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Backcasting from non-overlapping sustainability principles — a framework for strategic planning

by

John Holmberg[a] and Karl-Henrik Robèrt[a,b]

[a]Physical Resource Theory, Chalmers University of Technology and Göteborg University, S-41296, Göteborg, Sweden. E-mail: frtjh@fy.chalmers.se (Corresponding author)
[b]The Natural Step Foundation, Wallingatan 22, S-111 24 Stockholm, Sweden.

Abstract
Backcasting is a planning methodology that is particularly helpful when problems at hand are complex and when present trends are part of the problems. When applied in planning towards sustainability, backcasting can increase the likelihood of handling the ecologically complex issues in a systematic and coordinated way, and also to foresee certain changes, even from a self-beneficial point of view, of the market and increase the chances of a relatively strong economic performance. To that end, backcasting should be performed from a set of non-overlapping principles that are general enough to be helpful in the coordination of different sectors of society and in business, as well as to cover relevant aspects of sustainability. Such principles are helpful when developing reliable non-overlapping indicators for monitoring of the development when coordinating various measures from different sectors of the society or within individual firms with each other, and when handling trade-offs in a relevant way. Furthermore, the transition can benefit from being undertaken in a strategic step-by-step manner, by which such investments should be searched for that combine two qualities: (i) technical flexibility to serve as platforms for future investments in line with non-overlapping principles of sustainability, and (ii) good possibilities of giving relatively fast return on investment. This framework for planning is developed together with the Natural Step, a non-government organization, and in collaboration with a network of scientists and business. Examples are given from firms applying the framework.

Key words: sustainability, socio-ecological principles, system conditions, strategic planning, backcasting, the natural step

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1. INTRODUCTION

Industrial society can be said to be a highly manipulated part of the natural ecosystem, but its dependence on, and influence on, the natural ecosystems are determined by the same basic laws of nature that are in operation in nature itself. Ever larger parts of nature are manipulated to meet the demands of society, and ever-smaller parts can be said to be untouched by human activities (Vitousek *et al.* 1997). In a world where soon 10 billion people will seek to meet their needs, most people in business realize that, in some way, tomorrow's market place will change. Many people also realize that we need to correct today's influence by the industrial society on ecosystems. Industrial Ecology (IE) can be perceived as merging the aspects of economy and ecology into one. From an intuitive level, it is close at hand to expect a strategic step-by-step alignment of industrial activities with principles of sustainability to be good for business. But, can we also find a logical rationale behind such a strategy? How can ecology and economy be merged together into one strategy that makes sense in the short term as well as in the long term, and from a business perspective as well as for the common good?

The need to identify business strategies for sustainable development, that are based on systems thinking, is based on a number of observations:

- Environmental problems have changed character towards a situation with: environmental effects on larger scales, more diffuse emissions, longer time lags from cause to effect, and with more actors involved. The environmental problems have thus expanded towards larger complexity (Holmberg & Karlsson 1992). At the same time, Earth's population is increasing and is not expected to level off until around 10 billion people (United Nations 1992). Furthermore, the global per capita demand on energy increases (Lazarus 1993 and Johansson *et al.* 1993), and the same is true for many other resources.
- Many environmental problems are serious both in the sense that they are difficult to solve and that they have potential for major adverse impacts. Marginal changes to deal with the situation are not sufficient in many sectors of society.
- The scientific uncertainty is huge for many environmental problems. As a consequence, the debate in society often deals with one problem at a time in a fragmented fashion. The result is often confusion and sub-optimized measures that are not integrated in a large enough system perspective.
- There is often a lack of logical rationales to deal with trade-offs. Most measures are such that they lead to positive effects in certain aspects and negative in others. For instance, a belt-way around a city that may decrease emissions in the city center, but decrease ecologically fertile areas and increase the risks for an unwanted expansion of the number of cars. Or, an investment in a process that will decrease emissions but that will use more energy.
- The costs for certain proactive investments are relatively simple to estimate, but the costs for maintaining business as usual (for instance costs from deprivation of future ecological values, or consequences of the polluter pays principle) is an even more complex issue. The imbalance of reliability in estimates of marginal costs and marginal profits for proactivity favors business as usual on the account of proactivity.

All the problems described above, adding to the complexity of problems linked to the fast evolving field of Industrial Ecology, highlight the lack of a generally accepted framework for discussing such problems and their solutions. This is also in line with the concluding statements from the 1996 Norwegian Academy of Technological Science -seminar: "Industrial Ecology and Sustainable Product Design" (Brattebø 1996). The importance of system thinking has been pointed out by Bucciarelli (1998), who means that the design processes within the field of IE is full of uncertainty and it is therefore a need to see the system as a whole to consider the big picture. The designer must learn to strip away all that is irrelevant.

The connection between the field of IE and the concept of sustainable development has been discussed by several authors (Frosch & Gallopoulos 1989; Ehrenfeld 1992; Socolow et al. 1994; Graedel & Allenby et al. 1995; Ayres & Ayres 1996; Allenby 1998). Bras (1996) writes that the system focus of IE is on a meso level under sustainable development and over many different tools and methodologies. This does not mean that one level is more important than any other level. It means that the IE level also is very important and it is strongly related to the discussion on sustainable development. Thus, IE is system analysis of the societal industrial metabolism from a sustainability perspective. The analysis aims at identification of characteristics in different energy and material flows as well as identification of restrictions and possibilities for the adaptation of the societal metabolism to sustainability

The framework presented in this paper is not an alternative to other existing decision supporting tools for reduced environmental impact, e.g., Life-Cycle Assessment (LCA), streamlined LCA, Design for Environment (DfE), ecological footprint, factor x, environmental space, or the environmental management systems ISO 14001, EMAS and BS7750 (Vellinga et al. (1997) give a good overview of different tools). Instead, the framework, which is based on a description of conditions for sustainability in the whole ecosphere, highlights the need for those more specific tools, and can be helpful in coordinating those to the benefit of the whole. Hence, the conditions for *sustainability* presented in this paper can be used to guide specific tools for *sustainable development*.

