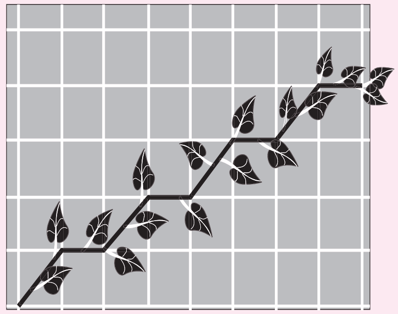
THE PROSPECT OF SUSTAINABLE DEVELOPMENT

25

Sustainable development is a development, which cares for the environment, for a just sharing of resources, and for the well-being and possibilities of future generations. It is a development that relies on renewable resources, and that carefully manages the flow of matter. The young father and son hopefully look at their future with confidence on this pile of the renewable resource timber. (Photo: Lars Rydén.)

"We stand at a critical moment in Earth's history, a time when humanity must choose its future. As the world becomes increasingly interdependent and fragile, the future at once holds great peril and great promise. To move forward we must recognize that in the midst of a magnificent diversity of cultures and life forms we are one human family and one Earth community with a common destiny. We must join together to bring forth a sustainable global society founded on respect for nature, universal human rights, economic justice, and a culture of peace. Towards this end, it is imperative that we, the peoples of Earth, declare our responsibility to one another, to the greater community of life, and to future generations."



The Earth Charter, Preamble
(http://www.earthcharter.org/earthcharter/charter.htm)

How can we deal with the environmental dilemma? The question from the beginning of the book has got many answers in the preceding chapters. Most of them, however, do not go to the root of the problem - the way our societies work. The paradigm of sustainable development attempts to do just this.

Instead of combating pollution as an isolated problem sustainability deals with the way resources are used in society. It emphasises that resources should be efficiently used and not be turned into pollution. After use resources should be returned to the biogeochemical cycles. Resources should, in particular, be renewable to make their long term use possible.

The same applies for land use. A sustainable use of land needs to take into account the long-term productivity of land as well as the return of all resources, e.g. nutrients, as part of the recycling of resources. This is again the long-term use approach.

Sustainability requires that man and nature be viewed holistically, as part of a single system. This system has several subsystems that each has to be viewed from the point of view of sustainability. Even if we here will focus on the ecological aspects we need to bear in mind that the economic and social dimension of the society are such subsystems. The social aspects refer importantly to the political institutions, where democracy is especially crucial to sustainability.

The introduction of sustainability in our societies was the topic of the Rio conference in 1992. At this occasion the Agenda 21 document was agreed on by almost all countries on earth. Agenda 21, an agenda for developing sustainability during the 21st century, underlines participatory democracy as an important component.

Sustainability is, however, most importantly a new way to see our lives and our societies. This thinking is relevant in all areas of life. It is a long-term project for humanity as a whole. It is a result of the concern for our global environment but it needs to be introduced on a local level. It is a concern for all levels of society from the global institutions to the municipalities to each individual.

In this final chapter we will search the roots, the meaning and the practice of sustainability. We will review how sustainable strategies are developed in energy and materials management, in housing and transport, and in industry, agriculture, forestry and fishery. In so doing we will partly review the entire book, since many of these topics have been discussed before, but in the perspective of sustainability. We will, however, do it in the spirit of a positive criticism of society and its organization.

If sustainable development, this new project of humankind, will be successful we are on our way to a new civilization, where finally the environmental dilemma will be resolved.

Authors of this chapter
Tage Sundström and Lars Rydén.

The prospect of a sustainable society

The origin of sustainability

Concepts of sustainability

Sustainability in practice – materials and energy management

Towards sustainable production – industry and agriculture

Future perspectives

The origin of sustainability

Figure 25.1. The World Summit for Sustainable Development in Johannesburg in September 2002 was the first summit where the wording sustainable development occurred in the title. It is thus not until recently that the concept has been fully accepted by all in the global community. Here we see a few of the some 50.000 delegates in front of a tent in the shape of planet Earth. The Johannesburg Summit was a "from words to action" conference and the main document was the "Plan of Implementation" of Agenda 21. Special concern was directed towards the five so-called millenium goals: water and sanitation; health; energy; agriculture; and biodiversity, also referred to as WHEAB. (Photo: Jon Hrusa/Pressens bild.)

Environment and sustainability

The creation of a world where the environment not is endangered by waste, pollution and intrusion by man will not be possible only by implementing good management practices, good legal framework and efficient technological solutions. During the 1980s it became increasingly clear that it will require a far more drastic change of society, a change which includes economic and social reforms. It will also require that instead of focusing on the *exhaust side* of the material flows, such as waste and emissions, we will have to focus on the *resource side* and adopt new principles for resource management. The principles and skills needed for this is discussed under the concept of sustainable development.

The changes required to achieve a sustainable society will be dramatic and amount to a step into a new civilisation. Just as we, a hundred years ago, left the agricultural society behind to enter the industrial, we now have to leave the industrial society behind and enter into the sustainable society. This is needed to protect the environment and in fact the human existence in the long run. In this chapter we will attempt to describe what is characteristic for sustainable strategies and solutions of many environmental problems. We will on many places refer to discussions in previous chapters, especially when it comes to the technical solutions.

The sustainable development concept has been referred to in the earlier chapters in its most circulated definitions from the Brundtland report. "Sustainable development meets the needs of the present generation without compromising the ability of future generations to meet their needs." We will here qualify this discussion.

The sheer concept sustainability, the kind of thinking it arouses and the social movements in its sphere of interest, are – also – in a state of evolution. Like anything else it has a prehistory; not even the Brundtland definition of sustainability from 1987 was the beginning. The concept of the common global environment has emerged through an interesting historical process which presupposes problem identification, communication, education and a wide scientific and cultural debate. Humans are the sole carriers of ideas and this process is fundamentally human – social, economic and political.

Up to now the goal of sustainable development has proven to many people to be only more relevant, comprehensive and meaningful. It has in the real world tens of thousands of applications in many different ways. As an intellectual concept it may continue to function as a guideline, or a compass needle, for the options that the development in the society always makes available. It is imperative that – in the end – most of the human society will be influenced by the idea of sustainable development, and this movement will have implications in house-keeping and public affairs on all levels.

Sustainability is concerned with every aspect of the society. Environmental concerns are, however, especially tightly linked to sustainable development. Damaging environmental impact, depletion of natural resources and decreased biodiversity are all incompatible with sustainability and these trends have to be reversed to approach the goal of sustainability. But this is only the beginning of sustainable development. It became obvious during the work of the Brundtland commission in particular, that the environment will not be protected unless people have an acceptable social and economic situation. The dignity of human life ought to be an urgency in any society of the world. Life should be supported with basic needs for food, shelter, clothing, health, education, etc. But the life-

The origin of sustainability

The International Union for the Conservation of Nature, IUCN, is an organisation with several hundred member bodies, both governments and non-government organi-sations. IUCN was founded in 1946. In 1980 IUCN published the World Conservation Strategy, in which the concept of sustainable development was brought to publicity.

In 1984 IUCN set up its Ethics Working Group, EWG, which embraced about 500 participants from 50 countries. The group is still active with Ronald Engel as the chairman. The box in Chapter 21, page 640, gives a quotation from a resulting document: Caring for the Earth – A Strategy for Sustainable living, IUCN, 1992.

Figure 25.2. Paradise, one of the oldest myths of mankind, takes modern shape in the vision of sustainability in all its dimensions. It is clear that sustainability in essence is an ethical concept, just as is happiness, health and peace. It may be considered an utopian concept but as such it is extremely concrete in its implementation. The illustration is from the book of Genesis chpt 2 in an 19th century bible.

support systems have to operate without over-burdening either the resources of the ecosystems or the environment through discharges of waste and pollution. It is also maintained that to achieve this democracy should be developed and furthered. The cultural and emotional aspects of human life should not be forgotten.

The concepts of sustainable development recognises that these aspects are all tightly linked. We have to address several dimensions of development to work successfully for sustainability. We talk abut three dimensions of sustainability: environmental (sometimes labelled ecological), social and economic.

Let us first look at the origin of the notion of sustainable development.

The origin of sustainability: Justice

The origin of the human reactions to the global ecological crises has a philosophical foundation in ethics. Humans, with their searching and inquiring mind, have always looked at matters that constituted problems in their daily lives, they made critical judgements before making their decisions for future action, they recorded meaningful signals from the environment, but they also listened for hints of advice from friends around them. They frequently developed systems of ideas, philosophies, world views – with local or global ambitions – and ethical guidelines.

The cultural roots of the sustainability concept can be traced far back in our history. Even Kant's categorical imperative, formulated more than two hundred years ago, can well be applied in connection with sustainable development. It says: ”I should act in such a way that I want my maxim to become a universal law”. This is, expressed differently, a question of respect and justice. Respect for others and just access to resources. We have already noticed that sustainability was connected to the issue of *inter-generational* justice: Justice between this generation and the following ones. It is equally important to point to the *intra-generational* justice, justice with respect to those living here and now. In practical policy the first justice is recognised when e.g. limited resources are not depleted but kept for the future. The second justice is recognised when all people on the planet, at least in principle, are given equal rights. One example is the right to emit carbon dioxide, as is the case in the climate negotiations. It is very much linked to the fight for equal rights between poor and rich countries, between the South and the North, and the concept of a just development.

We should also point to the fact that *democracy*, in the same spirit, is considered part of sustainable development. In other words all citizens in a society should have an equal possibility to have a word when decisions are made. In the Agenda 21 document emphasis is put on participatory democracy, when also the implementation of decision are made in co-operation with citizens. This is in other words a further aspect of the ethics of justice.

The ethics of Man and Nature

In the more specific environmental issues we may notice that early environmentalists, primarily on the American continent, could be described as belonging to one of two branches: the preservationists and the conservationists. The *preservationists* claimed that the wilderness should be preserved from all but recreational and educational activities, while *conservationists* preferred the rights to exploit resources for human use, if only in a considerate way. These two basic views of environmentalism can still be discerned, also in connection with the debate of the sustainability concept.

The conservationists are human-centred, or anthropocentric environmentalists, and see the present and future human generations as the subjects when developing practical and political policies. The philosophy of the preservationists is, on the other hand, rather ecosystem-centred. As far as sustainability is concerned, they favour that humankind is in its dreadful environmental situation today only because the natural systems have been treated as mere resources for human action. They see the anthropocentric attitude as the source of the problems. We therefore need to develop new attitudes and beliefs to the effect that humans are not allowed to manipulate the natural systems for the benefit of humans only. Nature has not only an instrumental, but an intrinsic, value. The animals are also our fellow creatures and our solidarity must be extended to the ants and the grass – and the entire ecosystem.

The eco-centric or bio-centric ethics was certainly dominating among those who developed the "World conservation strategy" published by IUCN in 1980 (See Chapter 21).This is where the concept of sustainable development was introduced for a larger audience for the first time. It can be said that the work that led up to this document was in turn initiated already after the 1972 Stockholm Conference. It was inspired by the World Council of Churches, in its programme on Justice and Peace, although the details of this history still remains to be written. This kind of eco-centric ethics seems now to extend its territory, especially among young people, demonstrated by the animal rights movement. The spreading vegetarianism and veganism are also branches on the same tree. The endangered species, whether plants, insects or other animals are to the preservationists a central issue in the environmental discussion.

Looking at the Rio documents, it is, on the contrary, the anthropocentric ethics that is argued for. The sustainability prospect is by most people strongly connected to the future interests of humankind. The concept of carrying capacity is related to the conservationist ethics, if it indicates that the ecosystem can be strained to any limit if it only serves durably the human needs. Many environmentally concerned people of today, especially those who defend the principle of equity between people in the poor societies and those in the affluent societies, as well as those who are concerned about the equity between people of different generations, have inherited such views.

It must be understood, as a background to the ethical debate, that today only humans, among the species of the ecosystem, have strong enough instruments to seriously influence and damage the whole of the ecosystem. The human impact on nature could be evaluated either on the basis of what effect it has on every living creature or on the basis of how it affects humans. There is in the former view an element of biotic egalitarianism, a radical form of a non-anthropocentric ethics. The fundamental question is which living beings are "morally considerable". In the perspective of the 21st century there are dramatic consequences of the two alternative ethical views, and the debate may certainly sometimes be very hot.

Stenmark (2002) raised these issues in a chapter on Humans and the Value of Nature. He asks: "Which environmental ethics ought we to adopt? Is there anything like 'an ethics of sustainable development?'" Stenmark concludes that whether we save nature because it is good for our human sake or for its own sake does not really matter, as long as we save it. The great dividing line today is between environmentalists and non-environmentalists. The challenge is to motivate the large part of the population who is indifferent to ecological issues. The sustainable development paradigm must now be supported both on the individual and the political level.

The scientific process

An important landmark in the events that led up to the concept of sustainability was the publication of the book *the Limits to Growth* by the Club of Rome in 1972. This thin book reports from a work conducted by a group of scientists (with a firm footing at Jay Forrester's Systems Dynamics at Massachusetts

The seven faces of sustainability

Sustainability has many faces. Here are seven which regularely appears in the discussion. For each of them the most often referred to context or document is given.

1. Sustainability as a political initiative (the Brundtland Commission and Our Common Future).

2. Sustainability as a scientific study (the Club of Rome and Limits to Growth).

3. Sustainability as an expression of respect for nature (IUCN and Caring for the Earth).

4. Sustainability as a new dimension of participatory democracy (the Rio Conference and Agenda 21).

5. Sustainability as justice for future generations, inter-generational justice (the Brundtland Commission and Our Common Future).

6. Sustainability as justice towards fellow humans, intra-generational justice (the Factor 10 Club and the factor 10 document).

7. Sustainability as a vision of the good life (a host of NGOs and the Earth Charter document).

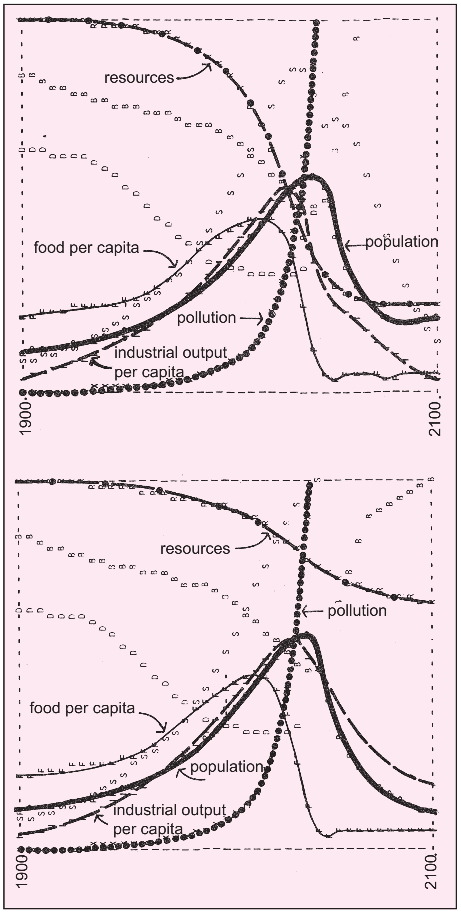


Figure 25.3. The Limits to Growth. Between 1970-72 a research team under the leadership of Professor Dennis Meadow on the commission of the Club of Rome studied the long-term development of the Earth and human society. They constructed the so-called "World Model" consisting of some 40 differential equations relating parameters such as world population, pollution, natural resources, productivity etc to each other. The model was fed with real data for 1900-1970, and then run for the period 1900 to 2100, under varying assumptions using systems dynamics methods. The conclusions were alarming. Above we see the result of the so-called standard run (development along existing trends). Here resources are depleted and pollution inceasing dramatically around 2050. As a result productivity (food per capita) and population collapses. In another run resources were assumed to be unlimited (below). Then pollution increases even faster and productivity and population collaps faster. A main result of the study is that pollution control is the most urgent measure. (Meadows et al., 1972.)

