The Past and Future of Constructive Technology Assessment

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ABSTRACT

Constructive technology assessment (CTA) is a member of the family of technology assessment approaches, developed in particular in the Netherlands and Denmark. CTA shifts the focus away from assessing impacts of new technologies to broadening design, development, and implementation processes. Explicit CTA has concentrated on dialogue among and early interaction with new actors. The idea has been taken up by actors other than governments (consumers, producers). CTA implies a modulation of ongoing technological developments, and an understanding of the dynamics of such modulation is used to identify and briefly discuss three generic strategies for CTA: technology forcing, strategic niche management, and loci for alignment. Modulation activities are to be located in the broader issue of how our societies handle new technology at all. The established division of labor between promotion and control should be mitigated by sociotechnical criticism. This underlines the need for reflection on role and value profile of CTA agents. © 1997 Elsevier Science Inc.

Introduction

In the three decades since the first articulation of technology assessment (TA), a whole family of TA approaches has emerged. Smits, Leyten, and Den Hertog [1] distinguish awareness TA, strategic TA, and constructive TA. Grin and van der Graaf [2] emphasize interactive TA, a more symmetrical version of what used to be called participatory TA [3]. This family of approaches is characterized by its commitment to what we see as an overall TA philosophy: 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.

One member of this family of approaches is constructive TA (CTA), which originated in the mid-1980s in the Netherlands. In the 1984 Policy Memorandum on TA [4] the interest in constructive approaches is clear, and the term constructive is used regularly. In 1987, the Netherlands Organisation of Technology Assessment (NOTA) published a background study on CTA [5]. Since then, policy makers, commentators, and researchers in various countries have taken up the concept of CTA and further articulated it. As
a result, CTA has a diffuse and emerging character, allowing each participant in the articulation process to emphasize different aspects. At the same time, however, there is a general recognition of the overall thrust of CTA: to broaden the design of new technologies (and the redesign of old technologies). Feedback of TA activities into the actual construction of technology is crucial, and strategies and tools contributing to such feedback make up CTA. Such strategies and tools can range from dialogue workshops and social experiments, to technology forcing programs and platforms. One can now speak of a paradigm of CTA to indicate the combination of the widely shared diagnosis of the need for broadening of technical design and the exemplary experiences available [6].

The aim of this article is to present and evaluate what has happened already under the label of CTA and to discuss the future of CTA. In the second section, we describe where, how, and why the idea of CTA was formulated and how it was taken up. In the third section we evaluate how far CTA has evolved. The future of CTA is addressed in two ways: in the fourth section we discuss three generic strategices to implement CTA; in the fifth section we argue that CTA (and TA generally) is never just a tool or a particular kind of policy analysis. It is always also part of the “politics” of managing technology in society. Managing must be taken here in a broad sense, referring to patterns in the actions of actors responding to an evolving situation. This makes it clear that CTA analysis and action must reflect on its wider implications, and in the fifth section we use the Luddite actions against textile machines in the early 19th century as an example. Luddite actions are often misperceived as a conservative reaction to technical innovations. We point out their intent to integrate societal concerns in technical change and argue that their form of socio-technical criticism is reincarnated in constructive TA. In the sixth and last section we address the question of who decides which ways of handling technologies are best, and suggest that CTA agents might do well to develop a competence in irony.

The Past of Constructive TA

The Dutch policy Memorandum of 1984 [4] positioned itself as being part of a new phase of TA, where TA is linked to decision making (as exemplified by the approach of the U.S. Office of Technology Assessment [OTA]) and is also embedded in broader political and societal processes of articulation of opinions and decisions about scientific and technological innovation. Accordingly, the Memorandum formulated an overall goal for this new TA (the label CTA was not used in the Memorandum, nor any other): broader decision making about science and technology in society. “Broader” must be taken here as referring to the substantial criteria taken into account in technological development, as well as referring to the groups, organizations and institutions involved. The Memorandum argued that the function of TA studies should be to let societal aspects become additional design criteria.

In the Netherlands, one result of the Memorandum was the establishment, in 1986, of the Netherlands Organisation of Technology Assessment (NOTA), now called

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The emphasis on construction explains why the development of CTA has been guided by (and was closely linked to) the development of technologies studies. This is far less the case for other branches of the TA family, that have been influenced by other disciplines and interdisciplinary fields. CTA needed a theory on technology dynamics for identifying feedback mechanisms. In addition, research on CTA (feedback processes and use of tools) will help sharpen insights about technology dynamics.
NOTA developed its ideas on new and broader TA through several projects, evaluations, and studies. In retrospect, it is possible to see two paths emerging. One path, becoming dominant, focused on stimulating discussions and analysis that would contribute to a social debate and the articulation of political opinion (in Parliament) [7]. The Rathenau Institute used several methods for organizing a broader debate, among others the public debate based on the Danish model of consensus conferences [8]. In a public debate, a panel of citizens, recruited through advertisements in the newspapers, discuss a specific subject with experts in a well-prepared two- or three-day meeting. The outcome is a statement made by the citizen panel containing its judgments and questions for further development. The experts have the opportunity to comment on the final statement. According to the Rathenau Institute, these debates serve a dual purpose: (1) “to introduce the viewpoints of citizens in the process of political opinion forming”; and (2) “to stimulate interest in and discussion on a subject concerning society as a whole” ([9], page 26).

