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Technology Assessment as Constructive Design and Governance

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Technology Assessment (TA) aims to support the designing and shaping of technology in society. TA is supposed to "to reduce the human costs of trial and error learning in society's handling of new technologies, and to do so by anticipating potential impacts and feeding these insights back into decision making, and into actors' strategies" (Schot & Rip 1997, 251). TA practices are intended to create, communicate and apply knowledge about and reflection on the potential and actual interaction of (new) technology and societal actors and forces.[1] The TAMI project, a joint effort of European TA agents to summarize the state of the art of TA, offered the following overarching definition: "Technology assessment is a scientific, interactive and communicative process which aims to contribute to the formation of public and political opinion on societal aspects of science and technology." (TAMI project 2003, 4)

First concepts of TA were developed in the US at the end of the 1960s. At that time a need to assess the potential, normally unexpected negative effects of new technologies was perceived which led in 1972 to the creation of the Office of Technology Assessment (OTA) as a research based service and early warning mechanism of the United States Congress; OTA worked for more than twenty years with quite some success; 1995 it was closed down by a Republican majority in Congress (Smits et al. 2010; Smits and Leyten 1991). The OTA served as a model for various forms of parliamentary TA services established in European countries, directly or indirectly linked to parliamentarian decision making (such as in the UK, Germany, Denmark, the Netherlands or Switzerland).

Since the late 1990s TA concepts have increasingly adopted a *dedicated design ambition*. In the meantime, there is a considerable variety of TA approaches such as Expert TA, Participatory TA, Interactive TA, Rational TA, Real-time TA, and Constructive TA (CTA).

In particular CTA aims to understand social issues arising with new technologies and to influence design practices. This development has been driven by three independent but interrelated forces: (1) after the nuclear and computer technologies of the 20th century, today *new and emerging technologies* are again attracting our attention, such as nanoscience and technology, life sciences (e.g. genomics), characterised by a considerable heterogeneity of related knowledge bases, new forms of interdisciplinary exchange (e.g. "translational research" in bio-medicine) as well as generic fields of

[1] Since the early days of TA experts have uttered a dedicated design ambition, see e.g. Coates 1975; Bimber and Guston 1997; Rip et al. 1995; Smits et al. 1995. This holds even more for most recent TA works such as Robinson (2010) or te Kulve (2011).

application with potentially far reaching effects in economy and society. (2) more than in earlier days TA experts feel confident to be able to cope with the Collingridge-dilemma (Collingridge 1980), i.e. they see a good chance to effectively *shape technological development* already at early stages, before design and societal embedding have become irreversible. This hope draws not at least on insights of international interdisciplinary science, technology and innovation studies (STIS): Today we dispose of a good socio-economic understanding of innovation processes (e.g. Dosi 1982), framed by long-term specific technological, economic, social, political, cultural „regimes" (Nelson and Winter 1977; 1982; Rip and Kemp 1998), stretching across multi-level systems (e.g. Geels and Schot 2007), shaped by specific forms of grown *de facto* governance. The better one understands these interrelations the more likely and robust a prospective „modulation" of technological developments will become (z.B. Rip 2006). (3) As a third force we see, at least in Europe, since the late 1990s, a growing interest in TA concepts drawing on *participatory* elements in the design of new technologies, now conceptualised as process of innovation: „Users" are interfering in innovation (e.g. Oudshoorn and Pinch 2003; von Hippel 2005; Oost et al. 2008) – think of the enthusiasm of Linux-based open domain software communities, or of the dedication of voluntary contributors to the various Wiki-databases.

On such grounds a „realistic", i.e. a modest though dedicated design ambition towards technologies can emerge: If in today's polyvalent society literally "everything goes" – why shouldn't it be possible to design and shape technology in an explicit and at the same time reflexive way?

The present chapter[2] will sketch a dynamic concept of TA – with a focus an CTA – and its contribution to the governance of technological innovation. A constructivist and reflexive TA concept will be suggested: Informed by heuristics-based analyses CTA will be presented as modulating ferment in the social process of technological innovation and as a building brick of its emerging *de facto* governance. Finally we will suggest the metaphor of TA as a dance of three elements:[3] The „practice" of technological innovation, the „theory" of science, technology and innovation studies, and the „policy", i.e. public and private governance ambitions.

