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The Matrix of Convivial Technology – Assessing technologies for degrowth

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ABSTRACT

This article introduces the notion of convivial technology as a conceptual framework for technologies suitable for degrowth societies. This paper is inspired by Ivan Illich's notion of convivial tools but reconsiders it in the light of current practices and discussions. Looking for a definition of convivial technologies it uses qualitative empirical research conducted with degrowth-oriented groups developing or adapting grassroots technologies like Open Source cargo bikes or composting toilets in Germany. The basic ethical values and design criteria that guide these different groups in relation to technology are summed up into five dimensions: relatedness, adaptability, accessibility, bio-interaction and appropriateness. These dimensions can be correlated with the four life-cycle levels material, production, use and infrastructure to form the Matrix for Convivial Technology (MCT). The MCT is a 20-field schema that can be filled in. Experiences with the tool in different fields are presented. The MCT is itself a convivial tool as it allows for degrowth-oriented groups to self-assess their work and products in a qualitative, context-sensitive and independent way. It is a normative schema that fosters discussion concerning degrowth technologies in contexts of political education. And it is a research method as it helps collecting data about underlying ethical assumptions and aspirations of individuals and groups engaged in developing technology.

1. Introduction

Technological innovation is a core term for the development of green growth strategies – whether it is explicated as eco-innovation (OECD, 2010; Pansera, 2012), green, environmental or sustainable innovation (Franceschini et al., 2016), design for sustainability (Arnette et al., 2014) or Cradle to Cradle design (Braungart and McDonough, 2013). Technological innovation is seen in these concepts as a guarantee for economic growth – a notion dating back to Schumpeter's influential ideas (Schumpeter, 1934). Degrowth theory opposes the very idea of green growth as a possible path to solve ecological and social problems, because absolute decoupling between economic growth and material metabolism is not observed in reality (Jackson, 2009; Kerschner and O'Neill, 2015; Santarius, 2015; Schneider, 2010). If it is true, that 1. innovation leads to economic growth as economical theory following Schumpeter puts it, and 2. economic growth can not be absolutely decoupled from resource use, then technological innovation in itself cannot pave the way to a degrowth future, which is defined by an economic contraction (Petridis et al., 2015). However, in this article a definition of degrowth is used, which emphasizes that degrowth does not mean contraction alone but a differently organized society:

> Degrowth signifies a society with a smaller metabolism, but more importantly, a society with a metabolism that has a different structure and serves new functions. Degrowth does not call for doing less of the same. The objective is not to make an elephant leaner, but to turn an elephant into a snail. In a degrowth society everything will be different: different activities, different forms and uses of energy, different relations, different gender roles, different allocations of time between paid and non-paid work, different relations with the non-human world. (Kallis et al., 2014: 4)

An equally important aspect of a future degrowth society, that (D'Alisa et al., 2014) did not mention, is a different type of technology. But what are the criteria that can guide the development of

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technologies suitable for degrowth societies, if it is not newness (innovation) and the promise of a high profit? How can such a technology be defined and named?

The present article examines this question with the instruments of a cultural anthropologist, using qualitative empirical methods such as narrative interviews, participant observation, historical research and media analysis (Atkinson and Coffey, 2001). With this focused ethnography (Knoblauch, 2005) answers to the above question are to be found within the degrowth movement (Demaria et al., 2013) itself. Formerly not related practically oriented groups and networks such as grassroot tinkerers, makers, eco-activists and permaculturalists now see themselves partly as part of the European degrowth movement – reflected in the fact that they join degrowth conferences and publish in degrowth contexts.[1] They develop and try out grassroots technologies like Open Source cargo bikes, composting toilets, small scale wind turbines or micro pyrolizers (Vetter, 2012, 2015a; Vetter and Best, 2015). These groups are guided by specific values and design criteria derived from these values for the production of their technologies. This article supposes to summarize the basic ethical values and design criteria that guide these different groups by the term *convivial technology*. Instead of defining in a merely theoretical manner criteria that could be useful for degrowth technologies, this paper takes the practices of these groups as starting point to develop a definition of convivial technologies. Considering the different ways in which these groups work and use technology, five dimensions of convivial technologies were defined during research: relatedness, adaptability, accessibility, bio-interaction and appropriateness. A tool is presented – the Matrix for Convivial Technology (MCT) – which is a 20-field schema correlating these five dimensions with four levels of the life-cycle of a technological artefact – materials, manufacturing, use and infrastructure. It is a tool to make different ethical values behind a technology visible and to weight these dimensions against each other. The MCT makes findings about convivial technologies accessible in different fields: it can be used for research (to get to know more about ethics of a group of developers or users), for the self-assessment of degrowth-oriented groups developing technology or for political education (to bring technology out of the black box).

In the following pages this paper elaborates on this concept and explains the MCT by first presenting debates of the last 40 years about possible definitions of a technology beyond growth and what can be drawn from them. Then the method used for developing the Matrix is explained. At the core of this paper stands the matrix (Table 1) whose dimensions are explained using empirical material. This is followed by a discussion of the possibilities and shortcomings of the matrix, as well as experiences with the use of the tool in different scientific and educational contexts. It concludes with a summary of possible uses of the Matrix in future as well as the discussion on “convivial technologies” as concept inspired by Ivan Illich's *Tools for Conviviality* (Illich, 1973).

