marxist theory of ideology. The second section expands the concept of materialized ideology by revisiting Marcuse and similar thinkers who conceive of technologies as physical manifestations of social interests, beliefs, and values. We integrate the concept of technology as ideology within the negative conception of ideology, arguing that some technologies conceal social and social-ecological contradictions.

The negative conception of ideology

Marx and Engels (1977: 47) famously argue in *The German Ideology* that social problems do not result from the wrong ideas, but that a distorted consciousness is the product of a contradictory reality created by human practice. But consciousness does not simply 'reflect' reality. Marx's theory of ideology is based on his assumption that practical activity mediates reality and consciousness (Larrain, 1979). Ideology, both as 'internal' ideas and acted sets of practices, should be theorized as a reaction to, and author of, real contradictions. Humans create a social world and alter the natural environment through human practice. Over time, practices crystalize or solidify into structural forms (institutions) that, though created by individuals, are forced upon future individuals as an external force that create a contradictory reality. Humans participate in 'reproductive practices' in everyday life that maintain current conditions due to structural imperatives. Thus, ideology is said to be a central means to *reproduce* existing social conditions.

Because ideologies reproduce the social order, they serve the interests of those who benefit from the social order's reproduction: the ruling class (Langman, 2015). The ruling class is far from the only architect of ideology and ideology is rarely a deliberately manufactured fiction. However, those with more resources and means are better positioned to promote and disperse ideologies that legitimate existing power relations (e.g., via materialization) (DeMarrais et al., 1996). As observed by Marcuse (1964) and Debord (1983), the ruling class controls the mass media and communication and therefore has great power to perpetuate ideology – strategically concealing how the institutions they are promoting benefit them at the expense of others.

Marx also argues that real contradictions (e.g., between wage labor and capital) can only be resolved or overcome in practice, not in consciousness (see also Adorno, 1973). The term *ideology*, when strictly referring to immaterial ideas, refers to the reconciliation of real contradictions in consciousness, but not in reality: ideology is 'a solution in the mind to contradictions which cannot be solved in practice; it is the necessary projection in consciousness of man's practical inabilities' (Larrain, 1979: 46). This is why Marxists often argue that ideology 'masks' contradictions. In addition to being concealed through descriptive, explanatory, and/or normative claims that grant legitimacy to the social order (*legitimation*) and/or posit the naturalness and immutability of the social order (*reification*) (Lukes, 1974; Thompson, 1984), contradictions are also masked through the *materialization* of ideology. As explained in the introduction, ideology in 'material' form is often meant to refer to taken-for-granted reproductive practices structured by institutions (e.g., Althusser, 1971; Debord, 1983). However, as DeMarrais et al. (1996) show, ideology is also materialized in physical objects, such as texts (see also Thompson, 1984) and symbolic objects. Our theoretical aim is to bring together the theory of the materialization of ideology and the negative conception of ideology – when ideology is understood as a form of contradiction-concealment that reproduces the social order – within the context of technological solutions to environmental problems.

Technology as ideology

The subsection above summarized the Marxist theory of ideology as contradiction-concealing ideas and practices. This subsection reviews thinkers who have extended the concept of ideology to theorize technological artifacts, namely, Marcuse, Feenberg, Hornborg, and Greenfield, and then brings these two lines of analysis together.

Marcuse's (1978: 138–9) conceptualization of technology is broad and includes the totality of late capitalist social organization, material technical artifacts, as well as the modern mode of instrumental thinking. He argues that technology has social impacts and society influences the development of technology. One of his most important contributions is theorizing the ways in which technology is shaped by powerful social interests. The interests and values of society, especially those in power, are embodied in technological developments and even individual artifacts: 'the machine, the instrument, does not exist outside an ensemble, a technological totality; it exists only as an element of technicity', whereby, 'domination is transferred to machines and directed against nature' (Marcuse, 1989: 123, 127). Technological artifacts are used to dominate the external world due to the 'presence' of ruling interests 'in' them, determining 'their number, their life span, their power, their place in life, and the need for them' (Marcuse, 1969: 12). In other words, '[t]echnology is always a historical-social project: in it is projected what a society and its ruling interests intend to do with men and things' (Marcuse, 1968: 223–4).

