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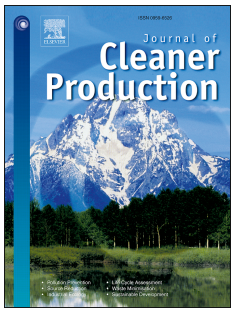


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# Diverging Pathways to Overcoming the Environmental Crisis: a Critique of Eco-Modernism from a Technology Assessment Perspective

*Armin Grunwald*

## Abstract

The current controversies on "sustainable growth", "green growth" and "degrowth" cover many issues in the relations between human behavior, societal regulation and technology in face of the need to overcome the environmental crisis. The point of departure of this paper is the observation that the roles of technology and of technological progress in realizing an ecologically sound development often are simply taken as mere assumptions or else are taken for granted. The objective of this paper is to critically scrutinize assumptions and expectations of the eco-modernist approach from the perspective of technology assessment in the context of the debate on growth and degrowth. By reconstructing the basic arguments, assumptions, and premises of the eco-modernist approach and their critical assessment, the analysis culminates in the diagnosis of the eco-modernist approach being morally hazardous because it expects to overcome the ecological crisis by technological progress and its acceleration only, ignoring the ambivalences of technology and the issue of unintended side effects. Following this result, conclusions will be drawn in two directions: from the experience of technology assessment for degrowth, and from degrowth thinking for technology assessment.

## Keywords

eco-modernism, techno-optimism, technology assessment, responsibility ethics, unintended side effects

## 1. Point of departure

The notion of permanent technological progress and the paradigm of an equally permanent economic growth are twin concepts (Kerschner/Ehlers 2016). They have come about in parallel with the industrial revolution and have gained momentum in parallel during the second half of the 20$^{th}$ century. They have both become globalized and have emerged as objectives not only for industrialized countries but nowadays also for a large part of global society. The Western approach combining the ideas of economic growth and technological progress has become the dominant model for emerging and developing countries. These "twins" support each other mutually: technical progress is regarded as the central driving force for innovation and growth in global competition, while economic growth allows technical progress to be maintained financially through appropriate publicly funded as well as industrial research. Both paradigms, moreover, are not just empirical descriptions of actual ongoing processes but also have a *normative* component (e.g., Smith/Stirling 2010): across wide sections of society, business and politics, economic growth and technological progress are considered *at least politically if not morally desirable* and are the subject of political rhetoric and public encouragement. In light of the normative ideals of future

ethics (Jonas 1984) and the need to overcome the global environmental crisis this does, however, pose far-reaching questions as to the reconcilability of unlimited growth given the finite nature of resources and the limited capability of nature to work as a sink for emissions (e.g., Dietz/O'Neill 2013; Kerschner/O'Neill 2015) – and as to the role of technological progress, which lies at the heart of this paper.

As ideal types, it is possible to distinguish between two conflicting positions regarding the growth issue:[1]

- *Degrowth position*: The degrowth debate (e.g., Latouche 1984; D'Alisa et al. 2014; Demaria et al. 2013; Fournier 2008; Kerschner 2010) works on the premise of a basic irreconcilability between the paradigm of continuous economic growth and the vulnerability and limitedness of Planet Earth (e.g., Dietz/O'Neill 2013; Kerschner 2010). It develops societal and business models beyond the growth paradigm. Far-reaching changes in society such as new political regulation, adequate systems of incentives and behavioral changes are being called for.
- *Eco-modernist positions*: In contrast, positions referred to as "eco-modernist" (Manifesto 2015; Fücks 2011) strongly refer to market forces and argue that it is in principle possible to reconcile economic growth and the needs to protect a functioning ecosphere. "Green growth" would be the key to this strategy, e.g., following OECD (2011) and UNEP (2011) postulating accelerated technological progress. This postulate in particular addresses strategies to increase efficiency, e.g., in the context of Factor 5 (Weizsäcker et al. 2009) or Factor 10 strategies (Schmidt-Bleek 2008).

The expectations of technological progress run counter to this distinction. Techno-optimism (e.g., Ehlers/Kerschner 2014) clearly dominates the eco-modernist position (cf. Sects. 2 and 3), whereas the growth-critical debate comprises a number of different positions. It is often expected and postulated that technological progress should have a supportive effect although it does not take center stage.

It is my initial observation that the justification of expectations associated with technological progress to achieve an ecologically sound development is the subject of little systematic debate. Instead, expectations regarding major problem-solving capabilities of new technology often take the form of unquestioned premises. Answers to the question of how large the contribution of technological progress to overcoming the environmental problems could be – whether, for example, it could take on a part of the solution or even shoulder the entire burden – are often akin to expressions of faith and philosophical convictions rather than being argued out rationally and scrutinized with reference to their premises.

Against this background, this paper aims at uncovering the central arguments (Sec. 2) and premises of the eco-modernist position (Sec. 3) and at discussing them critically, especially with a view to the expectations of technological progress and the possibility of meeting them (Sec. 4). I will use perspectives and experiences of Technology Assessment (Schot/Rip 1997; Grunwald 2009) for a critical debate. My findings are (1) that the degrowth movement should, based on this assessment, develop a clearer position with regard to expectations concerning the technological progress,

[1] The authors subsumed under the both ideal types do not converge in all of their premises and positions. However, with regard to the argumentation presented in this paper it seems legitimate to present this rough juxtaposition.

and that (2) the recently published formulation of the eco-modernist position (Manifesto 2015) provides an ideal point of departure for a transparent and precise conceptual debate. The Special Issue to which this paper belongs might be regarded a major step in this direction based on earlier more philosophical reasoning provided by Ivan Illich and Jaques Ellul. An adequate counterpart of the Ecomodernist Manifesto – a Degrowth Manifesto – is still missing at this level.