A second path NOTA took is the development of CTA. Among NOTA’s activities oriented explicitly toward CTA, a first step was a background study on CTA [5]. This study was important in identifying opportunities for CTA, in highlighting the importance of what was called “societal learning how to handle new technology,” and in offering concrete recommendations. One recommendation, to devote at least 1% of the funding in every technological innovation stimulation program to TA studies, was adopted in a few cases, for example, in the stimulation program for biotechnology. The results of this first study influenced several NOTA projects. It resulted, for example, in an emphasis on including technology developers and on articulating design criteria in various projects. In its report, “Technology Assessment: To Adjust or to Channel,” published after three years of work in order to present NOTA’s approach, the section on telecommunication TA activities finished as follows: “this programme illustrated that it is quite feasible, and indeed pertinent, that developers of technology enter discussions with other concerned parties in society during the actual designing process and by doing so contribute toward the further development and introduction of the relevant technology” ([10], page 4).

Already in the 1984 Memorandum, the importance of demonstration projects in which construction principles and design criteria are developed was recognized ([4], page 22). This led to a major project set up to stimulate the introduction of environmentally friendly technologies in firms and other organizations, the so-called PRISMA project [11].

In parallel, NOTA continued to invest in further work to articulate the CTA perspective. In 1990, a study was done on how CTA could profit from insights from technology studies [12]. In 1991, an international workshop was supported (together with the Dutch Ministry of Economic Affairs) resulting in a 1995 book publication [6]. In 1995, a study of CTA methodology for biotechnology firms was commissioned [13]. The results of these studies guide our following evaluation of CTA.

CTA was taken up by various other organizations in the Netherlands. For example, the institute for consumer research (SWOKA) developed a procedure, called Future Images for Consumers, for incorporating consumers and their wishes into design processes [14]. The procedure consists of a process of iterative meetings in which room is created for discussions and negotiations on design criteria and visions of both producers...

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2 The other main effect of the Memorandum was the establishment of a Foundation for Public Understanding of Science and Technology, to develop information and public understanding activities itself, as well as fund such activities by others.
and consumers. The method has been tried in such cases as a project commissioned by the Dutch Program on Sustainable Technologies (DTO) on the introduction of novel protein foods which could replace meat in the diet. In a final declaration issued after a third meeting, design requirements for such new foods were stipulated, and market opportunities and possible actions were defined [15]. The DTO program will continue to incorporate CTA elements in its activities as part of its attempts to set up so-called illustration processes of new sustainable technologies [16].

The idea of CTA also influenced the development of technology policy in the Netherlands ([17], page 19; [10], page 11). In several documents, the Ministry of Economic Affairs highlighted the need for a third phase in technology policy that would focus upon improving the societal embedding of new technologies, thus complementing the supply policies emphasized in the first phase and the diffusion policies of the second phase. The newly proposed policy was implemented through: (1) the organization of strategic conferences with a broad set of constituencies discussing new priorities and leading to demand articulation and design criteria; and (2) the stimulation of experiments with new technologies in which citizens participate. An example is Digital City Amsterdam, a project in which citizens experiment with e-mail and Internet, build user competence, and provide input for further technology development. A series of education initiatives also form part of the policy [18].

CTA activities were not developed only in the Netherlands. In Denmark, such activities emerged in the late 1980s when the overall shift to more proactive approaches took up the challenge of feeding TA insights back into technological development and adoption. The form these activities took relates to the Danish political culture where public involvement has always been considered important. Thus, there was and is an emphasis on awareness initiatives [8], on social experiments (e.g., with information and communication technology) [3], and on consensus conferences and dialogue workshops (organized among others by the Danish TA organization) [19, 20]. Most of these activities are not labeled as CTA by their organizers. However, some Danish evaluators of these activities have found this label useful to position the changes that occurred in Danish TA practice because the overall thrust of these activities is aimed at influencing technological design and implementation.

In other countries, CTA activities are present but not labeled as such. Examples can be found in Norway [21] and Germany [22]. In addition, CTA is now discussed in technology policy documents. In an Organization for Economic Cooperation and Development (OECD) report, the emphasis on investment in new technologies is complemented by an argument for a more subtle approach to technology assessment [23]. Under the heading, “towards a broad-based consensus: the role of constructive technology assessment,” OECD considers the role of the state in counteracting externalities of technological change and recommends experimentation with new institutional structures and arrangements (Section J of the Conclusions and Recommendations). For OECD, the term “constructive” indicates the expectation of minimizing mismatches, wrong investments, and possible social conflict, which one can read as a version of our formulation of constructive technology assessment.

In the new R&D programs of the European Union (the 4th Framework Program and the 5th Program in the making), strengthening links with users and an orientation of R&D toward social conditions for innovation can be seen [1]. The same trend is visible in the 1992 report of the Carnegie Commission in the United States ([24]; see also [25], pages 21–26, 167–201). The limitations of supply-driven initiatives are recognized, while the report calls for more interaction between supply and demand.
Attention is paid to the capacity of society to incorporate technological changes and the need to articulate demand and acceptability. The point is made even more forcefully by the economist Soete [26] when he argues that technology policies aiming at promotion and CTA are two sides of the same coin—a strategy for achieving goals of wealth creation, sustainable development, safety, and quality of life. Therefore, as we have argued elsewhere, CTA can thus be seen as part of a redefinition of the boundary between current technology policies and technology assessment [6]. In an action perspective, both aim at promoting technologies that promise to have many desirable and few undesirable impacts.

