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INTRODUCTION

Visioneering Socio-Technical Innovations — a Missing Piece of the Puzzle

Martin Sand · Christoph Schneider

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A Brief History of a Short Hype

Let us begin by introducing an example with a view to elaborating the concept of 'visioneering' that has been adopted from the historian Patrick McCray and forms the backdrop to this special section. Ray Kurzweil, who could be considered a prototypical 'visioneer', includes the following rather breathtaking passage at the beginning of his book 'The Age of Spiritual Machines':

> The twenty-first century will be different. The human species, along with the computational technology it created, will be able to solve age-old problems of need, if not desire, and will be in a position to change the nature of mortality in a postbiological future. […] The pace of change is accelerating and has been since the inception of invention […]. The result will be far greater transformations in the first two decades of the twenty-first century than we saw in the entire twentieth century. [1]

The book is full of similarly bold and confident predictions about the future of humanity's biological condition, health and mortality, all of them connected to the development of artificial intelligence in the twenty-first century. Written and published in 1999, it is one of a number of publications of the same year that deal with the future of artificial intelligence [2]. The most provocative statements concern the rise of artificial intelligence at the beginning of the twenty-first century, and are confidently expressed on the basis of the so-called 'law of accelerated returns'. Kurzweil acknowledges that this law is the driving force that will eventually lead to the emergence of superintelligence. Today, almost two decades after its publication, it must be asserted that many of the predictions in Kurzweil's book have failed to materialize. One might then ask at this point why we should care about a book full of far-fetched predictions and utopian thinking. Given the number of argumentative errors that can be found in the book, such as the permanent equivocation of computation, intelligence and consciousness, factual mistakes about the history of computation and other shortcomings, one might be inclined to reject such shoddy work for consideration in Science and Technology Studies (STS). However, there's another side to the coin.

What is remarkable about Kurzweil's book 'The Age of Spiritual Machines' is the extraordinary public recognition it received. Despite the aforementioned defects, a number of eminent philosophers commented on the book, among them John Searle, Colin McGinn and Diane Proudfoot [3–5]. All of them made critical remarks about Kurzweil's speculations concerning the nature of mind and intelligence. McGinn, however, attributes an additional value to the book and puts forward one reason why it should be read despite its flaws.

M. Sand (✉) · C. Schneider
Karlsruhe Institute of Technology (KIT), Institute for Technology Assessment and Systems Analysis (ITAS), Karlstraße 11, 76133 Karlsruhe, Germany
e-mail: Martin.sand@kit.edu

C. Schneider
e-mail: christoph.schneider3@kit.edu

For our purposes, the most interesting aspect of McGinn's review is the following question, which he raises at the outset: '[…] is the whole idea [of machines taking over the world] just a clever marketing ploy for the investment-hungry artificial intelligence industry?' [3] This is a legitimate question given Kurzweil's varied entrepreneurial efforts and in view of his position as a former leading engineer at Google. By adopting such a perspective we transcend simple questions regarding the content of Kurzweil's vision and the groundedness of his predictions and direct our attention instead to the ways in which his vision has been used to transform and influence past and present realities. Kurzweil clearly does not appear to us as a technological forecaster or scenario builder: he is an advocate of change and as such should be considered a visioneer and his publication a 'tool' of visioneering.

