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Dialectics of Technical Emancipation—Considerations on a Reflexive, Sustainable Technology Development

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Abstract The modern idea of emancipation is linked to the goal of overcoming dependencies and domination. However, as argued in the article, negative dialectics of emancipation must also be problematized. The project of emancipation, as it was formulated in the Age of Enlightenment, was often particular and was associated with the establishment of new forms of domination. Especially the project of liberation from the constraints of nature through technical development led to the domination of nature. In view of the ecological crisis, the dark side of this project is becoming apparent today. The ecological base of human development is at risk. It is therefore necessary to pursue the idea of a reflexive emancipation, which also takes nature into account in order to enable a sustainable technology development. Emancipatory Technology Studies should therefore support an emancipatory technology policy which promotes a positive dialectical movement that overcomes the contrast between submission to nature and technical mastery of nature.

Keywords Emancipative technologies · Domination of nature · Sustainable development · Reflexive emancipation

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Introduction

In the public and political discourse on technology development dominate technological-deterministic perspectives. At the same time, the existing economic and social conditions in which technology is used are considered unchangeable. In contrast, emancipatory technical studies rightly point out the potential for emancipative appropriation of technologies by the society.

However, it is also necessary to reflect critically on the idea of 'emancipation' to which reference is made. Because the coupling of technology and capitalist utilization logic in contemporary society can be seen as a result of emancipation processes of modernity, as the historical review in the article makes clear. These processes were associated with problematic ambivalences and a negative dialectic: the project of the technical emancipation of man from the power of nature overturned in the subjection of external and internal nature. Likewise, the liberation of man from traditional feudal ties as a consequence of bourgeois emancipation led to the increasing power of the bourgeois class and the market over men. The modern capitalist industrial society emerged as a result of the combination of these two emancipatory movements. In line with Polanyi [1], this process can also be described as 'disembedding' of the market and the bourgeois subject of society and nature.

Today, in the face of increasing social and environmental crises, the shady sides and the non-sustainability

of this 'simple' emancipation are becoming apparent. Against the background of these crises, it is necessary to develop a project of *reflexive emancipation*, which includes the nature and the subordinated people suppressed in modern times. What is needed for a sustainable development are technologies that involve or promote the 're-embedding' of the market in society and of society in nature.

However, such a countermovement towards re-embedding is also associated with the danger that positive emancipatory achievements and potential will also be lost, as Fraser rightly points out. She therefore proposes replacing Polanyi's 'double movement' of disembedding and re-embedding with a "triple movement" [2] which integrate emancipation and solidarity.

In line with this, it is argued in the article that Emancipatory Technology Studies should support an emancipatory technology policy which promotes a positive dialectical triple movement in the Hegelian sense: it overcomes the contrast between blind technical (and market-dominated) progress and the countermovement and antithesis towards a 're-embedded' limited technique. The goal is the synthesis of a technology development that harmonizes with the sustainability of social and natural development.

Enlightenment and Emancipation

The term 'emancipation' originally refers in Latin to the release of a person, i.e., in particular the freeing of children from paternal authority or even slaves from the power of their masters. Around 1800, the meaning of the term emancipation was expanded and it became a guiding concept of modernity. It expressed the various political, industrial, and cultural revolutions of the time.

Lyotard rightly argues that the idea of emancipation is one of the great legitimizing narratives of modernity: "I will use the term modern to designate any science that legitimates itself with reference to a metadiscourse of this kind making an explicit appeal to some grand narrative, such as the dialectics of Spirit (…), the emancipation of the rational or working subject, or the creation of wealth." [3, p. xxiii] In recent decades, however, there have been social and ecological downsides to the modernist project. An "incredulity toward metanarratives" [3, p. xxiv] was stated by post-modern thinkers and the problematic dialectics of modernity were discussed. These ambivalences of modernity can in particular be illustrated by the idea of emancipation.

An article on the term emancipation in a German encyclopedia from 1840 is instructive. The anonymous author, who is presumably identical with the editor of the encyclopedia J.G. Gruber, first also mentions the "emancipation of children" [4, p. 50) as the primary meaning of the term, but then connects it with further connotations and gives it a universal anthropological significance: "In addition to this initially mere juridical concept of emancipation, there is now a broader meaning of this word in the political, philosophical and world historical sense; which (…) is based on the nature of humanity and the course of its development with necessity, and through which emancipation has become the practically most important of all concepts (…) of our time." [4, p. 51].[1]

The principle of the release of the children should extend to "all such personal relationships of dependency (…) the cessation of which (…) is a requirement of reason. (…) In this way, the term emancipation develops, as civil or political equality for all those who were or are in a (…) dependency relationship with others" [4, p. 51]. In a political sense, this is understood as the "emancipation of entire classes of people (…) e.g. Emancipation of the Peasants, Citizens, Women, Jews, Catholics etc." [4, p. 51). In a further meaning, it means the abolition of impersonal dependency relationships like the "emancipation of marriage, agriculture, industry and trade, (…) emancipation of the school from the patronage of the church speaks" [4, p. 52]. Here, it becomes clear that the term subsumes all of the social changes that were associated with overcoming feudal dependencies and the transition to modern society as a result of the industrial-political revolution of the eighteenth century.