Institute of Technology in Cambridge, Mass, USA, under Dennis Meadows, (see e.g. Meadows and Fiddaman, 1994) on the consequences of the ever increasing world population and the increased resource use. The group constructed the so-called "World Model" in which a large number of parameters showing the behaviour of the world system, such as human population, crop production, waste accumulation, pollution etc were interconnected in a systems analysis model using 40 differential equations. Although it may appear overwhelming it was not more complicated than that the calculations today, 30 years later, easily are made on an ordinary PC. But at the time it was at the forefront of automatic computation and required many days of machine time. Later, models of the world's food and energy systems have been developed at e.g. the International Institute for Applied Systems Analysis, IIASA, in Austria.

The calculations that were made suggested that the unavoidable consequence of development, continuing along the existing trends with a much increased world population, would be that waste and pollution increased to the extent that the productivity of the Earth would finally go down and the population would not any longer be supported. A collapse of the productive systems was predicted for around year 2050. The message was that there is a limited carrying capacity of the world and we were already close to it. Today we would say that the development was unsustainable.

The Club of Rome study constitutes an important component of the roots of the scientific parts of sustainability. Here the question is simply – how large human population can the world sustain? This is referred to as the carrying capacity. It is symptomatic to see that the limit in the study was not the productive capacity as such but that this capacity was damaged by the accumulated pollution. This conclusion is corroborated by what we know today. The consequences of increasing environmental load, such as greenhouse gases and acidifying precipitation, has an impact long before the resources are emptied.

The natural science studies of development is the objective side of sustainability. Today they have developed into efforts to make the process better understood and quantified in e.g. systems ecology and the development of a series of indicators for sustainability. In this area science is just in the beginning.

The political process

The growth of environmental awareness during the 20th century can be looked at as a formal political history, in which nations and national bodies make their decisions and international agreements are made. Formal corner stones on the international arena (See further Chapter 23) are the formation of the United Nations in 1945, and the UN conferences in Stockholm in 1972 and Rio de Janeiro in 1992.

Two events in this history must be remembered specially. Firstly the UN World Committee on Environment and Development (WCED) which was appointed in 1984 and produced its influential so called Brundtland report Our Common Future in 1987. This work was based on thorough scientific investigations of problems relating to natural resources, environment and social issues, environment with its close connection to development. It was based on public hearings around the world and it expressed a consensus for the principles of a responsible management of natural and human resources and the related world affairs. Its "call for action" was an appeal to the states and a large number of other bodies in the world .

It should however also be recognised that the Brundtland report was the result of a political compromise between the South and the North. The North asked for environmental protection, as it saw the degradation of the environment and natural resources of the world progressing. The South asked for a way out of poverty, for development. The sum of the two became development within the capacity of the environment, that is, sustainable development. It led to the insight that the environment would never be protected by people that were hungry, fighting for survival, or combating wars. The two, environmental protection and development, were inseparably linked.

In its historical context the WCED report must be considered as an epoch-making work, that summarised a great deal of the ecological, ethical and humanitarian discussion up to then. The sustainability concept does not only refer to this work – its roots range, as we have seen, many years back in our history – but here it obtained a canonical reference and a comparatively original, although in a way limited, definition of "sustainable development", emphasising the aspect of equity between generations.

Secondly the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, made a big impact in the environmental discussion and promoted change of practises. The conference (Chapter 23) was attended by 178 governments and 120 Heads of States. It was the biggest international conference ever held. As a result the environmental concerns are now a prominent interest to all public and private sectors and affect human activities within a wide range. Also here a large number of NGOs contributed in preparatory work, in conducting discussions and follow-up activities.

The outcome of the Rio conference in the form of Agenda 21 and the subsequent deepening of the sustainability discussion are parts of the present development. The 20th century ended with a multitude of social, administrative, political and economical discussions and initiatives which all aim at a qualification and application of the sustainability concept in the 21st century. This has resulted in practical measures for protecting the atmosphere, the hydrosphere, the freshwater and land resources, the conservation of biological diversity, and means for handling hazardous wastes and toxic chemicals. The new knowledge will be essential to the opinion in the world societies from this time onwards.

Figure 25.4. A request for development. In the 1984 World Commission the South requested development rather that environmental protection. Regrettably the support to development did not increase after the 1992 Rio Conference. However poverty eradiction was an important issue in Johannesburg ten years later. Here in Uganda by Lake Victoria a large programme for regional sustainable development started in 2001 with inspiration from the work around the Baltic Sea. Today Lake Victoria is seriously eutrofied, fishing is decreasing, poverty wide-spread, and the social and health status of the population low. (Photo: Lars Rydén.)

The future of sustainability

It is evident that the sustainability concept is open to discussion and interpretation as are many highly abstract and visionary ideas. This implies good conditions for an integration of the environmental and development goals. As long as there is no unique definition of the notion, and no universal understanding of it, there is no limitation to it either. Its a key phrase with fringe applications in nearly every niche of the ecosystem and to every member of a society. Below we will give some rather practical examples of views on a few sustainability queries. Hopefully these may contribute to raising further questions for the reader, questions which may perhaps promote a more comprehensive view on environmental development. Such views must not necessarily be identically the same to everyone, but may become part of personal thinking. New pieces of knowledge may emerge and new thoughts and attitudes may permeate the cultures of the future.

The results of the Rio conference have concurrently been followed up on many different levels. A Commission for Sustainable Development has been created within the UN system for this purpose. Another commission is the International Council for Local Environmental Initiatives (ICLEI). Many practical activities have been initiated to establish the Agenda 21 programme. This involves many parties of the society from the public and administrative bodies to the NGOs and to private activities. Thousands of communities in over 60 countries in the world have developed local Agenda 21 programmes for adjustment of local routines to the new environmental aims. The aim of this work is that in the end every individual in the society should be involved in processes whose goal is to favour justice and the environmental and ecological interest.

CONCEPTS OF SUSTAINABILITY

Sustainability is a concept that each one has to conquer and understand. This is both a weakness and a strength that sustainable development shares with other concepts basic for human existence, such as peace, health and happiness.

Making sustainability operational

Sustainability is in its origin an abstract notion. This represents a strength of the sustainability concept: it must be conquered, like democracy, in every location and every situation. It must be interpreted and applied by the human agents wherever they are and whatever their occupation is. In order to discuss the practical consequences of sustainable development it has to be operationalised. In so doing one should attempt to integrate the social, environmental and economic dimensions of sustainability.

The economic societal system is sustainable as long as the environment may be considered as being in a steady state. The environmental dimension is the physical one, and it deals with the stability of the ecosphere. The human society depends on the ecosphere as its life support base, but the ecosphere in turn depends on the larger environmental system for flows of energy and matter. It is important that the natural resources utilised for the society are restricted to magnitudes that do not over-burden the environment. "Ecology worries about resource flows, since these are what contribute to environmental impacts" (Spangenberg et al, 1997). The stocks and deposits of natural resources are commonly classified as economic issues.

There are many obvious examples today that illustrate the non-sustainable development of the society. The practical procedures and the whole society must change, but how? Do we have to abandon the idea of improvement, progress and growth in thinking about the future? Historians point at a long period of human history – over some three or four hundred years, that has been characterised by a partly subconscious and partly formulated understanding that life conditions only become better as time goes on. Does this attitude have to be fundamentally reconsidered ? The overall evolution, or what we call development, does not *per se* favour improvement, progress or qualification of qualities and patterns.

It is evident that dependence on fossil fuels and deposited natural resources must be replaced by longer lasting resources and that the transformation of resources has to be made with much more concern for the ecological conditions. It is conceivable that the natural systems can pass a critical point where they will break down and fail to support what they have supported in the past. The world population is growing and the total physical activities of that population is growing even more.

The society has to operate within the boundaries of a global ecosystem which has – very definitely – a *finite capacity* to supply resources and to absorb the discharges. The same argument holds for the full variety of services that are offered by the ecosphere in providing clean air, good quality and quantity of water, clean and usable top soils and sustainable conditions for agricultural and industrial production, transportation and living. The sustainability scenario also has to affect the economical and the administrative systems which should be considered as subsets of the total natural system in which humanity dwells together with other species.

Pysical conditions for sustainability

1. The productive capacity of the ecosphere must not systematically deteriorate.
2. Substances from the lithosphere must not systematically accumulate in the ecosphere.
3. Human-made substances must not systematically accumulate in the ecosphere.
4. The use of resources must be efficient and just with respect for human needs.

See further page 64

Subsystems of sustainability

Still with this background the sustainability concept remains vague. An objective according to Barbier (1987) is to "maximise simultaneously the *biological* system goals (genetic diversity, resistance, biological productivity), the *economic* system goals (satisfaction of basic needs, enhancement of equity, increasing useful goods and services) and *social* system goals (cultural diversity, institutional sustainability, social justice, participation)".

The principle of co-evolution between a system and its environment is relevant also in the human society. The world consists of a multitude of local subsistence cultures besides the modern societies. All cultures have their special traits in very sophisticated patterns, on the so called eco-strategies (See Chapter 1). What one local society does influences the neighbouring ones. This may be utilised for mutual support in unforeseeable ways. Norgaard (1994) refers to the co-evolutionary paradigm. The 'advanced' countries co-evolve around western science and fossil energy, similar crops and the same brands of fertilisers and pesticides. But co-evolutionary thinking would maintain that "sustainability would be enhanced if differences in the 'development styles' in different countries were greater". Cultural diversity must be appreciated and promoted rather than uniformity and mono-culturalism. Norgaard alludes to what he names *reculturization*. It is easy to refer these arguments to the Baltic region, with its many different cultures in the west, east, south and north. They have ample opportunities to co-operate and exchange goods and ideas, with "long threads across the Baltic from east to west".

Carrying capacity

A group of Dutch scientists (van Latesteijn et al, 1996) have elaborated on the question of the fragility – or robustness – of the natural environment by introducing four paradigms of sustainability:

- The *utilising* paradigm expresses the attitude that human activities have an effect on the environment but the impacts can be absorbed, the risks are small and technology is to some extent self-regulatory.
- The *saving* paradigm admits that the environment, or 'nature', has a limited absorbing capacity and mankind must adjust to lower levels of consumption.
- The *managing* paradigm sees nature as vulnerable and the solution is technologies that adapt to the environmental condition – consumption levels cannot be drastically altered.
- The *preserving* paradigm considers nature to be fragile and society has to adapt in many ways: society is flexible and changes in its behaviour can be accomplished.

The environmental sustainability presupposes for the ecosystem a steady state, with small enough flows of resources through the supported systems. The *critical load* was defined by Spangenberg and Schmidt-Bleek as "the maximum continually supportable rate of *output*". The *carrying capacity* was understood as "the maximum continually supportable *rate of flow*". The origin of the latter term is biological and refers in the ecological context to the number of individuals of a given species that can be sustained over time without over-burdening the host system (See further chapter 3). For humans the population explosion is an alarming factor which increases the demand for provisions of natural resources. This points in the direction of an unsustainable situation.

The carrying capacity of an ecosystem inhabited by humans restricts the population which can be supported sustainably. This means that the natural resources must not be over-exploited. The rate of resource use must be limited to what the local system can support. Many authors use the words equilibrium or balance, in the sense that the ecosystem has to recover when deprived of substances that are utilised as natural resources. The sustainability concept integrates these ideas, since it aims at sustaining life indefinitely. The carrying capacity has to be operationalized in practical measures for all the ingredients in the supply flows from the environmental systems.

Subsystems

Sustainability is a *relationship* between dynamic human economic systems and dynamic but slower ecological systems, in which:

- human *life* can develop indefinitely;
- human *individuals* can flourish;
- human *culture* can develop and
- effects of human *activities* remain within bounds so as not to destroy the diversity, complexity and functioning of the ecological life-support system.

R. Constanza (1992)

Biological conditions for sustainability

1. The disposal of waste and replenishment of nutrients must be made by recycling all elements.
2. The ultimate source of energy must be sunlight.
3. The consumer population must not exceed the carrying capacity.
4. Biodiversity should be maintained.

See further page 78

The basic question is weather a society can become sustainable within the *modern paradigm* (the domination of nature through science and technology, growth and consumption), that is through better technology and accurate pricing, or whether sustainability requires the transition to a post-modern world. The former may be called *technological* sustainability; the latter *ecological* sustainability (Orr, 1992).

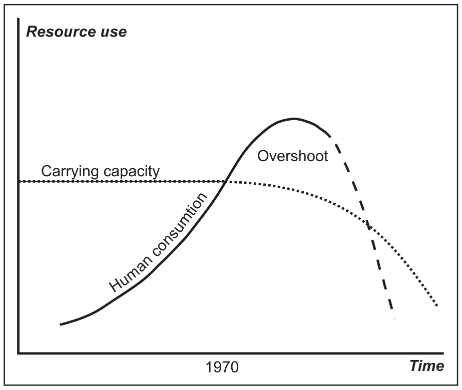


Figure 25.5. Sustainability requires that the society stays within carrying capacity. But as the affluent society consumes more than is available as renewable resources, the capital of the planet is emptied. The diagram (See page 30) shows that presently, natural capital is decreasing, and carrying capacity is decreasing in absolute terms, and even more so when calculated as per capita as population increases. (After Wackernagel and Rees, 1996.)

How to calculate the ecological footprint

It is easiest is to calculate a footprint for a country since the statistics needed are usually available on a national basis. The energy used, food products, built areas, paper consumed etc., all in the national statistics, may be converteted to per capita by dividing with the number of inhabitants.

Detailed statistics are used for the calulations. For example what is the footprint of a daily newspaper? One tonne of paper requires 1.8 m^3 of wood. This is compared to the productivity of 2.3 m^3/ha/yr (an approximate value for Baltic region forests), to become 0.78 ha. Since a common daily paper itself weighs more than 100 kg a year, it has a footprint of 0.078 ha. This is an underestimation since many components, for example energy and transport, were not included. On the other hand the use of recycled paper decreases the figure, up to three times (up to 2/3 of the fibres may come from recycling).

For energy calculations three methods have been used. For 100 Gigajoules biomass, some 1.25 ha land will be neeed. If wood is converted into ethanol we get the same figure, 1.25 ha. If we estimate the area needed for CO_2 absorption corresponding to the same amount it is 1.0 ha. The area for producing 100 Gigajoules is much smaller for windmills and hydropower stations (See further http://www.RedefiningProgress.org).

From M. Wackernagel and W. Rees (1996), *Our Ecolgical Footprint. Reducing human impact on the Earth.*

At the same time as population is increasing the capacity to support the growing number of humans is decreasing. There are many examples to the effect that the carrying capacity has been reduced or destroyed by modern methods that have been introduced without a detailed knowledge of the consequences. New species have been introduced in local ecosystems, new crops, new methods, new means of subsistence etc. Colonial exploitation has disrupted traditional societies and spoiled local systems. In concrete terms we have overfished the seas, deforested the lands, and lost vast areas of fertile soil through erosion. Much of it was done unknowingly. In fact most of the serious environmental problems that we worry about today have come as surprises.

A technical innovation is not only a matter of attempting a small change and expecting a small consequence. There are often examples of non-linearities, which means that small causes may have large effects. The complex systems of nature are often partly chaotic and may respond to minor disturbances by catastrophic evolution. Spangenberg and Schmidt-Bleek (1997) refer to the precautionary principle: "decision-makers must steer the economy, not by scratching the guard-rails, but by staying clear of them, keeping the economy in the middle of the road towards sustainability".

