Technology Assessment of Socio-Technical Futures—A Discussion Paper

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Summary

Problem: Visions of technology, future scenarios, guiding visions (Leitbilder) represent imaginations of future states of affairs that play a functional role in processes of technological research, development and innovation—e.g. as a means to create attention, communication, coordination, or for the strategic exertion of influence. Since a couple of years there is a growing attention for such imaginations of futures in politics, the economy, research and the civil society. This trend concerns technology assessment (TA) as an observer of these processes and a consultant on the implications of technology and innovation. TA faces increasing demands to assess imaginations of futures that circulate in the present and to participate in shaping these through scenarios or foresights. More than ever, this raises the question, which propositions can be made based on these imaginations by TA and how this can be used in advisory practices. Imaginations of futures are relevant for TA not as predictions but in their significance and effectiveness in the present, which need to be understood and assessed.

Contents: This discussion paper outlines how present significance and effects of imagined futures in technological research and innovation processes can be conceived and analyzed. In this paper, all forms of imaginations of technology futures will be called "socio-technical futures" because

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within them technological developments and social changes are interwoven and inseparably interrelated. In this paper, we discuss (1) why TA should analyze socio-technical futures, (2) how such analyses can grasp the societal conditions (e.g. power structures) that are expressed in the imagined futures and how these become effective in processes of technology development, communication, decision making etc. We raise the question (3) which self-reflexive positioning or possible realignment of TA is needed as a response to its increased concern with assessing and even co-producing socio-technical futures. The latter is often demanded regarding the growing attention by politics and publics to imaginations of futures with wide temporal and spatial reach.

Addressee of this paper is the TA community in a broader sense. The *aim* is to sensitize colleagues for the topic and its challenges, to consolidate discussions and to provide theoretical and methodical suggestions for research in TA and related advisory practices with respect to socio-technical futures. This paper has been originally initiated during the workshop "The present of technological futures-theoretical and methodical challenges for Technology Assessment" (March 2016, Karlsruhe), in which all of the paper's authors participated. The contents of this discussion paper are preliminary results that shall initiate and guide further discussions.

1   Introduction

To fulfil its purpose, i.e., estimating and assessing both intended and unintended consequences of technological developments and innovation processes for society and environment, technology assessment (TA) inevitably has to deal with disputed and sometimes highly speculative imaginations of the future. For more than ten years, an increasing commitment of the TA community with technology-related ideas of the future (such as future imaginaries, technological visions, scenarios, guiding visions) can be observed. We grasp all kinds of these imaginations regarding the future by the provisional term "socio-technical futures". This term does not refer to the reification of futures. We therefore speak of socio-technical futures as these futures always relate technological developments to social change. With a different range, these socio-technical futures envision connections between technological and social changes. They express the desires, fears, interests and preferences of their producers and users (see Sect. 2). The reason why TA is dealing increasingly with such socio-technical futures has been and is, on

the one hand, the expanding orientation of TA towards new and emerging sciences and technologies (NEST). On the other hand, there is a growing demand e.g., of politics for orientational knowledge when it comes to decision-making processes regarding temporally far-reaching transformations. Respective examples are the energy transformation, the digitalization of society, measures against climate change or in the context of political support programs such as responsible research and innovation (RRI).

In its dealing with socio-technical futures for its research and advice purposes, which knowledge can be generated by TA at all? The imaginations of the future cannot actually predict what the future reality will be like. However, both public debates and debates among experts (whether in the mass media, in research policy, in the context of participation procedures or in the context of research and development) cannot be imagined without them. The necessity for TA to analyze and assess those imaginations results from the fact that their impact on research-political strategies or on public opinions cannot be denied. Socio-technical futures assert their significance in the present. This is why TA must know the roles, functions and consequences of such socio-technical futures when it comes to the processes of creating, spreading and using them. Thus TA is demanded to analyze these futures as an expression of the current society. This means to consider different and sometimes disputed interests, desires, preferences and claims to power of groups, which are part of our present society and which design, distribute and communicate socio-technical futures and finally base their decision-making and actions on them. In this context, TA has the task of putting narratives of "purely technological innovation" into question, of criticizing too narrow views of certain options for the future and of pointing out alternatives. But what does this imply for TA in terms of theory, methods, empirical work and its advisory practice?