This also includes the formation of the modern nation state and thus the "national emancipation", as another author of the time emphasizes in relation to the Germans: "The spirit of the nations has become a power. Their spirit demands emancipation of the nationalities. (…) Even the quiet, thinking

[1] Translations from texts in German were made by the author.

people of the Germans are moved by it; this people, too, wants emancipation of its nationality." [5, p. 4].

But this does not mean that the expansion of meaning is complete. In the encyclopedia, the emancipation is, influenced by the spirit of the Enlightenment, furthermore connected to the development of humanity and thus an even further extension is made towards the "philosophical and world-historical concept of emancipation (…) where it then results that all more significant (…) developments of the history of mankind as a whole and of the individual can be subsumed under this concept of emancipation" [4, p. 52].

The starting point of this idea of a "universal emancipation process" [4, p. 52] is the Enlightenment image of man, which in the tradition of ancient humanism defines man as the center and crown of creation. According to it, man is due to his special abilities above all other natural beings. To this, the author counts the ability to make with his hands in a technical way "the hostile and obstructive nature subservient", as well as the "ability to speak, Promethean spark of heaven (…) whereby (…) the whole civilization and culture becomes possible" [4, p. 53].

This predisposition is now also the prerequisite for the process of human emancipation, which the author conceives as the development of the potentials inherent in his particular nature. Man is destined for freedom in three ways: "Firstly, independence from the external nature (…) to which man feels himself destined to be master, (…). Secondly, independence from the arbitrary violence of other human beings (…) thirdly, the independence of each individual from the implanted lowly or sensual instincts." [4, p. 58] But this freedom is not simply given to man, he must win it: "Man finds himself in a threefold dependence (…) that is why the completely human life in this relationship appears as a threefold struggle for emancipation." [4, p. 59].

For the topic of the connection between emancipation, technology, and ecological crisis, the first point is particularly interesting. According to the author, "first (…) man has to survive this struggle with the outer world or nature" [4, p. 59], since the latter does not provide all necessary things, and must be made serviceable to the human purpose: "So work is necessary and useful to man (…) and the outer material emergency is the first agitator for the physical or material emancipation of mankind from the slavery of the force of nature." [4, p. 60].

The author also deals with the problem that the appropriation of nature in industrial society in turn tends to enslave man and that therefore also an "emancipation of our workers" who "are degraded to mere machines and abused as such" [4, p. 60] is to be striven for—he thereby anticipates Marx's demand for an "emancipation of the working class" [6, p. 288].

In second place in the encyclopedia is the "ideal of political emancipation" [4, p. 65], which is not defined as absolute freedom of rule, but as "a perfectly just civil constitution in which freedom is found to the greatest extent possible under external laws, combined with the irresistible power of the leader" [4, p. 64].

The third level of emancipation finally results from the struggle of man with the sensuality implanted in him by nature. Man as a double being therefore has lower, sensual desires, but at the same time also higher aspirations that strive for truth and morality. With explicit reference to Kant's moral philosophy, the "life of natural necessity" is contrasted with a "life of freedom" [4, p. 67]. Through this, a "emancipation of the spirit from the servitude of lower desires" [4, p. 68) is made possible: "We can call this struggle between the higher and lower life of the human spirit the moral emancipation struggle, and its goal the moral emancipation ideal". [4, p. 68].

These formulations illustrate the close relationship between enlightenment and emancipation. It is true that the concept of emancipation is not found in the writings of Kant and other Enlighteners. However, the rise of the concept of emancipation to a guiding principle of modernity after 1800 is undoubtedly influenced by the spirit of the Enlightenment.

This now implies at the same time that the ambivalence of the liberation of man from the domination of inner and outer nature, described by Horkheimer and Adorno as the "dialectic of enlightenment" [7], can also be described as a 'dialectic of emancipation'.

Dialectics of Emancipation

Both the idea of human emancipation from the "slavery of the force of nature" [4, p. 60] and the overcoming of dependence on sensuality are connected with

a negative dialectic: the emancipation of man from the constraints of nature leads to increasing domination over external and internal nature. In this sense, Horkheimer writes: "Man experiences the fate of the rest of the world in the process of his emancipation. Mastery of nature includes domination of humans" [8, p. 97].

This negative dialectic, with which the idea of emancipation is connected, is not incidental. The liberation from the power of nature can be seen as the basis of the emancipation project of modernity: "The European emancipation movement began with the mastery of nature. Knowledge was initially power over nature. (…) The bourgeoisie achieved its emancipation essentially through technical knowledge." [9, p. 14].

