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IDENTIFYING INTERVENTIONS FOR RESPONSIBLE INNOVATION: THE SOCIOTECHNICAL VALUE MAP

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ABSTRACT

This chapter presents the sociotechnical value map (STVM) as a method to map out values in a sociotechnical system. To identify these values, the publics that are or can be related to a given technology must be traced. The STVM combines elements from evolutionary theory of technology development and value sensitive design (VSD). It consists of the following steps: first, the relevant societal stakeholders are identified; second, VSD helps us design values into a technology. These findings allow us to reconstruct a sociotechnical public. The chapter examines the elements that make up a STVM, and its underlying theoretical considerations. It concludes by a short discussion on the benefits and shortcomings of the method, and on the reception of students.

SOCIOTECHNICAL VALUE MAP, VALUE SENSITIVE DESIGN, RESPONSIBLE RESEARCH AND INNOVATION, RESPONSIBLE INNOVATION SYSTEM, SOCIOTECHNICAL SYSTEM

1. INTRODUCTION

Any new technology will raise questions about its societal and ethical acceptability (Taebi, 2016). Innovations such as artificial intelligence, genetic engineering, synthetic biology, climate mitigation technologies, and quantum computing all need to be assessed in terms of their use and effects as they create winners and losers, opportunities and challenges. A general tendency appears to be that questions about the acceptability of new technologies are framed in binary terms: technologies are either seen as acceptable or not acceptable, implying that the further development of a certain technology is to be persevered or ought to be stopped. This binary framing of acceptability is unproductive; it would make much more sense to ask under which conditions a new technology can become acceptable.

This chapter introduces a method that allows recommendations about interventions in the development of new technologies to be formulated so that these will become societally and ethically acceptable. This method, called the sociotechnical value map (STVM), is in line with the framework of responsible research and innovation (RRI). This framework, which has been developed in the last decade, combines insights from ethics, science and technology studies (STS), and innovation theory (Taebi, Correljé, Cuppen, Dignum, & Pesch, 2014). RRI aims to contribute to making innovation responsible by providing guidance to researchers and technology developers. As will be more elaborately discussed in the third section, RRI scholars propose that such guidance can take the shape of principles to be taken into account during innovation processes (Owen et al., 2013), or by making sure that the relevant public values are attended to by the new innovation. It is this latter approach that motivates the STVM: the method revolves around the identification of societal values and the incorporation of these values into a sociotechnical system.

2. A NEW SOCIAL CONTRACT FOR INNOVATION

In many cases, societal and moral assessments of new technologies assume the so-called 'linear model' of technology development (see Godin, 2006). In this linear model, the development of a technology is understood as the application of science-based knowledge, and societal ramifications of technology are mainly seen as side-effects that might require some political adjustment, but which do not affect the technology itself. This leads to a responsibility gap: as the application of science, technology becomes conceptually detached from real-world settings, so that no one appears to be responsible for the effects of technology in society (see Latour, 1987; Law & Mol, 2001; Pesch, 2021).

Until half a century ago, no need to challenge the linear model was felt. In general, people appeared to agree upon the positive results of technology development. However, over the last decades awareness has grown that technologies can have adverse effects. As Ulrich Beck (1992) makes clear, technology serves the need to control risks, while technologies themselves also bring about risks. These technological risks prompt us to rethink the idea that technologies, on the whole, yield positive results. Following all these considerations that lead to moral discomfort, Owen et al. (2013) state that we have to develop a new 'social contract for innovation', a new way to think the way society deals with the promises and risks of emerging technologies.

Such a new social contract ought to be based on a range of insights that are developed regarding the actual workings of technology, taking distance from the starting points of the linear model. First, technologies are always 'worldly': there is no technology that exists separately from its actual use. As such, technologies are inevitably part of a sociotechnical system, which not only relates to the artefacts or objects that make up the technology, but also the use of these artefacts by concrete actors in specific societal contexts. Second, technologies are created by people. These people will have interests, beliefs, resources, and so on, that motivate them to contribute to the processes of innovation. Third, technologies have concrete repercussions on our lives. As such, it would make sense to think about the way new technologies are desirable or acceptable, which makes no sense if technology is placed outside of society. Fourth, technology does not only concern the application of scientific findings. In many cases, technologies are made without their developers knowing what the underlying explanations for the technology are.