In *One-Dimensional Man* (1964), Marcuse argues that advances in information and communication technologies, embedded in monopoly-consumer capitalism, make possible new forms of social control. Late capitalism is said to both manufacture and satisfy 'false needs', thereby creating the deceptive belief that the depth of our desires, hopes, and dreams have already been met via mass consumption. Individuals in consumer-monopoly capitalist societies are manipulated into indifferently or affirmatively accepting 'the way things are'. Marcuse invokes the common critical theoretical distinction between what is *actual* and what is *possible* in his explanation for one-dimensionality: by levelling the tension between 'the given and the possible' (Marcuse, 1964: 8), consumer-monopoly capitalism and its new forms of social control, like media and information technologies, allow for a smoother reproduction of the expansion of the accumulation process by fashioning automotive-like passive consumer-workers who believe (correctly) that conformity is useful (Marcuse, 1964: 2).

Cohen (1969: 42–3) argues that Marcuse's assertion that technical artifacts themselves are part of the social organization that forms one-dimensional consciousness is 'not Marxist'. Instead, the proper Marxist position is supposedly the following claim: 'what shapes consciousness is not the tool, but the mode of association men adopt to use it'. For example, Marcuse (1964: xvii) argues that even pre-theoretical experience of the conditions of modern technological societies – for example, 'by simply looking at television or listening to the AM radio for one consecutive hour for a couple of days, not shutting off the commercials, and now and then switching the station' – are facts that 'speak for themselves, the conditions speak loudly enough'. To clarify Marcuse's point, he does not abandon the 'interpos[ition of] organizational facts between persons and things' (Cohen, 1969: 43), but strengthens this starting point by showing how organizational facts are *embodied* or *materialized* in things, or, '[t]he impress of social relations can be traced in the technology' (Feenberg, 1999b: 87). These social relations embodied in technology influence the consciousness and practices of users and (usually) reproduce social conditions. The importance of this argument is that many technological artifacts themselves are *ideological*. By 'flattening out' the tension between what is actual and what is possible, many technological artifacts help to conceal underlying contradictions, i.e. they function as ideology.

Feenberg has explicated and expanded upon Marcuse's critical theory of technology (Feenberg, 1999a; 1999b; 2005a; 2005b; for a helpful overview, see Valkenburg, 2012: 478ff). Drawing from Marcuse, Feenberg's critical theory of technology argues that technology is not neutral, as it is commonly believed to be, but, instead, it is *value-laden* (Feenberg, 1999b). For those schooled in science and technology studies since the late 1980s, this argument seems trite, even dated (e.g., Bijker et al., 1987; MacKenzie and Wajcman, 1985). What makes Marcuse's earlier approach distinct from the general argument that social values and interests shape or construct technologies is the more specific argument that, more often than not, technological design and use are extensions of the imperatives of capital. The goals of profit-maximization and cost-effectiveness condition the design and use of many technologies: 'design embodies only a subset of the values circulating in society at any given time' and capitalism is unique in that the range of possible value-mediations of technology are reduced due to 'conflict[s] with a narrow pecuniary interest' (Feenberg, 2005b: 105). These technological goals and interests support the expansion of wealth in the ruling class.

Another contribution of Marcuse explicated and expanded by Feenberg is the argument that contemporary technological rationality, because it is unable to identify social alternatives in the existing order, is *ideological*. Modern technological rationality declares that the 'empirically observed thing is the only reality' (i.e., cannot detect alternative social futures within the present) (Feenberg, 2005b: 87), and sees nature as 'stuff of control and organization' (Marcuse, 1964: 153). Due to its inability to identify social alternatives within the current social order, technological rationality contributes to *social reproduction*. However, it is not only technological rationality (a pattern of thinking) that participates in social reproduction; so do technological artifacts. Feenberg (1999b: 86–7) uses the term 'technological hegemony' to describe the way in which technological design 'incorporates broader assumptions about social values'. Technological design is structurally constrained and formed by often unquestioned assumptions and imperatives. For example, factory machines used to be designed for children. Although we are struck by pictures of children standing next to machines that are constructed for their shorter heights, it would not have struck the engineers and technologists that designed the child-suited machines as disturbing because, '[d]esign specifications simply incorporated the sociological fact of child labor into the structure of devices' (Feenberg, 1999b: 87).