This techno-scientific emancipation begins in the early seventeenth century and is associated with the names Descartes and Bacon. Descartes postulates that knowledge of the laws of nature should make people "masters and possessors of nature" [10, p. 78]. And Bacon writes in the Novum Organon: "Human knowledge and human power meet in one; for where the cause is not known the effect cannot be produced. Nature to be commanded must be obeyed; and that which in contemplation is as the cause is in operation as the rule." [11, p. 67] Bacon's writings can be considered as the central imaginary of technoscientific emancipation from nature. It can also be added that the dark side of the modern world and, in particular, the ecological crisis have their origins here as well. Horkheimer and Adorno write in the *Dialectic of Enlightenment* in this sense: "Bacon well understood the scientific temper which was to come after him. (…) Knowledge, which is power, knows no limits, either in its enslavement of creation or in its deference to worldly masters." [7, p 2].

Other authors have also referred to these dialectics of emancipation in continuation of critical theory. For example, Sana writes in *The Dialectic of Human Emancipation*: "The belief in the perfection of man through the improvement of his social and living conditions, which forms the starting point of emancipatory thinking, has, on the whole, turned out to be a fallacy. (…) This process of revolutionization of the conditions of existence and society has eliminated or greatly reduced many pre-industrial constraints, needs and problems, but at the same time has created new, previously non-existent ones." [12, p. 15] The instruments and institutions that enable emancipation from old forms of domination establish other dependencies.

Schweppenhäuser also deals with this problem in *Dialectic of Emancipation* [13]. In order to liberate himself from the power of the first, original nature, man creates a social system that becomes quasi a second nature and is connected with new constraints. Furthermore, many emancipation movements are only particular under these conditions. They only liberate some groups, which then again become part of the oppressive classes: "It shows the emancipation a Janus face. The proletarian emancipation points back to the pre-proletarian: it is a piece of class struggle with the historical stigma of the previous ones, which served the conquest of power. (…) It was the removal from the slave state only the introduction into the master state, which remained dependent on slaves." [13, p. 400].

Janowski also points out that emancipation is two-faced and cannot escape the constraints of political-economic domination: "The historical preconditions of the dialectic of emancipation are quickly summarized: The legal and political partial emancipations, from the liberation of slaves to the emancipation of the bourgeois-liberal economic subject, were not aimed at the abolition of domination, but at the liberation of individuals or groups to free subjects, i.e. subjects who exercise domination." [14, p. 450].

This dialectics of emancipation can also be stated in other areas: bourgeois emancipation means liberation from traditional rule and at the same time implied the freedom to exercise power over others. The national emancipation movements of the nineteenth century culminated in the fascist catastrophe. The emancipation of the bourgeois-capitalist subject also implied the right to subordinate other people as wage-dependent workers under the power of capital. The emancipation of the individual led to the elimination or marginalization of concepts of a community-oriented organization of work and life.

As Schweppenhäuser argues, an "emancipation from emancipations" [13, p. 400] is therefore necessary, which frees from the social constraints of the second nature. In his opinion, a comprehensive proletarian revolution could lead to this liberation: "Proletarian emancipation (…) points to a future in which the rule of the classes together can abolish itself. It is the beginning of a qualitative transformation of

emancipation—the beginning of emancipation from emancipations, i.e. the context that forced emancipations, defined in their particularity." [13, p. 400].

However, there is still the problem that this emancipation movement, which apparently involves all subjects, has an 'outside' that remains dominated and subjugated. Thus, the project of the emancipation of the working class propagated by Marx continued to be linked to the domination of nature. It was especially the eco-feminist critique that pointed to this particularity of the traditional understanding of emancipation—whether in bourgeois or socialist form. Mies and Shiva therefore reject the Enlightenment concept of emancipation altogether and postulate an opposition between "freedom and emancipation" and a "contradiction between the enlightenment logic of emancipation and the eco-logic of preserving and nurturing cycles of regeneration" [15, p. 7]. The critique of the oppression of women is linked here with the critique of the domination of nature and post-colonial thinking: "But our critique of the Enlightenment emancipation-logic was impelled not only by an insight into its consequences for women, but also a concern for those victims, who, since the White Man's march towards 'the realm freedom' had paid for this freedom by the denial of their own subjectivity, freedom and, often, their survival base. As well as women, these include nature and other peoples—the colonized and 'naturized'—opened up 'for free exploitation and subordination, transformed into the 'others', the 'objects', in the process of European (male) 'subject's' emancipation from the 'realm of necessity'." [15, p. 8].

This connection between emancipation and the colonial project of occidental world domination is particularly evident in the American ideal of emancipation, which also legitimized an imperial program.

Emancipation, Expansion, and Salvation

A primary goal of the emancipation of the USA from the patronage of the English crown was the right to conquer 'virgin land' in the west and to oust and eliminated the Indians. The USA can be seen as the country in which a liberal, capitalist, technology-oriented understanding of emancipation has been paradigmatically realized and gained a central role in their self-image:

"The Americans (…) interpreted and glorified their national history as the history of liberation, of emancipation from all kinds of rule. Regardless of whether domination was shaped by natural constraints, by social and political constraints, or by the individual, self-compulsion: American society, the United States, the Americans had gotten rid of them (…). If the liberation of the colonies from the mother country and the construction of the United States were considered acts of social and political emancipation, the further development of American society was interpreted as an incessant emancipatory process of epochal rank." [16, p. 137].