3. RESPONSIBLE RESEARCH AND INNOVATION

These characteristics underscore the need to reconsider the societal and ethical responsibilities of technology developers. The notion of responsible research and innovation (RRI) aims to address this need. RRI has quickly gained prominence in academic and policy circles, as is evidenced by an increasing range of book and journal publications, funding schemes, research projects, educational programs, etc. (Cuppen, van de Grift, & Pesch, 2019).

According to Armin Grunwald (2014), the notion of responsible research and innovation builds forth on Technology Assessment (TA) and the field of engineering ethics. TA emerged in the 1970s as an early-warning tool to prevent new technologies from having negative effects on society, but over the years this framework has been rearticulated in line with insights developed in Science and Technology Studies (STS), a domain which researches scientific and technological processes as events that are intrinsically socio-cultural (Smits, Leyten, & den Hertog, 1995). The other source of RRI, that of engineering ethics, started with a particular interest in questions for the responsibility of engineers. For instance, in the creation of nuclear weapons and products that had negative impacts on the environment. Very much resembling the early stages of TA, this initial question for engineering responsibility assumed that technology developed in isolation from society and that moral values only came into play when technologies were applied. However, also in engineering ethics, awareness grew that this is not the case: technologies are not value-neutral, but values are intrinsically embedded in them (Verbeek, 2006; Winner, 1980).

To quite an extent, these two sources return in the main approaches developed in the context of RRI. On the one hand, there are authors who use STS as a point of departure to develop a framework for the governance of innovation (Stilgoe, Owen, & Macnaghten, 2013). On the other hand, we can see authors reasoning in line with engineering ethics, focusing on the question how to design values into the technological artifact or system (Taebi et al., 2014; von Schomberg, 2013). This latter approach furthers ideas about value-sensitive design (VSD) from the field of ICT. VSD aims to create a technological design that adequately incorporates the relevant public values, seeking solutions through design changes. The methodology that is proposed in VSD consists of an iterative tripartite process composed of conceptual, empirical, and technical investigations (Manders-Huits, 2011; Nissenbaum, 2005). The conceptual investigations include the identification and articulation of the central values in a particular design context and the identification of stakeholders that are affected by this design. In the empirical investigations, the findings from the conceptual investigations are used in order to find out how stakeholders experience technologies with regard to the values they consider important. The technological investigation aims to contribute directly to the design and performance of the technology in question, by focusing primarily on the question how the technology can support the human moral values that are found to be relevant.

4. THE SOCIOTECHNICAL VALUE MAP

This paper presents a method that aims to map a technology based on its embeddedness in a sociotechnical system and, at the same time, it will explicitly account for the public values that are to be secured in the design of technologies or surrounding institutional context. This method can be seen as a value-centric extension of Rohracher's approach to mapping a new technology set within the context of a broader sociotechnical system (2002). Rohracher's original idea of mapping a sociotechnical development was aimed at informing strategic policies for the stimulation of new environmentally friendly technologies by using a range of insights derived from STS-literature (Rohracher, 2002: 474). In line with this idea, the STVM is: 1) based on insights from literature on sociotechnical systems; 2) analyses the development of the technology; 3) forecasts the eventual hindrances for the further development of the technology; and 4) gives options for interventions in the development of the technology – in case of the STVM, this is done by identifying the relevant values and by giving suggestions about how to design these values into the technological system. The added value of the STVM compared to VSD is that it considers a technology as embedded in an existing socio-technical system and with that does not separate a technology from its wider context.

Drawing up the STVM entails a number of steps that are introduced below. The first of these steps involves the formulation of a technology map, which can be seen as a description of the technology itself, and of the technical and institutional networks in which this technology is developed. The second step is that of the stakeholder map, in which the actors are identified that are or can be affected by the technology. The third step concerns the value map, in this map the values that can be connected to the technology and the stakeholders need to be identified. Having an oversight of these technical, social and moral implications of the technology that is in development allows for the possible interventions in the development of the technology that allow for values to be attended. These interventions can be seen as recommendations for making the innovation more responsible.