Thus, this paper is one contribution to the important task of identifying frameworks which focuses on the interface between sustainability and IE and, hence, can be helpful in guiding many different planning processes and tools. Such a framework implies an important task because when humans become aware of problems, and perceive them from a shared systems perspective, we often have an ability to turn them into challenges and to find possibilities and creative solutions. The role of a shared systems perspective to facilitate communication is often underestimated. The importance of communication in IE has been pointed out by Weijnen (1998), who says that in real IE projects it is seldom the technology, but rather the communication, that is the stumbling block. This is also the experience from many proactive firms and organizations (Nattrass & Altomare 1999).

There exists an extensive literature which discuss the societal interaction with the natural environment (Boulding 1966; Ayres and Kneese 1969; Hart and Socolow 1971; Odum 1971; Ehrlich and Holdren 1972; Meadows et al.1972; Geogescu-Roegen 1977; Prigogine and Stengers 1984; Cleveland 1987; Martinez-Alier 1987; Costanza 1991; Daly 1992; Meadows et al. 1992; Ayres and Simmonis 1995; Wackernagel and Rees 1996 to name a few) some authors have tried to structure this information into operational principles for sustainability (Daly 1990; Jacobs 1991; Goodland et al. 1992; Holdren et al 1992; Schmidheiny 1992). The principles (system conditions) which are essential parts of the framework presented in this paper have been presented before and compared with work of others (Holmberg 1995; Holmberg et al. 1996; Holmberg & Robèrt 1997; Robèrt et al. 1997). In this paper we discuss the rationale for — and prerequisites for — backcasting in planning for sustainable business, and relate the principles to that purpose. *Backcasting* is a methodology for planning under uncertain circumstances. In the context of sustainable development, it means to start planning from a description of the requirements that have to be met when society has successfully become sustainable, then the planning process proceeds by linking today with tomorrow in a strategic way: what shall we do today to get there? What are the economically most effective investments to make the society ecologically and socially attractive? In this paper we discuss how backcasting differs from the more commonly referred to methodology of *forecasting*: and deal with the following questions:

- Is there a rationale from a business point of view for backcasting in planning for sustainability?
- If such a rationale can be found, how would a strategy for harvesting the potential self-benefit be formulated?
- What are the demands for making such a strategy effective? We discuss a set of non-overlapping principles for sustainability and the rationale for them in this context.

This framework for planning, presented in this paper, is developed together with the Natural Step, a non-government organization, and in collaboration with a network of scientists and business. At the end of the paper we give examples from firms applying the framework.

2. BACKCASTING IN PLANNING FOR SUSTAINABILITY

The future is often viewed through the mirror of the past. This can be risky, if past trends are allowed to influence or even determine what is considered a realistic strategy. This is particularly true if such factors are part, or even the main drivers, of the present problems. If we look at the problem of non-sustainability, such factors could be today's use of fossil fuels, today's accounting systems for economic performance (GNP), today's traffic systems, and today's public knowledge about environmental issues. If those factors are allowed to be the main determinants of what is taken to be relevant and realistic in the planning process, the strategy is likely to transfer the problems that are due to these factors into the future

Backcasting stands out as an alternative to traditional forecast (Robinson 1990). It is a method in which the future desired conditions are envisioned and steps are then defined to attain those conditions, rather than to take steps that are merely a continuum of present methods extrapolated into the future. Backcasting is particularly useful when (Dreborg 1996):

- The problem to be studied is complex.
- There is a need for major change.
- Dominant trends are part of the problem.
- The problem to a great extent is a matter of externalities.
- The scope is wide enough and the time horizon long enough to leave considerable room for deliberate choice.

In order to illustrate the backcasting methodology, we can see what it will imply for Life Cycle Assessments (LCA): Most of the LCA done today are calculated with data from today's situation, e.g., calculations are based on today's use of fossil fuels in electricity production and for transportation. From a backcasting perspective these LCA should be complemented with assessments that instead assume that the product or process exists in a sustainable society. What parameters will change when the whole society has a sustainable metabolism? The reason for doing this must not solely be to inspire altruism. It is rather a method to get early warning signals for when long-term investments based on today's structure can lead to dead ends and when marginal changes are not enough, i.e., when technological leaps are required. Marginal changes can be counter productive, even if they are reducing today's impact on nature. Marginal changes of an old system can lock up resources that could be used in a strategically smarter way.

2.1 Business rational for backcasting in sustainable development

Firstly, backcasting allows for a departure from present unsustainable extrapolations to attain new goals and define new conditions. The ability of backcasting to deal with the kind of complexity that is caused by conflicts between short term and long term is an advantage in itself once the decision for proactivity is made.

Secondly, backcasting can be applied to foresee certain changes in legislation or on the market, thereby being helpful in finding business opportunities and avoiding risks. When the consequences of non-sustainability are considered, it is often seen from an altruistic point of view, putting mainly ethical demands on business. Here, backcasting can be helpful in expanding the perspective. If the individual firm is considered from a backcasting perspective, this can be done either from a sustainable future or from a future where we continue to decrease the prerequisites for future generations.

Let us start from the less favorable alternative. In this case, degradation of the environment goes on due to insufficient proactivity in business and, or, politics. The room for maneuver will decrease more and more the longer it takes for the society to become sustainable. The prices for resources (especially renewable resources) are then likely to increase, and so will the costs for management of growing amounts of waste. Avoiding being a relatively large contributor to this problem, i.e., using less resources and producing less waste per added value, is a way of avoiding growing economical risks. Further, it is reasonable to assume that the risks are especially high if such economical dependence is based on investments with long pay-off times. Examples of other risks, where the same type of reasoning can be applied as on costs for resources and management of waste, are: increased costs and prices for insurance, taxes, and loans on activities with relatively large impacts on the environment. Finally, there will probably be disadvantages with regard to sudden losses in credibility in a number of important areas, such as finance institutes, the market and amongst employees. This is often forgotten when proactive measures are discussed only in economic terms. One of the most common arguments for a passive attitude is that the market is not prepared to pay for the needed development costs. But making good business is not only to get paid, but also to avoid unnecessary costs today and in the future. Of course we cannot foresee exactly how large the costs for a certain non-sustainable activity will be, exactly when it will happen, and if the polluter in each given situation will be forced to pay or not. But it is obvious that the *chances* for the individual polluter to avoid his or her individual economical responsibility will decline over time, as long as the decline in resources and assimilation capacity leaves less room for maneuver**.**

If we go on and back-cast from a presumptive sustainable future, the result is similar. Costs and other problems are likely to increase for the same non-sustainable activities, even if the mechanisms may then be different. Green taxes and legislation, and, or, more and more socially and ecologically concerned competitors in a more and more responsible market, will create the same consequences for a relatively non-proactive business.