**CTA Revisited**

How far has CTA evolved? It is not a clearly defined area, as we noted above, and it need not, perhaps, become one. CTA is not simply a management tool. CTA can be seen as a new design practice (which includes tools) in which impacts are anticipated, users and other impacted communities are involved from the start and in an interactive way, and which contains an element of societal learning. This perspective allows us to identify three achievements, and their limitations, of CTA, and to develop more systematically the overall thrust of CTA and what this implies for the future. Thus, we combine a retrospective evaluation of CTA with an articulation of its further potential. It is the latter which we discuss in the next section, when we present generic strategies for CTA.

**THREE ACHIEVEMENTS OF CTA, AND THEIR LIMITATIONS**

Several methods have been developed that, while not exclusive, were particularly suited to CTA. In every TA study, technological developments as well as societal issues, views and preferences need to be mapped. Such “social mapping” [27] is an extension of stakeholder analysis as practiced by OTA. For CTA, it can and should be further extended by mapping the dynamics of technological developments—sociotechnical mapping for short [28]. Other methods relate to anticipatory agenda building, with the Future Images of Consumers Procedure about new technologies, developed by SWOKA and dialogue workshops introduced in Denmark, as two interesting examples.

Methods for early and controlled experimentation with new technologies are increasingly recognized as important, and applied. Such experiments can be seen as forceful sociotechnical demonstrators. They allow the translation of broader societal scenarios and agendas into actual design criteria and other orienters of technological development. Sociotechnical demonstrators embody visions concretely, and the experience with them allows modification of the vision and the technology in one movement. The potential of these methods can be further exploited if the aspect of (societal) learning, characteristic for CTA, is taken up explicitly.

Full-fledged CTA activities in the Netherlands and Denmark, as well as some of the recent technology policy declarations, emphasize dialogue and the articulation of demand and acceptability. This is an important and necessary part of CTA. It leads to (diffuse) societal agenda building for new technology. However, it turns out to be difficult to organize feedback of such societal agendas into actual technological development. There often is no special effort at feedback other than publicizing results and hoping that technology actors will respond. There may well be effects of such exercises, however, for example through diffuse credibility pressure (see the next section), or
when technology actors have a (legitimation) problem that they cannot solve in a usual way (as happened in modern biotechnology).

Semi-governmental (C)TA agents like the Dutch Rathenau Institute and the Danish Board of Technology are well placed to create spaces for interaction and dialogue, and their activities have shown the usefulness of such exercises. Clearly, to come closer to the original goal of achieving better technologies (in a better society), a concerted attempt at feedback into decision making, and strategies of technology actors and other forms of leverage are an important next step. We see this as the future of CTA, and we will develop generic strategies to influence technological developments in the next section.

Interestingly, within the world of technological development, and also with consumer and social pressure groups, de facto CTA activities, in the sense of attempts to broaden design and implementation processes, are increasing. The attempts at concurrent (or simultaneous) engineering, where product development, production, implementation, and marketing are worked on in parallel, instead of sequentially, are sometimes extended to include work on waste management, social acceptance, and adoption. This happens emphatically in biotechnological firms which have encountered legitimation and acceptance problems that they could not solve by traditional means [13, 29]. Environmental pressures have led to so-called integral chain management with its ambition to close material cycles. Accordingly, waste handling activities need to be connected to design and production activities [30]. New networks have been established, such as the European Partners for the Environment, in which NGOs, businesses, governments, and researchers work together in sustainability laboratories to develop new products and processes and define design criteria. Consumers and pressure groups have become interested in building “nexusses” between technological worlds and society [14, 31]. Increasingly, they are asked to participate in “platforms” (established for the introduction of new technology such as high definition TV) and to discuss technological and product options with firms.

What is becoming clear is that there are more CTA agents than the governmental, parliamentarian, and semi-governmental bodies that were the main CTA agents until recently, and they are still the most visible ones. Firms, consumer organizations, and other actors can anticipate and work toward feedback into technological developments, and may well be able to do so more effectively than governmental agents. Thus, it is important to recognize these developments and introduce consumer CTA (cCTA) [14], producer CTA (pCTA) [13], etc. and elaborate the specifics of these approaches.

An additional point is that responsibility for “managing” technology in society, as we call it [6], is not limited to governmental actors. We can develop this point a little further, using a distinction introduced in the background study [5]. Feedback into technological developments is an activity where three kinds of actors are involved. “Technology actors” are those who invest in, and carry, technological developments, and are always the target of CTA activities. Examples of technology actors are firms, some government agencies, national laboratories, and technology programs. Second are “societal actors” who anticipate and try to feed back into technological developments (through regulation, campaigning, educating, etc.). Examples are government agencies and various societal groups, but firms and other technology actors can play this role as well, and thus short-circuit the feedback. Third, there are actors at a meta level. Governments adjudicating among actors are an obvious example. Without the authority of government agencies, meta-level activity still occurs, but it is better described as facilitation and modulation of the interaction between technology actors and societal
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actors. TA institutions could take on this role, but so could government agencies or institutions without an explicit TA mandate.