The full STVM can be represented in Figure 1.

Below, these four steps are further elaborated. This is done by firstly introducing the theoretical notions that underpin these steps, and secondly by outlining the information that is to be collected in order to construct a STVM.

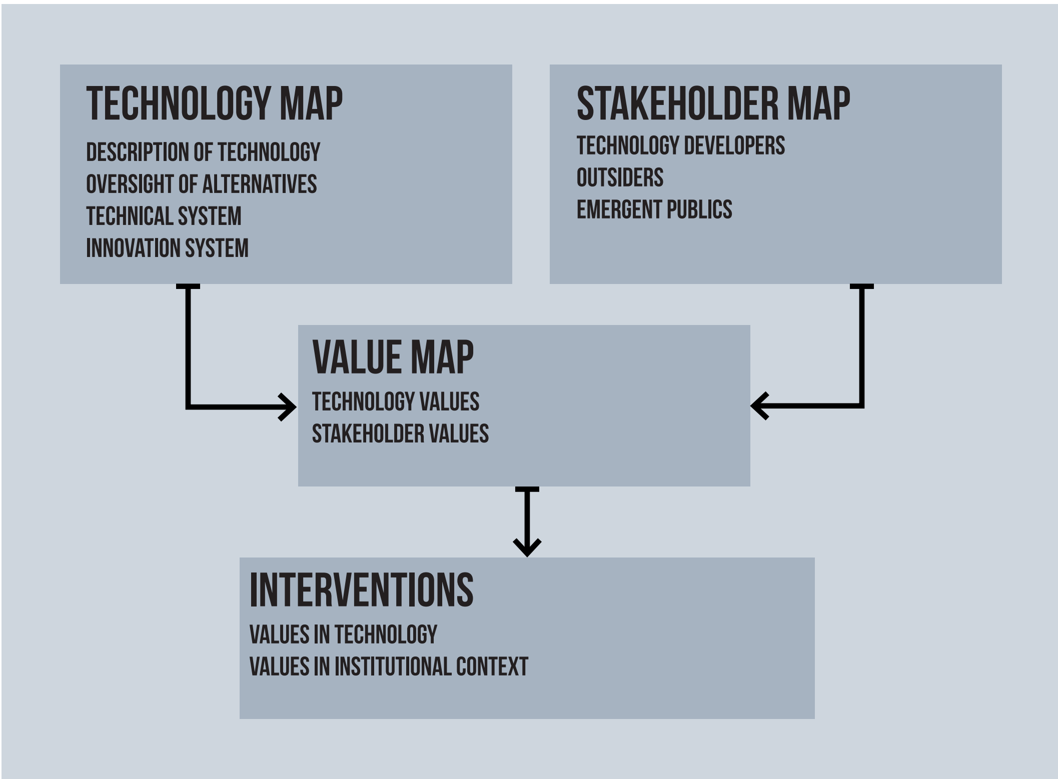

Figure 1: The steps of the Sociotechnical Value Map. Diagram by author.

5. MAPPING THE TECHNOLOGY

The STVM assumes a technological development to involve a sequence of confrontations between technology developers and society. This sequence of confrontations can also be described in terms of variation and selection, like evolutionary processes in biology, as is done in the theory of evolutionary economics (Dosi & Nelson, 1994). Evolutionary economics is grounded in the work of Joseph Schumpeter (2000 [1942]) who portrayed the market as a system in which entrepreneurs have to develop new technologies to gain a business advantage over their competitors. According to Dosi and Winter (1994), the aggregate outcome of these entrepreneurial activities resembles an evolutionary process: the entrepreneurs are, together with actors like engineers and companies, part of a variation environment in which variations of new technological designs are developed. On the other side, there is the selection environment, composed of consumers, regulators, and so on, who decide which of the technological variations are chosen, and as such decide which alternatives eventually become successful.