Measuring sustainability

There is a long tradition in developing methods to measure resource use. These data have been used for various purposes, only recently for sustainability. They deal with energy flows, material flows and surface use.

Energy analysis was initiated in many countries in the 1960's. This was in the spirit of safeguarding energy as a prime motor of industrial development when the societies more clearly became dependent on fossil resources, especially oil. It became even more accentuated after the oil price crisis in 1973. However as a measure to study sustainability it has a limited value. Energy use is in itself not problematic (Chapter 10). It is the material flows connected to it, such as carbon flows and auxiliary sulphur and nitrogen flows, that damage the environment.

In the late 1980s and early 1990s *material flows* studies were initiated and organised in several countries, primarily in USA, Japan, Germany and Sweden. The Wuppertal Institute in Germany, under the leadership of F. Schmidt-Bleek, developed Material Flows Analysis, MFAs, to a useful measure of sustainability. Some results have been cited and discussed earlier (See Chapter 13). Here we will only repeat that the average flows in western Europe is on a level of some 60 tonnes per capita and year, a figure that only includes solid materials, not water, nor gaseous substances. A considerable part of this material is non-renewable resources, in particular fossil fuels, but also materials moved in mining of metals. Preliminary data for Poland are slightly lower, about 50 tonnes per capita and year, while the values for USA are larger, around 80.

A third way to make the overall estimation of sustainability is to measure used surface. This is called the *ecological footprint*, a concept introduced by Reeds and Wackernagel in the 1990's. The footprint designates the *area* which is taken into account to supply energy and matter to a supported system and absorb its discharged waste and pollution. It can be associated with individuals, a population group, an enterprise or a community. This area does not have to coincide with the area of the populated region but it forms an indicator of the ecological load, or better *ecological service* used. It depends on the material standards and the utilised techniques, the quality and quantity of production and consumption, the ecological consciousness – the social habits and the cultural preferences.

The ecological footprint has the advantage over the other measures that it is obvious which area is available for the inhabitants of the planet. Subtracting the oceans, glaciers and other sterile land there is today some 2.0 ha per person on the planet. The calculated footprint can thus immediately be related to the available area to indicate overuse of the natural systems like excessive use of land and water as well as material deficits that result from ongoing activities. It provides a reference for practical judment of the conditions for sustainability. An evident example is that the ecological footprint per capita in the affluent parts of the world is much larger that in the non-industrialised countries. Again, as has been pointed out earlier in this chapter, it draws attention to the importance of land area. The economic system does not consider this as an important asset, but it is of paramount importance in any ecological context.

Factor 10

The 10-fold reduction of material flows in industrialized countries needed to achieve sustainability. The factor 10 has been calculated assuming that the world as a whole has to reduce resource flows by a factor of two, and that developing countries should be allowed to increase their resource use by a factor of two.

Reducing material flows – Factor 10

The Wuppertal group made an overall estimation on the material flows that earth could sustain in the longer run and concluded that it would be about half of the present flow world-wide. We may conclude that we need to reduce the flows by a factor of two to achieve sustainability, but this is not so simple. The now existing flow is very unevenly distributed over the world. The richer 20% of the population of the planet moves about 80% of the total, while the poorer 80% moves the residual 20% of the material. Assuming that the developing countries should be "allowed" to increase their material flows by a factor of two as part of their development, and that in the end every society on the planet should have the same access to materials, they conclude that the richer *industrialised societies should decrease their flows by a factor of about ten!* This trivial calculation thus leads to a dramatic conclusion. As a result a number of wellknown scientists and politicians formed the Factor 10 Club in the early 1990's. It has been quite

Review Box 25.1 — Implementing Factor 10

Decrease material flows by 3% yearly

The flows of materials need to be reduced by a factor of 10 in the industrialised countries. Is this realistic? Counted over a 30-50 year period it would amount to a reduction of the absolute size of material flows with 3-4 % yearly. Let us compare this with the efficiency increase in the business sector. Today many companies count on 4 % improvements yearly as a requirement to stay competitive. This means that the value of production compared to costs should increase with this amount.

Efficiency increase since the dawn of industrialization

Seen over a period of some 150 years, that is from the beginning of the industrial revolution, the value of the work of one person has increased by about 150-200 times. To illustrate this let us look on agriculture. 100 years ago some 80 % of the population was working in agriculture to produce a scarcity of food for a much smaller population than today. Now in some countries, such as Sweden, about 2.5 % of the population is producing a surplus of food to a larger population. The reason is better machinery, crops, methods etc. It is symbolic to see that a hundred years ago a miner worked with spade and picket to move kilos of rock. Today he has access to big machines to move hundreds of tonnes daily.

During this same period the value per input of resources has increased about 2 fold. GDP per material input started to increase slowly but steadily in the early 1970's in industrialised countries. But resource flow did not decrease since the increased consumption and GDP has compensated for that possibility. This is the so called *rebound effect* (Malaska, 1999).

How to improve resource productivity?

The cost of natural resources has not increased much, not at all as the salary. Suppose that resources would cost more. There are all reasons to believe that society would be able to accommodate to this situation and create value with less resources.

To see resources, rather than human work, as limited would correspond better to the actual situation. Political tools that try to achieve this is the green tax shift. But to construct more clear economic signals would be necessary. Thus internalisation of external environmental costs is necessary. To wait until the resources start to actually be exhausted and therefore have a higher price would be devastating for the environment.

It should also be noticed that if economic growth in society continues to increase it has to take place without increasing resource use. Today e.g. energy use in a society is fairly proportional to GDP or living standard (as income, US dollars per capita). These kinds of relationships have to be uncoupled if we wish to create a society that is built on sustainable flow of resources. But the dematerialised values (friends, music, nature etc.), may increase indefinitely.

Sustainable growth?

Is economic growth possible together with sustainable developement? Yes, as long as it does not require increased material resources. An economic increase in the service sector, typical for post-industrial (or postmodern) economy may be sustain-able. This is sometimes called ”smart growth”. In a study of the growth of Finnish economy during the 1990s (a total of 3%, typical for western economies) half, or 1.5%, was found sustainable (Malaska, 1999).

influential and in fact Factor 10 is today official politics in many countries, as well as in the European Union.

The most distinct criticism against using MFA for estimating sustainability has focused on the fact that not all material flows are equivalent. Some are perhaps uninteresting, e.g. moving sand and gravel when building infrastructure, while others are extremely toxic, such as several metals and organic pollutants. The Wuppertal group maintains that these toxic flows constitute a fairly constant proportion of the whole and thus the gross value reflects the situation well. They also remind us that the chemical industry alone is responsible for the emission of some 100,000 different substances, whereas the input is on the order of less than 100 abiotic substances, including the energy carriers. The input points are limited to altogether about 20,000, whereas the exits are beyond any control. It is thus practical policy to focus on the inputs to provide a high regulatory efficiency, where monitoring and control is possible (Spangenberg 1997, p 39). Even if material flows are not perfect it is meaningful and can be used until we have better analysis.

Applying quantitative sustainability – defining the limits

Several comprehensive measures of sustainability including also other dimensions than environment, especially economic ones, have been developed. The *Environmental Utilisation Space, EUS*, is an measure of the amount of environmental pressure that an ecosystem can be subjected to without being seriously damaged. The EUS concept was developed by Dutch researchers on environment and economy, Siebert (1982) and Opschoor et al (1994).

The EUS is dependent on human technology. New resources, new technology and new refined ways to handle the support system may expand the EUS of a region. When such technology is developed it facilitates increased utilities with preserved environmental conditions and less pollution: the environmental space is virtually expanded. The future society has the possibility to develop altogether clean technologies and increased resource productivity to achieve such an expansion of the EUS.

If the EUS is temporarily surpassed the space will have to shrink subsequently in order for the environment to be regenerated and to recover. The reverse may also be the case. The EUS method can be applied in connection with different economic instruments when implementing environmental policies.

Spangenberg & Schmidt-Bleek (1997) utilised the notion of environmental space, ES, as a normative concept, bridging between the physical, socio-economic and developmental dimensions. The environmental space focuses on the *functions* of the natural systems to support the societal activities. Its social dimension is based on a global equity principle – ”widespread poverty, hunger and lack of participation are not sustainable”. Sustainability can be defined as ”living within the environmental space”. Spangenberg & Schmidt-Bleek launched the notion of *a culture of sufficiency* which ought be created in the Western world. This will unavoidably take its time – may be a period of 30 to 50 years. Besides technical innovation the social and economic structures must be adapted and adjusted, hopefully without social disturbances and conflicts.

What is the lowest limit of the environmental space, ask Spangenberg & Schmidt-Bleek. If over-consumption is reduced to approach living conditions within the environmental space, is it possible to similarly operationalize “the minimum annual quantity of resources needed per person in order to live a dignified life”? Today it exists as a minimum for food, clothing and shelter, water supply, health service, education, social and democratic participation, mobility, security, access to societal institutions, etc. elaborated within the UN system. This is however defined for mere survival, which ought to be the same all over the world.

Environmental Utilization Space

The term environmental utilization space (EUS) was first used by Horst Siebert in 1982. The concept has been applied to sustainable development and developed in some detail by Opschoor et. al. (1994), with particular emphasis on understanding the dynamic interaction between physical limits and human demands on the environment. The ecospace concept has been adopted with enthusiasm by NGOs, notably Friends of the Earth, who see it as a basis for achieving more equitable distribution of access to global environmental services (use of resources and the "right to pollute").

From:
http://www.sustainableliving.org/appene.htm

Figure 25.6. A culture of sufficiency does not necessarily mean a poor life but it does mean a life with less material flows. A relaxed breakfast with the children during summer vacation is just fine. (Photo: Lars Rydén.)

Energy, materials and land are the core categories of environmental space. Of course the three of them can be subdivided. Air, water, biotics and soils for the minerals, fossil and nuclear fuels and flows based on solar radiation for energy. Areas comprise land and water. Attempts have been made to reduce the space to one sole variable, the area, which is generally involved. This condenses the measure to the ecological footprint.

There are estimates that the total human per capita claim on land area today amounts to about twice the global available land. This reflects that we are already at – or beyond – the limits of the carrying capacity. As mentioned above also the material flows analysis points to an overuse of resources of about 100%. It appears (Wackernagel, 1996) that the world passed its carrying capacity at about 1970 and that since then the overuse has increased (e.g. use of more non-renewable resources). The carrying capacity itself has decreased (e.g. desertification and overfishing) at the same time as the population increases. For the sake of both inter- and intra-generational justice it is in practice inevitable that the resource use in the affluent countries must be reduced. The factor 10 launched to explain what is required seems not at all too provocative in this perspective.

According to the paradigm of ecological sustainability humans are thus not yet ecologically literate. The future citizenship must be associated with a new ethics, new ecological competence significant to the post-modern world, new awareness of the systems approach and a long enough time perspective. The human intellect reduces, in the modern system, most details of the very complex to oversimplification. Much of the traditional knowledge is many times superior in respects that have to do with subsistence and survival.

Indicators of sustainability

During the 1990's Local Agenda 21 has been implemented in many municipalities, in addition to a series of other A21 projects in everything from small places, such as schools, to the national and even regional projects. In this context a need to monitor the work has become a major concern. What are the practical possibilities, and what do we want to know?

The different measures developed are named *indicators of sustainability*. They are typically extremely diverse and not always easy to relate to the basic assumptions of sustainability. They are often divided in three categories environmental, economic and social. Indicators may either be made for a

Goals and core indicators for Baltic 21

Baltic 21 is the intergovernmental co-operation for sustainable development in the Baltic Sea region, the regional Agenda 21. The essential objective of Baltic 21 is the constant improvement of the living and working conditions of peoples in the region, within the framework of sustainable development, sustainable management of natural resources, and protection of the environment. The goals and indicators for these goals were agreed on between the countries as follows:

1. *A safe and healthy life for current and future generations.* **Indicators**: Life expectancy at birth, Infant mortality rate, Population ozone exposure.
2. *A co-operative and prosperous economy and a society for all.* **Indicators**: Regional GDP/capita, including lowest versus highest GDP/capita in the region, Income distribution, Unemployment rates, Inflation.
3. *That local and regional co-operation is based on democracy, openness and participation.* **Indicators**: Participation in national and local elections.
4. *That biological and ecosystem diversity and productivity are restored or maintained.*
5. *That pollution to the atmosphere, land and water does not exceed the carrying capacity of nature.* **Indicators**: CO_2 emissions, SO_2 emissions, NO_x emissions, Land area where depositions are above critical loads for acidification and eutrophication, Load of nutrients to the Baltic Sea, Emission and discharges of metals to the Baltic Sea, Consumption of ozone depleting substances, Protected areas versus total area.
6. *That renewable resources are efficiently used and managed, within their regeneration capacity.*
7. *That material flows of non-renewable resources are made efficient and cyclic, and that renewable substitutes are created and promoted.* **Indicators**: Energy intensity (energy supply versus GDP), Renewable energy/total energy supply.
8. *That awareness of the elements and processes leading to sustainability is high among different actors and levels of society.*

The Baltic Sea Region recognises its interdependence with other parts of the world and makes its contribution to the fulfilment of sustainable development goals at the global and European level.

See further on http://www.ee/baltic21

particular activity or sector, such as forestry or agriculture, or be so-called global, that is refer to development of the society in general.

The CSD, UN Commission for Sustainable Development, handbook for indicators describes no less than 1200 different categories under five headings. The European Union Sustainable Cities and Towns Campaign has during 1998-99 collected indicators from its then more than 600 member cities and received some 300 indicators for sustainable urban development. Of these 10 were selected as core indicators during spring 2000, and all member cities (now close to 1,000) are asked to report values for these (page 786). It is interesting to note that Stockholm, one of the member cities, all by itself was able to collect 300 indicators and of these selected 20 that were going to reflect the work for a more sustainable city. They are all reported on the Stockholm city Agenda 21 homepage.

Environmental indicators for cities all contain typically emissions of greenhouse gases, especially carbon dioxide, air quality in the city, waste management such as percentage of recycled waste, and energy savings or efficiency. They have indicators to measure use of mass transport, as well as traffic. It is interesting to note that the social indicators are well represented. The lists of common European indicators start with the question “Do you like to live in your city?”. Others relate to safety; do you feel safe in the city, to children’s schools and health. It is often more difficult to construct economic indicators that are clearly related to sustainability. Unemployment rate is often included, as well as several standard economic measures such as local equivalents of GDP, which does not say too much about sustainability.

The Baltic 21 work, that is the Agenda 21 for the Baltic Sea region, has so far developed 9 sectors and several joint actions. All of these are developing their own indicators. A first report was published in 2000 and the next is planned for 2003. It is clear that it is not easy to find relevant indicators for all fields. Several sectors, such as forestry, have used indicators developed earlier in other, European, contexts. Some sectors have developed their own indicators, while others, such as tourism, are still lacking indicators.

Indicators are used to follow the development in an area. In the best case they may be constructed to allow a deeper analysis and then also to propose actions to improve the situation. Ideally the indicators should have targets, values that would be considered acceptable from the point of view of sustainability. Sometimes it is easy to set targets. For example for the indicator “percentage of renewable energy resources”, the target should be 100%. If we talk about percentage of an area that is protected, such as a natural park, it is less easy to know what is required to protect biodiversity. One rule was that 10% of each type of land should be set aside as protected area, but many other concerns need to be included. For example the area has to have a certain size and it should not be fragmented. Setting targets is even more unclear when it comes to social and economic indicators. What is acceptable for example for the indicator “feeling secure in the city”. Of course one would like that everybody feels secure but that is unrealistic, and it is not in itself required by sustainability.

