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ARTICLE

Obstacles to and potentials of the societal implementation of sustainable development: a comparative analysis of two case studies

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Currently, a growing societal awareness of problems in the context of unsustainable development meets with conflicts of interest, and the actual implementation of sustainability research, and sustainable innovations and technologies, has only been mildly successful. Sustainable development demands nothing less than a radical change in our modes of consumption, production, technology, and decision-making. We have investigated the obstacles to and potentials of such a change in two representative case studies, one focusing on the role of sustainability research within science, the other on the energy-efficient refurbishment of old buildings. A short presentation of the methodological approaches, and the respective results, is followed by a comparative systemic analysis of the two fields of investigation. Finally, we discuss possible implications of the discovered systemic comparisons for societal transition processes.

KEYWORDS*:* sustainable development, case studies, social responsibility, environmental awareness, social attitudes, conflict of interests, decision making, appropriate technology, innovations, energy efficiency, research, social change

Introduction

Sustainable development demands nothing less than a radical change in our current modes of consumption, production, technology, and decision-making (Rammel, 2003). On the one hand, this demand for a sustainable transition is based on growing societal awareness[1] and on the considerable support of NGOs, governments, and the business community, and moreover is corroborated by an increasing body of literature and data in the field of sustainability research. On the other hand, the actual implementation of sustainability research, sustainable innovations, and technologies is frequently characterised by lack of interest and minor success. Compared to the claimed urgency of appropriate and radical changes, the overall transition towards ecologically and socially sound societies is alarmingly slow. In particular, the pace at which green technologies and sustainable innovations are being implemented reveals a present need for well-aimed action in a field of complex interdependencies across various social dimensions and fields of practice.

As an attempt to analyse the barriers and potentials inherent in such processes of societal transition towards sustainability, the following article focuses upon the results of a series of research projects undertaken in Austria 1999-2004 by an interdisciplinary research group[2]

[1] The article uses the term ”societal”, like “gesellschaftlich” in German, to refer to a certain society or social system, whereas it uses “social,” like the German “sozial”, to refer to the social dimension (additive to the ecological and economic dimension in the context of sustainable development) of a given system.

[2] Co-ordination: Roland Albert (bio-ecology), Fritz Schiemer (limnology), Peter Weish (human ecology); core team: Michaela Egger-Steiner (sociology), Karen Kastenhofer (bio-ecology), Christian Rammel (ecological economics); together with: Anja Götz (psychology), Christoph Hahn

sponsored by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, BMLFUW). The assumption underlying the following discussion is that the potential for change through singular and one-dimensional approaches is insufficient and too narrow. Hence, this article draws a wider scope, taking the specific systemic contexts relevant to the problem in their multidimensional and complex identity into account. Only in a second step, and after an in-depth analysis, can the systemic perspective be reduced to a model open to further and carefully directed interpretation. In this way, hindrances relating to attributes of the complex systems structure are taken into account, hindrances that would otherwise suffer from a reductionist approach.

We chose two very different contexts for our two comparative case studies, to give an example of the variety of problems the implementation of sustainable development may encounter. Nevertheless, the two cases share a presently perceived unsustainable state, resistance to direct control due to complex interdependencies, and a perceived need for steering intervention, or, in other words, for governance. We will try to represent the heuristic benefit of such a comparative view in the last section of this paper.

Choosing a systemic view

Societal problems in the context of reduced sustainability can be characterised by the following aspects:

- They are caused by a combination of effects of actions undertaken on diverse societal levels.
- Those who suffer from the subsequent negative impacts often differ from those causing them.
- Information, communication, and awareness play a crucial role in possible participatory solutions.
- Win-win-solutions are limited: There is no pre-defined absolute optimum to be aimed at, but only procedural compromises between different interest groups who share some of the normative guidelines.
- Ecological, economic, and social subsystems, as well as multi-dimensional ones, have to be taken into account.

A variety of players and actions, the fragmentation of interests, decision processes, power and responsibility, interactions on local, regional, national and global levels, the complex cause-effect relations, and other prominent aspects in the field of sustainable development call for integration on a wider scope, i.e., a complex-systemic analytical approach. Such an approach would draw attention to the specific characteristics of complex systems: a multiplicity of legitimate perspectives, non-linearity, emergence, self-organisation, multiplicity of scales, and irreducible uncertainty (Gallopín, 2001).

Looking at a particular complex-systemic case from a scientific viewpoint raises the following introductory question: How can a possible system model be developed, a model which is still complex enough to show the critical players, interrelations, and structures, and which at the same time has enough explanatory power to lead to helpful conclusions?