From Visioneers to the Visioneering of Socio-Technical Innovations

What exactly does 'visioneering' mean? Ray Kurzweil's 'The Age of Spiritual Machines' is a book full of far-fetched and poorly justified predictions, many based on a shallow theory of the mind and a more or less specific picture of technological development. It is a technological vision that not only offers a narrative of a future world in which intelligent machines are interwoven with our lives, our actions and our society, but also puts forward arguments for embarking upon such a path. In other words, the book not only offers a vision of the future, but actually advertises it. This is explicitly expressed in comments such as the following on the value of developing nanobots: 'There is a clear incentive to go down this path' (p. 140). The author likes to prepare readers for the upcoming events and convince them of their advantages and their inevitability.[1] While the discussion about the feasibility of strong artificial intelligence was certainly ongoing before the book was published (and is currently on the rise again [6, 7]), there is no doubt that the book received huge attention at the time of publication. It fueled a public debate about the possibilities of artificial intelligence, the tip of whose iceberg we surveyed briefly in the previous section. 'The Age of Spiritual Machines' briefly generated an AI 'hype' and had enormous societal impact [8]. Though such an impact need not necessarily result in growing public awareness of an emerging technology, this may be one of its many effects. Visioneers like Kurzweil use visions such as that of strong AI to promote their own research endeavors and the projects of their companies. Influencing the dynamics of public discourse through vast narratives may be in the long-term interests of someone who is convinced of the desirability of such a future and seeks it.[2] Kurzweil does not merely promote the narrative of a technological future: as a programmer, researcher and entrepreneur he has been – and still is – a driving force in bringing this future about.

There are no ways in which Kurzweil is not alone in the field: on the one hand, he is not a single player in the pursuit of strengthening AI research and development. He is backed by his and a number of other companies (the vast majority of which are in the United States), private investors and tech enthusiasts, some of them with close ties to political institutions. On the other hand there are other actors who are involved in a similarly broad range of activities relating to a narrative of the future; their intention is to drive forward and realize their vision and attribute a meaning to particular techno-scientific practices [9]. Patrick McCray analyzed the activities of many other visioneers such as Eric Drexler and Gerard O'Neill in his book. McCray believes that what links actors such as O'Neill, Drexler and Kurzweil and distinguishes them from other 'futurists', science-fiction writers and spiritualists is their additional active engagement with the development of the technologies promoted. Their unshakeable belief in the fragility of the present and the promises of an inevitable and magnificent future resemble the missionary aspirations of the (socio-political) utopians of the nineteenth century [10]. However, their focus on technologies as the means by which to reach this future and their shared belief that 'technology offered a sure path to social change' is unique and distinguishes visioneers from classic utopians [11–13]. Regarding their authority as certified engineers or scientists, visioneers should

[1] Kurzweil (like many other utopians) has paradoxical opinions regarding this question. Does the revolution need to be pursued or is it inevitable? He does not let us know (p. 130). Sometimes, as in the title of the prologue, he speaks of its 'inexorable emergence', while other times he suggests that there is a certain 'freedom in design'.

[2] 'To put this another way, inventors and corporate research departments create not only products but also compelling narratives about how these new devices will fit into everyday life. They need to do this to get venture capital, and companies need to market such scenarios to get a return on investment.' [47] See also Beckert on the importance of fictional expectations and narratives of the future for capitalist dynamics [45].

not be underestimated or trifled with [11, 14–16]. As McCray puts it:

> Unlike armchair futurists, these people–many of whom had advanced training in science and engineering–also carried out detailed research and engineering studies in order to realize their ideas. They made critical connections between their technical expertise and their visions of a more expansive future that would be created by the technologies they studied, designed and promoted. [13]

In 'California Dreamin': Visioneering the Technological Future', the article cited here, McCray coined the term 'visioneering' to denote the multitude of activities that are related not only to inventing, engineering and creating new technologies, but also to promoting visions of the future of those technologies and their potential application, both with a view to attracting attention to them and to helping realize them. Later, in his 2012 book entitled 'The visioneers. How a group of elite scientists pursued space colonies, nanotechnology and a limitless future', he established a more detailed definition of the 'visioneer' concept. He perfectly captures the social phenomenon described above using the example of Ray Kurzweil when he writes:

> 'To sum: visioneering means developing a broad and comprehensive vision for how the future might be radically changed by technology, doing research and engineering to advance this vision, and promoting one's ideas to the public and policy makers in the hopes of generating attention and perhaps even realization. Throughout all these diverse activities, [visioneers work] to build technical and social foundations for their own particular conceptions of the technological future. [10]