This evolutionary account informs us that innovations do not start from scratch. Instead, they are created against the background of an already existing sociotechnical system. Innovations can be seen as variations to existing technologies that inform expectations about successful ways to overcome certain understandings of societal problems. This means that, the way an innovation trajectory will branch off is not only a technical matter, it is based instead on what people believe with regards to the new technology or what they are used to. Think for instance about the development of electric vehicles or self-driving cars. These technologies are explicitly constructed as alternatives to the dominant design of the passenger car. How cars look and how cars function are based on the expectations that are motivated by the traditional car, in which there are two seats in the front and a bench in the back, an engine, which has to be filled up for fuel every 500 kilometres or so, which has two brightly shining headlights and two clear red taillights, etc. New types of personal transport are designed in order to fit this mental model (Dosi & Nelson, 1994), even though the technical capacities of these new types would allow totally new paradigms – such as autonomous vehicles without lights as proposed by Stone at al. (2020). The fact that such ideas can be considered as out-of-the-box, testifies that both producers and users are generally guided by what they are used to and by the full range of possibilities.

To describe the way a technology is connected to other, existing technologies, the notion of technical systems is used. This notion, introduced by Thomas Hughes (1983; 1987), takes the interdependence of technologies as its starting point. Technical systems are especially recognisable in network technologies, such as electricity systems, infrastructures and ICT. These systems are based on the connection between different components that are geared towards a common goal. Because of these connections, the technologies that are part of the technical system have a strong influence on each other, but also on the system as a whole. In fact, specific technologies or social factors may hamper the further growth of a sociotechnical system, as they lag behind the development of the full system. Inventors, engineers, entrepreneurs, and others often direct their creative and constructive efforts mainly at overcoming these obstructions by redefining them into solvable social or technical challenges. With that, such problem definitions will be translated into new technological designs and new social arrangements that are aimed to resolve the problems at hand. In our analysis of the history of a technology, we may observe a series of bifurcations: moments in which a specific development of the technology is further taken up at the expense of alternative approaches.

The role of problem definitions directs us to the impact of beliefs in the development of new technologies. We tend to think of technology as things that are essentially tangible: instruments, tools, artefacts, infrastructures, and so on. Moreover, when we talk about future technologies, we first seem to think about its physical appearance. Future technologies, however, do not exist in empirical reality, they only exist as conceptual entities (Pesch, 2015). In the words of Jasanoff and Kim (2009), they are *elements of* 'sociotechnical imaginaries': representations of a future sociotechnical system in which a new technology will become embedded. In the realm of technology, such future visions shape trajectories of research and innovation and with that they become performative: they create their own reality like self-fulfilling promises (Borup, Brown, Konrad, & Van Lente, 2006; Brown & Michael, 2003; Selin, 2008). The awareness that technological development starts with the creation, articulation, and dissemination of expectations, prompts us to look at the software of technology development, instead of looking at the hardware. Talking about responsible innovation is akin to talking about things that are not there, and, in most cases, is akin to talking about things whose possible existence we are not sure of, and if they will come to exist, what they will look like, how they will be used, and what the impact of their use will be.

Expectations do not emerge out of thin air; they are the result of human agency. In technology development, the construction of expectations often is a deliberate form of activity. Actors strategically raise expectations by promising that a new technology allows them to solve current or future practical problems, they do so in order to mobilise resources for their work. Engineers, scientists, and technology developers try to appeal to an audience of actors who can provide the financial means, time, policy support, and/or organisational capacity to substantiate the technology. Moreover, technological promises and the construction of visions helps coordinate actions by various stakeholders (Dierkes, Hoffmann, & Marz, 1996; Grin, 2000; Quist, 2007). If people share expectations about the future, including the role that a technology-to-be will play, they can adjust their activities to that imagined future. Once the awareness about the constitutive role of promises is there, examples are easily found. For instance, the allocation of resources in new technology is often justified by pointing at the possible development of new medical drugs, for instance in the case of quantum computing, artificial intelligence, nanotechnology, etc. Also salient is the belief that digitalisation will lead to more efficient business and policy processes, or that financial innovations such as blockchain will eradicate transaction costs, as when the internet promised to give rise to a 'friction-free economy' (Pesch & Ishmaev, 2019).