Although neither author draws from Marcuse and Feenberg, both Greenfield and Hornborg have developed overlapping accounts of technology as ideology. Greenfield (2017b) shows how modern information technology and software development are outcomes of the usually unreflective values of engineers, which themselves are a product of dominant social values and interests and social-structural imperatives. The goal of technological development and design at Apple, Amazon, Google, Facebook, and Microsoft is always the same: 'to mediate and monetize everyday life to the maximum possible extent' (Greenfield, 2017b: 283). In a summary piece, Greenfield (2017a) makes his thesis in starker terms: networked technologies are 'bearers of ideology'. Even the technologies developed by technologists and engineers with radical intentions (e.g., to reduce material scarcity) are swept up in existing power structures and have unintended outcomes. In a systems-theoretical argument, Greenfield argues that we ought not to pay attention to the designer's ideology, when ideology is traditionally understood as immaterial ideas, and, instead, examine 'what states of being they [technologies] are actually seen to enact' (Greenfield, 2017b: 302). In the language of this project, materialized ideology is made to serve existing social-structural conditions, even if the designer is unaware of this relation.

Hornborg (1992; 2001a; 2001b; 2003; 2009) develops a similar theory to materialized ideology in the form of technology in world-systems and ecological context, though he employs the overlapping concept of 'fetishism'. or 'cultural representation[s] over which its authors have lost control, which at the same time mystifies and constitutes their social reality' (Hornborg, 2001a: 484). For Hornborg, modern societies are marked by a 'machine fetishism': 'machines conceal significant aspects of social reality, while at the same time constituting that reality' (Hornborg, 2001a: 485; see also 1992; 2001b; 2009). Comparing our commonsensical relation to the modern machine to the Inka peasant's relation to the emperor's rituals, the gist and power of Hornborg's insight are contained in the following passage:

> [i]n both cases, it seems essential for their [socio-technical arrangements'] viability that technical agency and material bounty are represented as the result of autonomous productivity rather than unequal social distribution. To expose the agency of a 'productive force' as a transmutation of deflection of the agency of other humans is to render morally suspect that which had been couched in the deceptive neutrality of the merely technical. (2001a: 491)

Machine fetishism describes the common illusion of the neutrality of productive technologies, which simultaneously conceals and constitutes social-ecological processes, such as unequal exchange and the Global North's forgotten dependence on land. Machine fetishism is also, or, rather, simultaneously, discursive (cf. Fisher, 2010). For example, since around the mid-1970s, and especially since the 1990s, there has been a 'discursive shift . . . geared to disengaging concerns about environment and development from the criticism of industrial capitalism as such' (Hornborg, 2003: 207).

To summarize, the interests and values of those in power and the structural necessity to maximize profits shape technology design and use. Technologies may establish power relations or deepen existing power relations. Technological artifacts are ideological when they conceal social or social-ecological contradictions, a concealment that aids in the reproduction or deepening of the existing social order and its power relations. The following section outlines a form of technology assessment when technology is interpreted as materialized ideology.

Technology assessment as ideology critique

If technological solutions to environmental problems that mask and perpetuate, rather than overcome, social-ecological contradictions are ideological, then it follows that technologies that mediate human-nature relations can be examined through similar methods used to assess ideology. Below, we develop and employ a method of technology assessment that more closely resembles the method of ideology critique than it does utilitarian cost-benefit analysis, on the one hand, and substantive and sometimes romantic forms of technology criticism (characteristic of Martin Heidegger, Jacques Ellul, Ivan Illich, and others), on the other.[2] This section briefly elucidates what it means to develop a critique of technology when technology is conceived of as materialized ideology.

Ideology critique is a method of social criticism rooted in Hegel, revised and employed by Marx, and adopted by the Frankfurt School (Antonio, 1981; Benhabib, 1986; Ng, 2015). The Marxist conception of ideology and the adjoining method of ideology critique are usually employed to explain why workers willingly accept an alienated existence, contrary to their interests, instead of revolting (Langman, 2015). If ideology 'masks' or 'conceals' contradictions, the task of ideology critique is to 'unmask' or 'expose' these contradictions.

The point of 'critique' since Hegel is to employ a form of enlightened 'oppositional thinking' to achieve 'reflection on a system of constraints which are humanly produced' in order to overcome undesirable power relations and irrational social conditions (Connerton, 1976: 16, 18). In a social-ecological context, ideology critique entails 'immanent critique', or, comparing what society claims to be or values with what it actually is or values; historicizing seemingly natural and immutable social conditions; and diagnosing social-ecological contradictions and crises (Gunderson, 2017).