Clearly, the set of activities and the role of technological change encompassed in McCray's definition are not limited to agents at the early stages of nanotechnology or space colonization.[3] Current areas of endeavor such as space tourism, Mars colonialization, synthetic biology, big data, artificial intelligence, genome editing, augmented reality, smart grids, in-vitro meat, 3D printing or assisted living, to name but a few, can be considered as emerging technologies in which visioneering plays a crucial role in their current dynamics. To better understand the emergence of such technologies in innovation processes we need to go beyond McCray's focus on individuals as visioneers and scrutinize visioneering as a social activity; one in which both individual and collective agents work on visions and one that is an inextricable part of innovation processes. Viewed from this process perspective, the focus on visioneering provides an important piece of the puzzle when it comes to understanding the role of imagined notions of the future and activities concerned with imagining futures in innovation processes. In a complex manner, visions of the future are actively created, shaped and utilized to transform the present. Research on and an assessment of visioneering practices is therefore an important step towards an improved understanding of how futures are shaped in innovation and transformation processes and, by extension, of these processes themselves [16]. We will discuss how this perspective complements existing research on imaginaries of the future in innovation processes in the following section.

Questioning the 'Engineering' of Visions

This special section presents the results of the session 'Visioneering socio-technical innovations: the making of visions' that took place at the *Anticipation* Conference in Trento in November 2015 and was organized by the guest editors. We invited scholars from a variety of fields to discuss the phenomenon visioneering and its implications. As part of the 'Visions as socio-epistemic practices'[4] project at the Institute of Technology Assessment and Systems Analysis (ITAS) in Karlsruhe, Germany, we came across McCray's conceptualization of visioneers, which we found to be an intriguing and important addition to recent studies on imaginations and visions in socio-technical innovation processes. This is because it interconnects 'visions' and 'engineering', that is to say imaginations of the future, their construction processes, and their strategic use. In the following, we discuss some previous and ongoing ways

[3] It is probably necessary to consider their relationship with the counterculture of Silicon Valley in order to understand Kurzweil's and Drexler's quasi-spiritual aspirations and this distinctive community. The aforementioned counterculture must be seen as a set of beliefs in liberalism and free markets and as a 'spiritual' faith in information technologies [13]. See also [48]. Note that McCray explicitly advocates that the 'visioneer' concept be transferred to other fields of emerging technologies and mentions geo-engineering, synthetic biology, fusion energy, and cloud computing as appropriate examples [10].

[4] http://www.itas.kit.edu/english/projects_loes14_luv.php

of looking at the importance of visions and show why an examination of their collective engineering serves as a timely and important addition to these debates.

Vision-

There have been several waves of scholarly dedication to the roles of imaginations and visions of the future in socio-technical endeavors. In the 1990s, a group of scholars in Germany developed the approach of 'Leitbild' (guiding visions) research that focused on the working mechanisms of guiding visions in socio-technical enterprises [17, 18]. Their studies were able to show that the use of guiding visions such as the typewriter allowed the expectations of the agents involved to be homogenized and synchronized, used as rhetorical umbrellas and steer common activities. In this sense guiding vision researchers would probably agree with McCray's concluding statement that 'visions of the technological future have helped catalyze action and innovation' (p. 276). However, guiding vision research has focused largely on the effectiveness of visions in smaller-scale systems (societal agents directly involved in designing and engineering artefacts – experts [17]). Since these researchers also tried to influence and even 'steer' and manage innovation processes, they could indeed be considered visioneers. Such ambitions have been criticized, however; moreover, hardly any proof that the activities of the social scientist were effective has been put forward [19, 20]. Another now almost classic approach to imaginations of the future is the 'sociology of expectations'. Likewise in the 1990s, researchers explored how actors expect particular futures and how such expectations become collectively shared and exert a force on innovation processes. They no longer aspired to influence such expectations, however; instead, their studies focused typically on an actor-centered discourse analysis [21–23]. Going beyond such an actor-centered approach, it has been shown that visions and expectations can function as media between different actors, enabling their communication but without necessarily leading to shared expectations [24]. In this manner visions can become 'boundary objects' [25] within discourses that take place in different societal spheres. Visions demarcate a shared imagined space that may be differently assessed, desired or feared [26].