2. Past debates

Up to now there is no consistent definition of what technologies suitable for a degrowth society should look like and how they could be named. Generally there is a tension between more techno-pessimistic and more techno-optimistic views in degrowth debates (Ehlers and Kerschner, 2014; Kerschner and Ehlers, 2016). The critical current referring to older techno critiques like Jacques Ellul's or Lewis Mumford's gained some dominance during the first Degrowth Conferences, especially through the influence of Serge Latouche, who cited them widely, although other currents referring to thinkers like André Gorz also mentioned the opportunities of alternative production modes opened up by digitalization (Ellul, 1954; Gorz, 2003; Latouche, 2013; Mumford, 1967). This emphasis on scepticism is visible in the outcomes of the GAP groups[2] dealing with technologies at the 2010 Barcelona Conference on Degrowth. The participants did mention possibilities but emphasized mainly risk management and strategies to limit technological infrastructures (GAP Barcelona, 2010). More recently however, new points of view have emerged from a commons perspective, where an emancipatory potential in new technologies was perceived, especially in possibilities opened up by digitalization (Siefkes, 2012). This is reflected in the strong presence of advocates of peer production at the 2014 Leipzig Degrowth Conference, where Michel Bauwens, founder of the P2P-foundation, was one of the keynote speakers (Bauwens, 2014; GAP Group “Technology and Production,” 2014). However, a certain incompatibility of these techno-optimistic and techno-pessimistic views is not solved yet. (Nierling, 2014) proposes to take the 8 R's from Serge Latouche (Reconceptualising; Reevaluating; Restructuring; Redistributing; Relocalising; Reducing; Reusing; Recycling) as point of departure to define a framework of suitable technologies for degrowth – but this is not a clearly developed perspective yet. (Pansera and Sarkar, 2016; this issue) propose to use the idea of “frugal innovations” emphasizing that these innovators in the Global South do not act as homo oecomomicus but are guided by normative values to solve local problems. However, it is not clear whether this approach can be applied for the Global North alike. In (D'Alisa et al., 2014), the most comprehensive summary of degrowth research up to today, there is neither an entry for “technology”, nor for “infrastructure”, “technique” or the like.

However, the idea that we need a definition of a desirable technology not aimed at growth is not new. It was a central issue to the first wave of growth critique in the 1970s and early 1980s. Unlike earlier authors like Jacques Ellul (1954), Gunther Anders (1956), Lewis Mumford (1967) or Herbert Marcuse (1964) who – with quite different theoretical backgrounds and explanations – all opposed technocratic societies and the alienation of human beings caused by the technocratic megamachine, the ideas that sprung up after the influential study “Limits to Growth” (Meadows et al., 1972) went a step further moving from analysis to the constructing of new technologies – at home and abroad. They were aimed at realizable concepts and partly embedded in the newly sprung up counter culture that wanted to try out “alternative” ideas immediately in communes, in citizens initiatives or on ecological farms (e.g. Boyle and Harper, 1976). Parallel to the intellectual critique of “development” of the third world the terms “appropriate technology” and “intermediate technology” were created (Schumacher, 1974). Appropriate technology proposed an alternative path to development using locally adapted materials and technologies that can be built, maintained and repaired without foreign experts. However, the concept omits the question of who owns these technologies – whether local enterprises, global companies or the people themselves.[3] In direct reaction to the energy crises of the

[1] Most visibly on the platform http://www.degrowth.de (accessed 25.07.2016) in the project “degrowth in movement(s)” (2016); see also program of the 2014 Leipzig degrowth conference.

[2] The Group Assembly Process (GAP) was part of several Conferences on Degrowth. Its aim was discussing the current state of the debate on different questions concerning degrowth in a participatory way between scientists and activists and to find out possible points of consensus.

[3] The recently sprung up idea of “Open Source appropriate technology” works on this question in promoting appropriate technology should be Open Source (Buitenhuis et al., 2010).

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Table 1
The Matrix of Convivial Technology.