The development of beliefs about a future technology takes place within an innovation system, which can be seen as the institutional context which contains the resources necessary to develop new technologies (Carlsson, Jacobsson, Holmén, & Rickne, 2002; Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007). This innovation system includes the linkages between knowledge institutes, industrial networks and governmental agencies appear as most relevant, and available resources such as knowledge, investments and legitimacy have to be aligned as optimally as possible (see Cunningham & Werker, 2012; Sovacool & Hess, 2017).

This innovation system accommodates the so-called 'insiders' or 'technology enactors' (Garud & Ahlstrom, 1997). These are the actors that are directly involved in the process of technology development, not only the technology developers, but also those actors that make up the 'innovation system', which includes for instance investors, researchers and policy-makers. The questions are, what knowledge, finance, political leverage and so on do insiders have and use to turn an idea into something real, and what are the beliefs about the future of the technology.

Taken together these theoretical considerations give rise to the following elements that make up the technology map.

A DESCRIPTION OF THE TECHNOLOGY AND AN OVERSIGHT OF TECHNICAL ALTERNATIVES

First, it is necessary shown what the character of the technology is. Is it a product or a service, an artefact, a system, or is it a concept that combines different technological developments?

How far is the technology in its development? Is it just an idea, is there a prototype? What is the history of the technological development? What are the various performance standards: so how much will it cost; what are environmental (dis)advantages; how safe is it?

The technical alternatives that are available on the market or under development also have to be presented here. If possible, a hierarchy of technical alternatives should be determined and an indication of what determines the selection of alternatives should be presented.

THE TECHNICAL SYSTEM

How can the technology be seen as part of a technical system? What is the speed of development of this system, and what are the factors that hamper its further development? Apart from the connection with other technologies, the connection to existing or likely regulation and legal arrangements must also be made explicit. For instance, are there or will there be laws that prevent or stimulate the further success of the technology? Also, think about appropriation: will a company decide to apply for patents so that its specifics have to be published? Will the company try to keep its technology secret? Or will it make its findings accessible for everyone without further ado?

THE INNOVATION SYSTEM

The activities of the actors described above take place against the background of an innovation system that figures as the general environment in which the new technology is produced. To depict the innovation system, we have to sketch out the characteristics of industry, policy, and science and we have to indicate their relationships in the context of the technology development at stake. Which parties can be recognised, what do these parties do, and how do these parties interact? What are the capacities for resource mobilisation? Does the innovation system give rise to the concerted creation of expectations and problem definitions, for instance by the development of supporting policies, business strategies, or scientific programmes? In the description of the innovation system, it is important to make a geographical delineation, so as to allow for empirical detail and a fine-grained analysis.

6. MAPPING THE STAKEHOLDERS

The second step of the STVM concerns the stakeholder map, which focuses on the actors that are possibly affected by the new technology. The goal of this part of the STVM is to sketch out the way by which a heterogeneity of societal actors plays a role in the assessment of a technology and may have the ability to stimulate or hamper the further uptake of that technology. In other words, a new technology may become a subject of contention in a social arena, so that the development of a technology is impacted in each and every aspect.

Above, we have looked at the role of insiders. However, innovation is also influenced by 'outsiders' that are not represented in the innovation system, but which will be affected by the new technology. Van de Poel (2000: 384) defines such outsiders as actors that are outside the network in which technical development is taking place. Van de Poel identifies the following categories of outsiders: 1) outsider firms; 2) professional engineers and scientists; and 3) societal pressure groups. Outsider firms can be companies that enter a market by providing an alternative technology. One may for instance think about how Google wallet or Apple pay aim to play a role in the financial sector. Professional engineers and scientists may develop new knowledge or products that affect the dominant production or use of a certain technology. What these two categories most basically do is to introduce an additional problem definition, which might have a profound impact on the further development and uptake of a technology. The third category of outsiders, that of societal pressure groups, is most notably populated by NGOs, a category that is especially relevant as these groups may mobilise public opinion or influence government and users, endorsing specific sets of values that as such may become relevant for the technology.