Recently, Sheila Jasanoff and her colleagues have popularized the notion of 'sociotechnical imaginaries'. Jasanoff criticizes STS for failing to adequately represent the non-material dimension of technological systems and the way in which cultural and social norms are interwoven with the material world and are able as such to influence technoscientific change [27]. By arguing in this fashion, Jasanoff advanced her own theory of how technologies are co-produced. In her opinion, the theory of co-production was not able to adequately explain many instances of technologies that failed despite concerted efforts to produce them. Since the degree of success achieved in certain technological fields across various nations and cultures differs hugely, the reasons for these divergences should be sought neither in the technologies themselves nor, as is often suggested, in the natural and economic differences between the countries in question. This is where the concept 'sociotechnical imaginary' fills a crucial explanatory gap. Hence, she defines socio-technical imaginaries as 'collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through and supportive of, advances in science and technology.' [27] This definition of a socio-technical imaginary as a relatively stable and widely shared entity differs in a key way from the research mentioned above. Furthermore, she sets forth: 'Though collectively held, sociotechnical imaginaries can originate in the visions of single individuals or small collectives, gaining traction through blatant exercises of power or sustained acts of coalition building. Only when the originator's "vanguard vision" (Hilgartner 2015) come to be communally adopted, however, does it rise to the status of an imaginary.' [27] Let us further explore how investigations into visioneering may help us understand the processes of construction and contention that turn confined ideas about the future into shared imaginaries – or do not.

Amid such activities pursued by individuals and these practices of observing, analyzing, and assessing visions and in some cases giving advice to policy makers and the public, Technology Assessment (TA) increasingly finds itself confronted with visions of technological futures. Several approaches have been developed in an attempt to understand and evaluate the early phases of innovation processes in which visions are paramount yet actual artefacts and socio-technical arrangements are scarce. 'Vision assessment' started out as a critique of the contents and claims of visions [20]. The uncertainty surrounding emerging technologies and the simultaneous need for orientation requires TA to look at the emerging

process at a different level. As we mentioned at the outset, the visions and predictions encountered when exploring an emerging field are often implausible and unsound, and in many people's view are not worthy of closer inspection or assessment [28]. Many TA researchers have now widened their focus so as to understand the interplays of 'visions in society' and of 'society in visions' [29, 30]. Armin Grunwald suggests in accordance with our reasoning:

> The factual importance and power of futuristic visions in the governance of science and in public debates are a strong argument in favor of the necessity of providing early public and policy advice in the NEST fields (Grunwald 2013a). Policy makers and society should know more about these positive or negative visions and their background. They should understand what is going on scientifically and technologically, what is or might be at stake for future developments, where the grand challenges to society are in relation to NEST fields under consideration, and who might be affected by societal developments based on NEST progress. In summary, this needs uncovering which meaning, values, and interests are hidden in the techno-futures being communicated. [9]

Grunwald describes the systematic compilation of such 'meta-information' as 'hermeneutic orientation' (p. 283). Taking Grunwald's ideas one step further, we increasingly find cases in which TA and other STS-related researchers are involved in assessing, communicating and at times even co-creating visions of the future (see Gudowsky and Sotoudeh, this issue). There may be many instances in which TA practices form part of the constellations of visioneering [16, 31].

We focus in our own approach on the crucial 'backdrop' to visions – the 'socio-epistemic practices' in which visions are shaped, contested, communicated, explored and transformed (see Ferrari and Lösch, this issue; [30]). As a result of our interest in socio-epistemic practices, we regard visioneering as one such practice; moreover, one that appears extremely important yet has so far been virtually neglected in most STS and TA studies of imaginations of socio-technical futures. Being the process by which visions come about, visioneering offers vast potential for investigations and increasing public, political and scientific relevance. Yet how can we construe and consider visioneering as a social technology, as an 'engineering' of imaginations?