So, from an overall point of view, the conditions for business on the future market are likely to change in such a way that firms that can satisfy the needs of their customers with less and less impact on the ecosystems will have greater chance of being economically successful. We still need to handle the problem of balancing marginal costs for investments that reduce the risks for not being proactive, with the marginal profits. But the potential self-benefit is there, and the rest is a matter of timing, strategic planning and economic risk assessments. There are economic risks with most investments, and particularly when the investment is part of transition into something new and unknown. On the other hand, since change in this case is necessary, there is also a risk in doing nothing. For decision-making, these risks should be balanced. The intellectual demands on the rationales for business as usual should not be weaker than on the rationales for proactivity. In practical terms, this means that the risk in making progress too fast must be balanced with the risk of being too late. In conclusion, this reasoning creates a logically motivated *potential* for self-benefit in proactive planning – partly by the possibility of being rewarded by the market, partly by avoiding risks that will increase relatively more amongst non-proactive competitors. This will be further discussed in section 4.

2.2. A strategy to harness the potential self-benefit of backcasting from future sustainable business.

Once a firm has decided to go for a certain vision where its impact on ecosystems are minimal in relation to its efficiency in providing services to the market, the overall strategy to link short term with long term follows from plain logic. Two qualities of all investments should be combined, particularly when large resources are bound:

(i) Investments should be technically and ecologically as *flexible as possible platforms* for further investments in line with the vision of sustainability, and

(ii) amongst the various flexible alternatives, *the low hanging fruits* should be picked first, i.e., measures that give early return on investment. It relates to the need of aligning the long-term goal with the short-term economic reality.

The rationale lies in the *combining* of the two qualities, i.e., in the same time as each measure is designed to fit a path towards sustainability, the measures must also pay off soon enough. In this way, chances of optimizing future progress get fueled by a relatively stronger economy in a positive spiral. If the qualities are not combined, the actor might run out of money, find their competitive position diminished (Esty and Porter 1998), or pick low hanging fruits in a sub-optimized way (Lovins, Lovins & Weizsäcker 1997).

In practical terms, the strategy is followed by posing questions of the following kind:

_ *Will this measure bring us closer to sustainability and is our perspective broad enough socially and ecologically to determine this*? For instance, will it reduce our dependence on emitting such compounds that are today accumulating in the ecosphere? Is our focus local, or do we have a global perspective? Is our focus on human services, or on traditional commodities to provide those services? There are numerous companies that have already emerged from the danger of traditional thinking, companies that sell preservation of food at home rather than refrigerators, fast and nutritious food at a low price rather than hamburgers, and light and indoor climate rather than kilowatt-hours. This is to get rid of such restrictions to creativity that are due to traditional thinking, and to open up avenues for creative measures and strategies in a market that gets more and more globalized.

- *Is this measure taken a platform for the next?* Will it be possible to go from there to the next step, and reduce our impact on nature even more? For instance, applying this more efficient technology on renewable resources? There are car-companies that are planning to introduce cars with an efficient fuel cell that can utilize the existing structure of petrol stations because petrol can be reformed into hydrogen aboard the vehicle. In this way, the market for hydrogen, or hydrogen-rich renewable fuels, can be created.
- *Is the measure a low hanging fruit?* Can it save resources and money? Will it give early return on investment? Can today's structure - infrastructure or other examples of technical design - be utilized? Does the demand already exist somewhere in the market?

2.3. Non-linear evolution on the market further emphasizes the need for backcasting.

If, for instance, incompetence and lobbying would successfully keep the market and politicians complacent, this will create a growing gap between what is going on and what should be going on. In this gap the damage to nature will increase, and policy and market reactions can occur more and more abruptly due to various threshold effects. Such threshold effects exist in ecosystems, and they exist in society when the spread of knowledge is eventually leading to changes on the market. This means that the difference in future stakes between proactive and reactive companies will probably be larger - not smaller - the slower the market and politicians reacts. And the reverse is also true: the faster and more powerfully the market and politicians put demands on sustainable development, the smaller the difference will probably be between proactive companies and the companies that only react to signals or stimuli on the market.

It is true that proactive companies can move ahead only at a relatively slower pace if the market is lethargic (Esty and Porter 1998). But the point is that they can prepare themselves and avoid sudden and perhaps overwhelming demands for solutions – for instance by developing pilot projects and identifying proactive market niches. When backcasting is used in planning, *realism* should only be allowed to determine the pace by which transition can occur, not the direction.

2.4. A frame given by principles – a prerequisite for rational backcasting

Backcasting takes its starting point from a future situation. In order to find flexible strategies for the transition, it is important not to try to view the future situation in detail, but rather to find guiding principles, which can act as a frame for many possible futures. How can such principles be defined regarding sustainability?

Experience tells us that individuals are generally very clever in discovering guiding principles even in complex problems, and then in aligning the details of the planning with the principles. Let's say that a family is going to move from Chicago into a new house in Miami, because the family members have got new jobs there. The house-moving-project is in fact a complex project, with many details that must be aligned with a set of guiding principles of this project: (i) the house must be located in a way that makes it possible for the family members to make it in time to their jobs and back, (ii) they must be able to afford the new living, (iii) it must meet certain individual minimal requirements of the family (e.g., number of bedrooms) and (iv) it must meet certain overall demands on the house itself (decent enough indoor climate).

Those principles are functionally different and cover aspects that are relevant. This means that the planning proceeds from a backcasting perspective, where all these principles are met. What shall we do today, to make all details in the planning coherent with those principles? For instance, the first principle can be met either with public transport (which often creates restrictions as regards possible areas to live in), or with one or more cars (which expands the possible area, but negatively influence the second condition, which in turn may influence the options as regards details to meet the third and fourth principles). If the family was not aware of the principles of the project, and clever enough to organize the details in a dynamic way so that they fit all principles, they might end up in a castle in New Jersey they couldn't afford, trying to figure out what went wrong. This generally doesn't happen when individuals are planning their own lives, because individuals are clever in systems-planning, the consequences of failure are often very direct, and there is no one else to blame.