In reacting to this challenging situation, we have chosen a comparatively open approach, similar to sociological methodology. We have concentrated on two additive case studies, one on sustainability research within the science system, the other on the reduction of CO_2-emissions caused by the energy-efficient refurbishment of urban buildings. The common point of departure is the formulated problem situation, namely conceivable and socially undesired environmental degradation, lower life quality, social imbalance, and a failing attempt to contribute to the problems' reduction. The formulated goal of the research series is to look for ecologically, as well as socially sound, possibilities to deal with these problem situations and contribute to sustainable societal transitions.

The resulting projects differ from traditional scientific research, as the research question has been raised not by the scientific enterprise of cumulative knowledge production, but by public concern. Furthermore, the fields of interest have not been defined beforehand, but are open to subsequent discussion so as to fulfil the specific need to clarify, and help to solve, the given problem. Accordingly, the research projects are not restricted by any disciplinary boundaries, but rather undertaken by an interdisciplinary team in close interaction with experts from various practical fields. In this article, two exemplary case studies are briefly presented. Their results are discussed in a comparative approach, and their relevance for the broader context of sustainability research and policy is highlighted in the concluding remarks.

Case study I: Sustainability research in Austria

Case study I focuses on a specific societal subsystem involved in the process of sustainable development, i.e., scientific research and education in Austria (Egger-Steiner et al., 2002).

Objectives

An increasing societal and political awareness of problems caused by unsustainable situations in our present society has led to intensified scientific research and education. Specific research programmes and funding schemes have fostered sustainability research on both national and international scientific levels. Much has been said and done under the label of 'sustainability research' during the last decade. Nevertheless, attempts to estimate the overall efficiency of these science-based efforts have left us with some doubt as to their success in triggering a socio-economic transition towards sustainability that would meet the currently estimated necessity for change.

On the one hand, this shortcoming can be explained by a lack of societal awareness and interest in scientific results (an assumption addressed in case study II); on the other hand it can be interpreted as a failure of the scientific community to take a leading role in the process of sustainable development.

Case study I deals with this second assumption, which has already been discussed on a broad theoretical basis in science research for inter- and transdisciplinary

(vegetation ecology), Astrid Kuffner (environmental economics), Markus Staudinger (biology).

science (Funtowicz & Ravetz, 1993; Gibbons, 1994; Häberli & Grossenbacher-Mansuy, 1998).

Basically, three modes of explanation for the hermetic failure of science are conceivable (Kastenhofer, 2002):

(a) The scientific system fails to communicate its results successfully to societal players (decision makers, stakeholders, consumers, etc.). A possible solution to the problem can be achieved by a better presentation of scientific results to the public by making use of the education system and mass media.
(b) Despite the high *quantity* of sustainability research, there still is a lack of a *qualitative* scientific grounding, which results in a lack of scientific understanding of crucial points of intersection in the complex factor pattern of sustainable development. Building on a traditional approach, additional research projects on disciplinary and interdisciplinary bases are called for.
(c) The prevailing paradigms of classical scientific analysis are *generally* not apt for an understanding of the overall causal relations of societal sustainability and the formulation of suitable steering processes. This interpretation result calls for transdisciplinary research and post-normal science.

Research area and methods

In case study I, an investigation on Austrian universities and extra-university research institutes was conducted (see chapter 7 of this research report for further details). The aim was to obtain a general view of the quantity, quality, and dissemination of sustainability research within the public sector.

In a first step, a nationwide survey identified relevant institutions and scientists engaged in sustainability research. A short questionnaire was sent to all heads of public scientific institutes (n = 1093, response: n = 311). [3] It inquired about the involvement of the respective institution in sustainability research and/or education, and about relevant players within this institution.

In a second step, a detailed questionnaire, addressed to the mentioned players, raised a wide range of questions about the quantity and quality of the researchers' involvement in sustainability research and education, and about their perceived obstacles and potentials (n = 832; response: n = 246). [4]

In a third step, the results of this survey were presented to the scientific community during a one-day workshop, which was also open for individual reactions and for plenary discussions on the central findings, especially between well-established scientists (primary orientation mostly disciplinary) and 'new-comers' (primary orientation often transdisciplinary).

An integrative analysis of all three steps resulted in a concluding report compiled by the interdisciplinary research team. Herein, additional in-depth interviews with selected experts helped to clarify some specific questions raised throughout the process.