Dimensions // Levels →	Materials *Harvesting, processing and disposal of raw matter*	Production *Assembling raw materials and preproducts*	Use *Procuring the task it was built for*	Infrastructure *Needed environment for using*
Remarks on Levels -->				
Relatedness *What does it bring about between people?*	Process fixed -- Right to creative input Fixed world concepts -- Learning from different sources Market-driven -- Need-driven Top down control -- Bottom-up control Organization centralized -- Organization distributed Alien implementation -- Respects local traditions	Fosters competition -- Supports trust Distance-creating -- Conjoint experience Market-driven -- Need-driven Top down control -- Bottom-up control Organization centralized -- Organization distributed Process fixed -- Right to creative input Creates borders -- Integrates Alien implementation -- Respects local traditions Creates senselessness -- Creates art Uglifying -- Creates beauty	Fosters competition -- Supports trust Fosters individual advantage -- Supports community Prefigured use only -- Allows creativity One solution fits all -- Respects local traditions Discourages care -- Simplifies care Uglifying -- Creates beauty Creates senselessness -- Creates art Alienating from own body -- Useful body enhancement Heteronomy -- Self-determination Compulsory -- Voluntarily	Fosters competition -- Sustains trust Distance-creating -- Connects with eco processes Market-driven -- Need-driven Top down control -- Bottom-up control Fosters individual advantage -- Supports community Creates senselessness -- Creates art Uglifying -- Creates beauty Humans as inferior part of a system -- Humans as equal part of a complex system Discourages care -- Simplifies care
Access *Who can produce/use it where and how?*	Elitist -- Open to anyone Investor-owned -- Producer-owned Cost-intensive -- Low-cost Secret or patented -- Knowledge freely accessible Need of foreign expert -- Use of local knowledge Specialized processes -- Standardized processes Hinders skill building -- Supports skill building Abstract -- Comprehensible	Elitist -- Open to anyone Investor-owned -- Producer-owned Cost intensive -- Low Cost Secret or patented -- Knowledge freely accessible Hinders skill building -- Sustains skill building Need of foreign expert -- Use of local knowledge Abstract -- Comprehensible Not able to fulfill needs -- Fulfilling basic needs Opaque organization -- Transparent communication Specialized processes -- Standardized processes	Usable by an elite -- Usable by anyone Investor-controlled -- Producer-owned Cost intensive -- Low Cost Need of foreign expert -- Use of local knowledge Not able to fulfill needs -- Fulfilling basic needs Abstract -- Comprehensible Repugnant -- Attractive Enforces cultural restraints -- Transforms cultural restraints	Usable by an elite -- Usable by anyone Cost intensive -- Low Cost Abstract -- Comprehensible Enforces cultural restraints -- Transforms cultural restraints Not able to fulfill needs -- Fulfilling basic needs
Adaptability *How independent and linkable is it?*	Special machines -- Everyday tools Big scale economical -- Small scale economical Special conditions -- Everywhere possible Special materials -- Standardized materials	Fixed once finished -- Permanently changeable Isolated -- Interoperable Size fixed -- Scalable Special machines -- Everyday tools Big scale economical -- Small scale economical Heteronomous -- Self-determined One way processes -- Dis-/reassembly possible Special conditions -- Everywhere possible One piece -- Modular	Fixed once finished -- Permanently changeable Isolated -- Interoperable Size fixed -- Scalable One-dimensional -- Multi-functional Infrastructure needed -- Independent use possible Repairable by experts -- Repairable by skilled Close survey needed -- Uses self-regulation Monolithic -- Interchangeable One solution fits all -- Encourages diversity One piece -- Modular	Fixed once finished -- Permanently changeable Isolated -- Interoperable Size fixed -- Scalable One-dimensional -- Multi-functional Centralized -- Distributed One solution fits all -- Encourages diversity Compulsory -- Voluntarily Linear systems -- Non-linear systems Repairable by experts -- Repairable by skilled Operable only from distance -- Locally operable
Bio-Interaction *How does it interact with living organisms?*	Illness/death -- Supports health Deteriorating soil -- Improving soil Water-polluting -- Improving water quality Air-polluting -- Supports clean air Violent -- Nonviolent Hazardous potential -- Safety proven and tested Toxic waste -- Biodegradable Suppresses organic processes -- Allows co-productivity	Illness/death -- Supports health Deteriorating soil -- Improving soil Water-polluting -- Improving water quality Air-polluting -- Supports clean air Violent -- Nonviolent Hazardous potential -- Safety proven and tested Suppresses organic processes -- Allows co-productivity	Illness/death -- Supports health Deteriorating soil -- Improving soil Water-polluting -- Improving water quality Air-polluting -- Supports clean air Violent -- Nonviolent Hazardous potential -- Safety proven and tested Toxic waste -- Biodegradable Suppresses organic processes -- Allows co-productivitys	Illness/death -- Supports health Deteriorating soil -- Improving soil Water-polluting -- Improving water quality Air-polluting -- Supports clean air Violent -- Nonviolent Hazardous potential -- Safety proven and tested Toxic waste -- Biodegradable Suppresses organic processes -- Allows co-productivity
Appropriateness *What is the relation between input and output considering the context?*	Non renewable -- Renewable Far away -- Locally available New -- Re-used Non recyclable -- Easily recyclable Nondurable -- Durable Needs painful worktime -- Allows joyful worktime Fossil energy -- Renewable energy	Thriftless material use -- Frugal material use Special tools -- Standardized tools Against local settings -- Uses local settings Needs painful worktime -- Allows joyful worktime Fossil energy -- Renewable energy Creates waste -- Byproducts are used	Encourages waste -- Sustains sufficiency New -- Re-used Nondurable -- Durable Against local settings -- Uses local settings Needs painful time- -- Allows joyful time Fossil energy -- Renewable energy Creates waste -- Byproducts are used	Thriftless material use -- Frugal material use Encourages waste -- Sustains sufficiency New -- Re-used Nondurable -- Durable Against local settings -- Uses local settings Needs painful time- -- Allows joyful time Fossil energy -- Renewable energy Creates waste -- Byproducts are used
	Materials	**Manufacturing**	**Use**	**Infrastructure**

early 1970s and the rapidly growing critique of nuclear power the terms “soft technology” and “alternative technology”, often interchangeably used, came into being (Lovins, 1977; Müllert, 1978). This began in the early 70s with the idea to depict a “soft” path to a convivial and sustainable society but rapidly evolved until the end of the decade to a concept being highly compatible with profit generation and economic growth and also promoted to be so (Boyle and Harper, 1976; Galtung and Jungk, 1969; Lovins, 1977). Noticing this shift in meaning in the mid-1970s a group of young leftist ecological activist in Great Britain coined the idea of a “radical technology”, aimed at commons and well-being and far from profit (Boyle and Harper, 1976). Some of them joined the then recently founded “Centre for Alternative Technologies” in Wales, that up to date is a rich source for sustainable technologies. Their book on radical technology had the form of a bibliography of already existing “radical” technologies – in the same vein the “Whole Earth Catalogue” was published in the US between 1968-1972,[4] and in Mexico the social philosopher and historian Ivan Illich published together with his colleague Valentina Borremanns an English bibliography of convivial tools, the latter term based on the more general social philosophic essay on “tools for conviviality” from 1973 (Borremanns, 1978; Illich, 1973).

Obviously the world of technology has changed since the 1970s – digitalization has changed production, infrastructure and culture deeply. The 40-year-old concepts do not reflect the current situation accurately. But nevertheless these past debates revisited can be of great value for the search of a suitable definition of degrowth technologies, because they have some central features in common: they highlight the need for decentralization and a certain autonomy of hierarchical infrastructures, scalability, and the necessity to look for technologies that are not harmful to the environment. The concepts of convivial tools and radical technology emphasize the importance of the social that constructs and is constructed by technology.