It is possible also to use the measures of sustainability as such for cities. Several cities have started to use ecological footprints as an indicator. This is difficult since the statistics normally required is not collected on the level of the municipality. However it has been done in e.g. several Finnish and some Dutch cities. There is, as far as we know, no cases of Environmental Utilization Space, EUS, studied for cities.

Sustainability in practice

Materials and energy management

“We need to turn from a waste management strategy to a materials management strategy” (Karlsson 1997).

Materials management

The modern societies are responsible for a huge mobilisation of materials. The anthropogenic flows have become subject to analysis as regards the material intensity, which measures the amount – in kilograms – of materials that are used to provide various services. The input of flows to the anthroposphere and the technosphere are either invested in structures that will be durable for a longer or shorter time, but a great deal is dissipated and contributes in different ways to waste and pollution.

What can we do to improve the state of affairs of the materials management. How can the Mass Input Per Service unit, MIPS be reduced? How far away is the vision of sustainability in this context? The fundamental principles may be summarized as

- Care should be exerted when substances extracted from the lithosphere are accumulated in the ecosphere, when technologically produced substances are transferred to the ecosphere and when the physical conditions for production are designed.
- The resource management must be efficient and adequate not to strain the ecosystem.
- The quality of products should be improved to yield a longer life-span.
- The transportation involved in production processes should be considered and reduced as far as possible.

The environmental impact of the materials flows can be reduced by *dematerialization* or by *transmaterialization*. Dematerialization is achieved by *reducing* the flow, *increasing the efficiency* of the flow processes or by *closing the flow* through increased recycling. Technological progress over many years has demonstrated the potential for more efficient use of materials and energy. Stronger materials and higher quality have been combined with lighter weight. Miniaturisation is eminently demonstrated within electronics, where we start to see micro-electronic components in many kinds of equipment. In the future we have reasons to expect that even nano-technology will find wide applications in many fields. Applications can be diversified and elaborated, life-times of technical products can increase.

Recycling is a key project in the sustainable society. Things can be reused and materials can be recycled and fed back to new production. Feed-back loops can be applied at different levels in a production system. If not earlier, the outlet, whether gas, liquid or solid waste, will be a potential source of elements or chemical compounds. The materials intensity for services – the MIPS – of every output should be scrutinised. All kinds of waste can be substantially reduced, from households or companies, by separation into fractions for paper, cardboard, glassware, metals, plastics and rubber and so on. Metals can be further separated into their elements. Biotic material must be composted. Such anti-dissipatory processes in principle require exergy (see below). This indicates the importance of a systems perspective of the whole of this activity. The exergy efficiency of recycling systems must cover all activities including transportation. Unnecessary mixing should always be avoided. Mixing is dissipation, while purity is order and structure. Loss of concentration is loss of resources.

Sustainable materials management strategies

1. Reducing the flows – use less material for a service

Use the material more efficiently – higher voltage in a electric cable will require less copper for a given power.
Increse the quality – using the strength of todays alloys would allow us to build the Eiffel tour with seven times less metal.
Miniturization – use smaller equipment, for exampel in todays computers compared to the older ones.
Multifunctionality – let equipment serve several purposes, for exampel a solar panel can also be a roof.

2. Slowing down the flow – make the material last longer

Improve the quality of the material – the equipment will then serve for a longer time.
Protect the material in the equipment better – for example protection against corrosion makes a modern car last longer.
Improve maintenance – the equipment will last longer.
Repairability – make the equipment easier to repair and it will last longer.

3. Closing the flow – use the material again

Reuse the goods itself – this is normal, except for one-time only gadgets, sometimes it is part of a strategy, such as with glass bottles that are refilled.
Recycle the material in the production process – this is used in industry when wasted material is fed back into the process.
Recycle the materials in consumer goods – true recycling, important for materials that are e.g. toxic such as lead in batteries.
Cascading or down-cycling of materials – when there is a loss of quality in recycling such as for paper which can not be reused more than about six times.

4. Substitute the flow - use a different less harmful material

Substitute a harmful material for a less harmful one – such as when mercury is exchanged in thermometers.
Substitute a scarce material for a less scarce one – such as when using optical fibers instead of copper wires.
Substitute non-renewable material for a renewable one – such as when fossil fuel is subsituted for renewable e.g. from biomass.

From S. Karlsson, 1997

Transmaterialization is defined as substitution by other materials. Even though a material is efficient for some service it may be unwanted for environmental reasons. Transmaterialization means a shift to other substances that are available for the same kind of service. There are many examples that have been applied already, and this development should be strengthened and extended.

First an environmentally harmful material can be replaced by another less harmful. Mercury is an example of an element that we do not need for many services any more. Organic solvents that were earlier used in paints have successfully been replaced by water as a solvent through advanced development work. The CFC substances used in refrigerating devices are being phased out and replaced be other chemicals. We will probably have to pay a little more for substances that are the second best from the techno-economical point of view, in order to care for the ecosphere. Scarce materials may be exchanged for less scarce ones. The copper of telecommunications is nearly superfluous today because of the neat and effective optical fibres. Karlsson et al (1997) present a very comprehensive account of metals in nature and society.

Another reason for substitution is that a material is non-renewable. This includes first of all material produced form oil and coal, in particular as fuels. 95% of all oil is used for fuel and only some 5% for production of e.g. plastics. Other material that are scarce and non-renewable are several metals and the macro-nutrient phosphorous.

The energy sector

Energy, or rather *exergy* (see box 25.2), is the most important natural resource to humans and the society. When reading and using the conventional word energy it should be kept in mind that exergy is the essential part of the energy.

In the perspective of human ecology the first and most important energy source is food. It is surprising that most scientists today still do not observe that the food supply to humans is a part of the energy supply to the society. Energy is required also for collecting all other resources, water, minerals etc and for maintaining the whole collective machinery. A modern society develops mechanical structures for housing and performance of various activities such as communications and transportation, farming and industry etc. The utilisation of energy in a modern society is now totally dominated by other activities than gathering food.

In the affluent societies of the world humans are equipped with ‘energy slaves’, whose work is a condition for a complex society to function. ’Energy slaves’ are equipment or other services that are added to the food eaten by each person, which only amounts to some 3,000 kcal or 12,000 joules per day. In most industrialised countries the number of ‘energy slaves’ per person is of the order of one hundred! This constitutes the “systems solution” that members of the present societies are part of and cannot easily opt out of. Many people also appreciate the modern society with its opportunities for a pleasant living with recreation, travelling etc. It has become customary for people to buy their groceries and goods in shops, where it is not obviously revealed what multitude of activities, and what consumption of resources, that form the basis for what they purchase.

Energy utilisation in the welfare states towards the end of the twentieth century is at a level that has been reached rather recently. A study of energy growth in Scandinavia shows that commercial energy has grown by about 5% a year over a period of nearly 200 years. This corresponds, if the growth is exponential, to a doubling time of about 15 years. Indeed there are fluctuations – such as minor decreases during the world wars – but growth patterns have been remarkably constant over a long period. In the history to be written on human ecology this will be regarded as an important prerequisite for the ensuing problems. Sustainability cannot be consistent with such a dramatic growth and not even with such a high level of energy use.

This period of a dramatic energy growth has, however, come to an end in many societies. A remarkable change in the growth pattern occurred in October 1973, in connection with the so-called energy crisis. The details of the related historical data on globally important conflicts are treated elsewhere. The superficial reason for this breakpoint was a sudden rise in the world market price of oil by a factor of four. In 1979 another quick change occurred raising this price once more, this time by a factor of three. Since then many countries have achieved a drastically reduced oil consumption. The global commercial power was in 1990 no less than 12,2 TW (TeraWatt).

The present level of oil consumption in e.g. Sweden corresponds to 2,3 m^3 of oil per capita and per year. This results in a contribution of CO_2 to the atmosphere of six tonnes per capita and year. The world market price of oil has returned to the previous low level and is, towards the turn of the century, about 20 US dollars per barrel, 159 litres. No nations exhibit today the extreme growth that characterised the first few decades after the World War. An estimate based on reasonable human ecological values is that whatever growth there will be in the global per capita use of energy in the future, it ought to be devoted to the poorer countries.

Renewable resources will in the longer term have to replace the non-renewable ones. The replacement of fossil fuels and present nuclear technology are all-embracing projects for the near future in many modern societies. There are several alternatives (Chapter 10). Biomass has great potential as an energy source, even for replacement of the petrol and diesel oil in cars with alcohol. Biogas is one further possibility. Solar technologies are developing. Most countries in Europe have a resource consumption which is so high that it is technically no difficulties to save energy. Friends of the Earth, Netherlands, have estimated that by the year 2010 we should have reached reduced levels of fossil fuels by 60% (with fresh water by 38%, aluminium by 80%, agricultural land by 45% and timber by 65%). Below we will look into prospects for much more efficient energy (exergy) management.

Energy use has increased dramatically throughout human history. The hunter-gatherers used perhaps 2-4 times the energy in the food, for housing, cooking, clothing etc. The simple agricultural society used some 8 times more energy per person than in the food. The simple industrialized society, up to about 1950, used some 20 times more than the food and today in the affluent society – we use 80-100 times or more per person.

Exergy saving – saving energy quality

Much of the exergy use in the modern society represents very wasteful techniques. In order to tax our possibilities to increase the efficiency in exergy utilisation one has to remember, first of all, that exergy is characterised by two properties. The exergy content of a storage or a flow is measured by the product of an energy *quantity* and an energy *quality*. Both of these can be subject to conservation measures and efficiency improvements.

Saving *energy quantity* is a well known strategy. It has to do with tightening the leaks, improving e.g. heat insulation in the walls and the windows, the floors and the roofs of the housing. Even air tightening of windows and door frames may give good results. One should observe that a kitchen fan requires a few tens of watts to be operated, but it can ventilate several kilowatts of heat power by exchanging hot air for cold.

Saving of energy quantity may also of course be a matter of consuming less of the utilities that exergy is used for, reduced use of industrial products, shorter and fewer journeys and trips, smaller apartments for living and lower standards as far as indoor heating and lighting is concerned. These examples put a strain to living conditions and will not be treated further in this context.

The conservation measures for *energy quality* are different by nature, since the strategies most often have to do with the efficiency of the *systems* that are utilised. The most general principle for increasing the efficiency of

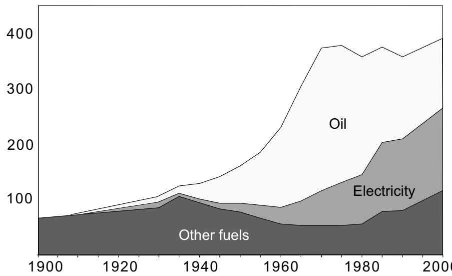


Figure 25.7. Energy use in Sweden during the 20th century. The curve illustrates our path towards unsustainbility. Up to about 1950 energy use was on a relatively low level. Between 1950 and 1973 it increased three times within one generation. The whole increase is accounted for by fossil fuel, that is non-renewable resources. We went from a ”traditional” society to the affluent unsustainable society. Since then energy use have been farily constant and the percentage of fossil fuel has decreased. Development of other kinds of resource use in society, such as industrial fertiliser in agriculture or metals in industry, follows very similar curves. (Based on compiled Swedish energy statistics.)

thermodynamic processes can be expressed as the ideal of *changes in small steps*. This ideal has many applications, it can be applied to speeds on the road or to temperatures and temperature changes. It is a laymen's rule that the less dramatic the temperature difference is, the higher is the exergy efficiency.

Most of our energy sources are characterised by a high quality, in fact it is overdone for many purposes. The quality factor of energy is, for all forms of heat, determined by a temperature difference, most often relative to the environment. Electricity, with its infinite temperature capacity, is the foremost example of a perfect quality (100%), and should be used with special care. It is particularly well suited for running machinery of all sorts and high temperature applications as lighting, hot plates and ovens etc. But also most fuels have a quality factor at normal burning conditions, usually about 90%. This should be viewed in the context that in many of our applications in the society the low quality demands are dominating, domestic heating and warm tap water etc.

A high temperature represents a special value and must not be wasted. When it is utilised one should make sure that, as far as possible, the next lower temperatures could perhaps be used for some further purpose. In the processing industries, for

Review
Box 25.2

On exergy, useful energy

Exergy is the ability to do work

The exergy quantity is defined as *the ability to do work*, it is present in a material system which can function as en *energy supply*. Exergy can also be described as composed of two measurable variables, *one quality factor and its quantity*, the latter being, like energy, measured in joules (J) or kilowatt hours (kWh).

Whereas energy is omnipresent, exergy represents a contrast, or a 'tension', and it must be referred to for instance a system and its surrounding. This demonstrates that exergy is an ecological resource concept. Furthermore, since every contrast in natural systems has a tendency to weaken, and in the end to be eliminated, *exergy can be consumed*! This is in effect an expression for the second law of thermodynamics.

It characterizes a relevant resource concept that it can be supplied, distributed, utilized and finally consumed. This is what holds for exergy, quite contrary to energy.

The definition of exergy

The *Carnot principle* (that can be studied in texts on Thermodynamics) demonstrates that the energy quality for quantities of heat can be calculated by means of a special temperature factor. If the temperature of the surrounding is T_o, a quantity of heat Q with temperature T (larger than T_o) can provide the work $Q \cdot (T - T_o)/T$; (T must be expressed in kelvin). The dimensionless factor $(T - T_o)/T$ measures the quality of the heat Q. This factor can be expressed as percentage or as a fraction, since it varies between zero and one. If $T = T_o$, that is if the two temperatures are equal, no work can be performed and the exergy is *zero*, all energy is background energy. Only if the surrounding temperature is close to absolute zero, does he factor become *one* in the limit.

Exergy can do work and is the 'driving agent' of all material processes and all changes of structure in matter. Exergy is a creative force in the small and the large scale. It provides the capability to develop new atomic architecture as well as architecture for humans. The solar flux to the surface of the earth contributes large amounts of exergy. It is exergy, not energy, that in essence sustains life and all evolutionary processes, also in the long and in the short time-scale.

Natural systems are exergy efficient

The exergy theory forms a framework for thinking about resource supply in a way that is relevant to an ecological perspective. It can clearly demonstrate that all physiological systems function with a practically perfect exergy efficiency. But the exergy concept can also be utilized to study very practical matters of housekeeping and energy conservation in a society with high technology. Needless to say, most human constructions operate at a much lower exergy efficiency than natural systems do. Those who want to study the potential of energy conservation measures ought to work within the framework of the exergy theory.

On energy efficency - the quality of energy is exergy

An important starting-point for the discussion of energy efficiency (as it is called by most people today) is that one must consider effective utilization of both the quantity and the quality of energy. The traditional energy conservation measure is to use less energy, to tighten the leaks and to be careful with all kinds of spending. Exergy efficiency also depends on clever handling of energy quality.

High energy quality has in practice some clear demonstrations: mechanical energy, electrical energy and high-temperature heat. The quality factor of electric energy is perfect. Electricity can be used for almost any purpose in technological systems, including production of heat. It has a very high 'temperature capacity'. The frequently applied technique of producing low-temperature heat (less than 100 degrees centigrade) by means of electricity is in principle extremely wasteful. Its exergy efficiency is in most cases less than 10 per cent. Therefore one now often defines special applications for electricity, namely, those that concern motion and high temperatures: transportation, mechanical machinery, lighting and hot-steam devices. For heating diffent sources than electricity should be considered.