Results

The results of step two (detailed questionnaires, n = 246) can be roughly summarised as follows:

- The survey results (step 1) show a dominance of techno-science in sustainability-labelled projects: 34% of the involved scientists come from the technical sciences and 26% from natural sciences. Only 14% hold a degree in economics, 12% in social sciences, 7% in the Arts, 2% in law, and 1% in medicine.
- Most researchers started with sustainability research in 1995 (12%), others between 1990 and 1992 (20%), in 1985 (6%), and in 1980 (5%), respectively.
- The assumed relative importance of the topic ranks highest in the technical sciences, followed by economics and the social sciences, lower in the natural sciences and the science of art, lowest in law, medicine, the humanities and theology.[5] It is more important for the individual scientists than for the institutions they work for (mentioned most often: financial and researchers' share per institute lower than 50%). This is true especially for university institutes, while several institutions specialising in sustainability research are to be found on an extra-university level (covering an overall share of 4%).
- The individual motivations of scientists to work in sustainability research can be divided into 3 clusters of similar size: topic-centred, ethically oriented or player- and network-oriented. Percentages of relative working time range mostly between 20% and 80%.
- The theoretical definition of sustainability is most frequently built upon the "three pillar model," emphasising the equal shares of ecological, economic and social factors. In practice, such a joint definition is not seen as central. Moreover, it is not totally reflected by a corresponding interdisciplinary setting of the undertaken research and education projects (only 26% of the mentioned sustainability projects integrate all three spheres, while 41% integrate two of the three aspects).
- Interdisciplinary communication occurs most frequently between technical and natural sciences, as well as between economics and social science. Least often, cooperation with the arts, law and medicine are mentioned, although the interest in cooperating with the other sciences is equally high.

[3] All research institutes (including natural, technical and social sciences, arts, humanities, medicine and law) were addressed. The short questionnaire was not very time-consuming for the interviewees and responses came mostly from departments active in sustainability research. With a response rate of 28%, response bias is presumably limited, with non-response mostly due to the specific institute being inactive in sustainability research. Random tests support this assumption.

[4] The detailed questionnaire covered 19 pages and required between 30 and 90 minutes to complete (according to the interviewees' accounts). A response rate of 30% may result in a response bias, while causes for non-response are unclear (though a lack of time is to be presumed in most cases). Quantitative representativity and qualitative completeness of the resulting data can be questioned to a certain degree. Nevertheless, the response rate is relatively high and the gathered detailed material overall satisfying.

[5] The survey follows the structure of the Austrian university system in 2001, comparable to German structures and differing from Anglo-American specifications in some points (especially in the Austrian labelling of the Arts and Humanities as 'Wissenschaften', i.e., 'sciences').

- The main focus of the mentioned research projects lies in limited natural resources (especially technical and natural sciences), followed by acceptance and diffusion (especially social sciences and interdisciplinary research), and implementation and operationalisation (technical sciences and interdisciplinary research).
- Sustainability research is mostly financed by national ministries, the European Community (EC) and national research funds. Self-financing by the institutions' basic public income is only mentioned in fifth place, funding by industry in sixth place.
- Transdisciplinary cooperation throughout research projects focuses on the communal level, NGO's, and private enterprises.
- The major effects of sustainability research on the scientific system can be defined as: interdisciplinary cooperation, the development of new qualification profiles for scientists, critical reflection upon one's own discipline, improved cooperation with clients from outside the scientific system (funding institutions, target groups), and the blurring of disciplinary boundaries. Negative impact is mentioned for the scientists' disciplinary affiliation and careers, and the chances to attract high level investments.
- Major obstacles to sustainability research are defined as:[6] low financial support (68%), differing priorities (63%), lack of interdisciplinary cooperation (50%), lack of publicity (47%), and a diffuse understanding of the term 'sustainability' (42%). Considerable pro *and* contra votes were given for lacking cooperation between research institutes (37% pro, 37% contra) and work overload (36% pro, 36% contra) as the causes. Lack of a common language and mutual understanding (32% pro, 38% contra), a scientific community for sustainability research (29% pro, 43% contra) and political steering (23% pro, 43% contra) were also considered to be relevant obstacles to sustainability research.
- With regard to the qualitative shortcomings of present sustainability research, the following areas were seen as lacking: holistic thinking and integrative solutions, inter- and trans-disciplinary cooperation, societal and political implementation of knowledge about natural systems, and the effects of interference. Other shortcomings were the lack of a methodological basis, precise indicators and criteria for sustainable development, the lack of relevance for the fields of practice, and the outsider position of sustainability research within the scientific community.
- Major obstacles to the societal implementation of sustainable development are seen in the economic growth paradigm, present price signals, the political framework, and the lack of empowerment of affected parties. Societal awareness, individual preferences, knowledge, public information and media coverage are also mentioned as areas of likely interference with the science system, but ranked considerably lower. Hence, the scientists themselves see major obstacles to change in essentially extra-scientific domains.