This paper offers suggestions on how TA can deal with the theoretical, methodical and empirical challenges when it comes to its analysis and assessment of the significance of technology-related ideas of the future as socio-technical futures, and as codes and ways of expressing current societal states of affair. These challenges are manifold and multi-levelled. Dealing with them requires specific analytical approaches to be able to understand (see e.g., the debate on "hermeneutical TA") what such socio-technical futures might mean for current constitution and dynamics of society in connection to their respective contexts and processes of production and use as well as what might be related consequences. This all requires the reflected integration of the theories, methods and

procedures of TA, and also of Science and Technology Studies (STS), and other disciplines of the humanities and the social sciences (see Sect. 3).

Thus, what the authors believe to be necessary is an original and TA-specific way of analyzing and assessing the present state of such socio-technical futures and the further development of the required methods of analysis and assessment. Dependent on the context (e.g., research, politics, development, mass media), technological visions-currently e.g., of big data, synthetic biology, open source or nursing robotics-do not only refer to different things, they also affect different processes (e.g. research, experiments, negotiations, planning or controversies) in different ways. Accordingly, the various challenges and consequences of making use of the relevant procedures for the advisory practices of TA as an interventionist science (e.g., as parliamentary TA, participative TA, constructive TA and as foresight) must be reflected upon. As TA is not just an observer and analyst of socio-technical futures but contributes-intentionally or unintentionally-to shaping them and intervenes in processes by means of its advice, the authors believe TA has to appropriately reflect on its own role and effects, and to position itself accordingly (see Sect. 4). The paper intends to support such an increased theoretical, empirical and methodical reflection by TA on present socio-technical futures as well as an appropriate self-reflection and positioning of TA when it comes to research and advice.

The focus is on why and how TA, in a theoretically and methodically reflected way, deals with socio-technical futures and on the resulting, necessary self-reflection of the practice of TA. The paper is divided into three parts:

1. Reasons are given why TA should deal with socio-technical futures as an expression of current society and with their efficacy;
2. it is shown how analyses of socio-technical futures may proceed methodically;
3. TA is situated as an actor involved in the processes under analysis.

The *addressees of the paper* are interested scientists from the TA community in a broader sense. Apart from advisory TA, which is oriented at intervening by way of advising political institutions and the governance of processes (e.g., parliaments, science, research and innovation policies), we also reckon other kinds of TA among this community/addressees. This involves foresights, futures research as well as innovation- and STS in the fields of humanities and social sciences if their research and advice performance deals with the analysis and assessment of technology-related ideas of the future (in the sense of socio-technical futures).

2   Why Should TA Analyze Socio-Technical Futures?

2.1   What are Socio-Technical Futures?

By socio-technical futures we mean projections and ideas, which-explicitly or implicitly-imagine connections of future technological and societal states of affair. These are produced by a variety of groups of actors of current society (e.g., developers, research policy makers, mass media). These futures are *socio*-technical as they are not limited to future technologies, but imagine and describe future socio-technical constellations, i.e. changes of social, political, legal, economic processes and structures coming along with new technologies. They are socio-*technical* as their generation and use is related to technological developments. To each respective technology we may attribute both structure-changing and structure-preserving effects. Socio-technical futures may refer to both unchanged, traditional technologies and to newly emerging ones. They always relate to technology, however the imagined technological developments may influence the imagined changes of societal situations to different degrees (e.g., technology as one factor out of many, such as with imaginations of climate change, e.g., technology as driving factor, such as with industrial robotics).

Imagined changes in the context of socio-technical futures may have different scales or range: socio-technical futures cover both widely shared "socio-technical imaginaries" (e.g. in the case of energy transformation or post-carbon society) and development- and innovation-guiding imaginations of the future which are limited e.g., to communities of engineers. However, they are also widely communicated visions, utopias, dystopias in the context of media discourses and/or scenarios from the political realm or governance contexts. Socio-technical futures are capable of describing, stating or proclaiming future changes of the entire society or of only some engineered sub-fields. They may refer to short-term or very far-reaching processes (e.g., a vision of a new product, a vision of a comprehensive reorganization of the world). Thus, socio-technical futures may be relevant for TA at its various and current places of activity, and in the context of its various processes (e.g., production processes, negotiation processes, e.g., laboratories, political arenas, media discourses). Particularly informative and instructive for TA are interactions and changes of these temporal and spatial dimensions of socio-technical futures.