New Attention for the Design and Governance of Science, Technology and Innovation

Increasingly politicians, industrial actors, societal groups and technology experts are concerned that inappropriate attempts at steering will hamper the realisation of desired effects of technological innovation. In the past, all too often technological development followed the model of "Economics of technoscientific promise" (Felt et al. 2007): Promises to industry and society, often far reaching, are a general feature of

[2] The text draws partially on Kuhlmann 2010 and 2007, and Rip 2008.

[3] See also Kuhlmann 2007 and Smits and Kuhlmann (2004). The dancing metaphor has earlier been used by Arie Rip (1992) with respect to the relation of science and technology, inspired by Derek de Solla Price's discussion of this relation (1965).

technological change and innovation, particularly visible in the mode of governance of emerging technosciences: biotechnologies and genomics, nanotechnologies, neurosciences, or ambient intelligence, all with typical characteristics: They require the creation of a fictitious, uncertain future in order to attract resources, financial, human, political, etc. They come along with a diagnosis that we are in a world competition and that we (Europe, the US, etc.) will not be able to afford our social model if we don't participate in the race and become leaders in understanding, fuelling, and exploiting the potential of technosciences: The model "works with a specific governance assumption: a division of labour between technology promoters and enactors, and civil society. Let us (= promoters) work on the promises without too much interference from civil society, so that you can be happy customers as well as citizens profiting from the European social model" (Felt et al. 2007, 25). Under this model of technoeconomic promises politics, science and industry take the lead, while the innovation needs and expectations represented in the society appear to remain in a rather passive consumer role.

Felt et al. (2007) suggest as an alternative model the "economics and socio-politics of collective experimentation", characterised by emerging or created situations which allow to try out things and to learn from them. The main difference with the other model is that "experimentation does not derive from promoting a particular technological promise, but from goals constructed around matters of concerns and that may be achieved at the collective level. Such goals will often be further articulated in the course of the experimentation" (Felt et al. 2007, 26f). This model requires a specific division of labour in terms of participation of a variety of actors, investing because they are concerned about a specific issue (see also Callon 2005). "Users matter" in innovation – that has been shown not in the least by our UT colleague Nelly Oudshoorn and her team (Oudshoorn & Pinch, 2003). Examples of such demand- and user driven innovation regimes include the information and communication sector (where the distinction between developers and users is not sharp), sports (e.g. von Lüthje et al. 2005) or the involvement of patient associations in health research (e.g. Rabeharisoa & Callon 2004) and pharmacogenomics (e.g. Boon et al. 2007). The concept of 'open innovation', debated around the user-driven development of non-patented Open Source software, and more generally in Hank Chesbrough's influential book (2003), is largely overlapping with the collective experimentation concept. The governance of such regimes is precarious since they require long-term commitment of actors who are not always equipped with strong organizational and other relevant means, and there is always some room for opportunistic behaviour. Nevertheless, the promise is innovation with sustainable effects.

Constructive Technology Assessment

So we are in need of a governance of technological innovation which is building on exchange, debate, negotiations and cooperation between companies, science, civil society and political system. Which role can TA adopt in this setting?

Which TA? Smits et al. (2010; Smits und Leyten 1991) differentiate watchdog TA and tracker TA. Watchdog TA is supposed to fulfil an early warning function for political decisionmakers. Related projects are often conducted by centralised (parliamentary) TA agencies. Actors in the innovation process don't play an active role in watchdog TA. . Tracker TA, on the other hand aims to proactively interfere in the process of technology development and design.