This implies not only that responsibility for “managing” technology in society is distributed over more actors, but also that the nature of the responsibility is different for different kinds of actors. In a sense, all three kinds of actors are necessary.

THE THRUST OF CTA AND ITS FURTHER POTENTIAL

CTA is built around the attempt to anticipate effects or impacts of new technologies or new projects with a strong technological component. This is a core component of any TA effort. In traditional TA, the technology or the project is taken as given, and thus seen as a static entity. For CTA, the dynamics of the process are central, and impacts are viewed as being built up, and co-produced, during the process of technical change. Many technology studies have shown that impacts are not just passive effects of a given technology on its environment, but are actively sought (or avoided) by technology producers, users, and third actors such as governments, unions, and pressure groups alike [32, 33, 53]. These actors are co-producers of impacts. (This should not be read to imply that we believe all actors have equal access and power in various stages of technology development.)

Co-production processes include anticipation. Technical change is driven partly by the historical experience of actors, their views of the future, and their perceptions of the promise or threat of impacts which will change over time. In turn, technical change generates new impacts when applied to new social settings. These dynamic, multi-actor, and decentralized co-production processes are shot through with assessments. Thus, the situation is not one where TA has to introduce assessment. Assessment occurs all the time, and it is a modulation of ongoing processes of assessment (and feedback) which is in order. This, we claim, is the thrust of CTA.

Modulation of ongoing processes is an empty phrase if one does not specify the goals or criteria that guide modulation activities. Actors have concrete goals, interests, and values. But CTA, like TA in general, should not be partisan and identify with particular actors’ goals and interests. Thus, meta-level criteria for desirable development should be specified [34]. In addition to the core idea of all TA approaches—that it is better to anticipate what happens—there are two other meta-level criteria.

Learning must occur, and it should be broad and deep. Broad learning entails an exploration of possible new linkages between a range of aspects such as design options, user demands, and issues of political and societal acceptability. With deep learning we indicate that both first-order learning and second-order learning occur. In first-order learning, one improves one’s working toward given goals, while second-order learning requires clarifying values and ways of relating values to each other, succinctly called collective value learning by Wynne [35].

Reflexivity is also needed, and for two reasons. First, reflexivity about technology is necessary to avoid falling back in a naive contrast between technology and society, and its attendant proponents-opponents dichotomies [36]. Actors need to be reflexive about co-production of technology and its effects, because this creates opportunities to improve the process. Second, reflexivity is necessary to recognize the different roles of actors in technological development and the need to have all three kinds of actors present.

Reflexivity and learning do not come easily, but even anticipation is more difficult than the ideology of prudence would suggest. Many studies have shown that technology actors do not use the results of TA studies, or even the results of marketing studies
If impacts, even if they are anticipated, are not taken into account in actual decision making, special efforts are necessary. It is the occurrence of such efforts that qualifies the development as a desirable development.

Independent of these issues of decision making, we argue that properties of a technology, artifact, or system are not given beforehand, but they co-evolve with the interactions occurring during development, implementation, adoption, and wider use. Rip and Kemp [33] summarize our understanding of the mechanisms as follows. The co-evolution processes start with novel options against a background of existing technological and societal regimes. With increasing investments (material, social, symbolic), irreversibilities such as sunk investments, lock-ins, and path dependencies emerge. There are patterns in the irreversibilities, but no a priori laws. Interactive processes determine outcomes, and no one actor can be singled out as exclusively responsible. Inversely, no one actor can force the process in the direction he or she desires. Command and control approaches do not work, and modulation is the best one can do.

Some path dependencies are better than others, even if one cannot specify beforehand which ones will turn out to be better. CTA is an attempt to improve our chances to arrive at better path dependencies by broadening technological design and development. The achievements so far, however, are not enough. Societal agenda building has been achieved, but feedback into technological development is not assured. Therefore, it is necessary to rethink the approach of CTA on the basis of our recent understanding of technology dynamics.

Basically, what we want to do is to develop "generic strategies" for CTA. We call the strategies generic because they can be taken up by all actors (although not in the same way). Each actor has its own limitations and opportunities to implement these CTA strategies. In such a multi-actor and decentralized situation, the notion of strategy takes a different complexion. Strategy does not refer to the intentional, almost military approach that boards of firms and some governments appear to embrace. It is like Mintzberg's [38] "pattern strategy": the pattern in the actions of actors responding to an evolving situation, which may become reflexive and consciously worked for.

The Future of CTA: CTA Strategies

Recent insights about technology dynamics allow us to identify three generic CTA strategies: technology forcing, strategic niche management, and stimulation (or creation) of alignment. These strategies have been discussed elsewhere in a preliminary way [33, 39, 40]. We discuss them separately, but note that a mix of the three should be sought for in each particular case in order to stimulate reflexivity, anticipation, and learning.

Inverse Anticipation and Feedback: Technology Forcing

Technology forcing, as an intentional effect of government regulation, seems an attractive option to link science and technology to societal goals. It is the inverse of traditional TA, which takes the technology as given and explores potential impacts. In technology forcing by regulation, desired impacts are stipulated; for example, levels of pollutants in motor car exhaust gases, and technology actors are challenged to come up with technologies that fulfill these requirements. While the term technology forcing was originally used to indicate an effect of government regulation, the approach can be used more broadly.