-eering

We would suggest that *visioneering as an 'engineering' of visions* can be analyzed by focusing on the interrelated questions of *who* visioneers, *how* this is done and *what* is visioneered. In his study, McCray makes it quite clear who the visioneers in his examples are. In his book, he describes 'How a group of elite scientists pursued space colonies, nanotechnology and a limitless future'; these visioneers are among the elites of Western societies and the influence they derive from their authority is greater than that of other actors or ordinary citizens.[5] Hence, problems of responsibility and normativity naturally arise. Visioneers can be causally effective as sources of change even on an individual level and can influence research agendas, policies, and social values. They may therefore have a particular moral responsibility for these effects, as Laura Cabrera argued [32]. Since such visioneers are no ordinary lab scientists, but rather juggle with different roles across a variety of affiliations and institutions, it is not appropriate to assign them role responsibility in the conventional manner [33]. Although their influence is obvious, however, it is not clear how this influence could be determined given the complex and opaque nature of the innovation process nor, as a result, how a particular visioneer could be held accountable for, say, a general decline in social warmth if for example his or her vision were to raise collective fears of emerging technologies (the grey goo scenario almost gave rise to such a collective aversion) [34, 35]. Clearly it will not be the visioneer alone who has played a role if such events do occur. The opaque nature of the innovation process led other scholars to reject individual responsibility altogether and establish theories of structural responsibility [36]. We find a clear overlap here between any assessment of the social dynamics brought about by visioneering and the debate about responsible research and innovation (RRI). As one of the authors has argued at length in a different paper, however, assigning *ex post* responsibility for failures or catastrophes may well entail the aforementioned difficulties, yet one should not reject notions of individual responsibility altogether but rather focus on other aspects of visioneering – for

[5] We are reminded of this by a remarkable anecdote in McCray's book (p. 2). While Gerard O'Neill and others were discussing space travel at California's first Space Day in August 1977, laid-off workers outside the Museum of Science and Industry in L.A. waved signs proclaiming 'Jobs on Earth, Not in Space'.

example the character traits of proponents of future narratives, such as their creativity and eagerness [37].

Apart from those individuals who are visioneers, we may find many more people who are involved in 'engineering' futures when we focus on the collective activities of visioneering. We should consider that visioneering activities can also involve people in other social roles, e.g., politicians, journalists, entrepreneurs, and managers; entire organizations such as institutions, ministries or newspaper outlets; and even heterogeneous networks of scientists, research funding programs, corporations, consumers, advertising agencies and others. Visioneering then branches out into many different aspects involving the promotion, driving forward and attempted realization of particular futures, e.g., activities such as publicizing, promoting, investing, debating, building prototypes, creating social networks and so on. From this kind of collective perspective, visioneering need not even be confined to actors who aim to transform technologies. Although this transcends McCray's initial ideas, we believe that this broadening of perspective is necessary, especially since 'technical' innovation has become the central goal of efforts to change, improve or stabilize society [38]. It is thus necessary to scrutinize the wider working mechanisms of future narratives (trans-institutionalized settings, the general public) to determine whether there are any conjoined activities that make narratives particularly effective or successful.

Just as the actors and their positions in society differ, however, so too does their power. In the last passages of his introduction, McCray reminds us that 'influence among [different societal actors] with differing views of the future is rarely symmetrical. Not all futures are created equal.' [13] The question of power is indeed an inherent element of visioneering. While most human beings are capable of imagining futures, the ability to make others believe in 'your' future is something quite different, as is the ability to use resources to pave a particular path to this future, i.e., to build technical prototypes, to create experimental arrangements in society, to influence policy making, to invest in specific companies or to build effective political organization. 'Thinking through futures highlights something not articulated in much social science, which is that power should be viewed as significantly a matter of uneven future-making.' [39] Following this idea put forward by John Urry, better understanding visioneering may also allow us to better understand the powers that make futures and, eventually, discover how such futures could be made differently.