Technology Assessment understood as constructive design process (CTA) starts from the assumption that actors involved in technology development can find themselves to two basically different positions: as insiders or outsiders to the development process. Garud and Ahlstrom (1997) suggested to differentiate the positions of "enactors" and "comparative selectors": Enactors are technology developers and promoters aiming to enact new technology; they "construct scenarios of progress, and identify obstacles to be overcome. They thus work and think in 'enactment cycles' which emphasize positive aspects" (te Kulve 2011, 31). Comparative selectors, on the other hand, observe technological development process from the outside and may be in a situation to compare the enactors' offers and performance with other, parallel developments. There are professional comparative selectors (such as regulatory bodies like the US Food and Drug Administration) using professional tools for their assessments, and amateur comparative selectors (such as critical consumers and NGOs, the latter increasingly turning professional) (te Kulve 2011, 32). Enactment cycles and comparative selection cycles and interfere in 'bridging events' (Garud and Ahlstrom 1997) with insiders and outsiders interacting. Such interaction may lead to variations in the technological design process and can have an impact on the direction of selection decisions. Such bridging events "can be constructed on purpose, by actors from enactor or selector positions, and by more disinterested actors such as Constructive Technology Assessment (CTA) agents" (te Kulve 2011, 33).

CTA agents start from the assumption that enactors and selectors of new technology make assessments all the time, so rather than making assessments (by TA agents) CTA aims to create and orchestrate bridging events as dedicated "spaces" for interaction, learning and reflection(Rip and te Kulve 2008). Both enactors and selectors can undergo first-order or second-order learning processes: According to Argyris and Schön (1978) first-order learning links outcomes of action to organisational strategies and assumptions which are modified so as to keep organisational performance within the range set by accepted organisational norms. The norms themselves remain unchanged. Second-order learning concerns inquiries which resolve incompatible organisational norms by setting new priorities and relevance of norms, or by restructuring the norms themselves together with associated strategies and assumptions, hence escaping tunnel vision and crossing borders.

CTA agents, in order to create dedicated spaces for first and second-order learning, organise interactive workshops, often enriched by the elaboration of alternative socio-technical scenarios, stimulating the debate of participants (see box TA Methods). Such scenarios "capture ongoing dynamics and develop assessments of future developments. They show the effects of interactions between enactors and selectors which provides more substance to interactions in workshops as actors can draw upon the scenarios for inspiration" (te Kulve 2011, 34).

TA Methods (source: TAMI project, 2003, 48-49)

Scientific methods include the "Delphi method, expert interviews for collecting expert knowledge, modelling and simulation, cost/benefit-analysis, systems analysis, risk analysis, material flow analysis, trend extrapolation, scenario technique for creating knowledge to think about the future (…), discourse analysis, value research, ethical analyses, value tree analysis".

Interactive methods include "consensus conferences, co-operative discourses, public expert hearings, focus groups, citizens' juries are belonging, currently in part supported by using electronic media".

Communication methods: include "newsletters, opinion articles, science theatre, (interactive) websites and various types of networking".

This interfering character of CTA, nevertheless, requires an explicit understanding of the room for manoeuvre of the involved actors – up to now a weak point of CTA concepts. To which extent can the participants effectively manage or steer the development, variation and selection processes? So the "governance" context of CTA-supported design processes needs to be explored and understood; governance means the coordination and control of autonomous but interdependent actors either by external authority or by internal mechanisms of self-regulation or self-control (Benz 2007, 3). This is of particular relevance when it comes to the development and design of new and emerging technology: the potential areas of application, the markets, the concerned actors and audiences, and the dimensions of potential effects are still in flux; political arenas, decision criteria and policy means are not yet determined.

Governance: CTA and Design in an Institutional Context

CTA and technological design are embedded in „inherited" economic and institutional environments. Any realistic attempt to shape technological design effectively has to understand the driving forces and hampering factors of this institutional context.

The school of evolutionary-economic analyses of technology dynamics offers a useful heuristic for this purpose. It is built on the findings of "innovation studies", in particular on the seminal work of Nelson and Winter (1977; 1982): In „search of a useful theory of innovation" and convinced of the stochastic, evolutionary, an organisationally complex and diverse character of innovation, the authors observed different technological "regimes" characterised by longstanding specific "search strategies" of engineers, determining to some extent he development trajectory of a given regime. Drawing on this basic observation other authors have defined technological regimes as "the complex of scientific knowledge, engineering practices, production process

technologies, product characteristics, user practices, skills and procedures, and institutions and infrastructures that make up the totality of a technology" (Van den Ende und Kemp 1999, 835). Rip and Kemp (1998) added to the „grammar" of a regime explicitly the public and private strategies and *policies* of relevant actors: Technology is conceptually and as artefact socially constructed, including the governance of a regime.