Conclusions

Beside the overall effect that societal awareness is only partially translated into motivation for action and change, as it has to compete with other and conflicting individual and societal aims, sustainability research struggles with structural barriers that are specific to the scientific (sub-)system itself. Research on sustainable development relies on the crossing of boundaries between the disciplines, as well as those between science and society. A mutual motivation for cooperation, mutual awareness of the restricted contribution of single disciplines to the problem solution, as well as a mutual ability to cooperate and communicate successfully across these boundaries, are necessary preconditions. So far, the corresponding time-consuming and personally challenging processes have drawn their motivation from the awareness of the general need for a societal shift towards sustainability alone. Furthermore, they have to compete with the traditional, mono-disciplinary approach for funding and for their status in individual scientists' careers. Science and scientists are trapped in an either/or-situation, which results in strengthening the boundaries between traditional and post-normal science rather than in fostering joint action.

Case study II: Energy-efficient refurbishment of old urban buildings

Case study II takes an even broader view: It is meant to analyse the relevant societal sub-system(s) involved in the implementation of sustainable development in the case of the energy-efficient refurbishment of old buildings (Egger-Steiner et al., 2003a; Egger-Steiner et al., 2003b). Existing obstacles and potentials are examined, and possible strategies discussed.

Objectives

The development and diffusion of sustainable innovations strongly depend on societal priorities and are particularly sensitive to the political and economic framework. Counterproductive interests and badly-directed/aimed incentives can be seen as selective filters in the process of sustainable development. They characterise an obvious deficit in the interactions between sustainability-oriented science and societal players.

Referring to this deficit, the Forum of Austrian Scientists for Environmental Protection (Forum Österreichischer Wissenschafter für Umweltschutz) was commissioned by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) to analyse socio-economic barriers to the communication and implementation of sustainability. In detail, the analytical focus of this project was on energy efficiency in the context of refurbishing old buildings. Its objective was to highlight the current barriers and chances for the market launch and implementation of energy-efficient refurbishment. Additionally, the links to

[6] multiple choice questions

general aspects of sustainable development were emphasized.

Research area

The energy-efficient refurbishment of old buildings is one of the major fields where energy-efficient technologies are applied to reduce unsustainable dependency on fossil energy, as well as unsustainable emissions of greenhouse gases. Leutgöb et al. (2001) emphasize that the energy-efficient refurbishment of old buildings is one of the most important strategies for fulfilling the objectives of the Kyoto-Protocol, with an overall potential to achieve one-third of the Austrian share of the desired CO_2-reduction. Consequently, its implementation plays a major role in all policies aimed against climate change and is of high importance to the national strategy of sustainable development. About 60% of the total energy consumption in Austria takes place in the area of residential buildings and in the service sector; of this 60%, 80% is allocated to residential housing. Overall, 80% of the energy in Austrian households is used for heating (Leutgöb et al., 2002).

Methods

Increasing the share of energy-efficient buildings in Austria is an accepted aim of our national environmental policy. As the factors in question for steering interventions reflect a wide spectrum, from legal requirements over individual criteria of living comfort to efforts of maximisation in business management, a diversified and gradual methodological approach was chosen. An integrative and interactive scenario-workshop (Weinbrenner & Retzmann, 1998) represents the central methodological instrument of the case study.

In this workshop the participants – chosen from all pre-defined areas related to the energy-efficient refurbishment of old buildings – discussed the interdependencies and crucial interfaces, from technological and institutional innovations (heat isolation, contracting, etc.) up to their actual implementation (from installation to everyday operation). Possible future scenarios, worst case as well as best case, were developed in mixed working groups.

In summary, the scenario-workshop technique has shown a strong capacity to integrate the relevant key players and interfaces of the implementation process in terms of highlighting the wide spectrum of insider knowledge, their respective points of view, and the individual interests of the players concerned. Additionally, the workshop supported a dynamic learning process in the addressed field, thus fostering communication far beyond the workshop period.