With regards to this last category of outsiders, we should not only look at societal pressure groups, but also at the roles that members from the general public can have. These actors may take on the role of protestors, for instance, if they contest the implementation of technologies like wind power, shale gas, or carbon capture and storage – at times leading to the termination of technology projects (Cuppen, Brunsting, Pesch, & Feenstra, 2015). Another role of the public is that of the public-as-producers of new technology (Pesch, Spekkink, & Quist, 2019). In the field of energy production, for instance, we can observe the emergence of so-called prosumers: citizens that produce their own energy, not only by making use of existing technology such as solar power or heat pumps, but also by developing new sociotechnical arrangements. A similar role of the public can be retraced in the notion of 'open innovation' (Chesbrough & Crowther, 2006; Von Hippel, 2009), which highlights the capacity of actors outside of the main arenas of technology development to contribute to innovation. In short, members from the general public have to be included because innovation affects their lifeworld and as such have to be consulted from a democratic point of view; resistance of the public can lead to the cancellation of new technologies that may benefit society as a whole; and because the public can contribute to innovation. But how can you identify the public? How can you find actors and voices if they are not organised? This is a fundamental conundrum that cannot be solved, but only circumvented, for instance, by looking at social controversies that urge a diversity of actors to articulate their interests, knowledge, values, and so on (Rip, 1986). The problem here is that an analyst has to discuss possible courses of action, relying on analogy or conjecture instead of on material that can be retrieved from existing empirical sources.

THE TECHNOLOGY DEVELOPERS

Here, the actors that are directly involved in the creation of the technology have to be identified. So, who are the scientists that have worked on the knowledge-base of the technology, which companies or state organisations are involved in its development? What are the activities that are embarked on? What also has to be addressed are the beliefs, expectations, promises, and problem definitions that are held by the technology developers, and which figure as the reasons for them to designate resources to the innovation process: so, what are the promises that have been raised for this technology, and by whom are these championed; what is the problem or need the new technology is intended to resolve; what are the expectations that vigour with regards to the technology?

THE OUTSIDERS

The innovation system presents the actors that can be seen as insiders, but as stated, it is also important to include the outsiders in our analysis. Not only because it is essential for responsible innovation to include a wide range of actors and a diversity of voices in the decision-making process on the technology, but also because outsiders may have a significant impact on the technology-to-be, for instance, by presenting alternative problem definitions and understandings that challenge the problem definition of the insiders. As such, first the NGOs, competing firms, and outsider engineers and scientists that forward alternative problem definitions and solutions with regards to the technology at stake need to be identified. It needs to be reflected upon how these competing definitions and solutions can have an impact on the further development of the technology at stake, for instance by taking their legitimacy into account, but also by looking at the respective powers of these parties. Do they have the leverage to change the process of technology development?

THE EMERGENT PUBLICS

The general public can be seen as a special category of outsiders. Unlike the parties shown above, the public is fundamentally intangible, as you just never know whether a new group of actors will emerge and try to influence the development of a technology. The identification of the innovation system and of the outsiders can be based on retrospective empirical research, but with regards to groups that emerge from the general public, one can only be explorative, for instance, by looking at potential societal challenges, and by taking account of the roles that the public can play as user, protestor or producer.

7. MAPPING THE VALUES

In the value map, the values of the actors described in the previous part are identified. The first two parts of the STVM are primarily empirical exercises, aimed at gathering and organising the right material from social reality. In the value map, a coherent interpretation of these empirical results needs to be made. The values that are affected by the technology, and the values that are forwarded by the stakeholders have to be analysed so that the author of the STVM may provide concrete recommendations for designing these values into the sociotechnical system, the following step of the STVM.

In this, it needs to be acknowledged that it is an intrinsic feature of technologies to be imbued with values. They are designed to fulfil certain functionalities, also based on implicit normative ideas of the technology developers. In the design of a new technology, designers use certain images or representations of their 'target audience'. Often these images or representations are only held unconsciously by the designers, but they have the effect that certain tastes, competences, motives, aspirations, and prejudices become inscribed in the artefact (Akrich, 1992; Oudshoorn, Saetnan, & Lie, 2002). We may also derive insights here from 'actor network-theory' (ANT). This approach emphasises that, and explains why, objects cannot be seen as neutral with respect to moral and social behaviour (Latour, 1992). Think for instance of a speed bump, this is not just a value-neutral object, but it is something that imposes a rule upon us – instructing us not to drive too fast. A speed sign is an artefact with the same function, but it does not compel us to drive slowly at the extent of physical unease. It does so by appealing to our morality. As such, technologies mediate values and affordances, making us act in certain ways (Verbeek, 2006). In many ways, the objects of technology are strongly value-laden, as they incorporate certain (often dominant) values while failing to represent others. Furthermore, they may also give rise to new types of behaviour, and with that they also lead to new expectations and new sets of values.

