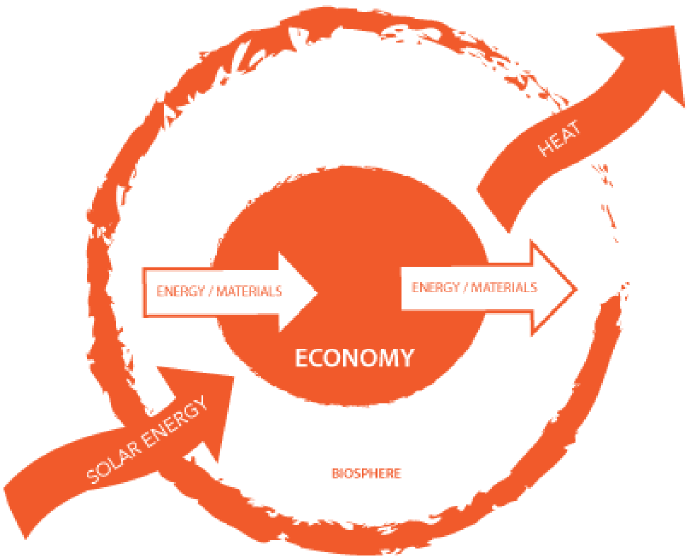
Ecological Economics



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Introduction to the website/eBook

The aim of this website/eBook is to present the subject of ecological economics to upper-secondary schools and other interested parties. In order to meet the needs of different readers, the content can be accessed in a variety of ways. For those who are familiar with the digital world of the Internet, the content can be read as a so-called *eBook* on a computer, tablet or smart phone, while those who prefer a more traditional book can download all the material in PDF format.

The content is divided into 10 sections, which in principle can be read independently. We recommend that sections 1 and 2 are read first as they represent a foundation for the remaining topics. Each section has its own front page, which includes a brief introduction and a number of articles that make up the content of the theme. On the website, there are 10 sections on the front page and in the main menu, while they are arranged as successive book chapters in the eBook, where the first five chapters interpret the problems from different angles, the sixth chapter deals with political decisions, while chapters 7 to 9 discuss various potential solutions. The individual sections represent different research programmes in the field of ecological economics with the programmes that are presented under section 1 and 2 constituting a kind of foundation for the remaining. Finally, section 10 is an attempt to present some theoretical concepts from other economic schools, which are often used in ecological economics and which appear in many different analyses. This section has been named 'theoretical glasses' because different theories can be thought of as different pairs of glasses that you can wear with each allowing you to view the world in a different way. This approach generally applies to the subject of ecological economics, which is characterised by its biophysical perspective on the study of economics and society. This is like wearing a special pair of glasses, which makes it possible to see things that are different from what you would normally see when wearing glasses that have a more traditional economics focus.

The website/eBook is non-profit and independent of commercial interests. Access to the material is unlimited and everyone has the right to share and disseminate the content of the page as long as it is done with respect to the material and with a clear reference to the source. In this spirit, we have also taken the liberty of using figures and graphs from other material and like-minded websites. This is done with gratitude and with source references and links, which indicate where the individual figures and graphs originate.

While preparing the material, we received feedback from a small group of dedicated high school teachers who participated in a workshop and provided valuable input and comments. We owe these teachers a big thank you.

We are also very grateful to the VELUX FOUNDATIONS for funding the work on the website as part of the EcoMac project: Ecological Macroeconomics and Sustainable Transitions - Critical and Constructive Perspectives.

This is the first edition of the material and, therefore, there may be some errors and inaccuracies. Any corrections will be greatly received.

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Contents

Ecological economics - an introduction

Inge Røpke

Ecological economics is a scientific field that cuts across the natural, social and human sciences. The basic concept of ecological economics is that human societies can be perceived as biological systems - metabolic organisms that are kept alive by the flow of energy and materials. Like other biological systems, human societies have physical and chemical properties, which means that social and economic processes can also be regarded as biophysical processes. Most people would agree with this, but ecological economics goes one step further and emphasises that social and economic processes should, therefore, not only be studied with terms taken from the social sciences, but also with terms from the natural sciences such as ecology and thermodynamics.

The idea that economic theory should include natural science understandings is not new. Following the formulation of thermodynamic theory in the 19th century, there was, for example, an attempt to give the concept of energy a central role in economic theory, and since then many other related ideas have been put forward. However, it was only when environmental and resource problems first appeared on the agenda in the 1960s that the time became ripe for the wider dissemination of the idea. In the field of economics, not least Nicholas Georgescu-Roegen and his student Herman Daly contributed to giving the ideas a more modern expression. In the 1970s and 1980s, researchers who studied fields as diverse as economics, energy, ecosystems and systems theory began to collaborate having been inspired by the ideas of Georgescu-Roegen and Daly. In the late 1980s, this resulted in the creation of ecological economics as an independent scientific field with an association and a scientific journal.

Compared to many other scientific fields, not least economics, the delimitation of ecological economics is very fluid and there are significant differences between the views of those who call themselves ecological economists. However, the basic notion of adopting a biophysical perspective involves some shared ideas.

Basic concepts in ecological economics

Limits to growth

First and foremost, the biophysical perspective involves limits to economic growth. In a thermodynamic perspective, the Earth is a closed system in which (almost) only energy is exchanged with the surrounding universe, and the economy is a metabolic organism that grows within the limits set by the biosphere. The larger the organism becomes - based on an ever-increasing flow of energy and materials - the greater the risk that it will undermine its own life-sustaining conditions.

The greatest risk is that the life-sustaining systems will be changed to such an extent that the world will be less well suited to human habitation. For example, we depend on the composition of the atmosphere, the water cycle, the nutrient cycle, the pollination of plants and soil fertility. The challenges are connected, for example, when attempts to restrict the use of fossil fuels for climate reasons lead to increased use of biomass for energy purposes and, thereby, to the overexploitation of land and water resources and pressure on biodiversity. Today, we live in a ‘full world' where the economy has become so large compared to the biosphere that the systems that sustain life for humans are under threat in many ways.

Technology and caution

Technological optimists (including some traditional economists) are of the opinion that environmental challenges can be solved through technological development, while at the same time the standard of living in rich countries can continue to increase. However, ecological economists are sceptical of this because they think that the problems are so great that they need to be approached on all fronts: identifying technological improvements that increase the efficiency of resource use; limiting the increase in living standards and limiting population growth. In addition, only embracing technological change is problematic because our understanding of nature and our interaction with it is limited. The dynamics of nature's development are so complex that we can not expect to become so insightful that we will be able to control it. There will not only be uncertainty about the effects of interfering with nature, but also basic ignorance in that we do not know what we do not know. As technological development often turns out to have unexpected side-effects, launching large-scale experiments, where the side-effects may be dramatic is particularly problematic. For example, typically, ecological economists prefer to intervene in order to limit climate change through prevention rather than hoping that future developments in geo-engineering will make it possible to manipulate the climate on a large scale.

The current challenge in an energy-historical perspective

When ecological economists describe the current challenge as being very great, it is related to an energy-historical perspective. In order for a species to be able to survive, it must be able to obtain more energy through food than the amount of energy that is required to produce the food, while there must be a surplus for reproduction and to cope with the inroads made by its external and internal enemies. Because of the central importance of energy, a biophysical perspective on humanity's history will focus on how people over time have acquired the necessary energy, whether there has been an energy surplus and if so, how it has been utilised. A distinction is made between three periods in human history each with its own energy basis. Firstly, the hunter-gatherer society, for which the energy basis was purely photosynthesis, which provided biomass for food and heating.

This was followed by the agricultural society where the exploitation of biomass was made increasingly efficient through cultivation and was also converted into pulling power from animals, and where energy based on water and wind power was mobilised. Finally, the industrial society emerged, which primarily exploited fossil energy sources. Biomass is, of course, still essential in the form of food, but fossil fuel became completely dominant as an energy source and still is. The use of fossil fuels in combination with the technologies that can exploit them has enabled a huge leap in living standards and massive population growth. Therefore, today, we consume a great deal of energy, while at the same time we need to find a new energy basis because the climate problem means that we have to limit carbon emissions. We are on the brink of a radical transformation into a fourth phase in humanity's energy history.

Many economists do not consider the importance of energy because energy production represents a very small part of GDP. However, when you look at energy in a thermodynamic perspective, it becomes clear that fossil fuels play a major role in economic growth because they are in the form of concentrated work energy (also called exergy, i.e. high quality energy that can be used to perform work, in contrast to heat energy). Replacing them will be a great challenge because the alternatives do not have the qualities of fossil fuels and because the conversion process requires major changes to the physical and social structures of society.

The ethical demand and values

The way in which the nature of the challenge is perceived involves values. It is not uncommon for economists to think of their own theories as being value-free, i.e. descriptive and analytical tools which are in themselves neutral, but which can be used by different political groups to promote their respective political goals. However, in the field of ecological economics, it is generally acknowledged that values are always embedded in the concepts and perspectives that are applied to societal development regardless of whether the theorist is aware of it or not. The idea that there is a limit to growth in terms of resource consumption and pollution, and that the challenges can not only be tackled with technological change forms the basis for the value-related view that society should aim to achieve a more even distribution of resources at both the national and international level. Taking both future generations and the disadvantaged in the present into account is seen as an ethical demand. If those with the best standard of living continue to aim for an ever-increasing standard of living, it will be at the expense of other people's opportunities for improving their situation.

It is, of course, possible to apply a different value perspective: when resources are limited, it becomes a question of gaining as large a share as possible. Some biologists see this as a sort of extension of the 'survival of the fittest' in nature, but it is not very common that this point of view is expressed explicitly, although it can be discerned as a tacit premise behind much economic theory and politics. It is more common to cover up the point of view by looking at the economy in traditional economic terms, whereby the fundamental challenge of distribution is concealed by the fact that infinite growth seems to be possible.

Economic theory as a context for ecological economics

Economics is about keeping a house: How do people secure their livelihoods? How are the resources used? Which social institutions are part of the process of securing livelihoods and distributing the output? Throughout human history, much thought has been given to such issues, but it can only be characterised as economic theory once the idea has been established that the economy can be distinguished as a special focus area, a special social system or a particular aspect of the social system, which can be studied in its own right. This idea was first established in the 17th and 18th centuries. Books about the history of economic theory usually trace early economic reasoning back to the ancient Greeks and then describe mercantilists and physiocrats from the 17th and 18th centuries as early economic theorists, but the story really begins with the classic economists such as Smith, Malthus and Ricardo.

Without going into the historical development of theory, it can be concluded that since the establishment of neoclassical economics in approximately 1870, two different schools of economic theory have emerged. Neoclassical economists aimed to develop economic theory as a scientific field, which was inspired by Newtonian physics with the development of general laws based on abstraction and the use of mathematical models. The assumptions behind the models typically include rational agents, transparency and full information about the future. The models are based on the principle of methodological individualism, whereby explanations can ultimately be traced back to the agents' motives, which are determined outside the model (exogenous preferences). Because this idea is so dominant in economic theory, it is often referred to as the mainstream, while the concurrent thinking that runs contrary to this idea is referred to as heterodox economics, which is based on the notion that the economy is constantly evolving, and that 'general' laws rarely make sense beyond highly delimited fields within microeconomics. Therefore, the focus is on the specific historical development of socio-economic institutions and their importance for economic processes. At the same time, the emphasis is placed on trying to explain the agents' motives within the model in interaction with institutional changes (endogenous preferences). There are many different schools or research programmes that can be said to fall under heterodox economics, such as institutional, evolutionary, post-Keynesian and Marxist economics as well as economic sociology. It can be said that Keynes's theories have been developed in two directions, partly within the mainstream as part of the so-called neoclassical synthesis, and partly by post-Keynesians, who identify themselves as being opposed to neoclassical theory.

Although the roots of ecological economics go far back in history, this line of thought does not become a part of the story of economic theory until the late 1960s. Apart from the physiocrats, most forerunners belong to fields of science other than economics such as chemistry. The field distinguishes itself from the other economic schools by ascribing the natural basis of the economy a much more prominent role in theoretical thinking. At the same time, the modern version of ecological economics is part of the heterodox trend in economic theory - as opposed to environmental economics, which is based on a neoclassical understanding.

The fact that ecological economics was established as a theoretical field in the 1960s can be seen as an example of a historical tendency in that the breakthrough of economic theories is often dependent on societal developments. In the 1930s, the Great Depression helped pave the way for Keynes's theories, while in the 1960s, environmental and resource problems came to the attention of the public, which paved the way for and demanded new theories that could explain these phenomena. A similar trend can be seen today, as various crises are demanding the development of new explanatory models. This gives reason to expect even more progress for ecological economics and similar understandings.

The energy basis

Energy combined with humanity's ability to exploit its different forms is an important key to understanding the economic development of society. Since the beginning of humanity, we have learned to utilise an increasing number of energy sources for an increasing number of purposes. This development has been instrumental in the success of human beings and the emergence of our high-tech civilisation. In this theme, we will look more closely at the role of energy in the development of human beings from hunter-gatherer cultures to modern industrialised societies. Fossil fuels are an important factor in this story, firstly because they made industrialisation possible, and secondly that the burning of these fuels is the main cause of climate change, which is currently in full swing. Therefore, this theme also focuses on the challenge that is currently facing humanity; making the transition to a new, renewable energy basis.

Humanity's energy history

Inge Røpke

In this section, we look at how people have gradually learned to utilise a greater number of energy sources, which has been an important factor in the establishment of the highly developed society we have today. But before we begin to discuss this energy story, we must first introduce some basic concepts and a few useful terms.

Several conditions must be met in order for humans to survive. For example, a sufficient amount of oxygen in the atmosphere, the availability of fresh water and, not least, access to energy, which is consumed in the form of food. The energy content of food comes from photosynthesis in plants, which involves converting solar radiation into chemical energy, which is stored in the biomass of plants.

People can consume this energy directly by eating plants or indirectly by eating herbivorous or carnivorous animals, all of which ultimately get their energy from the photosynthesis of plants. This is called the food chain. When an organism dies, bacteria and other organisms break it down so its biological components once again become part of the food chain. This cycle does not necessarily imply that all the biomass is recycled. For example, fossil fuel energy reserves have been formed because biomass from plants and animals has been stored underground for many millions of years. When humans started to mine for this stored biomass, you could say that they gained access to a very large store of solar energy (chemical energy resulting from photosynthesis) in a very convenient and easily usable form.

Because of the key importance of energy, it is important to examine how humans have used it over time. For this purpose, the concepts *endosomatic* and *exosomatic* energy consumption, which were introduced by the biologist, Alfred Lotka, in the early 20th century, are useful. Endosomatic energy consumption consists of the energy that one species absorbs through food and transforms into growth, movement and heat. All species have an endosomatic energy consumption, whereas until now, only humans have been able to exploit energy exosomatically. Exosomatic energy consumption refers to the use of energy for processes outside the body. The first time that humans were able to consume energy exosomatically was when they learned how to control fire. However, today, humans exploit a very large amount of energy exosomatically for innumerable activities and purposes such as transport, heating and street lighting.

Another useful concept for the story that follows is Human Energy Equivalent (HEE), which is used to denote the amount of endosomatic energy needed to keep a human being alive. The amount varies between individuals and between different climatic regions, but the two ecological economists, Michael Common and Sigrid Stagl, estimate that 10 megajoules per day is a good estimate of the average HEE.

Hunter-gatherer societies

Throughout the history of the Earth, there have been dramatic changes in the composition of the atmosphere, the climate, etc., which have developed in interaction with the forms of life that have emerged. Human beings are believed to have arisen and evolved into their modern form during the geological epoch called the *Pleistocene*. Human history is thought to extend back some 200,000 to 250,000 years, while biologically modern human beings emerged about 100,000 years ago. For most of this period, people lived as hunter-gatherers, leading a nomadic lifestyle and moving around after prey. When humans began to exploit fire, i.e. developing an exosomatic energy consumption, it became possible to expand their food base and migrate to cooler regions. Hunter-gatherers derived their energy solely from photosynthesis that provided biomass as food and wood for heating. It is estimated that the resulting energy consumption was around 2 HEE, i.e. twice as much as endosomatic energy consumption. Even as hunter-gatherers, in some areas, humans had a significant impact on the surrounding nature. It is believed that the spread of humans led to pressure on different plant species and contributed to the extinction of a number of major animal species which had become the humans’ prey.

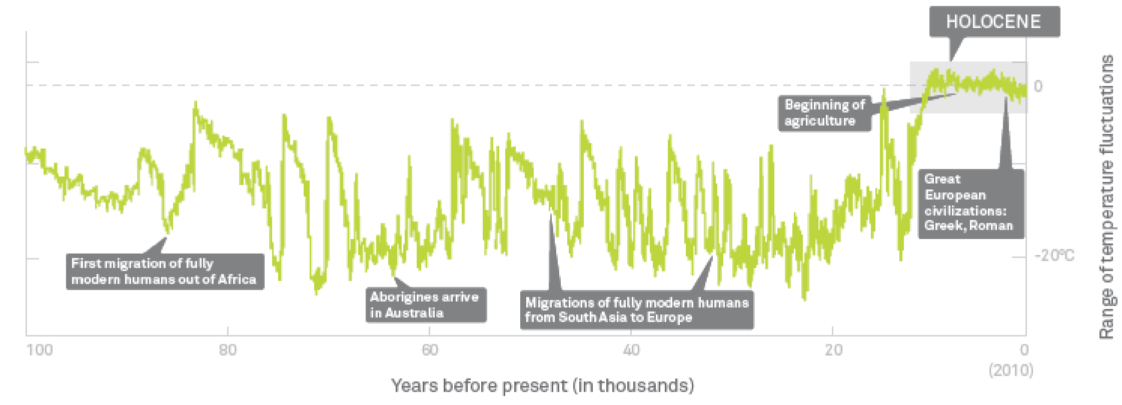
The degree of specialisation was relatively limited in hunter-gatherer societies, and the societal surplus is thought to have been used especially for social activities. The number of items you can transport around with you when living a nomadic lifestyle is limited. In fertile areas, the time spent obtaining food was relatively limited, the humans’ health was relatively good, but life was risky.

The agricultural society

About 12,000 years ago, at the end of the last ice age, the climate warmed significantly and stabilised. During the geological period that followed, called the *Holocene*, conditions for humans became particularly favourable. The fluctuations in temperature became much smaller than they had been in the Pleistocene, which facilitated the establishment of long-term settlements and agriculture.

In contrast to the hunter-gatherer societies, agricultural societies were characterised by specialisation and hierarchy, while the organisation of the agricultural operations made it possible to obtain a significantly larger amount of biomass from a given area. Agricultural societies secured more energy by converting biomass to pulling power from animals and by using water and wind power. The energy consumption of agricultural societies is estimated at 3-4 HEE per person.

One might think that the increased energy surplus would improve living conditions, but for most, it was actually the reverse. Specialisation involved hard work and a short life for many, while the social surplus was used to construct magnificent structures, provide culture for the few and to wage war. In the transition from hunter-gatherer societies to agricultural societies, the latter were clearly the strongest, but hunter-gatherer societies survived in isolated pockets in some areas, and some even still exist today.



Over the past 100,000 years of human history, climatic conditions have fluctuated wildly. Only in the Holocene epoch, beginning 10,000 years ago, did temperatures stabilize enough for human settlement.

Global temperature fluctuations in the last 100,000 years. During the last 12,000 years, the temperature has been remarkably stable, which has been a major advantage in terms of the development of human civilisation. Source: Stockholm Resilience Centre.
http://www.stockholmresilience.org/download/18.5004bd9712b572e3de680006830/seed-carl-folke-on-resilience.pdf

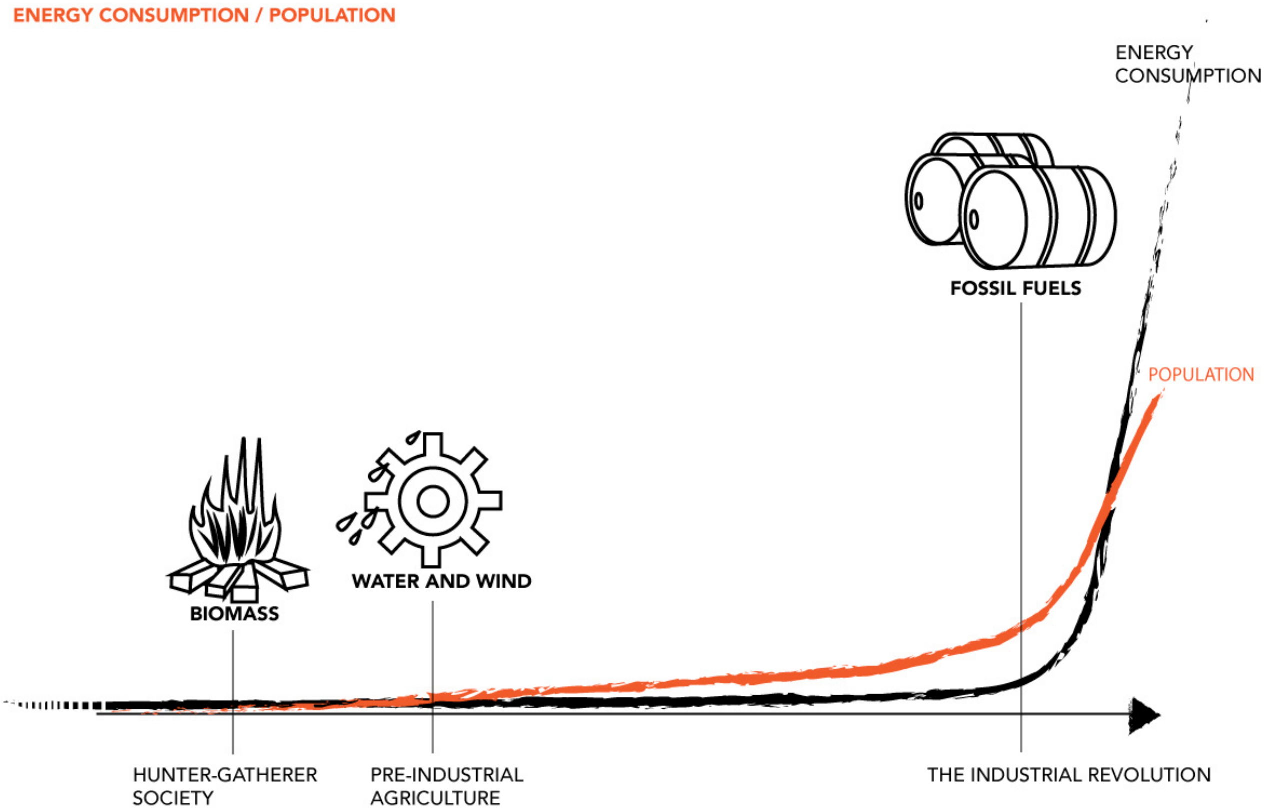
Agricultural operations involved significant changes to ecosystems as large areas were cleared of vegetation other than the intended crop. In some cases, farming communities gradually undermined their own livelihoods because the cultivation methods and the use of wood as raw material and fuel led to deforestation, salinisation and soil erosion, and because they did not find ways of solving these problems in time.

Industrial society (from around 1800)

The transition to the industrial society was, among other things, due to increasing resource problems in the agricultural society. In England, the use of timber had led to deforestation and a lack of wood as an energy source. For a long time, people had been aware of the potential of using coal, but it was only when a lack of wood became apparent that demand for coal increased. This stimulated technological development because the excavation of coal in deep mines required pumps to keep the water out and the operation of pumps stimulated the development of the steam engine, which required iron. The production of which demanded more coal. This spiral in technological development gradually led to coal becoming the primary source of energy in conjunction with key technologies related to the production of iron and the use of the steam engine.

With the discovery of oil and gas, industrialisation became linked to the internal combustion engine and then to the electric motor with the introduction of electrification. The use of fossil fuels combined with mechanisation and subsequently automation resulted in a significant increase in labour productivity. According to Common and Stagl, the average global exosomatic energy consumption in 1900 was approximately 14 HEE per person, which is as if every individual had 14 'energy slaves' at their disposal. Since then, this figure has risen further and it is estimated that in

2000, on average, each human being had 19 ‘energy slaves’ at their disposal. However, this average was very unevenly distributed because, according to Common and Stagl, an American had about 93 ‘energy slaves’, while someone living in Bangladesh only had about 4 ‘energy slaves’ at their disposal.



Energy and population over time. Illustration: Sonja Winckelmann Thomsen

Initially, it was primarily the manufacture of craft products that was mechanised, but later agricultural production also became industrialised. Human labour and horses were replaced by machines, and fossil fuels formed the basis for the production of fertilisers and pesticides to control weeds and pests. In combination with increasing meat production, mechanisation has resulted in agriculture now being a net consumer of energy, i.e. the amount of energy in the food that has been produced is less than the amount of energy used to produce it. This is in contrast to pre-industrial agriculture, where the yield expressed in energy was much greater than the energy used in the form of labour and draught animals. This surplus was due to photosynthesis, which is based on a generous gift in the form of solar energy. Even though modern agriculture also receives this gift, there is still no energy surplus. The advantage primarily lies in the significant increase in labour productivity, which is achieved by replacing labour with machines and fossil energy, while area productivity can often also be increased. In a way, one can say that today we are eating fossil fuels.

The importance of the energy base

Emil Urhammer & Inge Røpke

One of the important differences between ecological economics and mainstream economics is the interpretation of the role of energy in overall production and economic growth. The following extract taken from a book on mainstream economics may help illustrate this difference.

> "*But the term society cake is more appropriate than most would probably expect. In general, when a baker produces cakes, the same factors are required as when creating GDP.*
>
> *It requires a large amount of raw materials; typically flour, sugar, cream, butter and cocoa. Employees, such as a baker's assistant and a shop assistant, are also needed in the store. This is the labour. A dough-mixing machine and, of course, an oven, are also required. The baker also typically has a van to collect and deliver goods. These machines are referred to as the capital stock. But one of the most important factors is the recipe and the process that produces the cake. This is called efficiency or productivity and refers to how fast and efficiently the cake is produced. If the baker has an excellent computer-controlled mixer and a very good oven, the process will be much faster and easier than if using old and slow procedures, where everything is done by hand and without modern technology.*
>
> *If the baker has a good education and has baked the same cake many times, it can probably also be produced more efficiently and quickly because he has a lot of experience about how to optimise the whole bakery."* (translated from Pedersen & Skovgaard: Økonomisk vækst og velstand i Danmark, Jurist- og Økonomforbundets Forlag 2017, pp. 18-19).

In the above, socioeconomic production is explained by using the example of a baker's, but the word 'energy' is not mentioned at all. This is despite the fact that producing the raw materials, powering the oven and mixing machine and transporting the goods all require energy. Thus energy is involved at all stages of the production process, but this factor is omitted in the narrative. Instead, the quality of the capital stock, the manufacturing process and the baker's education are highlighted as the important factors of production. This is not wrong, but without energy it is not possible.

Without energy, a good idea is not worth much. Illustration: Sonja Winckelmann Thomsen.

When mainstream economists explain what results in growth, they emphasise labour, capital and technological development. Technological development is presented as if the only important factor is having a good idea. However, a good idea is nothing in itself because it depends on energy - in most cases fossil fuels. This has been forgotten in mainstream theory about economic growth, whereas it is emphasised as being central in ecological economics. Thus an important element in ecological economics is emphasising that technological innovation and energy are inextricably linked. Technological innovation, which mainstream economists emphasise as being crucial for economic growth, is completely ineffective without energy. Without fossil fuels, the industrialisation and massive growth in the industrialised world since World War II would not have taken place. Therefore, we face major challenges in the future because climate change demands that we find a new, renewable energy base.

Thermodynamics and energy quality

In the field of ecological economics, the discipline of thermodynamics plays an important role. This is due to the fact that thermodynamics provides an understanding of the concept of energy and the benefit people can have from different energy sources. Thermodynamics encompasses a number of laws, but in the following, we only mention the first and the second, which are particularly important for ecological economics.

1. The first law of thermodynamics states that: *Energy can neither be created nor destroyed; it just changes form.*

If we take petrol that is burned in a car engine as an example; according to the first law, there is no creation and no energy is lost in this process. What happens is that the chemical energy in the petrol is transformed into mechanical energy: the pistons move up and down, the drive shaft rotates, the wheels rotate, and the car moves forward. All this mechanical energy ultimately becomes heat - molecular mechanical energy. In short, the chemical energy has not disappeared; it has just become heat (molecular motion).

2. The second law of thermodynamics states that: *Every time energy changes into a new form, an 'energy loss' occurs.*

However, 'energy loss' does not mean that the lost energy has disappeared, it just means that it has turned into a less useful form. Let's continue with the example above. A certain amount of chemical energy is used to move the car from A to B. One can now say that the energy has performed a useful job, but during the process, all the chemical energy in the fuel has become heat. This heat consists of molecular motion in the surroundings, which is very difficult to exploit for a useful purpose. Energy has, therefore, performed a useful task, but a 'loss' has occurred during the process.

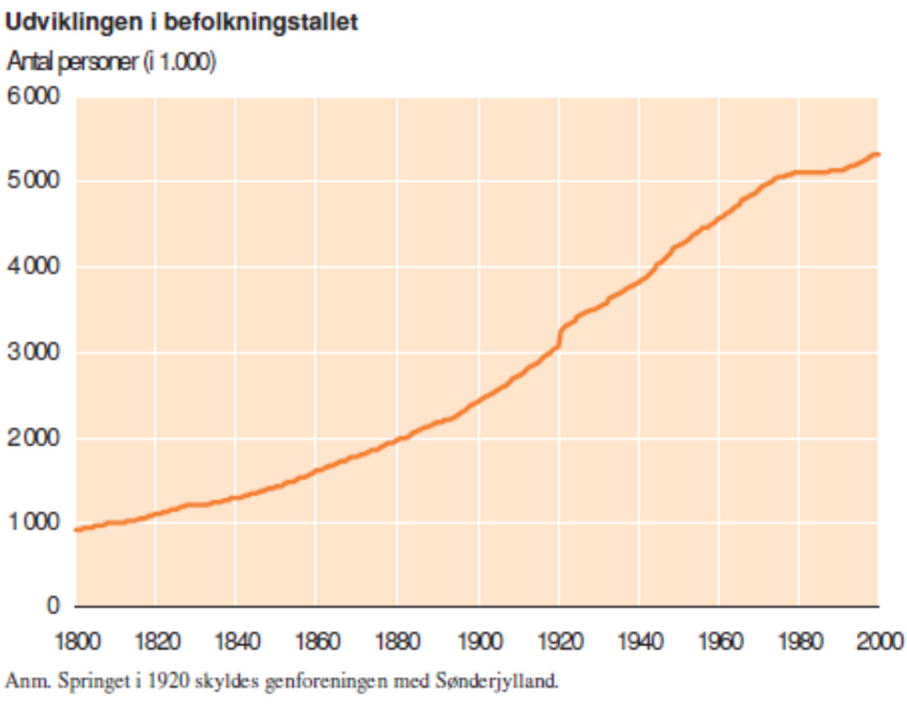
According to the two ecological economists, Herman Daly and Joshua Farley, the reason why these two laws are important for the economy is that the first law tells us that there is a limited amount of energy available, while the other law tells us that there is also a limit to how many times we can use the available energy. Each time we use energy, it transforms into a form that is difficult to exploit.

In this context, the concept of '*energy quality*' is important. Energy quality refers to the potential of energy to perform useful work. The easier it is to convert energy into useful work, the higher the energy quality. The waste heat from a petrol engine contains a sizeable amount of energy, but it is difficult to use for practical purposes. The chemical energy in fossil fuel, on the other hand, is relatively easy to convert into useful work. Therefore, one can say that the waste heat is of low energy quality, while fossil fuels are of high energy quality.

Energy and population

Another very important aspect of energy and the energy base is the role of energy in population growth. Vaclav Smil, who has worked extensively with the connections between energy, the environment and the population, emphasises that the unprecedented population growth which has taken place in the last 80 years, simply could not have taken place without fossil fuels. This is because energy is indispensable for fundamental survival factors such as food, shelter and work. Industrialised agriculture provided the growing population with the necessary food; urban development provided the necessary housing, and industrialisation created jobs for more and more people - all driven by fossil fuels.

With regards to food production, it is important to stress that fossil fuels are indispensable for modern industrialised agriculture, which uses them to power agricultural machinery, for fertilisers, pesticides (weed control and pest control) and transport. Therefore, we are currently facing a twofold challenge: On the one hand, we need to switch our energy consumption from fossil fuels to renewable energy sources, while on the other hand, the global population is increasing, which makes this challenge particularly difficult. This means that one of the great challenges in the future will be to find out how to feed a growing population without fossil fuels. One of the obvious answers is to try to stabilise the global population at a sustainable level. In many countries, a decrease in the size of the population is considered to be a problem. If the decrease is due to major social problems, widespread alcoholism or genetic damage caused by chemicals, there are of course good reasons to address these problems. However, falling population is not a problem in itself, but rather, it should be seen as a contribution to a sustainable transition. The decrease may give rise to transition problems as a result of changes in the age composition of the population, but it is better to find solutions to such problems than to increase the risk of destroying our own basis for life.