Finally, these conceptual elements were combined in the heuristic of a „multi-level-perspective" on socio-technical transitions (e.g. Geels and Schot 2007, characterised by niche innovations on a micro-level (developing in emerging or created and protected incubation spaces), socio-technical regimes on the meso-level, and wider socio-technical landscapes on the macro-level (macro-economic, cultural and macro-political developments). Studied with the help of this heuristic one can see regime transitions, sometimes incremental sometime radical, sometimes driven by basic changes in the overarching landscape, or stimulated through niche innovations undermining dominant regimes (see exhibit 1).

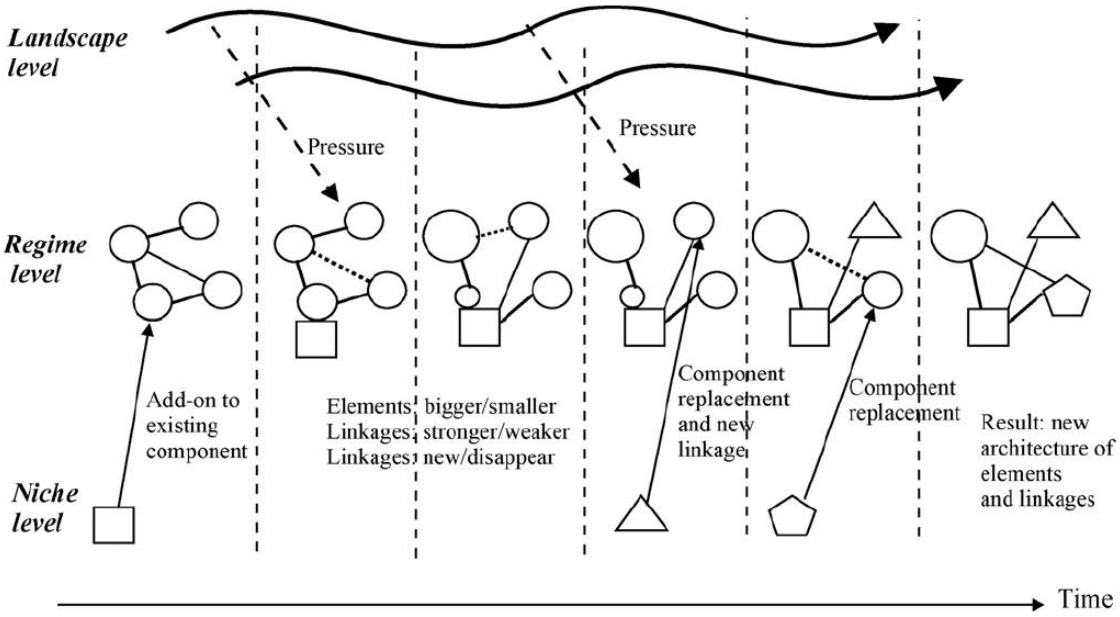

Exhibit. 1: Schematic presentation of reconfiguration of a technological regime (Geels and Schot 2007, 412).

Such transition processes are fuelled by promises and expectations about technological options and innovation (van Lente 1993). Actors anticipate and assess their options vis-à-vis changing regimes and create de facto new patterns of (Rip 2001) which can trigger "*irreversibilities"* (Callon 1991) resulting in "*endogeneous futures" (*Rip 2001). In other words, the analysis of the transition of socio-technical regimes offers a heuristic helping to open-up the allegedly fatal transition point of the Collingridge-Dilemma for empirical

research. This holds also for the governance of technological developments in a regime context: We understand better the options and limitations for dedicated shaping.

Here it is useful to clarify the underlying concept of "governance": The concept is used here as a heuristic, borrowed from political science, denoting the dynamic interrelation of involved (mostly organized) actors, their resources, interests and power, fora for debate and arenas for negotiation between actors, rules of the game, and policy instruments applied (e.g. Kuhlmann 2001; Benz 2007). Governance profiles and their quality and direction are reflected not at least in the character of public debates between stakeholders, policy makers and experts. Think of the debates on genetically modified organism (GMO), or – still more in status nascendi – debates on the governance of an emerging, cross-cutting STI filed like nanotechnology (e.g. Joly and Rip 2007).