In order to retrace values, the 'value hierarchy' (van de Poel, 2014) can be used. At the highest – most abstract – level, there are fundamental values someone may hold paramount, such as safety, environmental friendliness, economic efficiency, and so forth. Contestations do not (often) arise from what constitutes a value. Everybody will supposedly endorse abstract values like safety, equity, and efficiency. Rather, controversy arises from how the value is specified into norms. Norms are located at the second level of hierarchy and form prescriptions for or restrictions on actions. Such norms may include objectives (like 'maximise safety', 'safeguard the environment', or 'minimise costs' without a specific target), goals that specify a more tangible target, and constraints that set boundaries or minimum conditions. The bottom level of the value hierarchy, which is also the most concrete one, indicates the technical and institutional design requirements that are derived from the norms. Van de Poel (2014) applies this hierarchy to the case of chicken husbandries, where the general value of animal welfare is translated into the norms of living space, the ability to lay eggs, to take dust baths, and rest on perches. Subsequently, these norms are operationalised in the design requirements which indicate the space in square centimetres, the number of chickens per square meter, the materials and shape of the battery cage.

The value hierarchy can be used both as an analytical tool and as a design tool. As an analytical tool, it can help to analyse why, or for the sake of what, something is being done or preferred by someone. It can help to explicate the values that underlie certain decisions or characteristics of a design and it can help to illuminate controversies when values and/or norms were specified in the design process but not incorporated in the design. As a design tool, the value hierarchy can be used to come up with a design that is robust in the sense that it can bring together divergent values and norms into a coherent set of design requirements.

THE VALUES OF THE TECHNOLOGY

Based on the analysis of the functional characteristics of the technology, an analysis in terms of values can be made. It has to be addressed which values are intended to be effectuated by the new technology or which values have already become embedded in the design. It also needs to be addressed whether these technological values may change in the further development of a sociotechnical system.

THE VALUES OF THE PUBLIC

Based on the stakeholder map, the public values can be charted out. The problem definitions, viewpoints, arguments of all stakeholders have to be rearticulated in values – making use of the value hierarchy. Not only must these values be rearticulated, it is also necessary to present how the different stakeholders relate to these values, how different stakeholders understand the different values, and whether there are any conflicts between the values themselves or between different understandings of the values.

8. INTERVENTIONS FOR RESPONSIBLE INNOVATION

The fourth step of the STVM explores how the relevant values can be designed into the technology. The main question that needs to be addressed is how the new technology can be implemented in a responsible way by addressing values that are found to be relevant. This is far from an easy task as in many cases the values will be conflicting, and embedding the full set of values in a design may be impossible. With the right analysis, however, one may identify the minimum set of values, which are the minimum values that need to be incorporated into the design in order to make the technology successful. In other cases, a clever design that solves value conflicts may be constructed. For instance, using new composite materials allows aeroplanes to be both strong and lightweight, so the values of safety and sustainability are both catered to.

The main idea of VSD is that values can be attended to in the design of a technological artefact. It seems sensible, however, to extend the scope of design and also consider the redesign of institutional contexts in which technologies are embedded. Two categories of institutions can be distinguished: 1) formal institutions such as laws, standards, regulations, and contracts; and 2) informal institutions such as customs, traditions, and routines. Many of these institutions, especially the formal ones, may be subjected to redesign to accommodate divergent values (Correljé & Groenewegen, 2009). Before thinking about interventions in institutional context, we can think for instance about changes in the innovation system, the direction of the development of a technology may be influenced directly. Policies may be created that aim to 'nudge' the demand side of the system (Edler & Georghiou, 2007; Tödtling & Trippl, 2005). This can be done by direct regulation, which in general pertains to sectors that are considered to serve some public good, such as health, education, or infrastructure (Blind, 2012). Public organisations can also aim to influence the direction of innovation by changing the demand side, for instance, by public procurement that is believed to stimulate companies to develop products that fulfil societal needs (Aschhoff & Sofka, 2009). We can also think of effective forms of participatory decision making, based on dialogue, compensation and ownership arrangements, and so on (Pesch, Correljé, Cuppen, & Taebi, 2017).