2.2   In Which Ways and Where do Socio-Technical Futures Appear?

Socio-technical futures are found in many places of society. They are found in sciences, in research, development as well as in research policy and in the media. They appear in the context of communication and action processes of a variety of social actors-from major corporations as far as to new social movements. They play a role even for popular culture. Often they appear in plurality-even concerning the same topic-and proclaim different or even contradicting future states. Thus, socio-technical futures (or the solutions predicted by them) are not seldom the cause of controversies. These may be great public controversies, such as in the case of nuclear energy, but they may as well be limited to certain groups, such as the controversies among scientists in the early days of nanotechnology. For TA, socio-technical futures are relevant at all the places where they have an effect, due to their influence on current processes.

According to the great number of places where they have an effect, socio-technical futures may appear in very different ways, e.g., in the form of guiding visions of technologies, which are supposed to coordinate or provide orientation for research guidelines, or just for the practical work of a development department or project. They may also be part of products developed by help of scientific means, such as simulations, scenarios or roadmaps, which are explicitly created to provide orientation for decision-making and as a means of the further production of knowledge. Furthermore they may be formulated as long-term visions, for the purpose of raising the attention of certain communities, or of motivating actors to contribute to their realization. They are found in the context of utopias or dystopias structuring e.g. public controversies or motivating social movements. Socio-technical futures are always the products of heterogeneously distributed processes with actors from various fields of society (such as sciences, politics, business, law or art) contributing. All these kinds of socio-technical futures are relevant for TA if they are part of the technological developments and innovation processes the respective TA project is dealing with. However, socio-technical futures are not only formulated in the form of texts (such as research programs and the media) mentioning them; just the same they may be materially articulated in devices, images etc. or even organizations. Materials may explicitly stage socio-technical futures; just the same, certain socio-technical futures which were e.g., preferred by developers, may be implicitly inscribed into materials. TA should be capable of identifying all these kinds of socio-technical futures and should take them into consideration for analysis and assessment.

2.3   What is the Effect of Socio-Technical Futures in Present Times?

Socio-technical futures are efficacious in society, as they influence the actions, knowledge and decision-making of those actors who are dealing with them. This is due to the fact that they give expression to certain desires, fears, goals, interests, states of social groups or individuals, and to the way in which they see themselves. Due to prioritizing certain options, they have a feedback effect on the further development of the society and technology, as they present these options as being inevitable for solving current problems. Often socio-technical futures are subject to the rules of social "attention economy", they motivate actions, legitimate decisions and influence e.g., funding, regulation and the ways in which upcoming innovations are used and consumed. However, they may also be based on unquestioned and tacitly assumed ideas of the future (such as traffic always being characterized by the car). Also "incumbents" evading the attention of society have an action-motivating and decision-legitimating effect. Thus, socio-technical futures are always an expression of current states of affair and processes while in turn, contributing to shaping these states and processes at the same time. They reflect e.g., the predominance of certain constellations of actors and the matter-of-course nature of certain assumptions of the future. In the same way, they influence the course of processes of most different kinds (such as negotiations, production processes, regulations). TA must be capable of recognizing the ways in which they influence such processes and how they affect mentioned processes, as a precondition for critical assessment and, perhaps, to contribute to shaping them in a reflected way.

2.4   Why Should TA Deal Critically with Socio-Technical Futures?

Reflecting on converging and competing socio-technical futures enables TA to recognize both the plurality of future options and the limitations to certain options for the future. TA's critical dealing with socio-technical futures keeps us from considering those future changes as being predicted by one predominant socio-technical future, the sole promising option for the future. This way, an enlightened way of thinking in alternatives is supported. Each imagined socio-technical future necessarily prioritizes certain options at the expense of alternative possibilities. By making the ways and processes of this selection transparent,

TA keeps different options for future developments (e.g., "low-tech" or "no-tech" instead of "high-tech" solutions for current problems) open. Furthermore, the assessment of socio-technical futures by TA makes motivations, interests, ideas and expectations explicit, which have influenced their genesis and use. As a result of this "making explicit", they can be differentiated and negotiated. Their assessment is quite a crucial issue for TA, because they provide the basis on which innovation-relevant actors (try to) shape the future.