In the field of sustainable technologies – sustainability defined as a balance between social, ecological and economical development (United Nations, 1987) – a lot of concepts like eco-innovation, cradle-to-cradle, or eco design have been developed since the 1980s that certainly show important features also for technologies in a degrowth society (Braungart and McDonough, 2013; OECD, 2010; Pansera, 2012) but they all do not depart from the idea that economic growth is a basic condition for human well-being. However, the term this paper is looking for has to strongly emphasize the point that in order to describe a degrowth society that is not one of recession but of blossom a “decolonization of the social imaginary” is of the highest importance (Latouche, 2009;

[4] Today the Whole Earth Catalogue is available in a digitalized form at http://wholeearth.com (accessed 25.07.2016).

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Muraca, 2013). This means a deep questioning of socially accepted and often unconsciously believed basic concepts of a society – especially the widely held notion that economic growth is crucial for human well-being. This conception of well-being is based on the idea that humans are ever-greedy autonomous rational individuals fighting each other, as exemplified in the economist construction of the figure of the homo oeconomicus. In degrowth discussions another conception of the human being is valued: the concept of conviviality, dating back to Ivan Illich (1973). It is closely linked to the work of the anti-utilitarian group of french social theorists M.A.U.S.S. (Caillé, 2011), the theory of gift of the French anthropologist Alain Caillé (2000), referring to Marcel Mauss (1966), and was recently developed further by the German sociologist Frank Adloff (2016) and popularized by the convivialist manifesto (Les Convivialistes, 2014). In convivialist conceptions people are seen as inherently interwoven in social networks and relations and driven by complex motivations (Caillé, 2000). Illich set the path in placing "interdependence" as the central category for conviviality:

> "I consider conviviality to be individual freedom realized in personal interdependence and, as such, an intrinsic ethical value. I believe that, in any society, as conviviality is reduced below a certain level, no amount of industrial productivity can effectively satisfy the needs it creates among society's members." (Illich, 1973: 11)

In this article interdependence is understood as interdependence between people but also between technology and humans, reflecting the social construction of technology as well as the technological construction of human behaviour (Bijker, 1997; Feenberg, 1999; Latour, 1993). This makes it possible to talk about "convivial technologies", a term Ivan Illich did not use. The use of the term "convivial technologies" in this article differs from Illich's "convivial tools". He used to speak of "tools" as a notion that was not restricted to technology in a narrow sense (except in the bibliography with (Borremanns, 1978)) but referred to all kinds of rationally designed institutions like schools and bureaucracies (Illich, 1973). Whereas Illich (1973, 1974) in his writings about tools concentrated strongly on the definition of thresholds where productivity backfires into counter-productivity, the approach taken in this article follows more his ideas about the necessity of creativity and autonomy for convivial tools. Other than Illich (1973, 1974), who concentrated mainly on the *use* of tools, this project considers the side of production first and goes further than Illich's essayist social theory approach in taking empirical research into account, in this way developing five dimensions that define convivial technologies further.

3. Methodology

Basic research perspective for this project was the approach of convivial research.[5] This means a kind of engaged and collaborative research (Holmes and Marcus, 2008) which allows the researcher to take a political standpoint herself and sees the researched as partners in the process of knowledge acquisition. To take this claim seriously it is important for the researcher to give the research partners something in return in order to support their self-reflection. For this article, the research question therefore is: How can a tool be constructed that a) helps developers of potentially convivial technologies to self-asses their products and b) helps to popularize the idea of convivial technologies?

To empirically find and theoretically define such a tool for convivial technologies ethnographic methods were used. This encompasses historical research of sources like the aforementioned discussions about alternative technologies that took place in printed books as well as in "grey" literature, that is not officially available. Main research tools were participatory observation in groups that develop "grassroots technologies" and narrative interviews with important people (sometimes repeated after some time) in these groups about their motivation, the process of development and their basic ethical assumptions about technology (Atkinson and Coffey, 2001). It also contained analysis of online media like websites, wikis and videos related to the researched groups (online ethnography: Collins and Durington, 2015). Research took place between 2012 and 2016 in different groups and sites in and around Berlin and also in other parts of Germany and Austria: two permacultural and one bio-dynamic farm, a 72 h-Permaculture course, workshops on Terra Preta production, the Open Source Ecology Berlin group, the Cargo Bike Network Berlin, the site of the Fusion music and arts festival north of Berlin, the Climate Camp 2015 in Rhineland, the Open Design City working space at co-working space Betahouse in Berlin; several spontaneous and planned workshops and group discussions at public events like the conference of the Solidarity Economy Network in Kassel 2012, the German Commons Summer School 2014, the German Degrowth Summer School 2015 or the Elevate Festival for Arts and Discourse in Graz 2015, several testing sessions with engineering students at the Technical University of Berlin, and others. Due to accessibility the research took place mainly in Germany. However, a lot of the researched groups see themselves as part of transnational collectives. Nevertheless it would be worth another project to see if research in different countries would not bring forth also different criteria of convivial technologies.

As ethnographic research asks for a "total immersion" of the researcher into the field, research can take place practically everywhere because in every situation of her life the researcher can come across relevant data for her research question (Lindner, 2003). One of the fundamental questions of ethnographic research is therefore the construction of the research field, to distinguish which phenomena are part of the field, and which are not. In this research the idea of "grassroots technology" served as a helping construction to guide the entrance to the field: grassroots technologies in the sense of technologies that are developed and used by a person or group that is not profit-oriented, not part of a big corporation or university-funded, but independent, and that is developed and used in order to serve locally articulated needs (this definition is close to "grassroots innovation" as described by Pansera and Sarkar, 2016). As the research went on, the idea of "grassroots technology" lost its importance because in 2016 all researched groups or at least individuals within the groups identified themselves fully or partially with the degrowth movement, which was not at all the case when the research started in 2012. Considering this identification the focus for field construction was adjusted to degrowth-affiliated groups that work on technology.