A good example of technology forcing by a government is the clean air standards set in California in 1988. The state prescribed that by 1998 2% of car sales must be
zero-emission vehicles. While this mandate does not prescribe a specific technological solution, it has become clear that only the electric vehicle will be able to meet the standard in 1998. Government regulation in fact induced a broadening of the existing R&D and technological development activities to include new requirements, in this case the design and production of a zero-emission vehicle. Note that it is not necessary to work through regulation; a procurement program that creates an assured market for a new technology could also have a technology forcing effect. For electric vehicles, this route has been followed in Sweden.3

In general terms, the strategy of technology forcing is to prescribe specifications to be achieved in an authoritative manner. Then, the required technology will somehow be developed. There is a general problem, however: how can a government anticipate what are realistic requirements on technology yet to be developed? Actors may well contest the feasibility of the requirements, and use this as an argument not to work in the desired direction. In addition, in many cases technology forcing is not possible because governments are not in the position and/or not willing or able to formulate stringent standards due to lobbying efforts of pressure groups, lack of societal backing, and other barriers. For example, California standards cannot be formulated by national governments in the European Union because they would be considered barriers to free trade.

While the approach of technology forcing is clear, the actual implementation is beset with problems. The linear dream, of wishes and requirements leading to desired, well-functioning technology, is just that—a dream. It is important to analyze the nature of the difficulties in order to develop technology forcing into a realistic CTA approach.

At the "forcing" side there is an actor (most often a government agency) wanting to get functions realized, at some distance from the actors who should do the realizing. That is, it must be seen as a strategy of a principal or purported principal trying to get agents to do the work. Such a strategy runs into trouble because of lack of information with the principal, lack of power and/or understanding of possibilities with the principal, and counter-strategies of the agents building on these limitations of the principal. The Clean Air Act of the 1970s foundered because of these reasons. The automobile industry argued that they could not meet the standards, and turned this into a self-fulfilling prophecy—with congressional support—when the introduction of the standards was postponed several times [41, 42]. The clean car policy of California in the 1990s has faced the same difficulties, and its goals have also been postponed.

Such delays need not be viewed as only strategic undermining of the right thing to do. They allow repair work to be done which is often needed in cases of moving targets. Technology forcing is played out in and through strategic games, and it actually becomes effective that way. Analysts have argued the governments should act accordingly and follow a "fail-soft strategy" [28, 42]. Governments must be strict, and must be seen to be strict in order to create a technology forcing effect. At the same time, however, if industry shows good faith efforts and still fails to meet the standards, they must not be punished for noncompliance. This is not, however, a simple recipe to resolve the dilemma of how to keep the regulation pressure high while at the same time ensuring constructive reactions from industry. Technology forcers might want to follow the

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3 The Swedish National Board for Industrial and Technical Development (NUTEK) was instrumental in developing a purchasing program through which various fleet operators have formed a consortium and specified product requirements. The consortium invited producers to bid and offered in return a guaranteed sale if they were able to meet the requirements.
suggestion of Schot, Hoogma, and Elzen [40] and combine technology forcing with strategies of niche management and network building.

Even without the struggle between the self-styled principal and the technology actors, the complexities of the technology part of the strategy of technology forcing are sufficient to make a linear goal-setting and implementation approach unrealistic. The technology to be realized depends on sociotechnical linkages (existing and to be created), on path dependencies, and on the peculiarities of adoption and diffusion which determine the actual functioning of a technology. In addition, impacts are dynamic: they are elaborated and evolve across the course of lengthy development and implementation projects. Therefore, even if clear values are present and shared, it is often impossible to identify an optimum strategy beforehand. Thus, even with good faith efforts from everyone involved, success will fail to materialize if the heterogeneity, the historical character of technological development, and the need for experimentation and societal learning are not taken into account [43].

For CTA, it is important to recognize that the strategy of inverse anticipation, that is, technology forcing in the broad sense can also be applied by other actors such as banks, insurance companies, standard-setting bodies, user-firms, and social pressure groups. Of course, such actors have no (or occasionally only delegated) authority to make technology forcing standards mandatory. Still, in particular cases, their action might have substantial impacts, directly or because of actual or potential take up by the government. Insurance companies could prescribe certain technologies in order to limit their risks. Government could be instrumental by developing a strict liability regime for risks of products and processes. (Note that such a regime might also lead to a risk-averse product and process development policy within firms.) Manufacturers using chemicals could impose demands on their suppliers. For example, firms within the food-packaging industry are asking for plastic without PVC; car manufacturers are demanding plastics that can be recycled more easily. Government agencies can take measures to encourage this, for example by making producers responsible for take-back of their products, as is happening in several European countries. Credibility pressure can be reinforced by governments, for example through forcing reporting requirements on firms. The Bhopal explosion in 1984 prompted the U.S. Congress to enact the Emergency Planning and Community Right to Know Act in 1986, requiring facilities to disclose chemical information to the wider public. This caused many firms to implement new environmental and safety technologies, to achieve greater safety, and to be able to tell a better story to the public.