The challenge is to make a group of individuals, like a business corporation, municipality, or country, operate with a shared mental framework based on principles so that they can function as teams. What are the principles for a successful planning, and who is responsible for that those are taken into account? This is an important challenge, because when the project boundaries are even larger than in the house moving example, like in the project 'moving into a sustainable company', the need for principles to coordinate it all are at least as large. How does the company align its tools for this purpose (e.g., LCA, ISO 14000, and indicators for environmental auditing) with a future perspective in which the principles for sustainability are met?

To harvest as much as possible of the potential economic and ecological benefit of backcasting, it should be performed from a framework set by *principles* for sustainability of the whole ecosphere. The future cannot be foreseen, but its principles can. Without such a framework, the strategically desirable flexibility of investments can be difficult to achieve, and much of the potential of backcasting in line with the above, can be lost. Such principles can be helpful when developing reliable non-overlapping indicators for monitoring development, when coordinating various measures from different sectors of the society, or within individual firms with each other, and when handling trade-offs in an optimized way. <u>To fit the methodology of backcasting, they should be principles of the outcome (sustainability), not the transition (sustainable development)</u>. Further, in order to be general enough to cover relevant aspects of sustainability, allow coordination on various levels, and still avoid overlapping, they should be *first-order* principles. This is exemplified by the 'house-moving' example above. Thus, by first-order principles of a system, we mean the core principles that provide the overall description of the system. Parts of the system and other principles of the system can be related to the first-order principles. Soccer or chess, for instance, are defined by the first-order principles of these games — the objectives and the rules of the games — not by various exercises, strategies, and skills to become a good player. But, in order to become a good player, the starting point is to learn about the objectives and rules. This is the easy part. After that, the more advanced and demanding training to become a good player begins. The strategies and skills are then elaborated in line with the first-order principles. Hence, by first-order we do not mean more important than anything else. It is rather the opposite way around. Out of respect for the important knowledge that is needed to deal with the complexity in a system it is often helpful to try to identify first-order principles for the system. The system conditions presented in the next section are aimed to be first-order principles of sustainability. It is easy to understand that they must be complemented with much knowledge about the complex interaction between society and nature. There are so many complex questions that need to be addressed in sustainable development that the first-order principles themselves cannot answer. But, the experience from several firms, municipalities, and organizations is that they can make more sense of and coordinate the complex information and questions. We have developed the system conditions to be used in backcasting and the aim is that these first-order principles shall support the following aspects:

_ simplicity without reduction — they aim at making it simpler to deal with complexity, yet don't simplify in the sense of disregarding any of the complexity (Broman et al. 1998).
_ valid at various scales — this makes it easier to coordinate various parts and details to meet the first-order principles.
_ shared mental framework — it is easier to make teams or groups of people share the first-order principles of a vision, than to make them share detailed pictures of the vision.
_ non-prescriptive — creativity is supported if experts in various fields share the framework for planning on a principle level, but are allowed to be free to handle the concrete details within that framework.
_ thinking upstream in causal chains — upstream causes of any problem can often more easily be properly understood and addressed than the complexity downstream. Analyses of detailed downstream problems can then flow more logically.
_ they can make more sense of tools like ISO 14000 and LCA — such tools do not in themselves contain a framework for successful planning, or a vision.

As was mentioned in the introduction, there have been several attempts to develop principles for sustainability, which are intended to be supportive when the broad concept of sustainability is discussed (Daly 1990; Jacobs 1991; Goodland et al. 1992; Holdren et al 1992; Schmidheiny 1992; Holmberg et al. 1996). The suggested principles are in most cases not meant to be prescriptive, but rather to help different actors to structure there views of sustainability and hence guide them when they ask themselves relevant questions. The system conditions have been further elaborated and compared with principles suggested by others in previous publications (Holmberg 1995; Holmberg *et al.* 1996; Holmberg & Robèrt 1997; Robèrt *et al.* 1997). Here we discuss the rationale for applying them for the presented purpose.

3. THE RATIONALE BEHIND THE SYSTEM CONDITIONS

Since there is probably no limit to the number of possible designs of sustainable societies, the definition must be searched for on the principle level – any sustainable society would meet such principles. Since *sustainability* was a non-relevant expression until non-sustainability started to exist due to human activities, it is logical to design the system conditions as restrictions, i.e., principles that determine what human activities must *not* do. In what principle ways could we destroy the ecosphere's ability to sustain us?

Humans can destroy the functions and biodiversity of the ecosphere[1] by:

1. A systematic increase in concentration of matter that is net-introduced into the ecosphere from outside.
2. A systematic increase in concentration of matter that is produced within the ecosphere.

3. A systematic physical deterioration (harvesting and manipulation) of the ecosphere's ability to utilize waste as building blocks for primary production, and to provide other essential functions.

The system conditions are phrased as not allowing the destruction of the ecosphere, by adding a negation to these principles for destruction:

In order for a society to be sustainable, nature's functions and diversity are not systematically[2]:

I. ... subject to increasing concentrations of substances extracted from the Earth's crust;

II. ... subject to increasing concentrations of substances produced by society;

III. … impoverished[3] by over-harvesting or other forms of ecosystem manipulation

Together, the three first system conditions give a framework for ecological sustainability. It implies a set of restrictions within which the sustainable societal activities must be incorporated. Based on that reasoning, a first-order principle for the society's internal turnover of resources is formulated – the fourth principle:
IV. ...resources are used fairly and efficiently in order to meet basic human needs world wide.