Approaching technology assessment as a form of ideology critique draws attention to four interrelated queries:

1. What historically contingent social conditions gave birth to the given technology, even if the designers and users of the technology are unaware of this social-structural backdrop? This question is a key step into developing a critical theory of technology: to historicize and sociologize the given technology. As Feenberg (1999b: 87) put it, if '[t]he legitimating effectiveness of technology depends on unconsciousness of the cultural-political horizon under which it was designed', then a 'critical theory of technology can uncover that horizon, demystify the illusion of technical necessity, and expose the relativity of the prevailing technical choices'. One of critical theory's central contributions to theorizing technology-society relations is attention to how productive forces are conditioned by the relations of production, of which ideology is one expression; specifically, the way the narrow interests of capital enable and constrain technology design and use.
2. Is the technology being deliberately developed to mask a social-ecological contradiction and/or will/does its adoption and use conceal the existence of the given contradiction? What social alternatives are *not* being pursued while the technological solution is being pursued (see point 3)? Materialized ideology masks contradictions in various ways. One way is enhancing and consolidating power over those who may otherwise resist arbitrary power, from the 'tools of empire' used to penetrate, conquer, and consolidate power over colonies (Headrick, 1981) to solidifying class power through control over energy via fossil fuel mining and combustion technology (Malm, 2016). The most prevalent and subtle way that technology masks contradictions is to appear neutral and even necessary despite deepening and reproducing existing power relations.
3. Does the given technology 'leave existing modes of domination mostly intact' (Greenfield, 2017b: 8) and can one reasonably anticipate or project that the technology will reproduce or even strengthen the existing social order? Common ways that a technology can reproduce or strengthen the social order is by diverting resources or attention from possible social-structural changes that could transcend the given contradiction and through benefiting those already in power.
4. Finally, can or will the given technology 'ever truly be turned to liberatory ends' (Greenfield, 2017b: 8)? In other words, if embedded in a different form of social organization (e.g., if the technology were collectively owned and/or democratically controlled), could the technology be implemented in ways that improve human-nature relations and increase well-being? Although we conclude by

> condemning misplaced hopes in curing social and environmental ills with techno-fixes and emphasize throughout that technology is value-laden, these are not reasons to preclude cases in which technological possibilities constrained by capital can be 'unfettered' and improved upon to serve more rational ends in different social conditions.

The following two sections provide two examples of currently promoted technologies that are influenced by the imperatives of profit-maximization, mask social-ecological contradictions, and serve to reproduce the existing social order: solar geoengineering and agricultural biotechnology. The purpose of the examples is to briefly illustrate the theory of materialized ideology and apply ideology critique to technology. Thus, the applications of theory and method are concise, and the examples lend themselves to a particularly negative assessment. We provide an example of a potentially liberatory technology in the Conclusion.

Solar geoengineering as ideology

Geoengineering is defined by the IPCC as 'a broad set of methods and technologies that aim to deliberately alter the climate system in order to alleviate impacts of climate change' (Boucher et al., 2013). Geoengineering can be divided into Carbon Dioxide Removal and Solar Radiation Management (SRM) strategies. Here we focus on a form of SRM: Stratospheric Aerosol Injection (SAI). SAI is considered the most economical SRM strategy and is the most widely discussed geoengineering strategy overall. SAI was inspired by volcanoes: sulfur aerosols in the atmosphere after eruptions reduce incoming solar radiation and global temperatures. To emulate this process, planes, balloons, or ground cannons could release particles into the stratosphere where they would combine with dust and water, forming aerosols that increase albedo (reflection). Aerosols would likely last for about one year; therefore, this strategy would require continued deposition (Keith, 2013). This approach first received serious attention after a publication by Crutzen (2006), which broke a long silence on SRM and stated that since attempts to reduce greenhouse gas (GHG) emissions have been 'grossly unsuccessful', SAI should be studied and possibly considered for implementation. This article transformed geoengineering from a fringe topic into an international research endeavor and the focus of hundreds of studies and reports (Boettcher and Schafer, 2017). Thus, SAI emerged as a technological option in response to the failure to address climate change through political and social means.