The analysis of the material – transcribed interviews, field notes and saved websites or online discussions – took place via coding of the material with the qualitative analysis software MaxQDA (Corbin and Strauss, 2008). The central codes – introduced as headlines to different sub-sets of the initial In-Vivo-Codes in a first version early in the research process – were adjusted during a 4-years-process closely referring to theoretical debates about conviviality, in discussion with several research partners from the field and continually re-tested and modified within the field. Finally five core dimensions – which cannot be reduced to one another – remained as central features of convivial technologies: relatedness,

[5] Further developed in the author's PhD Thesis at Humboldt University Berlin which this article is based upon. The thesis (working title "convivial technologies") will be finished in 2017.

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adaptability, accessibility, bio-interaction and appropriateness. They were grouped as the Matrix of Convivial Technology (MCT), correlated to four levels of a life-cycle: materials, production, use and infrastructure (Table 1). These five dimensions were then in turn used again as pre-set codes to organize the accumulated material once again in order to refine the dimensions. In a first step, already formulated criteria from the approaches in the aforementioned literature review were filled in the grid. In a second step, insights gained through interviews and participant observation were concentrated to keywords and added to the chart. The resulting table was then - in a third step - reduced via clustering to 5 to 10 antagonistic terms in each of the 20-sub-fields of the table. These terms are presented in a random order that does not indicate importance. They are to be understood as examples and some of them can be omitted or changed in a case-sensitive way.

The MCT was originally developed as a tool to discuss the ethical values of a given technology or technological artefact with the research partners and to make explicit that every decision to produce or use a technology means weighting the 20 fields against each other. The MCT can be filled in by participants by making crosses on the line in between the opposites in each field, showing to which side the chosen artefact or technology leans more. The form of antagonistic terms is used because this proofed to be a way in which participants could easily fill in the matrix.

4. The five dimensions of convivial technologies

Convivial technologies as introduced by this article can be described by five core dimensions, which are of different importance each for the researched projects: relatedness, accessibility, adaptability, bio-interaction and appropriateness. In the following paragraphs each dimension is explained referring to literature and empirical material. This can be done here only exemplarily – not each antagonistic term can be discussed, but examples are given to understand more generally the quality of each dimension. In the MCT each dimension is differentiated in the levels of material, production, use and infrastructure of a given technological artefact.[6] The research for this article concentrated due to its empirical data mainly on materials and production of technology, but use and infrastructure are also mentioned. Disposal is not listed as a separate level, because in the concept of convivial technologies disposal is already closely linked to materials and production and can be dealt within these levels, as testing has revealed.

4.1. Relatedness

The category of relatedness is crucial for the thinking about conviviality. Conviviality mirrors the human capability to relate to others, the fact that no person ever is without relations (Praetorius, 2015). Technological artefacts and infrastructures play a crucial role in the way these relations are performed. In the idea of developers of convivial technology relatedness expands the realm of humanity. So builders of composting toilet systems or kitchen waste bokashi[7] explain their wish for these forms of composting with the desire to be part of an ecological cycle and to be able to directly see this relatedness on their own ground, in their own garden (see Table 1, field relatedness/infrastructure, “Humans as equal part of a complex system”). Using composting toilets, where the faeces can be seen and often a separation between urine and faeces has to be taken into account, challenges people to think about their bodily routines and their incorporated feelings of shame and disgust (Bourdieu, 1977; Vetter, 2015b). It allows people to decolonize their imaginary concerning the value of their own body wastes which can serve as fertilizer (see Table 1, field relatedness/infrastructure, “Connects with ecological processes”). The practice of using composting toilets often shows friction between theory and practice: even people who value intellectually the idea of a composting toilet can at the beginning feel uncomfortable or even literally be unable to use them – this simple example makes clear that decolonizing ones imaginary has to go together with decolonizing the body – decolonization is not only an intellectual act, but a bodily transformation. Here relatedness interferes with access (see Table 1, field acess/use, “Transforming cultural restraints”). The value of relatedness can also take on more abstract forms: For Open Source activists the idea to be part of a worldwide connection of people developing ecological hardware accessible to anyone is a strong motivation. The very fact that they liked videos or websites about US Open Source Ecology[8] brought young people, mostly male, together in Berlin to voluntarily build an open source cargo bike that they later donated to the also web-based organization Food Sharing[9] (see Table 1, field relatedness/production, “Sustains trust”). They could have built a cargo bike with a lot of other groups in Berlin – but the idea to be part of a movement, of the label Open Source Ecology, to be related to this idea, was valuable to these young men and women. In the “value statement” of Open Source Ecology Germany (OSEG) as it is formulated online on the Wiki of OSEG they emphasize the “human and organizational value” of “cooperation and relation” (OSEG, 2015; author's translation). Another point is the expansion of knowledge and creation of a convivial atmosphere of peer learning in building (low) technology together that is a very important issue for most groups researched in this project (see Table 1, field relatedness/production, “Conjoint experience”). In the Hacker Ethics, important background for the Open Source movement, the debate of centralization vs. distributed organization is important: “Mistrust authority – promote decentralization”, says one rule (“Hacker Ethic,” 2015) (see Table 1, fields relatedness/materials and relatedness/production “Organization distributed”). This is ensured through the possibility of a ‘fork’ – because all information is open any group can split apart from the starter or main group at any time and develop from this point their own version of a software or other tool (Kelty, 2008). The central question for the dimension of relatedness is then: what does it bring about between people?

4.2. Accessibility

Accessibility means access to material and immaterial necessities to build or use a technology. It is a very important driving force to build grassroots technologies for most groups researched within this project. Looking at the literature it is interesting to see that the immaterial access (to blueprints and knowledge) was not as central to most thinkers about alternative technologies in the

[6] See for this differentiation literature on life-cycle assessment (ISO 14040, 2006), which normally uses the four levels material extraction, production, use, disposal. In this article the four levels mentioned above were chosen, because they proved suitable in the testing phases with the research partners. For the sake of clearness and shortness of the article the main focus lies on explaining the dimensions. The levels are explained more in depth in the author's PhD Thesis.