A second approach is to shelter new innovations against evolutionary pressures such as R&D laboratories, subsidised demonstration projects, or small market niches where users have special demands and are willing to support emerging innovations (Kemp, Schot, & Hoogma, 1998; Schot & Geels, 2008). The deliberate creation of niches has been given the name of strategic niche management (SNM), an approach that aims to use the niche to instigate various learning processes that will create a stable sociotechnical configuration that challenges the dominant regimes. Such niches can be considered as breeding grounds for innovation, safe places where innovations can be tried, tested, and mature. Whereas large, often long-term changes are difficult to design, manage, and control, niches do promise a certain level of influence and control. The aim is to create a level playing field for sustainable innovations; once they flourish, they can compete with alternative, mainstream technologies.

An important way to bring in public values is by involving the public itself through participatory methods in innovation processes (Hagendijk & Irwin, 2006; Pellizzoni, 2003; van Oudheusden, 2014). With regards to innovation, participation is usually organised within the tradition of technology assessment (Decker & Ladikas, 2004; Smits et al., 1995). Modern versions of TA include a wide range of participatory methods for involving stakeholders in decisions about technology (Felt et al., 2013). Among the most elaborate of these methods is constructive technology assessment (CTA), which tackles the pathologies of the linear model by organising 'bridging events' between the 'enactors' that develop new technology and the 'selectors' who will be affected somehow by this technology (te Kulve & Rip, 2011). By organising the joint articulation of needs, expectations, world views, values, and so on, technologies can be developed in a way that adheres more directly to the needs and values of society.

VALUES IN THE TECHNOLOGICAL DESIGN

Here, we need to explore whether there are any values and/or norms missing in the current technological design, and we need to question how these can be specified into design requirements.

VALUES IN THE INSTITUTIONAL CONTEXT

Are there any values and/or norms missing in the current institutional context? How can these be specified into design requirements? The institutional context includes the processes in which the different groups of stakeholders interact, which may not only be seen as contexts that are open for redesign, but also as processes in which the stakeholders can articulate their values even further.

POSSIBLE INTERVENTION STRATEGIES

What can the actors that make up the innovation system do to make the technology aligned with the values identified above? How can these actors make innovation more responsible by accommodating the values of the sociotechnical public and what other policy options allow the increase of responsiveness regarding the innovation under study?

9. CONCLUSION

The sociotechnical value map provides a systematic and comprehensive method to identify values and to design these values into a sociotechnical system. The benefit of the method is that it takes a broad scope towards technology, by embedding it in institutions and practices, instead of regarding a technology as an isolated artefact or design. Moreover, the STVM highlights the societal and institutional dynamics that characterise innovation processes. It sketches out technology development as something imagined, created, and used by people. These features seem self-evident, but are surprisingly often overlooked.

In this chapter, a limited number of examples have been given, but in principle the STVM can be used to analyse any technology. The scale of technologies will obviously differ, as well as their manifestation, but every technology relies on the commitment of financial and institutional resources, as well as beliefs. Many students at different courses at the Delft University of Technology have been given the STVM as an assignment, and the students have chosen a wide variety of technologies, producing valuable insights into how innovations can be understood and be more responsive to societal and moral demands. Moreover, students have reacted very enthusiastically to this assignment. In course evaluations, they have indicated that it has been both fun and instructive to approach a technology from this perspective, which for them, implies another way of looking at technologies and their role in society.

In this, it needs to be added that the STVM is a snapshot: it pertains to only one moment in time. At the same time, it should be emphasised that technology is always a work-in-progress. There is no finite design, not only because technologies will evolve further, but also, and perhaps more importantly, because society will always be subject to change. This means that the connection between values and technology is fundamentally volatile.

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