Mainstream strategies to address climate change have failed in part due to their concealment of the capital-climate contradiction (Gunderson et al., 2018a). This refers to the contradiction between capitalism's drive to expand production and the destructive effects of this expanded production on the climate system. In other words, there is an incompatibility between the goals of capitalism (never-ending profit and economic growth) and reducing GHG emissions. For example, GDP growth by 1 percent equals a 0.6 percent growth in material use (Wiedmann et al., 2015) and a 0.5–0.7 percent increase in carbon emissions (Burke et al., 2015). Attempts to address climate change that support economic growth, including carbon markets and green technologies, all fail to significantly reduce GHG emissions because they fail to address the ongoing production and consumption associated with capitalism (Gunderson et al., 2018a). Instead of acknowledging this relationship and making the necessary social-structural changes, a technological fix is proposed. SAI becomes rational to those who presuppose, even if unreflectively, that capitalism is immutable, capitalism is optimal, or that all problems can be solved within the constraints of capitalism. As put by Surprise (2018), SAI is 'an increasingly normalized tactic emerging within existing forms of hegemony'.

SAI is a technological fix that supports the maintenance of the current system and those who benefit from it. Evidence demonstrates increasing support for geoengineering from fossil fuel companies, conservative organizations, wealthy individuals, and conservative politicians – all benefiting from the current economic system. For example, ExxonMobil, British Petroleum, ConocoPhillips, and Royal Dutch Shell have all funded, supported, or contributed to geoengineering research in some way (Hamilton, 2013). Geoengineering is also supported by what Foster (2018) calls 'the billionaire class'. For example, Bill Gates has funded Climeworks, a Swiss company working on geoengineering (Doyle, 2017), as well as a recent SAI experiment in Arizona (Chen, 2017). While denying climate change in the past, the Heartland Institute, the American Enterprise Institute, and the Hoover Institute all now promote geoengineering (Ellison, 2018; Klein, 2014). Lastly, a rising number of conservative politicians who denied climate change have come out in support of geoengineering (Bajak, 2018; Ellison, 2018). While it is impossible to know the intentions behind the support from these individuals and organizations, evidence increasingly suggests that strategies like SAI represent a strategic system maintenance strategy (Gunderson et al., 2019; Hamilton, 2015; Klein, 2014). In other words, technological fixes to address climate change conceal the capital-climate contradiction and help to perpetuate the capitalist system that fossil fuel companies, elites, and conservatives continue to benefit from.

Not only would SAI deployment 'leave existing modes of domination mostly intact' (Greenfield, 2017b: 8), it would likely serve to increase capital accumulation in the ruling class. For example, Hamilton (2015) found 28 patents issued for geoengineering technologies, such as Intellectual Ventures' StratoShield that uses hoses suspended by blimps to spray aerosols into the atmosphere. Geoengineering investmentors could quickly profit from the responses of the energy, aerospace, and defense sectors to a climate-related crisis (Buck, 2012). A related question concerns the procurement structure of a solar geoengineering market, which would likely be a monopsony or oligopsony, with the government buying from corporations (Reynolds et al., 2018).

Geoengineering also diverts attention away from more transformative and effective solutions. This 'moral hazard' case against geoengineering runs as follows: if people think that geoengineering is a solution, they will abandon efforts to reduce GHG emissions or adapt to climate change (Hamilton, 2013; Royal Society, 2009). Therefore, the development of strategies like SAI can be used to argue against the urgency to address climate change, the need to keep fossil fuels in the ground, and the necessity to rethink our economic system. Even geoengineering scientists fear that increased support for their work will dissolve efforts to reduce GHG emissions. In response to enthusiasm from within the Trump administration, David Keith – *the* leading SAI scientist – responded: '[o]ne of the main concerns I and everyone involved in this have, is that Trump might tweet "geoengineering solves everything – we don't have to bother about emissions"' (quoted in Connolly, 2017). Casting aside other approaches is dangerous as most geoengineering strategies remain 'speculative' and in the form of 'back-of-the-envelope calculations, computer models and simulations, [and] laboratory and field experiments' (Boettcher and Schafer, 2017: 270). Considering geoengineering as a solution to climate change conceals the social-structural changes necessary to effectively reduce GHG emissions. These changes would likely entail an abandonment of the economic growth imperative, buying out and nationalizing fossil fuel companies, and lower levels of energy and material use in developed nations (see Gunderson et al., 2018b).