[7] Bokashi is a form of lactic acid fermentation of kitchen waste with the help of Effective Microorganisms and charcoal.

[8] Research was undertaken at Open Source Ecology Berlin, a subgroup of Open Source Ecology Germany. Open Source Ecology has several nationally or internationally organized sub-groups which can be regarded as a kind of “fork” of the original project, as they use the name and partly have the same goals, but have no organizational or financial connection with the original OSE.

[9] Food Sharing is a mainly German network of people who “save” food that would have been dumped otherwise: https://foodsharing.de/ (accessed 25.07.2016).

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1970s (e.g. Galtung and Jungk, 1969; Schumacher, 1974) as it is in more recent publications about Open Source Hardware and Peer Production (e.g. Benkler, 2006; Rifkin, 2014) (see Table 1, fields access/materials and acess/production, "Knowledge freely accesible"). The more bibliographically oriented approaches like the "Reference Guide to Convivial Tools" however stressed access to knowledge, too: Borremanns (1978) recommended small communities to invest in a library in order to ensure access to information on how to build their own tools. Accessibility is a dimension that often differs in theory and practice: while Open Source licences were highly valued in nearly all groups, the research for this project showed they were often difficult to put into practice due to documentation problems or unclear documentation standards. OSEG Berlin lost its documentation of a cargo bike because it was documented on the online platform of a small start-up enterprise that promised to open source its platform as soon as success would allow it. But instead the start-up vanished and with it all the produced content (see Table 1, fields access/materials and acess/production, "Knowledge freely accesible"). Accessibility also addresses the question of culturally restrained access: in all researched projects a lot more men than women were involved – a survey in the field of Open Source Hardware showed that 94 percent of the persons involved were men (OSHW, 2012). Knowledge about technology is clearly a male domain. The enhancement of "technological literacy" (Mota, 2014: 245–247), in general an important issue for convivial technologies, seems to be especially crucial for women (see Table 1, fields access/materials and acess/production, "Open to everybody"). The question who owns the means of production was, in the small groups this research was undertaken in, mostly solved by ownership of a non-profit association cooperating with the group: the association managed the workshop and owned the tools; on the farms tools and workshop also belonged to the farmers' (see Table 1, fields access/materials and acess/production, "Producer owned"). As long as production merely had a non-profit character these cooperations were easy. It became clear that the production of convivial technologies sometimes collides with the need to earn one's own living: it is mainly undertaken when participants are students, temporarily subsidized by private or public funds, or integrated as one part of a diversified individual strategy to reduce living costs and earn money with different projects (see Table 1, fields access/materials and acess/production, "Fulfilling basic needs"). However, some groups also thought about or did indeed start a small enterprise or a social business. It is still an open discussion if in the long run Open Source production hinders or fosters the commercialization of products: does it help to find new ways of production beyond profit? Or is it going to increase profits and accelerate market dynamics? (Bauwens, 2009; Habermann, 2016; Kostakis et al., 2016; Kratzwald, 2014; Rifkin, 2014) (see Table 1, fields relatedness/materials and relatedness/production, "Need driven"). The central question for the dimension of accessibility is then: who can build or use it where and how?

4.3. Adaptability

The autonomy to decide whether to use a technological device or not is one of the central arguments of Illich (1973). If it is not possible to be part of a given society without using a certain technology a "radical monopoly" exists (ibd.) (see Table 1, field adaptability/infrastructure, "Voluntarily"). Independence from state-owned infrastructures is an important motive in building infrastructures like composting toilets as Pickering (2010) shows for adepts of counterculture in Hawai'i (see Table 1, field adaptability/use, "Independent use possible"). However, adaptability is not only about independence but about linkage – to be able to decide whether one wants to be independent or linked. It appears as a question of scale, for example in the Permaculture principle "Use small and slow solutions", which is explained in the following way: "Systems should be designed to perform functions at the smallest scale that is practical and energy-efficient for that function" (Holmgren, 2013: 18) (see Table 1, all level-fields of adaptability, "Scalable" and "Small Scale Economical"). The smallest possible scale can also be rather big, as in the use of currently over 200 composting toilets for the 70.000 guests of the annual 5-day Fusion Festival, which makes clear that the composting of a big amount of stuff coming in a very short time requires different measures than the 'usual' composting toilet used all year round by a more or less constant amount of family members. Within Open Source Ecology Germany several values deal with aspects of adaptability on a technological level, most importantly "modularity", "scalability" and "suitability for D.I.Y" (OSEG, 2015) (see Table 1, all level-fields of adaptability, "Everyday tools", "Modular", "Scalable"). Sometimes this search for autonomy or self-determination is acted out in a mainly symbolic way: at the Climate Camp in Rhineland 2015 a small Piggot wind turbine was built from scratch within one week. However, it was too small and the produced current too irregular to be of substantial value for the infrastructure of the camp – but the main goal of the action was achieved: the participants trained their skills and felt practically empowered to resist the coal mine (see Table 1, field adaptability/production, "self-determined"). The central question for the dimension of adaptability is then: How independent and linkable is it?