Results

Pre-workshop investigations (including interviews with experts in the fields of practice and various feedback loops) led to a systemic model of the relevant player-fields and their modes of interaction. With regard to the scenario-technique, they can be divided into four spheres of influence characterised by three major variables each: technology (quality of products, potentials of production, costs of production), supply (integrative planning, know-how, flexibility), demand (user groups, degree and quality of information, financing) and political steering (legal framework, national housing programs, environmental policy). For each variable, both a qualitative and a quantitative descriptor have been formulated, yielding a list of 24 descriptors (e.g., for demand/information: 'information available to user-groups' and 'actual criteria for decisions made by user-groups').

During the scenario-workshop, this descriptive model, agreed upon in advance by all 19 participants, was elaborated. The result is a factor-matrix displaying the 12 variables, and the estimated impacts exercised on and caused by each variable, in relation to all other variables in a quantified mode (assigning 0, 1, 2 or 3, depending on strength of impact). The matrix allows us to calculate the sums of the passive and active involvement of each variable, indicating active, reactive, buffering or critical roles within the system (see Figure 2).

These findings were integrated into both best- and worst-case scenarios, and later on by the options to all players involved, both formulated by the experts invited to the workshop. Additionally, all discussions between the various experts arising throughout the workshop were recorded and considered in the final analysis of the workshop results.

Conclusions

The problems of a successful implementation of the energy-efficient refurbishment of old urban buildings reflect to a high degree the crucial aspects of the current barriers to initiating and guiding sustainable socio-economic transitions. Particular aspects are:

- The deficit of information and communication between the particular stakeholders across the different levels of decision-making and implementation processes.
- The dominance of short-term economic optimisation, with a tendency to support cost-efficient processes characterised by minimum transaction costs.
- The existence of routines blocking innovations.
- The lack of a participative integration of all relevant players and respective fields of action.
- The confusion of responsibilities and the incoherence of legal guidelines.
- The complexity of a process that is highly dependent on socio-economic, institutional, and political dynamics.

Referring to the previous aspects, the following options are open to national politics and public administration:

- Legal requirements should establish a clear framework.
- Well-directed subsidies help to enhance innovative pioneers and examples of best practice.
- Systemic intervention helps to make use of possible synergies.
- Clear, long-term, and reliable political statements improve future planning options and increase societal support of sustainable development.

- A gradual, anticipatory and integrative process supports the involved players in taking immediate actions towards sustainability.

Systemic integration of the two case studies and their interpretation in a wide societal context

The use of exemplary case studies as a methodological approach towards the analysis of general problem situations became increasingly popular in the last decades of transdisciplinary research in general, and sustainability research in particular. The underlying assumption is that general patterns of system behaviour can only be identified by taking a closer look at specific, localised processes. The studied case serves as a meeting point of theoretical concepts and practical experience. A growing body of knowledge and insight drawing on this interaction-oriented and experience-grounded method confirms its value for our understanding of society and sustainability.

On the other hand, inter- and transdisciplinary research is confronted with constraints additional to those of traditional scientific enterprises (Abel, 1998). As sustainability research is mostly oriented towards public goods and public welfare, financial support by the private industrial sector is scarce. Since sustainability research is a cross-disciplinary science with low chances for institutionalisation within the traditional science system, there is no regular public funding to rely on. Research projects are planned in a context of limited resources and high procedural demands. As they are based upon the close cooperation of scientists from different disciplines, and a successful interaction between science and other societal fields, and as sustainability research is to a great extent unable to retreat into a neutral and interest-free sphere of objectified knowledge, but rather confronted with complex, normative questions, the estimated workload and working time are frequently exceeded during the research process (Kastenhofer et al., 2003). Moreover, throughout a period of intensifying contact between the researchers and their fields of research, the former tend to loosen their grip on the 'big questions' and general theoretical considerations in favour of the specific characteristics of the case at hand. Consequently, the last step of the research projects, i.e., the discussion of the results in a broader scientific and integrative context, is likely to be reduced to a minimum – even more so if the success of the project depends on the satisfaction of the funding institution and the field of study alone, and is not embedded in a strong scientific community.

In the following section we will try to add such an integrative discussion to a series of projects on 'science and sustainability,' concentrating on the two case studies presented above. Though it offers not much more than a sketch of general ideas and hypotheses, we hope it might trigger similar interpretative attempts in this field. The opportunity to do so we owe to the favourable fact that an interdisciplinary research group with a stable core team has been working on the same central issue, namely the role of scientific and societal differentiation in sustainable development, in three consecutive projects within a period of five years.