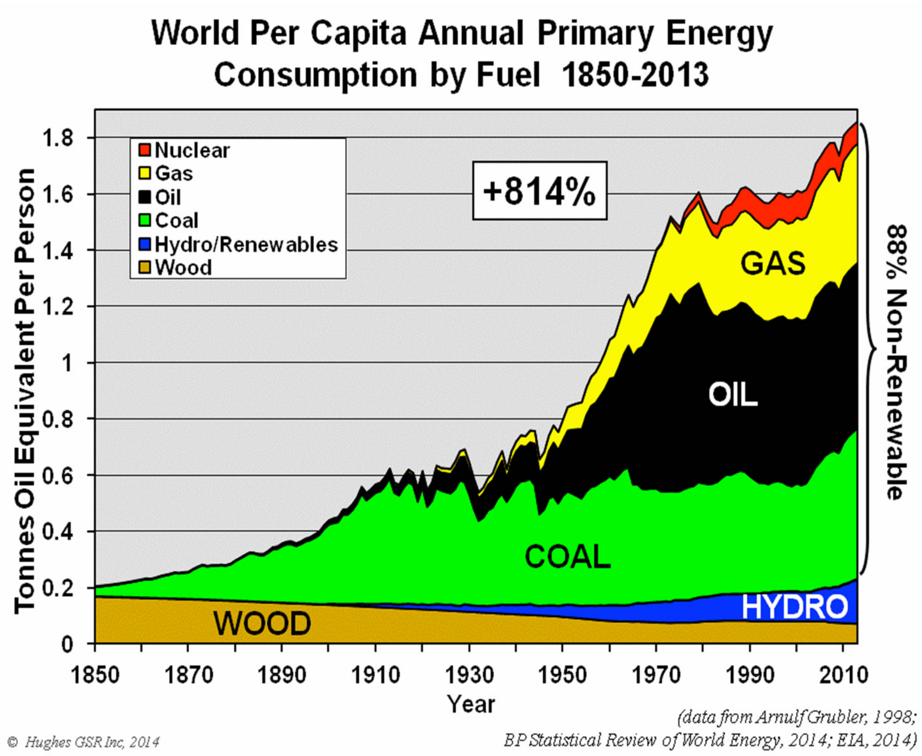


The population has also increased significantly in Denmark. Source: Statistics Denmark *http://www.dst.dk/da/Statistik/Publikationer/VisPub?cid=4576*

The current challenge

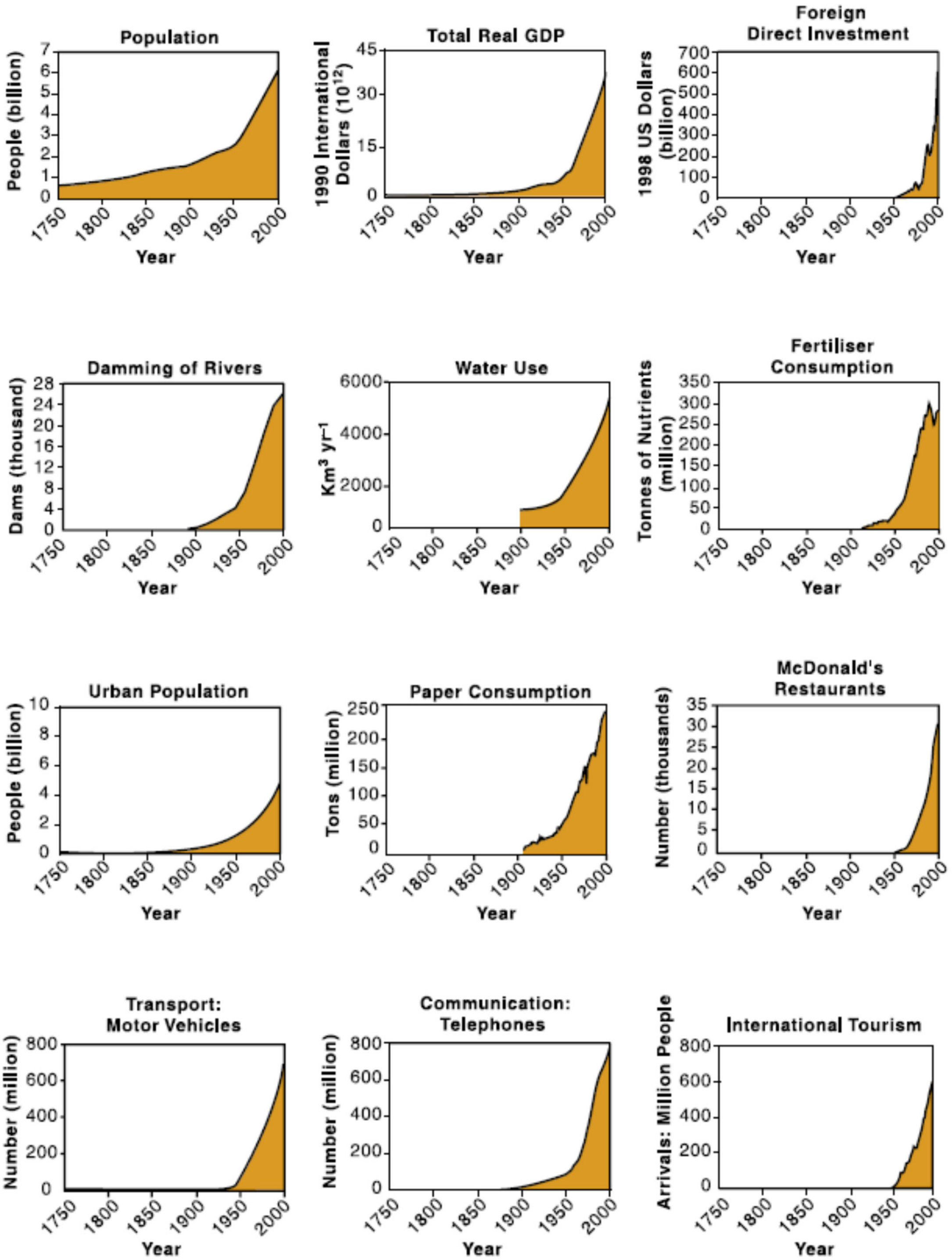
Inge Røpke

The analysis of human history from an energy perspective makes it possible to understand the nature of the most fundamental current challenge: Humanity is in the process of finding a new energy base, and we are in the middle of a radical transformation into a fourth phase in our energy history, a new socio-ecological regime. It involves a far more radical change than any that occurred in the development of different versions of capitalism and planned economies. The size of the challenge is illustrated in the figure below, which shows that the world’s energy supply is still predominantly based on fossil fuels. In Denmark, fossil fuels also play a significant role in total energy consumption, although renewable energy sources make a major contribution to electricity production.



Global energy consumption per person by fuel type 1850 – 2013. Source: Richard Heinberg, Post Carbon Institute.
http://www.postcarbon.org/our-renewable-future-essay/

As a result of the use of fossil fuels, humanity has had such an impact on nature that the changes can be measured on a geological scale. Firstly, the emission of carbon into the atmosphere has intensified the greenhouse effect and contributed to a gradual increase in temperatures, acidification of the oceans, an increase in water levels, etc. - and it will do so much more in the future. Secondly, the availability of cheap energy has made it possible to influence the flow of materials so much that it exceeds the previously naturally occurring movements, resulting in significant environmental problems. Thirdly, the growth in population and living standards have led to the appropriation of an increasing amount of land and freshwater for human purposes, which has resulted in a severe decrease in biodiversity. This development has especially been occurring since the end of World War II, which is referred to as ‘the great acceleration’: All curves point upwards.



Use of a wide range of important variables, e.g. water, paper and fertilisers, has exploded since the start of industrialisation. Source: http://www.igbp.net/download/18.1b8ae20512db692f2a680007761/1376383137895/IGBP_ExecSummary_eng.pdf

The changes are so significant that geologists are discussing whether we have already moved out of the Holocene and into a new geological epoch that may be called the *Anthropocene* because of the role human activity has played in the change. Since the conditions in the Holocene epoch have been particularly favourable for humans, there are good reasons to try to avoid the changes heralded by the Anthropocene epoch.

Environmental problems are multifarious and call for different strategies - chemical regulation, the recycling of materials, the reestablishment of ecosystems, etc., but the renewal of the energy base is the most fundamental.

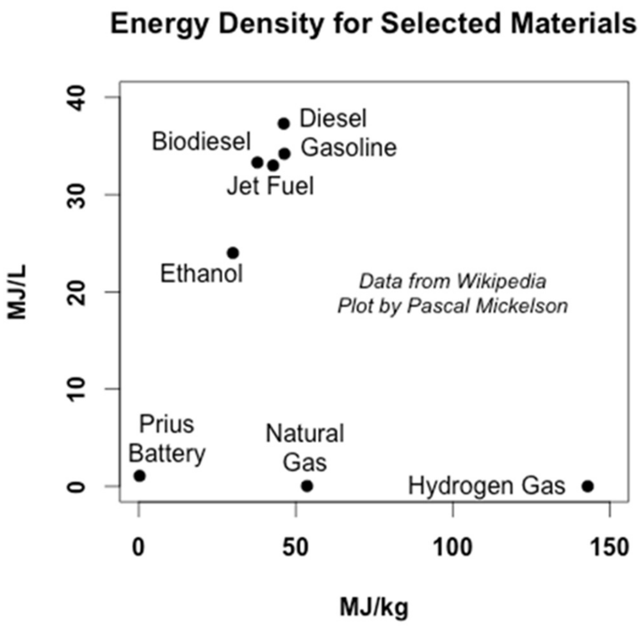
A new energy base

The use of fossil fuels hits a limit into two ways. In the past, there has been a focus on the potential for a lack of fuel. Up to now, this problem has manifested itself by the fact that reserves are becoming increasingly difficult to get hold of because one, of course, starts to extract the most available resources first. Gradually, it takes more and more energy to extract energy, so the net surplus gets smaller. This applies to the extraction of both oil and gas from fields in the sea, the extraction of oil from tar sands, oil and gas from fracking and the extraction of coal from mines where the coal is harder to obtain or is of poorer quality. The concept EROI - Energy Return On (energy) Input – is used to put a figure on this development: During the early phase of oil extraction, which focused on the most easily retrieved oil sources, it was possible to get 100 barrels of oil from using 1 barrel of oil in the extraction process, i.e. EROI was 100. When oil is being extracted from the sea, EROI is often as low as 10. EROI is often measured in relation to the energy input needed for the actual extraction, but energy is also used during the subsequent refining process and transportation to consumers, as well as the more indirect energy consumption connected with the construction of the necessary infrastructure in the form of, for example, roads, cars, petrol stations, car parks, etc. This means that EROI during extraction has to be relatively high to ensure that the society functions.

The other limit is related to carbon emissions. In 2012, the IEA (International Energy Agency) concluded that two-thirds of the known reserves of fossil fuels must remain unused if the increase in temperature is to be kept under 2 degrees. Recent studies have adjusted this figure to three-quarters, but in any case, it seems that not using the reserves is a much bigger challenge than the fact they are scarcer and harder to obtain than previously. Some hope that we can continue to use fossil fuels by using methods to collect the carbon emissions and storing them, such as Carbon Capture and Storage (CCS), but the technology is still at the developmental stage, and the use will exacerbate the problem of decreasing EROI. However, the alternatives to fossil fuels are also associated with problems, while the transition itself is very demanding.

Challenges for an energy transition

- Technologies that can exploit renewable energy sources with sufficiently high EROI must be developed.
- Some of the energy sources should preferably (like fossil fuels) have a high energy density, i.e. the amount of energy per weight unit, and be mobile so that they can be used for example in airplanes. In addition, there is a challenge in developing alternatives that can compete with the high energy content per volume of fossil fuels. This is, for example, a challenge for battery technologies, which still can not compete with fossil fuels in this area (see figure: energy density for selected materials).
- Systems where the energy sources support each other must be developed. The systems will be different in different areas, depending on the resources that are available. For example, solar and wind resources are very unevenly distributed.
- Energy needs to be stored because renewable energy sources, such as sun and wind, are erratic.
- Investments in infrastructure that make it possible to exploit energy sources must be made.
- The use of biomass as an energy source must be limited because it competes with land use for food production and the maintenance of biodiversity.
- Solutions must be sought to environmental and social problems that are linked to the alternative sources of energy, e.g. the problems associated with the extraction of minerals for batteries and electronics, or the environmental and safety issues associated with nuclear power.



Energy carriers and their energy densities. Storage of wind and solar energy in batteries is not yet a particularly good substitute for fossil fuels. Source: Richard Heinberg and Pascal Mickelson, Post Carbon Institute.

http://www.postcarbon.org/our-renewable-future-essay/

A particular challenge is that the transition itself is energy-intensive. The concept *energy cannibalism* (originally used in connection with nuclear power) refers to a situation where so much energy is used in the expansion of renewable energy that it surpasses the amount of energy contributed by the renewable energy sources. This, of course, only applies to the period where renewable energy is expanding rapidly, but it makes it difficult to replace fossil fuels sufficiently quickly, especially if you imagine that everyone should also have an even higher standard of living.

The biophysical perspective

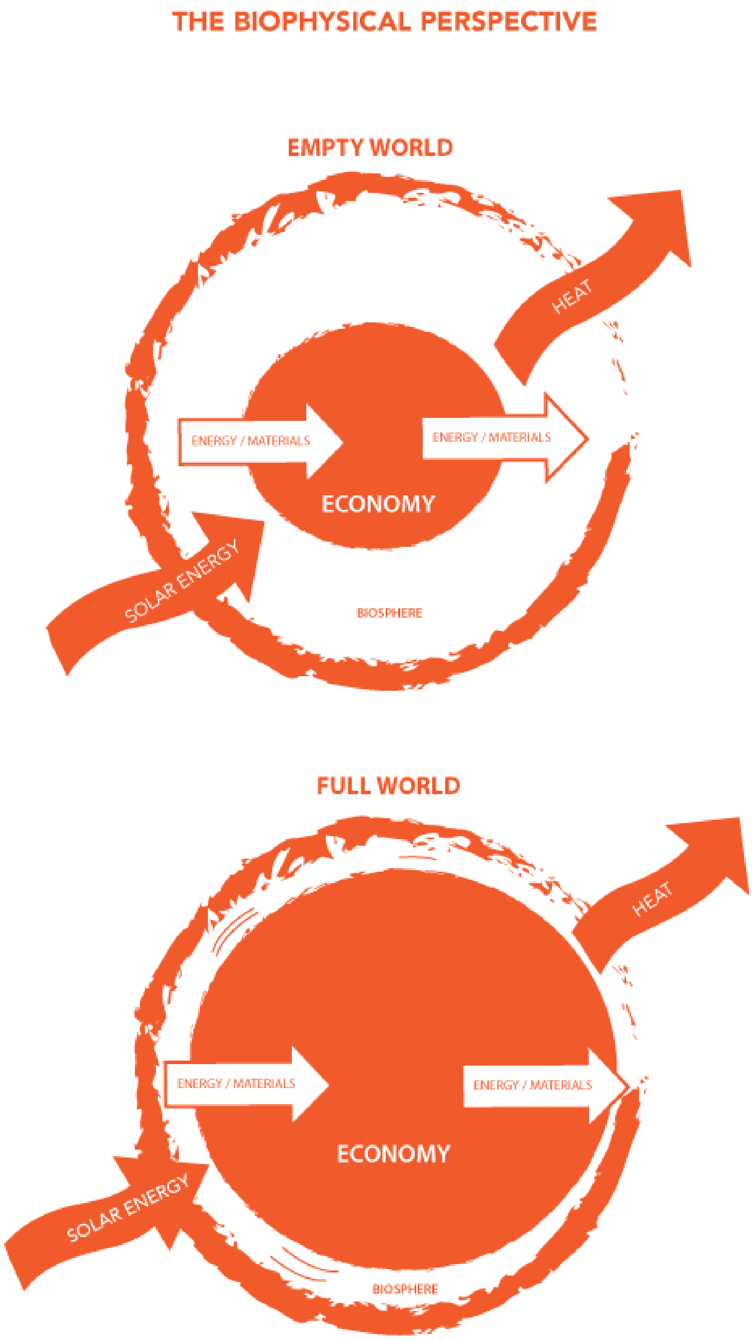
In this theme, the economy is presented as a so-called metabolic organism, i.e an organism with a metabolism. This focuses on the economy in a biophysical perspective, which makes an important contribution to the understanding of the economy and economic theory. When one looks at the economy as a metabolic organism, the focus is on all the materials, the energy and land required to maintain the economy. This means that the size of the economy comes into focus. It has been shown that there is a clear connection between the size of the economy and the amount of raw materials, energy and land the economy needs to keep going. In order to get a better sense of the size of the economy in a biophysical sense, different measures have been developed to help us get a picture of the economy's overall metabolism. As well as presenting the economy in a biophysical perspective, we also briefly describe some of the most widely used measures of the size of the economy in a biophysical sense.

A metabolic organism

Inge Røpke

The basic idea of ecological economics is that the economy can be perceived as a biological system - a metabolic organism that is kept alive by the flow of energy and materials. The word, metabolism, stems from the Old Greek word for change or transition and refers to the transformation of materials and energy. A metabolic organism is an organism with a metabolism. A metabolic organism consumes materials and energy from its environment into its digestive system and uses them to maintain its life processes. Through its metabolism, an organism is, thus, able to keep itself alive, but its metabolism also has an effect on the environment. The materials and energy that the organism absorbs later leave the organism in new forms and become part of cycles and processes in the surrounding environment. In many situations, a metabolic organism's waste becomes useful elements in the surrounding environment, while in other cases, it can be considered harmful. In the case of the economy, one can say that it is an organism whose waste is sometimes harmful to the surrounding environment and to us.

Ecological economics thus views the economy as an organism with physical and chemical characteristics just like other biological organisms, which makes it possible to perceive economic processes as so-called biophysical processes. What is special about ecological economics is that it both describes economic processes with terms from ordinary economic theories, and with terms from the natural sciences such as biology and physics. For example, when economic theories describe economic development with terms such as prices, wages, balance of payments and economic growth, the same development can be seen from a biophysical perspective and be described with terms such as flows of energy and materials. When applying the biophysical perspective, you see connections other than those you see with traditional economic perspectives, and it can act, therefore, as a kind of critical tool of traditional understandings of economic connections. Firstly, people's dependency on nature is emphasised in a completely different way, and secondly, the unequal distribution of resources between different groups of people is made clearer.



The ecological economics standard model. The economy is a metabolic organism embedded in the biosphere. The organism survives by absorbing and transforming materials and energy from its surroundings. As part of this process, waste is emitted to the environment, and energy is transformed into new forms. As there were not many people in the world and the consumption of fossil fuels was still very limited, the economy was not very large compared to the biosphere. However, now we live in a 'full world'. Illustration: Sonja Winckelmann Thomsen.

Measuring the economy's metabolism

Inge Røpke

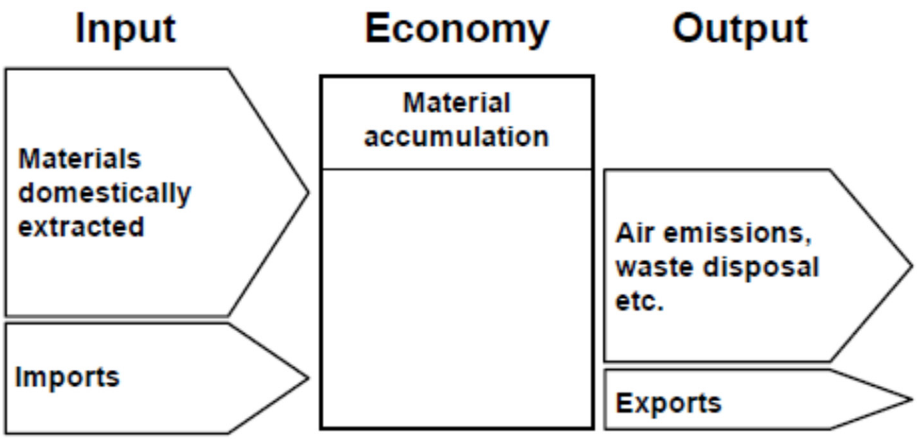
In order to contribute to the sustainable transition of the economy, politicians and other actors need to be aware of how the metabolic process of the economy is going and how different policies affect it. In environmental and energy policy, there is a tradition of focusing on many different issues separately: the state of the aquatic environment, the use of hazardous chemicals, the reduction of CO_2 emissions, etc. It is essential to keep track of the individual areas and prepare specific policies, but this does not give a general overview of whether progress is being made, or otherwise, at the macro level. For example, when attempting to determine whether the Danish economy is 'healthy', there is a tradition of using economic indicators: GDP growth; balance of payments; full employment; an appropriate increase in the level of prices, etc. In particular, there is much focus on the increase in GDP as an indicator of progress. However, from an ecological economics point of view, there are a lot of problems with GDP as an indicator because it does not say anything relevant about how it is going with the sustainable transition or welfare in the society. GDP is primarily a measure of the level of activity in the formal economy: the more that is sold on markets or is made available by the public sector, the higher the GDP. These activities are included in GDP, even if they are the result of the exploitation of resources that can not be replaced. GDP also increases when the arrangement of society creates problems, such as traffic accidents, diseases or pollution, which give rise to economic activity. When the activity itself is central, the advantages and disadvantages are added together, and this is not suitable as a management tool for sustainable transition.

Biophysical indicators

In the field of ecological economics, an important task has been the development of indicators that are better than GDP at demonstrating whether progress in a biophysical sense is being made or not. As previously mentioned, this is difficult to determine by looking at how it is going with solving the long list of specific environmental problems. Instead, you can look at the size of the total input that enters the society's metabolic organism: How much energy and materials do we use and how large an area do we take up? The idea is that the total inputs can be used as indicators of how large society's metabolic organism has become in relation to the biosphere, and that this size, which is also called the scale of the economy, is important for the extent of the many different specific problems. In addition to measuring input, it is also important to monitor carbon emissions on the output side of the metabolic organism because it is so crucial in terms of the climate problem. There follows some examples of input indicators that supplement each other, but also partially overlap. Initially, the focus is on how the metabolism can be measured globally. Then measurements for different parts of the global economy are included.

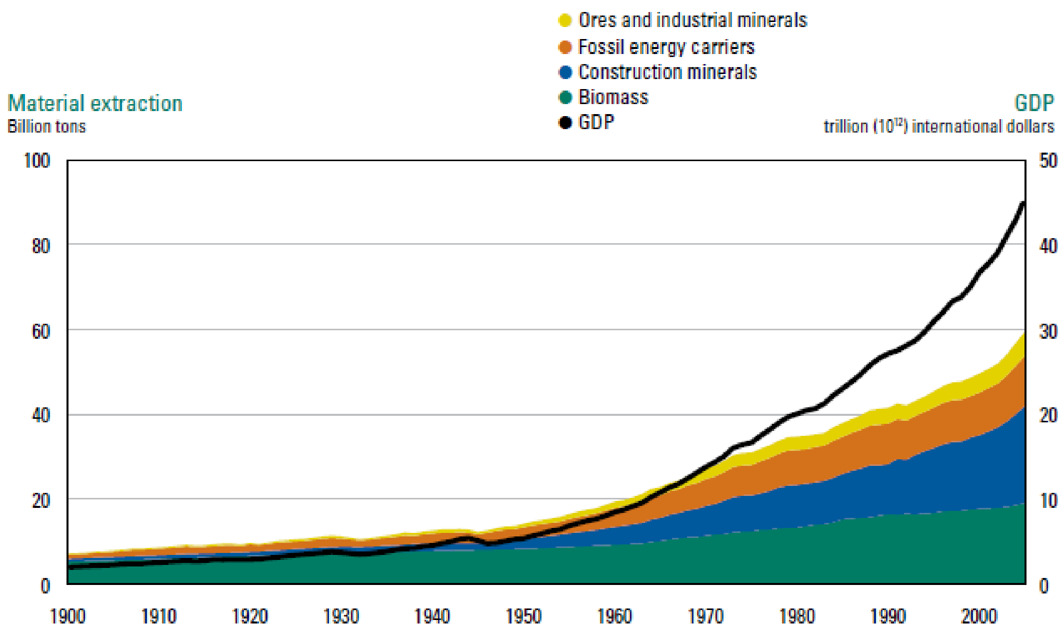
MFA

One of the methods for measuring the metabolism of the economy consists of calculating the weight measured in tonnes of the amount of materials supplied to the economy over the course of one year. The method is called Material Flow Accounting (MFA). As the name suggests, it is the flows of materials that are in focus, but at the same time, it also calculates how much material accumulates in the economy, for example, in the form of buildings and roads. In order to be consistent, the accounts must fulfil the material balance principle: The amount of materials added to the economy in a given year must correspond to the sum of the materials that accumulate in the economy and the materials that leave it in the form of waste and emissions in the same year. In order to set up such accounts, it is necessary to establish some system boundaries. For example, it is said that materials have left the economy when society has lost control of them as happens, e.g. when fertilisers are spread on fields.

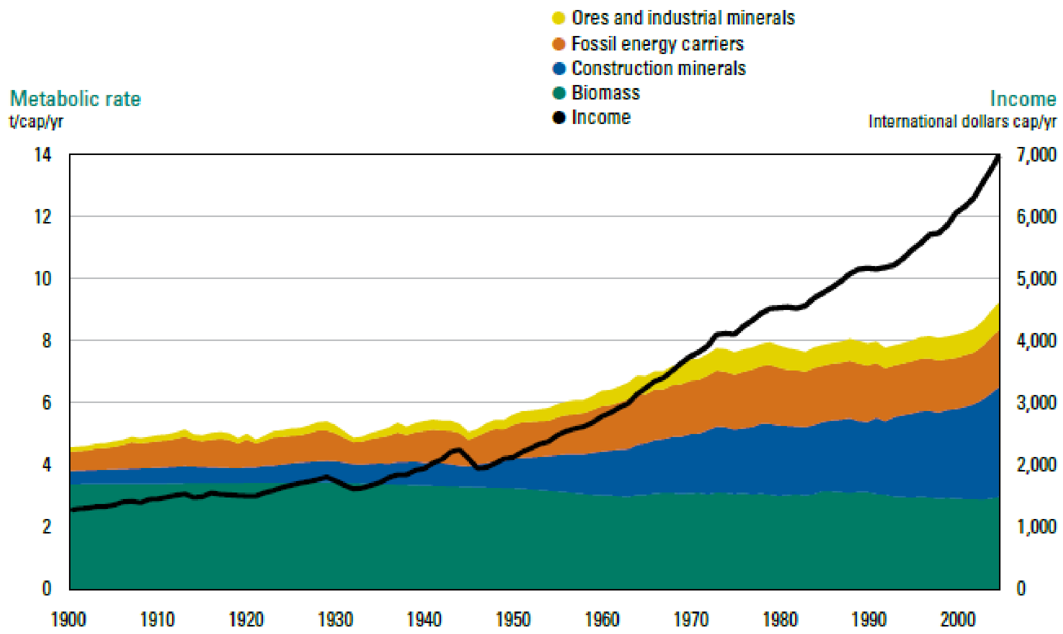


Standard model for material flow analysis: Total input = total output + net accumulation. Source: European Communities (2001): Economy-wide material flow accounts and derived indicators. A methodological guide.

The materials are divided into four main groups: biomass, construction materials, fossil fuels and metals and industrial minerals. Water is not included because it would dominate the picture to such an extent that other developmental trends would be obscured (in order to comply with the material balance principle, one must, therefore, account for biomass as dry matter - otherwise water vapour would have to be included on the emissions side). The figures below show how the material flows for the global economy changed from 1900 to 2005. In the first half of the 20th century, growth was modest, while the three decades after the World War II were marked by high growth (the great acceleration). Growth became somewhat lower from the early 1970s until a new growth period began in the early 2000s. The economic crisis, which began in 2008, is not included in the figures, but it led to a slowdown in growth. Over the period as a whole, a metabolic shift occurred as the share of material flows that is biomass decreased from 75% to 40%. Fossil fuels gained much greater weight and there was a dramatic increase in the use of construction materials. In a developed economy such as Denmark’s, one might think that there was no need for such expansion, but the annual net accumulation has been calculated at 11 tonnes per person/year for 1990.



Global extraction of materials in billion tonnes – 1990 – 2005. Source: Krausmann et al. 2009. "Growth in global materials use, GDP and population during the 20th century", Ecological Economics. Here taken from: United Nations Environment Programme (2011): Decoupling natural resource use and environmental impacts from economic growth.



Global material consumption measured in tonnes/person/year together with global income/person – 1990-2005. Source: Krausmann et al. 2009. "Growth in global materials use, GDP and population during the 20th century", Ecological Economics. Here taken from: United Nations Environment Programme (2011): Decoupling natural resource use and environmental impacts from economic growth.

The data behind the figures only relate to the used material flows, i.e. the materials that have obtained the status of products in the economy. In addition, approximately the same amount of materials has been moved around, but has not been used. These so-called hidden flows include, for example, overburden and excavated material in connection with mining, which can also have significant environmental effects.

Energy

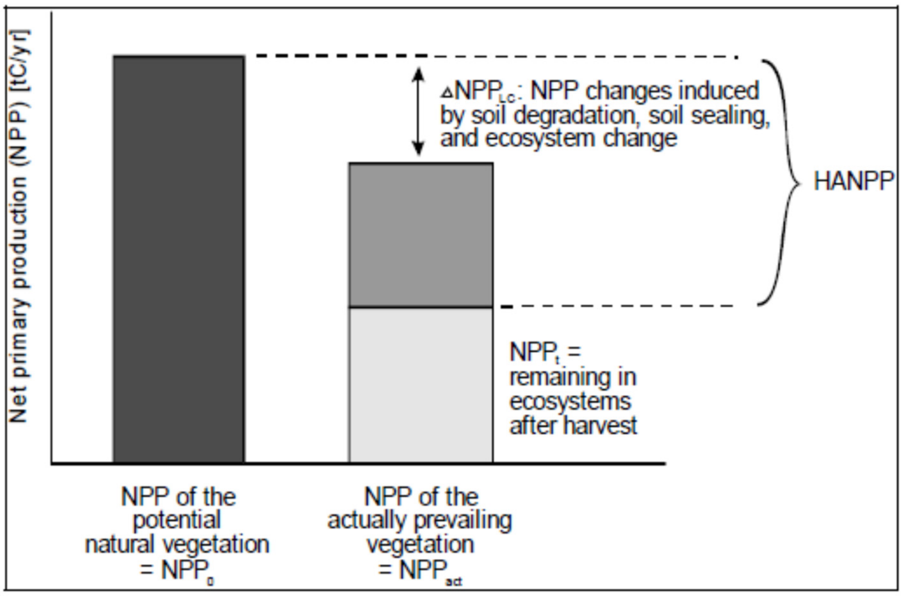
Another method of measuring the metabolism of the economy focuses on calculating energy consumption. Energy is included in material flow analyses as the weight of the fossil fuels and biomass that is used for energy purposes, but several other energy sources, such as hydropower, nuclear power, wind power, solar and geothermal energy, fall outside. Due to the key role of energy in the economy, it is interesting to calculate the total input of primary energy, i.e. the energy that is embedded in natural resources before they are converted to energy carriers such as petrol or electricity. Primary energy resources include, for example, oil, coal, uranium, sunlight, wind, timber and flowing water in rivers. Energy resources can be combined because, in principle, they can all be expressed in the same unit of measurement – the joule. For fossil energy sources, there is consensus regarding the calculation of the energy contained in a given amount of the energy source (for example, the energy content of 1 ton of oil or coal), but for other energy sources, such as renewable energy, it is not that simple. For wind power, for example, you can either choose to set the primary energy equivalent to the energy obtained from the energy source in the form of electricity, or you can assume that wind power involves an energy loss during conversion corresponding to fossil energy so that the amount of primary energy from wind power is estimated to be a significantly larger figure.

During the period 1900 to 2005, total primary energy consumption on a global scale has increased by a factor of 11, which is slightly more than the increase in material consumption, which, according to Krausmann and others, increased by a factor of 8.4. If you include the quality of the energy consumption, growth was even greater. When the different energy sources are combined on the basis of their potential conversion to heat, the fact that there is greater loss during conversion to energy carriers for some energy sources than for others is not taken into account, nor is the fact that some energy sources are suitable for use as work energy (e.g. to power machines), while others can only be converted to heat. Over time, there has been a significant improvement in the efficiency of converting energy sources into energy carriers. Furthermore, the relatively high growth in fossil fuel use compared to biomass has increased the consumption of labour energy significantly more than the consumption of energy in general.

HANPP

The material flow analyses include biomass, but it is also the starting point for a specific measure. Ultimately, all plants and animals (including humans) live from the production of biomass that plants produce by photosynthesis. The amount of biomass that the plants do not exploit for their own survival is called Net Primary Production (NPP). The annual NPP is measured in kilograms of dry matter (or in joule or carbon - the result is the same) and it is available to all animal species through the food chain. To get an idea of how much of the biosphere people ‘take up’, how great a share of NPP humans appropriate is calculated. This share is called Human Appropriation of Net Primary Production (HANPP). It has been estimated that, in 2005, HANPP amounted to about 25%

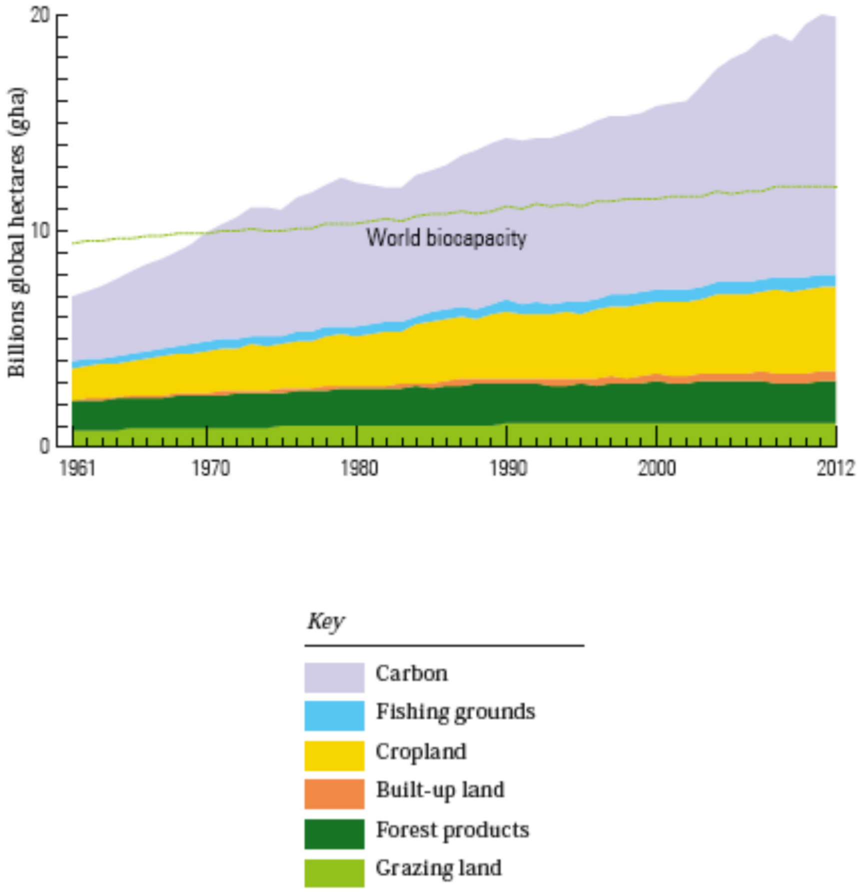
of the land-based photosynthesis (biomass production in seas and watercourses is not included), cf. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3690849/. Considering how many species need the NPP, 25% is a very large number for a single species - and the greater the number becomes, the more the living conditions of other species deteriorate – as do the conditions for humans in the long term because ecosystems are disturbed.



HANPP. Source: http://isecoeco.org/pdf/2007_march_hanpp.pdf

Ecological footprint

In contrast to material flow analysis, the focus of the ecological footprint is on land use. Humans' ecological footprint is defined as the area needed to produce our total annual consumption of goods and services and to neutralise the effect of our greenhouse gas emissions in the same year. For the annual consumption, humans primarily appropriate areas for the cultivation of biomass, which is used for food either directly or indirectly through feed for livestock. In addition, biomass is used as fuel and for the production of, e.g. housing, furniture and paper. Area is also appropriated through construction and infrastructure. As well as the actual use of land, so-called virtual land use is included, which is connected to the use of fossil fuels. The method calculates how large an area it would be necessary to plant with trees in order to absorb and neutralise the carbon emissions resulting from the annual fossil fuel consumption. One may say that fossil fuels constitute a kind of 'saved area', which today allows more land to be used than is currently available on the planet. It is estimated that today we use 1.5 Earths.



Ecological footprint. Source: WWF: Living Planet Report, 2016. Risk and resilience in a new era.