4.4. Bio-interaction

Whereas eco-innovation and related concepts usually state that they want to produce technology that is less harmful to the environment (e.g. Pansera, 2012), the ideal of convivial technologies is clearly that of being useful in an ecological cycle. This claim is made explicitly in Permaculture – its first core value is "Care for the earth," which is explicated as "husband soil, forests and water" (Holmgren, 2013: 7) (see Table 1, all level-fields of bio-interaction, "Improving soil", "Improving water quality"). Care in this sense means to contribute beneficially to ecosystems, not only to "produce no waste", but also to "obtain a yield" (Holmgren, 2013) (see Table 1, all level-fields of bio-interaction, "Allows co-productivity"). This ideal is related to the idea of Cradle-to-Cradle design, which promotes production processes and especially new materials that are useful to natural systems (Braungart and McDonough, 2013). However Cradle-to-Cradle is deeply rooted in the idea of necessary economic growth and does not think about a possible rebound effect if e.g. too many land is used for the production of consumer goods instead of food (Frenzel et al., 2014). There is also an emerging community of bio-hackers who want to produce Open Source materials that are useful and degradable, but this movement is still in its very beginnings and its basic ethics to open source DNA as "code of life" could also lead to hazardous developments (Meyer, 2012) (see Table 1, field bio-interaction/materials "biodegradable"). The idea of usefulness and of the possibility to enhance the quality of air, water and soil by human action is also fuelled by recent discussions about Terra Preta do Indío, a very rich human made soil found in the Amazon and produced about 1000 years ago by the indigenous population (De Gisi et al., 2014), which inspires a lot of groups currently working on degrowth technologies. The central question for the dimension of adaptability is then: How does it interact with living organisms?

4.5. Appropriateness

This dimension is about the relation between input and output considering a given context. Appropriateness is a dimension made strong in the appropriate technology movement after Schumacher

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(1974): to take the whole situation into account, consider the local availability of materials and skills, and then to decide where a technology makes sense and where not (see Table 1, field appropriateness/materials, “Locally available”). The “Academy for Sufficiency”[10] uses as much recycled materials as possible in building rooms and furniture for their guests to show how a low-tech and inspiring aesthetics can be reached (see Table 1, field appropriateness/materials and appropriateness/use, “Re-used”). But the claim to recycle can also intervene with the reusability of materials: the builders of the XYZ-Cargo Bike[11] who use only square bar steels and bolts for their type of cargo bike emphasize, that all these materials can be re-built into other structures without loss of quality. The Berlin Werkstatt-Lastenrad[12] (cargo bike workshop) tried instead to build a cargo bike only with recycled materials from old bikes nobody used anymore. Whereas the XYZ-bike needs freshly fabricated steel, but allows to reuse it, the cargo-bike-workshop bike recycles old material gone useless, but does not allow for another cycle of reuse – the old frames soldered anew would probably break if disrupted, taken to pieces and used yet another time (see Table 1, field appropriateness/materials “Easily recyclable”). It has to be decided within a given context with the people involved which practice is appropriate. Within the researched groups the role of efficiency in time is ambiguous. Whereas time-saving is an important argument e.g. for an Open Source hand sowing machine[13] (which according to its builder allows to put onions into the earth 10 times faster than if done by hand), the time consuming activity of building one's own cargo bike collectively without the advantage of big scale production is highlighted as a valued and joyful experience. For convivial technologies the argument of time-saving has always to be put in relation to the activity in question: for the farmer the time saved in putting onions is existential, because in spring a lot of different activities have to be done in a short time. For the bike builders there is no need to shorten a meaningful and joyful activity where they can learn a lot (see Table 1, all fields of appropriateness “Allows joyful time”).

5. Discussion of Matrix of Convivial Technology (MCT)

The MCT is a specific tool to make findings of qualitative social research accessible to different stakeholders. In the following paragraphs experiences with three possible uses are discussed and their possibilities and shortcomings are shown.

1. The MCT can be used for the self-assessment of degrowth-oriented groups developing or adapting technology. This was already tested three times and proved to be, as participants mentioned, a very insightful way for the participants of the projects to learn about the advantages and shortcomings of their own products and systems and to weight them. It helped the groups to reflect on the main goals of their developments and to accept semi-optimal solutions in other dimensions. It also encouraged them to think about improving fields they did not think about so far. For this purpose also a void table without the antagonistic terms in each field of the MCT can be used – a procedure that has been tested once. The MCT differs from other tools to assess technological products like Life-Cycle (Sustainability) Assessment (LC(S)A) insofar as it is adapted to the scope, visions and needs of degrowth-oriented groups. It is a simple qualitative tool, that can be used by developers themselves, and it is best used in non-hierarchical group discussions – instead of a quantitative assessment conducted by experts and later communicated to decision makers (e.g. Finkbeiner et al., 2010). Thus the MCT can be considered a convivial tool itself. The MCT does not aim at an optimized business usability considering ecological sustainability and social impacts (as e.g. Neugebauer et al., 2016) but helps in self-reflecting central issues of degrowth thinking. It cannot provide additional information but encourages developers to start a guided ethical discussion about features of their technology.
2. The MCT can also be used as an educational tool to foster reflection about technologies in general and to disseminate ideas about degrowth e.g. as part of a workshop about convivial technologies. This was tested four times with engineering students at the Technical University of Berlin and in three workshops as part of public summer schools and festivals; in addition, the MCT was adapted to a method set for global learning in secondary schools.[14] Different settings were used here: either every participant, or small groups could choose a technology themselves and fill in all fields, or a specific technology was agreed upon before, and every group only filled in one field and results were later discussed together. The second method proved to be better suited to foster a common group discussion. In this contexts the MCT was not only used to assess degrowth-oriented technologies but also conventional ones like smartphones. Especially the case of the smartphone discussed two times with engineering students showed results that started processes of self-reflection and a possible decolonizing of given imaginaries about so called advanced technologies. Instead of falling into a dichotomic discussion about smartphones as good or evil technology the MCT enabled them to thoroughly compare the performance in 20 different fields, weighting ecological against social or cultural questions. It could be interesting to investigate this possibility further: common technologies assessed with the MCT reveal their normally hidden rucksack of social, cultural and environmental shortcomings. This shows a usefulness of the MCT to question technologies and to create a consciousness about problems they cause. Because it was developed to assess small technologies linked to the degrowth movement it takes them as model. In the MCT, therefore, a water toilet can fall short in several fields compared to a composting toilet. In contrast to most methods of Technological Assessment (TA) that are conducted by experts (Grunwald, 2009) and take in the opinion of the public (Hennen, 2012) the MCT can be used by anyone and also on technologies that are old or have been uncontroversial hitherto. It is not a neutral method to solve conflicts around technology but actively promotes normative values derived from the researched degrowth projects. In this way it challenges the social imaginary concerning a given technology.
3. The MCT was used during the research for this project as a research tool in itself to collect data and refine analysis. Discussions with the groups mentioned above while filling in the MCT were recorded and transcribed and in turn used to sharpen and alter dimensions, levels and antagonistic terms within each field of the MCT. Thus the MCT constantly evolved during research and surely will also do so during further use, which is also one of the intentions of a future digital version of the MCT on the website convivialtechnologies.org. It is a context-sensitive tool and therefore open to change by use. Especially the antagonistic terms within each field of the MCT have to be