The colonization of the 'Virgin Land' in the West by the settlers and their "frontiers experience" [17, p. 205] was also paradigmatic. The "American West as Symbol and Myth" [18] emerged, which became an emancipatory symbol for all Americans: "Because they believed they had gotten rid of the natural constraints through unprecedented cultivation and civilization processes, they incorporated the settlers' collective emancipation experiences into their creed." [16, p. 139].

It should also be mentioned that the idea of emancipation in the USA is also closely linked to Abraham Lincoln's "Emancipation Proclamation" and thus the liberation of slaves [19].

In the American self-image, these various emancipation movements form a unit that also legitimized expansive and imperial practices. An "ideological dialectic of emancipation and expansion" [16, p. 143] can therefore be stated, as "the emancipation of the non-American world on the basis of generally applicable principles" [16, p. 143] became a guiding principle of American imperial policy. This expansive emancipation ideology is still effective today and is connected to the myth of a "Manifest Destiny" of the USA and a "Myth of the Frontier" [20]. These myths repeatedly legitimized not only a political leadership of the USA, but furthermore the liberation from all restrictive bonds and the colonization of spaces and natures.

This ideology is currently recognizable in new levels of nature control as fracking or new programs for conquering outer space. Trump announced for example in his NASA space policy directive a new expansionism: "After braving the vast unknown and discovering the new world, our forefathers did not only merely sail home (…). They stayed, they explored,

(…) they imagined all of the possibilities that few dared to dream. Today, the same spirit beckons us to begin new journeys of exploration and discovery." [21]

Connected with this expansionism and technocratic emancipationism is a rejection of all natural limitations—this applies on the one hand to the old natural barriers from which the project of the Enlightenment always wanted to free itself. On the other hand, it is a refusal to recognize new natural limits and "Planetary Boundaries " [22] of growth and expansion, which are becoming apparent in the face of the ecological crisis. This is made clear, for example, by the questioning of climate change and the rejection of the Paris climate agreement of Paris by Trump.

Also, the development of digital-cybernetic machines has raised hopes for a revolutionary broadening of horizons and emancipation from natural boundaries. A transfer of the American Frontier myth to cyberspace takes place. In the manifesto "Cyberspace and the American Dream: A Magna Carta for the Knowledge Age", the advance of a "new electronic frontier of knowledge" (ibid.) was explicitly placed in the tradition of the conquest of the nineteenth century: "As America continued to explore new frontiers – from the Northwest Territory to the Oklahoma land-rush – it consistently returned to this fundamental principle of rights, reaffirming, time after time, that power resides with the people." [23]

Even the prophets of the so called post- and transhumanism promise a world without borders and a liberation from all natural- and especially biological bonds, for example, in *Robot—Mere machine to transcendent mind* [24]. Hans Moravec announces an "Age of Mind" in which "our mind will have been transplanted from our biological brain into artificial hardware" and in which it is possible to "transcend the physical and sensory limitations of the, home' body" [24, p. 170].

Here religious motives in technical emancipation thinking become apparent. This is not surprising, as "a discourse of radical emancipation first came up with Christianity, and its specific form was salvation" [25, p. 32]. The Judeo-Christian apocalypticism was particularly influential and this was radicalized in the ancient religious movement of Gnosis. The transhumanist visions are rightly called "cybergnosis" [26, p. 259], because they contain an almost religious component and show similarities to ancient gnosis and its longing for emancipation from the bonds of the earthly world and the body.

However, the ways of salvation are different, because liberation from nature is not sought through spiritual practices, but through technical means: "While transhumanism does not replicate ancient Gnosticism exactly, it is the reappearance of a recurring philosophy that permeates history and continues to shape human cultures. Transhumanism shares the Gnostic notion of bodies and the world being prisons, but it differs from Gnosticism in that our emancipation will come from our commitment to pragmatic and technological solutions." [27, p. 7].

This gnostic motives are also recognizable in Ray Kurzweil's work *The Singularity is Near. When Humans Transcend Biology* [28]. An overcoming of all natural limits is promised. The basis is an "exponential growth of the capacity of information technology" that leads to singularity and "a world that is still human but that transcends our biological roots" [28, p. 9].

With this belief in a technological singularity is also associated the hope, that all apparent natural limits and the ecological crises can be overcome by technological innovations. In analogy to the increase of the potentials of the digital technologies also an awake efficiency of the solar technologies and thus the solution of all energy problems is promised. He answers the doubters that, "they were ignoring the exponential growth [of solar panel production] just as they ignored the exponential growth of the Internet and genome project" [29]. Linked to this is the promise that the ecological crisis can also be solved by technologies.