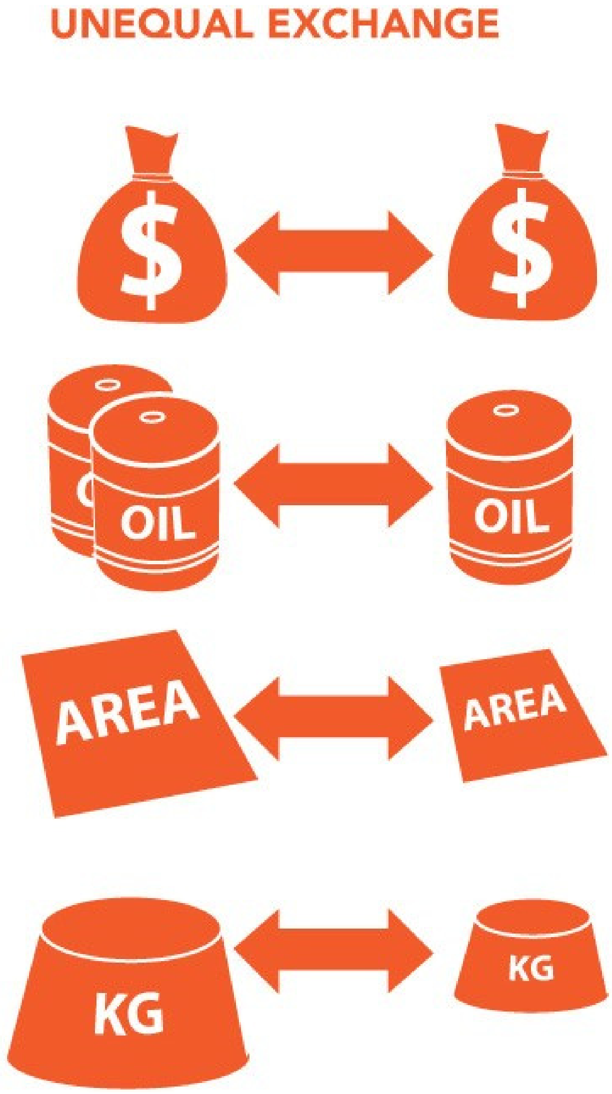
Part of the global metabolism

Above, the different measures for metabolism are explained based on the global economy as a whole. However, it becomes a bit more complicated, for example, to measure the metabolism at the national or regional level, or if you want to look at the metabolism that is associated with a single individual's consumption. In this case, it is necessary to look at the flows of energy and materials internally in the world economy's metabolic organism, and not just input and output relative to the biosphere. For example, if you want to measure an individual's energy consumption, it is not enough to look at the direct energy consumption in the form of electricity, petrol, heating, etc. It is also necessary to include the indirect energy consumption used to produce and transport the other goods and services that the individual has purchased. Behind this there is usually a long production chain. In principle, it is possible to analyse each of these production chains, but it is far too complicated when analysing the total consumption for one individual or group. Instead, input-output tables are used that show how much different sectors of the economy supply to each other in terms of value. For example, it is possible to calculate how much production different sectors need to supply to make possible 100 DKK worth of consumption of a particular product group such as IT equipment or pork. This calculation can then be combined with data on energy consumption in the different sectors so that you can estimate the total energy consumption associated with 100 DKK consumption of IT equipment or pork. In addition to the value-based input-output tables, there are also physical input-output tables that show how much the different sectors supply to each other by weight.

This type of data on the production chains makes it possible to calculate the metabolism at the national level, for a city or for a household. At the national level, for example, it is interesting to see how many resources a country's population appropriate when imports and exports are taken into account. For example, if you look at material flows, not only does the weight of the products that cross the border in connection with trade need to be counted, but also the weight of the resources that were involved in the production and transportation of the product before it crossed the border. The same applies when calculating 'embodied HANPP', i.e. the amount of biomass that has been used to produce, for example, a food product.

From the 1980s up to the financial crisis in 2008, there was a sharp increase in international trade, both in money and biophysical terms. Just as we discuss a country's balance of payments with foreign countries, there is also a biophysical balance of payments, where the relationship between the country's import and export of resources is calculated. Although there is a reasonable balance regarding the total trade between the EU as a whole and the rest of the world, the EU has a major deficit regarding the biophysical balance of payments: we import far more resources than we export.

The increasing awareness of the biophysical aspects of international trade has led to a new perspective on an old discussion of unequal exchange between countries. When countries exchange two products that have the same price, it appears to be a straight exchange, but at the same time the exchange can be unequal if the goods are compared according to a different measure. Back in the 1970s, the alternative measure was work hours. The concept of unequal exchange was used to describe the fact that export products from developing countries often required many more work hours to produce than the work hours necessary to produce the goods the developing countries imported from the industrialised countries. This perspective is now supplemented by the fact that there may be unequal exchanges in biophysical terms: In the figure below, the exchange is equal in terms of money, but many developing countries are in a situation where their export products are produced using many more resources (such as energy, materials, biomass, water) than the goods they import. The trade can, thus, undermine the country's environment and future production potential, especially if the imports are not properly managed (for more information, see the theme, Driving forces, under the section, Trade and globalisation). However, it is not possible to say that all developing countries are in the same situation, while all industrialised countries are in the opposite situation. For example, Australia is a major exporter of resources.



Unequal exchange. Illustration: Sonja Winckelmann Thomsen

In a world where economic development encounters biophysical limits, governments at the national level have a twofold responsibility. It is important to improve the efficiency of resource use and to adapt the production systems so that they can function with fewer resources. At the same time, it is equally important to limit the total consumption of resources appropriated by the population whether it is linked to domestic or foreign production. Denmark's position in relation to this twofold responsibility is ambiguous: On the one hand, we are doing better than many other countries regarding the transition of the energy system (and less well for other provision systems). On the other hand, our total resource consumption per person is higher than in most countries. If we are to accept our share of the responsibility, it is important to formulate goals for both production and consumption. So far, it has been difficult to get consumption on the agenda.

Growth and the environment

Economic growth is a central theme in economic thinking and it is usually presented as a social good - a necessity for social development. In this theme, we look at economic growth through a pair of ecological economics glasses. When we do this, several problems arise. Among other things, it becomes apparent that there are limits to growth in a biophysical sense, but there are also challenges regarding the way we measure economic growth. One can justifiably ask whether the measure of economic growth we currently use (GDP) is the right one at a time when the economy is changing and our world is being threatened by growing environmental crises. Finally, attention may also be paid to the fact that growth is a social dilemma because while on the one hand it is a successful recipe for welfare and stability, on the other hand, it involves significant environmental consequences.

Biophysical limits to growth

Inge Røpke & Emil Urhammer

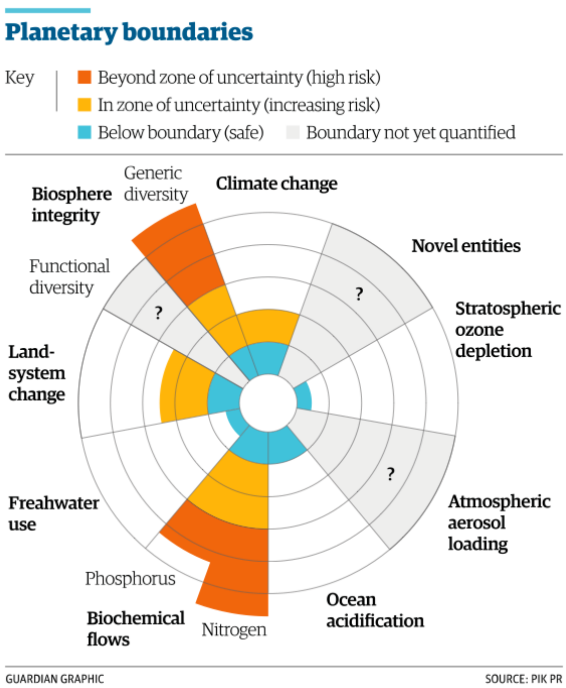
One of the consequences of the biophysical perspective on the economy is the emphasis on limits to growth. In the biophysical perspective, the Earth is a system that primarily gets its energy from the sun, while the economy is seen as a metabolic organism that develops within the limits of the biosphere. The larger the organism - based on an ever-increasing flow of energy and materials - the greater the risk of the organism undermining its own conditions for life. The greatest risk is that the life-sustaining systems will be changed in ways that make the Earth less habitable for humans. The life-sustaining systems, for example, have an influence on the composition of the atmosphere, the water cycle, the nutrient cycle, the pollination of plants and soil fertility. Climate change is one of the many challenges that have arisen as a result of the fact that the economy's metabolic organism has become too large. Many of the challenges are linked because, for example, attempts to restrict fossil fuel use lead to the increased use of biomass for energy purposes and, thus, to the overexploitation of agricultural land and water resources and pressure on biodiversity.

Limits to Growth

In 1972, a group of young researchers at MIT in the United States published a groundbreaking study called 'Limits to Growth'. In the study, a calculation model was used to prepare different global scenarios for the future. In the scenarios, an attempt was made to extrapolate the development of five global variables under different conditions. The five variables were: population, food production, industrial production, pollution and consumption of non-renewable resources. One of the scenarios was called the 'standard run', which was an estimate of how the five variables would change if the global economy continued on its current growth path. According to the model calculations, this would result in the collapse of the global economy in the middle of the 21st century if the course was not changed through political interventions. The group's report was received with widespread scepticism and was met with great opposition from mainstream economists and politicians. The report was often seen as a prediction rather than as the warning it was intended to be. A subsequent study from 2008, which compares the original collapse scenario with the actual development since 1972, shows a clear connection between the scenario and the actual data, which suggests that the warning has unfortunately not been heard.

Planetary boundaries

In 2009, a group of researchers led by the Swede, Johan Rockström, published a scientific study that has made a major contribution to the understanding of our present challenges and need for a sustainable transition. In the study, the group identifies nine so-called planetary boundaries, which must not be exceeded if the Earth is to remain a safe habitat for humans and other species. The boundaries were determined by investigating human-induced global changes of a magnitude that may be considered undesirable for the Earth's life-sustaining systems. Climate change, biodiversity loss, acidification of the oceans, global consumption of fresh water and conversion of land to agriculture are some of the environmental problems for which the research team has defined planetary boundaries. By boundary is meant the point where the system transforms to a new state. With regards to climate change, the researchers determine the limit with the help of the amount of CO_2 in the atmosphere and they estimate that this amount has already exceeded the critical limit at which point the climate system is about to transition to a new and much more unstable state. According to the researchers, several other planetary boundaries have also already been exceeded. This is true, for example, in the case of biodiversity as they believe that species loss is so advanced that it can have catastrophic consequences for the Earth's ecosystems.

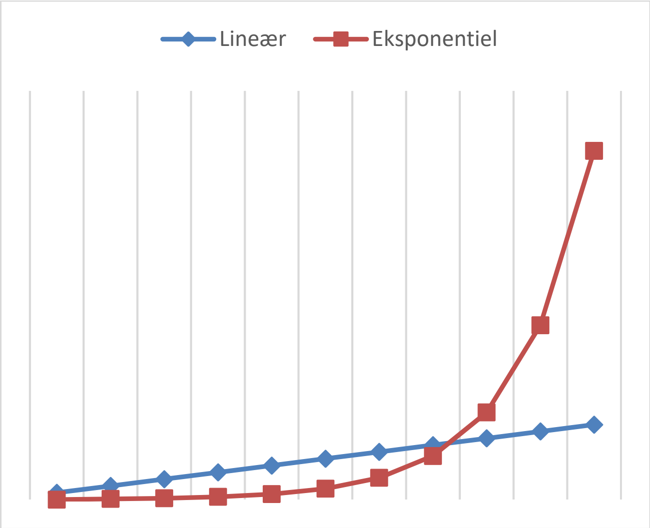


The nine planetary boundaries. Source: Stockholm Resilience Centre.
http://www.stockholmresilience.org/research/planetary-boundaries/planetary-boundaries/about-the-research/the-nine-planetary-boundaries.html

Exponential growth and doubling time

The two info-boxes above present two studies that highlight a mathematical phenomenon called exponential growth. In order to investigate the issue of growth and sustainability a little more, it is useful to focus on this phenomenon. This is because several of the processes that are currently threatening vital ecosystems and climatic balances are characterised by this kind of growth.

Most are familiar with so-called linear growth, where something grows by the same amount for each unit of time. For example, a child who grows eight centimetres a year, or a savings of pocket money that increases by 10 kroner each week. Exponential growth, on the other hand, is characterised by something that increases by a fixed percentage of the total amount for each unit of time. A population that increases by 1% of the total amount a year grows exponentially as does a savings with an interest rate of 5% per annum.



Linear and exponential growth

Exponential growth is often seen in biological systems. A colony of yeast cells, for example, where each cell divides in two every ten minutes grows exponentially with a growth rate of 100% every tenth minute. However, exponential growth is also found in the economy, where GDP may grow exponentially, and in the financial world where property prices can grow exponentially, which may eventually result in the bursting of a bubble.

In contrast to linear growth, the absolute amount with which an exponentially growing amount increases per time unit is not constant. If you have savings of 5,000,000 DKK at an interest rate of 5%, the savings will grow by 250,000 DKK in the first year, while in the next year, it will grow by 262,500 DKK, etc. This relationship makes exponential growth a tricky phenomenon because in the beginning, the growth seems to be harmless, but suddenly and very quickly it can explode. We can see this when we look at the phenomenon that some have called the great acceleration (see section 1), where a large number of factors, such as the global population and resource consumption, have grown exponentially and exploded in recent times. This growth has resulted in a lot of pressure and is threatening to destroy important global ecosystems.

An important concept in relation to exponential growth is doubling time, i.e. the time it takes for a certain amount of a particular unit to become twice as large. There are a number of stories that illustrate the surprising nature of doubling time in relation to exponential growth. For example, there is an ancient anecdote about the emperor of China, who wanted to reward the inventor of chess with a gift to say thank you for the amazing game. The inventor asked for a gift of rice. On the first square of the chessboard, the emperor was asked to put one grain of rice, on the second; two, on the third; four, on the fourth; eight, etc. On each new square, double the number of grains that were on the previous square. The emperor thought that this was a modest request, but he apparently was unaware of exponential growth because there was not enough rice in the whole of China to meet the inventor's wish. Indeed, even before reaching the final square on the chessboard, the number of rice grains would exceed today's total global rice production. And when reaching the final square, you would have to put down 2^{63} grain of rice, which is a fantastically large number. It should be mentioned that the growth in each doubling time is greater than all the previous growth. Therefore, every time the amount doubles, more than the entire previous growth needs to be added.

Another example of doubling time comes from an old French riddle about water lilies, which illustrates how suddenly something can grow. The riddle is as follows: You own a small lake on which there grows a water lily. Every day, the area of the lake's surface that the plant covers with its floating leaves doubles. If you do not keep the water lily's growth in check, it will cover the entire lake in 30 days. If this happens, not enough sunlight will reach the lake, which will be catastrophic for the other species living in the lake. For many days, the water lily does not cover much of the lake, so you do nothing to limit its growth. In fact, you decide that you will only do something about it when it covers half of the lake's surface. The question is – on which day will that be? The answer is day number 29; that is the day before it covers the entire lake, which means that you only have one day to do something about the problem. The morale of this riddle is that exponential growth may seem unproblematic and manageable, but it suddenly becomes too late to do anything about the problem.

One of the factors that make our present time so complicated is that it is characterised by interlinking exponential growth with regards to several variables: consumption of resources, pollution, global population, house prices, etc. As we have tried to illustrate, exponential growth is a tricky phenomenon which makes it very difficult to discern the change in these interlinking variables and systems.

Growth rate (% per year)	Doubling time (years)
0.1	700
0.5	140
1.0	70
2.0	35
4.0	18
5.0	14
7.0	10
10.0	7

Overview of the doubling times of different growth rates. There is a rule of thumb for estimating the doubling time of exponential growth. You simply divide the number 70 by the growth rate. Example:

Growth rate = 5%. 70/5 = 14.

Production result - the ’real cake’

Inge Røpke

According to ecological economics, there is no doubt that there are limits to growth in biophysical terms. But does this also mean that there are limits to growth in economic terms? This depends, of course, on what you really mean by ‘economic growth’. Before we turn to the definition of economic growth that is connected to the concept of GDP, there follows some more fundamental considerations of what is available to society. A fundamental problem in economic theory is whether one can define what a society has available for consumption and investment during the course of one year. Can you say that in one year, society produces a ‘real cake’ - a production result, some of which is reserved for investment, while some is shared between the members of society for consumption? And can the ‘cake’ be measured?

For ecological economics, it would be natural to look at society’s energy surplus as a measure of the size of the cake. When people live in a society that has access to much more energy than the amount needed for survival (the endosomatic energy consumption multiplied by the population size), the members of society have the opportunity to achieve a high standard of living. Although this makes sense, it is not very satisfactory to measure the size of the production result in direct proportion to the size of the input. The potential for a high standard of living is not the same as achieving it. A lot of energy may be available to a society without it being transformed into something of great value for them. Firstly, part of the energy may be lost in the form of waste in the process, and secondly, production may consist of products that are not useful to the society. Therefore, it would be more satisfactory if the production result could be considered in a way that reflects the use value.

Producing and consuming the cake

When the output result can not be measured in a meaningful way from the input side, can it be done from the output side? Here the key question is what the production result actually consists of: What should be included in the 'real cake' that has resulted from the year's efforts and what should be considered as consumption of the cake? Throughout the history of economic theory, what should be considered part of the production result and, thus, what human activities should be considered productive activities and which consumption activities, respectively, has been a controversial question. It is fairly easy to agree that the production of food, clothing and housing are productive activities that contribute positively to the production result. In the past, it was common to regard only the procurement of the necessities for life as productive because they form the basis for everything else: only once the productive are able to procure more necessities for life than they can use themselves, can society afford for others to spend their time caring for the elderly and the sick, holding concerts and practising religious rituals. However, if the perspective is to be meaningful, the range of productive activities quickly becomes wide because many activities are prerequisites for the direct production of the necessities for life, such as the production of the tools to be used and the care and education activities that are needed to ensure that a new labour force grows up and obtains the necessary qualifications. The more complex societies become, the wider the range of activities that come to play a more or less central role in the basis of life: The necessities of life not only have to be produced, but also distributed, while the waste must be disposed of, etc. Just like in an ants' nest or an ecosystem, the many different functions are interdependent. In addition, it becomes increasingly difficult to define what the most basic necessities for life are. It does not really make sense to identify ever larger homes and increasingly varied food and clothing necessities for life if care for the elderly and sick, holding concerts, etc. are not.

When it is so difficult to define productive activities in a meaningful way, it is natural to choose the opposite extremity, i.e. that all activities are productive and contribute to the production result. However, this does not seem very satisfactory either. Firstly, it is common to distinguish between production and consumption, where productive work is seen as a prerequisite for consumption activities: Food must first be produced before it can be eaten. Although nutrition is a prerequisite for production, it is nevertheless common to consider dining as a kind of purpose of the productive activities and, hence, a consumption activity. In the literature on time studies, there is a proposal for a general criterion for how to distinguish between production and consumption: An activity should be considered consumption if it can only be performed by the active person - or if its value decreases as a result of being transferred to others. As Erik Ib Schmidt writes, "You can not let others eat and drink for you, or let them sleep, go for a walk, play football or read a good book for you, and you can not leave it to someone else to listen to good music for you or love for you." (translated from "Behøver vi nå det hele?" Spektrum 1990). At the same time, it is acknowledged that the criterion involves borderline cases. For example, education is inextricably linked to the person who takes the education, which means the criterion suggests that education should be defined as consumption, even though, at the same time, it can have the character of a productive investment. In order to produce measurements and statistics, borderline cases must be addressed, but this is not essential for more fundamental considerations.

Another reason not to consider all activities as productive is based on the view that some activities do not increase the production result, but rather involve waste or are directly harmful. For example, some will doubt the usefulness of trying to persuade people (for example, through advertising) to use something that they can easily do without; or the useful in producing something that is harmful to health (such as tobacco) or increases the risk of war (such as weapons). In addition, it is important to take into account the fact that many useful activities can also have harmful effects in the form of, for example, pollution. This suggests that the production result should be applied as net term from which the harmful effects are deducted.

Thirdly, some activities involve redistribution rather than production. For example, many would doubt that there is anything productive about an activity such as stealing, even though Robin Hood may have increased the overall quality of life by taking from the rich and giving to the poor. In many societies, the production result is redistributed to take care of, for example, the elderly and sick, who can not contribute to the production of the goods themselves. However, redistribution is not considered production. As discussed in the section on distribution, societies also have mechanisms that secure strong groups a share of the production result at the expense of others.

These arguments suggest that it makes sense to distinguish between productive and non-productive activities, even in complex societies: Even though everything is connected, it seems obvious to distinguish between production and consumption. In addition, it is common to distinguish between activities that contribute to the production of use values and those that redistribute the use values. However, at the same time, the specific dividing lines are controversial. From an ecological economics perspective, some of the frequently applied criteria do not make sense. For example, productive and unproductive activities can not be distinguished based on a criterion that is based on the economic entity that performed the activity: An activity does not become more or less productive because it is performed by a private enterprise instead of a household or the public sector. It does not matter if vegetables are grown in a horticultural business or in a private garden, or if children are taken care of in a public nursery, by a privately-employed au pair or by the parents; it is still a contribution to the production result. Furthermore, whether someone earns money by performing a task is not a relevant criterion. One can say that payment is a kind of proof that someone perceives something as useful, but a lack of payment does not necessarily indicate the opposite. Whether money is earned or not has something to do with the distributive mechanisms, which is discussed in the section on distribution.

The size of the cake and its use

When the production result is seen as a 'real cake' - a quantity of use values that are available to a society in a given year - it makes most sense to refer to the final cake so that raw materials and intermediates are not included in the calculation several times. In the course of the year, some use values are used to produce other use values. Since they have only been a means to an end, they should not be included in the real cake: In other words, the real cake is the final baked cake - not the flour, the eggs and the sugar that are used to make it. Some of the use values in the final real cake are set aside to be used to increase future production. Such investments include, for example, new buildings, machinery, education and research activities as well as nature restoration (consumer goods that are stored for later can also be considered investments). Other use values consist of goods and services such as food, clothing, housing use, theatre visits, childcare and health services that can be seen as consumption. What should be defined as consumption and investment can be discussed, but this delimitation is not crucial here (it is, however, when producing statistics and models). In the section on dynamics and distribution, we look at why the cake grows over time and how it is shared among social groups.

Although what has been presented here is in line with the idea that, in the course of a year, a society provides a production result, it must be noted that no suggestion has been made for how this amount of use values can be measured in a meaningful manner on the output side. Ecological economics has a suggestion for the biophysical measurements of the inputs used in production, but not for the measurement of output: There is no relevant common biophysical quality of output that makes it possible to combine the use values together. Nevertheless, the concept of the real cake will be used as an abstract idea of a quantity of use values in other sections.

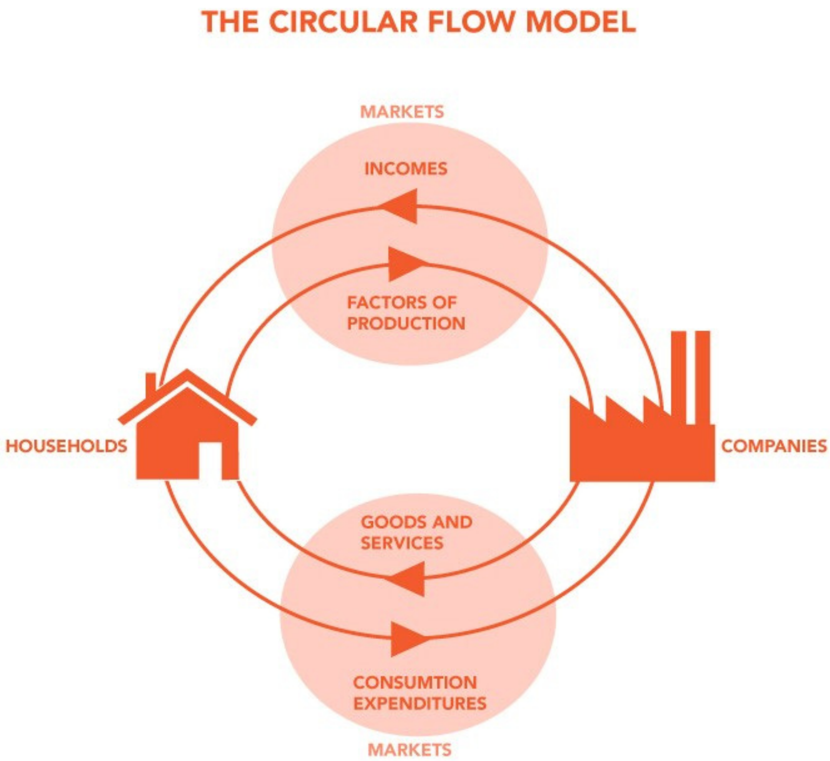
Gross domestic product

In order to be able to combine the values together, they must have a shared feature. As the market economy develops, an increasing number of goods and services are traded on markets, and it becomes obvious to use prices as the common measure. Then the total sum of the year's production of use values can be calculated by multiplying each individual item (or service) by its price and then combining them all together. In order to avoid double accounting, i.e. raw materials and intermediates being counted several times - the value of the inputs used from other producers must be deducted from the price of the individual product. In this way, the market value of the final baked cake can be calculated. It is this thinking that was embodied in the concept of Gross Domestic Product, GDP, in the 1930s. In the following, we focus on GDP without discussing why ecological economists are sceptical about the use of prices as a measure. We address this issue in the themes Driving forces and distribution and Political Decisions.

The idea behind GDP is derived from the simple cyclical model from neoclassical economics, where companies supply households with goods in return for payment on finished goods markets, while households supply companies with inputs to production in return for payment on the markets for production factors (based on the view that households ultimately are owners of all production factors). Based on this simple model (which excludes investments, the public sector and foreign countries), GDP can be calculated in three ways, which in principle give the same result. GDP is the annual sum of:

- The value added in all companies, i.e. the price of the goods minus the value of inputs from other companies (see above).
- The production value of all finished goods that are sold to the households (based on the price of the finished product without deducting inputs).
- The households' income in the form of salary, dividends, interest, etc.

In practice, the calculations are, of course, more complicated, partly because investments, the public sector and foreign countries must also be included.



The Circular Flow Model with markets. Illustration: Sonja Winckelmann Thomsen.

Attempts to develop statistical statements of society's total production or income go back a long way, but it was not until around the time of the Great Depression in the 1930s that a serious focus was directed to managing the macro-economy and, hence, tools for measuring total economic activity. After the Wall Street Crash in 1929 and the subsequent explosion in unemployment, Western governments needed detailed statistics for the economy. In the United States, the economist, Simon Kuznets, was therefore given the task of creating a measure of the condition of the overall US economy, which led to one of the first proposals for what we today call Gross Domestic Product, GDP. Kuznets's initial ambition was to create a measure of economic well-being, so he suggested, for example, deducting expenses for weapons, advertising and financial speculation from the national income. However, this focus changed crucially due to the preparation for war because it was important to calculate how many resources could be included in the war effort and because this effort should not appear to be a drain on the economy.

In this early phase of the development of the GDP measure, the accounts were a means to help tackle unemployment and mobilise resources for the war and it was not intended to be an end in itself. It was not until the 1950s and 1960s that GDP growth emerged on the agenda as a goal. This was, among other things, motivated by the competition with the Soviet Union. The Organisation for Economic Cooperation and Development (OECD) was one of the main driving forces behind making GDP a measure of economic growth and economic growth a top priority for economic policy.

Today, one does not have to follow the debate about the Danish economy closely to realise that economic growth is an indisputable central theme and one of the main objectives of economic policy. Economic growth is often perceived as being synonymous with prosperity, progress and surplus, while recession - the opposite of economic growth - is associated with poverty, regression and deficit. This status is due to, amongst others, the connection between economic growth and employment and the financing of the welfare state.

Criticism of GDP

While the GDP measure has become important in economic policy, criticism of the indicator has also grown. This criticism is becoming increasingly widespread, especially in connection with the emergence of global environmental problems.

The classic objections to GDP highlight the problems that Kuznets himself was concerned with. When all financial transactions are said to contribute to GDP, the result will not be a good measure of well-being. Firstly, GDP increases as a result of having to clean up after pollution and car accidents. Again, there is no deduction to GDP when economic activities reduce the stock of natural resources, such as oil, impoverish agricultural land or damage habitats for animals and plants. Secondly, there are many useful activities that are not included in GDP because they are not traded on a market. This applies to, for example, domestic work at home and voluntary work in associations. When more women entered the labour market in the 1960s, and more children were taken care of in child care centres, it resulted in an increase in GDP.

In addition, focusing on GDP as the central goal of welfare means that other aspects of welfare receive lower priority. For example, in recent years, there has been a lot of discussion about the importance of equality for the welfare of a society. On the basis of comprehensive statistical analyses, the social epidemiologists, Wilkinson and Pickett, have argued that more equal societies experience greater welfare, measured on a large number of parameters related to public health and crime. Similarly, others have pointed out that greater equality increases the degree of mutual trust and, thus, welfare in the society.

Many other criticisms of GDP have been expressed, while the actual calculation methods are changing continuously. For example, a controversial issue is how the financial sector's contribution to GDP should be calculated (should the activities be considered productive or should the income of finance rather be seen as a deduction from the income of other sectors), while there is also a discussion about how statistics can capture what is happening in the digital economy, where many services are free.

The growth dilemma

Emil Urhammer & Inge Røpke

Despite various criticisms, it is clear that economic growth, measured as GDP growth, is still the key objective of economic policy. However, since the financial crisis in 2008, it has become more common to talk about being on the brink of a systemic crisis in which economic and environmental crises occur simultaneously and are interwoven together in a variety of complex ways. The ecological economist, Tim Jackson, has said that we are in a dilemma - the growth dilemma - where economic growth, on the one hand, is undermining the environment through climate change and ecosystem destruction, while growth, on the other hand, is necessary to maintain prosperity, employment and the financing of the welfare state, due to the way our economic system is organised today.

In this video, you can listen to Tim Jackson talking about the growth dilemma
http://www.youtube.com/watch?v=JRvk9Nl31X4

Decoupling

In order to overcome the dilemma of growth, growth supporters often put their faith in decoupling, which suggests that with the help of technological innovations and resource efficiency, it will be possible to disconnect economic growth from the environmental impact. However, in a critical analysis of the idea of decoupling, Tim Jackson argues that it is an unrealistic hope.

In order to understand Jackson's arguments, it is necessary to distinguish between two different types of decoupling: relative and absolute. Relative decoupling means that the environmental impact per unit of economic output decreases. This does not mean that the environmental impact in itself is falling, but that GDP has increased more than the environmental impact. In contrast to relative decoupling, absolute decoupling means that the environmental impact has fallen in absolute terms, although GDP has increased.

The IPAT equation

The IPAT equation describes the relationship between, on the one hand, environmental impact and, on the other hand, population size, affluence and a technology factor, which denotes the environmental impact per unit of GDP. IPAT can be seen as a tool for understanding and discussing relationships between environmental impact, population size, affluence and technological ability.

The equation itself is as follows:

$I = P \times A \times T$ (Impact = Population × Affluence × Technology).

Where I is the environmental impact (measured in different units depending on the environmental problem being investigated), P is population, A is affluence (measured in GDP per person) and T is a technology factor (measured in environmental impact per unit of GDP).

An example of the use of the equation could be to look at global CO_2 emissions. In this case, I denotes global CO_2 emissions given by:

CO_2 (gigatons) = P (population) × A (GDP/population) × T (gigatons/GDP).

Where population is the total population of the planet, and GDP is the global GDP.

The equation can be used for several different problems, where I will often denote pollution or resource consumption.

The IPAT equation (see the infobox above) can be used to get a better sense of the difference between relative and absolute decoupling. If T, i.e. the environmental impact per. unit of GDP, becomes smaller, relative decoupling has occurred, while absolute decoupling has occurred when I becomes smaller. As a rule of thumb, one can say that absolute decoupling in a world where both the population and GDP per inhabitant is increasing can only be achieved if relative decoupling compensates for the effect of population and income growth. When adopting a global perspective, it is difficult to find any historical examples of something like this occurring.

To illustrate this, Jackson uses the IPAT equation to analyse global CO_2 emissions, which means that I denotes global CO_2 emissions, and T denotes CO_2 intensity. CO_2 intensity means CO_2 emissions per unit of GDP. High intensity means that a large amount of CO_2 per GDP unit has been emitted, while low intensity means the opposite. High CO_2 intensity is, thus, the same as low CO_2 efficiency.

Jackson points out that CO_2 intensity has fallen by, on average, 0.7% per annum since 1990. However, this has been counteracted by an average population growth rate of 1.3% per year and an average income increase of 1.4% per year, which means that the efficiency improvements have not offset the effects of a growing world population. Instead, total CO_2 emissions rose on average by 2% per year from 1990 to 2007.

Similarly, Jackson also examines the potential for absolute CO_2 decoupling in the future. He concludes that with the official projections for the world population and income per person, the improvement necessary for T is of an order of magnitude that must be considered virtually impossible – in any case it has never been seen previously in history. In addition, including the idea of greater equality in income at the global level makes the challenge even more enormous. For example, if all people in the world are to have the same level of income as those living in Europe, by 2050, the world economy will have to be six times larger than it is now. If we are to stay within the IPCC's limits for CO_2 in the atmosphere, CO_2 intensity will have to decrease by about 9% per year until 2050.

With a 0.7% drop in intensity per year, which we have seen since 1990, we can conclude that the challenge for efficiency improvements is quite significant. In response to this problem, Jackson suggests that we begin to consider whether continual economic growth is appropriate instead of hoping that technology will bring about the necessary improvements in efficiency. With regards to the IPAT equation, this means that Jackson suggests that we should begin to reduce A and P so that T is not the only factor that can reduce I, thus creating absolute decoupling.

Rebound effects

When dealing with the opportunities for decoupling economic growth from consumption of energy and resources, another challenge arises called rebound effects, which refers to the problem where energy or resource efficiency improvements often lead to additional consumption, which offsets the effect of the efficiency improvements. To take car use as an example: If you replace your old car with a newer, more energy-efficient model that can drive further per litre, what often happens is that the economic savings gained as a result of the increased efficiency are transformed into increased use of the car. In this way, efficiency improvements result in more driving instead of energy savings. This mechanism is also known from house insulation, where improved insulation can lead to higher room temperatures instead of decreasing energy consumption. Finally, rebound effects are also seen in connection with increased consumption due to the economic savings achieved by energy or resource efficiency improvements. To take the example of the car again: If you do not in fact start to drive more or further having purchased a new energy-saving car, you will save money. However, if this saving is then converted into additional consumption because, for example, you buy a new mobile phone, then a rebound effect in the form of an environmental impact will have arisen.