## 2. Eco-modernism: its project of an ecologically sound future

The relation between technological advance and solving the environmental crisis is ambivalent. On the one hand, overcoming the major environmental problems of the present day seems to be inconceivable without further technological progress and the utilization of its results. On the other, however, climate change, loss of biodiversity or the depletion of resources – all these phenomena are largely attributable to the technological progress of the past 250 years. As early as in 1984, Hans Jonas's prime concern regarding the ethics of technology was not for technology that does *not* work and, e.g., leads to serious accidents. His diagnosis instead was that major problems were caused by technology *in full working order*: namely through the unintended, in part unexpected side effects which are often felt only much later and more gradually. Our situation today reads like a confirmation of this diagnosis: climate change, to cite just one example, is the result of technology that *works*, e.g., in the form of combustion engines or fossil power plants. However, different conclusions may be drawn from this observation, following an analysis by Kerschner/Ehlers (2016, Fig. 2) on different techno-attitudes of researchers. In the light of the argumentation of this paper their subcategories of technophile, technophobe, and technocrat perceptions of the role of technology are particularly helpful:

(1) In order to reduce environmental burden, technological progress would need to be slowed down or halted, possibly even reversed. Since more technology has apparently meant more problems to the environment, *less* technology would be the solution or at least a vital contribution towards any solutions.

(2) Technological advances to date might have followed the wrong or at least biased (e.g., techno-economic efficiency) objectives. If the objectives of environmentally friendly development were to become part and parcel of the development of new technology (e.g., Weaver et al. 2000), future technological advances could be oriented in such a way that they would contribute rather than run counter to solving environmental problems.

(3) Technological progress also, so a more radical version of position (2), might be regarded not only as being *part* of the solution but *the solution* to the problem. It must be speeded up in order to disconnect human civilization from the natural environment as soon as possible (Manifesto 2015).

In the debate of the last few decades, different expressions and emphases of the second and third position have largely prevailed, while the first position outlined above has virtually disappeared from view, at least in public debate. The main idea is that by significantly boosting the efficiency of technology, it would be possible to reduce the consumption of resources as well as environmental pollution without calling the growth paradigm into question (Weizsäcker et al. 1995). The gain in efficiency made possible by technological progress should come about at a much quicker rate than economic growth, so that notwithstanding this growth it is feasible to achieve positive sustainability effects. This makes political sense: as far as the population and hence

the electorate is concerned, the implication is that *by and large* everything can stay the way they are used to. This model is also of interest to the economy since the fundamental logic of economic activity is not questioned: given that the achievement of efficiency gains can be seen as a societal task, state subsidies can be applied for. Strategies that primarily rely on efficiency are attractive to political manifestos from a wide political spectrum (Huber 1995).

The principle of sustainable development was installed by the Brundtland Commission (WCED 1987) and further developed during the Rio process. Parts of this movement concentrated on enhanced efficiency and technological progress (e.g., Weizsäcker et al. 1995). The degrowth movement, however, criticized the underlying premises and assumptions as being too optimistic with regard to efficiency gains based on early critical analyses (Latouche 1984; Georgescu-Roegen 1978; see for recent work Dietz/O'Neill 2013; Kerschner 2010). The question of the degree to which a reorientation of human civilization can contribute to overcoming the environmental problems by exploiting technological progress and the contribution that economic, social and political measures, and behavioral change have to make is still open.

A group of US American researchers and writers has recently presented a remarkably succinct version of the techno-optimistic position (Manifesto 2015), which refers to itself as eco-modernist. With the aim of achieving a "good Anthropocene", the group radicalizes their expectations of technological progress in the form of the above-mentioned third option. Thanks to the clear presentation and the pointed argument, this manifesto is very well suited to analyze these views and premises.

The designation "eco-modernism" adopted for their statements is highly appropriate. The "eco" prefix points to the fact that the dramatic ecological problems of the present day are indeed taken seriously when it comes, e.g., to climate change, the loss of biodiversity and the growing repression of wild nature ("wilderness") caused by the increasing land use. The "modernist" tag refers to the fundamental way in which the environmental crisis may be overcome. This happens entirely within the framework of traditional modernist notions of progress that in the last resort go back to David Hume and Francis Bacon (Schäfer 1993). A most comprehensive emancipation and decoupling of human civilization from nature should be achieved by consistently pursuing this program of enlightenment. According to the authors, the environmental crisis illustrates that this emancipation has not been fully accomplished to date. Instead of reaching the conclusion – like the majority of the European environmental movement has done – that it is necessary to turn back from the path of classical modernity, the eco-modernists' message is that humankind should not grind to a halt and then turn back at the halfway point but should move forward emphatically and indeed at a faster rate.