Tage Sundström

production of e.g. metals, pulp and paper, a high temperature is produced (in a steam boiler) by burning a fuel, and then different demands of reaction temperatures are supplied along the steam flow on its way to spontaneously lower and lower temperatures. Industries that, at the low temperature end of such flows, serve a district plant for residential heating in the surrounding city or suburb, are very energy efficient.

Efficient heating of houses – the heat pump

A rough pattern that is significant for the energy sector of many industrialised countries is that about 40% of the primary energy goes to industry, 20% to transportation and 40% to a large number of small items centred around the human household (housing and business), where the heating of buildings is, in the Baltic region, the main consumption. It is notable that the food for the human bodies constitutes only 1%. Of these three kinds of energy use the one of housing and business is estimated to be comparatively easy to reduce. Use of energy in industry is in some sectors difficult to reduce while energy in the transport sectors is particularly difficult to address.

The demand of energy quality for residential heating can easily be calculated. On the quality scale between one (or 100%) for the perfect quality and zero for the background energy, the room temperature (T) corresponds to 20 °C inside on a winter day with, say, minus 25 degrees outside (T_o), the real demand of energy quality is $(T - T_o)/T$, where temperatures should be expressed in degrees Kelvin. This very significant quality factor is 0.15.

The most excessive waste of exergy is demonstrated by *electric heating*. The exergy supply has too high a temperature capacity to be well suited for this purpose. In fact the quality of 100% has to be adjusted to below 20% before it is of any real use. More than 80% of the exergy has to be destroyed with no purpose at all, other than waste, before serving its purpose of providing a convenient room temperature inside. From this ideal exergy efficiency one then has to subtract a further fraction for heat losses and imperfections in the technical solutions. The same arguments hold also for supplies of warm tap water.

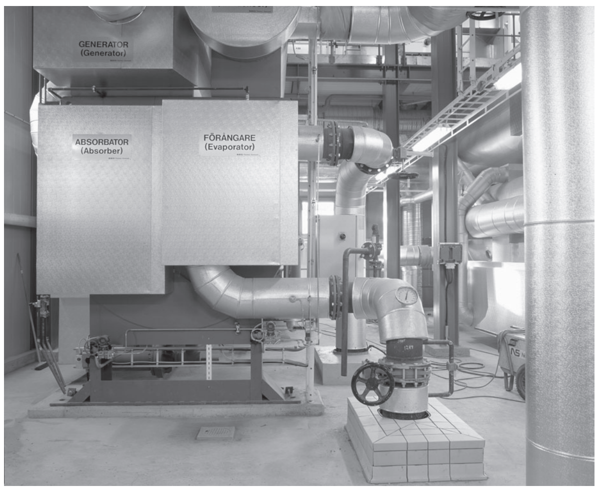
The first alternative to get around this problem is to investigate whether there is a good source available in the vicinity where some *low temperature heat* can be extracted. Solar radiation can produce rather exactly the required energy quality of heat by a plane solar collector. Many industries produce flows of luke warm water with a low energy quality that may be sufficient for this purpose, but is often intentionally wasted into a river. Every operating heat engine discharges a flux of heat into the environment, which could in principle be utilized.

The *heat pump* has become a very popular alternative for increasing the exergy efficiency in connection with heating of housing. The heat pump is exactly the reverse of a heat engine. Whereas a engine produces work and is driven by a temperature difference, the heat pump is driven by work and produces a temperature difference. This can be very properly fitted to a residential home to deliver heat at an appropriate temperature that can be chosen by technical means. The heat pump is in effect a refrigerating device, used in the reversed direction, for air-conditioning in warm countries. Every freezer or refrigerating machine is driven by work, where primarily electricity is the exergy source. The point with the heat pump is that its cooling power is applied outside, so that the background energy in the environment be harvested. Low temperature heat can be collected in air, water or the solid ground. A great deal of the heat is delivered to the house free of charge (!). The loss of background energy outside is replaced by the solar heat when the spring arrives, if not earlier.

If a *heat engine* is again compared to a heat pump one may take it as normal characteristics that the heat engine has an efficiency of about one third. The means that 2/3 of the heat consumed is discharged for no use at all. For the heat

Figure 25.8. Housing. Insulation of a house as here may decrease energy demands considerably. Additional possibilities for reducing energy costs are installation of a heat pump, and use of solar panels.

Figure 25.9. Using heat pumps. This large industrial heat pump is taking its heat from the flue gases from waste combustion at Uppsala Energy. In the process the gases condenses and the heat extracted is transferred to the distict heating system. In other large-scale applications heat is extracted from sewage water or surface water. The chilled water may be used for district cooling. Most heat pumps are smaller and used for individual homes. (Photo: Kjell-Arne Larsson.)



Applying a systems perspective

A school in Kungsbacka in western Sweden is an interesting example of a complex system for indoor heating. The supporting fuel is diesel oil, that operates an engine, the cooling water of which is used for heating. The engine drives a heat pump that collects low temperature heat, through pipes that form a web in the ground under the sports field of the school, to a depth of several tens of meters. Solar collectors in the summer add heat to that same bulk of matter through a complimentary pipe system. (The sports field is often rid of snow in the early winter.) The heat pump contributes most of the indoor heating. The real point of this solution is the systems aspect. Once established the heating efficiency is excellent.

pump, on the other hand, the quantity of useful energy for heating is multiplied by three, with comparable data. One may formulate this point that in the exergy flow which is going into the heat pump, the quantity is magnified while the quality is reduced. There is nothing negative in that reduction, since the demand of quality for this purpose is very low. The heat pump normally increases the heating efficiency by factors between 2,5 and 4.2.

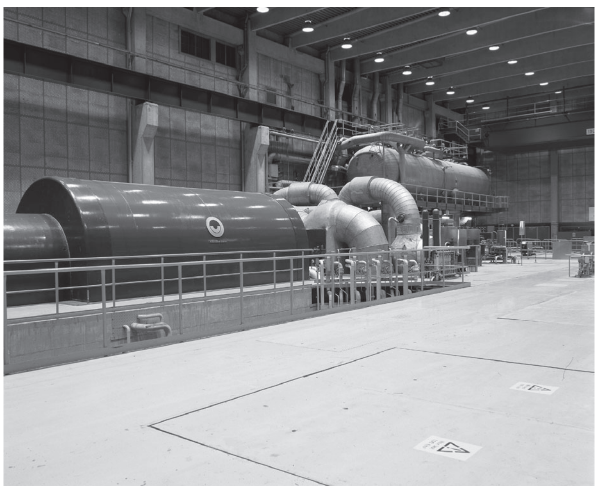
Energy efficiency – co-generation

Co-generation. The heat engine and the heat pump can both serve an important purpose in improving the exergy efficiency. Wherever there is fuel consumed in combustion for heat production at a large scale one ought to have an electric generator connected, which can deliver an amount of high quality energy in the form of electricity. Any heat plant ought to be constructed for *co-generation* of electricity and heat. The efficiency is greatly enhanced by the fact that electricity is produced and the heat is not discharged in the environment. The advantage of the heat pump is the mirror example of this. It makes even the background energy useful for heating by a rather modest upgrading of temperature. Even the water under the ice of frozen lakes can be used as low temperature heat sources.

The two techniques, co-generation of heat and electricity and the heat pump, are examples of *systems solutions* that can improve the exergy efficiency of the society as a whole. There are also many examples, in Sweden for instance, of such techniques for exergy conservation. More than half the number or Swedish communities now run comparatively large district heating plants. The combustion process and the flue gases can be momentarily controlled. Another advantage is that any mixture of fuel, or other supplied exergy, can by used. Today all new plants are equipped with co-generation facilities.

The number of heat pumps that have been installed for domestic heating in Sweden is now over a quarter of a million. There are small ones for separate houses and large once for feeding, as means of relief, the district heating plants. A common way to do it, is to utilise the bulk of water at the sewage treatment works, which has even in the winter a temperature of say 15 degrees. By cooling it to one degree before letting it out in the river, a lot of low temperature heat is released and the heat pump upgrades its temperature. This corresponds to a sort of recirculation of heat, since this water is second hand tap water.

Figure 25.10. Co-generation. Combustion for heat production may be coupled to electricity generation in turbins, as in this turbin hall. When the hot steam is pressed through the turbins electricity is generated. The steam is cooled to temperatures appropriate for the district heating system. With this combined system efficiency is close to theoretical maximum. (Photo: Kjell-Arne Larsson.)



Problems with the present transport systems

The normal traffic on roads is a great shame from the ecological point of view. The heat engine technology is in general wasteful, since the major part of the exergy content of the fuel is destroyed for no use. The combustion occurs at extreme conditions – in small volumes between the metal pistons and the cylinder top – at temperatures of at least 1,500 degrees Celsius around the spark plug. Cars have been improved through the development of catalytic converters in the exhaust system. These contribute to a reduction of several damaging components in the exhaust gases when the engine and the catalytic converter (!) are hot. As long as the fuels are fossil the carbon dioxide emissions will be inevitable.

A social problem relating to the private car is that statistically the journey that a person undertakes is likely to be a short trip in town. In many cultures the representative mileage covered, when an average person enters his or her car, is only 5-7 km. That distance is too short for an ecologically acceptable function. Local traffic is also associated with congestion, accident rate, unrest, acoustic pollution of the town areas etc. In other words: it is the traffic in cities and population centres that constitute the first problem as far as car traffic is concerned. This must be considered as one of the most urgent environmental matters to tackle today, along with other examples of poorly performed techniques in combustion and agriculture.

The neat private car is probably around the world a most captivating dream of many people today. Much development work is spent, although the pace of real change is slow, to make the car engines more effective and clean. Experiments are made with different engines and new combinations. Hybrid cars will have either two kinds of fuels, where e.g. methane (natural gas), methanol or ethanol are tested, or two kinds of engines. An evenly and smoothly running traditional engine can continuously charge an electric battery on board, which yields in turn the driving force in cities.

In the meanwhile, before new technical alternatives are broadly available, efforts are made to restrict unnecessary car traffic in city centres. Discussions on prohibited zones, strongly reduced speeds, systems for fees, taxes and tariffs for entering certain areas are initiated in many cities.

Air and sea traffic are in many cases abominable in the ecological perspective. It is well known that the modern aircraft produce awful exhaust gases and spend a lot of fuel especially in their brutally irreversible way of gaining height. The exergy theory points clearly at the slow and the silent methods as particularly well adapted to the ecological ideal. The fast little motorboats in the coastal areas of the Baltic Sea are disgusting, since they are inefficient in using their fuel, they are rarely equipped with any exhaust gas cleaning and they pollute the ecosystem for all life in the water even by their excessive noise. The small heat engines in out board motors of small boats and in lawn mowers, power saws and mopeds and are among the worst. The large ships and ferries, which are so numerous in the Baltic Sea, are primarily driven by large diesel engines that utilise rough inexpensive diesel oil. Their great problem with exhaust gases and other pollution must be attended concurrently and likewise for the careless oil spills by the whole sea freight system. These problems are particularly pressing in the type of water to which belongs the Baltic Sea.

Figure 25.11. Transport. In todays transport system the car is the most problematic for sustainability. It can, however, be improved by for example, increasing number of passengers (from 1 to 4 makes a Factor 4), by improved fuel efficiency (technically a factor of 2-3 is possible) and improved useage and life-span. In the city car use should however be minimised and substituted by muncipal transport or biking. (Photo: Lars Rydén.)

Efficient transportation

Are there any means for more efficient transportation? From the point of view of human ecology it must be observed how effective all those transports are that are mediated by biological systems. The muscular power of humans and animals without any exception have an excellent efficiency in exerting physical work. The most exergy effective way to transport a human being is the bicycle – the natural evolution had to wait for human ingenuity for the wheel to emerge.

It can be estimated that with one day's human exergy consumption, normally 12 MJ, (which corresponds to the exergy available in a few decilitres of petrol), a well trained athlete can transport himself or herself some 200 km (or more?), which corresponds to an exergy expenditure of about 1,5% of that of a car. Cyclism is also growing at an impressive rate in the world today. Also walking, running, swimming or even riding a horse is far more effective transportation than any technical means.

Among the exergy effective technical solutions for transportation of humans and goods the electric train must be mentioned first. There are two scientific reasons why the exergy destruction is so limited in this kind of transport. The steel against steel contact between the wheels and the rails is far more elastic – about three times – than the corresponding contact between a rubber wheel and the road. Moreover the electric power is well suited, as mentioned, for running the engine. The efficiency of a modern electric locomotive is over 90%. Altogether the goods is transported about 8 times more efficiently with this kind or railroad system than by lorries on the roads.

The systems solution with hydroelectric power production at the one end, and the railway (or tram or subway) transportation systems at the other, is

Figure 25.12. Biking. A bike is an extraordinarily efficient means to transfer muscle work to transport. Increased use of bikes for short distance personal travels would solve many problems connected to present traffic and transport. (Photo: Magnus Lehman.)

Review Box 25.3

Sustainable urban development

Providing the world population with decent and healthy living is a main concern. Several UN conferences have focused on this, especially the so called Habitat agenda. In the Baltic region habitation is also a major concern in all societies. How can this be done in a sustainable way.

Energy. Providing a residential area with energy seem to be no principle problem. Many housing areas today use less energy and also produce their own energy not the least through solar panels. Zero energy houses and in fact zero energy neighbourhoods exist in e.g. Germany and Sweden.

Waste. Waste management that sort waste, compost organic waste and recycle waste is already routine in many areas.

Nutrient flows. Residential areas where separating toilets allow collection of urine, which contain most of the nutrients, that is used in neighbouring field s for fertilisation is working in many areas. In other cities all organic waste, from households, restaurants, slaughter houses and wastewater treatment plants, is collected to provide biogas for buses and cars.

Traffic. Cities with little car traffic are still not common. Several efforts are made to make cities more efficient for communication without cars (so called densification) and provide efficient railway connections between cities.

Social aspects. Many new projects in urban development are concerned that both working and living places exist in new or rebuilt areas.

Economic aspects. Efforts are made to provide affordable housing and schemes for self sufficiency, such as small garden lots, and working places in many new areas.

Ideal cities. The classical models for ideal cities, in particular garden cities, are much discussed in new trends in urban development.

Sustainable cities and towns

The European Sustainable Cities & Towns Campaign was launched at the end of the First European Conference on Sustainable Cities & Towns, which took place in Aalborg, Denmark in May 1994. The participants of this first European conference discussed and adopted the Charter of European Cities and Towns Towards Sustainability (The Aalborg Charter). To date, over 1650 local and regional authorities (metropolitan areas, cities, towns, counties, etc.) from 39 countries have signed up to the Aalborg Charter. With this number of participants, the Campaign is the biggest European initiative for local sustainable development and Local Agenda 21. One of the initiatives was to develop a set of ten common indicators (below) for sustainable cities development. It is interesting to see how well social and economic factors are represented in this short list. The complete list contains some 300 different indicators.

1. Citizen satisfaction with the community
2. Contribution to global climatic change
3. Mobility and passenger transportation
4. Availability of public green areas and local services
5. Quality of outdoor air
6. Children's journeys to and from school
7. Sustainable management of the local authority and local businesses
8. Noise pollution
9. Sustainable land use
10. Products promoting sustainability

(www.sustainable-cities.org/indicators/)

exquisite, since the high energy quality is conserved throughout all the energy transformations, from the potential energy of the water, to the kinetic energy in water and turbines, the electricity on the grid and the motion of the train. The illustrative Swedish example of this effectivity is that one out of 17 power stations in one of the many rivers in the north is enough to keep every train in the country moving – as long as the water is running the system is in operation!