3.1. Clarification of the system conditions

I. The societal influence on the ecosphere due to accumulation of lithospheric material is covered by the first principle. The balance of flows between the ecosphere and the lithosphere must be such that *concentrations* of substances from the lithosphere do not systematically increase in the whole ecosphere, or in parts of it. Besides the upstream influence on this balance through the amounts of mining and choices of mined minerals, the balance can be influenced by the quality of final deposits, and the societal competence to technically safeguard the flows through recycling and other measures. What concentration can be accepted in the long run depends on properties such as ecotoxicity, here taken in a broad sense to include effects on the geophysical systems, and bioaccumulation. Due to the complexity and delay mechanisms in the ecosphere, it is often very difficult to foresee what concentration will lead to unacceptable consequences. A general rule is not to allow societal-caused deviations from the natural state that are large in comparison to natural fluctuations. In particular, such deviations should not be allowed to increase systematically. Therefore, what must at *least* be achieved is a stop to systematic increases in concentration. Depending on the characteristics of the substance and the recipient, the critical concentrations differ. In some recipients an increasing concentration of some substances can have a positive effect before a further increase in concentration will be problematic. In other cases the acceptable concentration has already been exceeded.

II. The societal influence on the ecosphere due to accumulation of substances produced in society is covered by the second principle. It implies that the flows of societally produced molecules and nuclides to the ecosphere must not be so large that they can neither be integrated into the natural cycles within the ecosphere nor be deposited into the lithosphere. The balance of flows must be such that concentrations of substances produced in the society do not systematically increase in the whole ecosphere or in parts of it. Besides the upstream influence on this balance through production volumes and characteristics of what is produced, such as degradability of the produced substances, the balance can be influenced by the quality of final deposits, and the societal competence to technically safeguard the flows through measures such as recycling and incineration.

III. The societal influence on the ecosphere due to manipulation and harvesting of funds and flows within the ecosphere is covered by the third principle. It implies that the resource basis for: (i) productivity in the ecosphere such as fertile areas, thickness and quality of soils, availability of fresh water, and (ii) biodiversity is not systematically deteriorated by over-harvesting, mismanagement or displacement.

IV. The internal societal metabolism and the production of services to the humans are covered by the fourth principle. It implies that if the societal ambition is to meet human needs (at least basic human needs) everywhere today and in the future, while conforming to the restrictions with regard to available resources given by the first three principles, then the use of resources must be efficient in meeting these needs. If we are more efficient, technically, in organization and socially, more services with the possibility of meeting more human needs can be provided for a given level of impact in nature. Efficiency in that context, if the perspective is large enough, implies not only reduced resource flows per utility, but also improved means of dealing with social issues like equity, fairness, and population growth.

3.2. Three levels of complexity

Increasing amounts of carbon dioxide in the atmosphere, of phosphorous in lakes, of heavy metals in soils and in our bodies, and increasing amounts of DDT and PCB in biota and radioactive gases in the atmosphere are examples of accumulation covered by the system conditions one and two. Deforestation, erosion, extinction of species, and ground water depletion are examples of physical deterioration of nature (system condition three) that decreases its resilience and capacity to assimilate waste[4].

Deleterious effects in the ecosphere occur when accumulation has resulted in increases in concentration of substances beyond a certain level which is often difficult to foresee (due to the complexity and delay mechanisms in the ecosphere). We can identify three levels of complexity in the risk assessment following accumulation of waste:

I. Accumulation of waste occurs when emissions are higher than the assimilation capacity of the recipient.

II. Effects in the ecosystems are linked (often non-linearly linked) to concentrations. Moving the focus upstream, the potential magnitude of these concentrations can be estimated already before the compounds have reached nature. This enables priorities in society's preventative measures to be adopted well before the mechanisms for destruction in nature are explicitly known or identified. Our first three system conditions deal with this level. In Holmberg *et al.* (1996) we give examples on two types of such indicators: (i) the antropogenic flow of different elements from the lithosphere to the ecosphere (mining and flows associated with fossil fuels) compared with the natural flows from the lithosphere to the ecosphere (weathering and volcanic activities); (ii) the accumulated mining of different elements compared with the amount in the top soil layer. Both of these indicators show that the antropogenic flows are large compared to the natural flows for many metals, e.g., the societal flow of copper exceeds the natural flow by a factor of 20. These two indicators focus on the intake of substances to society. They, therefore, give a very rough indication of potential increase of concentration. More such indicators are given by Azar *et al.* (1995). The actual leakage to nature depends on how the metals are used in society. Bergbäck (1992) has estimated the actual leakage of some heavy metals from the production and the consumption sector of the Swedish economy. He has also compared these flows with a rough estimate of the natural flows in Sweden. Tyler (1993) has taken a further step in the causal chain and compared the actual heavy metal load with the natural baseline concentration in Swedish forest soils. He has found that the critical concentrations (lowest concentrations for measurable adverse effects) are three to five times the current baseline values for Cd, Cu, Pb, Zn, Hg, and Ni.

III. For the same relative increases in concentration, the magnitudes of deleterious effects vary with different substances, the chemical form of the substance, the physical characteristics of the recipient (e.g., temperature, pH), the biological characteristics (e.g., the uptake, other kind of stress) The correlation to concentration is therefore often non-linear and environmental effects are characterized by threshold effects. Furthermore, the natural baseline concentrations also vary in different sites and over time. All these complex problems are layered on top of level II.

Problems inherent in the assessment of the effects on level III, do not justify negligence to assess levels I and II. In fact, any problem concerning the difficulties to assess complexity – or trusting data – on levels I and II is often severely magnified on level III. Furthermore, considerations on levels I and II make it possible to avoid future damage that is hitherto unknown. Consequently, measures should be performed on all levels. In spite of this, reality often shows us that most work is performed on levels III *instead* of levels I and II. One explanation for this can be that the focus has traditionally been on occupational health (often acute effects) rather than long term ecotoxity.

3.4. Principles as minimum requirements

For some substances the system conditions have been violated for so long that the system conditions have turned into minimum requirements. Certain compounds have *already* reached such concentrations in nature that they are causing harm. There are numerous examples, for instance CFC:s, nitrogen compounds and some heavy metals. In those cases we are facing two problems: first the concentration must be decreased to an acceptable level, and then we must meet the principles.