This position conflicts sharply with many present-day analyses that in fact regard the basic premises of classical modernity as the causes of the environmental crisis. They claim that a purely instrumental understanding of nature, great trust both in the problem-solving capacity of technological progress and aiming at gaining full dominion over nature have led to the irresponsible exploitation of Planet Earth. Hence, they are misguided in continuing to advocate a classical modernist approach (e.g., Meyer-Abich 1984). Modernist-critical analyses going at least as far back as the "Dialectic of Enlightenment" (Horkheimer/Adorno 1947) have resulted in a call for fundamental corrections to the traditional modernist model, e.g., in the model of "reflexive modernization" (Beck et al. 1994) or "alternative modernity" (Feenberg 1995). At the core of

those theories is the diagnosis that the classical modernity (Schäfer 1993) shows inherently produced, dialectic, self-destroying consequences among which the environmental crisis is one example.

The eco-modernist manifesto offers no clues to such basic thoughts on a "different modernity" but instead looks for the solution *within the paradigm of classical modernity*. The authors point out that technological advances achieved to date have already led to a significant reduction in per capita nature consumption (e.g., the area required to provide sustenance for a human being). Hence, it would be misguided to reverse this trend (e.g., through alternative extensive agriculture requiring more land); instead, it would need to be speeded up. The ideal expressed in the Manifesto is that of a human society that becomes largely emancipated from the natural world and organizes itself independent of natural resources:

> "Intensifying many human activities – particularly farming, energy extraction, forestry, and settlement – so that they use less land and interfere less with the natural world is the key to decoupling human development from environmental impacts" (Manifesto 2015, 7).

Technological progress should drastically reduce nature consumption (there is frequent mention of land requirement). A growing world population with continually growing wealth is to be made possible with lower land-use and requiring ever fewer resources:

> "Urbanization, aquaculture, agricultural intensification, nuclear power, and desalination are all processes with a demonstrated potential to reduce human demands on the environment, allowing more room for non-human species" (Manifesto 2015, 18).

Technological progress should *simultaneously* allow further economic growth in the framework of a growing world population and the inherent rightful restitution of nature. The implication, if these ideas are taken to their logical conclusion, is a dichotomy of planet earth: humankind would use as small a part of the earth's surface as possible, living in densely populated conurbations with highly intensive agriculture or synthetic food production, while another part that would be as large as possible would be free from human exploitation and largely left to nature. While many green-ecological utopias speak of an ecologically sound civilization, e.g. in the sense of a responsibly managed "garden", eco-modernists maintain that humankind should withdraw from nature into a synthetic high-tech society. Man and nature should be decoupled as far as possible. The withdrawal of humankind into high-tech reservations would allow wilderness to reclaim large areas which, and this is a crucial argument of the authors, would then be accessible to aesthetic human experience rather than being an economic resource and hence an object of exploitation. The ideal of "wilderness" which is deeply rooted in American culture (Marx 1964) clearly plays an important role in this context. In the synthetic high-tech reservation there would be no recognizable limits to further growth. The "good Anthropocene", named in the manifesto as the ideal, would be the side-by-side existence of a flourishing technical civilization of humanity in synthetic worlds, e.g. driven by technologies based on nanotechnology (Fleischer/Grunwald 2008), and large parts of the earth's surface reverted back to wilderness.

The extreme in this direction of development would be concentrating human civilization in more or less purely synthetic worlds. Examples of synthetic worlds exist particularly in tourism. Tropical parks and lakes under glass roofs in northern countries, huge cruise ships that serve as artificial environments for thousands of people for a number of weeks, indoor skiing facilities in areas where there is hardly ever any snow, and artificial sights including Disneyland in Florida or outside Paris enjoy great

popularity and are economic success models. It is worth asking the question whether such artificial worlds may not be ecologically, socially and culturally more sustainable than the excessive use of the original counterparts. Yet, whether they serve as a good model for global society as a whole would be an entirely different matter – especially since an environmental balance for these artificial worlds would need to take into account all input and output scenarios at the interfaces with the real world.

It seems interesting to note that Europe also has an eco-modernist movement with very similar principles, although some of the conclusions reached have been diametrically opposed, in particular in the field of energy. To put it very simple: European ideas are in favor of renewables, while Americans prefer nuclear power. The concept of an ecologically oriented modernity emerged from the ranks of Germany's Green Party (Fücks 2011). This concept no longer speaks of the "Limits to Growth" (Meadows et al. 1972), but of a "Growth of Limits", that is to say of a deferral of the supposed limits to growth (Sloterdijk 2011). This deferral – and at this point these ideas coincide with those expressed in the Ecomodernist Manifesto (2015) – is expected to come from technological progress (cf. Sec. 3).

Although the general argument is identical, there is a specific distinction. While the Ecomodernist Manifesto talks relatively unspecifically about technological progress being guided by ideas of sustainability, Fücks takes up an idea expressed by the philosopher Ernst Bloch. His idea was that technology should no longer be developed and deployed "against nature," which Bloch regarded and criticized as a trademark of classical modernity. Technological development should not regard nature as an adversary and should not try to bring it under complete control but should be pursued in "alliance" with nature. Hence, we also find criticism here of the basic principles of classical modernity such as Francis Bacon's ideal of control. Nonetheless, this approach is still an integral part of eco-modernism since the "twins" of growth and technological progress are supporting pillars, with Bloch's technology utopia having a formative influence (cf. Sec. 3).

This European model of eco-modernism would not (at least not invariably) lead to a dichotomy of the planet into a high-tech region for humankind and nature left to its own devices. Instead, a cultivated side-by-side of humankind and nature would be conceivable. This is where the European tradition of the "garden" becomes more prominent than the American "wilderness" idea.