Which leeway do actors in a given regime actually have? One has to understand the *de facto* governance of a given social contex. Conceptually we can draw here upon the „actor-centred institutionalism" of (Mayntz and Scharpf 1995; Scharpf 2000). The *de facto* governance of socio-technical regimes can be analysed as a web of cognitive, normative and regulatory rules. Actors have to cope with these rules; while inevitably reproducing them they can also incrementally change them through deviating behaviour. In the context of emerging socio-technical regimes actors cannot achieve more (but also not less) than shape what will happen anyway, while at the same time rules are being transformed (Rip 2008).

Against this background TA, in particular CTA, can be understood as a modulating factor of the de facto governance and of the co-evolutionary development of a regime. The better we have understood the de facto governance in a given regime, the more can CTA in a realistic and constructive manner modulate technological development and design. CTA as a means of reflexive governance is aware of the limits of dedicated governance; this awareness is even a strategic underpinning of its ambition (Voss et al. 2006; Rip 2006).

CTA as dance: Strategic Intelligence, the Role of Studies and Fora

CTA as a means of reflexive governance aims to make the diverging perspectives and interests of relevant actors visible and debatable aiming to increase the learning capacity. Here we suggest the metaphor of a *dance of "practice", "policy", and "theory"* (see exhibit 2); they can be seen as partners on a dancing floor, moving to varying music and exposing different configurations.

"Theory" is represented by the arsenal of dedicated and methodologically rich Science, Technology, and Innovation Studies (STIS)[4]. The above sketched multi-level analysis of regime transitions is of particular value for the application of CTA as a means of reflexive governance (e.g. Konrad et al. 2008; Markard and Truffer 2008). As a dance partner STIS (theory) is moving about in a constructivist and reflexive manner (Robinson 2010), analysing the perspectives and interests of the other dance partners and reflecting on the own position (sometimes even changing own beliefs): CTA becomes a means of reflexive governance.

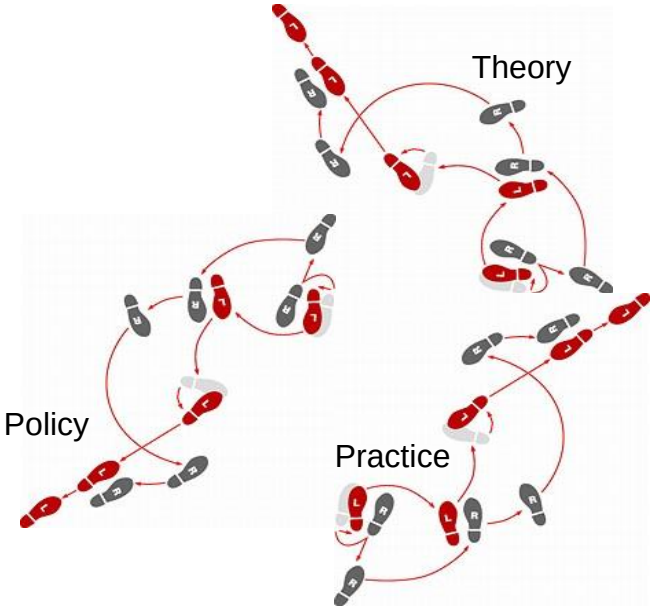

Exhibit 2: Dance of „Practice", „Policy" and „Theory" (Kuhlmann 2007)

The "dance floor" for CTA can be conceptualised as a "forum", defined as institutionalised space specifically designed for deliberation or other interaction between heterogeneous actors with the purpose of informing and conditioning the form and direction of strategic social choices in the governance of science and technology (see exhibit 3, and Edler et al. 2006). A forum can draw upon 'Strategic Intelligence' (SI). SI has been defined as a set of sources of information and explorative as well as analytical (theoretical, heuristic, methodological) tools - often distributed across organizations and countries - employed to produce useful insight in the actual or potential costs and effects of public or private policy and management (Kuhlmann et al. 1999). Strategic intelligence is "injected" and "digested' in fora, with the potential of enlightening the debate. SI can draw on semi-public intelligence services (such as statistical agencies), on 'folk' intelligence provided by practitioners, and in particular on STI Studies.