The question of who is involved in visioneering already entails the question of *how* this is being done. It is clear from McCray's analysis that visioneering is not only a matter of imagining futures, but in a profound sense also a matter of *future-making*.[6] McCray's visioneers deploy imaginations in textual, narrative and technical form through artifacts and prototypes; significantly, they also deploy various social technologies and organizational strategies to bring about supportive networks, financial investment, organizations and public discourse to 'mobilize, explore, and push the limits of the possible' [10]. Because visioneering is a planned and often concerted endeavor, we need to view such explorations and strategic usages of futures as being an increasingly important skill in contemporary innovation processes [40]. The nature of this skill and the instruments used for it are extremely relevant when it comes to understanding the extent to which futures are made unequally. Importantly, however, we should not restrict visioneering to the practices of techno-scientists or entrepreneurs, or indeed of a combination of the two, as is the case in the examples discussed by McCray. There are highly important investigations that emphasize the power of a technoscience-business nexus in contemporary future-making, especially through US 'high-tech' companies and cultures [39, 41]. Nonetheless, visioneering when defined broadly is not only a technoscientific-commercial activity. Different forms of political lobbyism or recent social movements such as the open source hardware movement, which notably created a novel 'open' path for digital fabrication in the form of 3D printing [42, 43]; the transition town movement that is attempting to foster a bottom-up energy transition; and the Democracy in Europe Movement 2025 that aims to build a novel democratic infrastructure along with a new democratic vision for Europe (www.diem25.org, accessed January 2017); all of these can be regarded as being involved in forms of visioneering. Yet the

[6] For in-depth discussions of the different ways in which futures are made, see [49] and [39].

'engineering', that is to say the practices and principles applied in the construction of futures, may differ significantly in each case. Understanding the varieties of visioneering is tantamount to thinking in alternatives and to pluralizing options for the future.

Visioneering can be used strategically for different ends; however, the consequences of visioneering may go beyond the intentions of the visioneers. This gets obvious when we take its collective nature into account. The German idea of an 'Energiewende' (energy transition) for example was initially visioneered in bottom-up networks of the environmental movement, but has now become an umbrella term to describe the government's recent efforts to centrally steer an energy transition – a policy that is primarily top-down in orientation [44]. *What* exactly is visioneered in different cases is thus a central question. While commercially successful technical products are no doubt a central goal of many visioneering activities, many other effects of different forms of visioneering are conceivable. If we look at collective visioneering processes rather than focusing on individual actors, we may find that visioneering influences public opinion, political agendas, science and technology policy, evaluations of everyday life, specific ways of conceiving of 'the future', political protests, controversies, ethics committees, STS research and so on. Although the intentions, interests and motivations of individuals and organizations can serve as an important starting point for a wider analysis, the effects of visioneering need not necessarily correspond to these. Visioneering can give rise to visions that acquire 'objective' qualities and become relatively detached from the 'subjects' that initially desired and produced them.[7] In asking what is being visioneered, we follow the lifecycle of the vision, tracking its products, manifestations, and arenas, as well as its opposition, connectivity or appropriateness to other narratives and imaginaries.

As we mentioned before, visions held by certain individuals may differ considerably from collectively stabilized imaginaries, and may entail many complex social processes that are neglected in current STS and TA research. In our example of Ray Kurzweil's AI vision we also saw the values entailed therein – his implicit and explicit attribution of desirability to the vision. However, the obvious difference between visioneers' narratives and socio-technical imaginaries is the fact that they are not necessarily commonly adopted by a community or nation state. While visioneering is socially relevant and effective, it does not achieve this in the same way as socio-technical imaginaries do; these – being by nature shared desires – are commonly pursued (or commonly rejected). Visioneers are effective by dint of their underlying activities 'on behalf of the narratives'. However, Jasanoff writes that socio-technical imaginaries can 'originate in the visions of single individuals and small collectives' [27]. What was once the eccentric or 'vanguard vision' of individual flight pioneers became the common imaginary of (and desire for) cross-oceanic travel by airplane.