Green growth

An earlier section discussed how growth supporters put their faith in decoupling economic growth and environmental damage to solve the growth dilemma. This approach is often referred to as *green growth* and can be considered a political programme for solving the many economic and environmental crises of our time. In green growth, there is a particular focus on resource efficiency, investment in renewable energy and green innovation. With this focus, green growth is strongly linked to market-oriented solutions, which is also reflected in the idea of using price-regulating interventions, such as resource and environmental taxation, to change economic behaviour, increase resource efficiency and reduce the environmental impact. Furthermore, among some supporters of green growth, a desire to find a new measure for economic growth has also been expressed. The idea often involves supplementing or correcting GDP by means of other indicators that measure environmental and social effects which are not included in GDP.

Degrowth

In line with Tim Jackson's scepticism about the possibility of decoupling, an international movement called *degrowth* has emerged since the financial crisis of 2008. Degrowth supporters argue that economic growth has reached its environmental limits and that it is, therefore, high time that a transition was made to a new economy, which is not based on economic growth. Degrowth is an extensive political programme that addresses many different aspects of the economy, where the solution to the growth dilemma involves transitioning to a non-growth economy that focuses on fair distribution of the resources of the Earth and global society. This does not mean that supporters of degrowth are against resource efficiency and innovation; it just means that they think much more is necessary to solve the growth dilemma. In a global economy that is characterised by resource and environmental constraints, it is also necessary that the limited resources are shared fairly between individuals and nations. In this way, the idea of equality is central to the degrowth movement.

In contrast to green growth, degrowth is a political programme that requires a radical break with the predominant economic logic of economic growth, public cutbacks and increased labour supply. Instead, it involves slowing growth, the fair distribution of income and resources, reducing working hours, and maximum and minimum limits for income, and the opportunity for an unconditional basic income for all.

Another important theme for the degrowth movement is the influence of large companies and super rich individuals on the economy and democracy. This influence is manifested in, amongst others, environmental conflicts where multinational companies attempt to take control and exploit natural resources such as drinking water, oil and fish stocks at the expense of local populations who have lived for centuries in the areas where these resources are present. Therefore, part of the degrowth movement's intention is also to draw attention to these conflicts and to problematise the abuse of the rights of marginalised populations. In this way, degrowth also involves fighting against multinational companies and extremely wealthy individuals' control of natural resources and their influence on politics.

A final point in relation to degrowth also needs to be mentioned, and that is that the financial sector is seen as a significant societal problem and as a central cause of economic instability and inequality. Therefore, for supporters of degrowth it is important that radical steps are taken to control the financial sector through comprehensive regulation, the breaking up of banks that have become too large, and greater government involvement in the financial sector's activities in general. In this way, the financial sector will help the economy instead of being a sector that primarily focuses on how to make a profit from complicated financial transactions.

Growth agnosticisim

Closely related to the degrowth idea is the concept of growth agnosticism, which assumes that economic growth is just not the key socioeconomic problem of our time. For growth agnostics, there is no need to spend so much time discussing whether it is good or bad that GDP goes up or down or what a new measure of growth should look like as there are more important problems, such as climate change, unemployment and inequality, to solve. In this light, discussions and efforts to achieve economic growth are considered an unnecessary obstacle to solving society's most urgent problems.

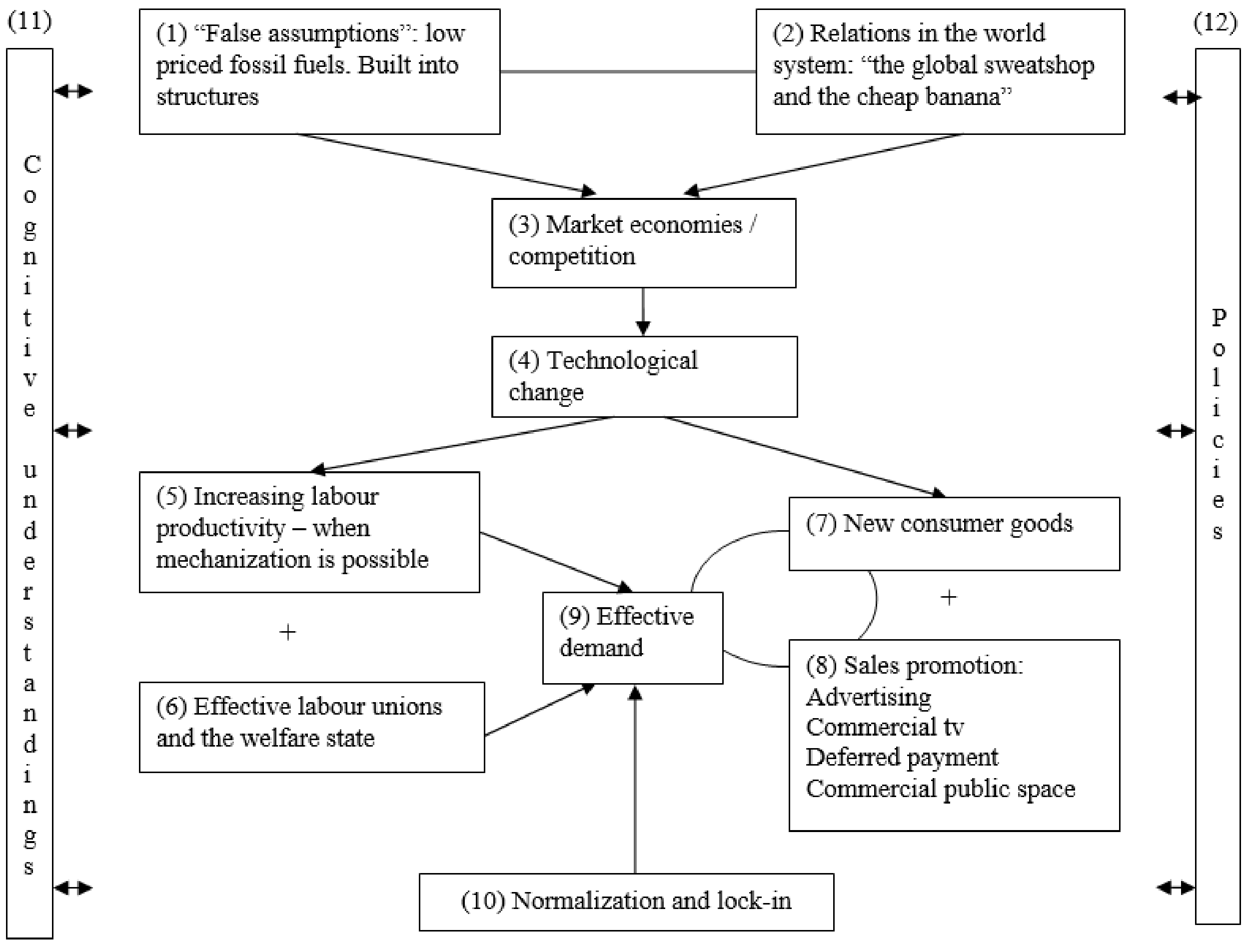
Driving forces and distribution

In the theme on the relationship between growth and the environment, it is argued that there are environmental limits to growth in living standards. But what drives growth and how growth is distributed is not addressed. In this theme, the focus is on the driving forces behind economic growth and the relationship between growth and distribution. Distribution is about who benefits from the growth and there are two aspects to this. Firstly, inequality in itself is one of the driving forces behind the fact that in the rich countries we have been able to increase our material consumption by so much. Secondly, limits to growth mean that there is an ethical responsibility to share.

The growth engine

Inge Røpke

Since the start of industrialisation and especially during the post-WW2 period, we who live in the rich countries have been able to increase our material consumption significantly. In the figure below, some of the key mechanisms behind the growing consumption are outlined. In the accompanying explanation, the numbers in brackets refer to the boxes in the figure. This section illustrates how the unequal distribution itself contributes to growth of the metabolism.



The Growth Engine

The basic prerequisites for growth in consumption

There are two basic prerequisites for the strong growth of living standards in the rich part of the world. First, the significant growth in consumption since the start of industrialisation would have been impossible without access to cheap fossil fuels (1). Fossil fuels equip us with many 'energy slaves' that are used to mechanise production processes and allow large increases in labour productivity, i.e. in the production of goods per work hour. Until recently, fuels have, in general, been relatively cheap because extracting them has been cheap - but prices have also fluctuated and have been heavily influenced by particular political conditions. In contrast, prices only reflect the long-range of environmental and social costs caused by the extraction and use of fossil fuels to a very limited extent. Such costs include mining accidents, oil spills, acidification, particle pollution and global warming. As these costs are not reflected in the price, economic growth can be said to be based on 'false assumptions', and after more than one-hundred-and-fifty years with these assumptions, they have been built into the social and physical structures of society, such as the development of private car ownership and the associated road systems, suburban developments and shopping centres based on low petrol prices.

The second basic prerequisite for high consumption is linked to international relations and the balance of power between the countries in the world system as the early industrialised countries achieved a power position that made it possible to procure raw materials and exploit cheap labour in other parts of the world (2). As industrialisation developed, international relations were already marked by the European countries' colonisation of other parts of the world, and industrialisation reinforced the need to collect raw materials in the colonies. For example, England obtained cotton from India for the development of its textile industry, while India's textile production was undermined by trade restrictions. Not least with the help of protectionism, a number of European countries, the United States and Japan managed to catch up with England, which had been leading in terms of industrialisation, while the colonies were kept as commodity suppliers. Despite decolonisation after World War II, raw material exports still play a major role in many countries, partly because many mechanisms in the global trade and capital transfer systems make it difficult to break the patterns. A certain amount of industrialisation in connection with the relocation of activities from rich to poor countries has occurred, and the global production chains ensure cheap goods from work in the global sweatshop. In addition, political interventions support access to raw materials and agricultural goods in slightly more elegant ways than the military coup in Guatemala, which, as described by the ecological economist, Juliet Schor, secured the 'cheap banana' in 1954. However, as discussed in the section on trade and globalisation below, some countries, such as South Korea and China, have successfully established an internal industrial dynamic and changed the country's position in the world system.

The global balance of power has made it possible to obtain cheap raw materials from mines, forests and agricultural land in poor countries, and gradually the low-paid labour has also delivered industrial products such as textiles, electronics, toys, etc. at very low prices. In biophysical terms, the massive growth in international trade since the Second World War has contributed to the fact that the population in rich countries have been able to increase their material living standards very significantly: the low prices mean that a lot of material resources can be bought for the money. Even in the poor countries, some groups have become richer, but in many places, trade union organisations and social systems are weak or non-existent, so there are large groups that do not receive much of the results. In addition, the environmental costs are enormous including pollution, deforestation, the impoverishment of soil and water resources, while in many areas, native populations have been crushed as resources are extracted in increasingly remote areas. In the field of ecological economics and political ecology, a key research field involves highlighting the environmental conflicts that arise as a result of the extraction and processing of raw materials and the disposal of waste.

Environmental conflicts

The unequal global balance of power and the activities of large companies around the globe often give rise to so-called environmental conflicts, where local populations and other activists fight against an environmentally harmful activity of a company or state. The term 'commodity frontiers' is used to denote the hot spots where such environmental conflicts arise. Commodity frontiers, thus, refer to the places in the world where the extraction and processing of raw materials and waste disposal take place.

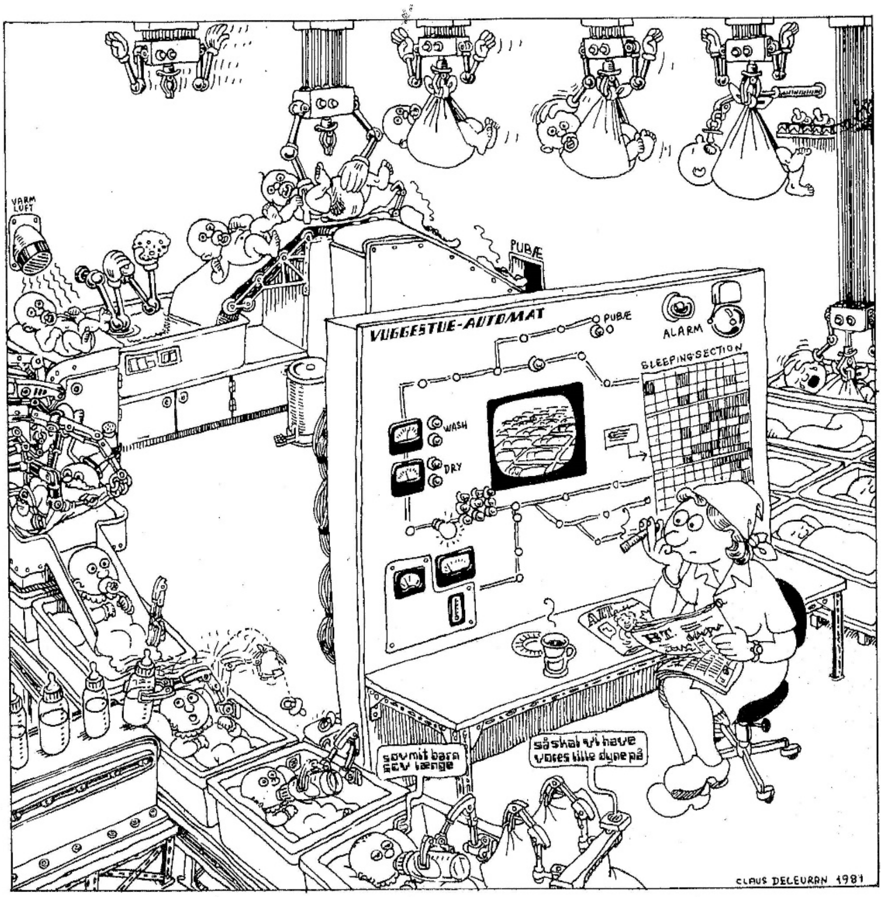
In a major international research project called EJOLT (Environmental Justice Organisations, Liabilities and Trade), researchers and activists, for a number of years, have mapped and described environmental conflicts worldwide in an interactive atlas called the Environmental Justice Atlas (see http://ejatlas.org/). The aim of the atlas is to give a voice to groups who are struggling for environmental justice and to focus on endangered local communities, which are often powerless against multinational companies and national politics and are rarely represented in the media. Furthermore, the project's goal is to draw attention to the negative consequences of the privatisation of natural resources such as water.

The atlas provides several opportunities for locating and investigating environmental conflicts around the world. It is possible to search for conflicts that involve a particular resource (water or gold, for example) or for conflicts involving a particular company (e.g. Shell).

One of the conclusions of the project is that the adverse consequences of the extraction and processing of raw materials and the disposal of waste are unfairly distributed and most often affect the poor, women, minorities and, in particular, indigenous peoples.

The driving forces behind consumption growth

The basic preconditions for high consumption - cheap fossil fuels and access to other cheap resources and labour - are complemented by a strong engine: market economy competition (3). A capitalistic market economy is based on competition between the producers, who must constantly strive to develop technological and organisational innovations (4). If a company's activities are insufficiently profitable, it will not be able to attract capital and ensure its long-term survival, and renewal is crucial to profitability. The innovations partly aim at reducing costs, and partly at offering consumers new and tempting goods and services. When energy is cheap, efforts to reduce costs will be concentrated on increasing labour productivity through mechanisation and automation, where energy in combination with machines replaces labour (5). This focus is enhanced when employees succeed in obtaining higher wages and greater social security through the formation of trade unions and the establishment of a social security net in the welfare state (6). Such strength positions enable employees to get a share in the yield of increased labour productivity and achieve an ever higher standard of living - a process that encourages a continued focus on increasing labour productivity. However, not all production processes are easy to mechanise: It is difficult to provide certain labour-intensive services such as care, repair, hair cutting and theatre performances more effectively through the use of fossil fuels, so they tend to become increasingly expensive compared to material goods. In this way, consumers are motivated to buy more material goods rather than ‘sacrificing’ still more of these in order to purchase labour-intensive services.



Automatic nursery machine. Relative prices: One of the reasons for increasing material consumption is that it is much easier to mechanise the production of material goods than services such as care. Therefore, care becomes still more expensive measured in material goods.

Drawing: Claus Deleuran. Used with permission from the family.

When employees succeed in gaining higher wages, a market for the products that are produced by the companies emerges and consumer demand is stimulated by the supply of new consumer goods, new variants of known goods (7) and various forms of promotion such as advertisements and hire purchase systems (8). Everyday life becomes increasingly embedded in commercial offers as both television and public spaces display the many tempting opportunities. With the exception of the periodic crises, the supply and demand of consumer goods, thus, reinforce each other: Increasing wages ensure customers’ ability to purchase the products (9). The mutually reinforcing circle of supply and demand, productivity growth and rising standards of living constitute a growth engine that enlarges the biophysical metabolism over time. However, supply and demand are not always in balance at the macro-level - demand may be insufficient; the profitable investment opportunities too limited; bubbles in the financial sector may affect the real economy - so in periods, growth is interrupted by economic crises involving bankruptcies and unemployment.

Maintaining consumption growth: normalisation and lock-in

Most people in the Global North willingly play their role as consumers in the growth engine and do not consider themselves to be particularly extravagant. This is due, among other things, to the processes linked to normalisation and lock-in (10). When there is an economic boom, there is often a craze for a particular type of consumer good, as illustrated, for example, by the wave of housing improvements (first kitchens and then bathrooms) that were made up to the financial crisis or the purchase of flat screens in the 2000s. When the boom is in progress, improvements may seem extravagant and feel like pampering, but as time passes, the new standards become normalised: Having more than one bathroom in the home and flat screens in several rooms will become the new norm and will be expected. Some normalisation processes involve changes on several levels, such as changes in social discourses, political measures, institutional renewal, construction of infrastructure and new scientific insights. The story of the spread of air conditioning in a number of countries is an interesting example of a normalisation process that involves all these aspects, and currently, the integration of information and communication technologies in everyday life provides an opportunity to study such processes in full development.

When new products and a higher standard of living become normalised, the new standards are built into society's social and material structures and can, thus, develop into a form of constraint. In a car-based society with vast suburbs and an inadequately developed collective transport system, the car becomes a necessity, or at least a good that is difficult to do without. In this way, the other side of the coin of freedom is constraint. When there are no longer any local stores, you have to shop in the supermarket and when houses are built to include air conditioning, they can be uninhabitable without, and when music can no longer be purchased on vinyl, the music lover must start to buy the new media. In addition to material constraints and incentives, various institutional factors can also help maintain living standards and consumption patterns. For example, car transport is encouraged by regulatory institutions such as transport allowance and the demand that unemployed people must accept job offers from employers located far from their homes. Normative and cognitive institutions, such as the perception that passing a driving test is a ritual step on the way to adulthood and the tendency to associate the car with personal freedom, have a similar influence.

In general, social and material inflexibility can help to bind consumers to resource-intensive lifestyles. For example, the labour market institutions in many countries are calling for full-time employment because the rules make it more expensive for employers to have a large number of employees sharing a set number of work hours. When the system encourages employees to choose income instead of leisure time, it initiates a process that Schor has termed a 'work-and-spend cycle' - a cycle that is also stimulated by the busyness of modern families and the development of shopping as a popular recreational activity.

The ideological and political framework for consumption growth

The engine of consumption growth functions within a supporting framework of cognitive understandings and policies. The cognitive understandings (11) include the idea of economic growth as an absolute good, regardless of the standard of living a society has already achieved. There are many other ideas such as: welfare is directly linked to income; economic growth in the rich countries has a positive effect in poor countries through the demand for their products; free trade is good for all parties involved; markets and healthy competition contribute to the common good; technological change is synonymous with social progress; and environmental problems can be solved with more efficient technologies. These ideas are controversial, but they are still dominant and are reflected in different policies (12), such as the promotion of free trade (although at times excluding trade restrictions, which are beneficial to the rich countries) and competitiveness, the privatisation and liberalisation of markets, the implementation of consumer policies that focus on ensuring low prices, the construction of more and more highways and the continuance of low energy prices.

Trade and globalisation

Inge Røpke

The idea that free trade is good can be seen as one of the ideas that support the growth engine. However, the idea is challenged when adopting an ecological economics perspective. This section gives an example of how a different picture emerges when looking through biophysical glasses than when wearing more traditional economy glasses.

It is widely accepted that free trade is good. The most important argument is that trade provides greater potential for the division of labour and specialisation, which means that overall production will increase because resources are used in the most efficient manner. Each country can specialise in the industries for which they are best equipped and through trade gain access to a greater amount of goods than the country could have produced in isolation. The obstruction of access to larger markets by barriers may be problematic, especially in small countries because the national market may be too small to exploit economies of scale. Furthermore, an argument for free trade is that everyone is exposed to competition, which means they are forced to increase productivity.

The idea of free trade as being good for everyone has been thoroughly criticised, also from other perspectives than the biophysical. For example, the idea can be criticised for adopting a static perspective by emphasising the benefits that are connected to the division of labour and specialisation at a given point in time. In contrast, a dynamic perspective would emphasise the importance of trade for the development of a country over time. In order to complete the transition from an agricultural to industrial society, it is obviously essential to build industry. However, this may be difficult if the process is not protected from competition from more advanced countries. If predominantly raw material-producing countries are forced into free trade, they run the risk of ending up in a specialisation trap, which may be difficult to escape. Therefore, it is no surprise that the vast majority of countries that have successfully undergone industrialisation have managed to do so through protection against foreign competition. As industry becomes stronger, the country can gradually be exposed to competition, thereby increasing the pressure for efficiency. What may also be crucial for a successful industrialisation process is the regulation of the composition of imports by the state so that, for example, machines for industry receive higher priority than consumer goods, which is what Denmark did after World War II.

The process can be made difficult in many ways. For example, the industrialised countries have used a form of asymmetric trade liberalisation by refraining from imposing duties on imports of raw materials, such as cotton from developing countries, while imposing high duties or quantitative restrictions on imports of finished goods such as cotton clothing from the same countries, which therefore found it more difficult to industrialise. As another example, the EU's state aid for its agricultural production and exports has made it difficult for some developing countries to develop their agricultural sector. At the same time, local elites in some developing countries have prioritised making themselves rich through raw material exports instead of investing in economic development.

In recent decades, some developing countries have managed to industrialise and use trade as a tool in the process. One often hears the argument that trade and globalisation have contributed to lifting 300 million Chinese people out of poverty. It is true that regulated trade (not free trade) has been an important part of industrialisation, not least in China, which needed to import advanced technology from other countries and obtained the necessary funds for the imports through the export of labour-intensive industrial goods (textiles, assembly of electronics, household utensils, tools, toys). However, from a biophysical perspective, the fact that the development process involved the population of the rich countries increasing their material consumption is problematic. Due to the very low wages in the newly-industrialised countries, many products became very cheap, which helped to promote the throw-away culture in the rich countries and that a given amount of money could mobilise a larger amount of material resources. Furthermore, in the case of many products, this meant that production resulted in more pollution because Chinese energy production was based on coal from less efficient power plants. The point of this perspective is not to argue that China and other countries should not industrialise and lift their population out of poverty, but to illustrate the absurdity that the present system only allows the process by making the rich richer and by undermining the environment. A more environmentally rational and more ethically defensible system would lift people out of poverty without increasing the consumption of those who already have so much.

The biophysical perspective includes other criticisms. For example, it is obvious to focus on the environmental aspects of transport. The strong growth in global trade is based, amongst others, on low and declining transport costs because of major efficiency improvements, especially in the form of labour-saving technology. Even though the energy consumption per transported unit has also fallen, energy consumption and pollution that result from freight transport are significant - costs which are not paid for. If the environmental costs of transportation had to be paid for, it would not be worth engaging in trade to the same extent as now. Global trade flows also hamper the circular economy for biomass. For example, exporting soy from Latin America to feed pigs in Denmark, which results in nutrients ending up in Danish watercourses, is not very rational.

Ecological economics also highlights the problematic fact that trade helps to conceal biophysical limits. On the one hand, that countries complement each other in a biophysical sense may be seen as a great advantage. When economic growth in a country encounters biophysical limits, such as a lack of soil, water, forest, minerals, energy - trade makes it possible to overcome the barriers and continue growth. On the other hand, this process means that all resources are exploited to the utmost, and that humanity approaches many biophysical limits at once. The potential to bypass the limits means that we are oblivious to the danger signals that could have served as a feedback mechanism making us change course.

So far, the discussion on trade has implied that it takes place between countries, but most trade actually occurs between companies. Nation states can regulate the framework, but today many companies are so large that they have significant influence on the framework and can play states against each other. The theory that trade is beneficial to all the countries involved is based on the assumption that production factors, such as work and capital, are tied to particular countries in the same way as raw materials. However, the increasing liberalisation of, in particular, international capital flows since the 1980s has meant that this assumption is being met less and less frequently. The large multi-national companies organise supply chains throughout the world and exploit the benefits that are associated with specific locations, and organise capital transfers in order to minimise their tax payments. Globalisation, to a great extent, challenges states' ability to regulate product standards and environmental conditions, while undermining unions' ability to defend labour and working conditions. In addition, companies are trying to privatise an ever-increasing number of areas, so money can be made from, for example, water supply, education and health services, which are or have been organised collectively in many countries. Current discussions on trade agreements only concern the reduction of tariffs and the elimination of quantitative restrictions to a limited extent. They are more concerned with expanding the scope of the transnational corporations, making more areas subject to privatisation, preventing states from tightening product and environmental regulation and securing earnings on intellectual property rights.

Even though the old free trade argument has been undermined by the mobility of capital, liberalists still assert that free trade is beneficial to everyone because it results in goods being as cheap as possible: they are produced where the costs are lowest, while competition constantly ensures that productivity increases by as much as possible. Whether this is actually the case in practice may be questioned, but what is more important is that high costs are excluded from the calculation: the environment suffers damage, working conditions are undermined, and the welfare states can not be financed. For the individual, that it is possible to fly cheaply with low-cost airlines may seem like a gain, but the collective costs include climate destruction, deteriorating working conditions and the dismantling of the welfare state.

The effects on distribution are complex. On the one hand, that income has risen for large groups in poor countries may be considered progress, but on the other hand, globalisation has increased inequality in many industrialised countries, especially in the United States and the UK, where the wealthiest have become richer, while the middle-class have lost ground. The fact that there have not been many protests for a long time is probably due to the combination of low prices for many product groups and the significant growth in credit, which has made it possible to maintain living standards - until the financial crisis put an end to that.

In the longer term, an ecological economics approach would suggest that the economies be more self-sustaining in the biophysical sense, so that the cycles can be more easily closed, transport reduced and the constraints made more visible. In many areas, demographic and technological development has made trade unavoidable - in some areas, enough food can only be obtained in this way, while in Denmark, for example, it is hard to imagine an economy without electronic equipment, for which we do not have the resources to manufacture. However, regulation of the environment, working conditions, capital flows and much more is necessary to ensure that trade occurs on reasonable terms and that we do not get the goods too cheaply.

Distribution of use values in a society

Inge Røpke

As previously mentioned in the theme on growth, ecological economics supports the idea that a society produces a 'real cake' during the course of a year, an amount of use values that society can either consume during the year or invest in future consumption opportunities. Even though the production result can not be measured in a meaningful way, we still have a clear idea that it will be unevenly distributed. Some groups in the society get better food, have larger homes, are more mobile, etc. than others. The distribution of goods is an aspect of the way society and the economic activities are organised.

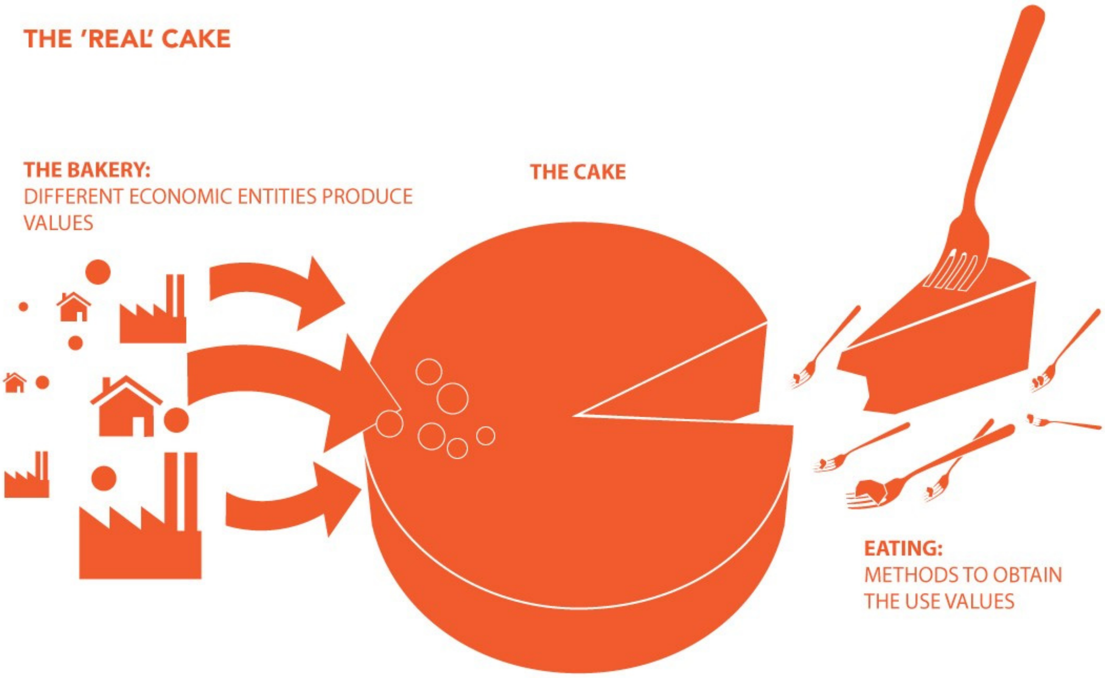
Distribution is considered to be a political question, which mainstream economists will often seek to avoid by directing it to politicians. Many mainstream economists believe that their personal theories about how the economy works is value-free and can be used as a neutral basis for political debates. However, ecological economists consider this view to be totally misleading and instead emphasise that values are integrated in the concepts and perspectives one uses. In the field of ecological economics, distribution is clearly addressed: the recognition of biophysical limits is combined with a desire to redistribute to the benefit of the poor. Today we live in a world of great inequality and widespread poverty, and there is a great need to improve the living conditions of the most disadvantaged.

Biophysical limits imply that it is impossible to solve poverty problems solely through growth. Technological development may well make it possible to obtain more use value and higher living standards out of the resources, but this will still be insufficient. If this view of the situation is combined with a value-based belief that all people should be guaranteed good living standards, it results in an ethical demand to redistribute to the benefit of the poor.

Basic model for distribution

The traditional neoclassical circular flow model, where companies sell goods and services to households, which sell production factors to companies, encompasses the idea that production factors are paid in proportion to their contribution to production. The theory, thus, legitimises inequality as a result of anonymous market forces. In ecological economics, the basic model is different: there is no circular flow where everything fits together.

Instead, on the one hand, there is a production process where many different economic entities (companies, households, public institutions, local communities, organisations, etc.) help produce the production result - the real cake of use values - some of which are traded on markets. On the other hand, there is a distribution and consumption process, whereby members of society gain access to the use values by way of a number of methods. To continue with the cake metaphor, there is no general connection between individuals' contribution to the bakery and their access to eat the cake. The allocation mechanisms are far more complex and are based on a long history of conflicts and power relationships that have crystallised into the current institutions and mechanisms.



Sharing society's cake: Sonja Winckelmann Thomsen

Distribution mechanisms

The most decisive factor in terms of an individual's access to use values is where they were born or possibly where they are living. Branco Milanovic, who is an expert in the study of distribution, calls it 'citizenship rent' - that an individual's living standards depend more on where they are than what they do. You can be hard-working in a developing country and yet get very little out of it because your tools and society's infrastructure are poor (as neoclassical economists would emphasise), and because local and global power structures put you in a weak position in the struggle for distribution. Personal effort is not the most decisive in terms of benefit.

It is obvious to divide a society's allocation mechanisms into two broad groups depending on whether they are linked to markets or not. In markets, access to goods is determined by whether you have purchasing power in the form of money, while access in other contexts is decided by other types of institutions. For example, the distribution mechanisms within a household are usually based on conventions about who is entitled to what, to which there is a major element of care attached. With regards to the public sector, the distribution of goods is often based on rights. These may be rights to the transfer of purchasing power in the form of, for example, pensions or support for education, or they could be in the form of access to use goods, such as medical assistance or education, which are made available by the public sector.

As previously mentioned, purchasing power is crucial to be able to secure goods on markets. In modern societies, the vast majority depend on acquiring purchasing power. Some use value is created within households, for example, when we grow vegetables in the garden, make food, clean and look after the children. However, households also need a lot of goods and services that they can not produce themselves, while they have to acquire raw materials and equipment from other parts of the economy for their own production. How do they obtain purchasing power? In our society, most people would probably first think about working to gain purchasing power: When we contribute to producing the real cake, we get a salary. Purchasing power can also be obtained by virtue of ownership of assets that are used in production such as land, buildings, machinery, patents, trademarks and other rights. The assets may be owned by individuals directly or indirectly through their ownership of, for example, shares in a company. Financing production through lending can also provide access to payment in the form of interest.

According to the neoclassical circular flow model, everything fits together: When companies sell goods, an amount is received which pays for the production factors in the form of salary, interest on loans, payment for the use of patents, stock dividends, etc. However, everything does not fit, partly because purchasing power also occurs in the form of capital gains. If a company is successful with its goods or if it owns an important patent, the price of its shares may increase. The owners can convert this into purchasing power through, for example, borrowing. Purchasing power can also arise in relation to the ownership of other assets as property rights sometimes provide a particularly high profit as a result of changes in society. For example, when railways were established, the land near the new stations increased in value. This form of earnings which is created by society is called ‘rent’ or ‘unearned income’ - a gain that the owner of the asset acquires solely through ownership and not by virtue of any effort. A more recent Danish example is the capital gains that many homeowners received as a result of the introduction of new types of loan in the early 2000s. Assets can also decrease in value, for example, land or houses losing value due to the construction of wind turbines or motorways nearby.

The allocation of purchasing power among society’s citizens, to a large extent, is based on the balance of power and associated institutions. The balance of power is decisive, not least for the relationship between what can be earned through work and ownership of assets, respectively. In societies with strong employee organisations, a relatively higher amount can be earned via paid employment than in societies with weak organisation. Historical conditions play a major role in the balance of power. For example, the large sacrifices made during WWII created the basis for strong ideological support to the construction of a welfare society for all, which was, amongst others, based on wealth taxes and a high rate of tax on high incomes. The establishment of the welfare state's social security system also put a limit on how hard workers could be pressurised. In many countries, this social compromise was actively attacked from the 1980s onwards, so the owners of assets became far stronger in the struggle over distribution. This has gradually manifested itself in the form of changed tax systems and a weaker social security safety net. In addition, privatisation has facilitated the establishment of private property rights for assets that had previously been communal or publicly owned. For example, this applies to different types of infrastructure and resources such as fish. Furthermore, the patenting of new areas, such as software and genetically-modified organisms, has been opened.

