Limits and options for sustaining technological development through systems renewal

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Abstract

The article explains why sustainable technology development needs fundamentally new strategies in process-architecture, management and policy. The concepts for developing new technologies that claim to contribute to a more sustainable future have great options but also limits. Such limits can be seen as disadvantages just as well as important challenges to be taken. *Limit 1*. resource efficiency requires real cost verity; *limit 2*. consumerism and the rebound-effect overcompensate all economizing effects; *limit 3*. velocity of innovation kills the possibility of feed-back and learning; *limit 4*. sustainable development requires a change in individual life-styles; *limit 5*. institutional obstacles act as impediments for renewing the system; *limit 6*. regional economies and local initiatives are the basis for sustainability but are heavily under the pressure of globalisation.

The main lacks and hindrances within the development concepts for new technologies themselves are: *hindrance 1*. problem-oriented strategies instead of *option 1*. working with vision-oriented strategies; *hindrance 2*. repairing principle instead of *option 2*. precautionary principles; *hindrance 3*. strategies that concentrate on product- and technology-orientation instead of *option 3*. system- and impact- oriented strategies; *hindrance 4*. strategies that focus on technical restrictions instead of *option 4*. clarifying restrictions of awareness; *hindrance 5*. strategies for conserving the economic-technological structures instead of *option 5*. learning and evolving concepts including reflection and feed-back; and last but not least *hindrance 6*. great lack of knowledge, wisdom or even courage in taking ecological and ethical principles into politics and technosphere as opposed to *option 6*, which would be the opposite.

To give a positive contribution I suggest a technology development concept with a six step architecture. It consists of a loop with six steps and after step 6 the cycle starts again with step 1:

1) **Networking:** Forming and positioning a network
2) **Visioning**: Creating long-term guiding visions and future scenarios
3) **Backcasting**: Planning objectives and actions (long-, mid- and short-term)
4) **Innovating:** Definition of short term action and goals
5) **Experiencing**: Gaining experiences by concreting the ideas through projects
6) **Reflecting**: Integration of feed-back loops and learning methods
1) **Networking**: Establish operational participation and communication structures

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The proposed process tries to stimulate the dialogue of creating a new vision that might have the power to turn around our unsustainable technological systems. Hereby also national and EU politicians are directly addressed and called upon to establish opportunities for real system renewal through a new, open and participatory process in sustainable product and technology development.

1. General Introduction - Limits of our system

Sustainable technology development needs fundamentally new strategies in process-architecture, management and policy. But the common strategies for developing new technologies have great limits even if they emphasize that they contribute to a more sustainable future. Such limits can be seen either as disadvantages or as important challenges. Those limits derive mainly from our economic-technological system and can be formulated in the following six theses.

Limit 1. *The lack of cost verity is a great barrier to resource efficiency.* Every strategy to increase resource and eco-efficiency can only be sustainable if the underlying system (e.g. the transport system) itself is questioned in the first place. Then a fundamental course has to be set up and followed in the direction of sustainable development. True costs of products and services are one of the major requirements and necessities for initiating this change.

Limit 2. *Consumption overcompensates all economizing effects.* Examining the history of technology, we realise that the common paths of development are definitely not sustainable at all. While there has always been the hope of handling imminent problems by applying powerful new technical solutions, this route has only been successful in the short term. In the long term it has almost invariably led to a change for the worse. It is perhaps an inevitable consequence of world market conditions, and maybe also of human nature, that technological progress gets generally "abused." The accompanying potential for dematerialization always ended up in growing world population and in generating always more products, services, energy use and so forth. This common development-scheme leads to such an extent of resource use that it massively overcompensates for the original technological progress made, and essentially eliminates any potential overall reduction ("rebound effect"). This means, that the subsequent erosion of the positive potential of technological innovation by the increase in overall activity, and by the concomitant increase in consumption of material and energy have to be avoided through a change in values, behaviour and habits. There even might be a deeply rooted need for it because one main result of flooding the world with consumer goods is deep human dissatisfaction, as Victor Papanek diagnosed.