A comparative systemic analysis

With regard to the interpretation and discussion of the gained results, applying a systemic view – as done and illustrated in case studies I and II – has several advantages. Systems analysis and integrative modelling can serve as heuristic tools to deepen the understanding of the characteristics of the present situation. They can be used for prognostic reasons and help to draw a picture of possible steering interventions. The steering of systems as such can refer to particular qualities of the system elements, to relations between these elements (i.e., the system structure) or to patterns of such relations (i.e., the system character or identity; Gunderson & Holling, 2002).

Given the two different analyses of societal interactions in the context of perceived unsustainable development (case studies I and II) and a preceding claim that society needs to change towards sustainability, a broader discussion on a higher level of integration looks promising.

Before we start with this integrative system analysis, the preconditions for such integration need to be clarified: Both case studies focus on specific societal sub-systems in a broad sense, and both are situated within the Austrian political and administrative system. Both take a closer look at individual players, at their multidimensional interrelations and at intersections of relevant fields of practice. They try to identify the obstacles to joint activities towards sustainability, and to formulate potentially helpful modes of intervention. Still, the two case studies do not strictly follow the same logic. Rather, they represent two snapshots taken from two distinct angles, showing two facets of our present societal system. To achieve an in-depth integrative analysis of the two cases we will have to bear in mind, and make use of, their complementary character. The centre of the following discussion is a comparative approach that develops the differences and similarities of the two cases, thus taking a further step towards the understanding of societal processes in the context of sustainability.

Whereas for case study I we have chosen the science system as an already (institutionally and culturally) well-differentiated sub-system of our society, in case study II no such 'sub-system,' in the strict sense of a semi-autonomous functional part of society,[7] exists. The second 'object' of our study has only developed throughout the research process itself: it can be seen as the result of a certain question we initially asked (i.e., how to foster the implementation of energy-efficient refurbishment) related to a certain problem perceived (i.e., climate change). Hence, case study I deals with a societal sub-system *sensu stricto*[8] and the efforts required to open it up for external objectives (i.e., sustainable development), while case study II deals with external effects of various, loosely linked

[7] A system is characterised by a functional unity, i.e. "an entity capable of performing certain tasks which relies on the functional integrity of all of its parts for maintaining that capacity." (Bonsack, 1990 as quoted by Thellefsen & Thellefsen, 1998)

[8] "Systems are most generally characterized by their complexity, their coherence and relative permanence, and their tendency to seek their own survival. These general conditions dominate the whole concept." (Thellefsen & Thellefsen, 1998)

societal player-fields according to their varied objectives, which result in a socially perceived problem situation and a solution-oriented definition of a sub-system suitable for sustainable change. In the following sections, these results of the comparative analysis are described in greater detail.

The science system: an 'ex-ante-system'?

Scientific research and education in Austria is embedded in scientific networks on international levels and can be seen as the result of a historical process of institutional differentiation (Stichweh, 1994). Presently, it is located either within the university system, within public but extra-university departments, or within private industry. Case study I is restricted to the former two, which are more easily accessible for data collection and, moreover, directly linked to the public authorities. The university system, as a place of scientific education and socialisation (Huber, 1990; Grün, 1994), as well as the international scientific community, as the respective context of validation and reference, are both organised in a hierarchy of 'science sets' (natural sciences, technical sciences, social sciences, etc.), disciplines, sub-disciplines and specialised research fields (Figure 1). These units on different levels of aggregation are characterised and continuously re-confirmed by their specific social structures, rules and community cultures (Pinch, 1990; Austin, 1990). Research projects are traditionally localised within one such research field and embedded in the corresponding discipline belonging to a certain set of sciences. In contrast, sustainability research is primarily oriented towards the solution of societal, non-scientific problems (Funtowicz & Ravetz, 1990). This may lead to interdisciplinarity, also extending across scientific cultures. It certainly leads to transdisciplinarity, because it transcends the (sub-) system borders towards society, from the formulation of the research interests to the presentation of the results to the public.

Thus, in sustainability research the societal struggle for increased sustainability meets an already well-defined and highly-structured societal and institutional (sub-)system, functioning relatively autonomously, and stabilised by self-organising processes of community building, gate keeping and boundary work (Gieryn, 1983) on the various levels of integration. Science as a societal sub-system had already existed before the societal objective of sustainability developed. At the same time, its functioning is of fundamental relevance to the pursuit of the objective. We therefore call it an ***'ex-ante system,'*** as it is related to the societal efforts towards sustainable development.