Potential solar geoengineering deployment is irrational, risky, and will result in the further domination of the ruling class. It does nothing to address GHG emissions and ocean acidification. It also entails significant risks including possible drought, famine, and rapid heating if injections were terminated (Ferraro et al., 2014; Robock et al., 2010; Zhang et al., 2015). The fact that SAI seems rational to some indicates that, to those individuals and organizations, alternatives that reshape our economic system are impossible. The idea that capitalism is inevitable and must go on is presupposed in the development of geoengineering technology. Material technologies, such as blimps with hoses used for SAI, embody the successful concealment of the capital-climate contradiction. The deployment of SAI would literally mask the capital-climate contradiciton. Due to the risks and how SAI would benefit those already in power, it does not hold out the promise of being 'turned to liberatory ends' (Greenfield, 2017b: 8). Given the current trajectory of research and support for geoengineering, along with ongoing stagnation in climate policy, we expect to see continued development and possible deployment of geoengineering technology despite its irrationality.

Agricultural biotechnology as ideology

In *First the Seed*, Kloppenburg (2004) examines the history and political economy of plant biotechnology, describing the first steps in the commodification of the seed through patent and protect acts, starting in the 1930s. While the ecological challenges and unpredictability of environmental factors in agriculture long undermined capitalist expansion into crop production (Mann and Dickinson, 1978), this did not stop input companies (selling seeds, fertilizers, and pesticides) as well as processing, distribution, and retail companies from adopting a capitalist model that uses farmers as contracted labor (Lewontin, 2000). Over time, farmers have invested more and more resources into farm inputs and have become increasingly dependent on input and seed companies (Kloppenburg, 2004). As explained by Lewontin (2000: 96): '[t]he problem for industrial capital, then, has been to wrest control of the choices from the farmers, forcing them into a farming process that uses a package of inputs of maximum value to the producers of those inputs.' The commodification of the seed, and protections through patents and laws restricting use, likely represent the most significant shift in power in the agricultural system. As stated by Kloppenburg (2004: 233), 'Control over the seed becomes a matter of considerable importance.'

Here we focus on genetically modified (GM) seeds. Seed biotechnology has evolved rapidly, starting in the 1970s. As described by Kloppenburg (2004), in 1976, a scientist and a venture-capitalist founded Genentech, 'a research company devoted to commercializing the advances of genetic technology' (Kloppenburg, 2004: 195). Similar unions between scientists and venture-capitalists in the following decade resulted in the creation of hundreds of biotech firms. This soon attracted the attention of multinational corporations. As described by Kloppenburg (2004), the seed became a way for corporations to control and profit extensively from agriculture. Throughout the 1990s, mergers and acquisitions resulted in the emergence of a dominant firm creating the vast majority of GM seeds (Food and Water Watch, 2013). GM crop production quickly became widespread after commercial approval in 1994, and by 2010 over 140 million hectares in 29 countries were being used to grow GM crops (Barrows et al., 2014).

Through a series of technological and legal maneuvers, companies that produce GM seeds have increased their control over farmers and agriculture as a whole. These maneuvers include terminator seed technology, patent protection, the legal framework for proprietary rights, contract agreements, and monitoring and enforcement of violations (Kloppenburg, 2004). To maximize profits, seeds are not allowed to be saved and must be repurchased by farmers each year. Compliance is monitored through DNA testing and what farmers call the 'seed police' – who identify contract violators and subject them to penalties or law suits (Bartlett and Steele, 2008; Lewontin, 2000). All of these represent strategic moves to increase profits. In addition, companies controlling seeds are increasingly also those controlling other inputs such as fertilizers, pesticides, and herbicides. For example, seeds for herbicide-resistant crops are designed to work in conjunction with increased herbicide application – with both the seeds and the herbicide sold by the same company. The GM seed, therefore, represents a strategic capture of agriculture by capital (Kloppenburg, 2004). GM seeds are designed to support ever increasing profits for biotech companies in the industrial monoculture cropping system. However, the dominant narratives surrounding the purpose of these seeds, as explained to farmers and the public, paint a different picture.