It should therefore be pointed out that any scrutiny of visioneering also enhances our understanding of how socio-technical imaginaries emerge by uncovering the pre-stage dynamics that result in certain established and shared images of desired or undesired presents and futures. Whether visioneering gives rise to widely desired imaginaries or fears is also a question of how visioneering activities are based upon and linked to ideologies, organized interests, public discourses, established markets and industries, political power and institutions. Visioneering is charged with tensions between the new and the old, between that which does not yet exist and that which already does, and is not necessarily interested in dramatic change. There may even be cases in which great effort is undertaken in visioneering to stabilize the present rather than transforming it into a (radically) alternated future – we need to remember that capitalist dynamics and the changes it entails are a 'normalized' (and, therefore, largely unquestioned) aspect of modern societies [45, 46]. A change in commodities rarely entails a significant societal change. Focusing on the consequences of visioneering allows us to distinguish between the different forms of 'change' that are engendered through it. We advance our understanding of processes of social contestation, debate, production, stabilization and transformation of imaginations and visions of the future. How do socio-technical imaginaries and the imaginations of particular actors correspond or come into conflict, and how are particular imaginations selected so as to be transformed into widely shared imaginaries? These questions can be approached by examining visioneering activities.

[7] In some cases we may think of visions as 'boundary objects'or 'media'[25, 26]

Summary of Contributions

Energy transitions worldwide entail many divergent ideas and inherent complexities, and raise the question of whether and how they can be actively steered towards common goals. Urte Brand and Arnim von Gleich focus on two cases in Germany in which processes involving different stakeholders are aimed at influencing and guiding local socio-technical energy innovations. The authors have observed these cases for several years and have developed a conceptual model that addresses different levels of guiding ideas and different phases of their use. The case studies reconstruct how the ideas of either sustainability or resilience have been used to provide stakeholders with guidance in each case. The authors show that particular factors and dynamics are at play that promote or hinder the uptake of such – visionary – guiding ideas in transformation processes. The authors argue that there can be ways in which to influence and steer socio-technical innovation processes through ideas of the future, even though this demands particular circumstances. By highlighting these, the authors help us understand how visioneering can take place and how it could be used to improve the governance of the complex transitions that lie ahead in many socio-technical systems.

Few technological narratives in the past decades have proven as powerful as digital utopias such as Web 2.0, and very few technological fields produce a similarly inexhaustible number of prophets who constantly advocate the technological narrative in question and adjust its content and meaning. By investigating the discourses surrounding Web 2.0 and 3D printing, Jan-Felix Schrape and Sascha Dickel provide insights into the basic semantic structures of these media (their factual, temporal and social dimensions) and into the way they function. The authors uncover the revolutionary baseline of these utopias, that is to say the focus on radical social change that these technologies are allegedly able to produce. In both discourses the optimism about democratization, emancipation, and decentralization are dominant patterns. This is paradigmatically expressed in the 'prosumer' idea central to the 3D printing discourse. The authors link their investigation back to classic utopian research and regard modern media utopias as the heirs of typical social utopias, thus challenging the dichotomy between utopias with either a solely social or a solely technological focus. The authors explain that the performative power of modern media utopias stems from a reduction of complexity which makes them easily popularized and connected to other societal discourses. This contribution can rightly be viewed as a study of the connection between 'elitist' visioneering and wider societal discourses and imaginaries.