This is also evident in Elon Musk, who promises to contribute with his company Tesla to a fundamental change in energy use. Solar energy and electromobility are central elements of his "Plan To Save The World" [30]. On this basis, the warning about limits to growth can be answered with the message of green growth. The response to the ecological crisis is not a reflection of borders, but a further emancipation from natural bounds and a new transgressing of boundaries, as his plan for the colonization of Mars makes clear.

The perception of the unintended ecological side effects of the modern project of technoscientifical nature control does not lead in the mentioned

concepts to a critical questioning of this project and a reflection of the limits of technoscientifical rationality. Rather, a new, intensified stage of control over nature is seen as the solution to the problems.

This is also evident in the concepts of geoengineering, which promise to overcome the ecological crisis and in particular the risks of climate change through comprehensive technical control and manipulation of geo- and biochemical cycles [31].

In my opinion, these approaches to achieving sustainability through technical innovation and new forms of mastery of nature will not contribute to overcoming the ecological crisis as they continue the expansive dynamics of modernity. They do not problematize neither the imperial-colonial logic of modernity nor the capitalistic logic of economic growth nor the technoscientific imperialism of the Bacon project. As has been shown above, in the Age of Enlightenment, the idea of emancipation was closely linked to the project of overcoming dependence on internal and external nature. This idea also determines the technocentric concepts that are supposed to achieve sustainability. It is to be expected that this approaches will ultimately lead to new negative dialectics of enlightenment and emancipation, i.e., to new unintended side effects. In contrast a real transition to a sustainable future must go hand in hand a departure from the traditional idea of emancipation from nature through technoscientific domination of nature.

A Plea for a Reflexive Emancipation

This outlined dialectic of the 'simple emancipation' of modernity must be critically reflected upon today. A blind reference to the emancipation euphoria and the Promethean spirit of the industrial society would be a naive regression into the nineteenth century. The ecological and postcolonial critique of the project of modernity should be taken into account and the dangers associated with the current cybergnostic radicalization of the modern emancipation project must be considered.

This diagnosis should not be misunderstood as a plea for a complete rejection of the achievements of technical progress and the Promethean project. In place of the simple promises of emancipation of modernity, however, a reflexive concept of emancipation must be put forward. That which has been excluded, subordinated, dominated by the emancipations of modernity must now be included in the emancipation movement. And this includes nature in particular. Neither a return to nature nor an adherence to the myths of eternal emancipation should be aspired to—but a 'forward' to nature through a synthesis of emancipation and (re)reconnection.

Against a glorification of an imagined original unity with a 'mother' nature and thus the submission to a nature myth, the emancipative progress of modernity and thus also its technical achievements can certainly be appreciated and defended. The romanticizing myths of benevolent nature are still to be questioned—for man, as a natural-cultural double being, there was never a perfect unity with a nature and the history of mankind be described as a successful history of emancipation from an imperfect nature.

At the same time, however, the dark side of the modern project of emancipation, i.e., the violent colonization of nature, must also be taken into account from a decolonial perspective. A project of an 'emancipatory technologies', which defines itself only in dissociation from nature and refuses to reflect on the dark side of the domination of nature, would ultimately only reproduce the myths of modernity. A new, expanded, and reflexive emancipation project should be sought. This project does not imply a backward-looking condemnation of technology, but rather an emancipation of technology from current social power and production relations.

But what exactly is meant by reflexive emancipation and what transformation is associated with it? In the following, a more concrete definition will be given with reference to Ulrich Beck and his description of reflexive modernization. Beck has defined this as follows:

"Let us call the autonomous, undesired and unseen, transition from industrial to risk society reflexivity (to differentiate it from and contrast it with reflection). Then 'reflexive modernization' means self-confrontation with the effects of risk society that cannot be dealt with and assimilated in the system of industrial society. (…) This very constellation may later, in a second stage, in turn become the object of (public, political and scientific) reflection." [6, 32]

In line with this, reflexive emancipation on a first level can be understood as result of the unintended consequences of the negative side effects of simple emancipation—i.e., the increase of those dark sides that were described above as dialectics of emancipation.

In a subsequent stage, however, this can also lead to a perception of the side effects in society and to an extended, reflective project of emancipation.

This also opens up a more optimistic perspective: The dialectics of emancipation and enlightenment were discussed by the authors of critical theory only as "negative dialectics" [33]. Emancipation produces its own opposite and leads to new domination. But there is also another, more positive concept of dialectics. As is well known, dialectic describes a philosophical method which regards contradictions as the driving force of development. Hegel took the position that "contradiction is not mer opposition (…). Contradiction occurs when a position follows is own logic and thereby finds itself at odds with itself" [34, p. 12]. The contrast between thesis and antithesis is dissolved and annulled, which in turn leads to a third concept, the 'synthesis', which unifies the first two. Thus, the movement goes beyond a negative dialectic, which is also relevant for understanding the dialectic of emancipation: "Emancipatory politics, contrast, refuses to see contradiction as opposition. There is no enemy whose defeat would eliminate contradiction because contradiction is constitutive of subjectivity and society. The point, for the project of emancipation, is sustaining it." [34, p. 214].