GM seeds are promoted as *the* solution to almost all problems associated with industrial agriculture. Increasing challenges have emerged, indicating fundamental problems with industrial agriculture, including soil erosion, salinization, pest outbreaks, nutrient depletion, water pollution, biodiversity loss, and climate change impacts as well as contributions to GHG emissions (Delonge et al., 2016; Weis, 2010). GM crops have been proposed as the technological solution to address many of these problems. For example, insect problems associated with monoculture crop production can be addressed through insect-resistant crops that produce *Bacillus thuringiensis* (Bt) (Barrows et al., 2014) or insect pheromones (Bruce et al., 2015). Salinity in soils is an increasingly occurring consequence of industrial practices and reduces crop productivity. GM crops are being designed to cope with and counteract salinity stress (Arzani and Ashraf, 2016). Scientists have also proposed addressing loss of soil nutrients and associated pollution through GM crops that are designed to more effectively absorb nutrients (Oldroyd and Dixon, 2014; Jez et al., 2016). Finally, while climate change projections indicate increasing periods of drought, GM crops are being created with increased drought tolerance (Rabara et al., 2014). This, however, does nothing to address how input-intensive agriculture continues to release GHG emissions and contribute to climate change (EPA, 2015).

Over two decades ago, Levidow (1998: 223) was astute enough to identify how biotechnology was redefining agricultural problems and solutions and concealing fundamental relationships:

> [b]iotechnology R&D defines the problem as inadequate control over nature's potential cornucopia and over environmental threats to agriculture. The inherent socio-agronomic problems of intensive monoculture are attributed to genetic defects which must be corrected at the molecular level.

While emerging challenges could expose the unsustainability of industrial crop production and demand the restoration of the dominant agricultural system, GM solutions mask this reality and reinforce the notion that industrial agriculture is the most efficient and the best (or only) way to produce food. Weis (2010: 319) suggests this is a deception propagated by those invested in the current industrial system and that every new challenge that farmers face is met with a new short-term fix. GM seeds have emerged as the ultimate fix. By proposing GM solutions to agricultural challenges, seed companies are masking the underlying contradictions in order to maintain the current industrial system. GM seeds therefore 'leave existing modes of domination mostly intact' (Greenfield, 2017b: 8). In addition, 'GM crops as the solution' intensifies farmers' dependence on seed companies, increasing corporate wealth and power.

Solutions through GM seeds diminish the possibility of more transformative solutions that could address challenges in agriculture. Agroecological, polyculture, and permaculture approaches have been increasingly (re)introduced with promising results in terms of producing enough food without the ecological impacts that could undermine industrial production. For example, Altieri et al. (2017: 3) argue that agroecological methods have been 'consistently proven capable of sustainably increasing productivity and [have] far greater potential for fighting hunger'. For those concerned with food security, efforts should focus on transforming the vast acres of cropland in the US currently growing corn for cattle feed or ethanol, not food for human consumption, as well as addressing food distribution and waste problems (Fraser et al., 2016). These solutions would, however, involve less or no synthetic inputs and GM seeds and would threaten the meat, dairy, and biofuel industries. This reality explains the strong and well-funded resistance to recreating the food system. In contrast, in a food system not dictated by economic growth, a wide range of social and ecological benefits could be realized (Gomiero, 2018).

The continued reliance on GM seeds to address agricultural challenges will likely result in increased environmental degradation and could threaten human health and food security. While some studies demonstrate reduced pesticide use associated with GM crops (e.g., Klumper and Qaim, 2014), GM crops are also associated with increased glyphosate (herbicide) use, glyphosate water and soil pollution, the evolution of glyphosate-resistant (super) weeds, and other issues (Myers et al., 2016). Further, there is still no scientific consensus that GM crops are safe for humans (Hilbeck et al., 2015). Evidence suggests GM crops are creating more problems than they solve and it is difficult to imagine social conditions in which these problems would dissipate. It is unlikely GM crops could be turned to 'liberatory ends' (Greenfield, 2017b: 8). However, they continue to represent a powerful ideology about what agriculture is and how it should be done. For now, we remain on a trajectory of using more inputs and short-term fixes to support mono-crop agriculture – a path that may ultimately result in a global food crisis (Fraser et al., 2016).

Conclusion

This project expands upon the concept of ideology as material, or, that ideology takes on physical form, usually institutionalized, unreflective practices (Althusser, 1971; Debord, 1983; DeMarrais et al., 1996). It draws on Herbert Marcuse and related thinkers to conceptualize technology as materialized ideological responses to social-ecological contradictions, that, by concealing contradictions, reproduce existing social conditions. We outline a method of technology assessment as ideology critique that draws attention to: (1) the social determinants of technology; (2) whether the technology conceals or masks social-ecological contradictions; (3) whether the technology reproduces existing social conditions; and (4) if the technology can be used for more rational or emancipatory ends in different social conditions.