## 3. Eco-modernism: its central premises

The following central premises are common to both of the eco-modernist approaches described above:

*(1) No alternative to growth paradigm*

The growth paradigm is not questioned but looked upon as a constitutive characteristic of modern societies. The Ecomodernist Manifesto presupposes this as so obvious as to require no mention, let alone any reason or explanation, – presumably owing to the US American debate, which, following, e.g., the primaries preceding presidential elections, seemingly does not leave space for political positions beyond the economic growth paradigm. However, a differentiated view is taken on developed and developing countries, assuming that strong growth will take place in the future mainly in de-

veloping countries. In Europe, though, it is the very aim of the green-modernist position advocated by Fücks (2011) that a new growth orientation should be set up in the midst of a green movement that is at least partially critical of growth. To this end, and this is an interesting point, reference is made to a philosophical argument in favor of growth. No less a person than the German philosopher Peter Sloterdijk attempts to demonstrate an "anthropological need" for growth:

> The connection between self-preservation and self-improvement implies a preliminary decision in favor of a culture where affluence, wastefulness and luxury acquire the status of civil rights (Sloterdijk 2011, 15f; translation A.G.).

In this position, economic growth is regarded as part of the human destiny and as such non-negotiable. Growth is seen as a principle of human existence that cannot be altered without calling the human existence itself into question. The debate about degrowth, therefore, would be tantamount to an attack on human existence, dignity, and evolution. Given the fact that permanent growth is a fairly recent (200 years are not a long period in terms of the history of humanity) guiding principle of political and economic action, this argument may seem weak and exaggerated. It should at least be recognized, though, that Sloterdijk attempts to provide *explicit* grounds for the growth paradigm, while others often simply assume that it is without alternative.

*(2) Compromising natural limitations to infinite growth*

One of the starting points and central diagnoses of the sustainability debate is the awareness of the finite nature of resources here on earth (Dietz/O'Neill 2013; Kerschner/Ehlers 2016; Kerschner 2010; Kerschner/O'Neill 2015). This finite nature and the environment's limited ability to absorb emissions should invariably conflict with the idea of limitless growth, as one of the founding texts suggests (Meadows et al. 1972). The Manifesto (2015) as well as Fücks (2011) and Sloterdijk (2011) make explicit reference to this original diagnosis and question it:

> Despite frequent assertions starting in the 1970s of fundamental "limits to growth", there is still remarkably little evidence that human population and economic expansion will outstrip the capacity to grow food or procure critical material resources in the foreseeable future. To the degree to which there are fixed physical boundaries to human consumption, they are so theoretical as to be functionally irrelevant (Manifesto 2015, 9f).

This position denies the existence of physical and hence "objective" limits to growth. Two arguments are put forward in support. The first is a reference to the fact that uncertainty prevails where the earth's actual resources are concerned:

> As yet, we do not know what developments might become possible once the geosphere and the biosphere are developed further by the technosphere and noosphere. It is not out of the question a priori that this might produce effects tantamount to a multiplication of the earth (Sloterdijk 2011, 16). And: Nobody as yet has specified what Planet Earth is capable of (ibid.) (translation A.G.).

The conclusion from this statement is that instead of speaking about the limits to growth we should speak about the growth of limits (Fücks 2011), i.e., that limits do not objectively exist but may be pushed back. The uncertainty of our knowledge of the earth's actual resources is pushed to the limit argumentatively to claim that we may assume the resources are infinite until we have reliable statements that resources are finite. Unless the finite nature can be proven and the amount of resources cannot be indicated beyond doubt, the finite nature does not need to be taken into consideration in economic or political actions.

Yet, there are undoubtedly physical limits to the amount of resources, even though we do not have unequivocal knowledge of these limits. This observation should be cancelled out by the second argument from the discussion about the finite nature of fossil resources. This states that while the amount of resources is finite "in principle," it is in fact (virtually) unlimited since any shortage would only lead to the exploitation of further, hitherto unprofitable deposits that would become worthwhile because of rising prices. Hence, the shortage would in fact become irrelevant (see the position of the neoclassical economic optimism or conucopianism in Kerschner/Ehlers 2016). The resulting price increases would be the optimum driving force for efficiency improvements that would allow an ever-increasing economic benefit to be derived from an objectively smaller quantity of fossil resources. Hence, there are no actual limits to growth despite the real finiteness of resources. A further argument used for the possibility of unlimited growth relies on the availability of new generations of nuclear power plants. The main assumption is that technology will be able to provide unlimited energy as source of unlimited growth. This position leads directly on to expectations of technological progress.

*(3) Technological progress as the central problem-solver*

Eco-modernism assigns the central role for solving environmental problems to technological progress and proper management, which is also part of the neoclassical paradigm in economics:

> With proper management, humans are at no risk of lacking sufficient agricultural land for food. Given plentiful land and unlimited energy, substitute for other material inputs to human well-being can easily be found if those inputs become scarce or expensive (Manifesto 2015, 10) … Meaningful climate mitigation is fundamentally a technological challenge (ibid., 21).