3.5. Complementary principles

Intensive farming may effect all system conditions – the problems that are associated with the accumulation in the soil of cadmium and other heavy metals contaminating the phosphate fertilizers (system condition 1), accumulation of pesticides in soils and emissions of nitrogen compounds into bodies of water (system condition 2), manipulation causing erosion and depletion of soil minerals and loss of biodiversity (system condition 3) and various examples of inefficiency in the use of resources, functioning as drivers of the problems above (system condition 4). However, the fact that many conditions can be effected at the same time in a certain process does not mean that the *conditions* are functionally overlapping. An analogy could be when the gearbox and the engine go to pieces at the same time in a car; they are functionally separate technical systems even if they are combined in the same overall technical system. It should be noted that system condition 4, which focus on the internal societal resource turnover, of course influences the possibility to deal with the other three system conditions. Still they do not overlap functionally as mechanisms.

3.6. Distinction between principles for sustainability, principles for sustainable development, and means to meet such principles

When applying the methodology of planning suggested in this paper, it is essential to distinguish principles of sustainability (the system conditions), from principles of sustainable development (e.g., precautionary principle and flexible platforms that are low hanging fruits) and from means of sustainable development (e.g., renewable energy and recycling).

The first three system conditions constitute a definition of the goal of ecological sustainability. This distinguishes them from the kind of principles that are formulated as means for reaching sustainability. This point can be exemplified by the following: sometimes renewable energy is claimed to be a principle of sustainability. However, transformation into renewable energy is a *measure* to meet the four system conditions. The rationale for renewable energy is that:

- Compounds from the Earth's crust such as fossil carbon forming carbon dioxide and radioactive elements must not accumulate in the ecosphere (system condition 1).
- Compounds that are produced in the energy conversion such as nitrogen oxides or plutonium should not accumulate in the ecosphere (system condition 2).
- The exploitation of energy sources must not destabilize the conditions which support the life processes of Earth such as degradation of ecosystems in the sea due to drilling for, and transportation of, oil, or degradation of ecosystems on land due to mining for uranium (system condition 3).

- We must not waste resources and eventually run out of our potential to meet human needs further ahead (system condition 4).

Thus the system conditions *underlie* the idea of renewable energy. If this distinction is forgotten we can end up with too many principles and numerous risks for misjudgments. One example would be if we would meet the principle renewable energy through extensive bioenergy plantation in tropical rain forests, leading to soil erosion and losses of biodiversity (violation of S.C. 3). And, besides the risk of jumping from one problem to another, an erroneous set of principles may also lead to unnecessary restrictions. It might be acceptable to use non-renewable energy in a sustainable society even if it is used until the resource is depleted – so long as the system conditions can be met. There is, for instance, an ongoing discussion and experiments, on the possibility of sequestering of carbon dioxide from fossil fuels in old natural gas wells or aquifers (Williams 1996).

4. MAKING THE SYSTEM CONDITIONS OPERATIONAL

To make the system conditions operational to the individual organization, we must first elaborate them into the presented backcasting strategy.

4.1. Elaboration of the system conditions into guidelines

To meet the principles in the future, the whole civilization must – step by step – decrease its economical dependence on:

- Mining to cover dissipative use of fossil fuels and scarce metals, particularly such metals that are already increasing in concentration in the ecosphere (system condition 1).
- Dissipative use, as well as unintentional production of persistent compounds foreign to nature, and of naturally occurring compounds that are already increasing in concentration in the ecosphere (system condition 2).
- Manipulation and over-harvesting of the ecosphere, causing reduced long term production capacity and biodiversity (system condition 3).
- Wasting of resources in relation to meeting human needs (system condition 4).

How these guidelines apply at the individual level can vary depending on agreements and negotiations between actors within the society, but as a first approximation these guidelines are also valid for each individual firm. Combined with the strategy of giving priority of such investments that are flexible platforms and low hanging fruits, this creates a strategy for systematic sustainable development that makes sense also from a business point of view, not only for the common good, see Figure 1. Examples will be given in section 4.3.

4.2. Economic risk assessment

Those who want to apply this framework should be made aware of the difference between the system conditions for sustainability on the one hand, and the consequences of the system conditions as regards permitted flows of matter on the other. The total sustainable flows of matter still remain to be calculated. However, one does not have to await detailed analysis of those issues to apply the framework. Sometimes the permitted flows per capita are so close to zero, e.g., concerning the dissipative use of mercury (system condition 1), that the lack of concrete data is no problem for strategic planning. And, when the total permitted flows are much higher, for instance concerning emissions of N_2O (system condition 2), the relevant questions can at least be raised: Is it possible that we – in our business corporation or municipality – are investing ourselves into a dependence on N_2O emissions that may exceed our 'permitted' share of the total assimilation capacity of N_2O? And even more intriguing: If today's total emissions of N_2O cause accumulation of this gas in the atmosphere, what is the guarantee that the margins to severe problems related to further accumulation of N_2O gives us a secure life-span for this investment? In this way, the framework allows that the requirements for proof are shifted from the public to the polluters and their investments. A clear and stringent framework is helpful, even if it does not immediately lead you to very concrete consequences regarding figures and measures. And conversely: the lack of very precise figures does not justify ill-defined frameworks.

People at a large chemical company thought that system condition two was defined as ”phased-out production of persistent compounds foreign to nature”. However, this phrasing is not system condition two, but an *interpretation* of system condition two. System condition two reads: In order for the society to be sustainable, natures functions and diversity are not systematically subject to increasing concentrations of substances produced by society. Thereafter the intellectual and economic consequences must be drawn. The technical problems and costs linked to a safeguarding of persistent compounds foreign to nature must be compared with alternative compounds that fulfill the same function, but without requiring technically difficult and costly solutions. To phase out persistent compounds foreign to nature then often seems to be a wise strategy.

4.3. Applications

Together, the system conditions, and the presented backcasting strategy, provide a framework, that can be applied for: (i) *problem analyzing and designing of investment strategies,* and (ii) *dialogue and as a shared mental model for community building*.

Problem analyzing and designing of investment strategies

The long-term environmental problems can be discussed in a systematic way, system condition by system condition for any field. Practical experience has been gathered in scientific consensus building in Sweden. Thus, the quality of the framework to serve as an instrument for systematic problem analyzing has been helpful in the preparation of consensus documents, produced by invited experts from business and science about various problems areas such as agriculture, forestry, the use of metals, the use of energy, political and economical measures to support sustainable development and to design principles for local agenda 21 planning. The result is often more challenging than when the discussion is focused on what experts disagree upon. Firstly, the area of agreement is often larger than expected and, secondly, often the dispute turns out to be about the different means to handle certain requirements for sustainability rather than about the requirements themselves.