How is technology forcing evaluated from a CTA perspective? It is a way to broaden design, directly (if technology forcing dilemmas are recognized and worked upon) and indirectly through anticipatory and forceful agenda building. This relates to the process of technology forcing, when it leads to a number of iterative explorations of potential impacts of a range of technologies, systems or regimes, and assessment of their desirability. These explorations will influence and modify expectations that guide ongoing technological development. The California zero-emission standard, for example, changed existing expectations about the future of the electric vehicle and eventually led to higher investments in both electric vehicles and other alternatives for reducing emissions substantially. The California initiative turned the electric vehicle from a toy and R&D project with no future, into a marketable product. Around this product a speculative market of early promises and expectations emerged. In this market, expectations about a range of other alternatives (including hybrids, improved gasoline cars, natural gas vehicles) also became better articulated (for more details see [38]). Due to the
rising importance of this market, electric vehicle design requirements were negotiated, included better specifications, were more broadly shared, and were backed by studies and test results.

Thus, through a process of assessments, technology actors are better able to anticipate and accordingly shape their R&D and introduction strategies. Use of tools such as dialogue workshops can be of help. To maintain the characteristic orchestrating aspect of this generic strategy, the forcing aspect should not disappear altogether.

GRADED LEARNING AND FEEDBACK: STRATEGIC NICHE MANAGEMENT

In technology forcing, there is a distance between the forcing actor and the technology developers, and this creates problems for modulating and broadening design processes. One can start at the other end, with the technology developers, and ask how processes of development and introduction can be broadened from the start. We again use government experience, now of agencies developing desired technologies themselves, or having them developed under their direct authority (where the developer is thus directly linked to political authority and accountability), as a stepping stone to articulate a generic CTA strategy.

Governments have tried to help develop so-called alternative technologies. In the energy sector, the development of alternatives such as solar and wind energy were subsidized. Other examples are production technologies developed to enhance workers' qualifications and technology for the handicapped. In all these cases, some successes have been achieved. At the same time, the risk of this "support and subsidy route" has become clear. It can result in technologies with limited societal robustness and/or viability in the marketplace. They continue to need to be protected from the wider world. Governments developing desired technological options themselves may end up with second-rate technology. It can only become competitive through exposure to increasingly demanding environments (which is difficult for a public agent) and/or mobilization of firms to produce such technologies. Immediate privatization and market testing is not a solution, however. An alternative technology needs some protection, a safe niche in an otherwise too harsh selection environment. Too much protection, on the other hand, will only create expensive failures.

Governments developing and introducing new technologies aimed at solving identified problems thus face major dilemmas that need to be recognized as such in order to mitigate them. The key step is ensuring the development of a technology that will be able to survive without government support. The question then is how to ensure a viable technology is developed through a process of learning and constructive assessments and reassessments of the various actors involved. Elsewhere, we have developed the concept of strategic niche management to describe such a process in general terms [40, 44]. Strategic niche management can be defined as the orchestration of the development and introduction of new technologies through setting up a series of experimental settings (niches) in which actors learn about the design, user needs, cultural and political acceptability, and other aspects.

To use strategic niche management as a CTA strategy, the learning component must take precedence over the goals of the technology actor. Learning must be broad (explore linkages) as well as deep (involve first and second-order learning). In the examples studied so far, first-order learning was dominant; learning was limited to a detailing of specific design requirements, user needs, or social acceptance. In addition, these aspects were seen as separate aspects and were taken up sequentially; that is, the technical was optimized before the social and other aspects were considered [29, 45].
Experiments with new technologies occur, and have become regular phenomena in some sectors. But they are often not used to learn about possible new linkages between technology, demand requirements and issues of cultural and political acceptability, nor are such insights fed back into the strategies of actors and used on future occasions.

More action research applying CTA criteria is necessary to develop this generic strategy further. The key point is that anticipation of later phases in the process of graded introduction links the actor, who at first only wants to be successful in introducing a new technology, to broader societal issues and thus forces him to broaden his design and development process.

LOCIS FOR REFLEXIVITY AND FEEDBACK: ALIGNMENT

With the first two generic strategies, the co-evolutionary dynamic of technology and society was modulated from the demand or societal side, and from the supply or technology side, respectively. A third generic strategy (not completely separable from the other two) focuses on the interactions as such and attempts to create and exploit loci: actual spaces, forums, and institutionalized linkages between supply and demand (or variation production and selection environment) offering opportunities to modulate developments.

Several opportunities exist already. First, in the context of TA and CTA actions forums (dialogue workshops, consensus conferences, etc.) have been used as instruments. The process of participating in such forums stimulates anticipation, learning (both in a broad and in a deep sense), and reflexivity. However, most often, these forums are temporary loci, and they are used in a context distant from technology development. Feedback is limited, and the outcomes have little force by themselves.

Second, in the context of technology policy and strategies for firms to get their new products accepted (for example for high definition TV, telework, and specific biotechnology applications), new platforms are created. Evaluations of these platforms have shown, however, that anticipation is often short circuited when attempting to identify the barriers to introduction, while feedback assists in attempts to remove these barriers. Having other actors involved (trade unionists, consumer representatives, environmentalists) is important and occurs in practice, even if primarily for legitimation purposes. Learning is restricted to first-order learning and does not include an exploration of new linkages.