Other measures like suitable political conditions or changes in behavior are not mentioned. Instead, "accelerating technological innovation" (Manifesto 2015, 30) becomes the central task. Similar examples of a trust in technological progress are to be found among the Green representatives of Germany's energy transition, albeit oriented towards Ernst Bloch's "alliance technology":

> The old industrial age that was fueled by fossil energy is replaced by a new, ecological mode of production that derives its energy from the sun, wind, geo-thermal energy, and the power of the sea. In addition, there is artificial photosynthesis which allows water and carbon dioxide to be converted into energy. Bio-reactors turn organic materials into fuels and chemicals. Photovoltaics, heat pumps and intelligent control technology allow buildings to become power plants that generate more energy than they consume. Miniaturization reduces material consumption. Computers, machines and engines become smaller, lighter and more efficient. Waste is a thing of the past, as all residues are returned to the biological or technical cycle (Fücks 2011; translation A.G.).

Building on the same basic premise, namely that technological progress will provide solutions as well as limitless growth, their recommendations differ greatly in detail. While the eco-modernist position, for instance, relies on nuclear power and agricultural intensification and is critical of Germany's energy transition's focus on renewable energies (Manifesto 2015, 28), the green-modernist representatives advocate renewable energy, decentralized technologies and, elsewhere, greater agricultural extensification.

Utopian expectations of what technology can accomplish have characterized the modernist movement ever since the industrial revolution. Expectations that technological progress can somehow provide salvation have been with us for the past 200

years. Their authors' philosophical beliefs are positioned as wide apart as Karl Marx, Ernst Bloch, Friedrich Dessauer or Eric Drexler. What they have in common is the hope that technological progress is not only able to solve fundamental societal problems such as reconciling capital and work, but that it will *in fact do so*. Eco-modernists regard the acceleration of technological progress as the best way to solve environmental problems. Their ideal is the complete decoupling of a high-tech world for humans and nature that affords plenty of scope for wilderness (see above). They put forward a historical argument for their case:

> Greater resource productivity associated with modern socio-technological systems has allowed human societies to meet human needs with fewer resource inputs and less impact on the environment (Manifesto 2015, 29).

This historical experience is taken as an indication that further pursuing this path eventually promises a solution to environmental problems.

*(4) Absence of unintended consequences*

In addition to the reliance on technological progress, eco-modernism assumes that efficiency-boosting technologies and measures will not be accompanied by any significant unintended side effects that would cancel out the expected positive effects of technological progress and pose new environmental and sustainability problems. However, they acknowledge that technological advances *to date* have not only led to efficiency benefits but have also involved considerable environmental problems:

> Human technologies, from those that first enabled agriculture to replace hunting and gathering, to those that drive today's globalized economy, have made humans less reliant upon the many ecosystems that once provided their only sustenance, even as those same ecosystems have often been left deeply damaged (Manifesto 2015, 8).

However, as far as the future is concerned the authors clearly expect that technological advances can and will come about without some devastating environmental problems as unintended consequences. The basic diagnosis of the ethics of responsibility already mentioned at the outset suggests that this is a very strong premise. According to Hans Jonas (1984), the real present-day problems are those that occur as unintended side effects which, developing gradually and often noticed late, can grow into serious challenges and threats to a continuation of dignified human life on earth. Today, the occurrence of unintended consequences is indeed considered a characteristic of modern society (e.g., Beck 1992) and of respective observations on a new and "reflexive" modernism (Beck et al. 1994). In addition to the temporal dimension of unintended consequences, also the spatial dimension has to be considered. In recent decades, local and regional environmental problems frequently have been solved at the price of negative global developments. These effects also have not been considered by the Manifesto.

It is therefore all the more surprising that eco-modernists do not even mention the problem of unintended side effects. It is clearly a central premise of the eco-modernist approach that unintended side effects can be avoided (at least largely) in further technological progress. However, no indication is given as to how such categorical progress may be realized in the future, in spite of past and present experience suggesting the exact opposite.

A typical – and at first in no way dramatic – unintended consequence of the availability of more efficient technologies is the known occurrence of rebound effects (Sorrell 2007; Sorrell/Dimitropolous 2008). As soon as more efficient technologies become

available, usage patterns and behaviors often change, thereby reducing or even cancelling out the expected efficiency gains. These kinds of consequences do not invariably lead to dramatic effects but may well undo the expected positive environmental consequences associated with technological advances. However, the Ecomodernist Manifesto (2015) builds on the premise that unintended consequences are not expected to occur. The expectation of the authors instead is that the gains resulting from technological advances can (largely) be translated without loss into the absolute environmental balance.

*

These four premises are not independent of each other. Adherence to the growth paradigm clearly presupposes the possibility of limitless growth. This in turn is only conceivable under the premise of a strong role being played by technological progress. A hierarchy of premises therefore exists: technological progress with the premises 3 and 4 is at the root. It is the background premise without which the adherence to the growth paradigm and the denial of limits to growth cannot be made plausible. The central role assigned to technology calls for a critical appraisal of this approach and of its premises against the background of our experience of technology assessment.

## 4. Eco-modernism: an assessment

The positions mentioned are not merely theoretical perspectives of the role of technological progress in solving environmental problems but widespread convictions among significant elites from business, the media, politics, and science (Smith/Stirling 2010). They are therefore also of practical relevance to political and economic actions. A critical and transparent evaluation appears urgent, especially in light of the practical challenges of overcoming the environmental problems.