One interesting example from the work with the consensus documents is a document on agriculture (Andersson et al. 1993). It was mutually produced by the Swedish farmer's federation, the Swedish federation of organic farming, and the Natural Step. The document denotes a need for radical change of Swedish farming, and it has substantially influenced the official policy on science and business in this field in Sweden (LRF 1997). Persson and Christerson (1998), from the Federation of Swedish Farmers (LRF), writes:

> "In 1992, the LRF made a strategic choice of course. Our annual general assembly formally committed the LRF to enhance its efforts to improve environmental work and animal welfare in Swedish agriculture. The purpose was twofold: to improve our competitive strength on a short-term basis and to achieve a sustainable agriculture over the long term.
>
> Strategic decisions always have to be made for the long term. That's why it's essential to have a compass pointing in the desired direction. If we want to achieve a sustainable agriculture, then we have to be able to describe what we mean by sustainability.
>
> To define a sustainable agriculture, the LRF and the Federation of Organic Farmers — under the leadership of the environmental organization the Natural Step — have produced a consensus document entitled the Vital Sector. That document presents the framework for a sustainable agriculture. The document was devised and has been reviewed by some 80 researchers in Sweden."

An example from business is the way by which Electrolux phased out CFC:s. Introduction of HCFC would have meant an improvement in relation to CFC as regards effects on the ozone layer. However, backcasting from a future frame given by the system conditions led to the following questions: can we trust that HCFC will be used large scale in the future, and if not, would the developed technology for HCFC be able to apply for other substances that would be less problematic from the system conditions point of view? The questions led to a completely different strategy towards hydrocarbons, using R134a as a flexible platform (Robèrt 1997). Electrolux was first in launching a whole family of freon-free refrigerators and freezers. The result was increased market shares in several important markets. They also presented a new overall business strategy, based on the system conditions (Electrolux 1994).

Another example was given by Tachi Kiuchi, Chairman of The Future 500, Managing Director of Mitsubishi Electric, at the Fifth International High-level Seminar on Cleaner Production, Seoul 1998. After having described a number of investments that later on proved to be costly dead ends (contributions to the violations of the system conditions), he proceeded: "This is a typical example that demonstrate well the importance of understanding The Natural Step's framework of thinking. The lesson is that severe environmental problems and business setbacks are inevitable unless companies dedicate themselves to meeting the basic conditions necessary for the sustainable development of our society". In similar ways, the framework has been applied for strategic planning in a large number of Swedish corporations such as manufacturers like JM Construction, trading-companies like IKEA, and service-companies like Swedish McDonald. It influences the routines in all areas of business: purchase, transport, choice of materials, product design, waste management and energy.

Dialogue and a shared mental model for community building

It is essential for groups of people to have a shared mental framework of principles, if they want to function as an effective team. The ability of our framework to reach out in organizations, to trigger creativity, and to make individual efforts aligned in a coordinated and effective way, is described in a doctoral dissertation on the implementation process in five corporations (Scandic Hotel, Interface, IKEA, Collins Pine, and Sånga Säby Conference hotel) (Nattrass & Altomare 1999). The general conclusion from this study was the framework's capacity of creating a shared mental model – a language – that enabled a more effective and creative dialogue between management and employees within the firm, and that a prerequisite for this was the teaching of the framework to all employees. At Scandic Hotel, after the framework had been explained to all employees, 1500 measures to bring the company closer to be aligned with the system conditions were launched within one year. They were all a result of suggestions given to the management team from the employees. The investments were all low hanging flexible fruits. The suggestions that were too costly were listed and communicated back to the employees as being on line for the future. One year after, 500 of these higher hanging fruits, were launched (Nattrass & Altomare 1999).

5. CONCLUSION

Backcasting is a methodology of planning. The term refers to the idea of planning from a future vision of a desirable outcome of the planning, followed by the question: what shall we do today to get there? It is a complement to forecasting, and is particularly relevant when the problems we are dealing with are complex, and when today's trends are part of the problem.

One reason for using backcasting is the potential self-benefit in it (if there would be no self-interest in it, backcasting would be useful only for policy making out of altruistic ambitions). Firstly, when problems are complex, backcasting provides the possibility of a more reliable and systematic approach of the planning procedure. Secondly, to systematically decrease ones own contribution to non-sustainability, is a way to be prepared for future market changes and to avoid costly head over heal measures that may otherwise occur. Some costs will increase, either as a consequence of further ecological depravation, or as a consequence of active political measures and proactive market demands to avoid such damage. Examples are escalating costs of scarce and non-polluted resources, management of toxic waste, differentiated green taxes, insurance, loans, bad reputation on the market, and competition from those who plan their activities to avoid such problems.

In order to harvest the potential self-benefit from a backcasting planning procedure two qualities of all investments should be combined, particularly when large resources are bound:

(i) Investments should be technically and ecologically as *flexible as possible platforms* for further investments in line with the vision of sustainability, and

(ii) amongst the various flexible alternatives, *the low hanging fruits* should be picked first, i.e. measures that give early return on investment. It relates to the need of aligning the long-term goal with the short-term economical reality.

The rationale lies in the *combining* of the two qualities, i.e. in the same time as each measure is designed to fit a path towards sustainability, the measures must also pay off soon enough.

Finally, to harvest as much as possible of the potential economic and ecological benefit of backcasting, it should be performed from a frame set by principles for sustainability of the whole ecosphere. The future cannot be foreseen, but its principles can. The system conditions can be applied for this purpose. They are all principles of sustainability, not sustainable development. That is a prerequisite for backcasting, since this methodology keeps principles for a certain state (sustainability) apart from the methods of meeting them (sustainable development). Further, they don't overlap functionally, and they cover relevant aspects of sustainability.