[4] For an overview see Silbey 2006; Hackett et al. 2007; Fagerberg et al. 2006. Scientific journals such as *Research Policy* (rather economics-oriented) or *Science, Technology, & Human Values* (rather sociologically oriented) enjoy a high reputation.

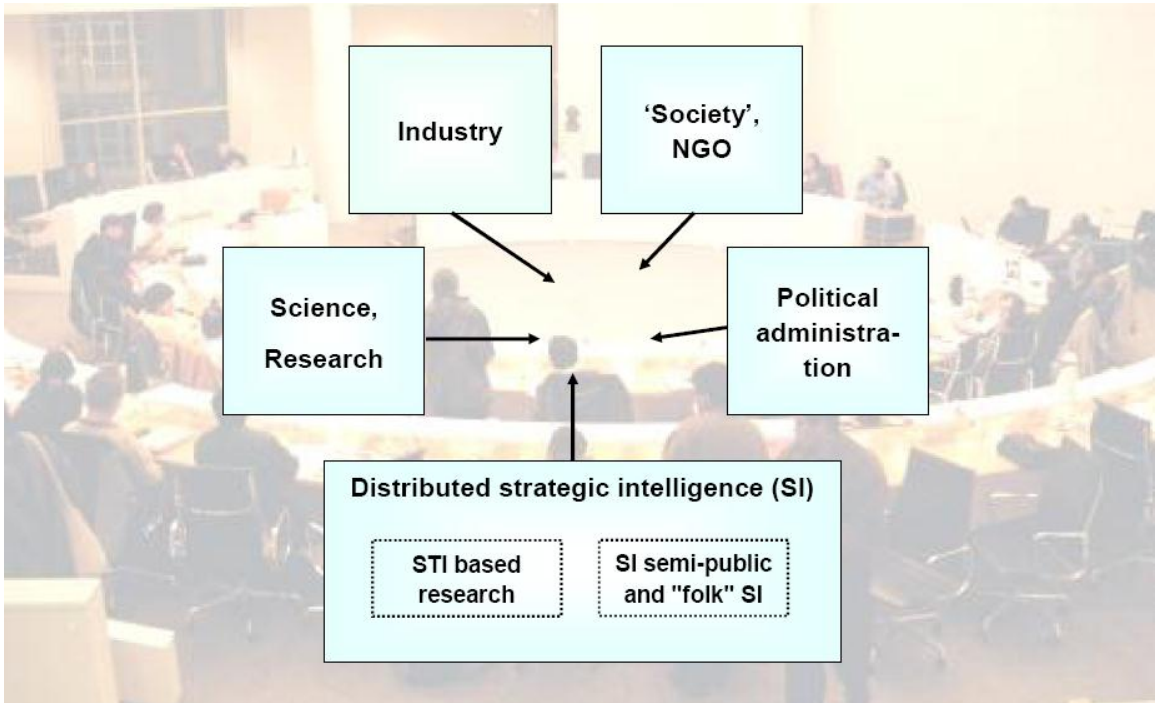

Exhibit 4: Forum for the deliberation of socio-technical themes (Kuhlmann 2007)

CTA and Reflexive Governance as Solution? Open Questions

Today Constructive TA is using a broad spectrum of scientific, interactive and communicative methodologies and Strategic Intelligence instruments in order to modulate on various fora the *de facto* governance of technological development and design, aiming to increase the learning capacity and reflexivity of involved actors (enactors and comparative selectors). Examples include the targeted mobilisation of "users" and the creation of "niches" as protected space for experimentation (e.g. Kemp et al. 1998), using inter alia consultation processes and scenario-workshops (z.B. Elzen et al. 2004; Stemerding and Swierstra 2006; Robinson 2010; te Kulve 2011).

Still one can question the practical relevance of CTA as a dance of Practice, Policy, and Theory in the daily life of industrial design practices. Is this, at the end of the day, more than just a dream of concerned idealists? After all, CTA is just one among many factors driving the actual socio-technical development. And there is a severe risk that TA plays just a symbolic role in the game. There is no final answer to such questions. But one thing is clear: Without the dedicated political will of leading actors in science, technology, industry, politics and society there will be no reflexive Technology Assessment as constructive design practice and governance.

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