### 4.1 Experience of technology assessment

Technology assessment (TA) has been developing from the 1960s on. Among its major objectives are to explore possible unintended and negative side effects of technology, to elaborate strategies for dealing with them, and to provide policy advice (following Grunwald 2012, Grunwald 2015). At the beginning of the history of TA environmental concerns have been a major driving force. While in its first period the idea of technology determinism dominated, the concept of shaping technology was introduced from the 1980s on only (Bijker/Law 1994). Its realization needs early reflection on possible later impacts and consequences of technology. The concept of constructive technology assessment (CTA) (cf. Schot/Rip 1997) applied social constructivism program to TA. Within this paradigm, a major objective of TA became shaping technology in order to contribute to overcome environmental problems. Contributing to developing more sustainable technologies (Weaver et al. 2000) is a crucial issue of TA from that time (Grunwald 2011). Approaches such as “transition management” (Elzen et al. 2004) and “reflexive governance” (Voss et al. 2006) were developed and applied to specific challenges. They are embedding environmental and sustainability assessments (Grunwald 2012) into a broader framework of technology development. Allowing for a maximal extent of learning and avoiding path dependencies as far as possible are major issues. Their basic diagnosis is - in accordance with technology assessment (Grunwald 2009, Grunwald 2012) that technology

as such will not be able to solve environmental problems. Instead, a socio-technical transformation is needed which requires considering technology as embedded in societal constellations from the very beginning of technology development (Schot/Rip 1997).

From a TA perspective technology is thus deeply related to society instead of being something external. The artifacts such as machines, products, or systems are not considered or assessed as such but rather as elements of socio-technical constellations (Rammert 2007). In decision-making processes on research and development of technology, in using and applying technology for creating innovation on the marketplace, in exploiting potentials of new technology for meeting grand challenges such as the environmental crisis, overall there are close relations between decision-making and values on the one hand and technology on the other.

A working definition of technology was proposed by the German Association of Engineers in its guideline on technology assessment (VDI 1991). Following this definition "technology encompasses

- the set of use-oriented, artificial, concrete objects (artefacts or object systems),
- the set of human actions and institutions in which object systems originate,
- the set of human activities in which object systems are utilised." (VDI 1991, 2)

Characteristic of the perspective of TA on technology is thus the embeddedness of technology in society, in decision-making processes, and in value systems (Rip et al. 1995). The basic experience of TA - the occurrence of unintended side-effects - gave rise to emphasize the ambivalence of technology (Grunwald 2009) and the necessity of considering the entire life cycle (). The latter issue motivates extending the definition of technology quoted above by mentioning explicitly its disposal (Schepelmann et al. 2009).

TA cannot draw on any relevant experience when it comes to the first two eco-modernist premises, namely the growth paradigm and the ability to extend the limits of resources. Although it has been working within the framework of the growth paradigm for more than 40 years, this has not been made the subject of explicit discussion yet. TA is involved in many ways in increasing resource productivity and efficiency (e.g., Vergragt 2006). However, this always relates to specific technologies and does not deal with the general question as to whether the pushing back of limits by increasing efficiency is reconcilable with ever further growth. The sustainability rule used to assess the environmental compatibility of specific technologies when dealing with non-renewable resources (Grunwald/Rösch 2011) would in any event not conflict with the second premise of eco-modernism.

According to the third premise of eco-modernism, technological progress is essential for coping with the challenges of the global environmental crisis. Adequate governance of technological progress through systems of incentives and regulation is considered necessary to push technological development to environmental compatibility. This calls for anticipative research to compare the environmental implications of various technology options with a view to selecting the one with the best ecological record. Whether technological progress generally has a positive or negative impact on the environmental dimension is not the issue here; instead, the question is how technologies and their use need to be designed so that the burden on the natural environment can be reduced.

However, there is some controversy as to whether and to what extent the future development of new technologies may be steered in a way to ensure that this actually happens. The experience of TA (Grunwald 2009) shows that expectations should not be too high because of two serious restrictions: (a) restricted ability to shape technology given the great uncertainties in predicting the comprehensive implications for the environmental dimension, and (b) the occurrence of unintended side effects.

(a) Statements on the environmental impact of technical options, technology consequences or innovation potentials involve considerable uncertainties that cannot be eliminated (Grunwald 2007). The environmental impact – both positive and negative – of future technologies is not only determined by technical parameters but also influenced by the interaction of societal developments during usage of the technology with the properties of the technology itself. An integrated environmental assessment calls for system analyses that combine the technical product properties with the economic manufacturing processes as well as the societal consumer patterns and lifestyles. While the technical performance characteristics are often quite well known even at early stages of development, this apparently hardly applies to the societal conditions of the later use phase. Hence, the accumulated environmental impact is difficult to anticipate successfully. Moreover, an environmental assessment of technology depends not only on the use phase but also on the "biography" of the products and systems, that is to say, on their supply chains and disposal after use. Life cycle assessments are essential prerequisites of any environmental assessment of technology (Schepelmann et al. 2009), in spite of the well-known challenges to determine adequate system boundaries. Using LCA in a prospective manner requires an even greater degree of anticipation, thus entailing further uncertainties (Wender et al. 2014; see more generally the observations in post-normal science e.g. Funtowicz/Ravetz 1993). Shaping technology with a view to ecological values should therefore not be understood as planning towards a defined objective but as an ongoing process involving high uncertainties (Voss et al. 2006).