Third, over time regular nexusses have developed between variation and selection, or supply and demand; one example is how test labs and trials have become an accepted activity of the technology developers, rather than sending new products out into the selection environment immediately [31]. Another example is environmental departments within firms, which introduce (or could introduce) environmental criteria into design processes [34]. When a nexus has become institutionalized, learning shifts from the issue of how variation and selection can be linked, to learning how to handle specific technologies within the nexus. The institutionalization of the nexus makes it forceful, but it may also create barriers to further broaden the design and development processes.

To be able to use the platforms, dialogue workshops and networks and other nexusses as a generic CTA strategy, further steps are necessary. The present examples are either too distant from design or too much a part of technology-push introduction strategies. To make them really effective for CTA, they should function as negotiation spaces in the sense of Staudenmaier's [46] critical analysis of modern technology as increasingly being developed in top-down systems approaches which push the alternative approach—negotiation—to the margins.
What becomes clear from this argument is that CTA strategies have to function in modern societies which have their own dynamics, and will thus depend on these dynamics for their success. On the other hand, these dynamics need not remain the same, and CTA activities are one input into processes of societal change.

**The Future of CTA: Management of Technology in Society**

The generic CTA strategies remain close to specific technologies, and they are often developed in an instrumental way. This may well make them effective in the short run, but as we have noted, there is more at stake. CTA activities are adopted in the hope of contributing to the realization of better technologies (in a better society), but this is embedded in the way modern societies handle technology more generally. Technical change is not perceived as a negotiable process. Actors often try to reduce space for negotiating to the direction and nature of technical change [46]. Negotiation, if it occurs, is forced into a storyline of proponents versus opponents [36]. Elsewhere, we have discussed the two-track regime of separation of promotion and control of technology, for example in the division of labor between government agencies [6].

The ultimate success of CTA strategies, therefore, depends on how our societies evolve, specifically whether more appreciation and space will emerge for broader negotiation processes, and whether sociotechnical criticism will be appreciated as an essential contribution in a society which has bound its fate to technology.

By way of contrast, it is interesting to look briefly at the situation in the early 19th century, when technology became an explicit component of modern society. At the time, there was sociotechnical criticism, carried by the Luddites—which by now have become stereotypical figures symbolizing unreasoned protest against new technology. Luddites—named for their legendary leader Ned Ludd—were textile workers who resisted the introduction of new machines, eventually through machine smashing. In contrast to the stereotypical view, we see Luddites as seeking to direct technology toward societal purposes and avoid negative impacts. There is much historical evidence that Luddites were neither anti-technology nor workers who were fighting against any novel development [47–49]. The Luddites judged machines on their contribution toward the quality of labor and society as a whole, as if they were constructive technology assessors *avant la lettre*. Luddite protests and actions were not an isolated happening. Such activities were common practice in early modern Europe and were allowed by common law and legal rules. The Luddites’ protest was not directed against machines or innovations in general, but it was taken up only where the introduction of new machinery threatened living standards, conditions of labor, quality of products, or craft status. Their interest, we could say, was not in the machines, but in the loss of access to and negotiation power about new technologies.

Do we need neo-Luddism? Not in a sense of smashing machines. The aim of CTA is to build better machines. However, Luddism, in the sense of sociotechnical criticism, remains important. It should not take the form of sabotage perhaps (although we do not condemn that out of hand). But the basic CTA philosophy does appear to have an element of Luddism. It criticizes as too limited the sequential approach of optimizing the technical before considering uptake, use, and effects, and it advocates broadening...
design criteria of the kind of actors involved. There are important stakes involved in neo-Luddite protest: to create and maintain space for sociotechnical criticism.

Why have we discussed Luddism at some length? It allows us to locate CTA in a longer history of challenges to an emerging, and after some time dominant, two-track regime of managing technology in society. In the two-track regime, promotional activities are separated from control and regulation. Our institutions are set up in this way, with regulatory agencies separate from technology-promotional agencies. Freedom of innovation is institutionalized in specialized academies and laboratories, while the political regulation of technology is restricted to only the most certain and negative consequences. Separating promotion and control effectively decoupled the multiple constituencies of a technology. Thus, promotion actors (engineers and others) need not realize that when they are engineering technology they are also engineering society. Many of the negative or undesirable outcomes of the activities of the promoters derive from this lack of insight. As we noted before, because promoters think their business is to focus on the technical, they redefine the social as barriers to be overcome and approach it as what they must do to make the technical successful. In this way, it becomes fortuitous if the outcome is sociotechnically optimal.

Another effect of the modern two-track regime is the dominant ideology that technological development cannot and should not be resisted. Increasingly, the broad concept of social progress became identified with a notion of technological progress, and Western societies came to see their emerging technological superiority as evidence of an overarching cultural superiority. While this diagnosis has been made before, and the ideology has been criticized and challenged, our point here is the difficulty of actually overcoming the disadvantages of the two-track regime. The limited impact of the Tennessee Valley Authority’s comprehensive sociotechnical planning, the regionalist movement associated with Lewis Mumford, and the alternative technology movement in the 1960s are indicators of the difficulties.

While there is a certain rationale to the separation of promotion and control, and we certainly do not want to advocate abolition of either or both tracks, we do conclude that it reduces opportunities for learning, anticipation, and reflexivity. Conversely, if CTA is applied widely, the two-track regime will be modified beyond recognition.