Electricity should be applied as much as possible to running of engines. As far as the electrical car is concerned, however, one has to be careful with the details of the whole system in which the electricity is produced, transmitted and stored before it is converted to work in a vehicle. Many technical solutions for batteries or fuel cells are today rather unsatisfactory. The cabin heating in an electric car will turn out to be a great load on the electricity, while the normal cars can boast of a reliable overproduction of cabin heat.

A word must be said on the *collective systems* of traffic. Buses and fast convenient trains can become the backbone in a traffic and transportation system where advanced complexity and service is supported with the help of computers. Electrified rail transport systems can be utilised in local suburban lines and city subways even in average size cities, and in regional, national and international communications. Buses can become available for local transports in time-tabled systems, smaller buses could be called on the telephone. Computers and electronic systems can support memorisation, communication and organisation.

The perfectly reversible process is impossible, but one can approach it indefinitely, which one does rather well by sailing on the sea, soaring in the air or riding the bicycle! The soft techniques are good alternatives to the strongly irreversible ones that appear in jet flight, space and other rockets, and motors sports of various kinds. In the culture of sufficiency saving time is not the utmost goal. The nearly reversible processes include all the small steps and contribute to relaxation.

Towards sustainable production

INDUSTRY AND AGRICULTURE

An ecological perspective on society – human ecology

It is an all-pervading theme of this chapter that the ecological model is general. Life, as demonstrated by every living species or humankind – the humansphere – depends instantly on the life-support processes. Similarly the human society involves the technosphere – whose machinery relies on equally constant technical-support processes. These together constitute the metabolism of the human ecosystem. They involve matter and energy, to be fed into the system and discharged to the environment.

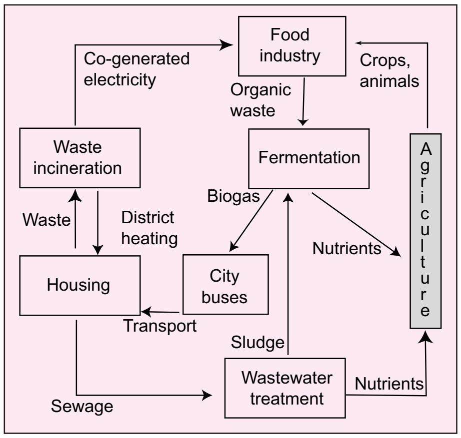
The characteristics of the ecological model are worth summarising. The most fundamental rules for the "life" of this ecosystem – referring to thermodynamics – are that nothing is destroyed (energy or matter) but everything is dispersed (exergy is consumed). Any point in the system is laterally interacting with adjacent points within the same space. Any change in the system involves a prehistory, and is perpetually heading for further change in future. Everything is interactions and processes. Whatever happens in the ecosystem is qualified to be described as *evolution*. This represents creativity although it is known that the totality of the processes are disorganising which threatens the surroundings and raises the perpetual need for support from the outside. The evolution in the system is invariably co-evolution with the environment.

The ecological model is effective in describing any material system that contains life and machinery, so also any industry, any company or any societal body, like a community or a school. (Campus Ecology, e.g., is a rather new concept developed for American universities.) Several variables describe the processes in the system, like variables from the natural sciences and the economy. Systems that involve technology and societal organisation are normally described as economic systems. The environmental crisis today clearly indicates that the natural laws are more fundamental than others – their consequences are inescapable – which does not mean that economy as means of understanding and operating the societal bodies is inferior or unimportant.

Above we have stressed the importance of the goal that each organisation, such as a company, municipality or school, need to have an ecological approach to their activities. Even a factory may function as an organism and must develop an integrated philosophy. The whole enterprise would benefit from an attitude of conservation, loop-closing and optimisation with every staff member on every level and in every speciality. A development of a company culture to form a staff consensus for joint efforts are means for practical abatement of pollution.

The industrial system must not be viewed in isolation from its surroundings. Another aspect of ecology is the interdependencies of all activities in a society. Solutions that take these interdependencies into account have above been referred to as systems solutions. In the industrial sector such solutions have often been referred to as *industrial symbiosis or ecology*. The classical examples of industrial ecology are all in the biotechnology. Thus when the manure from a production of eggs is used for fermenting and providing biogas to a second factory, and this factory in turn sells its waste material as the raw material to a third factory, it is called industrial symbiosis. The same approach can be used in a municipality. Thus typically household waste in a city is used for incineration to produce energy and the cooling water in the process for district heating (and cooling). At the same time we may see that the organic waste from the city, including

Figure 25.13. Systems solutions in the city. Some cities have established a system where waste becomes a resource. In this example solid waste is combusted to produce district heating and co-generated electricity used in industry; compostable waste from the food industry house is fermented to become biogas, which is the fuel used by city buses. Sewage sludge is also used. The interdependence between this system and the surrounding countryside is indicated.



Industrial sector B21 indicators

Sustainable development for the industrial sector in the Baltic Sea Region is maintaining continuity of economic, social, technological and environmental improvements. This means for the industrial sector in the region:

Reaching eco-efficiency by the delivery of competitively priced goods and services that satisfy human and social needs and bring quality of life while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with the estimated carrying capacity of the Baltic Sea Region with respect to biodiversity, ecosystem and use of natural resources. **Indicators**: Industrial production, Energy use, Renew-able energy, CO_2 emissions, NO_2 emis-sions, SO_2 emissions.

Applying sustainable strategies to resources, processes, products and services. **Indicators**: Number of companies applying Environmental Management Systems, Number of companies applying Quality Management Systems.

sludge from the wastewater treatment plant, used in fermentation to produce biogas that drives the buses in the city. An important aspect of such local systems is that the money stays on place. The are not spent for buying expensive fossil fuel far away but sustain work and productivity in the local system.

New attitudes to industrial production

The Brundtland report opens its discussion on industry by stating that industry "introduces both products and pollution into the environment. It has the power to enhance or degrade the environment; it invariably does both". The debate on reforms within the industrial sectors of the world has been intense for many years, still, in order to attain a sustainable development, the effective period of transformation lies ahead. The industrialisation of the third world is a primary goal which ought to obtain a strengthened international support.

The overall *economic growth* is favoured in the Brundtland report, but it is pointed out that the quality of the growth must be developed. The specific use of energy and raw materials should be reduced. The strategies for sustainable industrial development must focus on formulated goals, further regulations and new standards, application of effective economic instruments and environmental assessments. Great attention is directed to the risks of new materials, new technologies and industrial hazards. No less than four big disasters occurred during the very period when the Brundtland Commission worked (in Mexico City, Bophal, Chernobyl and Basel). The analytical work within the environmental industrial context has been intensified in the 1990's.

The major shift in opinion in recent years has been that companies and public bodies go from responses to the details of the problems to managing the entirety of the processes and taking responsibility for the totality of industrial work within a systems perspective. Preventive measures applied as early as possible is favourable in that it can avoid that some of the problems occur at all. Newly emerging notions are clean production, de- and trans-materialization as mentioned above, and – in the end – a holistic strategy of industrial ecology. Besides such innovations and regulations great hope is attached to market forces and wide collaboration with outside bodies and customers as well as employees and unions. The rising status of ecological awareness confirms that even competition can favour environmental efforts.

Some environmental technologies have already been touched on. The notion of *avoidance technology* also called *pollution prevention* schemes (Chapter 16 and 24) includes any means from equipment to methods for avoiding unwanted substances and providing materials and methods for substitution, recovery and recycling. Usually the whole approach is included under the heading of *cleaner production*.

Most details in a complex industrial structure can be altered – away from business as usual – including production and product design. Changes can also be made of industrial infrastructure, operational schemes and organisation to

Table 25.1. Increase of certified companies in the Baltic Sea region, one of the indicators for the B21 industrial sector. Number of companies that has been certified according to the ISO 14001 system. (Source: The ISO survey of ISO 9000 and ISO 14000 certificaes, eleventh cycle 2001, and http://www.iso.org/iso/en/iso9000-14000/index.html.)

	1995	1996	1997	1998	1999	2000	2001
Germany	35	166	352	651	962	1260	3380
Denmark	21	96	270	314	430	580	919
Estonia				1	4	18	24
Finland	10	41	151	206	470	508	687
Iceland			1	1	2	2	2
Lithuania				1	1	10	21
Latvia						4	4
Norway	3	13	35	61	133	227	298
Poland			8	15	72	66	294
Russian federation						3	12
Sweden	2	25	194	304	851	1370	2070

improve e.g. procurement policies and staff training, to establish just-in-time operation and to facilitate expedient accounting and life cycle assessment. All of these means are included under the concept of *environmental management systems* (Chapter 24).

Monitoring technologies (Chapter 16) can be developed for providing information on environmental conditions and risks. Both hard-ware and soft-ware can be utilised. *Control technologies* (Chapter 17) can be applied to purify flows that appear in many varieties in connection with incineration and other chemical processing, mechanical separation and bioprocessing. *Restoration technologies* (Chapter 18) may have wide applications to the surroundings, through purification of emissions, final cleanup of outlets and provision in the real ecosystem. Control of landfills, reforestation and development of both draught areas and wet-lands can be counted under this heading.

The consumer perspective did not classically have to do with industrial management. However, with the systems perspective, necessary in connection with the prospect of sustainable development, one should not separate production and consumption. Every element of production processes implies a contribution to environmental stress. The consumers now ask their well informed questions, all the more often, as the so called “green products” appear on the market. This is something that industry does pay attention to. There are many means for exchange of signals between suppliers and consumers on the market. Price is one, brand names and symbols may be other important sales arguments.

The notion of *sustainable consumption* is useful in developing ecological awareness in the society. Environmental labelling has been developed in different forms over a number of years as a concrete measure to assist consumers in their efforts to change habits and patterns of consumption (Chapter 24).

The notion of *extended producer responsibility* is intended to cover the whole life cycle of goods and services. Special care is devoted to the obligations in connection with waste. One possible producer responsibility is product takeback. Such schemes also draw attention to the alternative of an expedient product design and routines for dismantling, reuse and recirculation of material. The 16th article of the Rio Declaration of Environment and Development states that

> ”...National authorities should endeavour to promote the internalisation of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.”

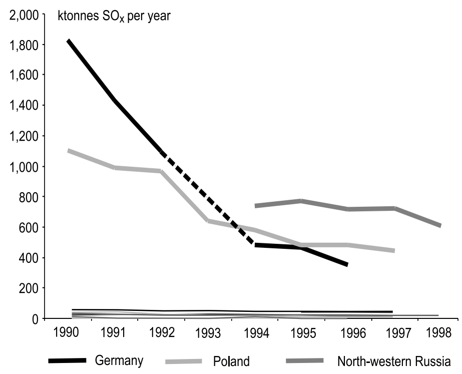


Figure 25.14. Emission of SO_X from industry in the Baltic 21 countries. The three large polluters are Germany, Poland and Russia. German and Polish industry have decreased their emissions considerably over the 1990s, while emissions from industry in Northwestern Russia is reduced only slightly. All other countries have values below 60 thousand tonnes per year. (Source: Baltic 21 First triannual report, 2001.)

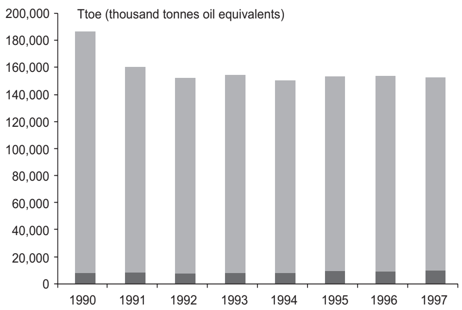


Figure 25.15. Industrial energy use. The energy use in Baltic Sea region industry is fairly constant. Renew-able energy sources have during the 1990s increased from about 4% to 6% of total. (Source: Baltic 21 First triannual report, 2001.)

Sustainable agriculture

What humans eat is perhaps the most fundamental factor relating to basic needs and to sustainable development. Humans need matter and exergy for their livelihood. The cultivated land and the solar exergy flux has been the basis of the natural resources for this supply for thousands of years. The present situation is that the world population rises at a deterrent rate and in many areas people live far beyond the carrying capacity of their ecosystem. It is a prerequisite for sustainability within this sector that local structures are developed for a sound relationship between the society and the natural stocks of land, water and air. It is expected that the agricultural policies in all countries around the Baltic Sea can be based on self-sufficiency in foodstuffs.

The crops in the Baltic region are dominated by wheat for humans and barley for animal feed; oil products, potatoes and sugar beet are other important products. The major portion of crops goes to animal production (up to 80%), which involves cows, pigs and poultry. Milk and eggs are important products as well. The ecological footprint indicates that the Baltic region – in the global comparison – is richly endowed by nature. If looked at in detail one would find, however, that relating to arable land, and even more so for marine areas, some "colonisation" is required. For instance tropical fruits and coffee, which claims considerable areas of first class arable land, is important in countries where land is in short supply.

The present state of agriculture in the region must be generally described as "chemical" or "industrial" agriculture, depending on artificial fertilisers, pesticides and increased mechanisation, which is dependent on more fossil fuels and electricity. Specialisation and rationalisation contributed to larger farms and mono-cultures. The traditions of small scale farming, crop rotation and mutually supporting cereal production and animal farming was in most cases abandoned (Chapter 7). This kind of agriculture has four main problems when analysed from the sustainability point of view. Improper management of nutrients, dependency of fossil fuels, dependency of chemicals and impact on biodiversity.

The *management of nutrients* is a big problem from the ecological point or view (Chapter 9). The animal farms produce a considerable surplus of nutrients which causes leaching to the environment and ammonia emissions to the air. The crop farmers purchase their nutrient demands in the form of mineral fertilisers, which either leach from the fields or follow the food and end up in wastewater treatment plants. This development, known as overexploitation of resources, cause serious pollution that damages the ecosystem and reduces the biodiversity. Is there any way to recreate a system of crop rotation, integration of animal and crop management and more efficient recirculation?

As people have come to understand the unsustainabity of the present system for food production, *ecological farming* has emerged as a key notion. Ecological farming is supposedly self-sustaining and has the natural ecosystem as the model (Bodin, 1997) . The system is integrated – the plant and animal production are not viewed as separate activities. Chemical products are not specifically introduced, but are made available in the management from natural sources. The quality of the available resources must be maintained or possibly enhanced.

In ecological farming the crop rotation extends over a period of four years or more. Ecological farming should be designed to reduce weeds and counteract infestations from insects and fungi through biological pest control. The soil nutrients are based on manure and plant debris, and as the systems are extended, also on human urine and sludge from wastewater treatment plants. Special use of leguminous plants contribute to nitrogen fixation and thereby satisfactory fertilisation. The ecosystem should be in balance with respect to the production of cereals or fodder. Grazing cattle and sheep must be appropriately fed on the farm and could utilise areas not suitable for crop production. The landscape and the biodiversity would be favoured by such a system and the animals would be kept by considerate methods, animal welfare. The management of nutrients in ecological farming will make a big difference as to the large scale methods. The objectives are broad recirculation and local integration. Some farmers have already started to exploit the human urine. The future society will have more frequent applications of urine-separating toilets which will facilitate collecting urine, first of all, for returning to farmland.

The ecological farming in the Baltic region is now practised on a fairly small farming area. The largest share is presently found in Sweden where still only 10% of the farmland is devoted to ecological farming. Government subsidies are available for this kind of transformation to support a higher level of labour and compensate for higher risk and lower yields than customary farming. It is expected that many consumers will be willing to pay a somewhat higher price for ecological products (about 15%), with reference to ethical reasons and valuation of health factors and ecological advantages.