Visions are not only causal factors in socio-technical developments, but are also in part their product. Franziska Engels and Anna Verena Münch investigate the visionary dynamics associated with an urban construction site. This 'test bed site' located at a former gas facility in Berlin has attracted a variety of societal actors who have been aiming to realize a vision in flux since 2007. Initially seen as land for potential commercial use, growing criticism led to an early transformation of the vision. The newly established aim was to build an international scientific forum, but it also proved impossible to realize this vision. The authors thus reconstruct the dynamics of the vision of the site as one that is permanently challenged and contested by external constraints like policy regulations (which, on the other hand, also stabilized the vision when the German government finally decided to transform the national energy system) and subject to a multitude of diverging preferences on the part of investors, political partners, tenants and stakeholders, not to mention the struggles to materialize the vision. The study highlights the various contestations that can themselves be a constituent part of visioneering. The authors provide detailed insight into a case that could very well be considered a counterexample to the central thesis of guiding vision research, namely that visions homogenize expectations [17]. Conversely, one could argue that practical constraints and diverging expectations shape visions and affect their performativity.

Big data, nanotechnology, synthetic biology, human enhancement, in-vitro meat, smart grids – many of the issues that currently demand the attention of societies and STS and TA researchers are often highly 'visionary'. In other words, despite a large number of debates, promises and visions surrounding novel technologies, there are as yet only few practical applications for them. Nonetheless, such emergent technologies are highly relevant and contested phenomena, as well as the means by which many societies govern their futures. Arianna Ferrari and Andreas Lösch propose analyzing the visions at play here; not so much by exploring the content of their narratives but by focusing on the functions visions have in different aspects of innovation and transformation

processes. Visions that are regarded as 'socio-epistemic practices' help the analyst understand how new knowledge and social arrangements are shaped in conjunction with visionary ideas. The authors illustrate the usefulness of their concept by analyzing two different cases: visions of smart grids in Germany and visions of in-vitro meat. By highlighting the ability of visions to connect, transform, exclude and include different aspects of social arrangements, this paper offers an insight into the collective dimensions of visioneering.

As a more democratic and inclusive counterpart to the elitist version of visioneering portrayed in the cases that McCray discusses, Niklas Gudowsky and Mahshid Sotoudeh present the CIVISTI method of public engagement. Motivated by the widely acknowledged idea of public engagement (mandatory in many European research projects and a matter of common sense in STS and TA) being the proper tool with which to co-create socio-technical knowledge and make policy, science and society mutually responsive, the authors give a detailed description of the way in which the CIVISTI method was employed in the Horizon2020 projects CIMULACT and CASI. The method was applied to different topics in Austria, such as ambient assisted living and future food and, more broadly, to science, technology and innovation. Heterogeneous groups of participants were given the opportunity to outline desirable futures approximately 30–40 years from today. These outlines formed the basis for policy advice. The authors present an example of visioneering that is inclusive and non-elitist, and as such is clearly a more democratic complement to the classic visioneering described above, as well as a serious alternative when it comes to creating the future more equally. The paper also introduces a case in which TA researchers were engaged in active visioneering [see 31].

Currently, hardly any other idea has been shaping the hopes and fears of industrial transformations to a greater extent than 'Industry 4.0'. This vision promises novel forms of digitized coordination and networking coupled with an increase in automation technologies designed to reshape manufacturing. Sabine Pfeiffer traces the emergence of the 'Industry 4.0' discourse. Part of this vision is the myth that it was visioneered by three German engineers and involves launching a fourth industrial revolution. This myth is debunked by the analysis, however, which reveals that the roots of this visionary discourse are to be found amid the 2009 global economic crisis. Pfeiffer shows that Industry 4.0 is not being driven forward by novel technologies that visionary engineers are developing but by a strategic agenda pursued by powerful networks of capitalists and politicians. The vision and its prominence are therefore deeply embedded in the tensions and structures of contemporary capitalism and, rather than revolutionizing the factory floor, may well intensify current trends. Focusing particularly on labor, this article raises fundamental questions about power and visioneering.

These articles have been inspired by McCray's work on visioneering and by fruitful discussions at the *Anticipation* Conference in Trento, 2015. Thanks to their different interpretations of and approaches to the 'engineering' of visions theme, the contributions advance and widen our perspectives on the creation and strategic use of visions and in turn improve our societies' prospects of better understanding the futures-in-the-making that are already shaping our lives.

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