Purchasing power through credit

In modern societies, credit plays a major role in the distribution of purchasing power and the relationship between the flow of purchasing power and the real cake. In societies with well-developed banking systems, it is possible for companies and people with new ideas to start something without having the necessary purchasing power. Furthermore, they do not need to borrow purchasing power from others who would have to give up purchasing power because the banks (and the state) can create new purchasing power. In practice, it works as follows: the bank gives the company a loan of, for example, 1 million DKK, partly by preparing a loan document, which says that the company owes the bank 1 million DKK, which is subject to a certain rate of interest and which has to be paid back in a certain way; and partly by increasing the amount in the company's bank account by 1 million DKK. The amount does not come from anywhere else; it is created as soon as the figure in the bank account is increased. The amount is now money, i.e. a commonly accepted means of payment. There is a limit to how much money a bank can create in this way, but there is a lot of scope for creating new purchasing power. The fact that money can be created through credit provides great opportunities for starting new production and, thus, increasing the real cake. At the same time, the process makes some new demands on the real cake. Firstly, the loan must be repaid plus interest. Secondly, the owners who may, for example, have contributed share capital, expect a return. The institutions of society can easily be arranged so that lenders and owners earn a return on their assets, which increases purchasing power more than the real cake increases as a result of the new initiative (if it was possible to measure the growth of the real cake).

The disparity between purchasing power and growth of the real cake is increased when banks create purchasing power, which they lend for the acquisition of existing assets such as housing. Trade in existing assets does not increase the real cake (although, in some cases, its usefulness), but the demands on the cake increase as the flow of purchasing power increases. The same occurs when the growth of society generates undeserved income in the form of capital gains. In addition, since the 1980s, the financial sector has developed increasingly complex mechanisms that increase the flow of purchasing power without contributing to the real cake. As a result, the total purchasing power demand on the real cake increases far more than the cake itself, and an increasing proportion of the demands are appropriated by the groups that are already best placed.

Increasing inequality is a problem in itself, especially in a world of biophysical limits. In addition, the imbalance contributes to the emergence of economic crises, while the financial mechanisms create bubbles with increasing asset prices as well as mountains of debt, which trigger financial crises.

The consequences of uneven distribution

Various institutions and mechanisms reinforce inequality once it has emerged. For example, the opportunity to inherit implies that new generations in rich families do not have to start from scratch, but instead enter the struggle over allocation with good cards in their hand. At the same time, large fortunes provide special opportunities to obtain higher interest rates and exploit tax havens, which companies in strong positions can utilise to become even stronger. In the United States, in particular, the question of whether significant inequality is undermining the political system because money has become so crucial for gaining political influence is being increasingly discussed.

The allocation mechanisms are sometimes defended by arguing that they help support technological development. For example, the patent system allows the initial outlay to be recouped after investing heavily in development. However, the system is being increasingly criticised for being too lucrative and, in some cases, a hindrance to development. More generally, it may make sense to introduce incentives that promote innovation, but the current structure of the allocation mechanisms leads to results that are completely out of proportion.

The desire to promote innovation is often linked to the idea that it increases the size of the real cake that is to be allocated. It is true that innovation can help increase the amount of use value derived from the resources, although this is not necessarily the case. In this regard, it is important to consider the more general point that both the direction of innovation and the composition of the cake are strongly influenced by the distribution of purchasing power. The cake is not baked first and then allocated afterwards. On the contrary, purchasing power determines what sort of cake is going to be baked.

Eflornithin and sleeping sickness
In this section, it is argued that the demand, based on the ability to pay, has an influence on the content of society's cake. There follows an example of this from the textbook on ecological economics by Herman Daly and Joshua Farley.

Some decades ago, the pharmaceutical company, Aventis, developed a drug called Eflornithin, which could cure African sleeping sickness. There was high demand for the drug among poor Africans, but unfortunately they did not have enough purchasing power to ensure satisfactory income from the product as far as Aventis was concerned. Instead of marketing the product by focusing on curing African sleeping sickness, Aventis chose to sell the patent to another pharmaceutical company, which used Eflornithin as a drug to treat unwanted facial hair on women. This new product was in high demand among wealthy Westerners. This illustrates how purchasing power can be decisive in terms of which products end up on the market, thereby becoming a part of society's cake.

However, this particular story ended well as the organisation, Médecins Sans Frontiers (Doctors Without Borders), threatened to publicise the issue, which forced Aventis to resume production of Eflornithin as a medicine against sleeping sickness for poor Africans.

View on nature and ethics

The term, nature, plays an important role in the understanding of sustainability. The way we perceive nature influences how we treat the different species with which we share the planet. If you think the ocean is a pantry for humans, you will probably be less inclined to think that life in the ocean is not necessarily just for human survival and satisfaction. If you primarily think of the pleasure you derive from eating meat, it is less likely that you will consider the fact that meat production raises ethical questions and has consequences for nature around us. Meat production often entails animals being caged in with very little space, tied up and exposed to pain.

Indeed, agriculture as a whole means that areas with great species diversity are continually being transformed into so-called monocultures, where the diversity has disappeared and only a few crops grow. This certainly meets human needs, but it does not benefit many other species on Earth. Through time, ethical problems of this type have been the subject of philosophical reflections about humans' relationships with nature. Such reflections concern the way nature is viewed and ethics; the latter meaning philosophical considerations of a moral type. In this theme, we provide a brief overview of some important topics in this field.

Nature and ecophilosophy

Emil Urhammer

At first glance, the word *nature* may not seem very complicated. Nature; it is the forests, mountains, rivers, animals and plants. However, if you think about it more deeply, it may not be so easy to define nature. Is a corn field that has been grown by humans, or a forest that has been planted by humans, or a stream whose meanders have been restored by humans, nature? There is probably no unequivocal answer to this question. Some would say *yes* because they think everything is nature. According to this understanding, human culture, cities, and technology are also considered to be part of nature. Such a view is also called deep ecology or ecophilosophy. According to the late Norwegian ecophilosopher, Arne Næss, human beings are an integral part of nature, and the moral basis for humanity is to achieve a situation where people are living in ecological balance with their surroundings. Næss believed that humans are the first species on Earth who are able to consciously relate to their own role in nature. For example, humans can assess whether the total number of people is too large for us to live in balance with the rest of life on Earth. This imposes a moral responsibility on humanity, which other species do not have. However, given the current situation, one may ask how worthy we are of this obligation.

In addition, some assert that human society and nature have become separated. For example, the biologist, Rasmus Ejrnæs, says: 'The separation between nature and humans now demands that we either file for a permanent divorce because living together has become too difficult, or that we prepare ourselves for peaceful coexistence and focus on biodiversity' (in the book *Natur*, Tænkepauser – viden til hverdagen, Århus Universitetsforlag 2013). Ejrnæs is a biologist who works with species diversity, which is also called biodiversity. The philosophical question of whether humans are part of nature is probably not his most important consideration. He just observes that the way people are currently living is in violent conflict with most of the other species on the planet, which is why he encourages us to recognise that we need to find a way of living in peaceful coexistence if we want to preserve biodiversity. In this way, Ejrnæs's interpretation is perhaps not so far from Næss's dream of people living in ecological balance with their surroundings.

Population

In terms of achieving balance and peaceful coexistence between humans and other species, the question of population plays a central role. Some think that the fact that there will soon be 10-11 billion individuals on the planet is not a problem, while others believe that the current population of approximately 7 billion is already far beyond what is beneficial to both humans and other species. This discussion is extremely complicated and involves both moral and more technical aspects. If you always think 'humans first', the fact that we are so many may be interpreted as a sign of humanity's strength and superiority. If you have this opinion, you may not think it is a problem that a lot of species are dying to provide space for human activities. On the other hand, if you think that all other species, in principle, also have the right to live, you will probably think that it is extremely problematic.

The more technical side of the issue is that we humans could probably learn to take up a lot less space and fewer resources if we just gave it some thought and organised ourselves differently. For example, several environmentalists believe that if we stopped eating meat, it would allow other species to thrive. The reason for this is that meat production takes up a lot of land because the animals that we eat need very large amounts of water and feed. In this way, we use a huge area of land to feed the animals we eat. If we did not eat animal products, this area would be reduced and could instead be used by other species.

Not only biological life

In the discussion of humans' place in nature, people often talk about humans in relation to other biological life, but the question is more comprehensive than that. In principle, these considerations also concern, for example, mountains, rivers and the oceans. What is the significance of blowing up mountain peaks to find coal? Or damming rivers? Or filling the ocean with plastic waste? Among indigenous tribes, it is not uncommon to consider mountains or rivers as living things which also have rights. If you understand the world in this way, how we treat the mountains, rivers, oceans and the air is very important as they are often perceived as conscious and sacred beings. According to such a perspective, not only humans have rights as mountains and rivers are also considered to be living creatures with special rights. For example, in South America, attempts have been made to include the rights of nature in the constitution of certain countries.

View on Nature
The philosopher, Hans Fink, has worked extensively with the concept of nature and has identified seven different widespread interpretations, which can be seen as different ways of perceiving nature. Here is a brief description of each.

1. Nature as ‘unspoiled’ is the idea of nature as being that which is completely untouched by humans. Therefore, nature is that which is still in its original state; untouched by human influence. According to this perspective, a remote desert or untouched virgin forest is nature.
2. Nature as 'wilderness' is the idea that nature as that which has not been cultivated by humans. This idea is connected to the difference between cultivated and non-cultivated land. According to this view, nature is: virgin forest, mountains, deserts, marshes, tundra and wilderness which is inaccessible to humans, although forests, heaths and beaches that people frequent and exploit for hunting, fishing and the gathering of wood, are also considered nature. The antithesis of nature, in this perspective, is the cultural landscape, which is the subject of human cultivation and planning.
3. Nature as 'rural' is the idea that nature encompasses everything in the countryside outside towns. In this view, it does not matter whether the land has been cultivated or is untouched. What is important is that it is not a town. The border of nature thus extends to the outskirts of the town.
4. Nature as 'green' is the notion of nature as living and organic. Therefore, the dividing line between nature and culture cuts across towns and countryside and concerns the difference between organic and synthetic. In this perspective, a wooden spoon is more natural than a computer or an artificial chemical, and the city’s gardens, parks and potted plants are also considered nature, whereas concrete buildings, asphalt roads and plastic bottles are not.
5. Nature as ‘physical’ is the idea of nature as that which science is concerned with. Therefore, nature is phenomena such as gravity, electromagnetism, atoms, black holes and energy. According to this view, nature is objective as opposed to subjective, social and cultural.
6. Nature as ‘earthly’ is the view of nature as that which has been created by a divine being. In this perspective, nature comprises the material world we live in, which is in contrast to the heavenly or spiritual kingdom where God resides.
7. Nature as ’everything’ is the idea that nature comprises everything: the world, the universe, the cosmos, etc. In this view, everything from deserts and cultivated fields to electronics and smart ideas are nature. Thus, in a way, all the other ideas are combined together into one: Everything is nature.

Listen to Hans Fink talking about the seven view of nature here:
https://www.youtube.com/watch?v=MspVir4Qr0

Nature - in the service of humans
Susse Georg

There are many ways of defining nature, but the view of nature as a resource has gradually become widespread. Here nature is regarded as a supplier of raw materials or resources, including the energy we use to maintain society. Among the essential raw materials are, for example, pure drinking water, agricultural land, rare earth metals and different types of energy carriers such as wood, coal and oil. Some of these materials are renewable, i.e. they can be restored (within the foreseeable future), while others can not and are considered non-renewable. Wood is considered renewable because a forest can grow again. On the other hand, coal, gas and oil - the fossil fuels, which are formed by organic matter (plants and algae) having been under pressure under the ground for many millions of years, are not considered renewable raw materials.

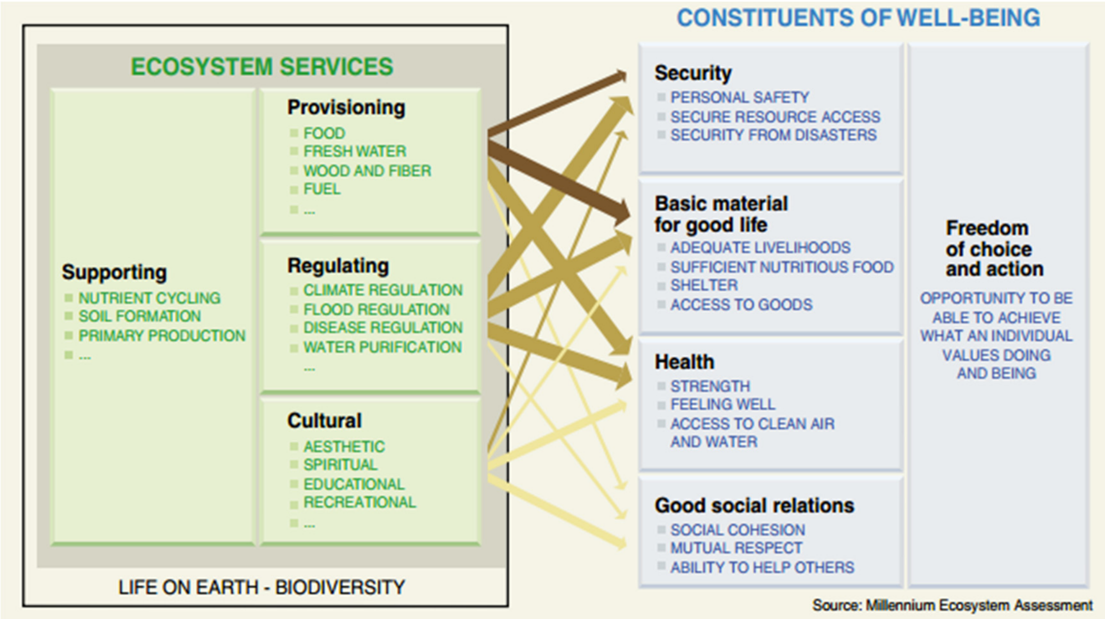
Humans use incredible amounts of raw materials. For this reason, there is great interest in determining the size of the stock of raw materials and how nature's material flows function. In view of the increasing human population, determining whether there are enough resources to maintain our growing consumption so that future generations will also have an opportunity to use natural resources has become important. However, there is no simple answer to this question. Some have stressed that there are 'limits to growth', while others claim that as a result of technological development we will be able to find alternatives and, thereby, reduce or completely eliminate our dependence on certain limited raw materials. Although this may, of course, be possible in many cases, there seem to be some raw materials that can not be replaced by others. This includes, for example, phosphorous, which plays a crucial role in plant photosynthesis and in food production.

One can also apply a so-called process view of nature, where material and energy flows and their interaction with living organisms are central. This interaction between living organisms and their physical environment - between the biotic and the abiotic – takes place in ecosystems whose development is determined by the mutual influence and dependency of organisms and their environment. Thus, biological, physical and chemical processes form part of a wide range of mutually influencing cycles.

From a human perspective, the results of these processes are often termed ecosystem services, and they are vital to the maintenance of life. A distinction is made between the following four types of ecosystem services:

1. *Provisioning services* such as the provision of food and wood for furniture production and construction. These services are not only based on natural resources and material/energy flows, but also depend on the use of human labour, machinery, etc.
2. *Regulatory services* which are linked to the capacity of ecosystems to, for example, convert (and retain) nutrients in the soil or water and in this way may affect soil and water quality. The pollination of plants is another extremely important regulatory service as it affects food production. If plants were not pollinated, production would decrease. In this connection, the decline in the number of bees has attracted much attention.
3. *Cultural services* are the experiences people can get from ecosystems, for example, in connection with recreational activities such as hiking in the woods, or picking flowers and berries. Landscapes can also provide such services by containing things that are considered valuable and worthy of conservation, for example, geological formations, such as cliffs, or different types of cultural heritage such as burial mounds.
4. *Supporting services* are those that support the provision of the other services. Examples include photosynthesis, nutrient cycles and different soil conditions.

Therefore, ecosystem services are crucial to our well-being - our mutual relationships, health, quality of life and safety. For this reason, these services must be protected or managed in such a way that they are not destroyed by pollution or overuse. For example, chemicals can leach into the groundwater and destroy our drinking water, agricultural soils can be exhausted so that it is not possible to maintain agricultural production, and the habitat of pollinating insects can disappear so that the population of such insects decreases or completely disappears.



Overview of ecosystem services and their relationship with important factors for human welfare. Source: the Millennium Ecosystem Assessment.

http://www.millenniumassessment.org/documents/document.356.aspx.pdf

However, there are many indications that our use of ecosystem services is out of control. According to the Millennium Ecosystem Assessment Report of 2005, during the last 50 years, ecosystems have changed so much that they are either overloaded or are about to be destroyed. In other words, humanity is well on the way to undermining society's opportunities for future development as there is a risk of rapid irreversible changes to ecosystems which may have serious consequences for our well-being. Against this background, many have begun to assert that there are limits to what the planet's ecosystems can cope with - the so-called planetary boundaries (see the infobox on 'planetary boundaries' in theme 3, 'Growth and the environment').

The two perspectives on human relationship with nature discussed above provide two different descriptions of the challenges we face. From a resource perspective, it is important to determine how many raw materials we have left, where they are and how accessible they are. What becomes worrying in this connection is whether we will run out of certain raw materials, and if so when, and whether it will be possible to find suitable alternatives and if not, what will be the social, political and economic consequences. In the process perspective, the focus is not on individual raw materials or resources, but rather the dynamic interaction between (biological) organisms and their surroundings and between different ecosystems. Thus, it represents a systemic perspective where the concern is not only that societal development will lead to resource scarcity, but also changes in the dynamics of ecosystems and, thus, their resilience. Limits to growth are also applicable here; limits connected to the destruction of the fragile balance of ecosystems, which, if pushed too far or destroyed, will undermine conditions for life. The transition of society in a more sustainable direction, thus, requires caution in terms of how we deal with nature regarding both our use of raw materials and ecosystem services.

Environmental ethics

Emil Urhammer

In this section, we introduce some important concepts in environmental ethics. These concepts function as tools for discussing various environmental dilemmas and conflicts.

Anthropocentrism and ecocentrism

The problems in this theme about the view on nature and ethics can also be considered with the help of the concepts anthropocentrism and ecocentrism. The word *anthropocentrism* is a combination of the ancient Greek word *anthropos* (human) and the Latin word *centrum* and refers to the view that the human species is the centre of the world and is above other species, and that the interests of humanity override concern for other species. Several environmentalists have used the concept to point out how concern for humanity's survival and well-being is now on a collision course with the life-sustaining systems on Earth to the detriment of other species and humanity itself.

In contrast to anthropocentrism, ecocentrism, like ecophilosophy, expresses the belief that humankind is just one of many equal pieces in the planet's whole ecosystem. In this way, ecocentrism highlights humans as being part of nature and not a species separate from it. According to an ecocentric world view, other species are equal to humans, and consideration of other species is just as important as consideration of humans. In relation to this, it should be mentioned that the environmental ethicist, Finn Arler, has put forward the argument that ecocentrism is also anthropocentric because it is not possible for humans to look beyond the horizon of their species. We humans will always put ourselves in the centre of our view of the surrounding world. This manifests itself in dilemmas, whereby, even though one wants the best for all species, one ends up prioritising human considerations. Rasmus Ejrnæs gives a humorous example of such a dilemma in connection with 'pests' such as Spanish slugs. On the one hand, one may argue that Spanish slugs have just as much right to live as any other species, but it may be necessary to kill them when they eat one's home-grown salad.

Intrinsic and instrumental value

In environmental ethics, the concepts inherent and instrumental are often used to talk about the value of different natural goods. If you believe that a rare butterfly or a particular plant has value in itself, i.e. value regardless of whether humans know of its existence or like it - one can say that the butterfly or plant has intrinsic value. If, on the other hand, you think that the rare butterfly or plant only has value because people derive pleasure from it or can use it for something, then the butterfly or the plant has instrumental value. In the latter case, the butterfly's beautiful colours or the plant's tasty berries could be examples of instrumental values.

When discussing different social priorities, such value perceptions may also play a role. To put it simply, one can say that there is often a tendency to prioritise natural goods higher when they have instrumental value, i.e. value for humans. An unspoilt nature area will, in the eyes of many, have greater value if people have access to it and can use it for recreational purposes than if it just exists somewhere untouched without being of direct benefit to humans. However, the unspoilt area may be the habitat for many species and is, therefore, important for preserving biodiversity.

In order to preserve biodiversity, it may be necessary to emphasise the inherent value of all species. This approach emphasises that a boring gray beetle has just as much right to live as a colourful butterfly or a pet. Rasmus Ejrnæs has argued that humanity does not need great biodiversity to survive on Earth, which means that the conservation of biodiversity requires other moral arguments such as the fact that all living beings have inherent value and thus the right to live regardless of whether we humans have a use for them or not.

If you think about it a little more, you will discover that inherent and instrumental value are not separate or mutually exclusive. It is, thus, possible to consider something as having both inherent and instrumental value at the same time. For example, you might enjoy a butterfly's colours, while at the same time thinking that the butterfly has value in itself, regardless of whether you enjoy looking at its colours or not.

The idea of intrinsic and instrumental value can also be linked to the more overall world views of anthropocentrism and ecocentrism in the sense that instrumental value can be understood as an anthropocentric value perspective, whereas intrinsic value is well-aligned with the ecocentrist perspective. However, there is no need to make a sharp distinction between the two and say that anthropocentrism only encompasses instrumental values and vice versa. Instrumental value can also be considered ecocentric, while intrinsic value can also be considered anthropocentric. For example, in the first case, a flower may have instrumental value for a bee (instead of a human being), so you could say that only humans are able to understand the concept of intrinsic value and, therefore, this whole idea is anthropocentric.

Ecosystem services

The idea of inherent and instrumental value is also related to our perception of ecosystems and their conservation. If you have an instrumental view of ecosystems, you will interpret an ecosystem as something that provides a service to people. Thus, from a human point of view, it is the function of the ecosystem that gives it value. For example, a forest is an ecosystem that supplies different services to humans. It can clean rainwater on its way down to the groundwater, thereby delivering clean drinking water. It can also deliver timber, and it can be a place where you can find peace or exercise.

If you have such a perspective on the forest, it becomes natural to want to attribute a monetary value on the services it provides. Thus, some believe that the ability of the forest to deliver clean drinking water has a monetary value that can be referred to when arguing that the forest should be maintained. On the other hand, others believe that this is a dangerous road to take as it means that other actions which have a higher monetary value can trump the goal of preserving different ecosystems. If we take a species rich and diverse forest as an example and assume that the ability of the forest ecosystem to clean rainwater is worth 5 million DKK a year. If I can demonstrate that felling all the trees and establishing an industrial plantation with only one species of tree would provide 7 million DKK a year, I would have a strong argument for felling the forest. Therefore, to avoid such a slippery slope, several environmentalists believe that we should instead emphasise the unique values and beauty of the forest without trying to put a monetary value on its services. The forest has inherent value and a right to life that can not be valued in money.

Incommensurability

One of the problems in the discussion of value is the question of value comparability or rather the lack of the same. For example, does it make sense to compare the value of an endangered animal species with the value of a large construction project that is threatening the habitat of the species? And is it at all possible, in such cases, to objectively determine what is most valuable and, therefore, should be given the highest priority?

As mentioned in the previous paragraph, some attempt to solve such problems by calculating monetary value as they believe that market prices can decide what is most valuable and should be given the highest priority. According to this logic, the market price is regarded as a credible expression of the value of something, which means that market prices enable comparison between very different things. However, among ecological economists, there is widespread scepticism about this view, and instead they propose that we must accept incomparability and that there is no single measure by which we can compare all values. Instead, democratic methods should be developed to discuss value, priorities and decisions from many different angles instead of blindly letting market prices dictate.

Political decisions

While in the themes on driving forces and distribution the focus is mostly on conflicts over distribution in relation to the environment in a very broad perspective, in this theme, we examine the conflicts and dilemmas that arise in relation to environmental challenges in a narrower and more local perspective. When the political system has to deal with environmental problems, it gives rise to many dilemmas, where different interests have to be weighed against each other. In a democracy, it is not possible to exercise brute force, which means the political battleground for the environment and many other causes is characterised by arguments and methods that make these arguments convincing. If you want to promote a special interest, it is particularly effective if you can make it appear to be in the interest of society as a whole. One of these battlegrounds is focused on the design of socio-economic analyses.

The next section discusses how socio-economic analyses are applied in practice and some of the controversies that are specifically associated with the use of cost-benefit analysis (CBA). Thereafter, some alternative methods are presented that may be used to support policy decisions, while in the last paragraph, some more fundamental considerations about value and prices are discussed.

Socio-economic analyses in practice

Jens Stissing Jensen

What is a socio-economic analysis?

Socio-economic analysis is a tool that is often used in connection with establishing political priorities for major societal investments. This could be, for example, investments in new roads, sewers or district heating systems. In addition, socio-economic analyses are also used to assess the impact of, for example, new taxes and levies or new energy-saving campaigns. The philosophy behind socioeconomic analysis is to weigh up the pros and cons of new investments and new types of regulation for society as a whole.

For example, a socioeconomic analysis can be used to assess the advantages and disadvantages of a new motorway. For some individuals, a new motorway will have positive effects because they will be able to get to work quicker. However, others who live close to the new road will experience negative effects in the form of increased noise and pollution. The mechanism behind a socioeconomic analysis of the new motorway would identify and weigh up all the experienced effects (also called use effects) for all the affected individuals relative to a situation in which the investment is not implemented. A key challenge in socioeconomic analysis is how to compare the different utility effects. How do we compare the negative use effects for individuals who experience increased noise, for example, against the positive use effects for the individuals who will be able to get to work quicker? In order to be able to compare such effects, they must each be assigned a price in DKK. For example, the negative use effect of increased noise can be priced by examining how much the market price of property exposed to noise falls. Another method is to ask the affected individuals how much they would be willing to pay to avoid the noise. A price for the positive use effects for individuals who will be able to get to work quicker can be estimated by calculating a price for their time (for example, 85 DKK/hour). By adding the time saved for all users of the new road together and multiplying the total by 85 DKK, the total use effect can now be calculated. Once all the positive and negative effects of the investment have been identified and converted into DKK, the overall social effect can be calculated by subtracting the negative effects from the positive.

An advantage of socio-economic calculations is that they make it possible to investigate where society gets most value for money. For example, socioeconomic calculations can be used to calculate whether the societal benefit of a new motorway on Zealand is greater or less than the societal benefit of investing in a new light railway in Aarhus. Socioeconomic analyses can also be used to identify the most effective method of solving specific problems. For example, socioeconomic analyses have been used to assess which methods are most effective at reducing Denmark's greenhouse gas emissions.

It is important to note that socio-economic analyses are fundamentally different from, for example, government budget analyses or business analyses. Such analyses calculate the effects of new investments for a single actor and only include the effects to which can be attributed economic value on a market. In contrast, socioeconomic analyses look at the effects for society as a whole, including both the effects that can be attributed economic value on markets and those that can not, e.g. noise and air pollution.

From good relationships to good analyses

The widespread use of socioeconomic analyses in Denmark only really began to gain momentum in the mid-1990s, when its use was promoted, in particular, by the Ministry of Finance, which at that time had developed into a strong and dominant ministry. While in the 1980s, the Ministry of Finance was primarily busy making sure that public consumption was more or less in balance with government revenue, in the 1990s, the ministry began to formulate a more active agenda for its work. The Ministry of Finance no longer wanted to simply ensure that budgets were met, but also that resources were used and distributed optimally. From the perspective of the Ministry of Finance, one of the key problems was that the allocation of resources largely depended on personal relationships. For example, if a ministry had a charismatic minister or a minister with good connections with the Prime Minister, there was a high probability that the ministry would be successful in securing funding for its initiatives. From the perspective of the Ministry of Finance, there was a high risk that this allocation mechanism did not lead to the most optimal use of state resources. Therefore, the Ministry of Finance began to argue that the allocation of resources should be based on the 'best analyses' rather than the best personal relationships. However, analyses were not much use if their results were not comparable within an individual policy area as well as across different policy areas. Therefore, the Ministry of Finance began to promote socio-economic analyses as a common analytical 'language' across the entire state administration. The ministry also began to develop standardised methods to ensure the comparability of analyses across different policy areas.

Thus, the capacity of the various ministries to attract resources for their initiatives became less dependent on charismatic ministers with good connections to the Prime Minister and more dependent on their ability to demonstrate socio-economic value creation through socio-economic analyses.

Socio-economic analysis as a political battleground

In principle, socioeconomic analyses should produce a clear calculation of the effects of a particular investment or new type of regulation. In practice, however, socioeconomic analyzes always involve a large number of assumptions about the effects that are to be included and how they should be priced. These methodological assumptions have evolved into a central political battleground because they have a major influence on the outcome of the analyses.

One of the decisive methodical assumptions is the so-called discount rate. The discount rate is used to address the phenomenon of future effects being estimated to have a lower value than effects that occur here and now. Therefore, it is necessary to discount future utility effects so that they reflect their so-called present value. For this purpose, a certain discount rate is applied. For example, a discount rate of 4 per cent means that a utility effect with a value of 104 DKK, which occurs in a year, has a present value of 100 DKK. In practice, the discount rate is of decisive importance when calculating the socio-economic value of long-term investments. A high discount rate means that future utility effects will have a very low present value, while a low discount rate means that any future utility effects will have a higher present value. In Denmark, the Ministry of Finance decides the discount rate and it has often been accused of using a very high discount rate. In recent years, the Ministry has repeatedly reduced the discount rate. This means that long-term investments are calculated to have higher socio-economic value.

Another methodical battleground concerns how concrete effects should be valued. For example, in relation to valuing air pollution, one of the key discussions has been about the value of lost years of life. As individuals who are exposed to air pollution statistically die earlier than otherwise, a higher value of lost lives leads to higher socio-economic costs of air pollution, and thus higher socio-economic valuation of initiatives that reduce air pollution.

Finally, defining which effects should be included in socio-economic analyses plays a crucial role. Such delimitations are necessary as it is impossible in practice to identify and calculate all the effects of new investments or regulations.

Socioeconomic analyses of investments in cycling infrastructure are an example of how the definition of the effects can be crucial. Traditionally, socio-economic analysis in the field of transport has only focused on adverse health effects related to accidents and air pollution. When the municipality of Copenhagen developed a analytical method for cycling some years ago, they also decided to incorporate the positive health effects of physically active forms of transport. The municipality succeeded in persuading the Ministry of Transport to include these effects in their methodological manuals. Health production has since become the decisive socio-economic argument for bicycle investments as the health production derived from a single kilometre amounts to no less than 7 DKK.

Another example of how defining the effects can play a crucial role is illustrated by discussions about the inclusion of so-called broader socio-economic effects, which refer to effects that have no immediate connection to the actual investment or regulation being investigated, but which can nevertheless be classified as indirect effects. An example of broader effects is so-called tax distortion effects, which were introduced by the Ministry of Finance as a mandatory element in socioeconomic analyses in 1999. Tax distortion effects refer to the assertion that investments that are financed through taxes may have specific negative effects. This is because, for example, taxes are assumed to have negative effects on motivation to work. Therefore, higher taxes are assumed to encourage workers to reduce working hours and increase leisure time because the gain from work is reduced. Therefore, tax-funded investments are assumed to lead to lower labour supply.

Based on this reasoning, the Ministry of Finance has introduced a tax distortion loss, which means that each tax-funded crown which is used for a given investment must be calculated to have a socio-economic cost of 1.2 DKK.

In response to the Ministry of Finance's introduction of the tax distortion loss, the Ministry of Transport has, for example, attempted to introduce positive broader effects of transport investments. The Ministry argues that transport time and transport costs constitute a distortion effect on the labour market. According to the Ministry, investments that reduce transport time will thus increase labour supply as the gain from working will increase. Similarly, the Ministry argues that markets for goods and services are optimised when transport costs are reduced through investments in new infrastructure.

What the above discussion illustrates is that socio-economic analysis is not an objective tool, which merely produces neutral assessments of the effects of new investments or regulations. Socio-economic analysis is rather a complex method of calculation, where many elements need to be set and adjusted. Thus, socio-economic analysis is also a political tool because the way in which the method is set up will always suit specific interests and agendas better than others.

Alternatives to cost-benefit analysis - an example

Emil Urhammer

Decision support tools

When discussing major construction projects, such as motorways, wind farms or bicycle infrastructure, it has gradually become routine to include socio-economic analyses in the form of cost-benefit analysis (CBA). Therefore, CBA has become an important tool of persuasion when it comes to making decisions about major public projects and investments. However, CBA is only one of several tools that can be used to guide what is a complicated and difficult decision. In the following, we present some different decision support tools which are based on a current example.

The Hærvej motorway

At the moment, there is a discussion about whether a new highway called the 'Hærvej motorway' should be built in Jutland. The incumbent government, several mayors in Jutland and business representatives are advocates of the project, while local activists, the Danish Society for Nature Conservation and the environmental organisation, NOAH, oppose it. The arguments on the yes-side focus on creating economic growth, reducing transport times and fighting congestion, while the arguments on the no-side focus on preserving the beautiful landscape, and assert that highways do not fight long-term congestion and that car-use is harmful to health, has negative consequences for the climate and is noisy.

CBA

If you want to use a CBA to determine whether the motorway should be built, all the benefits need to be added together to give a total from which all the disadvantages have to be deducted to see if the end result is in favour of the motorway or against it. On the positive side is reduced transport time and less congestion, while degraded nature values and noise pollution are on the negative side. However, one of the problems with this approach is that all the advantages and disadvantages must be assigned a monetary value in order to be included in the calculation. In practice, this means that many important elements are omitted from the calculation or are not assigned a reasonable value. Thus, there is a risk that the analysis will be in favour of the interests that are best at 'manipulating' the calculation to their benefit. Partly in order to overcome this problem, various alternatives to CBA have been developed over time. In the following, we present some of these.

Multi-Criteria Analysis

As the name suggests, multi-criteria analysis involves approaching a particular decision on the basis of several criteria. It should be stressed that these criteria are also numerical, but it is important to note that these figures do not have to be in DKK. Thus, if we take the example of the Hærvejs motorway, figures in the form of the construction cost (in DKK), reduction in transport time (in hours), increase in CO_2 emissions (in tonnes), noise increase (in decibels) and reduction of area (in square kilometres) may be included. This provides a more nuanced numerical analysis that does not reduce everything to monetary value. In addition, an attempt is made to involve alternative options. In the case of the Hærvej motorway, the alternatives could be the development of public transport or the expansion of existing motorways.

As well as the numerical calculations, multi-criteria analysis also involves some consistent roles in the decision-making process. For example, decision makers (e.g. a town council or government), analysts (e.g. experts in nature or traffic), stakeholders (e.g. landowners and companies) and citizens (the wider population with an interest in the problem). When you conduct the analysis, you can let the various stakeholders fill out a form where they prioritise the alternatives and indicate how they weigh the different figures in the analysis. An environmentalist would probably put more weight on figures that emphasise natural values, while a business owner would probably put more weight on transport times and opportunities for lower transport costs.

	Different alternatives				
Criteria	a	b	…	X	Weight
1	score	score	score	score	Weighting
2	”	”	”	”	”
3	”	”	”	”	”
…	”	”	”	”	”
y	”	”	”	”	”

Multi-criteria table. The table shows the general layout of a multi-criteria analysis, where alternative decision-making options are presented next to each other, and different criteria are given a specific weighted score. The table is a reproduction of a similar table in Arild Vatn's book 'Institutions and the Environment'.