Baltic 21 Agricultural sector goals

Some key features of sustainable agricultural systems are:

equitable.

efficient.

flexible, i.e. less vulnerable to expected variation in weather and periodic infestations of insects and diseases.

in principle *self-sufficient*, i.e. rely on locally available labour, soil, water, energy.

integrated in synergistic functions. National, regional and local systems complement each other so that waste and joint products from one process can be shared or redirected to other systems within the region with minimum disruption.

Source: Baltic 21
http://www.ee/baltic21/

Baltic 21 Forest sector goals

Sustainable forestry requires stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems.

Criteria for sustainable forest management are:

Maintenance and appropriate enhancement of *forest resources* and their contribution to global carbon cycles.

Maintenance of *forest ecosystem* health and vitality.

Maintenance and encouragement of the *productive functions* of forests (wood and non-wood).

Maintenance, conservation and appropriate enhancement of *biological diversity* in forest ecosystems.

Maintenance and appropriate enhancement of *protective functions* in forest management, notably soil and water.

Maintenance of other *socio-economic functions* and conditions.

Source: Baltic 21
http://www.ee/baltic21/

Figure 25.16. Green labelled fish. The first ecologically labeled aquaculture in Sweden was certified in July 1999. The cultivation of rainbow trout requires very clean water and a specially produced fodder, says the owner of the plant, Björn Lindqvist, and assures that the fish tastes better than those fished in the wild. (Photo: Tommy Svensson, Pressens Bild).

Sustainable forestry

Forestry is of large importance in the Baltic region, and forests cover a considerable area of the region. It involves coniferous forests, with spruce and fir, in the north, mixed forest in southern Scandinavia and the Baltic countries, broad-leaved deciduous forests on the continent and mountain forest in central Europe, again dominated by coniferous species (Chapter 3).

What are the requirements for sustainable forestry? Technically this has been discussed and in many ways solved – it was part of development of rational forestry about one hundred years ago – before the question was raised in any other sector for the simple reason that the turnover time in forestry is often about one man age, some 70 years, and it is not unusual that it is even longer. That is, the work you are investing today is harvested by the next generation in the spirit of the Brundtland definition of sustainability. It is also clear that the work to safeguard long term productivity has been successful and that most forests have increased their productivity during the last 100 years (Chapter 7).

The actions taken to ascertain a good and long term forest production have, however, been threatened or questioned in three ways.

Firstly the forests have become seriously damaged by *environmental stress* in many areas, which was not foreseen a hundred years ago. Acidification, eutrophication, drainage etc has thus to be dealt with, but mostly not by the forest sector itself.

Secondly new methods to manage forestry introduced later, often after the WW2, has turned forestry, like agriculture to *industrial forestry*. The use of large machines for timbering, chemicals to combat pests, and genetically identical or little varied plants for planting new forests has to be reconsidered just as it has to be done in agriculture.

Thirdly it is recognised that forests, just like agricultural land, are providing more services than just timber production. Forests are the homes for a large number of species other than the trees to become timber. Rational forestry is a threat towards these other species and thus the *biodiversity*. Since forests cover such a large area in the region, it is crucial, that changes to protect biodiversity are introduced even if productivity suffers. Forests for human enjoyment should also be mentioned as a special function in a society where *landscape diversity* is part of the heritage that we would like to save for our grandchildren.

Sustainable, ecological, forestry takes much of this into account. The mechanisms of *forestry certification* according to good management systems include

Agriculture, Silviculture, Aquaculture

How to produce food and fibres in a sustainable way? Using "domesticated systems" for crops (agriculture), forest products (silviculture) and marine production (aquaculture) is one way. These systems have to be limited in space, must not use too much resources, and not be polluting. Ecological agriculture and certified forestry is well established while ecological aquaculture so far is not common, but does exist.

The other option is to harvest the natural systems in a renewable way, as in ordinary fishing, most hunting, and for many other purposes, e.g. collecting berries. But too often these systems are overused, leading to a "tragedy of the commons".

Baltic 21 fishery sector goals and indicators

Sustainable fishery is achieved when a high probability of fish stocks being able to replenish themselves over a long period of time within a sound ecosystem, is assured, while offering stable economic and social conditions for all those involved in the fishing activity.

The goal for achieving sustainable development of fisheries in the Baltic Sea area thus means development of economically and socially sustainable, environmentally safe and responsible fisheries by:

Maintaining biological viable fish stocks, the marine and aquatic environment and associated biodiversity. **Indicators**: Spawning, Stock, Biomass, Fishing mortality, Recruitment.

Within these limits, establishing maximum fishing possibilities and appropriate selective fishing techniques for harvesting stocks. **Indicators**: Landings per country: tonnes of cod, salmon, herring, sprat, Number of fishing vessels per country operating in the Baltic Sea, Average fishing fleet engine power per country, Fish consumption per capita per country.

Distributing the direct and indirect benefits of open sea and coastal fishery resources between local communities in an equitable manner. **Indicators**: Number of full time fishermen engaged in the Baltic Sea Region, per country.

Source: Baltic 21
http://www.ee/baltic21/

Table 25.2. Indicators for fishing. Landings per country: total amount of landings in tonnes of Cod, Herring, and Sprat. (Source: Baltic Fishery Commission.)

	1998	1999	2000	2001
Cod				
EC	58,105	71,788	64,772	63,951
Estonia	1,170	1,030	514	778
Latvia	7,778	6,914	6,280	6,106
Lithuania	4,104	4,188	4,720	3,764
Poland	25,775	26,577	22,146	21,992
Russia	4,599	5,211	4,669	5,032
TOTAL	*101,531*	*115,708*	*103,101*	*101,623*
Herring				
EC	280,303	214,934	242,811	218,513
Estonia	42,721	43,956	41,735	41,738
Latvia	24,417	27,163	26,768	26,652
Lithuania	2,368	1,313	1,198	1,639
Poland	21,960	19,194	24,427	37,611
Russia	10,544	12,756	15,063	15,797
TOTAL	*382,313*	*319,316*	*352,002*	*341,950*
Sprat				
EC	239,806	222,953	160,872	146,788
Estonia	40,623	35,858	41,393	41,002
Latvia	44,858	42,834	46,186	42,944
Lithuania	5,513	2,979	1,681	3,118
Poland	59,215	71,727	84,341	85,846
Russia	21,078	31,627	30,369	31,959
TOTAL	*411,093*	*407,978*	*364,842*	*351,657*

preservation of biodiversity and is applied – not only to tropical forests – but also to the forests in the Baltic basin. Since the changes in forests are slow it will take many years before such approaches have full effect. It is possible however, as we already know from forests that have grown with such purposes since some 200 years (Chapter 15), unless of course species have been lost entirely.

Fishing

The Baltic Sea is inherently very productive as regards fish, although the number of species is limited: cod, herring and sprat dominate strongly (Chapter 6). But fishing in the Baltic Sea is very much threatened and its sustainability is in danger.

It has already been discussed how the environmental situation of the Baltic Sea has deteriorated, not the least by eutrophication, but also other pollutants, and this has a deleterious effect on the fish fauna. The cod has been threatened since their breeding conditions deteriorated in the 1980s. The Baltic Salmon is certainly not presently at good health since the outbreak of the M74 disease, which is most likely caused by pollution although still unknown how. The newly introduced European Union limits for allowed levels of dioxine in food (2002) has in one stroke made it illegal to sell Baltic Sea fish on the market since generally the levels are too high, a fact that may ironically save the Baltic Sea fish populations.

Still commercial fishing in the Baltic Sea is considerable. Most of the fish landed, which today is dominated by sprat, is used for animal feed. It is in fact the same number as in agriculture about 80%. Fishing has also become industrial just as agriculture and forestry. A few fishermen have invested considerable sums in boats with thrawls and modern electronic equipment to track the fish. They are thus very efficient, and may in principle vacuum-clean the Sea for fish.

Obviously sustainable fishing requires regulation to safeguard the fish populations. But it is done under protests, and with considerable number of illegal transgressions. It is not difficult to understand that the fishermen protest when limitations to catches are imposed as they have to be able to pay for their large investments in boats and equipment, and risk both bankruptcy and unemployment. However this is necessary. Advised by national fisheries authorities and scientists the so called Warsaw Commission, in which all Baltic Sea countries take part, decide yearly on a Total Allowable Catches, TAC, in tonnes per year for every species, and how it should be divided between the countries.

Fish farming is another way to increase fishing. It plays today only a marginal role in the Baltic Sea but has some potential and may increase in the future. But it should be noticed that the common way to catch less valuable fish in the open see to feed fish in aquaculture has been questioned as a sustainable strategy. It simply means one more step in the trophic chain and loss of up to 90% of the value in the first step.

The sustainability prospect is as important to fishing as to other sectors of the society. Since vast areas are involved in both cases the responsibility rests on research units and public agencies to form regulations and exert control measures. Those mentioned in connection with industry would still apply in this context. The work of the Helcom Commission and Baltic 21 to supervise the overall conditions in the Baltic Sea and the Baltic Region will continue to be important for promotion of a sustainable development. The most general imperative applies to every inhabitant in the region, and everyone operating industry, agriculture, forestry, fishing and all other activities in the region, to observe the environmental necessities and take them seriously.

Future perspectives

Figure 25.17. The meaning of sustainable development may simply be summarised as a good life for future generations. (Photo: Christian Andersson.)

The meaning of sustainable development

The environmental debate has a long history. During the passed hundred years the world has changed in ways that few people would have foreseen in the early decades of last century. The world population has increased at an immense rate – about threefold – and continues to do so. Urbanisation has taken over in all parts of the inhabited world, now more than 50% of the inhabitants live in cities, adding new loads to the transport and the supply systems. We just left a century with far too many wars and far too many victims of violence. The human societies have changed their structures in many ways. The support level has been extended manifold in some parts of the world but the development of affluence has been restricted to certain areas. The world is regrettably divided between rich and poor. The environmental problems have lately been in a state of deterrent growth. The total picture of the situation regarding the deposits, stocks and flows of natural resources must be viewed with great concern.

What can make humans optimistic at the turn of the century? Indeed this very situation – the awareness, probably for the first time in human history, of what the ultimate human conditions are on the global scale – is a first necessary component for change. The scope of science and the human funds of knowledge have increased enormously during the 20th century. Communications have become fast and effective for goods, people and information. The world society is reasonably well integrated and coherent. The prospects for humans to realise large scale and even exuberant projects have never been better. More and more people and societal bodies are able to form comprehensive and authoritative action programmes that aim at care-taking for the whole of the planet that humans depend on for their support, health and well-being. The value of an equitable society, locally and globally, is manifest. This may be considered as a good start of a new century.

The Brundtland report (Our Common Future, p 37) formulates the motives, the conditions and the criteria for sustainable development thoroughly. It is pointed out how different aspects of the present world development are co-ordinated. The environmental stresses are linked to one another, and they are linked to the patterns of economic development and to political factors. The "systemic features operate not merely within but also between nations". The consequences of national environmental problems are global. The poverty of a large number of nations is a challenge to the world community.

Environmental management has focused until now on recovery after damages: reforestation, reclaiming desert land, rebuilding urban environments and restoring the local ecosystems. The new perspective is to avoid the adverse effects of human operations and to integrate the environmental concerns at an early stage in every plan and every process of the society. But "no single blueprint of sustainability will be found" (p 39), as economic and social systems and conditions differ widely among the parts of the world. Although the whole project is global, each nation or region have to work out its own policies and cope with local practical implications.

The process of developing practically all the details of sustainable development, as it is viewed today, will not be easy. There are winners and losers in the game, says the Brundtland report. Strong forces will be active in opposition to each other. Many problems are created and boosted by inequalities in access to resources. The principles of equal rights must prevail in the future. Democracy should be revived for the purpose of sustainable development. If the ecological limits are surpassed and the resources become scarce the inequalities will have a tendency to sharpen so as to create violence and warfare.

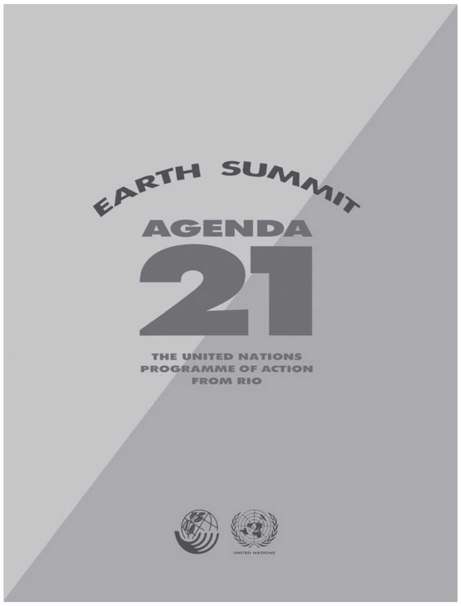


Figure 25.18. The Agenda 21 is a most remarkable document. It contains a complete programme for a centry-long effort to make the world sustainable. Every word is negotiated, a feat that was uniquely possible in the optimistic atmosphere the after the Cold War.

The social justice must permanently be the compass for the human endeavour that creates the future development of the society.

Agenda 21 – the agenda for action

The Rio protocols comprises three main problem areas which were regulated in comprehensive agreements, namely forestry, climate change and biodiversity, the Rio Declaration and the Agenda proper with its 40 chapters.

The Rio Declaration contains 27 principles. The first statement of the Rio Declaration is that humans are at the centre of concerns for sustainable development. Most principles place the rights and the liabilities on states, but participation of 'concerned citizens' is understood, as well as co-operation in wide terms. The perspective 'from below' is stressed repeatedly, every individual will be involved in the implementation. Important goals are that poverty should be eradicated, the developing countries should be given priority, unsustainable patterns should be reduced and eliminated, the ecosystem and the quality of life must be observed. Environmental Impact Assessment is mentioned as an important and general instrument in planning for the future.

Some points of the Declaration have become famous. The *Polluter Pays Principle* (nr 16), mentioned above, draws attention to "internalisation" of environmental costs and the use of economic instruments to the effect that the polluter should, in principle, bear the economic cost of pollution. The principle has been followed up in many communities although the organisation may vary.

The so called *Precautionary Principle* (nr 15) states that "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation". The lack of knowledge is difficult to estimate. Therefore the precautionary attitude is infinitely vital. Brave projects must be planned with special care. This principle is of decisive importance and is universally applicable.

Attention is also drawn to warfare, and its antithesis – peace. "Peace, development and environmental protection are interdependent and indivisible" (principle 25). International law must be respected by states and disputes shall be resolved peacefully.

The whole of *Agenda* 21 cannot easily be summarised. It involves many hundreds of pages and paragraphs under four headlines:

1. Social and Economic Dimensions,
2. Conservation and Management of Resources for Development,
3. Strengthening the role of Major Groups and
4. Means of Implementation.

The philosophy is participation on all levels. It appears that for the advancement of the sustainability principle whole governments must be committed and the policies must be formulated nationally. It is not enough with a Ministry of Environment, however well it is performing. The questions of energy, agriculture, forestry, industry, transportation etc. concern everyone, not the least the financial administration.

The actors of Agenda 21

The local authorities in each country are instructed to undertake consultations with their populations to formulate a "local Agenda 21" for the community (municipality). This has also been done in many countries, and thousands of local communities already have their local agendas. It often turns out that the pertinent *processes* are at the core of the intentions behind the sustainability paradigm. Having obtained an exchange of arguments in the local community, further education and practical planning are natural implications. Co-operation between neighbours, and thereby the social climate, is favoured by this development.