It is interesting to speculate about what could happen. In fact, if we view CTA as a social technology that is now being introduced, it is essential to anticipate according to our own perspective. One effect of different actors adopting CTA, and its becoming a regular part of societal practices, is that the role of government in managing technology in society will diminish. Agenda building as well as arrangements for better technology will occur at lower levels. Governments would have a role in monitoring the quality of societal learning in such situations. A further, and politically important, role of government as “overseer” is to ensure a balance in the access and voice of various constituencies involved in technical change (which might include support to develop the competence of members of a constituency). This is not just a general political stance of ours. The decentralization of management of technology in society made possible by CTA can easily lead to a situation of technological neo-corporatism, with its own rigidities.

Conclusion

As we illustrated in the second and third sections, CTA agents, as well as other bodies, organizations, firms, and societal groups, can be institutions charged with a TA mission. There is a tension derived from the action perspective of CTA. On one hand,
CTA agents are modulators of various kinds: mobilizers, advisers, mappers of co-production dynamics, change agents. On the other hand, to actually exert influence entails becoming an actor oneself, or at least a forceful visitor.

TA institutions feel this tension, especially when they want to emphasize CTA. For the OTA, it was important to maintain an image of objectivity, of standing above partisan struggles (even if this did not guarantee its institutional survival). For some of its European counterparts, especially in the Netherlands and Denmark, a measure of action and interference was accepted, as long as due processes were followed; for example, no exclusion of particular views and particular parties. These differences, as well as the common experience of the tension, derive from present political cultures. These cultures may evolve and accommodate more negotiation. From the point of view of actual feedback into design and development of technologies, one might even welcome controversies. It has been demonstrated that TA reports have a larger impact when there is a controversy involved [50, 51].

Deeper questions related to what we call the value profile of CTA agents cannot be avoided. One such question is about representation. Who represents actual or potential users, victims or impactees in CTA activities, and how? Questions of representation become even more tangled when future generations should be taken into account. At a practical level, very important for productive CTA practices, institutional questions have to be resolved: what sort of accountability can and must be organized for CTA agents? For TA institutions, there is a mission and some form of public accountability. For other CTA agents, say nongovernmental organizations and environmental groups, the situation is more diffuse.

CTA agents are intermediaries between a future better world and the present situation. Therefore, the issue of representation is easier when there is a broad consensus, even when this is a consensus about diffuse goals, such as environment, and more recently, sustainable development. CTA agents can assume the validity of such a goal and proceed to act on that basis. It is indicative that CTA activities with an emphasis on environmental aspects are the ones which have gone farthest in the direction of feedback and implementation.

If there is no consensus, a CTA agent has to accept responsibility for the goals embedded in its action. In the case of modern biotechnology, to mention one example, this requires hard choices: about possibilities and risks of technological progress, and about the legitimacy of the public concerns and their spokespersons. Accepting such a responsibility can be interpreted as choosing sides, and one can, indeed, not avoid doing so. But there should always be an argument in terms of anticipation, societal learning, reflexivity, and goals at a meta level that justifies the agent’s orientation and strategy.

Does this amount to a definable role and value profile of a CTA agent? To some extent, yes. CTA agents embrace values such as being anticipatory, reflexive, and oriented toward learning. While moral entrepreneurship for particular causes is widespread, characteristic for CTA is the attitude of making these causes part of an articulation strategy. Because of the latter, CTA agents have a moral thrust and moral justification of their being active as a CTA agent. Thus, they are also moral entrepreneurs, but on a meta level. This is very visible in the emphasis on process (in actual CTA activities and in the three generic strategies we outlined). The value accorded to articulation explains (and contains an argument) why open-ended societal learning processes, especially if these contain concrete technologies and experiments, are emphasized by CTA analysts.
CTA agents, however, will also act from their own perspective and interests. The Ludds of this world are often not interested in open-ended learning processes, but in pushing their perspective. Technology promoters are usually interested in CTA only as a matter of prudence. We have argued already that such dichotomies might lessen over time. Joint agenda building is what CTA agents contribute to, even when they act primarily for their own interests. Thus, opposition to technology, including contestation and harassment, is useful if it contributes, directly or indirectly, to the improvement of technology in society. It puts on the agenda the question that there might be problems on the horizon and that something may be done about it.

Our analysis of new responsibilities in managing technology in society might be read as an argument for everyone to share the value profile of the CTA agent. Industrialists as well as neo-Luddites are actors in CTA, whether the label is used or not, and they should accept the values involved. But there is an irony involved. If actors would identify completely with the open-ended learning values of intentional CTA, this would decrease the stakes in the interaction, and thus the incentives to learn (because it is much easier not to have to learn).

We can rephrase this as a dilemma for the future of CTA. On one hand, there is a notion of shared responsibilities for managing technology in society, with all actors working toward the CTA goals of learning, reflexivity, and anticipation. On the other hand, there are the struggles between opponents of various kinds that are necessary to have incentives to act and learn. Between the horns of this dilemma is the real world and its interdependencies between actors.

If actors accept this irony and develop a competence in coping with it when co-producing technology and its effects, and when co-producing learning about such processes and the goals involved, there need be no harmony. But there will be reflexivity, and a real chance to achieve better technology in a better society.

References


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