At the same time, sustainability research depends upon opening the (sub-)system to its societal environment. It emphasises a science system that perceives the need for sustainable change and initiates transitions, rather than a science system that uncritically collects more and more data and directs all scientific and educational efforts mainly towards hermetic insights or economic efficiency. Hence, it often leads to blurring boundaries between the scientific objectives of knowledge production, verification and accumulation, and the societal objectives of dealing with urgent problems, normative issues and opposed interest groups, as well as between the scientific quest for truth and the societal quest for justice.

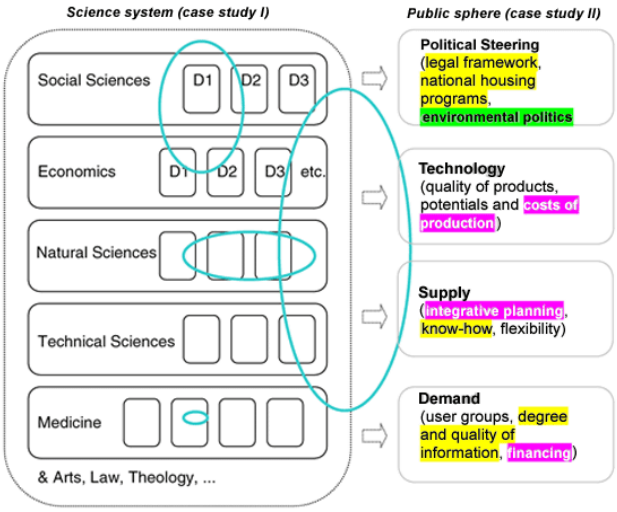

Figure 1. The science system as an 'ex-ante system', characterised by its social and institutional differentiations. Each set of sciences (e.g., 'social sciences') consists of different disciplines (D1, D2, D3, etc.) which are again split up into sub-disciplines and fields of research. Scientists and research projects (represented as blue circles in the figure) are traditionally located within such fields of research. Sustainability research crosses the given boundaries and adds interdisciplinary and transdisciplinary projects to the system.

Such indistinct boundaries present a certain threat to the autonomy and integrity of the (sub-) systems. It will – under normal circumstances – be met by processes of increased boundary work and gate keeping due to the self-regulatory capacity of the (sub-) systems. If so, we need to ask not only how the science system can be adapted to the present needs of sustainable development, but also how sustainability research can be integrated into the existing social structures in a sustainable way. Such sustainable integration has to consider the present role of science in our society (Wynne, 1993; Felt, 1999), its integrity as a semi-autonomous sub-system, and the societal preconditions and benefits of this differentiation (Fischer, 1999).

The player field of energy-efficient refurbishment: an 'ex-post-system'?

When compared to the science system described above, no similar social/societal coherence and systemic identity exists for case study II and the player fields involved in energy-efficient refurbishment. The relevant sub-system identified and analysed throughout the research process (Figure 2) has developed only as a heuristic construction related to the raised research question, and the problem situation, as perceived by society. Therefore, it does not represent a system in the strict sense of the meaning. We call it an '***ex-post system***' as related to the unsustainable syndrome of climate change (Figure 3).

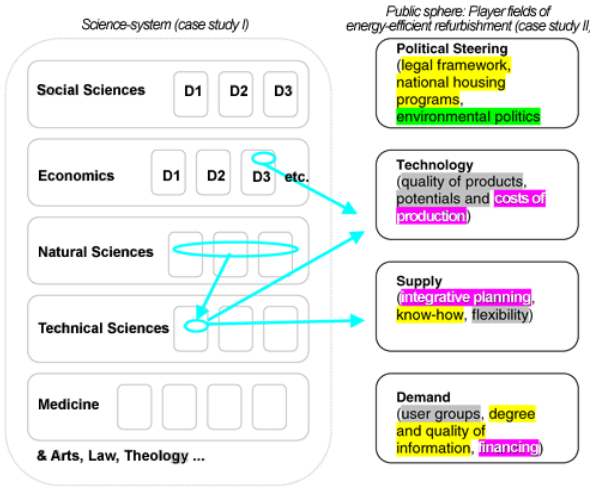

Figure 2. Player fields and related variables of energy-efficient refurbishment. To convey an idea of the results of case study II, both qualitative and quantitative variables of the four identified player fields are given: critical variables are marked red, buffering variables green, active variables yellow, reactive variables grey. To show the connection to the science system analysed in case study I, the integration of disciplinary research within technology and supply is indicated in an exemplary sketch.