In connection with this, I want to discuss reflexive emancipation as a possible result of a dialectic of emancipation that does not end in self-contradiction, but makes possible a "reconciliation" (Versöhnung) and annulment (Aufhebung) in the sense of Hegel. In the following, two approaches will be pursued:

(a) Following Fraser's critique of Polanyi's thesis of disembedding and re-embedding, which can also be described as a movement of emancipation and counter-emancipation, a dialectical "triple movement" [2] of emancipation is described.
(b) Subsequently, it is outlined what a reflexive emancipative politics of technology implies in relation to social conditions and the relations to nature.

From the Double Movement to a Emancipative Triple Movement

In his analysis in *The Great Transformation* [1], Polanyi depicts the emergence of the modern capitalist labor and industry society in Europe as the result of a process of disembedding: "Instead of economy being embedded in social relations, social relations are embedded in the economic system." [1, p. 60] Viewed systematically, the market society's assertion process centers initially on the marketization of the three "substances" or production factors labor, capital and land (the latter used by Polanyi as a synonym for nature), which assume the character of fictitious goods. The commodification of labor and nature and their transformation into goods thus lie at the start of the great transformation of the early industrial society [35, p. 9]. This process of disembedding the markets is also a consequence of economic and technical emancipation and the associated emancipation of the bourgeois subject. It is a consequence of the liberation of capital from the bonds of feudal structures and the development of technical productive forces.

Polanyi's work can thus be interpreted as an analysis of the dialectics of disembedding that are associated with economic emancipation. Since the commodification destroys social relationships and the natural environment, it also goes from the view of Polanyi hand-in-hand with a fundamental tendency towards crisis, i.e., in current terminology, it threatens social and ecological sustainability: "Machine production in a commercial society involves, in effect, no less a transformation than that of the natural and human substance of society into commodities. (…) The dislocation caused by such devices must disjoint man's relationships and threaten his natural habitat with annihilation." [1, p. 44].

This economy's disastrous effects on work and nature lead to a "countermovement (…) for the protection of society" [1, p. 136], whose goal is to limit market reach, bring about de-commodification and re-embed the disembedded market economy in society. The great transformation can therefore be described as a "double movement": "The one was the principle of economic liberalism, aiming at the establishment of a self-regulating market (…); the other was the principle of social protection aiming at the conservation of man and nature." [1, p. 136].

This counter-movement can also be connected to the above-described efforts for an "emancipation from emancipation" [13, p. 400], as which the emancipation project of the worker movement and its struggle for social protection in particular can be interpreted. In this sense, Bloch also writes from "the free revolutionary action of the proletariat, which emancipates

precisely from the emancipated bourgeois again" [36, p. 529].

The process of disembedding and re-embedding or commodification and attempt at partial de-commodification according to Polanyi [1] and Burawoy [37] repeats itself several times over the course of history. The first wave ran from the late 18th to the early twentieth century in the form of the original marketization of Europe's feudal societies. The countermovement was found in the nineteenth century's trade union movements, socialist parties and interventionist labor and social laws as well as in land laws, which were intended to limit the mobilization of labor and nature/land and thus also market reach [1 p. 187]. The second wave of marketization began with the renewed advance of the economy following World War I. Here, economic liberalism escalated in the form of a largely unregulated global economy, which pulled the national economies increasingly into the crisis and led to various protectionist measures. Polanyi's analysis centered above all on movements which favored repressive and anti-democratic forms of re-embedding—the great transformation ultimately led to the "fascist catastrophe" [1, 242]. His favored alternative—limiting the economy through Christian and democratic socialism—was not realized. The post-World War II countermovement to the further commodification of labor—in the form of the Fordist labor society—did indeed have protective effects, above all for a certain (male, white) portion of the working-class population in the northern hemisphere [35, p. 11].

The third wave of marketization of labor and nature began in the mid-1970s with the oil crisis and the neoliberal market offensive and led to a "disembedding global" [38, p. 96]. Since, as Burawoy argues, this third wave is characterized especially by increased appropriation of nature, the ecological problems it causes make protecting the environment a central goal for its countermovements: "The commodification of nature is at the heart of capitalism's impending crisis. The countermovement in the third period will have to limit capitalism's tendency to destroy the foundations of human existence." [37, p. 39].

Under the conditions of the ecological crisis, a comprehensive re-embedding is therefore necessary today, which limits the negative social and ecological side effects of the economic and technical emancipations of neoliberalism. In this sense Sommer and Welzer call for a "great transformation" by "reembedding the economy a) in the ethics of human communities and societies, b) in democracy (…) as well as c) in the ecological womb of planet earth" [39, p. 195].