Limit 3. *Velocity of innovation kills the possibility for system learning.* Charlie Chaplin said in the film “The Great Dictator” (1942): "We have developed speed, but we have shut ourselves in. Machinery that gives abundance has left us in want." Nowadays innovations are introduced into the market in shorter and shorter intervals. Consequently, the time span from the initial idea to the concrete realisation and

launch of the product has been dramatically reduced. Permanent introduction of new products does not encourage the consumer to give feed-back on quality and benefits in order to improve the product of the generation before. In a sense, technological progress has been the very means by which natural resources have been transformed with increasing rapidity into goods, services and functions. Dematerialization has, unfortunately, been one of the primary inputs into this acceleration process. In part this also results from the fact that up to now saving labour is a much more effective strategy to survive in the market than saving resources.

Limit 4. *Individual life-styles contradict principles of sustainable development.* Since 1980 the gross national product has increased in the rich Northern countries whereas the Index for Sustainable Economic Welfare (ISEW) has remained the same. Sustainable development has to put emphasis on increase of social welfare and requires a reconstruction of fields of life such as accommodation, nutrition, work, consumption, leisure time, education and mobility, all in consideration of a high living standard: „A good living instead of having a lot!“, so to speak. To safeguard the future is, more than anything, a question of our values and ethical principles: what do we consider good or bad, what do we desire or reject, what are we prepared to support or to fight for? Over time, human and social values have to change. Concepts that once seemed extraordinary (e.g. emancipating slaves, enfranchising women) are now taken for granted. New concepts like responsible consumerism, environmental justice, intra- and inter-generational equity are now coming up the curve. The main question is still: How can we reverse the current dangerous global trends of population growth, over-consumption of resources, poverty, decreasing quality of life and imminent global catastrophes?

Limit 5. *Institutional obstacles act as great impediments to renewing the system.* From the time on when institutional departments like administration, political divisions, universities, research institutions etc. were subdivided into sections we tend to look only for partial solutions instead of an optimal solution for the whole system (efficiency by synergy). But sustainable development is more a communicative than a technical process. Within the development of a new "global" framework, the world economic and political systems have to be modified to incorporate social, regional and ecological considerations in a globally adequate manner. Real improvements in pulling down the rebound effect requires holistic, intensive and ambitious efforts to achieve a fundamental change in culture, structure (institutional, political, systemic) and technology. This process therefore can be interpreted as a mixture of three important eco-principles: 1) sufficiency in fulfilling all social and cultural needs, that have to be legitimated by politics, bureaucracy and jurisdiction in their nature and extent; 2) effectiveness in the institutional and structural organisation of fulfilling these legitimated needs and 3) efficiency in the "translation" of these needs by means and tools of intelligent and safe technology.

Limit 6. Global market trends work against regional economies and local initiatives. Resource efficiency is one of the crucial targets on a global scale. But sustainable development needs to be established on a regional level. Hereby also the following

targets are of global necessity: use of renewable resources, service orientation, risk precaution, job preservation and many more. The establishment of appropriate global frameworks for sustainability needs to combine local contributions and activities with sustainability on the regional scale. Only local projects and initiatives can make contributions toward sustainable development, since they build up individual awareness of global problems and act as a model for further activities. However, local projects can have counterproductive effects if seen from a global perspective. This can be the case if they merely cause ecological and social burdens to be exported to other localities instead of avoiding the burdens altogether. Therefore, determining whether a local initiative is good often is a question of weighing the benefits against the drawbacks. A main factor for avoiding unsustainable results on the local scale is the orientation to a guiding vision which has to be developed by reflecting the common and world-wide principles of sustainability. Hence bottom-up processes are important counterbalances to top-down approaches derived from national or super-national authorities. By realizing that there is no way around the regions to initiate a course of change, the single states have to create appropriate conditions for setting off local initiatives that will forward the cause of sustainable development. Summing it up in the words of J. F. Kennedy: "All politics is local!"