Furthermore, imagined socio-technical futures often give expression to desires and fears the concerned actors are not aware of. This is, among others, due to the fact that these imaginations are not tied to individual actors or limited groups of actors, but circulate among very different discourses and fields of society and may thus develop "a life of their own", which has hardly anything in common with the intentions of their producers. Therefore, socio-technical futures contain and develop their own efficacy in the context of communication and action processes, e.g. between citizens and mass media, between private organizations, enterprises, public institutions or even states and supra-national associations of states. The analysis of this efficacy helps TA to understand the backgrounds of social controversies and to make their implicit, basic assumptions analyzable and criticizable. By dealing with socio-technical futures, TA may gain insights concerning current social power constellations within the respective innovation or transformation context analyzed.

A comparison of different socio-technical futures (e.g., in different national and trans-national contexts) allows for identifying invariants and shared assumptions in the respective field of society. Looking at the ways in which socio-technical futures are used, points to in-/stabilities of social situations, to the in-/exclusion of actors and their positions simply by virtue of selecting those technologies as being taken into consideration for the various socio-technical futures. Thereby, a differentiated analysis of the way socio-technical futures are being used, allows to uncover, question and assess the conditions for the selection and the construction of a problem and its solution. Narrow views in favor of technological options (such as nursing robots) while excluding or neglecting social solutions (such as a reorganization of nursing institutions) may be given as examples. By questioning these views TA takes a distance to narrations of "pure technological innovation". Such a critical view at technological innovations as social innovations is necessary for TA if it wants to analyze and assess the consequences of specific socio-technical futures in the context of innovation processes while, at the same time, taking care of, considering and directing its own position in the context of these processes (see Sect. 4).

3   How Could Socio-Technical Futures be Analyzed?

3.1   Which Analytical Dimensions Must be Distinguished?

Any analysis attempting to know in which ways current constellations and processes of society are included into socio-technical futures and, on the other hand, how these socio-technical futures change these constellations and processes, must try to understand the *mutual relation* of ideas about the future and current states of the society. For this purpose, each according to discursive and practice circumstances, contexts of making use of the various kinds of socio-technical futures have to be distinguished while their way of appearance has to be classified. Beyond this, it must be possible to record the interactions of forms and contexts. Thus, the following questions-among others-result: In which ways are innovation-guiding futures of engineers different from more general socio-technical futures such as visions, utopias or dystopias in the context of media discourses, and in which ways are these different from scenarios from the political realm and in governance contexts (see, places of effect and forms of socio-technical futures in Sect. 2.2)? And how could the interactions of the various kinds and contexts be analyzed?

For heuristic purposes, differentiating the contexts of the ways in which different kinds are used and recording the various interactions makes the distinction of two analytical dimensions reasonable. Only the inclusion of both dimensions allows to make statements on the significance and the effects of socio-technical futures. We take the analysis of how "*society finds expression in the futures*" as the first dimension; the second dimension is the analysis of the effect of *"futures in society"*. Here, society does not mean any totality such as "German society" or "globalized society" which can supposedly be reduced to one feature. Rather, "society" stands for those complex arrangements and dynamics of social actors that are being originated by actions, interests, power relations as well as negotiation and communication processes while, on the other hand, being characterized by established structures, norms, rules. Here, the society marks the respective context and process in the course of which socio-technical futures are produced, spread, used, controversially discussed.

The first analytical dimension focuses on finding out which current states of society find expression by a socio-technical future and in which way this leads to assumptions concerning future options that are desirable or undesirable or are considered realistic or unachievable. The second analytical dimension, on the other hand, focuses on grasping the effects (as well as the performativity) of a

socio-technical future in its respective social context. Both dimensions must complement each other in the practice of research, otherwise the interactions of socio-technical futures and the contexts and processes of their production and use cannot be understood.

