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Technologies, Resources, and Substitution: An Approach to Support the Discourse on Technological Innovations with a Focus on Sustainability

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1. Introduction

Technological innovations usually have implications for society at large. Technology Assessment (TA) is a process that aims to contribute to the formation of public and political opinion on societal aspects of technology. In TA studies, potential technological impacts are predicted – very often in the form of what-if scenarios – and then evaluated for their desirability or undesirability by the participants of the study. Both steps, prediction and evaluation, usually lead to controversies. For example, when the cellular networks were built and the mobile phone became popular, there was a debate about potential health impacts of the non-ionizing radiation emitted by the phones and the base station antennas. Predicting the induced health risk is different from evaluating it; even if we assume a certain non-zero additional cancer risk, for example, we could still argue that this were acceptable compared to an assumed potential benefit of the technology. Both predicting and evaluating potential impacts needs some form of discourse to build consensus. This is imperative for the evaluation phase because evaluation involves values, in this case the value of health and the value of other opportunities which are traded against it. Every normative statement that somebody contributes to a discussion (i.e., a judgment about whether a situation is desirable or undesirable) is based on personal values. It is therefore important to find discursive forms of TA that support the elicitation and discussion of the subjective values that may be hidden behind diverging opinions on the technological innovations. The aim of our research is to find better ways to separate descriptive from normative statements in discussions about technological innovation, to elicit the values behind, and to support ethical reflection where dilemmas emerge. By this approach, we want to contribute to the methodology of discursive TA [1].

An ex-post analysis of TA studies in the ICT field – especially on the type of innovation that has been called "pervasive computing" or "ubiquitous computing" in former years and "the Internet of things" today – has shown that the basic values behind normative statements include self-determination, legal/moral and social responsibility, and distributive justice [2]. Practical experience with such TA studies [3, 4, 5, 6] has also shown that abstract ethical ideas are, however, not sufficient to support the discourse during the TA study in a way that helps the contributing experts and stakeholders to separate their descriptive and normative positions and to explicitly address ethical values. We are therefore

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developing a method that aims to close this gap by supporting the discourse during a TA study. This method will provide practical tools in the form of questionnaires (that can be provided on paper or online) and a discursive workshop format. It is rooted in the paradigm of "sustainable use" formulated by Hilty and Aebischer [7]. Based on this paradigm, we will interpret a value as the *desire to sustain a resource* (or, more precisely, its function) and trace back differences in descriptive views, as far as possible, to different *assumptions about the substitutability* of resources.

2. The Sustainable Use Paradigm

We briefly introduce the paradigm of sustainable use that has been formulated in [7], building on ideas of Dobson [8] and Christen [9].

Essential for this paradigm are the concepts of system, function, and time. A system is anything that is perceived to fulfill a function over a period of time. The system can also be called "resource" because someone is using it to get a benefit from the function it provides. A function can be any effect of the system (or resource) that is perceived desirable by somebody [10].

Based on these concepts, we can now define "sustainable use": To make sustainable use of a system S with regard to a function F and a time horizon L ("length") means *to use S in a way that does not compromise S's ability to fulfill F for the period L.* In other words, a system is used sustainably if the user can sustain the process of using it "long enough", whatever "long enough" means for him or her in the given case, from moments to eternity. In the context of *sustainable development*, one would usually address time horizons of several generations. Note that S can be either a human-made (technological or organizational) or a natural system, or a combination of the two. [7]

3. Draft of the Method

This paradigm has the advantage that it highlights the role of technological substitution for the discourse of technological impacts. From the perspective of a user who uses S for the purpose of F, any system S' that fulfills F as well can replace S. In other words, the *substitutability relation* between S and S' with regard to F holds. As far as substitution is predicted to happen in the future, statements about substitutability are uncertain. Although such statements are descriptive (as opposed to normative), opinions about future substitutability of resources may differ considerably among people. One extreme position is the belief that a substitute system S' will always be found when needed, in particular that any natural system can be replaced by an artificial one, a position that is also discussed under the heading of "weak sustainability" [11, 12]. The philosopher Meyer-Abich made the remark that this may lead to the substitution of "swimming pools for seashores, leisure parks for historic regions, fitness centres for cross-country runs and walks" ([13], p. 296). The other extreme is the belief that no substitution is possible in any relevant case. For example, one would assume that the element indium used for producing flat screens and photovoltaic (PV) panels today will not be replaceable in this function when its scarcity increases and there will be no flatscreens or PV panels any more. Most people's (tacit) beliefs may be located in between the two extremes and are best described as a network of systems constituted by the substitutability relation.

Let's call these networks "substitutability networks". Elicitating people's subjective substitutability networks (one for each function) may sound like a challenging task, but we expect it to be rewarding as well because it may explain a large part of the controversy about technological innovations. Elicitation of substitutability networks is one of the goals of our method, besides the elicitation of the values behind normative statements.

Our method consists of the following steps:

1. Impacts: Participants state their views of the main opportunities and risks of the technological application under study. *Example: "Smart home", opportunity: efficient heating, risk: misuse for surveillance.*
2. Resources: Participants are asked to identify for each opportunity they listed in step 1 the system that is positively affected by the technological application; and for each risk, the system that is negatively affected. In either case, the system must be something providing a desirable function and the function must be identified as well. Moderators or an online system may help the participants to formulate answers. *Example continued: efficient heating: energy system and energy sources providing energy; surveillance: democratic political system providing freedom.*
3. Time: Participants assign to each function a time horizon in which it should be sustained in their opinion. *Example continued: 1000 years for both, energy and freedom.*
4. Distributive justice: Participants assign to each function the number of people that should be in the position to use the function on a scale reaching from 1 person to 100 % of the global population. *Example continued: 100% for both, energy and freedom.*
5. Responsibility: Participants are asked to identify at least one responsible party for each specific function. The responsible party shall ensure that the function is provided. Shortlists or examples may help the participants to formulate answers. *Example continued: energy companies for energy; the government for freedom.*
6. Substitution: For each system they listed, participants add a list of potential substitutes. The list may be empty or contain any other number of substitutes. A substitute is a system that, according to the participant's opinion, provide function equivalent to the function of the original system, or a function that is even more desirable. For each substitute, participants specify a time horizon in which they believe substitution will be possible.

3. Outlook

We will develop a questionnaire to implement this method and test the questionnaire to get feedback. An EnviroInfo ConverStation may be used for a test.

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