2. Hindrances and Options as answers to the sustainability challenge

As an overview the main hidden gaps (*hindrances*) in the common technology-development for increasing sustainability are listed below. The overview can be seen as an analysis of the main common technology development concepts, as Factor 4, 4+, 10 and beyond, MIPS - concept, industrial ecology, cleaner production and clean technologies, zero emission and upcycling, life cycle assessment and design, integrated-, eco- and sustainable product design, environmental management systems, eco-efficiency etc.. In the same list the hindrances are confronted with possible solutions (*options*) and strategies that might make technology development go into a more sustainable future.

Hindrance 1. *Problem orientation.* Problem-oriented strategies try to optimise, improve or re-design a special product or technology, which only leads to smaller "cosmetic corrections". Instead of focusing on the problems we have to learn more and more to think in solutions. In practise this leads to

Option 1. working with *vision-oriented strategies*, that focus on a fundamental renewal of our systems e.g. through paradigm shift, transdisciplinarity, networking, and causal-based instead of symptom-based concepts.

Hindrance 2. *Repairing principle*. Most eco-technologies are end-of-pipe and try to repair the damages to nature and/or society. Instead of this old-fashioned way of handling the problems a new paradigm has to succeed in gaining no more problems through

Option 2. *Precautionary principle*. Here clean and safe technologies are addressed, which try to fulfil the precautionary principle by opening the range of possibilities for the future instead of determining them.

Hindrance 3. Strategies that concentrated on *product- and technology-orientation* (like product design, classical technology development and others) instead of

Option 3. *System- and impact- oriented strategies* with new forms of participation of consumers, asking the needs and wants and reflecting them critically on sustainability principles.

Hindrance 4. Strategies that focus on *technical restrictions*, e.g. thinking that only the technology itself or economic criteria restrict development, not realising that restrictions are often blockades in mind.

Option 4. *Clarifying restrictions of awareness* is the basis for a fundamental renewal of our unsustainable society. All processes start in the mind and the heart when awareness over a certain topic has been build up.

Hindrance 5. Strategies for conserving the economic-technological structures are much more common and have much greater finance backbone instead of

Option 5. Learning and evolving concepts including reflection and feed-back. This might explain why today stagnation and "stagnovation" processes are common instead of the will for real innovations for a sustainable development;

Hindrance 6. A great *lack of knowledge, wisdom or even courage* can be observed in our society. The "civil society" which is forming nowadays is very young and is growing without control and direction.

Option 6. *Taking ecological and ethical principles into politics and technosphere*. Understanding ecosystems and the wisdom of nature give hope for new forms of participation, subsidiarity, democracy and long term sustainability.

3. A new strategy for developing sustainable technologies

Before explaining the strategy itself a set of main eco-principles should act as useful and even compulsory guidelines to reach the goal of a drastic minimization of resource exploitation and wastage. Such eco-principles or guidelines for redesigning industry can be derived directly from system analysis and bio-cybernetics of nature:

- sufficiency / effectiveness / efficiency (eco-efficiency)
- embeddedness / non-Invasiveness
- flexibility and ability of adaptation
- ability to learn, to reflect and to use / recognize (also negative) feed-back loops
- process ability and ability of evolutionary development
- mixed and multi functionality
- minimizing risk / toxicity / susceptibility to failure
- life-cycle orientation / need orientation
- paradigm shift and behaviour orientation

- creativity, beauty, attractiveness and ability to change life-styles.

Beyond doubt, this list is incomplete, but the usefulness of such a set of derived eco-principles is demonstrated in the points below that assemble a new strategy.

3.1 Systems renewal - a strategy will get us a sustainable future

Drastic improvements in the eco-efficiency or dematerialization of our processes and technologies have to fit in the time scope of the usual decision making and action planning that business is accustomed to. This leads to a threefold approach along parallel guiding lines (trajectories):

1.) System Optimisation, corresponding to operational processes like quality management, auditing, efficiency drives etc., all with time scales up to 5 years maximum and with an expected effect on eco-efficiency ranging up to a factor 2 ½.