In the first dimension, the focus is on the respective socio-technical future as an object. It is about understanding what finds expression in a socio-technical future (e.g., a narrative, a vision, an image). Content and kind of this socio-technical future are analyzed in relation to its context. In the second dimension, the focus is on those social constellations and processes within which the respective socio-technical future has an effect. The effects of a specific socio-technical future can only be understood through the processes of its use, the discursive and actor constellations of its production, use, reception, modification etc. These are the starting points of socio-technical arrangements and their changes, the socio-technical future being just one element among others.

The efficacy (or also the performative character) of socio-technical futures can be examined by analyzing the content and nature of the respective socio-technical future in relation to the existing constellations and processes (e.g., production, use and inclusion into innovation and political processes). An analysis which focuses on the content and nature of a socio-technical future is an indispensable element for grasping e.g., normative preliminary assumptions or prioritizations of certain technological options. By reflecting on the context of its use, the in/exclusion of options become visible, a certain socio-technical future and the states of society expressed by it can be criticized. An analysis, which focuses on constellations and processes, grasps the dynamics of the consequences of socio-technical futures as an element of socio-technical arrangements. We reckon besides the technical ones also the economic, political, social and cultural structures among such arrangements.

3.2   What Must be Taken into Consideration for Deciding About the Analytical Method?

For the practice of research, both analytical dimensions must be connected to each other in a reflected manner. An analysis of "societies in the futures", which rather focuses on socio-technical futures as an object and on their topics and kinds (first dimension), allows for the information of various addressees and for the criticism of particular dimensions of socio-technical futures, such as their normative settings, their focus on a certain technological option and the connected exclusion of alternatives. An analysis of the actual effects (as well as the performative transformation power) of socio-technical futures as a part of socio-technical

arrangements-that is "futures in society" (second dimension)-rather focusing on constellations and processes allows for an assessment and thus for criticism of the production, spread and use of certain socio-technical futures. Only such an empirical analysis allows for identifying socio-technical futures, which are momentous for innovation and transformation processes and are therefore relevant for TA.

The methods and procedures which might be applied are various and not at all new. Rather, there is a broad range of methodically structured analytical methods. For quite some time now, TA has been applying many different methods for its analysis of ideas about the future, such as vision assessment, scenario analysis and guideline assessment. According to what is necessary for a project, many of these theoretical concepts and methods are adopted and adjusted from other fields of practical work and sciences. Some of these fields might be STS, research on guiding visions, development of methods in sociology, philosophy, historical science, linguistic and cultural studies when it comes to the analysis of visionary discourses, collective expectations, models, symbols, metaphors, visual images, myths or also to the utopian contents of ideas of the future.

Basically, for the two dimensions of analyzing socio-technical futures, the same applies as for any reflected use of methods: the choice and combination of methods must be oriented towards the subject (e.g., the kind and nature of a socio-technical future), the goal of the respective study and its questions. According to the subject of "socio-technical futures", the qualitative methods of the humanities and the social sciences (e.g. from topical and discourse analyses via methods of field research as far as to constellation and process analyses) are in the fore. According to subject, other methods, such as from the cultural studies or economy, may be turned into a fruitful input for the analysis of socio-technical futures. Due to the complexity and variety of possible socio-technical futures (their kinds, places to have an effect, contexts etc.), the choice of methods requires reflected creativity.

4 How Could TA Situate Itself as an Actor of the Processes Under Analysis?

4.1 In Which Changing Contexts are Analyses Carried Out by TA?

TA's reflexive dealing with socio-technical futures requires a *contextualization of TA* within those constellations and processes of the current and changing society it is itself active in. Socio-technical futures have always been playing a role in

the development and innovation processes TA deals with. They fulfil their tasks in the present, for example, as to organizing, adjusting, coordinating and communicating actor groups, that are dealing with a particular technological development. This means socio-technical futures have communication, coordination and motivation functions in the present. Accordingly, TA has been dealing with these functions already in the past, such as by its assessments of guiding visions. These days, however, a growing attention of and an increasing demand for socio-technical futures can be observed. This comes along with an expansion of far-reaching discourses on the future (concerning the chronological range and the spatial extent of statements on the future). This affects the self-location and self-reflection of TA, regardless whether it deals with far-reaching socio-technical futures or, as in the past, with closely and functionally limited socio-technical futures.