If you wanted to conduct a multi-criteria analysis of the Hærvejs motorway, you would have to put a figure on all the different elements that are part of the problem: how much will it cost to build the motorway? By how much would transport time be reduced? How much valuable nature would we lose? By how much would noise increase? By how much would CO_2 emissions increase? And how would the various stakeholders weight these inputs? Ultimately, one hope that the tables prepared in connection with the analysis would guide the decision maker and provide a nuanced basis for the decision.

Deliberative methods

The so-called deliberative methods focus on communication, interaction and arguments. Here it is about involving the public in discussions about a given problem and providing input to decision makers. One of the purposes of the method is, thus, to create opportunities for achieving consensus and compromise in relation to various value conflicts. If you wanted to use deliberative methods in connection with the Hærvejs motorway, you would try to involve the public by establishing: *focus groups*, *citizen juries* and *consensus conferences*.

The focus group involves gathering together a randomly selected group, which is led by a chairman. The problem that the group has to discuss is defined in advance, and there must be no direct stakeholders or experts in the group. The work of the group is not meant to result in a conclusion. The aim is instead to contribute input to the decision-making process. For example, in the case of the Hærvejs motorway, the route of the motorway could be known in advance, and there must not be any people who would be directly affected by the motorway or any traffic experts in the group. Based on the knowledge and opinions of the individual members, the group should discuss the pros and cons of the motorway and send their reflections to decision-makers.

A citizens' jury, like the focus group, is also composed of randomly selected citizens, but in contrast to the focus group, there are more members, and the jury is tasked with reaching a final recommendation. In connection with the Hærvejs motorway, the recommendation could be, for example, that the motorway should not be built, and instead public transport should be extended. The idea is that the jury then convenes different stakeholders and experts who can qualify the jury's recommendation. A citizens' jury often lasts from three to five days, and it is preferable that the panel reaches a consensus regarding a recommendation, but if this can not be achieved, a final vote can be made.

Consensus conferences are almost the same as a citizens' jury, but they have a stronger focus on consensus, i.e. the panel discusses and reaches a consensus rather than voting on a decision. In Denmark, the Danish Board of Technology, in particular, has held a wide range of consensus conferences over the years.

Value-articulating institutions
When studying societal decisions, it becomes clear that certain institutions can help highlight some values while making sure that others stay in the background. In order to handle this value-forming characteristic of institutions, ecological economists, such as Arild Vatn, apply the concept of *value-articulating institutions*. Here institutions are understood in very broad sense as rules we follow in all kinds of different contexts: A family rule that the children have to clean up after dinner, or the procedure for setting up a cost-benefit analysis; both can thus be perceived as institutions. Both cases may be defined as value-articulating institutions. In the first example, the institution marks a family value that the children should also help with the housework, while in the latter case the institution determines which values should be taken into account when making a social decision and what price they should be assigned in the calculation. These two examples are very different, and usually the concept of value-articulating institutions is limited to different decision-making tools like those previously described in this section.

When cost-benefit analysis is used as a value-articulating institution, sometimes it is necessary to value a good that does not have a price. One of the methods used is to ask people about their willingness to pay for the good. For example, if the Hærvejs motorway were to be built through a special nature reserve, which would make the reserve less attractive, people could be asked what they would be willing to pay for an annual entrance ticket to the area, which could then be used to calculate the value of the area for people. This method means that people respond based on their own private interests, just as they would be expected to do when buying a product in a store. If, on the other hand, a deliberative method is used as a value-articulating institution, the participants are encouraged to formulate more collective values because they have to decide what would be best for society as a whole based on the different arguments they hear.

The reason why it is important to focus on value-articulating institutions is because their role as judges in terms of the question of value is often hidden. There is a tendency to think of value-articulating institutions, such as the CBA, as being objective and scientific, but they are in fact not value neutral, on the contrary, they favour some values at the expense of others when important decisions have to be made.

Ecological economists' view on value and prices

Inge Røpke

Socio-economic analyses such as CBA require a common unit of measurement in the form of money. When the advantages and disadvantages are put into monetary terms, things can be added and subtracted in order to reach a final result. From the point of view of mainstream economists, the fact that not all the pros and cons have a market price that can be included in the calculation is a challenge for CBA. If the construction of a motorway damages a nature reserve, there is no obvious market price of what has been lost. Therefore, the value of what has been lost has to be estimated by using different methods like those described in the first section of this theme.

Such efforts are based on the idea that market prices are an appropriate expression of what something is worth and, therefore, it is relevant to construct market prices when they are not available. Neoclassical economics can be critical of market prices as a value measure if they arise on markets that do not function optimally as they should according to the theory. On perfect markets, there must be, among other things, many buyers and sellers (i.e. not monopolies) and no so-called external costs, where production has unintended side-effects for others in the society that the producer does not pay for. However, the imperfect market is considered to be an exception, which does not seriously obstruct the use of market prices as a measure of value.

Ecological economics is more radical by arguing that market prices are not a relevant measure of value, even when markets function 'perfectly'. As discussed in the theme on growth, ecological economics has no suggestion as to how society's annual production of use values can be added together in order to measure the output. There is no common characteristic of use values that makes it possible. Ecological economists consider incommensurability to be a fundamental condition.

Historically, such a point of view has been unsatisfactory. According to the classical economists of the 19th century, goods are comparable through their exchange value, which is based on the amount of work that was used in their production - partly the direct work of the actual production process and partly indirect work involved in producing the raw materials, semi-manufactured materials and the machines that are gradually worn out. According to this labour theory of value, value is based on the work effort measured in time and is, thus, solely determined by conditions on the production side.

As an alternative, others have argued for the adoption of an energy value perspective, where the direct and indirect energy consumption involved in producing the goods determines their value. Due to the great importance that energy is ascribed in ecological economics, one may expect that the field would adopt such an attitude. However, this form of 'objective' measure of the value of a good, which is solely based on one or another kind of cost, is clearly unsatisfactory as a measure of what the good is worth to the user.

Therefore, how should we determine the value of a good from the user's perspective? Neoclassical economists suggest that utility is reflected in the user's willingness to pay at a given time. However, as neoclassical economists are aware, willingness to pay can not be found in the market price because some of the users would have been willing to pay more than the market price (in neoclassical theory this is referred to as the consumer surplus). In addition, willingness to pay is largely determined by ability to pay, which is very unevenly distributed. This means that the market price does not reflect the high value some goods may have for those who can not pay. Finally, willingness to pay is an expression of individual preferences rather than collective priorities, which may be thought to show more consideration for the common good and ethical principles. Neither willingness to pay nor market prices can be considered societally relevant indicators of what goods are worth.

In practice, market prices emerge as a result of interaction between supply and demand, which again reflect many different factors: uneven income and wealth distribution nationally and globally, physical and social structures that are based on decades where the environmental impacts of production have not been priced, power structures and cultural ideas that influence the relative wages for different types of work, etc. In other words, market prices are historically constructed and in many ways are influenced by inequality in the past and present. When we want to make societal priorities regarding the environment as well as in other areas, market prices can not be considered 'objective' input to the decision-making process. Furthermore, the validity of attempting to find the 'correct' prices for goods that do not have a market price is highly questionable. What goods are worth to us and what it has cost to produce them has no objective answer, but rather a series of different answers which depend on your particular point of view and priorities.

At the same time, the fact that we in society have to prioritise, set environmental goals and decide which methods to use to achieve the goals is unavoidable. When incommensurability is a fundamental condition, prioritisation must necessarily be a political process. Therefore, ecological economists often prefer prioritisation methods that illuminate the political decisions rather than hide them behind calculations that are supposed to be 'objective'. Consequently, research is conducted on some of the alternatives to CBA which were discussed above. This includes some of the problems which are associated with the deliberative methods, such as how to ensure representativeness and counteract the inequality that is associated with different groups' qualifications and background for participating in the debates.

In practice, ecological economists often find themselves in a position where it is necessary to become involved in a battleground, in which a CBA is designed, in order to promote a specific development in a particular area. However, as described in the section on the view on nature and ethics, this can be problematic as it paves the way for a logic that will always be able to suppress considerations for nature and ethics.

Control and regulation

In the themes on energy, metabolism and growth, the focus is on environmental problems in an overall perspective: changing the energy basis in a long-term perspective, growth of the economy as a metabolic organism and the ethical problems that are associated with the challenges. The themes also discuss how researchers have attempted to highlight the biophysical growth of the economy and the planetary boundaries we have either exceeded or are about to exceed. However, when it comes to environmental policy in practice, more delimited problems are often in focus. One can say that the overall growth of the metabolism is reflected in a wide range of specific environmental problems which have emerged over the years and demand attention. In this theme, we look at different methods of controlling and regulating these problems.

Specific environmental problems

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Specific environmental problems emerge in many different ways. A classic problem is that an important resource becomes depleted. As a Danish example, in his doctoral thesis (*Den danske revolution 1500-1800. En økohistorisk tolkning*, 1991), the historian, Thorkild Kjærgaard, discusses how Denmark, in the first half of the 18th century, ran into an ecological crisis, especially because the forests were disappearing. While 20-25% of the country was covered in forest around 1600, this percentage had fallen to only 8-10% of the country around 1750 (p. 23). As timber was the most important raw material and source of energy, the decline was a problem in itself, but it also led to other related problems such as worsening sandy drifts. Many interrelated factors contributed to the ecological recovery, while also creating the basis for more recent environmental problems; not least those that are linked to the increased use of fossil fuels.

Other classic problems are connected to societal changes such as rapid urbanisation with which infrastructure planning can not keep up, thereby leading to new side effects. The book *Det heles vel. Forureningsbekæmpelsen i Danmark fra loven om sundhedsvedtægterne i 1850'erne til miljøloven 1974* (1999) by the historian, Jens Engberg, talks about the horrible living conditions in Copenhagen in the mid-1800s, when the population grew from approximately 100,000 inhabitants in 1801 to approximately 155,000 in 1860 (p. 23), waste of all kinds piled up and mortality was very high. The book also highlights the many new problems that arose as a result of early industrialisation during the same period and the problems that arose following the introduction of new pesticides in agriculture in the 1930s. Establishing regulations of environmental problems takes a long time, and because new problems are constantly emerging, we are still not finished.

Acknowledging environmental problems

The first step in dealing with a problem is acknowledging that it is a problem. Throughout history, a lot of time has passed from when the first critical voices have begun to highlight something as being a problem to the first attempt is made to do something about it. For example, it took a long time before the first danger signs led to a recognition of the problems connected with lead in petrol, the use of asbestos in buildings, the collapse of fish stocks, and the consequences of pesticides for men's fertility (a large number of case studies are gathered in two reports from the European Environment Agency titled 'Late Lessons from Early Warnings', 2001, 2013).

Some problems may be difficult to discern because the harmful effects of a particular activity may not be apparent until much later or much further away, and because the causal relationships can be difficult to establish. However, at other times there may be solid evidence, which does not lead to action because it would cross powerful special interests, because it 'only' affects weak groups in society, or because the majority of society prioritises other issues. The opposition to doing something can be reflected in counter-documentation, although such a strategy is obviously difficult in situations where the connections are obvious. Therefore, highly visible problems can be easier to address, especially when they affect a number of groups in society at the same time.

Conflicts of interest and balancing

In a Danish context, the long road to modern environmental regulation is, as previously mentioned, described in Engberg's book. The book illustrates that many environmental problems, such as waste management, water supply, sewage, the use of toxins in agriculture and the pollution of various industries - have a long history, and that efforts to regulate have often encountered great resistance. One of the central problems is that environmental improvements often require interfering with property rights, i.e. the owner's right to do what they want with their property. When doctors attempted to improve people's health in Copenhagen in the 1850s and reduce the risk of epidemics, they saw no other way: "The free use of houses and grounds should be limited to such an extent that the individual's capriciousness or selfishness can not interfere with the common good"(Engberg, p. 47). At the time, this view came into conflict, just as it does today, with the traditional legal understanding of legal rights, which focuses on protecting owners from government intervention. Therefore, it has been an important aspect in the subsequent development of the field of environmental law to argue for another concept of legal rights that focuses on protecting the interests that may be affected by the owners' use of their property.

In addition to the countless examples of special interests, there have also been many examples in history of the more general dilemma that society faces; the fact that pollution control is not free. For example, in 1969, while preparing comprehensive legislation on pollution control, the Social Democrat, Erling Olsen, wrote: "What would we prefer? More clothes? Better food? Better and more furniture? More and longer holidays? Larger cars? Colour TV? Or fresh air, clean water and less noise in everyday life?" (Engberg, p. 378). When you read about the debate in Denmark at that time, it is easy to draw parallels with the current debate in China, where urgent environmental problems face aspirations for better living standards. In Denmark, environmental problems and consumption wishes have both changed, but the problem is still present.

The problem of side-effects and third parties

Susse Georg & Inge Røpke

Production and consumption involve both the use of resources and the emission of waste materials, which may cause two kinds of problems: First, resources can be overexploited and secondly, the waste materials from the process can have adverse effects. Neither of these can be said to be the aim of the process, so they must be defined as unintentional side-effects, which often affect people who derive no benefit from the production and consumption process that has caused the problems. In this case, the side-effects are said to affect third parties, which refer to people and not damage to animals or plants unless the damage is important to humans (the perspective is, thus, anthropocentric, see the theme on view on nature and ethics).

Pollution problems are often side-effects that affect third parties. The classic example is of a company that emits waste into lakes or streams, which damages fish stocks and, thus, fishermen's opportunities to catch fish. The same applies, of course, to the discharge of wastewater in towns and the leaching of nutrients from agricultural fertilisers, just as pollution affects interests other than fishing, for example, people's opportunities for bathing. As detailed in Engberg's book, Danish environmental history is rich in conflicts concerning the pollution of watercourses, and this continues today.

Right up until today, such conflicts have primarily been regulated through legislation involving bans and orders, often after a lot of discussion back and forth. Legislation prohibits various activities, for example, the use certain toxic substances in production, and the law demands that companies perform certain tasks in a prescribed manner. There is also extensive regulation of the products, so that users do not receive shocks from electrical items or become sick from eating food products, and so houses do not collapse. This removes the temptation for producers to make things as cheaply as possible regardless of any potential adverse side-effects for third parties.

Since the 1980s, it has become increasingly common to use other tools to regulate the conflicts, especially economic instruments. Economists, in particular, have argued that sometimes it is better to charge a tax, for example, on emissions of harmful substances instead of setting rules about how much pollution is allowed to be emitted. This is inappropriate, of course, if it concerns a substance that must be completely avoided, but if quantities need to be reduced, a tax can be useful. Firstly, it may be cheaper for society as a whole because the tax stimulates companies to reduce their emissions if it is relatively easy for them to do so, while emissions can continue in those companies for whom it is difficult to implement reductions – for them it is cheaper to pay the tax. Secondly, the tax provides an incentive for technical development, which in the longer term can reduce emissions in a more efficient way. Finally, the tax can raise funds for the treasury, which can, for example, use the money to solve some of the problems caused by the side effects.

In mainstream economics, side-effects are called *externalities* or *external effects* because they are external to the factors that are included in the decision-maker's considerations. For example, a company is interested in the revenue and costs it has to include in its accounts, not the effects that affect others. Concerning the environment, the external effects are often negative, although they may also be positive. The classic example is bee-keeping, where it is not only the owner of the hives that benefits from the pollination of flowers. In mainstream economics, use of the term externality is often associated with the idea that, in principle, it is possible to calculate the economic value of the externality and that the introduction of a tax of the right size will ensure an 'optimal' result. In ecological economics, such an idea does not make sense because market prices are not considered to be a valid expression of what something is worth (see the section on value and prices in the theme on political decisions). However, ecological economists agree that in some contexts using charges as a means of control is useful, although their level must be set based on considerations other than the idea of optimality.

Economic instruments also include quotas that can be traded (such as the EU's system of CO_2 quotas and the Danish fishing quota system), and subsidy schemes to encourage, for example, the development of cleaner technologies. They may also take the form of payments to farmers or forest owners to run their businesses in an environmentally-friendly manner. This form of support is called payment for ecosystem services (PES). In addition to the economic instruments, there are a number of other tools such as the eco-labelling of products, environmental certification for companies, voluntary agreements with industry and many others (a little more can be found in the section on institutions in the theme on theoretical glasses).

Types of good and the overexploitation of resources

Up to now we have focused especially on pollution problems, but the exploitation of resources can be seen in the same perspective because it may also give rise to side-effects that impact third parties. For example, when rainforest is cut down, it affects many more than those who benefit from the felled trees or the cleared land. In the short term, those who used to use the forest for their livelihoods through harvesting fruit, rubber and engaging in other activities will be affected, while in the longer term, the climate will deteriorate, thereby affecting everyone. However, side-effects connected with the use of natural resources are often discussed in a supplementary perspective, which highlights some particular difficulties regarding regulation.

The perspective is based on a classification of goods into two dimensions. One dimension is concerned with whether an individual's consumption of a good reduces what is available to others. If so, it is called competitive or rival consumption. A classic example is a piece of bread - if you eat a piece of bread, nobody else can eat it (unless the bread is shared). A classic example of non-rival consumption is the consumption of television signals, such as when we watch television - a household's television consumption does not limit the ability of other households to watch television.

The second dimension concerns whether it is easy or difficult to exclude others from using the good. For example, if a person does not want to pay for a good, is it practically possible to exclude the person from using it? Goods that are sold in stores are protected by surveillance cameras and by law that punishes anyone who steals them. However, in other cases, it is hard to exclude people from using a good because it can not be fenced or protected in some other way. For example, it is difficult to monitor a forest to make sure that people do not help themselves to logs, even though it is not allowed. It is particularly difficult to prevent people from using a good that is not divisible, such as clean air, or the signals from a lighthouse.

Based on these two dimensions, goods can be classified into four different types, as presented below:

- If it is easy to exclude others from consuming the good, while at the same time an individual's consumption reduces the consumption of others, it is called a *private good*. Typical examples are bottled water, food, clothing and many other types of good. If you drink the water or eat the food or wear the clothes, nobody else can do the same with these products.
- In cases where consumption of a good limits other people's consumption of it only to a limited extent or not at all, it is called a *club good* (also called ticket goods). A classic example of this is when television signals are put together in 'packages' on cable television, which one has to pay for to watch. Those who do not pay, can not watch the programmes that are included in the package, but when you watch a programme in the package, your usage will not reduce the ability of other paying consumers to also view the programmes in that package.

- If it is difficult to exclude people from consuming a good and there is no competitive consumption, it is called a *public good*. Typical examples are the prevention of crime or national defence, which provide protection to everyone within a specific area. As the goods can not be divided and sold to those who want to pay, they are usually secured through tax payments from the population of the relevant areas. In this way, governments seek to avoid situations where individuals can free-ride, i.e. attempt to avoid paying even though they benefit from the protection that others in the area pay for.
- In contrast, if consumption is competitive, and it is also difficult to exclude people from consuming the good, it is called a *common good* (or common pool resources). Fish stocks in the sea and groundwater resources exhibit these characteristics. It is difficult to prevent people from consuming such resources, and when too many people use them, problems connected with overuse may occur.

In practice, the classification is not as clear-cut as described above. There are many border cases between the different types, while the position of a good may change over time. For example, technological change may influence the potential for excluding people from using a good, such as GPS, which has made it easier to control who is catching fish in the oceans. The degree of scarcity also changes over time, so that natural goods, such as pure water, can change from being public goods with low rivalry in consumption to being common goods.

		Potential for exclusion	
		Easy	Difficult
Competitive consumption	Yes, high	Private goods	Common goods
	No, low	Club goods	Public goods

Schematic categorisation of types of good.

With regards to the environment, common goods and public goods give rise to particular problems. When there is a lot of pressure on resources, common goods can easily become overexploied. For example, overfishing can lead to the gradual depletion of the fish stock and, thus, limit fishing in the future. In order to solve such overuse problems, rules about who can fish, how much and when must be implemented. As a rule, the smaller the scale and the fewer the parties involved, the easier it is to establish these rules. In relation to the overexploitation of fish stocks, it is possible to control who has access (the right) to fish locally (in lakes, rivers or coastal waters) by issuing fishing permits. In the case of commercial fishing, where fishing takes place in certain marine areas, the countries that have fishing interests in these areas negotiate with each other about the size of the fishing quotas. During these negotiations, the countries decide who is permitted to fish in the area concerned, and how much fish they are allowed to take.

The climate problem is an example of how difficult it can be to share the burden when it comes to providing a public good, in this case a climate where the temperature rise is limited to one-and-a-half or two degrees. Our local consumption of fossil fuels and the associated CO_2 emissions contribute to the greenhouse effect and change of the global climate system. The consequences of this are not only felt now (for example, extreme weather conditions are occurring more frequently), but are also expected to affect the living conditions of future generations. Reducing CO_2 emissions would be beneficial for everyone, but it has proved very difficult to reach agreement on binding agreements to do so. This is due to several factors: the fact that many countries are heavily dependent on fossil fuels, differences in countries' development - for example, a fear among developing countries that their opportunities for improving living standards will be limited - and conflicting interests within each country with regard to the phasing out of fossil energy sources. If we do not get CO_2 emissions (and other greenhouse gases) under control, we expect a global temperature increase of as much as six degrees. According to the famous climate scientist, James Hansen, this would lead to 'a completely different planet'.

Property rights and commons

Susse Georg & Inge Røpke

The classification of the different types of goods is based on purely practical assessments of their characteristics: Is it practically possible to exclude people from using them, for example, if they do not want to or can not pay? Will an individual's consumption of a good reduce the ability of others to use it? Therefore, the types of good are not defined according to how property rights are organised. It is difficult to make some goods private property if it is not possible to exclude others from using them when they do not pay, but for other goods, there are many opportunities for organising property rights. A service such as hospital treatment is a private good because users can be excluded and because it is scarce. However, there are big differences in how different countries organise the supply of this good: while hospitals are mainly public in Denmark, they are private in the United States. A central discussion in the field of the environment is focused on how property rights for natural resources can best be organised in order to avoid overexploitation. Much of the debate has been based on the concept of commons.

Most are probably familiar with Fælledparken (the common park) as the place in Copenhagen where many celebrate 1st May. This very popular park was originally a common grazing area for cattle. From sometime in the 1400s to the early 1700s, the local residents had common property rights to the area. Each farmer could graze a certain number of cattle on the grass according to a carefully agreed system. Therefore, free access to unrestricted use of the common was not the case. Rather, access was organised in the form of a kind of quota system. From the early 1700s and the next two hundred years, the common was used for military purposes until the area was taken over by the City of Copenhagen and transformed into a public park (1908-12).

However, commons were not solely a phenomenon of Copenhagen, they also existed in many villages around the country. Their use was regulated by common law - rules which had gradually been developed in the village communities in order to safeguard against the overexploitation of the areas. The introduction of the agricultural reforms (in the mid-18th century) marked the start of the decline of the commons, while each landowner's land within the village was separated.

Such village commons have long since disappeared in Denmark. However, the phenomenon still attracts much attention, partly because many natural resources are common resources, but also because new forms of commons are emerging as a result of societal development.

One of the most well-known narratives about commons is that they are synonymous with tragedies; a connection that was established in the article 'The Tragedy of the Commons', which was published in the most prestigious journal *Science* in 1968. The article concerns a common grazing area that is accessible to all. According to the author, Garrett Hardin, the tragedy occurs because the most rational action for each individual farmer is to exploit the grazing area as much as possible (to graze his animals). When everyone acts in this way "Freedom in a commons brings ruin to all" (Hardin, p. 1244). There is an implicit assumption in Hardin's argument that the tragedy could be avoided by introducing private property rights. Only in this way would farmers have an incentive to take care of (their respective part of) the grazing area.

Many years passed before this narrative was criticised. The Nobel Prize winner, Elinor Ostrom, and her research group have documented how communities in many places around the world have actually developed different ways of managing their shared use of grazing areas and other forms of common resources, such as forests, fishing grounds and groundwater reservoirs. Against this background, they have been able to highlight the hidden assumptions in Hardin's story. Furthermore, they have pointed out that Hardin's story does not concern commons, but instead grazing in cases where there is free access to the limited resource (open access and, thereby, no social control). Therefore, he had overlooked the possibility that people in fact collaborate to find solutions to their common challenges.

Hardin's article compares two types of property rights system: *private, individual property rights*, which was Hardin's solution to avoiding the overuse of a scarce resource, and *open access*, which means that no one has ownership (or if someone has, it is not enforced). The latter was the tragic phenomenon he actually described. However, Ostrom has identified two additional systems of property rights (some call them property regimes): *group property rights*, which is developed in a group to regulate use and prevent others from exploiting the resource, and *state property*, which is when the state has the right to exploit the resource. One of the results of her research is that you can not say, in general, that one property rights system is better than another at regulating resource consumption as this must be determined in specific circumstances.

Based on her studies, Ostrom has established eight principles for managing common resources:

1. The group that wants access to shared resources must be clearly defined - when people know each other, they are more likely to trust each other.
2. The 'rules' for people's use of the shared resources must address local needs and conditions, otherwise there will be greater risk that people will not comply with the common rules.
3. For the same reason, those who are affected by the rules must also have the opportunity to influence their development. There must be a democratic process.
4. The local society's self-regulatory measures must be respected by external authorities.
5. A system that community members can use to monitor the behaviour of group members must be developed.
6. Sanctions for those who violate the community's rules must be graduated.
7. Provide accessible and inexpensive forms of conflict resolution.
8. The responsibility for regulating resource consumption must be built from below.

This does not mean that a local community will necessarily develop the rules or mechanisms that can manage the use of a common resource because many problems can arise along the way. For example, some may not want to comply, some may want to decide too much (be more powerful than the others), or other types of conflict may emerge.

Nevertheless, today, the concept of the commons serves as a model for how to find new ways of managing our resources. For example, many consider urban space as a form of commons - it is difficult (and/or costly) to exclude others from using it, while one person's consumption of it may well reduce the potential for others to enjoy the same urban space if the person, for example, vandalises the area. Kitchen gardens are something that all passers-by can enjoy, but they are difficult to protect against vandalism unless it is possible to develop a norm in the local area that such behaviour is unacceptable and somehow apply sanctions on those who destroy the gardens. For many, the question of (re) introducing commons in cities concerns residents' democratic right to influence the development of their neighbourhood.

Viewed from this perspective, commons encompass more than just biophysical common resources (see the examples of urban space or kitchen gardens above). In these examples, the commons are associated with fundamental ideas about what constitutes good urban life - what some call 'liveability' – and an ideal of getting closer to nature. At the same time, commons are also involving - people become engaged in ensuring the development of their local area, which can influence people's identity and their sense of belonging. Commons are socio-economic, biophysical systems or communities.

Markets and environmental regulation

Susse Georg & Inge Røpke

There is no direct connection between the way in which property rights for resources are organised and the way in which the products that are produced based on the resources reach consumers in the end. The products can reach the consumers in several ways. Firstly, producers can use the products themselves, which is what households often do when they grow their own vegetables or keep chickens in the garden, while fishermen can eat the fish they have caught. Secondly, products may be given away, such as between friends, or as often happens between the public authorities and citizens. Thirdly, the products may be distributed among consumers through markets. Markets can distribute goods that are made within the framework of different property rights systems and by different economic entities (households, companies, public authorities). This means, for example, that the ownership and use of a resource may be organised as a commons, while the products of resource use can be traded on a market. As markets in modern societies play an important role as a link in delivering the products to consumers, it is worth examining how they function and the role they can play in environmental regulation.

Free markets do not exist

In the debate about markets and the environment, a contrast is often made between free markets and regulation, where regulation is considered to be something that impedes the functioning of the free market. However, within ecological economics, this is considered to be a false distinction. As described in the sections on conflicts of interest and side-effects, environmental regulation may indeed imply restrictions on what the individual owner of a resource may do with his property because the interests of others or 'the common good' have to be taken into account. But this constitutes only a very small part of all the regulations that make up the conditions for a market. There is simply no such thing as a free market. As the development economist, Ha-Joon Chang, puts it (see: https://www.youtube.com/watch?v=R4BelDrWWt0), all markets are regulated: If you think a particular market is free, it is only because you agree so much with the regulations that support the market that you can not see them. For example, few would advocate reinstating child labour. The former US Labour Minister and political scientist, Robert Reich, makes a similar point here: https://www.youtube.com/watch?v=dikqwpp3ylA (myth No. 2). In an environmental perspective, what is important is regulating and designing markets in ways that promote environmental goals.

A market is often described as a place where trade occurs. It is a place where sellers and buyers meet. In return for payment, buyers receive some of the sellers' goods. Think of flower and fruit markets or flea markets: the buyer and seller are in close interaction, but this relationship becomes more distant in a supermarket. You are not in direct contact with the seller. There are other markets where this relationship is even less clear: Just think of the electricity market, the market for CO_2 quotas or the financial market. Here the distance between the buyer and the seller is very great, and the relationship between them very indirect. In order to maintain a market, there must be some buyers who keep returning. However, it is primarily the sellers who determine how stable markets are because it is they who decide what is sold and at what price. Although there is a certain degree of reciprocity between buyers and sellers, it is the sellers' interest to survive - to ensure a reasonable income (profit). The opportunities for this are influenced by who else is selling goods on the market – the competitors - and what they are doing.

Even though the above markets are very different in terms of the products and the type of buyers and sellers, they are all characterised by specific rules. The economic sociologist, Neil Fligstein, identifies three types of rule, which together characterise all markets. These are rules that specify: (1) property rights; (2) control or governance structures, and; (3) how trade occurs – how the transactions on the market take place. These rules are expressed in legislation as well as in the market actors' understandings and practices.

Without clear *property rights*, it is impossible to have a market because who owns what is not known and, therefore, who is entitled to trade with the product in question. In other words, property rights are rules that define who is entitled to the profit from the sale of the goods. However, property rights can assume many different legal forms, for example, related to the different types of companies (private/family owned, partnerships and limited liability companies). What ownership rights do is they define the relationships between the owners and everyone else, thereby defining the power relationship between the parties on the market.

Control or governance structures encompass two aspects: society's general rules regarding how competition should take place and the rules for how companies can be organised, i.e. which types of companies are allowed. These are the 'rules of the game' that determine how the market works. This is either stated formally in law or informally through institutionalised practices. The Competition Act, for example, aims to promote effective societal resource utilisation through effective competition for the benefit of businesses and consumers. Therefore, the law prohibits, for example, certain types of anti-competitive agreements. With regard to informal institutionalised practices, these primarily concern advice from professional organisations to market actors about how to best exploit the competition rules or how best to organise themselves in relation to their competitors.

Trade rules specify the conditions for how trade on the market - transactions - can take place. There are many different types of rules that focus on the health and safety of products, transport, insurance, contractual compliance, etc., all of which seek to stabilise the market and ensure that all companies on the market are subject to the same conditions. If trade is international, trade agreements between countries are particularly important.

In addition to these rules, the market actors' implicit understanding of how the market should function also plays an important role. This understanding evolves over time, especially with regard to the relationship between existing companies and new companies entering the market. The existing companies on the market do not want additional competitors and, therefore, attempt to establish different types of barriers (for example, in the form of production standards), which may block the entry of new companies onto the market. The new companies will be able to challenge market stability if they succeed in gaining a foothold on the market.

Even though these four factors contribute to creating the conditions on the market, i.e. property rights, and stabilising them by specifying the 'rules of the game' as to how the market should function (with the aid of the competition rules) and how the transactions should take place (for example, trade agreements), the conditions are constantly being challenged. The existing companies on the market, new companies wishing to enter the market, and consumers are all interested in influencing these four conditions and there is, therefore, a continual political struggle to change them. For this reason, the market is not something that is just *there*. It is the result of market actors' struggle to orchestrate, organise and design the market conditions so that they benefit themselves as much as possible. In other words, the market conditions are not a given as they could be changed if there was sufficient political support for it. Markets *are created*.

What creates the dynamics of the market is the competition between the sellers (companies) to ensure the buyers' favour so they come back and remain good customers. Competition is considered to be the solution at the moment as more and more social functions are being exposed to competition, for example, the liberalisation of the electricity market or the privatisation of water supply. The reason for this is the strong impression that competition between private suppliers will ensure that society's scarce resources are used most effectively. However, even according to mainstream economic theory, this only applies to perfect competition where the market is open to all (no barriers to the entry of new businesses), the companies are selling identical products, there are many companies present, and none of them can control the market price, while buyers have complete information about the products so that they can choose the best. However, this is far from the world of reality. Nevertheless, the idea that 'market forces' will ensure the most efficient utilisation of resources is widespread. Adherents to such an idea consider market forces to be natural and not something that are created by political processes.

Sustainable transitions

As the environmental consequences of increasing economic activities have become increasingly alarming, the need for a sustainable transition has also grown and become a more prominent theme in the public debate. Therefore, it is no longer uncommon to hear politicians and opinion formers talk about transforming our energy system, agriculture and transport into more sustainable alternatives such as wind and solar energy, organic farming, cycling and electric cars. In order to better understand and discuss such transition processes, it is useful to present some theoretical concepts that can clarify the problems. In this theme, therefore, we present some fundamental concepts and illustrative examples for understanding the sustainable transition of societal systems that can be applied to many different cases.

The term sustainable transition can cover several different areas, and one can talk about the sustainable transition of the whole of society's economic metabolism or just the transition of certain societal systems. The term societal systems refers to systems such as the energy system, agriculture, transport and water supply. Such systems are also called socio-technical systems or provision systems, but in this theme we use the term societal systems. An important common feature of such systems is that they all have one or more overall aims. In the case of the energy system, for example, the aim is to produce and distribute energy to various areas such as house heating, industrial production, and the operation of vital infrastructure. A societal system is also characterised by being composed of many diverse interacting components and possessing a high degree of complexity. A societal system is, thus, a system that encompasses technologies, infrastructure, regulation, markets, end-user practices, and which is influenced by political, organisational and economic interests.

However, when discussing the sustainable transition of such systems, there is often a tendency to focus narrowly on the technological or market-related aspects of the system, which can lead to simplistic understanding and an unrealistic assessment of the opportunities for transition. Therefore, in this theme, we attempt to make the understanding of a sustainable transition a little more nuanced. This is based on the fact that a large number of production units and companies have limited opportunities to act independently because they operate within a framework of overriding societal systems. The transition perspective, thus, focuses on how individual companies and production units are often intertwined with social systems, which are typically difficult for the individual company or production unit to change. The transition perspective, thus, highlights that, in many cases, sustainability can not solely be achieved through the introduction of new technology at an individual plant or production unit. On the contrary, sustainability often requires that new technology is combined with 'systemic' (holistic) changes to regulation, infrastructure, markets and end-user practices that are connected with the overriding social systems.