(b) A further problem is the justification of the fourth premise, namely the absence of relevant unintended side effects. Since the 1960's at least, considerable unintended side effects of scientific and technical developments have occurred with some dramatic manifestations. Accidents at technical installations (Chernobyl, Bhopal, Fukushima), impacts on the natural environment (air and water pollution, ozone hole, climate change, loss of biodiversity) as well as social and cultural side effects of technology (e.g., labor market problems as a consequence of automation) have made naive faith in progress fade into insignificance. Although hope for better technology still exists, its *ambivalence* (Grunwald 2009) has become a central diagnosis of the present day. This is to say that even if technological progress is focused on the ideals of environmental compatibility, it is very likely that unintended side effects also have to be reckoned with. Why it should be different here would in any event require a lot of explanation. Even technology that is very "well-meaning" and legitimized by ethical objectives can involve unintended side effects that run counter to these objectives and might even overcompensate them. A classic example in this context are rebound effects, where potential sustainability gains made possible by enhanced technological efficiency are used for other purposes, e.g., for greater luxury and comfort, so that in the final analysis no gain in terms of sustainability is achieved (Sorrell 2007; Binswanger 2001).

To sum up, it is evident that according to the experience of TA the technological optimism of premises 3 and 4 is not justified. We can neither assume that technology

can be designed with ecological values in mind, expecting guaranteed prospect of success, nor can we deny the possibility that far-reaching unintended side effects may occur. Eco-modernism thus loses its most important basis of argumentative validity.

### 4.2 Ethical constellation: the question of responsibility

What is the ethical implication of relying on premises that cannot be realized? There can hardly be any ethical doubt that the possibilities technological advances bring to solving environmental problems should be exploited within the framework of a responsible strategy which includes the anticipation of possible unintended side effects. Controversies arise as to the specific meaning of "responsible", what unintended side effects need to be reckoned with in what scenarios, how the evaluation processes between the potentials for environmental relief and possible side effects should be organized, and what measures promise the best overall effects. These are very much what we regard as the "normal" challenges of technology assessment (Grunwald 2009) to be dealt with, always related to concrete technologies and context-specific requirements. They therefore need not be further considered here. Instead, interest is focused here on further guiding imperatives that extend beyond individual technologies and contexts as can be found implicitly or explicitly in the eco-modernist position. According to the above analysis of premises, these are (following Sec. 2):

(1) Technological progress should be accelerated in order to cope with the environmental problems in the above-mentioned sense of a decoupling of human civilization and nature.

(2) Other measures such as a departure from the growth paradigm, behavioral changes or regulatory measures to reduce negative environmental effects need not be pursued – or at least not pursued as a matter of urgency – since (1) is expected to provide the problem solution.

These imperatives place the entire burden of solving environmental problems on technological progress and its potentials. Technological progress is therefore not only regarded as a *necessary* condition for overcoming the environmental crisis, but indeed seen as the *sufficient* condition within the eco-modernist approach.

However, this position needs to be critically questioned. The above-mentioned experience of modernity, in particular drawing on TA with its profound ambivalence of technology (Sec. 3.1), suggests that this attribution is, as it were, in argumentative limbo. It ignores the historically acquired experience and instead follows technological optimism as though it were a quasi-religious creed.

Things get even worse regarding the eco-modernist demand that technological progress should be accelerated. Experience of recent technology and its unintended side effects (see above) shows that any acceleration of technological progress will reduce the possibility of learning any lessons for further action. Learning involves monitoring, assessment and adjustment and thus takes time. Acceleration increases the dependence on technological progress and reduces the prospect of even being able to contemplate alternatives or complementary measures. It leads to constraints and undermines any "thinking in alternatives", which is indispensable where well-considered decisions on further action are concerned. The call for acceleration also blanks out questions as to the risks associated with a reliance on technological progress and what options remain should the reliance on technological progress turn out

to have been unwarranted. It could be part of the agenda of the degrowth movement to investigate carefully whether technology development should be slowed down (if this were possible) in order to open up spaces for monitoring, reflection and learning as indispensable elements of a more sustainable society.

Hans Jonas (1984) warned against making "the whole" the stake in a bet, yet this is precisely what the eco-modernist position does: it relies utterly on technological progress, thus making the future development in the Anthropocene entirely dependent on this reliance on technological progress being justified and opening up the path to a sustainable future. Yet, just in case this hope is not fulfilled – and we have discussed above that this is indeed a possibility –, grave problems would be possible or indeed probable. "The whole," according to Hans Jonas, would come under threat. The conclusion in this context is that the eco-modernist position relies on unjustifiable premises and takes them further still by calling for the acceleration of technological progress. In so doing, it may well threaten "the whole" and is therefore indefensible. In the last resort, eco-modernism as analyzed here is the position of a moral gambler who bets everything on one horse.

This gambling dimension is acknowledged quite inadvertently in a publication of the green-ecological variant of eco-modernism:

> Whether the transition to sustainable growth is accomplished is an open bet. We could well lose the race against the ecological crisis. Yet the future is unknown, and the innovative potential of modern societies is unlimited. That is what we may hope for (Fücks 2011; translation A.G.).

Hans Jonas's terminology of the "bet" is openly adopted here, though it is being used in the opposite sense. Fücks speaks of hope rather than of responsibility. However, relying on mere hope when "the whole" is at stake is nothing other than the aforementioned position of a moral gambler. If the experience of TA is taken seriously, that is to say, if the limitations to the possibility of shaping or designing technology are acknowledged and if the invariable occurrence also of unintended side effects of well-intentioned technology is not ignored, the eco-modernist position must be eliminated as an ethically justifiable approach to the issue of sustainability.