However, there is a danger that a re-embedding directed against disembedding will also reverse positive emancipatory effects. This would not lead to reflexive emancipation, but only to regression. In line with this Fraser warns of a simple request for re-embedding: "Polanyi's formula underestimates the emancipatory role of marketization in destabilizing traditional oppressions. And it fails to validate the inherently destabilizing yet undeniably emancipatory character of struggles against such oppressions." [40, p. 7] She furthermore points out that a metamorphosis of the re-embedding efforts into reactionary movements can be observed not only for fascism but also for many other regulatory models in the Fordist modern era. These led to the emergence of new forms of rule and took on an "oppressive character" [2, p. 118]. Indeed, it was precisely these weak points in Fordist re-embedding strategies that the emancipatory movements of the 1960s turned against. Fraser therefore proposes replacing Polanyi's "double movement" of disembedding and re-embedding with a "triple movement"—one which champions not only marketization (disembedding) and social protection (re-embedding) but also emancipation: "The triple movement suggests a political project for those of us who remain committed to emancipation. We might resolve to break off our dangerous liaison with neoliberalism and forge a principled new alliance with social protection. In thereby realigning the poles of the triple movement, we could integrate our longstanding interest in nondomination with the equally valid interest in solidarity and social security." [2, p. 132].

This idea of the triple movement can also be interpreted as a plea for a dialectical movement towards a reflective emancipation: While in Polanyi's double movement, the dark side of economic-capitalist emancipation is only reacted with an emancipation from emancipation through re-embedding, now a different kind of emancipation is the aim, which combine social cohesion and freedom.

These considerations can be applied to problems of the negative effects of technical emancipation and the associated danger of destroying the natural

foundations of society. A simple counter-emancipation in the sense of liberation from the constraints of industrial society by rejecting technology would be too simple. For this would also negate the emancipatory potentials of technology. The aim is a triple movement of technical emancipation, which combines emancipation with the protection of the environment and thus makes sustainable development possible. It overcomes the contrast between blind technical (and market-dominated) progress and the countermovement and antithesis towards limited technologies. The goal is the synthesis of a technology development that harmonizes with the sustainability of social and natural development. However, this requires a completely different form of technology use than the new and old techniques of nature control outlined above.

Concluding Considerations: Plea for Reflexive Emancipatory Technology Studies

For a program of Emancipatory Technology Studies this implies, that it must not be based on the traditional emancipation projects of the modern era, but also takes in a reflexive manner negative dialectics into account. However, new concepts also follow the traditional logic. Thus, the representatives of the so-called 'accelerationism' like Srnicek und Williams defend the Prometheanism and announce a left-wing emancipation project based on overcoming the ties to the biological-organic origin of humans: "Underlying this idea of emancipation is a vision of humanity as a transformative and constructible hypothesis (..). There is no authentic human essence to be realized, no harmonious unity to be returned to, no unalienated humanity obscured by false mediations, no organic wholeness to be achieved." [41, p. 82] With regard to external nature, Srnicek and Williams bear in mind ecological problems, but do not question the promises of prosperity of the modern age.

In contrast, in view of the ecological crisis, this article advocates for a fundamental revision of the emancipation project and the research related to it: Emancipation can never be absolute. The goal of emancipation is the liberation from domination, but not the overcoming of all ties. Real emancipation implies the freedom to choose one's own ties, which also means that the 'other' is not forced to bind. This also applies to the liberation from the ties to nature. Projects of a complete solution of the biological nature, as can be seen in the cybergnosis of the transhumanists shown above, are to be regarded as such radicalized, problematic emancipation projects. They destroy the connection to the natural origin of man. By being based on a far-reaching mastery of external and human nature, they lead to total enslavement of nature.

In contrast, a reflexive emancipation is necessary, which also includes nature in the project of emancipation. The limits of the availability of natural resources must be recognized for a sustainable development. In addition, the logic of ecosystems and the intrinsic value of nature should also be taken into account. This is the only way to achieve a reflective emancipation that incorporates the previously excluded nature.

This reveals a new form of emancipatory technology: In modern times, the majority of technologies served in the tradition of Bacon to the "enlarging of the bounds of human empire" [42, p. 398] through the technical mastery of nature and made nature an object. The results of ecosystem research, on the other hand, reveal planetary boundaries of human power [22]. This implies that forms of technology use must be developed that satisfy people's needs, but at the same time reduce resource use and negative environmental impact. Concepts of more efficient use of resources by technical innovations can contribute to this, but they are not sufficient—also because in a capitalist growth economy efficiency gains are canceled out by rebound effects [43].

More comprehensive socio-eco-technical innovations are therefore necessary. Rifkin and Mason have pointed to the opportunities offered by technological change for the transition to a different, post-capitalist society which is also more ecological. For example, Rifkin proclaims the genesis of a new economic system made possible by the intelligent use of new technologies, which is characterized by "collaborative commons" and a "sharing economy" [44]. Similarly, Mason evokes a transition, almost inevitably driven by technological development, to a non-hierarchical "PostCapitalism" characterized by collaborative control of production and environmental sustainability [45].