Theories of sustainable transition

Jens Stissing Jensen

Over the last 15 years, political interest in a sustainable transition has created the foundation for the establishment of a new independent research field with an interest in how societal systems emerge and develop as well as how such systems may change. This research field takes as its point of departure the fact that societal systems typically have a tendency to maintain and expand the solutions and technologies that have historically been dominant. Experience thus shows that established societal systems have a tendency to result in 'blindness' or 'hostility' towards new technologies and solutions. One example is the dominance of the internal combustion engine within the modern transport system. In the early development of the modern transport system, this technology was far from dominant. For example, in American cities, electric vehicles played a central role in the early 20th century. The internal combustion engine did not become central until World War I when the technology was developed and standardised for military use. However, once the technology had become dominant as a result of the military development, it became predominant, and numerous attempts to develop and promote alternative technologies have since failed.

Niche, regime and landscape

In transition research, it has become common to divide the studies into the following three levels: *niche*, *regime* and *landscape*:

- Niche denotes a segment of a societal system where new development, which is often called innovation, is taking place. An example of a niche is organic farming, where an alternative form of production has been established within the wider societal agricultural system.
- Regime denotes the most widespread functional form of a societal system, which in the case of agriculture is represented by conventional pesticide-based agriculture.
- Finally, the landscape level represents an overall context for the societal system. At the level of landscape, there are, among others, cross-cutting economic structures, political trends and broader environmental circumstances. In relation to agriculture, the landscape level may include the general economic condition of agriculture, which is characterised by high debt and fierce competition, the efforts of certain interest organisations to promote a particular political agenda, and advancing climate change.

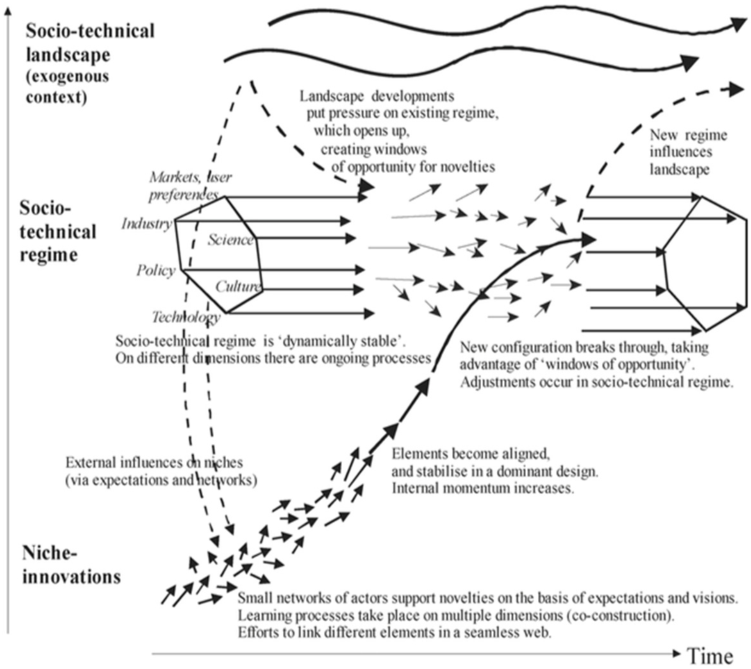
Selection

In the research literature, the tendency of societal systems to maintain and extend established technologies and solutions is typically explained using evolutionary systems logic. Within the social sciences, evolutionary systems logic was initially developed by innovation economists in the 1980s and 1990s.

Economists assumed that economic systems, like biological systems, evolve through evolutionary selection and variation processes. Like ecological systems that create diversity through mutations in connection with reproduction, economists assumed that economic systems constantly create new variations when companies and other entrepreneurs make new products, services, processes and business models. In order to explain which variations survive, become extinct or spread, economists also assumed that economic systems, like ecological systems, constitute so-called selective environments.

Analogous to the selective environment on the savannah or in the rainforest which consist of, for example, drought, cold, availability of food, diseases and predators, economists identified the key selection mechanisms in the selective environment of economic systems. They pointed out, for example, that physical infrastructure, technical standards, public regulation, industrial structures, the established knowledge-base of professions and the division of labour constitute selective mechanisms that are decisive in determining whether new variations survive and spread.

Based on this explanatory model, economists argued that only innovations that are competitive in relation to the overall system of selective mechanisms are viable within an economic system. This explained why established economic systems are typically hostile to radically new solutions because they often require that the selective mechanisms of the established economic system have a fundamentally different composition, for example new regulations, adaptation of the established infrastructure and completely new industrial standards. The evolutionary explanatory model, thus, described innovation as being 'path-dependent', in that only minor variations that are in line with the established selective mechanisms of the economic system survive and spread.



Transition dynamics in niche, regime and landscape. Source: Frank W. Geels and Johan Schot, "Typology of socio-technical transition pathways", Research Policy 2007.

Transition research, thus, suggests that system transition involves cultivating variations through niche strategies and changing the selective environments of the societal system so that the system becomes more open to radical innovations. Research also indicates that transition can rarely be planned in the traditional sense because the development dynamics of the systems can rarely be controlled by a single actor or organisation.

Control

As described above, an established societal system consists of a wide range of different components (infrastructure, regulation, user practices, industrial division of labour), which have become woven together over time in a relatively rigid structure. These system structures constitute path-dependent selective environments that are, in general, hostile to radical innovations. At the same time, the various system components are rarely controlled by a single actor or organisation, which can initiate a coordinated transition of the system on the basis of long-term societal considerations. Is it at all possible to design, control or influence sustainable system transitions?

The dominant strategic idea about how the transition of established societal systems can be influenced focuses on supporting experimental niches that give radical innovation processes opportunities to develop relatively shielded from the normal selective environment of the societal system. This strategy involves cultivating technological or organisational variations that would otherwise not have been possible. In the transport system, advantageous tax rules and favourable parking for electric cars are examples of such protective strategies. The aim of these schemes is to support the development and spread of electric cars despite the various disadvantages of the electric car compared with traditional petrol and diesel cars, such as high production and development costs, a relatively short range and a lack of infrastructure for recharging batteries or changing battery.

This strategy has two components. The first component involves shielding new innovations from the selective environment of the established system, while the second involves using this shielded space to allow the new innovation to mature in the best way possible.

The previous literature on strategic niches identified public development programmes, in particular, as a tool to shield radical innovations from the selection mechanisms of established systems. However, historical studies indicate that radical innovations can rarely count on public development programmes ensuring the necessary long-term shielding so that they can mature and influence the overall societal system. This is due, among other things, to the fact that several different innovations typically compete for the limited resources that are available for supporting the development of a social system. For example, in the energy system, technologies such as wind power, solar cells, biogas and carbon capture and storage (CCS) are currently competing to define the direction of the transition.

Typically, shielding strategies are short-sighted, changeable and the subject of intense controversy. An illustrative example of this is documented in a study of the development of solar cell technology in Britain. In the 1970s, the technology was initially promoted by established energy companies as a large-scale technology, which secured a number of small state subsidy schemes for the technology, which were, however, quickly phased out. Thereafter, a number of research groups were successful in attracting further support for technology development through material research programmes. This research-oriented niche development was later replaced by a more practical application in work with developing countries where the technology was promoted in areas without central energy systems. Later, the technology was again introduced to the UK market - this time as an integrated building component in the construction industry. Then the technology was once again promoted as large-scale technology, which was to be organised in large solar farms. Recently, the technology has been promoted as a local and decentralised energy technology, i.e. as an alternative to the centralised energy system. The support schemes are, therefore, currently aimed at more decentralised systems. What this example illustrates is that new innovations rarely have the opportunity to develop in a linear and coherent process in stable niches. On the contrary, the development of radical innovations usually depends on political lobbying, which manages to ensure shielding from established selective environments for a limited time by identifying and cultivating applications that are favourable at specific times.

In addition to shielding radical innovations from the selective environment of the societal system, niche strategies also aim to organise the development and maturing of the radical innovation in the most efficient way. These activities involve, in particular, creating a connection between isolated experimental activities and ensuring that the innovation is not only developed in a single dimension. The development of wind turbines in Denmark is an example of successful niche development. While wind turbine technology was undergoing experimental development throughout most of the 20th century, its development only really gained momentum in the early 1980s. This was due to the fact that isolated experimental activities in the development of wind turbines were linked together through annual wind turbine conventions where mutual problems and experiences could be exchanged. These coordinated learning processes led, among others, to the establishment of a national wind turbine test centre. They also led to the development of new forms of ownership. Whereas in the early 1980s, wind turbines were typically owned by individuals, during the course of the 1980s, ownership became increasingly organised in windmill guilds. This ensured demand for ever larger, more expensive and more efficient turbines. This ownership model culminated in the establishment of the semi-circular wind turbine farm at Middelgrunden, just off the coast of Copenhagen in the mid-1990s. Subsequently, the construction and operation of wind turbines has increasingly been taken over by commercial energy companies, and production has been organised in international groups. However, the interest of the incumbent actors in wind turbines has been dependent on the niche-organised development that took place during the 1980s and 1990s. The example of wind turbines, therefore, illustrates how long-term niche activity may be necessary to ensure that a radical innovation is sufficiently developed to be accepted as relevant by actors who operate within the established selective environment of a societal system.

While the niche strategies are based on actors who typically play a marginal role within the established societal system, another strategic approach to system transition takes its point of departure in actors who already play a key role within an established societal system. The philosophy behind this strategy is to motivate these actors to gradually transform the existing selective environment in a more sustainable direction. This transformation may, for example, involve avoiding costly investment in infrastructure that is likely to lock the societal system into a particular pathway for many decades into the future. A key element of this strategy is to combine long-term, sustainable system visions with a so-called backcasting methodology (as opposed to forecasting, i.e. prediction which is based on current trends). The strategy is based on established system actors jointly developing a long-term sustainable system vision, which is typically radically different from the established system design. Then the vision is broken down through backcasting into short-term and less radical sub-goals, which can be handled by actors working within the framework of the normal selective environment of the established system.

Transition research, thus, asserts that system transitions involve both cultivating variations through niche strategies and modulating the established selective environment of the societal system so that the system becomes more open to radical innovations. Research also highlights that transitions can rarely be planned in the traditional sense because the development dynamics of the systems are rarely controlled by a single player or organisation.

Cities as transition arenas

Jens Stissing Jensen

Traditionally, energy, transport and water systems have primarily been analysed as nationally delimited systems, whereas, for example, cities or regions have been understood as local hubs that are subordinate to these national systems.

In recent years, however, an increasing number of studies have begun to regard societal systems as being more independent regional and urban phenomena. There are several reasons for this. Firstly, both Denmark and the rest of the world are characterised by increasing urbanisation. More and more people live in cities and, thus, use the city's societal systems. Cities are, therefore, becoming increasingly central in the development of societal systems, and urban investments in system development and system transition are often significant.

Secondly, cities are often marked by problems and developmental processes that operate across individual societal systems. For example, developing urban areas requires coordinated planning of the connection between the urban practices and societal systems related to, for example, heat, energy, waste and mobility. Site-specific urban development processes often provide the opportunity to experiment with how different societal systems may be organised and integrated in new ways.

The development of Copenhagen's harbour in recent decades is an example of how site-specific urban development can create transition processes by establishing new connections between urban systems and the way the city is used. This development began in the early 1980s, when the harbour was still organised around industrial production. The harbour, thus, housed a large number of industrial production companies, which used harbour waters both as a transport route and as a reservoir for toxic wastewater from production. In addition, the harbour was an integral part of the sewage system. During episodes of heavy rain, sewage was thus discharged into the harbour via a large number of drainage works to avoid flooding in the city when the capacity of the sewage network was exceeded.

However, from the early 1980s, industrial production began to move out of the harbour, and the harbour was left as an abandoned industrial area. The relocation of industrial production initiated a number of development activities in order to redefine the societal systems and urban activities in the harbour. From the beginning of the 1980s, the water in the harbour began to be defined as 'biological water' rather than 'industrial water' and the municipality began to measure its biological water quality. From the early 1990s, these biological measurements were translated into strategic aims for the biological quality of the harbour water. This put pressure on the wastewater system to reduce the overflow of sewage into the harbour.

Therefore, the municipality invested a significant amount to increase the capacity of the wastewater system. These investments led to new ideas about how the harbour could be used by the city's citizens. These ideas involved the harbour as a natural area, which would offer the city's residents an alternative to the absence of nature in the city. For example, one plan was to establish a so-called 'harbour aquarium' in the form of a glass tunnel at the bottom of the harbour, which would offer the townspeople the opportunity to experience the biological life of the harbour.

However, in the first years after the turn of the millennium, the vision of the natural harbour was replaced by the visions of 'the city life harbour' and the plan for a harbour aquarium was therefore never realised. However, the vision of the city life harbour already began in the early 1990s, when a long-term area development plan for the harbour was adopted by the municipality. One of the elements of the plan was to develop the recreational potential of the harbour. In the municipality, this led to a focus on 'hygienic water quality' rather than 'biological water quality', which became increasingly central during the 1990s and led to a further expansion of the wastewater infrastructure in order to reduce the overflow from the sewage system into the harbour. By 2002, the water quality had reached such a high level that direct contact with the water was rarely dangerous to people. Against this background, in 2002, a permanent harbour bathing area was successfully established at Islands Brygge and since then, several harbour baths have been opened and the wastewater system has been further developed in such a way that most of the harbour today is of hygienic bathing water quality.

The development of the 'city life harbour' thus links investments in the wastewater system with recreational urban activities, such as harbour bathing and diving and swimming competitions. This has received international attention and was highlighted, for example, when Copenhagen was named the European Environment Capital in 2014. The example shows that systems at the urban level are sometimes less path dependent than systems that are mainly organised and controlled by, for example, national actors. This is because urban systems, such as the sewage system, rarely have clearly defined borders or functions. In connection with the development of the harbour, the sewage system was thus assigned to new functions: Firstly as a supplier of biological water quality and since as a supplier of hygienic bathing water. Urban systems are, thus, typically more flexible than national systems because they are continuously adapted to diverse site-specific development processes.

The circular economy

In a time of increased consumption of energy and resources, it has become commonplace to talk about a so-called circular economy, where energy comes from renewable sources, and products and materials are reused and recycled in 'closed' circuits. In this theme, we present some of the fundamental principles of a circular economy and then briefly look at this concept with ecological economic glasses.

Circular thinking

Emil Urhammer

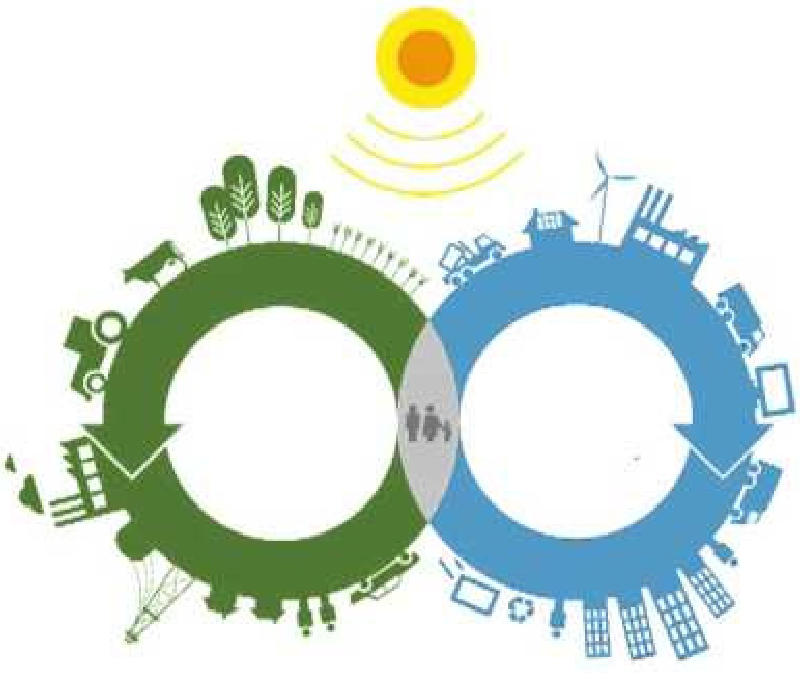
In order to understand what a circular economy is, it may be helpful to compare the concept to the so-called linear economy, which refers to a production and consumption form which could also be called 'use and throw away', where new resources are constantly being extracted to make products that are simply discarded as soon as they break or no longer interest us. The circular economy represents a break with this approach and encompasses the idea that there are clever and more sustainable ways of producing and consuming.

Biomimetics

One of the main inspirations for a circular economy is the biological cycle, where the 'waste' of one species enters, in a positive way, the ecosystem cycle of which it is part. In the biological cycles, there are no rubbish dumps, instead, materials are circulating constantly and the waste of one species is another's food source. It is all kept going thanks to the sun's energy, which maintains life in the ecosystems. It is this kind of sustainability that the circular economy tries to imitate and it, thus, involves the idea of industrial production being powered by renewable energy sources, where at the end of their lifetime, individual products are either used in new production processes or become part of the planet's biological cycles without problems.

Two cycles

The circular economy operates with two different cycles: *the biological* and *the technical*. The biological cycle was described in the previous paragraph, while the technical cycle is an industrial cycle that has to ensure that goods and resources are recycled and are included in new products instead of becoming pollution in the biological cycle. It is impossible to separate the two cycles, but the basic idea of a circular economy is that when the technical cycle releases materials to the biological, they must be able to enter the biological cycle without problems. In other words, waste from production and consumption, such as packaging, must be biodegradable. For example, a soft drink bottle that ends up in the ocean has to dissolve and become harmless elements in the marine ecosystem. Similarly, a disposable plate that is thrown on the ground must dissolve and become compost.



The biological and technical cycle. Source: Pinterest. *https://www.pinterest.com/sumdy/circular-economy-videos/*

Related concepts

There are also other concepts that resemble a circular economy. In this connection, cradle-to-cradle and industrial ecology should be emphasised. Cradle-to-cradle also represents a break with the linear economy, which is here called the cradle-to-grave economy. The cradle refers to the extraction of raw materials, while grave refers to a product ending up as waste. In contrast, the cradle-to-cradle approach considers old products to be cradles for new products, just like the circular economy.

Industrial ecology focuses on how different industries can exploit each other's waste products for their own production. In Denmark, the Kalundborg Symbiosis, where different factories exchange water, steam and plaster with each other, is a good example of industrial ecology.

Product chains

Emil Urhammer

A circular economy is mainly concerned with how so-called product chains can be transitioned so they create more value with fewer resources and less pollution. Product chain is a term that describes the life cycle of a product from the extraction of the materials used to produce it and the energy involved in the production until it ends up as waste in a landfill site or, as demanded by the circular economy, is reused or recycled. Such a process is called a product chain because it can be seen as a connected chain of value that is added through processing and design. To take a simple example, coffee, it is possible to say that the total product chain for coffee starts at the coffee plantation in South America or Africa and ends in rubbish bins in Denmark, where the coffee grounds end up after the coffee beans have been harvested, roasted, packed, transported, ground and brewed. At every step until the coffee has been drunk, value is added, but this stops once the coffee becomes grounds. The coffee is worth more once it has been picked than when it was still on the tree, just as the roasted beans are more valuable than they were before the process, etc.

However, coffee is a very simple example, which primarily illustrates the principle of added value, but even in such a relatively simple product chain as coffee there is potential for establishing circular upgrades. For example, in Denmark, coffee grounds have been used to grow mushrooms such as oyster hats, which can be sold and used in cooking. This is an example of how the biological cycle of coffee can be extended.

If you take a more advanced product such as the mobile phone, for example, the story becomes immediately more complicated, while the potential for circular upgrades also increases. A mobile phone is made up of a wide variety of materials such as metals, minerals and plastic, which through a linear product chain end up at a landfill site or in a combustion plant, if the phone does not end up in a loft to serve no purpose. According to circular thinking, however, all these materials should be included in new product chains, thereby remaining in the economy rather than becoming waste or lying somewhere unused. The simplest way to do this is by extending the life of the mobile phone by as much as possible so that the buyer keeps it for as long as possible, sell it or give it to someone else instead of throwing it away when she does not want to keep it any longer. The next option is to dismantle the phone into smaller parts, each of which can be included in new products. However, this approach demands a well-thought-out design to determine how the individual components can be removed and included in other products. Finally, the basic elements of the phone such as metals, minerals and plastic can be 'extracted' from the phone and included in new product chains. However, the problem with this approach is that it can be very difficult to remove the individual materials once they have been assembled into complex devices. Therefore, there is a limit to how much can be extracted, although this problem can be partially remedied with smart design solutions and advanced extraction technology.

Life Cycle Assessment

In order to investigate how well a particular product meets the ambitions of the circular economy, a so-called Life Cycle Assessment (LCA) of the product can be conducted. An LCA not only examines production at a single factory or company, but instead examines the entire product chain from the extraction of raw materials until the product is discarded. A good example is bottled water from France. In order to conduct an LCA of bottled water from France, you need to investigate the following:

- The environmental costs associated with pumping the water.
- The environmental costs associated with producing the plastic bottle.
- The amount of water and oil involved in producing the bottle.
- The amount of transport involved in the overall process from the water being pumped up in France until it is in plastic bottles in Danish supermarkets.
- The environmental problems created by the bottle after use.
- Where the bottle ends up after use.
- How likely it is that the bottle will end up as plastic waste in the ocean.
- The amount of CO_2 emitted if the bottle is burned.
- The amount of CO_2 that is emitted during the entire production process.

Once this analysis has been conducted, it is possible to start identifying opportunities for making the product chain more circular, by asking, e.g.:

- How can transport be reduced?
- Can the bottle be reused as a drinking bottle?
- Or is it better to use the plastic for new plastic products?

In the case of bottled drinking water, the most circular solution is to switch to Danish tap water instead. This would avoid all the environmental problems associated with transportation as well as the production and disposal of the bottle after use.

You can read more about life cycle assessment here:

https://lca-center.dk/

The circular economy is not the same as ecological economics

Emil Urhammer

It is our impression that similarities are often made between the circular economy and ecological economics. However, this is a mistake as the two are related, but nevertheless very different approaches. In brief, the difference between the two is that the circular economy is a strategy for sustainable production and consumption, while ecological economics is a transdiscipinary scientific field. Given this difference, it makes sense to look at the circular economy with ecological economic glasses. When this is done, it illustrates that the circular economy is an attempt to keep raw materials in the metabolic organism of the economy for as long as possible before new raw materials are extracted and the old are emitted as waste or are included as components in the biological cycle. In this way, the circular economy can be seen as a strategy to limit the size of the economy's metabolism without reducing the production of goods and services.

Having said that, one may ask what progress has been made with regards to this ambition. How circular is the global economy? A group of researchers consisting of Willi Haas and Fridolin Krausmann, amongst others, have investigated this in an article from 2015. They conclude that we are far from achieving a circular global economy. They find that only six percent of the total amount of raw materials that the global economy uses and processes is recycled, thus contributing to closing the circle. The two biggest challenges in this regard are that: 1) a very large share of the materials that are used in the economy are used for energy production, which means they can no longer be included in the cycle, and: 2) a large share of the materials is trapped in buildings and other infrastructure, which means that it can not be freed for new productive purposes. Therefore, with regards to energy, in order to achieve a circular economy it is important that the transition from fossil to renewable energy sources continues at a high pace. Overcoming the second challenge requires completely new ways of building and producing, where it is easy to dismantle things into their various separate components so that they can be included in new buildings and products.

One can also ask whether the circular economy is a strategy to achieve sustainability in general. In this connection, ecological economists would probably be sceptical. It is a little complicated to explain as it requires knowledge of some of the fundamental laws of physics, but part of the scepticism towards the circular economy is that the laws of thermodynamics limit the amount of materials that can be recycled. In this way, some people think that the laws of nature still set limits and that the circular economy is not a recipe for infinite green growth. In line with this, it has also been stated that the circular economy is in no way a guarantee for the conservation of biodiversity and ecosystem services. Materials that are circulating in the cycle also take up space so a growing circular economy would also pose major challenges in terms of the conservation of habitats and ecosystems.

Theoretical glasses

A theory can be understood as a particular type of glasses, which make it possible to see certain things while other things disappear. The glasses are, therefore, decisive in terms of what you are able to see. While the other sections present theoretical glasses that focus on what could be called the core subject matter of ecological economics, this section contains examples of theoretical perspectives that are not specifically about the environment. Ecological economics is inspired by and draws on different understandings originally developed within other theoretical schools. This applies to both general understandings such as systems thinking, which cut across academic disciplines and more specific theories from other economic schools that differ from mainstream economic theory such as classical institutional economics.

Reality depends on the eyes that are looking. What do you see above?

Systems thinking

Emil Urhammer

Among ecological economists, it is very common to use the word *system*. According to the system theorist, Donella Meadows, a system consists of a number of connected and interacting elements that are organised in such a way that they achieve something specific. In some cases, systems are organised with a particular aim in mind from the beginning, while in others, the organisation just gradually emerges. As a result of its internal organisation, a system can maintain its existence by means of a number of mechanisms in an interaction between its various parts.

According to Meadows, most system theorists agree on the following three overall features of systems: (1) The behaviour of systems is determined by their internal structure. External influences can change the functioning of a system, but the different modes of operation of the system are hidden as potential in the system itself. (2) It is very difficult to define a system. In most cases, no real system border will exist. Instead, the boundary between the system and the outside world is defined by the analysis that is conducted. (3) Systems can often be seen as systems within larger systems. In this way, systems are often characterised by a hierarchy with one system actually consisting of a number of smaller subsystems which are embedded in and function as elements in the larger system.

From the above very broad description, it is apparent that systems can be many different things. For example, a small forest lake with fish and aquatic plants can be seen as an example of a system - an ecosystem where different animal and plant species live and interact with each other. But systems are not only found in nature. For example, a society's transport network can also be seen as a system - the transport system - and a society's economy is also perceived by many as a system. In these examples it is possible to identify a hierarchical organisation. The forest lake is a subsystem of the entire forest ecosystem, train transport is a subsystem of the whole transport system, while the transport system can be seen as a subsystem of the overall economic system.

Through the interaction between different elements, a system can achieve a certain state that can change over time. For example, in the case of the forest lake, a particular species can ensure that the water in the lake is clear by eating algae, which would otherwise make the water cloudy. However, if the the system is pushed from the outside, its state can change. Perhaps nutrients from a farmer's field leach into the lake so the algae obtain plenty of food, or perhaps the species that keeps the algae population down disappears because of fishing. Both can help change the balance in the lake. Such changes are often very difficult to predict because they often rely on complex interactions between the internal elements of the system, which we do not understand or are even aware of.

As described above, you can apply systems glasses in the study of many different things, and interactions between species in nature, modes of transport and economic entities can all be seen as system interactions with different feedback mechanisms. Thus, it is possible to apply systems thinking across the gap between nature, society and the economy, and it is, as previously mentioned, very difficult to distinguish the different systems from each other. The small forest lake is connected to the economy because the farmer's economic activities influence its state, while the economy is connected to the transport system because goods and people need to be transported in order for the economy to function. Therefore, one of the major challenges in systems thinking is defining the system you want to investigate. However, this can be done by, for example, simplifying and omitting various connections to other systems.

In systems thinking and, in particular, the question of sustainability, *resilience* is an important concept, which concerns the ability of a system to maintain a certain state despite external influences. If we think about the forest lake's ability to keep the water clear, one can say that the resilience is low if the farmer can only apply very small amounts of nutrients before the water becomes cloudy. In the same way, one can say that the resilience is high if it is possible to catch a very large amount of fish which keep the algae level down before the lake becomes cloudy. In the latter case, the high resilience of the system may be due to the existence of other species of fish in the lake, which also help keep the overall volume of algae down. When a species is under pressure, other species can take over and perform the same task. This capacity is important for resilience and is one of the reasons why biodiversity is emphasised as being so important for the survival of ecosystems.

System theorists often also talk about so-called *tipping points*, which is the point where a system goes from one state to another. If we consider the forest lake again, the tipping point is precisely when the amount of nutrients entering the lake exceeds the ability of the system to keep the water clear; the result being that the water becomes cloudy. When looking at the economy, for example, the tipping point may be when a housing bubble bursts and the housing market collapses with plummeting house prices, bankruptcies and foreclosures.

Institutions

Susse Georg

We often talk about different kinds of institutions, such as children's institutions, educational institutions, prison institutions or more generally, public institutions. At the same time, many also use the term to refer to important organisations, such as the UN, which is an international political institution, or the World Bank, which is a major international financial institution. According to these applications, an institution may either be a physical place or an organisation that performs certain tasks. However, institution can also mean something completely different, i.e. social order or a social pattern, which is maintained through human interactions. Based on this definition, institutions regulate human behaviour and are, therefore, crucial for a sustainable transition of social development.

The word *institution* comes from the Latin word *instituere*, which means 'to set up or establish'. Although institutions are often taken for granted, they are not just *there*. They are socially created. Consider many of our everyday actions such as eating dinner together. It is something people have always done, and it is something that is done in many different ways. However, what is the same is that having dinner together is a learned act. In most families, it is the adults who decide when and where the family should eat (for example, at the dining table or in front of the television) and the children just comply. While adults are to some extent conscious of the habits they establish, children (especially younger ones) are unaware of them. For them, it is just the way things are done. When the children move away from home and establish their own families, it is quite likely that they will continue many of the same habits that they grew up with in their families. Over the years, a gradual *institutionalisation* of the way people eat dinner has occurred. According to the sociologists, Berger and Luckmann, this institutionalisation process consists of three steps: firstly, the habits must be established. In relation to the example above, this occurs when adults develop their eating habits (probably before they get children) and mutually acknowledge them. Berger and Luckmann refer to this mutual recognition as 'typification'. When the children arrive, they experience the habits as facts - as an external force which they have to comply with. The habit that was created by the parents becomes objective reality for the children. This step is referred to as 'objectivation'. The final step 'internalisation', is when the children reproduce 'what they learned at home'.

There are many other types of institution than those that regulate the way we eat our dinner. They are established, maintained and developed in the situations where people interact repeatedly. Institutions are essential and allow us to coordinate and control things. According to the sociologist, Richard Scott, institutions consist of cognitive, normative and regulatory structures that give social behaviour stability and meaning.

The *cognitive structures* relate to the conditions that can affect our thinking habits and understandings. Language is particularly important in this respect. Language is a system of signs that enables people to express themselves and it is, therefore, important for the above-mentioned objectivation of everyday reality. More generally, symbols - whether they be words, signs or gestures - all help us to understand what is happening around us. They influence how we make sense of things and contribute to establishing what some call our 'cognitive map' - the framework for understanding through which we make sense of things. The creation of meaning takes place individually as well as collectively - it takes place in a concrete connection and is, therefore, also influenced by the cultural context. In every context there are some fundamental rules that determine how things, relationships and processes are categorised, i.e. how the above-mentioned symbols are arranged. If we take the issue of climate change as an example, there are major differences in people's understanding of the seriousness of the situation. While the vast majority of people now consider climate change to be man-made, there are climate sceptics who believe that this is not the case. According to their world view, climate change is something that has always been around. The many scientific reports that document the seriousness of the situation in various ways have not influenced their perception of what is 'real'.

The *normative structures* encompass different types of rules for how to behave. In other words, they specify what is correct or appropriate, while at the same time they involve assessments of whether people are following the norm. There is an element of coercion because people are expected to comply with the norms. Norms influence many things, for example, what is considered the appropriate way of treating the elderly or foreigners, what behaviour is acceptable in the workplace or the appropriate use of mobile phones. If you do not comply with the norms, you may face different types of sanction, which may range from a raised eyebrow and a shake of the head to verbal reprimands. Bullying can be regarded as a particularly malicious form of sanctioning that implies that you do not fit in with some of your classmates' norms that dictate the right way to be.

What all norms have in common is that they are based on some underlying values as to what is desirable. This becomes a 'standard' against which people's behaviour is judged. Norms express certain expectations regarding our interpersonal relationships - they indicate the correct way to do things. In addition, it can be said that norms define what the appropriate - or legitimate - means are for achieving a specific goal. Legitimacy is something most organisations strive for as it represents their 'license to operate'. In the last 40 years of development in industry, norms for a company's social responsibility, known as Corporate Social Responsibility (CSR), have gradually developed, strongly encouraged by environmental, work environment and labour market legislation (see below). However, what CSR more specifically involves is something that many consultancy companies like to advise industrial companies about. Consultancy companies, among other things, earn their keep by formulating rules, guidelines and voluntary standards that define what constitutes responsible corporate operations. The spread of such rules and standards helps to define what is considered legitimate business conduct. In order for a company to maintain its legitimacy, it must be able to justify its choices/actions. For example, the VW Group has had a lot of difficulty with this in the aftermath of the repeated scandals in 2016 when it became known that their cars pollute much more than the company had stated.

The *regulatory structures* include legislation, rules, contracts and other forms of formal agreements as well as the necessary monitoring and sanction systems that are required to ensure compliance. This requires an authority with the necessary capacity to: (1) establish the rules; (2) investigate and monitor to ensure others are complying with the rules, and; (3) impose sanctions if necessary either in the form of a penalty or reward with a view to influencing the actions of others. What the regulatory structures have in common is a statement of what the involved parties may and may not do, and that there is one or another form of penalty if this is not followed.

Development in the environmental field serves as an interesting example of how regulatory, normative and cognitive structures are intertwined. The Environmental Protection Act was introduced to help ensure that societal development is sustainable by making companies reduce their pollution of the air, water, soil and underground. Companies are thus subject to a number of rules that they must adhere to. If not, they can be reported to the police and may receive a fine. During the 40-year history of the Environmental Protection Act, two significant changes have been made to the goals and measures of the law: From focusing on environmental protection, the goal has been changed to include the prevention of problems. At the same time, the widespread measures (approval of the companies' production and emissions) have been supplemented by an increased use of voluntary environmental management standards (self-regulation) to promote the companies' environmental work.

This development must be seen in the light of the great political interest in simplifying the legislation and streamlining the public sector, which is linked to the introduction of New Public Management in the public sector in the mid-80s. The authorities' limited resources to control companies was one of the factors that helped to legitimise an increased use of self-regulation. At the same time, many believed that in this way, they could achieve better (environmental) results because the companies would be more motivated and would find it easier to comply with conditions, the arrangement of which they had been involved in. The three types of institutions - cognitive, normative and regulatory - support each other: Environmental standards are normative regulations that stipulate how companies' environmental efforts should be organised. The introduction of these works together with ideas about what best encourages companies in terms of their environmental work, and with ideas about the need to streamline the public sector. Together, this justifies the use of normative instruments in addition to judicial regulation.

Institutions are important sources of power: The cognitive structures influence our framework of understanding; our perceptions of what is real and important. Our interpretation of what is happening (or has happened) around us depends on our knowledge and the models of understanding we apply. And here the normative structures, such as upbringing, schooling, educational choices, etc., play a role and shape our views on how to behave and how development should take place. The cognitive and normative structures thus work together in creating our understanding and expectations and, thus, have 'power to define' to a certain extent. The regulatory structures are perhaps more tangible as they are laid down in laws and contracts. By stipulating who is entitled to what, it is possible to ensure 'law and order' and protect the interests of the different parties. However, it is by no means certain that all interests are weighted equally. As a result, 'positional power' may be established, where some have more right or more rights than others. Such bastions of power are far from secure or stable - they can be and are challenged by people who think and act in a different way to that which is prescribed by the institutions.