2.) System Improvement, leaving fundamental structures and technologies unchanged but implementing incremental changes corresponding to processes like revision, reorganisation, and redesign with time scales from 5 to 20 years and with an expected effect on eco-efficiency ranging from a factor 2 ½ up to 5.

3.) System Renewal, by fundamental jump-like changes, resulting from long term research and affecting structure, culture and technology fundamentally, with time scales of over 25 years and possible efficiency factors of 20 and more (see fig. 1; Jansen 2000).

Since the strategies of optimisation and improvement are more or less covered by actual policies and policy instruments, e.g. through special programs in the member states of the EU, the real challenge is the ambitious initiation and implementation of processes for a real system renewal. But fundamental system renewal takes several years of time from concept to market. This period of time goes far beyond the terms which are usual in business.

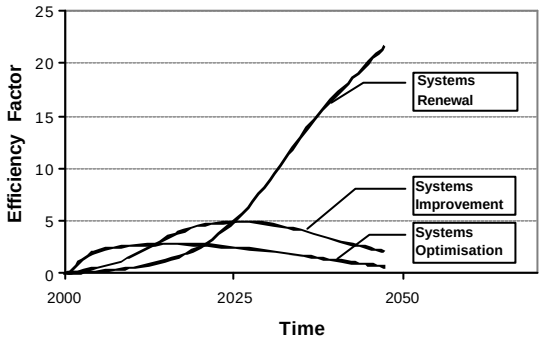

Fig. 1:
Different guiding lines - trajectories of change (systems optimisation, improvement and renewal) and their impact on efficiency factors in time (on the basis of Jansen, 2000)

3.2 Systems renewal - a strategy can lead us to factor 10 and beyond

To cope with the main challenges and dilemmas of today's world, the process of systems renewal has to have a special characteristic:

- handling uncertainties on long term trends and risks, including different risk perceptions based on different appreciation of normative and scientific analyses and future expectations,
- new roles and forms of co-operation between market, science & technology, government and NGO that take their specific strengths, weaknesses and responsibilities into account,
- involvement and participation of many actors, stake holders and partners,
- bridging the drive of competition and the necessity of co-operation,
- arrangements that are often crossing economic and sectoral borders,
- the three dimensions of sustainability - nature, economy and society - are considered not only from a principal point of view but also from the practical interest of viability of new means, products and processes.

All points mentioned above require transparency and new forms of participation in design, architecture and management of the process for a sustainable technology development. For breaking through to a new era of sustainable eco-technologies we have to try new ways. Since: "If you always do what you always did - you will always get what you always got (Benjamin Franklin)."

3.3 Management for systems renewal - the process architecture

On the basis of the analysis of the systemic limits and barriers towards a sustainable development and the inherent obstacles hindering the development process of new technologies themselves, a proposal for a step-wise process to break through the inertia in an evolutionary way is given below. Since we have more or less the knowledge of the main guiding principles for a sustainable development, a fundamentally new process for technology development has to be elaborated. As a preliminary scheme I suggest a model shown in table 1. To let this vision become true, political programmes for sustainable technology development in special fields like housing, mobility, consuming and nutrition have to be established regionally, nationally and globally.

Table 1: Six step concept for a "Sustainable Technology Development - Process"

Step 1: **Networking**	Forming and positioning a network - based on ecological, societal and ethical principles - for sustainable product development
Step 2: **Visioning**	Creating long-term guiding visions and future scenarios that act as motivating, orientating and coordinating means and help to open minds and hearts
Step 3: **Backcasting**	Planning objectives and actions in long-, mid- and short-term perspective by starting from the end (in mind) and stepping back to present
Step 4: **Innovating**	Definition of short term action and goals also by reversing and turning the classical concepts around and taking the whole system and the function into account
Step 5: **Experiencing**	Gaining experiences and knowledge by concreting the ideas and by setting up (and working in demonstration and) pilot projects
Step 6: **Reflecting**	Integration of feed-back loops and learning methods like time for reflection, self-evaluation and a cyclic process structure
Step 1. **Networking**	Establish operational participation and communication structures and forming synergetic co-evolutionary processes

3.4 Visioning and backcasting - heart of sustainable technology development

In systems renewal broadly shared future orientations serve primarily as a source for the backcasting procedure to design innovation paths for development of sustainable technologies or policy programs. Starting from a jointly developed guiding vision these orientations may as well help to focus ongoing system optimisation and system improvement or redesign. The four general positive functions of a guiding vision are orientation, coordination, motivation and legitimisation.