The progressive construction of the ex-post system model starts with the perceived problem of climate change and the scientific identification of the causal connection to green house gases, especially CO_2. It is followed by a political decision to reduce CO_2-emission loads within the household sector via steering interventions on a national level. Case study II aims to identify all players involved in the implementation of this task, and to analyse their actual and potential roles, be they beneficial or restraining, buffering or critical. Hence, a central aspect of the research process has been to build a systemic model of a section of our society, which *should* (in the context of sustainability), *but does not yet* function as a semi-autonomous, self-regulatory sub-system. It consists of various, loosely linked player-fields, variables, players and actions, and, respectively, effects. In a best-case scenario, political steering, technology, supply, demand, social, economic and environmental effects would be linked by direct and indirect connections, resulting in an iterative process of sustainable development. Therefore, causes and effects, presently separated by the lapse of time and a lack of integrating mechanisms and structures, need a link stronger than the merely passive contributions to a common external effect. Examples of strengthening social links are community building, participatory processes, and rising awareness. Other steering interventions, such as legal restrictions formulated by players external to the field of practice, and restrictions that change unpredictably (without feedback loops), result in a loosening of internal links, and prevent the formation of a self-regulatory sub-system. They direct the players' attentions towards an unpredictable environment, instead of raising their awareness of the predictable effects of their actions within particular fields.

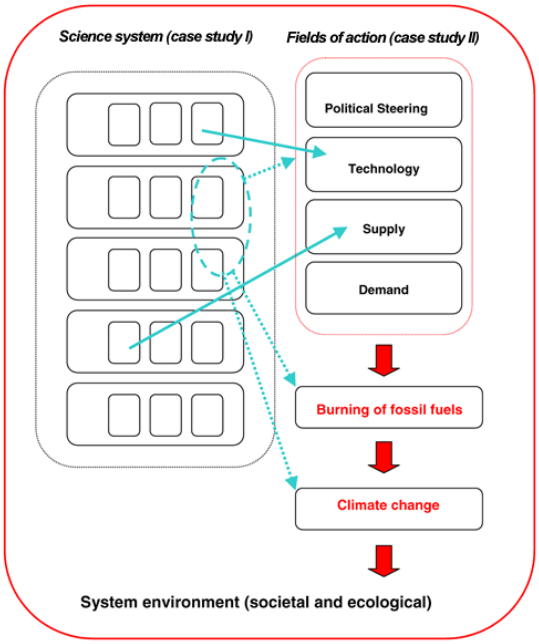

Figure 3. Player fields of energy-efficient refurbishment as an 'ex-post system' in the context of an unsustainable syndrome (climate change) . The systemic connection is only evident from bottom to top, starting with the effects perceived, then analysing the related causes, and finally identifying the relevant players and fields of action. Otherwise, the players form a loosely linked network without any perceivable systemic connection.

Far from giving preference to one or the other political instrument, we aim to highlight their systemic dimensions. One significant result of case study II is the crucial role of international environmental policy and national legal restrictions (as mentioned repeatedly in expert interviews and during the workshop), both operating on crucial variables, such as production costs and modes of planning and implementation. Consequently, a rather passive picture of the fields of practice, depending upon external factors, is drawn. A complementary description arises, given the fact that know-how within the supply field, the degree and quality of information within the spectrum of demand, and national housing programmes can play an active role. They are likely to do so if the crucial variables are handled with care, and planned and formulated with a long-term view and in close connection to the fields of practice.

Concluding remarks

By presenting our comparative systemic analysis of the two case studies and proposing a distinction between 'ex-ante' and 'ex-post' systems, we have tried to focus especially on societal structures and sustainable change. Without doubt, this distinction is only one among several. It draws one's attention to systemic differentiation and complex interactions. The overall goal of this particular

perspective is to clarify the present problems and potentials in the context of sustainable development in greater detail and, hopefully, to enrich the debate on societal transitions.

As mentioned above, the analysis in hand can be no more than a first step towards an integrative theoretical discussion of societal differentiation and sustainable change. Nevertheless, we have endeavoured to illustrate that obstacles to and potentials of sustainable development can be identified in greater detail if the specific systemic character of the field of implementation is taken into account, that transition management can be improved by carefully directed systemic intervention, and that we need to deepen our understanding of sustainability research and sustainability policy with regard to the roles they play in various systemic societal contexts.

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