Because institutions are socially constructed, they are also changeable. Things can be different. The introduction of new technology is often the reason why institutions change. Just think about the development of the Internet and the resulting opportunities to acquire information and keep in touch with people over great distances. At the same time, it has meant changes in our perceptions and norms. Ten years ago, reading a newspaper during a class was perhaps not unthinkable, but it was at least frowned upon. However, today, teachers have to deal with students' use of Facebook and other social media during teaching. Similarly, a few years ago, opening and reading post while in a meeting at work was unthinkable. You just did not do it. But today, checking email while in a meeting has almost become normal. This erosion of what is considered acceptable behaviour illustrates that institutions can be changed (relatively) quickly.

Ensuring a sustainable transition demands that changes are made to many institutions, from our perception of what constitutes human society (a metabolic organism) and what it can withstand, to our norms about how we should interact with each other and nature and to the legislation that needs to be formulated in order to promote the transformation of our energy system, etc.

Tools of persuasion

Emil Urhammer

In this section, we attempt to describe a feature of the economic measures and models that has not been the subject to much research - not in mainstream economics or ecological economics. However, they have been addressed in the so-called 'science and technology studies', which assert that economic measures and models are not passive reflections of a completed economic reality, but that instead they help to create and produce economic reality in certain ways. In this way, economic measures and models can be viewed as tools of political persuasion that have a major influence on social conditions. Examples of this are GDP, which helps define what is good and desirable in terms of societal development; cost-benefit analysis, which influences important policy decisions, and the Ministry of Finance's macroeconomic models, which are used to guide the government's economic policy. These tools are characterised by a particular view of the economy, where markets and prices are the dominant factors, while ecosystems and ethics do not really play a role. The struggle over economic policy can, thus, also be seen as a battle between different tools of persuasion, where mainstream economics emphasises GDP and cost-benefit analysis, while other economic schools apply biophysical indicators and emphasise distribution between different groups in society as crucial.

Societal measurement tools: management and performativity

Jens Stissing Jensen

Societal development largely depends on managing processes and systems such as 'the economy', 'the food production system' or 'the transport system'. However, these systems are phenomena that can not be observed or sensed in the same way as a house or an animal. Nevertheless, societal governance requires that such systems and processes are made visible. To this end, a large number of 'measurement tools', which attempt to determine the state of health and the development of these societal processes and systems, have been developed over time. Such measurement tools constitute a kind of expanded sensing device that politicians, planners and officials use to assess the necessity and effect of new policies and strategies. For example, the economic reality is presented as a controllable political and administrative entity by way of continuous measurements of GDP, unemployment and inflation.

However, measurement instruments can never give a full representation of the social reality because they only measure selected and delimited parameters. Therefore, societal governance may fail if the parameters measured by the instruments are not appropriately defined. For example, measuring inflation is typically used to assess the extent to which the economy is approaching overheating. However, measuring inflation was unable to identify the overheating of the economy that led to the financial crisis in 2008. This is, amongst others, due to the fact that inflation is only measured by price increases for consumer goods. The measurements, therefore, did not identify the explosive increase in house prices, shares and financial products as evidence of speculative economic overheating. Therefore, the economic overheating was not captured by the measurement instruments that are traditionally used to identify this phenomenon. Consequently, a challenge for societal governance is to continually adjust the measurement instruments in such a way that they provide an adequate representation of the social reality.

In addition to creating controllability, measurement instruments also have a so-called performative function, which means that they actively help shape the way in which planners and politicians perceive societal issues. This is because measurement instruments can be set up so that they make the social reality appear in many different ways. For example, the established economic measurement instruments primarily determine whether the economy balances in financial terms: Do the public finances balance? How big is the private debt? Are investments in production machinery increasing? As these financial balances are made visible through measurements, the balances become prominent issues in political reality. Thus, the measurement instruments exclude a number of important factors by, for example, not including any measures for the biophysical development of the economy.

Measurement instruments can also be used ‘performatively’, i.e. to redefine which phenomena and relationships are made visible or invisible, and thus what problems the political system is able to spot. For example, measurment instruments have played a performative role in the planning of cycling infrastructure in Copenhagen over the last 20 years. Until the mid-1990s, planning was primarily based on measuring the number of cycling accidents, which meant that most of the planning was directed at reducing bicycle accidents. Since then, a new measurement instrument has been developed; the so-called bicycle account, which also recorded cyclists’ experiences in terms of safety, comfort and convenience. Due to the influence of this visibility, planning began to focus on creating good and attractive cycling experiences. Recently, the City of Copenhagen has developed another measurement instrument that focuses on the health-promoting effects of cycling. This visibility has been central to the establishment of regional super cycle paths. The development of new measurement instruments has, thus, contributed to ‘redefine' cycling so that it is no longer defined by accidents, but instead is linked with good experiences and the promotion of health.

Societal governance and development are, thus, closely linked to the use of measurement tools. Measurement tools are necessary to describe and identify the state of health and development of societal processes and systems, which can not be done directly through our sensory apparatus. Societal measurement tools function as a sort of expanded sensory apparatus, which can be used to influence which issues attract the attention of the political system by making certain objects and relationships visible, while concealing others.

Keywords

Anthropocentrism: The word anthropocentrism is a combination of the ancient Greek word *anthropos* (human) and the Latin word *centrum* and refers to the view that humans are the centre of the world and that they are above other species, and their needs are more important than those of other species.

Biological cycle: The biological cycle is a term which, among others, is used in the circular economy, and which refers to the circulation of biological materials in the planet's various ecosystems.

Biomimetics: refers to attempts to mimic the ecological cycles of ecosystems when producing and consuming goods. In ecosystems, the different species do not create waste, but rather material that benefits the whole system.

Biophysical indicator: Just as GDP is a measure of economic activity, a biophysical indicator is a measure of biophysical activity and can, for example, measure how much materials, i.e. wood, coal, etc. a particular country uses in a year, or how much plant material people appropriate in a year.

Biosphere: is the part of the planet, where biological life exists. The biosphere stretches well into the atmosphere and about 10 kilometres below sea level and consists of, for example, the Earth's surface, rivers, forests, mountains, oceans and the air we breathe.

Common: A common area could be a grassy meadow for grazing, a forest or a river which is owned and managed by a community. The use of a common is governed by common law, which represents rules that have gradually developed in the community in order to prevent overexploitation of the common area.

Cost-benefit analysis (CBA): is a tool that is often used in connection with political priorities regarding large societal investments such as the construction of wind farms, motorways, sewage systems or district heating systems. The CBA approach involves weighing up the pros and cons of new investments or new types of regulation for society as a whole by assigning the various pros and cons of a given action market prices, adding it all together and seeing if the final figure is a plus or a minus. If it is a plus, it means that the advantages outweigh the disadvantages and vice versa if the final figure is a minus.

Cradle to cradle: is about ensuring that products do not end up in the grave (as waste), but instead in the cradle for new products.

Decoupling: The idea behind decoupling is that technological innovations and efficiency improvements can disconnect economic growth from environmental impact.

> *Relative decoupling* means that the environmental impact per unit of economic output is falling. This does not mean that the environmental impact in itself is reducing, but rather that GDP has increased more than the environmental impact.
> *Absolute decoupling* means that the environmental impact is falling in absolute terms, while at the same time GDP is increasing.

Degrowth: is a political programme and a popular movement that calls for a non-growth economy that focuses on the fair distribution of the resources of the Earth and society.

Deliberative methods: are methods that are used to aid decisions, which are based on communication and discussion. They entail involving the public in discussions about a given issue and providing decision makers with input from the discussions. They may take the form of focus groups, citizen juries or consensus conferences.

Discount rate: is one of the crucial elements of cost-benefit analysis and is used to deal with the

phenomenon that future effects are estimated to have lower value than effects that occur here and now. A high discount rate attributes a very low present value to future utility effects, while a low discount rate attributes a higher present value to future utility effects. If you have a high discount rate, this will mean, for example, that the benefits of a wind farm are diminished because they will occur quite a long time in the future.
Ecocentrism: expresses the belief that humans are just one of many equal pieces in the planetary ecosystem. In this way, ecocentrism asserts that humans are part of nature and not external to it. According to an ecocentric world view, other species are equal to humans, and considering the needs of other species is, in principle, as important as considering human needs.
Ecophilosophy: is a philosophical school within which human beings are seen as part of nature's total whole. In ecophilosophy, human beings have a moral obligation to try to live in some form of balance with and respect for the rest of nature.
Ecosystem: is a biophysical system consisting of both biological and physical components. A lake is an example of an ecosystem where biological elements, such as algae and fish, interact with physical components, such as water and stone, in a single system.
Endosomatic energy consumption: is the energy that a species absorbs through food and converts into growth, movement and heat.
Energy: According to the Danish Dictionary, the word energy comes from Greek word *energeia*, which means 'power'. Therefore, energy means the ability to perform something or to do a job by moving or relocating something. Energy must be used to move a rock from one place to another, and when the rock has been moved, a certain amount of work has been carried out that corresponds to a certain amount of energy. Over time, physicists have defined different types of energy. For example, there is movement energy, electrical energy and chemical energy. Energy is measured in joules.
Energy quality: Denotes the suitability of energy to perform useful work. The easier it is to convert energy into useful work, the higher the quality of the energy.
Environmental conflict: is a conflict between different parties over an environmental problem. Environmental conflicts often involve confrontation between one or more companies, on the one hand, and a local population and various environmental organisations, on the other. The role of the state in environmental conflicts is not always the same, but the state often sides with business interests in such conflicts. Examples of international environmental conflicts include the conflict over the Dakota Access Pipeline and the conflict over deforestation in connection with palm oil production in Indonesia. Examples of Danish environmental conflicts include the conflict over urban expansion on Amager Fælled in Copenhagen and the pollution of the aquatic environment by agriculture.
Environmental ethics: is the application of ethical considerations to environmental issues. Environmental ethics deals with all the many moral dilemmas that have arisen as a result of the fact that humanity has become a decisive factor for the environment in which we live. For example, is it morally right to cut down the rainforest so that we can produce feed for the meat industry? Or does the rainforest and all the species that live there have the right to life, which means that we have an obligation to preserve it?
EROI: Energy Return On (energy) Input describes the relationship between energy that is used to extract energy and the energy that is derived from the extraction. For example, if 1 litre of oil is used to extract 100 litres of oil, the EROI will be 100, whereas if 10 litres of oil is used to extract 100 litres, then the EROI will be 10. EROI can be used to understand our current situation in which

more and more energy is needed to extract fossil fuels, while some of the alternatives to fossil fuels still have a relatively low EROI.
Ethics: The word ethics originates from the Old Greek word *ethikos*, which means 'moral, showing moral character'. Therefore, ethics is the teaching of morality - what is right and wrong; a subject that has occupied philosophers for thousands of years. Ethics can also be interpreted as moral philosophy. Ethics also deals with values; what value is and how values arise.
Exosomatic energy consumption: means the use of energy by humans for processes outside the body. That is, energy for, for example, house heating, transport and lighting.
Exponential growth: is when something grows by a fixed percentage of the total amount for each time unit. A population that grows by 1% of the total population a year is growing exponentially.
Feedback mechanism: A feedback mechanism consists in interaction between different parts of a given system. For example, if you think of the economy as a system, there may be a feedback mechanism between total income and private consumption. If income falls, private consumption will also fall, which can lead to reduced demand and production and, thus, a further decline in income. If this cycle continues, you can talk about a feedback loop that is continuing in a downward spiral.
Fossil fuel: Is a certain form of biomass that consists of biological material from organisms that died many millions of years ago and have been compressed under the surface of the Earth under pressure. When the chemical energy in fossil fuels is transformed into motion through combustion, CO_2 is released.
GDP: is a measure of economic activity in a country for a given year. Since its development, it has gradually become the official measure of a country's economic growth and prosperity.
Goods (types of): Types of good refers to the fact that goods can be divided into different types according to two different dimensions: ease of exclusion and rivalry in consumption, which may either be high or low. This results in the identification of the following four main types of goods: private goods, common goods, club goods and public goods.
Green growth: is a political vision of sustainable economic growth. In green growth, there is a particular focus on resource efficiency, investment in renewable energy, green innovation and market solutions.
Growth (the dilemma of): describes the problem that economic growth ensures social stability and prosperity, but is also the main cause of today's many environmental crises, which undermine stability and prosperity in the long run.
Growth agnosticism: is a view on economic growth that asserts that the issue of growth is not the key socioeconomic problem of our time. Instead of continuing to argue about growth, we should start to solve the real problems - climate change, inequality and loss of biodiversity, etc., which are threatening our future.
HEE (Human Energy Equivalent): is the daily endosomatic energy needs of an adult human being who is living under favourable climatic conditions. This is not easy to calculate accurately, but a commonly used estimate is that it is approximately 10 megajoules per day.
Hierarchy: In systems theory, hierarchy refers to the fact that a system is organised as a ranking order. A system can be divided into a composite of subsystems, in which some subsystems are subordinate to others.
Incommensurability (the problem of): refers to whether it makes sense to compare different benefits based on a common measure. Does it make sense, for example, to compare the value of an endangered animal species with the value of a large construction project that is threatening the

habitat of the species? Or does it make sense to compare the value of education with the value of a clean aquatic environment?
Industrial ecology: is the study of the flow of energy and materials through industrial systems. The aim is, among other things, to show how an industry can utilise the waste products of other industries for its own production.
Institution: The word institution has many meanings. In this website/eBook, institution primarily means a social norm or rule that is maintained through human interactions. Based on this definition, institutions can be seen as structures that regulate behaviour.
Instrumental value: denotes the view that objects, plants and animals only have value because people enjoy them or can use them in some way. According to this logic, a flower has value because people think it is beautiful and bees have value because they pollinate our agricultural crops.
Intrinsic value: In environmental ethics, the concept of intrinsic value refers to the belief that all life has value in itself, so that all species have the right to live. According to this understanding, even an animal species which is completely unknown to humanity has value in itself and, thus, has the right to live.
Landscape: In transition research, landscape denotes the overall context of which a social system is part. Examples of landscape elements are socioeconomic structures, migration from the countryside to the city, wars and conflicts, new political trends or greater environmental awareness in the population. If opposition arises between landscape elements and a societal system, it may pave the way for system change.
Life cycle assessment: A life cycle assessment involves establishing the environmental impact of a particular product throughout its product chain from the extraction of the raw materials until the product is finally discarded.
Market prices: is the measure of value in mainstream economics. If there is no market for something that needs to be valued, mainstream economists will often try to estimate what the market price would have been if there had been a market. In ecological economics, market prices are not seen as objective measures of the value of things, while many other forms of valuation exist.
Metabolic organism: refers to an organism that keeps itself alive with the aid of a metabolism.
Metabolism: According to the Danish Dictionary, the word metabolism comes from the Old Greek word *metabole*, which means change or transition. More specifically, metabolism is a process in which materials and energy are absorbed into an organism and converted into other materials and forms of energy in order for the organism to survive. For example, a cow that grazes on a meadow; eats the plants and uses the energy they contain for its own life processes. The waste products of this metabolism include cowpats and methane gas.
Multicriteria analysis: is an alternative to cost-benefit analysis which is based on the consideration of many more criteria than just the pros and cons of an investment measured in market prices. An attempt is made to get a broader understanding of the decision-making situation by drawing on many different types of measure and expertise.
Niche: in transition research, a niche is a smaller part of a larger societal system that operates in a different way than the rest of the system. An important feature is that it involves something new that is experiencing growth. For example, when organic farming was in its infancy, it could be described as a niche within traditional farming.
Persuasion (tools of): One can argue that economic measurements and models are not passive

reflections of a completed economic reality, but instead actually influence the creation and production of economic realities in certain ways. Therefore, economic measurements and models can be seen as tools of political persuasion that have a major influence on societal conditions.
Planetary boundaries: are limits that should not be exceeded if the planet is to remain a safe habitat for humans and other species. The boundaries are defined by investigating human-induced global changes of a magnitude that can be considered detrimental to the world's life-sustaining systems.
Product chain: encompasses the life of a product from the extraction of the resources of which it is made to its end as waste in a landfill or in a combustion plant.
Property rights: refer to different forms of ownership. For example, individuals may have private property rights and the state may have state property. However, groups can also share property rights over a land area or a resource, and finally, the property rights of an area may be unspecified, so that there is free access, known as 'open access'.
Purchasing power: denotes the ability to acquire use value through the use of money. If you have high purchasing power, you can acquire a large portion of the real cake.
Real cake: The real cake represents the total amount of use value produced in a given year. The real cake only refers to the final use value, not to all the materials and activities that went into creating it.
Regime: in transition research, a regime refers to a societal system's most common way of functioning. For example, conventional agriculture, which is based on the use of pesticides and fertilisers, has constituted a regime in agriculture for many years. Regimes are often very difficult to change because it requires a coordinated change of many different elements of the regime. At the same time, the value of many investments in, for example, infrastructure may depreciate if the regime is changed.
Resilience: refers to the ability of a system to maintain a certain state despite external influences. The greater the external influence a system can handle without switching to a new state, the greater its resilience.
Selection: The word selection originates from evolutionary biology, which deals with species' survival, development and spread. In transition research, the word selection, on the other hand, is used to describe the survival, development and spread of technologies. Technologies are present in specific environments (selective environments), which make it easier for particular technologies to survive and develop than others. By using different interventions in the selection environment, it is possible to change the selective conditions and make it easier for 'weak' technologies to survive and spread. In the transport system, lower duties and advantageous parking opportunities for electric cars are examples of changes to the selection environment which increase the opportunities for electric cars to survive and increase in number. In agriculture, special subsidy schemes for organic farming can be seen as measures that change the selection environment to the benefit of organic farming.
Self-organisation: is the phenomenon whereby some systems are able to organise themselves in surprising, often for the system advantageous, patterns or structures without any form of external planning.
Side-effect: is an unintended effect caused by human activity. Side effects often occur in connection with production and consumption and are often environmentally harmful. Within mainstream economics, side-effects are called externalities or external effects because they are external to the factors that are part of the decision-maker's consideration.

Societal system: is a system that performs a social function, e.g. the provision of transport, heat, water, food, etc. Societal systems are composed of technologies, infrastructure, regulations, markets and user practices. Examples of social systems include: the energy system, the food production system, the transport system and water supply. Societal systems are different from sectors, which are demarcated on the basis of the production side. For example, agriculture is a production sector. In addition to production, the food production system also involves the distribution of food as well as the end users' practices concerning food.

Sustainable transition: is a very broad concept to which a wealth of different meanings can be assigned. In this section, sustainable transition means the fundamental change of a societal system so that it results in significantly fewer environmental problems. Examples of the sustainable transition of societal systems include changing the energy system so that it is no longer based on fossil fuels (oil, coal, gas), but on renewable energy (wind power, solar energy, hydropower, etc.) instead, or transforming the transport sector so that it is no longer powered by fossil fuels, but is instead based on renewable energy.

System: is a whole consisting of several individual parts that interact in different more or less complex ways. A system has one or more purposes. The aim of the transport system, for example, is to transport people and goods.

Technical cycle: The term technical cycle stems from the circular economy and denotes an industrial cycle that must ensure that goods and resources are recycled and form new products instead of becoming pollution in the biological cycle.

Thermodynamics: Originally, thermodynamics was the study of how heat moves, but it can also be said that thermodynamics is the study of how energy converts into new forms.

Use value: describes the value of an object (or a resource) in use. It is not possible to compare the use value of different objects.

Valuation: refers to the different ways in which we assign value to things. Valuation, therefore, involves how we decide what different things are worth. When making important political decisions, different values are usually included in the decision. The way in which these values are determined is decisive for the prioritisation and which decision is made.

Tasks

These tasks are originally made for Danish high school students. Many examples refer to Danish circumstances, and many links lead to sites in Danish. Nevertheless, we hope that the translation may inspire others to develop tasks that fit to local conditions.

Theme 1: Energy base

1. Energy is the basis of all human activities.
    a. Find examples of activities that do not require much energy.
    b. Find examples of activities that require a lot of energy.
    c. Are there any activities that do not require any energy at all?
2. Draw a diagram that shows what types of energy you use during the course of a day. Examples can be chemical energy from food, energy for transport (what types?) and energy for heating. If you are unsure about what types of energy are used for different activities, try to find the answer online. Here are a few links to get started with:
   https://ens.dk/
   http://www.energinet.dk/
   http://www.dst.dk/da/Statistik/nyt/NytHtml?cid=19663
   http://www.reo.dk/viden-om-energi/energikilder.aspx
3. Try to develop the diagram from task 2 so that it also shows how the energy that is used is not lost, but instead takes on new forms (see important concepts, 1st law of thermodynamics). For example, the chemical energy in the food you eat becomes movement energy when walking, running or cycling.
4. Energy consumption also has an environmental impact. Examine the environmental impact of the different energy types you use during the day.
5. Making energy usable in everyday life requires energy. Energy must be used to extract energy – actually, energy must be used at all stages from extraction to final use. Choose an energy type (coal, oil, sun, wind, etc.) and draw a map or a diagram that shows where energy is needed to make this type of energy useful in our daily lives.

Theme 2: The biophysical perspective

1. Use the ecological economics basic model (see first figure in this theme) as well as the concepts metabolism and metabolic organism to explain the relationship between the global economy and environmental issues such as: climate change, plastic pollution, cutting down the rainforest, pollution of groundwater and loss of biodiversity.
2. The Danish economy can be viewed as a metabolic organism. Use Statistics Denmark's page on environment and energy to get an overview of raw material extraction in Denmark, which can be considered part of this metabolism: http://www.dst.dk/da/Statistik/emner/geografi-miljoe-og-energi/miljoe-og-energi
3. Plastic pollution of the oceans can be seen as a result of human society's economic metabolism. Describe the problem of plastic pollution and include a list of actual suggestions to solve the problem. You can start your investigation by visiting the Plastic Change website: http://plasticchange.dk/
4. Investigate your global 'carbon footprint' using WWF's calculator: http://footprint.wwf.org.uk/

Theme 3: Growth and the environment

1. In mainstream economics, the circular flow model is used as a basic model for the economy. However, ecological economics uses a different basic model (the first figure in theme 2: the biophysical perspective).
   a) Discuss the differences between the two models.
   b) What role does the environment play in the two models?
   c) How can you describe economic growth with the two models?
   d) Can the two models be combined? If so how?
2. Think of arguments for and against the following statements:
   a) Economic growth is the same as increased wealth!
   b) Increased consumption results in increased joy of life!
   c) Economic growth is necessary for social stability!
   d) Economic growth is necessary for the survival of the welfare state!
   e) Growth and competition are key words when it comes to solving the climate problem!
3. In the debate about economic growth and the environment the possibility of decoupling economic growth and environmental impact is often mentioned.
   a) Argue for and against the assertion that decoupling has taken place in the past.
   b) Argue for and against that decoupling is taking place now.
   c) Argue for and against that decoupling will occur in the future.

   Try to use different models to substantiate your arguments. Models could be the IPAT equation and the ecological economics basic model (the first figure in theme 2: the biophysical perspective). For inspiration, you can read this article from Statistics Denmark, which claims that Denmark has decoupled GDP and greenhouse gas emissions: http://www.dst.dk/da/presse/Pressemeddelelser/2017/2017-03-15-saadan-paavirker-oekonomien-miljoeet
4. The circular economy (see theme 9: the circular economy) can be used as a strategy for green growth. Argue for and against the circular economy as a tool for decoupling economic growth and environmental impact.
5. Investigate the attitude towards economic growth among the parliamentary parties.
   a) Who are advocates of economic growth?
   b) Is anyone in favour of green growth, and if so, how do they interpret the concept?
   c) Is anyone sceptical about economic growth?
   d) Does anyone suggest alternatives to economic growth, and if so, what do they propose?
6. Memo 1. Imagine that Denmark's Prime Minister has asked for a memo about economic growth to determine whether Denmark should be a growth economy in the future or whether other alternatives should be identified. The Prime Minister wants to know whether Denmark should:
   a) Continue with economic growth without taking the environment into account.
   b) Focus on Green Growth.
   c) Work for degrowth.
   d) Not care about growth.
   e) Use a new measure of economic growth.

Write a memo to the Prime Minister with recommendations that address the above questions.

7. Memo 2. Write a memo that gives concrete recommendations for a political strategy that can achieve the recommendations in memo 1. If, for example, Denmark has been recommended to invest in green growth in memo 1, what should be the policy strategy for such a transition? What legislation should be implemented? What public investments should be made, etc.?
8. Memo 3: Imagine that Denmark's Prime Minister has established a group, who have been given the task to come up with recommendations for a new measure of economic growth in Denmark. You are the leader of the group and you have to prepare a memo containing recommendations to the Prime Minister. Use the links below for information and inspiration:
   http://www.dst.dk/da/Statistik/dokumentation/groent-nationalregnskab/et-groent-bnp
   http://www.dst.dk/da/Statistik/dokumentation/groent-nationalregnskab

Theme 4: Conflicts and distribution

1. This assignment requires proficiency in English and may be approached as a combination of the subjects social science and English. The Atlas of Environmental Justice is an interactive map of global environmental conflicts.
    a) Have a look at the map and try to get an overview of what it is about.
    b) Choose three conflicts and describe what they are about.
    c) Select three conflicts of the same type and see if you can find some interesting differences between them.
    d) Select three different types of conflict and see if you can find any similarities between them.
    e) A planned construction on Amager Fælled in Copenhagen is included on the map. Find the conflict. Compare the description of the conflict on the map with information about it online.
        i. Is the map's presentation of the conflict true and fair?
        ii. Are there sides of the case that are not mentioned on the map, and if so which?
2. Palm oil is the cause of environmental conflicts in many parts of the world. The organisations, WWF, Greenpeace and Danwatch have all documented and raised awareness of the environmental and social problems associated with palm oil production.
    a) Use the Internet to investigate what the palm oil conflicts are about.
    b) Where are the conflicts located?
    c) Use the Atlas of Environmental Justice to find an actual palm oil conflict.
        i. Make a list of the actors involved in the conflict
        ii. Make a list of the environmental problems.
        iii. Make a list of the social problems.
    d) Use the Atlas of Environmental Justice to compare the conflict you have chosen with other similar conflicts. Are there any players or problems that are present in several places?
    e) Make a list of the measures that have been proposed as solutions to palm oil conflicts?
    f) Devise a strategy for resolving a particular palm oil conflict?
    g) Discuss how to solve the palm oil problem more generally.

Theme 5: View on nature and ethics

1. Several organisations, funds and individuals work to protect nature in Denmark. Here are some links to some of them: http://www.dof.dk/ http://danarige.dk/ http://www.dn.dk/ http://ddnf.dk/ http://www.vildmedvilje.dk/
    a) Visit the websites and have a look around.
    b) Make a list of the key topics on the websites.
    c) Use Hans Fink's seven perspectives (see the infobox 'view on nature') to investigate which views on nature are expressed in these organisations' communication and activities.
    d) Make a list of the key actors involved in the issue of nature conservation in Denmark. In order to answer this, it may be necessary to visit other websites, such as the Nature Agency: http://naturstyrelsen.dk/
    e) Try to compare the different actors' interests, focus and approaches. What are the differences and similarities?
    f) Use the concepts anthropocentrism and ecocentrism to interpret the actors' approach to nature.
    g) Try to find out what the different actors consider to be valuable in nature.
    h) Use the concepts instrumental and intrinsic value to interpret the different actors' values in relation to nature.

Theme 6: Political decisions

1. How do we value things in our daily lives?
    a) Try to find examples of valuation where money and prices should not be used.
    b) Try to find examples where money and prices are a useful way of expressing value.
2. Memo 1: You have been given the task of helping decision-makers decide whether the Hærvej motorway should be built. You have to write a memo, which contains recommendations for a good decision-making process. Do not make recommendations about whether the motorway should be built, but rather about how the decision should be made. In your memo you must answer the following questions:
    a) What figures and calculations should be included in the decision-making process?
    b) Which interested parties should be listened to?
    c) Which experts should be consulted?
    d) How should the views of the public be heard?
    e) How would you design a decision-making process so that all the above elements are taken into consideration?
3. Memo 2: In this memo, you have to make an actual recommendation about whether construction of the Hærvej motorway should go ahead. Should it be built, or not? Regardless of your final recommendation, you should put forward arguments to support your recommendation.
    a) Specify the pros and cons of the decision.
    b) If you recommend a yes:
        i. Explain why the advantages outweigh the disadvantages.
        ii. Explain why there are no better alternatives.
    c) If you recommend a no:
        i. Explain why the disadvantages exceed the benefits.
        ii. Explain any better alternatives.

    Links for inspiration:
    http://haervejskomiteen.dk/
    http://haervejsmotorvejnejtak.dk/
    http://stoet.dn.dk/Default.aspx?ID=31633

Note: In tasks 2 and 3, the Hærvej motorway can be replaced by another major construction work or another important societal decision.

Theme 7: Control and regulation

1. Select a current environmental problem. Find inspiration in the publications about *Late lessons from early warnings*.
    a) When did the first warning about the problem emerge?
    b) How have the authorities attempted to regulate the problem? How has regulation evolved over time?
    c) Who wants the environmental problem to be solved? Does anybody want to obstruct the regulation?
    d) What progress has been made towards solving the problem?
2. Find some current examples of environmental side-effects that affect a third party, for example related to agriculture, industry or tourism.
    a) What methods can the state use to reduce the side-effects?
    b) What are the advantages and disadvantages of the various methods?
3. Find three examples of each of the four types of good.
    a) What type of good is the Internet?
    b) Try to find some examples of goods that have changed type over time.
4. The ozone layer is a layer in the atmosphere that protects biological life on the planet from ultraviolet radiation. It was discovered that the layer can be damaged by humans' use of the organic compound CFC. In this connection, an international agreement (the Montreal Protocol) was successful in phasing out the use of CFCs and similar substances, and it appears that the thinning of the ozone layer is slowing down. The ozone layer can be seen as a public good, where it is possible to reap the benefits of the good without doing anything. Can you think of any explanations as to why it has been so much easier to solve the problem of the ozone layer than to find effective solutions to the climate problem?
5. The atmosphere can be seen as both a public good and a global commons. Why?
    a) In December 2015, a global agreement (the Paris Agreement) was signed to maintain the global temperature increase below 2 degrees Celsius. How likely do you think it is that the Paris agreement will be successful? What interests are involved in the different countries?
6. A college kitchen can be seen as a form of commons. Can Ostrom's principles be used to establish rules for the use of the kitchen?
7. Explain how the markets for mobile phones, clothing and alcohol are regulated by the authorities and by other actors.
    a) What regulations apply to all the mentioned markets? What regulations are more specific?
    b) What are the arguments for and against the different regulations?
    c) Try to find examples of markets that are not regulated by the authorities. Are they regulated in other ways?
8. For many years, the supply of drinking water in Denmark has been carried out by local utilities owned by municipalities or by consumers jointly (as well as some private wells or boreholes that only supply water for a single house or a group of houses or for a business). The state regulates the utility companies' prices for water based on a non-profit principle, which means that the costs and investments must be covered, but no profit can be made. At the moment, discussions are taking place about whether the utilities should be

privatised, i.e. whether they should be sold to private actors. What are the different political parties' views on the privatisation of water supply and what arguments do they put forward?

Theme 8: Sustainable transition

1. The transportation system is an important societal system.
    a) What technologies are included in the transport system?
    b) What infrastructure needs to be in place to ensure that the transport system works?
    c) Where do market transactions occur in the system?
    d) Which laws regulate transport?
2. Draw a map that illustrates a societal system of your own choosing. You can write text on the map.
    a) Draw the system's infrastructure.
    b) Include the system's most important technologies.
    c) Indicate where market transactions occur on the map.
    d) Indicate where the different regulatory laws apply on the map.
3. Shipping is part of the societal system called the transport system, but it can also be seen as a societal system in itself. Find at least three examples of societal systems that are part of a larger societal system.
4. When politicians debate the transport system, the discussions usually focus on public transport versus private car transport.
    a) Investigate the different parliamentary parties' attitudes regarding this discussion.
    b) Find three arguments for increased transport with private cars.
    c) Find three arguments against increased transport with private cars.
        i. Discuss which arguments are the most convincing.
        ii. What role does the environment and sustainability play in these arguments?
    a) Discuss how different ideologies play a part in the discussion about public transport versus private car transport?
5. Political debates about societal systems often focus on the environment and sustainability. Choose a societal system.
    a) Examine which environmental problems are associated with the system.
    b) Find at least three political measures that could reduce these environmental problems.
6. Understanding the energy system as a societal system can be seen as a specific model of energy provisioning. However, mainstream economic theory focuses on the energy sector, which represents a different model of energy provisioning.
    a. Discuss the differences between the two models: societal system and sector.
7. Electric cars can be considered a niche in the transport system.
    a) What are the attitudes towards electric cars of the different parties in Denmark?
    b) What can be done politically to create a selection environment that promotes electric cars?
    c) What are the arguments for and against interventions that improve the selection environment for electric cars?
8. Choose a societal system.
    a) Identify a regime and a niche in this system.
    b) Specify the landscape factors that affect the development of the system.

c) Use the concepts of niche, regime, landscape, selection and selection environment to make as many hypotheses as possible about the future development of this system.

Note: Several of the above tasks can be varied by replacing the specified societal system with another. For example, in task 1, the transport system can be replaced by the food provisioning system.

Theme 9: The circular economy

1. Choose a product that you use in your everyday life, and try to draw a diagram of its entire life cycle from the cradle (resource extraction) to the grave (discarded) or new cradle (recycling).
    a) Make a list of the most important materials in the product and find out where they come from. Can any of these materials be recycled?
    b) Draw a diagram of the path of the product from the extraction of resources to you as a consumer.
    c) Try to find out where water is used to make the product.
    d) Try to find out how much energy is used on production and transportation.
    e) Try to find out how much CO_2 is emitted in connection with production and transportation.
    f) Discuss the following based on your own diagram:
        i. How can the product chain be made more circular?
        ii. Is it possible to separate the technical and biological cycles?

    If you need help getting started, you can get inspiration from the videos and links below:
    https://enviroliteracy.org/environment-society/life-cycle-analysis/
    http://storyofstuff.org/movies/story-of-stuff/
    http://storyofstuff.org/movies/story-of-electronics/
    http://storyofstuff.org/movies/story-of-cosmetics/
    http://storyofstuff.org/movies/story-of-bottled-water/
2. The circular economy has become a popular concept in Denmark, and several municipalities are striving to increase the recycling of resources. Find out what your municipality is doing to make the use of resources more circular.
    a) Does your municipality have a waste plan, and if so, what are the details?
    b) What role do recycling depots play in the circular economy in your municipality?
    c) What materials are recycled in your municipality and how?
    d) What are the arguments for increasing the recycling of resources?
3. Resources and the circular economy are also a national policy issue.
    a) What are the different parties' attitudes towards resources and recycling?
    b) Do any of the parties have a particularly strong profile in the field of resources, and if so, what is their position?
    c) What arguments are put forward in the debate on resources and recycling in Denmark?