This certainly does not mean that technological progress is considered to be of little relevance to the solution of environmental problems. The responsible-ethical argument merely warns against relying solely on technological progress like a gambler relying on a particular number in roulette. The "imperative of hope" (to take up Ernst Bloch once again) with regard to the expectations of technological progress that dominates eco-modernism must be complemented by the "imperative of responsibility" (Hans Jonas) that specifically deals with scenarios where blind trust in technological progress may be disappointed. The precautionary principle refers to this responsibility constellation involving high uncertainty (Schomberg 2005). An own effort (that would go beyond this paper) would be required to determine what this rather general statement should mean in specific contexts and cases.

## 5. Conclusions

The debates between growth criticism and eco-modernism involve different diagnoses and suggest diverging therapies for promising ways to overcome environmental problems. It is not clear to what extent the eco-modernist premise that technological progress promises to make central contributions to a more ecologically friendly world can be supported by sound arguments or whether these are subjective convictions

and ideologies. Although reference is made to historic arguments (Manifesto 2015), the historical findings of TA are being ignored. It seems to be a worthwhile task as a next step to reconstruct the logical structure of the debate surrounding growth criticism, eco-modernism or perhaps other positions on dealing with the environmental crisis. It would then need to become clear what knowledge stores are mobilized by which position, what different assessments of knowledge and non-knowledge these are founded on, and how and with what criteria and arguments assessments are being made. This would surely reveal whether these positions are guided by knowledge-based considerations, faith convictions, plausibilized "gut feelings", intuitive opinions, ideologies, values, or even concealed lobbying. This in turn could suggest how an argument-based debate between the positions might be conducted, e.g., in a cognitive mode that investigates the tenability of premises or in an ethical mode which is concerned with responsibility in the face of non-knowledge.

The major conclusions which can be drawn from the analysis given in this paper concern, on the one hand, what the degrowth community could learn from TA, and, on the other, what TA could learn from degrowth thinking. On the first-mentioned point the lessons learned are more or less clear: the TA experience provides the degrowth community with eicence-base arguments against naïve techno-optimism and major arguments of the ecomodernist movement:

1) The eco-modernist approach grounds on premises which are not based on knowledge or experience but rather on mere belief in the technological advance, ignoring, e.g., the TA experience of the occurrence of partially dramatic unintended side effects of technology.
2) With regard to the ethics of responsibility, this position is morally hazardous; according to the experiences of technology assessment in particular, the acceleration of technological advance is ambivalent and must not be regarded as the only problem-solver.
3) Rather, also other options should be taken into consideration, including options beyond mere technology.
4) It should even become part of the agenda of the degrowth movement to investigate whether technology development should be slowed down (if this were possible) in order to open up spaces for other elements of a more sustainable society.

Vice versa, there are some conclusions for the field of technology assessment itself that can be drawn from the analysis presented in this paper in relation with degrowth:

1) Technology will be part of the solution to the environmental crisis, but we do not know how big this part might be. According to the experiences of modernity, in particular by technology assessment, it does not seem responsible to trust in technological progress as the only or major problem-solver. Techno-optimistic approaches such as the eco-modernist one lack the dimension of precaution and thus cannot claim to be responsible (Sec. 4).
2) In spite of the fact that degrowth cannot be proved to be the only way to overcome the environmental crisis, it seems imperative to develop this option further in order to open up alternatives to techno-optimistic and merely efficiency-related approaches, and to meet requirements derived from the ethics of responsibility, taking seriously concerns about limitations to the "technological fix" (Huesemann/Huesemann 2011) (Sec. 4).

3) When exploring contributions and potentials of new technology to overcome environmental problems, the issue of unintended side effects must be taken into account from the very beginning. Technology assessment must not fuel the (misleading) impression that technology options that are considered as environmentally friendly will automatically produce the expected benefits, e.g., because of rebound effects.

4) Technology assessment also must be aware of the fact, or at least the possibility, that the expected positive environmental effects do occur, but that they are no more than cosmetic repairs to a system which in itself is not environmentally compatible. In that case, TA would only contribute towards stabilizing a system that as such is not worthwhile to be stabilized (Blühdorn 2007). It would thus delay or even prevent altogether the fundamentally necessary correction of the system and, while consciously doing something for the environment, would in fact work against the objectives of meeting environmental challenges.

Ultimately, this is a question of the system boundaries. Generally, TA does not ask itself whether the logics of the ambient societal systems, particularly of the economic system, and possible alternatives to them should also be the subject of study. On the contrary: the functional logics of the systems, and this includes the growth paradigm, are usually simply accepted as a given condition. In so doing, TA castrates itself, allowing itself to operate solely within the existing economic and societal system. The scope for possible alternatives is confined to options that are compatible with applicable paradigms and structures. TA becomes affirmative and deprives itself of the possibility to voice criticism.

The conclusion from these concerns is obvious. The role of restrictive system boundaries and the ensuing problems must be reflected on openly and transparently, while the environmental analyses of TA must be discussed against the backdrop of the "big questions." "Thinking in alternatives" empowered by TA must not be subjected to overly narrow limitations, e.g., by comparing the environmental impacts of technologies A and B. The alternatives also need to deal with the "big" questions such as, e.g., the role of the growth paradigm and expectations of technological progress. Otherwise, there is the very real danger that TA will eventually become a repair business condemned to failure for a system that is not sustainable itself.

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