[10] http://www.akademie-suffizienz.de/en/ (accessed 25.07.2016).
[11] http://www.xyzcargo.com/ (accessed 25.07.2016).
[12] http://www.werkstatt-lastenrad.de/ (accessed 25.07.2016).
[13] https://wiki.opensourceecology.de/Zukunftsger%C3%A4te#Download_Zwiebelleger (accessed 25.07.2016).

[14] It was adapted in a more visual form as “convivial flower” and made more easy for the use in schools: http://www.endlich-wachstum.de/kapitel/perspektiven-alternativen/methode/welche-technik-wollen-wir-praesentation-fehlt/ (accessed 25.07.2016).

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understood as propositions that can be changed, omitted or new ones added according to the needs of a group using it.

In testing the different functions of the MCT some blind spots arose. It emerged that it posed problems to some groups to distinguish between the current state of the project and their vision, especially in the dimension of accessibility. Therefore two additional states were introduced: "present" and "vision". It can be valuable for groups to fill in one MCT about the current state of the project, and another one for their vision. This gives the possibility to easily see the differences that exist between vision and current practice, as it often occurred with projects that wanted to open-source their knowledge but did not find enough time or dedication to do the documentation after the production was finished. This held true for as different projects as a cargo bike built by Open Source Ecology Berlin, the composting toilet system of the Fusion Festival or the technology of 3-D-printing, examined at a workshop at a Degrowth Summer School. To distinguish between these two states – present and vision – can also help to reveal the positive or negative potentials of a given technology not yet visible at present or to open up room for discussion what (political, social or technological) circumstances are needed to direct the project in the future to a more or less convivial version.

Another often disputed point was whether there is a possibility to aggregate the points of a field to a specific "field-value". It seemed not sensible to do so because it obscured the possibly different findings in each field; on the other hand it could help to compare the fields more easily to each other with one "number". Generally the MCT does not work quantitatively but is a strictly qualitative tool. Another shortcoming was that not every word-pair worked equally well for different technologies – this problem between specificity and generality of the MCT deserves further attention and the tool needs to be further developed at this point.

6. Conclusions

In this paper convivial technologies are developed as a notion describing desirable technologies for a degrowth society. The concept revisits terms of the 1970s growth critique debates proposing "appropriate", "soft", "alternative", or "radical" technologies, and "convivial tools" as possibilities that promote more equality for people and are less harmful to the environment. It takes these discussions as a starting point to ethnographically examine current practices of degrowth-related groups who produce, develop or adapt technologies. Researching their values and practices five core dimensions of convivial technologies were worked out: relatedness, accessibility, adaptability, bio-interaction and appropriateness. These dimensions propose an ideal of degrowth technologies that can serve as a focal point for the question of which technologies would be appropriate for a degrowth society.

The article introduces and discusses the Matrix for Convivial Technologies (MCT) that is a tool to work with different target groups on the topic of convivial technologies. The MCT is an unconventional transdisciplinary approach to discuss ethical values concerning technology with developers and a broader public alike. Insofar it has certain similarities with some approaches of Technological Assessment (Grunwald, 2009). Unlike these the MCT has an explicitly normative position derived from the ethnographic findings in the above mentioned projects.

It would be very insightful to compare the MCT thoroughly to other approaches like different forms of LCA or LCSA, the Eco-Compass[15] or the Slow Design Tool (Strauss and Fuad-Luke, 2008). However, this is beyond the scope of this paper. Generally speaking, the MCT is different from these approaches because it is made for 1. The use by small groups or social businesses aiming at a social and ecological transformation and developing or adapting technologies, 2. Course leaders in political education for sustainability or degrowth, 3. Researchers doing qualitative empirical studies in ethics of technology. None of the above mentioned tools aims at these groups. Most of them, especially LCA approaches, are complex and a costly effort that needs skillful experts. In contrast, the MCT is inexpensive, quick and easily done in a three-hour workshop – it does *not* provide new information to stakeholders like most of the other approaches do, but it helps to clarify, focus and discuss technology in a structured way.

With the MCT the term "assessment" can be understood differently in a degrowth context. It can help to bring back ethical discussions about technology into the public debate: Which technology do we want for which kind of society? Which impacts does a given technology have on the relations between people and also between humans and the non-human world? The dimensions of the MCT refer not to efficiency or economic performance but to conviviality, therefore it can change views about which technologies are desirable and which are not. Because of its form the MCT can help to structure discussions and to avoid simple dichotomies between techno-optimism against techno-pessimism.

[15] http://www.ekokompassi.fi/en/criteria/ (accessed 30.12.2016).

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