Some barriers to real systems renewal are obvious: A heavily co-ordinated top down procedure may well result in a killing bureaucratic system. The expression “future orientation” or "guiding vision" rather than “view” or “picture” not to say “blue print” is meant to indicate that the orientation should be a rough one giving room for specific interpretations and flexible adaptation - just like the WCED report “Our Common Future” (1987) gives an orientation on development. Another illustrative orientation is the common goal in the post (2nd World) War period in Western Europe:

Europe: Rebuild and Reconstruct Europe. Future orientations may well be developed top-down as well as bottom-up.

A conclusion can be made as following: Top-down and bottom-up approaches are both necessary, act complementary and may be applied without heavy formal co-ordination. Communication, dialogue and consensus between relevant parties, however, is essential. The different levels of exploration may be regarded as a sequence of divergent and convergent processes, but all of them are urgent for sustaining our society.

4. Conclusion - a new policy for sustainable technology development

An important question is whether and how the policies of the member states and of the EU itself can be directed to initiate innovation processes to develop sustainable options for the future. On the basis of a general future orientation on EU level, a framework for innovation processes in respective domains of need, in economic sectors and in different regions can be developed. Policies to initiate such innovation processes should recognise a double approach: top-down and bottom–up. Changes in societal systems and changes in governmental structures and procedures may run parallel in the sequence optimisation, – improvement, and - renewal and vice versa.

Another aspect has to be considered: Sustainability oriented governmental policies pointing to systems renewal differ essentially from more traditional environmental policies pointing to systems optimisation and improvement. The degree of uncertainty, the scope of action, the shift of accentuation in the sequence from production process to need fulfilment result in essentially differing driving forces and the effects of administrative incentives imply a different role and attitude from government. Trying to force technology into a certain direction by setting higher future standards may only lead to systems optimisation or improvement in a time scale up to middle long terms. Such regulations will not evoke private parties to undertake the risky development of system renewal. Government can forbid private parties to act irresponsibly but cannot command to take future risks of development.

Incentives have to create a new understanding of responsibility for the future. All this requires a fundamental but achievable change in the role of politics and governments. With respect to this new field of activity and as a basis to set up long term system renewal programs, governments have to take responsibility for the consensual development of common shared guiding visions (future orientations). Further they have to learn how to share risk with private parties when developing science and technology in broad long term system renewal development programs. Participating and co-operating between relevant stake holders and developing structures and opportunities for participation of non-industrial stake holders (NGO's etc.) are additionally of essential importance in sustaining future processes.

Meeting these demands requires a change in governmental attitude and structures in new forms of public management (Bemelmans et al., 1999). In time and intensity these changes may run parallel to the subsequent changes in systems from optimisation on the short term up to renewal on the long term scale. Moreover the implementation of processes for sustainable technology development also needs:

- creative incentives as for instance an education and awareness campaign leading to certain wants and market trends;
- a global taxation of resources and energy (eco-taxes) and a global system to finance the rebuilding und renewal of the system (certificates, vouchers etc.);
- new indicators for measuring real public welfare as for example the ISEW (Hochreiter, 1995) to act more efficiently against the falling quality of life;
- a new calculation of terms like return of invest, share- and stakeholder value as demonstrated by the Dow Jones Sustainability Group Index (DJSGI, 2000);
- building capacity in educational systems (Ehrenfeld et al., 2000) like signing, implementing and practising the Copernicus Charter;
- new forms of cooperation and dialogue, e.g. the "Dutch approach".