These visions undoubtedly open our eyes to the emancipative potential of new technologies. The new digital technologies and platforms are accompanied

by opportunities to modernize and expand community-based forms of regulation and shared use of goods with positive ecological effects. It should nevertheless be considered that Rifkins promise of an "economy of abundance" [44, p. 272] and a "sustainable cornucopia" [44, p. 273], made possible by an emancipatory use of digital technologies, is too optimistic. Given the limited availability of natural resources, which are also required for digital technologies, these hopes must be rejected. Furthermore, the expectation that digital technologies will inevitably lead to a post-capitalist sharing economy have given way to disillusionment. The adoption of the idea of an economy of sharing by companies of platform capitalism led to an erosion of labor standards and ecologically negative rebound effects.

This makes it clear that there is a need for political regulation for the social (re)appropriation of the platform economy. Such political regulation could, among other things, support "platform cooperativism" [46], which overcomes the deficits of the capitalistically appropriated sharing economy. Digital technologies could be the basis for this, if their use is not restricted to increasing resource efficiency and smart forms of production. These technologies are to be seen as cybernetic control technologies and the development of these "steering forces" [47, p. 331) thus makes possible new forms of regulation of society and natural relations beyond the market economy.

This reveals a fundamentally different connection between technology and emancipation. It is not a matter of emancipation from the constraints of nature through the establishment of a technoscientifical dominion over nature, which is often also connected with dominion over people, as in the concepts outlined above. Rather, it is a matter of an emancipation from the capitalist and technoscientifical modes of production through a social-ecological emancipative use of technologies.

This sustainable use of technology will presumably be accompanied by a departure from the modern promise of endless progress and increasing prosperity. This is especially true if one view nature not only as a resource and object, but as a subject to be included in the emancipation project. Nature is not a subject in the same sense as a human being, since it cannot express its will and needs directly. However, natural science can help to make the needs of living nature and of ecosystems aware.

For emancipatory technology studies is therefore an interdisciplinary collaboration between social sciences and natural sciences necessary, which also takes into account the concerns of nature, as will be explained in the following using the example of biodiversity.

The research of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has shown that "human actions threaten more species with global extinction now than ever before" [48, p. 4]. The acceleration-logic of modernity also implies above all the acceleration of destruction: "The global rate of species extinction is already at least at least to hundreds of times higher than the average rate over the past 10 million years and is accelerating." [48, p. 14] This is problematic when one considers the intrinsic value of nature. But nature's achievements for people are also endangered: "Nature and its vital contributions to people, which together embody biodiversity and ecosystem functions and services, are deteriorating worldwide." [48, p. 11] Josef Settele, who co-chaired the study, warns: "The essential, interconnected web of life on Earth is getting smaller and increasingly frayed." [49]

Under these conditions, the role of technology has to be redefined. The purpose should no longer be primarily liberation from the constraints of nature. Another form of technology becomes relevant, as it is related to the concept of "convivial technology." [50] The goal is not the further expansion of power over nature, but technologies for an ecological degrowth society that will allow for a "co-productivity" with nature: "The ideal of convivial technologies is clearly an ecological cycle." [50, p. 1782]. The aim is the re-embedding of technology in nature. However, the emancipatory potential of technology must not be rejected if one wants to achieve the dialectical 'triple movement' outlined above.

For this purpose, the contextualization of technology and labor in social production conditions as well as in ecosystems must be taken into account. This implies that the role of "Capitalism in the Web of Life" [51] and the associated organization of work must be analyzed. For this, Moore uses an expanded concept of work and examines the process of "transforming nature's work into the bourgeoisie's value" [51, p. 71]. He thereby no longer focuses on wage labor like classic Marxism, but on "the appropriation of unpaid human and extra-human work" that means "appropriating the unpaid work / energy of 'women, nature, and colonies" [52, p. 3].

This consideration of the work of nature makes possible an extended research on "work-nets" [53, p. 132]. In addition to the work of humans, this analysis also includes the work-net of technological artifacts as well as the networks of the web of life. On this basis, a project of an "emancipation of the working class" [6, p. 288] can be designed that goes beyond classic debates. It is not just about the emancipation of wage workers, but of all forms of work. The question now is also how to end the exploitation of nature's unpaid work and also the extinction of that work of nature which has no value in capitalist logic.

From this perspective, sustainable emancipation is only possible if the sustainability of nature's productivity is also guaranteed and their intrinsic value is respected. In the discussions about coping with the ecological crisis, some advocate in continuation of Polanyi that the "socio-ecological transformation of work society" [35] must be at the center of efforts for the transition to sustainability. Based on this, it can be argued that reflexive emancipatory technology studies must contribute to the emancipation of technologies from subordination under capitalist profit interests and the goal of mastery of nature. Instead, technologies must serve to promote a socio-ecological emancipation of the work of humans and (living) nature.

Bloch's utopia of a "technology of alliance" [34, p. 690] and his hope that "the proletariat as the turntable towards emancipation" could be combined with the "goal […] [of] the naturalization of man, humanization of nature" [54, p. 209] could be a guiding vision for this.

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