We provide two examples to illustrate the theory of technology as materialized ideology and the use of ideology critique as a form of technology assessment. SAI is being promoted and considered due to the political failure to reduce GHG emissions and represents a technological fix that conceals the capital-climate contradiction and reduces the likelihood of more transformative and effective approaches. In addition, it supports the current system and those who benefit from it and involves so many possible risks and injustices that it is unlikely to ever be emancipatory. The development of GM seed technology was a strategic move to reap vast profits from agricultural production. Its promotion as the solution to agricultural challenges conceals this underlying motive, the growing number of problems with industrial mono-crop production, and alternative production systems that could address challenges and increase social and ecological benefits. The risks of GM crops to the environment and human health make it far from a liberating solution.

Both examples illustrate our theoretical argument that brings together the notion of materialized ideology and the negative conception of ideology: some technologies can be understood as materialized ideologies that mask underlying contradictions, benefit the ruling class, and maintain the current social order. In other words, these technologies reinforce the social-structural conditions that benefit those in power. In addition to demonstrating our theoretical argument, our examples also illustrate the application of ideology critique to technological assessment and how it can reveal otherwise concealed relationships.

Technology assessment as a form of ideology critique allows for a critique of technology that is neither (only) romantic nor (only) based on cost-benefit analysis. Because we argue that solar geoengineering and agricultural biotechnology likely cannot be employed to serve emancipatory aims, it is helpful to conclude with a discussion of technology and emancipation in the context of human-nature relations. As technology always has unintended consequences and tends to outstrip or even betray the intentions of designers, Greenfield is skeptical of claims about the emancipatory or liberatory potential of various modern digital technologies. Putting effort into social-structural changes is a surer means:

> [i]f you want to end the depredations of scarcity, then, better, by far that you work for the just distribution of the goods we already have than wait for some cornucopian machine to solve the problem for you. If you want to contest the power of the state, take concrete steps to claim decision-making locally, rather than hoping than someone will release the code of an autonomous framework that instantly renders states obsolete. If you're interested in eliminating class and racial bias in the criminal justice system, work with one of the many civil society organizations established and chartered to do just that before handing the powers that be yet another tool and rationalization for their use of force. (Greenfield, 2017b: 304)

We generally agree with Greenfield's argument. With important exceptions (e.g., the birth control pill, the atomic bomb), few technologies have radically transformed social relations *only* due to their adoption and use (this does not mean that technologies do not impact societies, but that technologically-induced change is almost always also sociologically-induced change); that one should always be suspicious of enthusiastic claims about the humanitarian and ecological potential of various technological developments (so-called 'fixes'); and pursuing social-structural changes is usually a more effective and time-tested route for achieving just ends than waiting for technology to deliver utopia.

We add here that social-structural changes can transform the uses and benefits of particular technologies. One should never assume that technologies could not be used for more rational aims in different social conditions. For example, embedded in different property structures and decision-making models with the explicit goals of reducing GHG emissions and protecting ecological and social well-being (Gunderson et al., 2018b), alternative energy development could be used for more liberatory ends rather than merely increasing total energy use (York, 2016; Zehner, 2012). Assessment of the emancipatory or more rational potential of technology should be based on the properties of the specific technology in question.

Based on both known and unknown risks, the two technologies reviewed here have very little potential to improve social and ecological conditions. Instead, they represent materialized ideologies that conceal social-ecological contradictions. These 'spectacular technologies' exist as 'the material base of inverted truth' (Debord, 1983: Thesis 221), masking looming crises and the need for systemic transformation. Therefore, the critical task becomes unveiling these truths.

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Notes

1. Following others on the ambiguous use of the term ‘technology’ in English (e.g., Bijker et al., 1987: 4; MacKenzie and Wajcman, 1985: 3–4), the term’s use in this project includes, depending on context, (1) artifacts, from simple tools to industrial machines; (2) techniques/technics, or, the skills and activities employed to meet an end, which sometimes involve the use of (1); and/or (3) the social knowledge used to create or use (1) and guide (2). Most of the article is concerned with (1) and a specific rendition of (3) that emphasizes the pervasiveness of ‘technological’ or ‘instrumental’ rationality. We distinguish between artifacts, techniques, and knowledge when called for.
2. This is not to dismiss the still underappreciated contributions of these philosophers. Their work contains invaluable insights that overlap with critical theoretical accounts of technology, including the case that technology is value-laden. The preference for critical theory here is its steadfast attention to technology’s origins in productive relations.

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