But with all this we should never forget the main challenge of the next century and the final aim of all efforts: fulfilling all social and human needs in dignity by maintaining evolutionary capacity.

References

Bemelmans M. L. et al.: Renewing Government: A Tale for all Times, p. 13-34. In: Nelissen N. et al.: Renewing Government, Innovative and Inspiring Visions, Utrecht 1999.

Deutscher Bundestag, Drucksache 14/571/ 18.03.99, “Forschungs- und Technologiepolitik für eine nachhaltige Entwicklung”.

DJSGI: Charts of Dow Jones Sustainability Group Indexes, Mai 2000 (www.sustainability-index.com).

Ehrenfeld J., Conceição P., Heitor M.V. and Vieira P.S.: Towards Sustainable Universities: Challenges for engineering education in the learning economy, Presentation Lisbon 21.01.2000.

Forum für Klima und Global Change, Schweizerische Akademie der Naturwissenschaften (Hrsg.): Visionen der Forschenden. Forschung zu Nachhaltigkeit und Globalem Wandel – Wissenschaftspolitische Visionen der Schweizer Forschenden. 2. Aufl., Bern 1998.

Gavigan J.: EC-Technology Foresight for Engineering and Technology in Portugal, Views from IPTS - Joint Research Centre, Lisbon, 2000.

Grin, J., Grunwald, A.: Vision Assessemnt: Shaping Technology in 21st Century Society. Towards a Repertoire for Technology Assessment. Wissenschaftsethik und Technikfolgenbewertung Band 4, Berlin 2000.

Häberli, R., Scholz R. W., Bill, A., Welti, M. (Hrsg.): Transdisciplinarity: Joint Problem-Solving among Science, Technology and Society. Proceedings of the International Transdisciplinarity 2000 Conference. Zürich 2000.

Hochreiter H., Obermayr B., Steiner K., Stockhammer E.: Der Index of Sustainable Economic Welfare - ISEW: Eine empirische Studie zur Wohlstandsentwicklung in Österreich von 1955 bis 1992. Interdisziplinäres Institut für Umwelt und Wirtschaft- IUW, Wirtschaftsuniversität Wien, Wien 1995, S. 42.

Jansen L. A. et al.: STD Vision 2040 – 1998. Technology - Key to Sustainable Prosperity”, DTO Duurzame Technologische Ontwikkeling, Uitgever Publisher, Den Haag 1997.

Jansen L. A.: Europolis in Sustainable Development. The challenge of evolutionary change!, EU Workshop, Maastricht, 13.-14.4. 2000.

Moser A.: Eco-Technology as a new engineering discipline, Eco-Technology Newsletter No.2, Graz, July 1997.

Moser A. (Ed.): The Green Book of Eco-Tech. Strategy report form the 4th International Ecological Engineering Conference, Graz 1998.

Reeve N., Gandar P.: The New Zealand foresight project – An overview, p.101-110. In: Boekestein A. et al. (Ed.): Towards an agenda for agricultural research in Europe, Wageningen 2000.

Rutten H., Verkaik A. P., de Wit J.: Using foresight to develop strategies for science technology and innovation, p.91-99; In: Boekestein et al. (Ed.): Towards an Agenda for Agricultural Research in Europe, Wageningen 2000.

Strigl A. W.: Sustainable Product Development. Possibilities for restructuring the process of product and technology development through a vision-oriented innovation strategy for sustainable development. Study on behalf of the Federal Ministry for Transport, Innovation and Technology, Vienna 2000.

Strigl A. W., Kanatschnig D.: Systemic Effects of Sustainable Technologies. Analysis and Evaluation of systemic impacts of technologies with regard to the concept of a sustainable (technological) development. Study on behalf of the Federal Ministry for Science and Transport, Vienna 1998.

Weaver P., Jansen L., Grootveld G. v., Spiegel E. v., Vergragt P.: Sustainable Technology Development, Sheffield 2000.