Thus, in many of the fields of technological development TA deals with, on the one hand an *expansion of far-reaching discourses on the future* can be observed. This does not only apply for NEST, but also for great transformations such as energy transformation, measures against climate change, big data etc. Technological future expectations are often not limited to expectations concerning functionality or the actual usefulness of individual technologies (such as, in the past, computer-aided-design-technology). Rather, socio-technical futures are communicated (in the form of visions, guiding principles, scenarios) which demand or require global, cross-generational changes (e.g., because they concern wide parts of society instead of only limited groups of users). Thus, these socio-technical futures describe much more than only technological innovations in the stricter sense, they promise radical change and transformations which might affect wide parts of the society. Thereby, these discourses on the future are far-reaching, not only due to the periods of time they address, but also when it comes to the consequences they envisage. On the other hand, this expansion comes along with politics, business, civil society and research paying *increasing attention* to socio-technical futures. In our current, technologized society, socio-technical futures are an essential element of the debate on the future of society.

Comprehensive innovation processes are made possible by the positions taken by very different social actors and their networks, in which TA itself is an actor. Its dealing with socio-technical futures plays a functional role in this context. This gets complimented by the fact that actors and addressees become more pluralized and differentiated by socio-technical futures and for the purpose of them. Constellations in the case of NEST (such as nanotechnology) or big data can serve here as examples, where socio-technical futures have the function of attracting attention, of negotiation, of coordination for the purpose of construing new

fields of innovation to exploit great technological and economic potentials. Other constellations in which socio-technical futures become relevant and rather enable social movements are for example new ways of collective production (e.g., open source, open design) or the enabling and integration of real experiments including both experts and laypeople (such as the energy transformation). All these examples are about socio-technical constellations aiming at transformations, which fundamentally concern the society, both spatially and temporally. In this context, imagined futures play a crucial role as functional elements of the arrangements and processes of transformation; TA's dealing with socio-technical futures is always one element or practice of each overall constellation.

4.2   How Does Contextual Change Affect TA?

The expansion of discourses on the future and the growing attention of politics, business, research and the civil society correlates with a higher demand for visions and scenarios of future societal potentials of technology (e.g., when it comes to the socio-technical challenges of energy transformation). This becomes obvious by the increased activities of the strategic development of visions ("visioneering") and foresight methods, such as roadmaps and multi-dimensioned scenarios. In this changed context, TA's dealing with socio-technical futures becomes more important than before: on the one hand, TA is demanded to not only deal with limited socio-technical futures oriented at certain contexts (such as guiding visions for development), but also with so called far-reaching socio-technical futures. On the other hand, by its dealing with these futures, TA supports political guiding principles and programs. In this context, critical TA, is able to do critical agenda setting and to influence its context.

By way of its analyses and assessments of socio-technical futures, the research and advisory performance of TA-intended or unintended-contributes to modulating the discourses and practices of each respective context. Often this happens in competition with a variety of other actors and concerning unclear addressees of the respective TA expert opinion. These changed practice and intervention contexts of TA make obvious that it cannot play any non-situated, neutral role. Due to its dealing with the socio-technical futures of each respective context, TA obviously contributes to changing, thus modulating, these socio-technical futures and their consequences. If these influences are perceived as positive or negative, depends on each respective context and the self-reflective orientation of the respective TA practice.