The commitment and involvement of different social groups for effective implementation of the national programmes is one of the defining ideas. It is referred to as participation or "real social partnership" (item 23:4), and the key notion is *decentralisation*. Agenda 21 also must apply equally to all major groups. The potential of co-operation with NGOs has been mentioned. Many of the problems and solutions addressed by Agenda 21 have their roots in local activities, and therefore "local authorities will be a determining factor in fulfilling its objectives" (28: 1-2). The "level of governance closest to the people, play a vital role in educating, mobilising and responding to the public", a formulation which is often referred to as the *subsidiary principle*. Women have a vital role – "their full participation is essential" as well as the youth of the world, groups of indigenous people and people under oppression.

The grass roots are the fundamental agents in the Agenda process. They represent simultaneously the problems and – hopefully – the solutions. The first provisions may still have the character of "cleaning-up-strategies", but more far-reaching objectives are, also locally, the prevention policies. The examples of good practices tried in one community will be models for the other. Exchange of information through social "chain reactions" can contribute to an intensified activity for new awareness and new habits.

Agenda 21 aims at challenging all the ecological items which apply to human life and societal organisation during the next one hundred years. The work on this sustainability agenda has just started. There is much to say about how it started and what has been done already. But the 21st century still lies ahead. It is assumed throughout in the Agenda 21 discussion that creative forces will be working continuously to make this agenda more meaningful and effective in any future 'here-and-now'-situation.

Social construction of sustainability

How can the new agenda be implemented in society? We will finally point to a few steps that are essential to achieve this.

The problem must be accepted as such, to *become and issue*, to be addressed. "What is an environmental problem", asked Sörlin (1997). Nature is not a "subject having problems". It is the human society that constitutes the problem, but this very fact must also exist in the minds of people. Certainly in a historical perspective nature behaved in ways that we now designate as problematic even before humans on the spot discovered their problem. A novelty is often discovered historically by a small group of people, most often scientists. Even when they may have revealed a conspicuous environmental factor, the authorities, the political bodies and the public may be unknowing and are not expected to care. An environmental problem is established as an *issue* through a social process whereby an opinion is gradually formed.

Science has the role of *creating new knowledge* also on the state of the environment. "The scientists owned the instruments with which to draw the exact boundaries between the normal and the problematic". This is a necessary step, but it is not enough. The construction of an environmental agenda is a social process. It takes dissemination of the actual knowledge produced by the specialists – first to colleagues and friends, then to increasing numbers of people. It takes personal reaction in the form of learning and concern, and societal reaction in the form of mass media reports, commission declarations and political decisions sometimes for legislation etc. The possible consequences of CO_2 – emissions in the atmosphere were mentioned by a chemist (Arrhenius) before 1900. The notion of the "green-house effect" gradually became established in the 1960s and the global warming concept and the perspective of climate change had its breakthrough in the 1980s. Today millions of people around the world speculate about the reasons for changing weather conditions.

Living with Agenda 21

The notion of sustainable development, presented eloquently in the Brundtland report, is a backbone of the new obligations for humankind. Also the Rio declaration from 1992 underlines the same perspective:

Underlying the Earth Summit agreement is the idea that humanity has reached a turning point. We can continue with present policies which are deepening economic divisions within and between countries – which increase poverty, hunger, sickness and illiteracy and cause the continuing deterioration of the ecosystem on which life on Earth depends.

Or we can change course. We can act to improve the living standards of those who are in need. We can better manage and protect the ecosystem and bring about a more prosperous future for us all. No nation can achieve this on its own. Together we can – in a global partnership for sustainable development.

In practice such solemn declarations have to be broken down to mean something more concretely to the individual, to the family group or the household, to neighbours and people in the community. We have to realise that everybody is involved in the great movement for sustainability. It is in actual fact as simple as it was stated in the preface to the Brundtland report: "The 'environment' is where we all live, and 'development' is what we all do in attempting to improve our lot"

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Figure 25.19. Living for sustainability. In many hundreds of eco-villages in the Baltic region ethusiasts conduct living experiments to search for new ways to a sustainble life. Here in Hågaby eco-village outside Uppsala, Sweden, the inhabitants plant a tree for their future, in the old tradition for a new settlement. The houses in the background are recently built with a series of interesting solutions for improved energy, materials and nutrient management. Energy costs are about half of Swedish average while price for housing is average. (Photo: Per G. Berg.)

The facilities now exist as never before for the formation of world-wide opinion. The new agenda has a paramount global significance.

Education is important for the Agenda 21 objectives. Schools are thoroughly involved. Through class-room teaching and excursions pupils can acquire relevant knowledge and make important experiences. Natural sciences can be taught by sample testing in brooks, rivers and lakes and simultaneously results can be reported to local authorities. The ecosystems in the neighbourhoods of populated areas often must be more carefully supervised in the future. Further means of education is studies in minor groups – referred to in Sweden as “study circles”, informal education or adult education. Campaigns directed to youth in general are specially valuable. In all activities within this framework it may be stressed that the same procedures are followed all over the world. It is a clearly identified fact today that the necessary activities. Especially important is to raise the skills of those that work practically with planning and resource management in society. This *continued education* will improve professional competence in the field.

Local communities have a key role. Practical experiences indicate that it is easier for small communities than large ones to get started with the Agenda 21 process. This has to do with the general environmental disadvantage with big cities. The principle for the support of populations centres is that the town provides whatever the farmland is short of, and the countryside provides the physical and biological means for support of life and societal activities in town. The farm and forest land are also important for receiving part of the outputs from the supported system. Shorter distances and smaller scale projects facilitate easier handling of environmental matters. Local agreements can be made between consumers in town and producers in the country side to promote the use of local fuels and recycling of matter for the benefit of both parties. Composting, waste separation and reuse of resources are important techniques in this context.

The *initiative by smaller groups* are important for creating knowledge and inspiration. There are many examples of groups of people volunteering for “ecological living”. The eco-community movement comprises cities, towns and rural communities, which exchange information on new systemic solutions and results of experimental projects for ecological living conditions. New ways are tried for planning, building, and demolition, living, gardening, house heating and managing the input and output flows of water and other matter. The ecologically relevant patterns and habits can spread to any vocational and leisure time activities.

The future society ought to be characterised by a new kind of thinking based on human ecology. Around the world there are many examples of poor people who live in ecologically rich countries. Local populations in Africa feel obliged to produce farm products like coffee, tea, fruits and nuts for export. The energy for people in the so called "rich countries" has to be imported from sources far away, often in non-industrialised societies. The principle that must be a fundamental goal for sustainable living is local supply and fair distribution among the world population. In the first stage local trade must increase and international trade decrease, especially over very long distances. The universal goal is a functionally preserved ecosystem.

The environmental problems have been uncovered to the public through social constructions, and so we have to rely on similar processes for continued promotion of the notion of sustainability. As this basically social process has matured it has become evident that the environmental issues are part of daily life for most citizens. Agenda 21 is a witness that the ecological paradigm has become established, having been adopted, in its beginning, by 178 governments. Agenda 21 is a milestone and important as a symbol, but it is not pointing towards a steady state. Further knowledge must be created – and will be. We have great hopes to reach an even better understanding, and to have even better means in the future to exist with a good relationship to the ecosystem which we are a part of.

A sustainable society will not be built in one day. Many gradual improvements are needed. Human insights and practical developments will hopefully add up to a future agenda and evolution, which will confirm that there is no end to progress.

Review questions

1. Explain how the sustainable development concept is related to the concept of justice.
2. What kind of ethics do you see in sustainable development? What ethics do you wish to argue for yourself?
3. How is sustainability related to justice between North and South and the position that the developing countries should be allowed to increase their resource use to alleviate poverty and improve economy?
4. How is sustainability related to carrying capacity and how was it first introduced?
5. How can material flows analysis be used to measure sustainability? What is the result of such estimation of sustainability for the globe as a whole and for the countries in the Baltic Sea region
6. How can the ecological footprint be used to measure sustainability? What is the result of such estimation of sustainability for the globe as a whole and for the countries in the Baltic Sea region?
7. Mention some indicators of sustainability used by cities in e.g. Local agenda 21.
8. How is materials management strategies used to improve sustainable development? Describe at least four different ways to do this. Do you apply one of them yourself?
9. How is energy management strategies used to improve sustainable development? Mention at least four different ways to do this. Do you apply one of them yourself?
10. Explain what is exergy and how exergy saving can be maintained by proper technical solutions, e.g. for heating with heat pumps and co-generation in power stations.
11. Describe the strategies of systems solutions. Do you have examples of systems solutions in your city?
12. Mention at least two ways to improve the sustainability of transportation.
13. Describe how industrial production is approaching sustainability strategies.
14. Describe the Agenda 21 document and the principles for using the Agenda 21 especially on the local level, that is in cities and municipalities. Do you yourself take part in an Agenda 21 project?

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Internet resources

Baltic21 – An Agenda 21 for the Baltic Sea Region
http://www.ee/baltic21/

Calculate your Ecological Footprint
http://www.lead.org/leadnet/footprint/default.htm

Centre for Human Ecology
http://www.che.ac.uk/

The Club of Rome
http://www.clubofrome.org/

The Earth Charter, Preamble
http://www.earthcharter.org/earthcharter/charter.htm

The Eco-efficency Network of the Wuppertal Institute
http://www.eco-efficiency.de/index2.html#

Factor 10 Institute
http://www.factor10-institute.org/

Forest Stewardship Council
http://www.fscoax.org/

ICLEI – The International Council for Local Environmental Initiatives
http://www.iclei.org/

IEA Heat Pump Centre (HPC),
http://www.heatpumpcentre.org/

IIASA
http://www.iiasa.ac.at/

International Baltic Sea Fishery Commission
http://www.ibsfc.org/

International Energy Agency http://www.iea.org/

The International Organization for Standardization, ISO
http://www.iso.ch/iso/en/prods-services/otherpubs/pdf/survey11thcycle.pdf

IUCN – The World Conservation Union
http://www.unep.org/Documents/Default.asp?DocumentID=52

Material Flow Analysis and Sustainable Resource Management
http://www.wupperinst.org/Sites/Projects/material-flow-analysis/index.html

Pan European Forest Certification
http://www.pefc.org/

Revisiting Carrying Capacity: Area-Based Indicators of Sustainability
http://dieoff.com/page110.htm

The Society for Human Ecology
http://www.societyforhumanecology.org/

SUPERBS – Sustainable Urban Patterns around the Baltic Sea
http://www.pg.gda.pl/cerso/superbs

Sustainable Cities
http://www.rec.org/REC/Programs/SustainableCities/

The Sustainable Living Network
http://www.sustainableliving.org/appen-e.htm

UNEP – Agenda21
http://www.unep.org/Documents/Default.asp?DocumentID=52

UNEP – UN Conference on Environment and Development UNCED
”Earth Summit”, Rio de Janeiro
http://www.unep.org/unep/partners/un/unced/

US Energy Information Administration
http://eia.doe.gov/

World Watch Institute
www.worldwatch.org

Wuppertal Institute for Climate, Environment and Energy
www.wupperinst.org

100 Top Recycling Sites
http://www.100toprecycling.com/

Glossary

Agenda 21
Action program for the 21st century agreed on at the Rio Earth summit 1992

Baltic 21
the Agenda 21 for the Baltic Sea region to support sustainable regional development, which has so far developed action programs in 9 sectors and several joint actions

carrying capacity
in human ecology the maximum continually supportable rate of flow, or resource extraction from the environment

conservationists
the group that ethically claims the rights to exploit natural resources for human use, if only in a considerate way

co-evolution principle
evolution in which both a system and its environment is relevant, such as the human society and its environment

co-generation.
when fuel combustion for heat production in a power plant is combined with a generator, which uses the high temperature steam to produce electricity

critical load
the maximum continually supportable rate of output, or return flow, or maximum load of emissions and wastes

de-materialization
materials management strategies to use less material through e.g, reducing equipment size and weight, increased efficiency of the flow processes or increased recycling

ecological farming
self-sustaining farming with the natural ecosystem as the model, where plant and animal production is integrated, chemical products not used, and nutrients recycled

ecological footprint
area used to supply energy and matter to a system and absorb its discharged waste, an indicator of the ecological load, or ecological service used

ecological model
any material system with interdependent life and machinery which may be optimised, such as a university (campus ecology) several industries (industrial ecology) or a municipality (urban ecology)

ecological sustainability
achieving sustainability within the principles of human ecology, often understood as within the post-modern paradigm

energy analysis
reporting of energy use and available energy resources which started in many countries from the 1960's in the spirit of safeguarding energy as a prime motor of industrial development

GLOSSARY

Environmental Utilisation Space, EUS
concept developed by Dutch researchers Siebert and Opschoor, on environment and economy, as a measure of the amount of environmental pressure that an ecosystem can be subjected to without being seriously damaged

Environmental Space, ES
concept used by Spangenberg & Schmidt-Bleek, as a normative concept, bridging the physical, socio-economic and developmental dimensions, to measure of the natural systems which support societal activities

European Union Sustainable Cities and Towns Campaign
project run by the EU DG Environment committee on urban environment promoting Local Agenda 21 in European cities and contributed in many ways to sustainable urban development

exergy
is the ability to do work; formally it is the products of the quantity and quality of energy; for heat the quality is determined basically by its temperature; both electricity and fuels have a very high quality

Factor 10
the notion that the richer industrialised societies should decrease their material resource flows by a factor of about ten, to allow the total global resource flow to stay within carrying capacity and allow developing countries to increase their resource flows to twice the present

forestry certification
achieved after proper auditing to certify good environmental management, preservation of biodiversity, good landscape management and long-term production

heat pump
an device that is exactly the reverse of a refrigerator, driven by work (electricity) and produces a temperature difference; the *heat pump* has become a very popular alternative for increasing the exergy efficiency when heating houses

human ecology
a description in which both the society and the environment are part of the same ecological system

indicator target
value of a sustainability indicator that would be acceptable from a sustainability point of view

indicators of sustainability
all kinds of measures that are used to monitor development of society towards sustainability, often divided between ecological, social and economic

inter-generational justice
justice between this generation and the following ones, used in the Brundtland Commission's definition of sustainable development

intra-generational justice
justice with respect to those living here and now, used in the concept of a just development, and linked to the movement for equal rights between poor and rich countries

Limits to Growth
the 1972 report from the Club of Rome, which maintained that population growth and pollution, if not changed, would make the global resource production collapse at the end of the 21st century

Local Agenda 21
an Agenda 21 for the local community, in most cases the municipality, which has a considerable role to play in development and resources use and in addition is closer to the inhabitants to allow participatory approaches

material flows analysis
reporting of materials use, starting in some countries in the 1990's to monitor environmental impact and economic development, developed at the Wuppertal Institute in Germany, under the leadership of F. Schmidt-Bleek, to a useful measure of sustainability

modern paradigm
way in which human society develops, characterised by domination of nature through science and technology, and growth of economy and consumption

post-modern
assumed state of society after modernism or industrialism, often connected to information society, globalisation, and networking

preservationists
the group that ethically claims that the wilderness should be preserved from all but recreational and educational activities, that is not exploited by humans

rebound effect
used to refer to that western countries in spite of increasing the economic value per input of natural resources increased resource use as the GDP of societies increased even more

subsidiarity principle
principle saying that the lowest possible level of governance should be used, playing a vital role for Agenda 21 to educate, mobilise and respond to the public

sustainable consumption
a developing ecological awareness in society, when consumers make efforts to change habits and patterns of consumption to environmentally friendly ones

systems solutions
solutions where several individual techniques are interconnected to make the best total use of a resource; e.g. co-generation of heat and electricity, or an industry waste stream is connected to district heating

technological sustainability
achieving sustainability within the modern paradigm