Since the framework is constituted by principles, it is only useful for the overall structuring of relevant questions, thoughts and measures. There will always be a need for more knowledge to make the framework function efficiently during the transition towards sustainability, for instance in order to make appropriate priorities (Spiro 1997). Sometimes we don't know if the principles are met or not, and sometimes we have to violate the principles for a certain time period because other aspects of social life, such as economy, make anything else impossible. However, all the problems connected to violation of the system conditions exist whether we are aware of them or not, or want to handle them in a structured way or not. Our experience is that if the framework is applied in a non-prescriptive way to structure problems at hand, it is helpful in problem analyzing, to design investment strategies, to facilitate dialog and to recruit engagement, creativity and shared responsibility into the problem solving process.

By using the system conditions as a guide to what must be fulfilled in a future sustainable society on a general level, different actors within business, organizations and municipalities (who are experts within there own fields) can draw conclusions about what these restrictions imply for their specific activities. A number of creative solutions have emerged from this process in which they have used backcasting from the system conditions in a non-prescriptive way. For instance, the first system condition rises the following question to an actor: will the activity or investment cause emission (directly or indirectly) of substances extracted from the lithosphere? And will they be a part of a flow that lead to systematically increased concentrations in the ecosphere of elements extracted from the lithosphere? (Maybe some of the actual elements are already known to cause harmful effects?) If this is the case, the next question is then to figure out how this can be avoided. For different activities and investments different actors find different solutions to e.g.: finding a substitute for the specific element or, avoiding dissipative use, increasing the recycling, reducing the down-cycling or fulfilling the same service with less of the material. The other system conditions can be used in the same way.

In this paper we have described the framework from different points of view, and the rationales for its different components. In recent and current studies, various aspects of applying and implementing the framework is studied (Holmberg 1998; Nattrass & Altomare 1999). We are also studying how concepts like Ecological Footprint, LCA, ISO 14001 and Factor X can be used in a backcasting perspective, utilizing the framework presented here. (Holmberg et al. 1998; Andersson et al. 1998).

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Holmberg, J. and Robèrt, K-H. (2000). Backcasting from non-overlapping sustainability principles – a framework for strategic planning. International Journal of Sustainable Development and World Ecology 7:291-308.

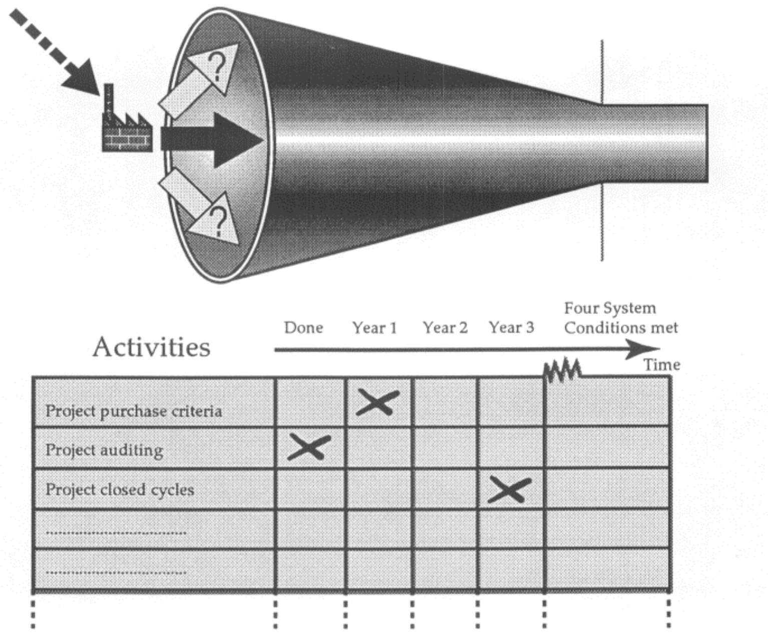

Figure 1. The concentrations of substances extracted from the lithosphere and produced in society are systematically increasing in the ecosphere and the long term productivity and biodiversity are declining (system condition 1-3). This means that the resource-potential for health and economy is systematically decreasing. At the same time, Earth's population is increasing and since the efficiency of fulfilling human needs are relatively low the average demand for resources are increasing (system condition 4). Non-sustainable development could be visualized as entering deeper and deeper into a funnel, in which the space becomes narrower and narrower. To the individual company, municipality, or country - wanting to make skillful investments, the crucial thing must then be to direct its investments towards the opening of the funnel, rather than into the wall. In reality this means that the smart investors make themselves less and less economically dependent on being a relatively large contributor to the violation of the system conditions. The wall of the funnel will superimpose itself more and more into daily economic reality in the following way: more and more environmentally concerned customers, stricter and stricter legislation, higher and higher costs and fees for resources as well as pollution, and tougher and tougher competition from competitors who invest themselves skillfully towards the opening of the funnel.

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Endnotes

[1]The *ecosphere* is that part of Earth which directly or indirectly maintains its structure and flow using the exergy (ordered energy, available work) flow from the ”sun/space battery”. With this definition the ecosphere contains the *biosphere* , the *atmosphere* (including the protective stratospheric ozone layer), the *hydrosphere* and the *pedosphere* (the free layer of soils above the bed-rock). The *lithosphere* is the rest of Earth, i.e., its core, mantle and crust. Processes in the lithosphere are mainly driven by radioactive decays of its heavy elements. The formation and concentration of minerals in the lithosphere is so slow that these resources, as viewed from the society, can be considered as finite stocks. There is a natural flow from the lithosphere into the ecosphere through volcanoes and through weathering processes and there are reversed flows through sedimentation. However, compared to the turnover within the ecosphere, the exchange of energy and matter between the ecosphere and the lithosphere is often much smaller.
[These definitions have earlier been used by Holmberg and Karlsson (1992). They deviate from current usage. The reason for introducing this definition is that society influences more than the biosphere, and depends on more than is traditionally included in the concept of biosphere (the part of the planet where life is active). An example is the deterioration of the ozone layer.]

[2] According to the Oxford English Dictionary the word "systematically" means: in a systematic manner; according to a system or organized plan; regularly or methodically. In this context systematically can be interpreted in two ways: (i) the deviation from the natural state must not systematically increase (increase more and more) due to the influence from society. (ii) the society must not be organized in such a way that it makes itself systematically dependent on activities that cause such (i) effects.

[3]i.e., the thickness of the productive soils, nutrient contents, ground water, genetic variation etc.

[4] The word waste is here used in a broad sense, which means that, e.g., "molecule" waste is included.