The change of its contexts implies a more self-reflective concern by TA for its own role as an actor within the process while dealing with socio-technical futures. It also requests improved theoretical, methodical as well as empirical foundations (see Sect. 3). This requirements must be complied in order for TA to systematically understand and, accordingly, to critically orient its own statements on and assessments of socio-technical futures. For its clients and due to the growing awareness of socio-technical futures, TA as a service provider is demanded to identify more and more options for the future, to analyze and assess them, as well as to contribute to their production and to moderate processes of negotiating socio-technical futures. The clients expect TA to judge on long-term promises articulated in the form of visions. Whereas, spatially and chronologically far-reaching socio-technical futures have the effect that indeed not technology, but the society and its change becomes more than ever a topic and subject of TA (such as energy transformation, grand challenges). In this situation, TA can and must analyze socio-technical futures (incl. those, to whose shaping it contributes) as an expression and projection of current societal states. TA must be able to assess and criticize them concerning their consequences as well as their performative power when it comes to changes of those fields of society being affected by the relevant innovation processes.

4.3   How Does TA Situate Itself Between Support and Criticism of Socio-Technical Futures?

TA cannot avoid explicitly positioning itself-or being positioned by others-in the area of tension between critical assessment, on the one hand, and the support of certain socio-technical futures on the other hand. However, precisely this provides an opportunity, by way of critical assessment and a methodically-theoretically reflected dealing with socio-technical futures, by way of persistently emphasizing its current functions to point out exaggerated expectations and excluded alternatives as well as to question both power constellations and tacitly assumed normality. The task of such a TA of socio-technical futures is not only the assessment of technological functionalities and consequences, but informing about and criticizing societal processes as well as contributing to shaping them in a reflexive manner. This way, TA becomes an actor of the process who, by means of dealing with and insisting on socio-technical futures as an expression of current society and their effect on the development of the society, allows for a transparent assessment and comprehensible contribution to the shaping of futures. Most of all, such a present time-related dealing of TA with socio-technical futures protects

from a thoughtless belief in certain socio-technical futures, as the only options for problem-solving and innovation. This position provides the basis for the reflected and critical moderation and also the co-shaping of those socio-technical futures, which are demanded under the conditions of each respective context.

From the implementations of its analyses about the current significance and function of socio-technical futures, result for TA, *as a research practice*, new knowledge desiderata. For classical TA, as the assessment of the consequences of limited technological developments, those desiderata were yet not necessary to this degree. Here, among others, comprehensive knowledge stocks of innovation research, STS, governance research, foresight studies and cultural studies have to be mentioned, whose inclusion must be achieved by increasing convergence and cooperation with the relevant sciences. The same applies for the implementation of the dimensions outlined under Sect. 3; it requires an improved integration of analytical knowledge and methods of linguistics, cultural studies and social sciences as well as philosophy to be able to empirically, functionally and critically analyze socio-technical futures by their current significance and effects, also in the context of extensive innovation and transformation processes. Furthermore, extensive practical skills are required in cases when the research practice of TA, as participatory and constructive TA (pTA; cTA), connects immediately to the practice of advice and shaping.

For *TA as an advisory practice* arise new demands to be able to derive advice-relevant knowledge from the knowledge of socio-technical futures; even more as there is a great number of potential addressees of TA expertise, from parliaments, scientists via civil society actors as far as to various publics. Accordingly, one must not only reflect on the question of which kind of knowledge is relevant for each advised actor, but also on the question of what might be the consequences of advisory practice in each respective constellation of actors. In this sense, TA opens up towards other kinds of expertise, also concerning its own production of knowledge, and welcomes the actors themselves to participate in the analysis process, not only as those seeking advice, but also as producers of knowledge. As pTA, it purposefully not only puts its knowledge and methodical expertise in the service of politics, but also enables civil society actors as well as the democratic public to reflect on socio-technical futures. With all its advice practices, however, TA must critically question which institutional, organizational, systemic, discursive, practical limitations the advisory practice in each respective constellation of innovation processes is subject to.

For *TA as a practice of the design* of socio-technical futures results that it must be more aware of its role as a modulating TA in the context of innovation and transformation processes. At the practical level, this implies that the analytics

suggested by this paper must also be applied to its own practices of generating socio-technical futures (such as the development of scenarios, strategic visioneering in the context of foresight, integrated and process-accompanying development by cTA and pTA). This knowledge "of oneself" might serve TA for making a more effective and more strategic use of its critical expert opinions, thus situating itself within the multitude of future-related practices. The new attention economies in the changed contexts of innovation and transformation processes require the invention of new practices of advice and communication and thus of practices of critical shaping.

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