THE DANISH COUNCIL OF ETHICS

Report on bioenergy, food production, and ethics in a globalised world

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A report from The Danish Council of Ethics

ISBN: 9788791112133
Published by The Danish Council of Ethics, 2014
Translated from the Danish report by Thomas Robinson

The publication is available on the Danish Council of Ethics' website at
www.etiskraad.dk

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Preface

The present report has been developed by a workgroup in the Danish Ethical Council with the following participants: Rikke Bagger Jørgensen (Chairwoman), Jacob Birkler, Niels Jørgen Cappelørn, Gunna Christiansen, Mickey Gjerris, Lene Kattrup, Peder Mouritsen, Jørgen Olesen, and Christina Wilson. Kasper Lippert-Rasmussen, who is Professor of Political Philosophy at the Department of Political Science at Aarhus University, was an external expert member. The report was evaluated and approved by the Ethical Council at meetings in February and March of 2012.

The Council and workgroup wishes to thank the many people who have contributed to the debate and thereby allowed access to their knowledge. Those in question are Christian Friis Bach, Honorary Professor at KU-LIFE, presently Minister for Foreign Aid, Henrik Wenzel, Professor at the Institute of Chemical Engineering, Biotechnology and Environmental Technology at the University of Southern Denmark, Klaus Grunert, Professor at the Institute for Marketing and Statistics at Business and Social Sciences, Aarhus University, Connie Hedegaard, EU Commissioner for Climate Action, Kristian Thorup-Kristensen, Professor at the Department for Plant and Environmental Sciences at the University of Copenhagen, John Erik Hermansen, Department of Agroecology at the University of, Aarhus, Torben Chrintz, Chief Knowledge Officer in Concito and Mikael Skou Andersen, Project Manager - Environmental economics and policies at The European Environmental Agency.

There is a special thanks to Niclas Scott Bentsen, PhD student at The Department of Forest and Landscape, University of Copenhagen. His affiliated memorandum *Bioenergi: Udvikling, anvendelse og miljømæssige forhold* [Bioenergy: development, use, and environmental impact] is available on the Ethical Council homepage. Also, he contributed in developing the chapter on bioenergy.

Anne Lykkeskov has been Project Manager for the workgroup at the Ethical Council. She and Morten Andreasen have, with assistance from Master's Student Rune Klingenberg, developed the manuscript on the basis of discussions in the workgroup and the Council.

April 2012

Jacob Birkler	Lise Wied Kirkegaard
Chairman of The Ethical Council	Director of Secretariat

Introduction

This report debates the often heard claim that there are substantial ethical problems related to the use of bioenergy. A main point of criticism is that energy crops take up sparse arable land and thereby compete with food crops, such that global food prices increase.[1] This development affects the poorest the most. Another point of criticism is that increasing demand for the production of energy crops can result in less room for nature.

Some kinds of bioenergy may reduce pressure on the climate along with their contribution to the energy supply. Thus, bioenergy can be a tool in battling two important global crises, namely the energy crisis and the climate crisis. However, it is important not to view the question concerning bioenergy in isolation, since growing energy crops may compete with food production and nature for scarce resources and thereby counter solutions to the equally acute crises concerning food- and natural resources. This results in ethical dilemmas, since different considerations and interests collide.

The Ethical Council wishes to focus upon the values that determine the choice of strategy in regard to countering these four challenges. In isolation, each of the crises constitute a serious threat to living conditions on the planet, but at the same time these crises are connected in such a way that they amplify each other. The Council wishes to point out that ethical deliberations should be more apparent in the political decision-making concerning crisis management.

When political decisions regarding climate and the environment are primarily based upon short sighted, economic considerations – often controlled by national interests – this also constitutes an ethical choice or perhaps disregard. Economic modelling rarely takes into account individuals who are distant in time or space, or biodiversity. Also, these are often not ascribed much value in comparison with immediate gain.

Not to include these considerations when developing strategies for countering the crises, expresses a normative choice; when we choose not to take action regarding global warming, we also choose to disregard the conditions of life for our descendants and people currently in existence that have their living conditions obliterated by climate change. The same applies when we choose overconsumption of certain limited resources or exhaust the natural basis for life, in which cases we also disregard concern for nature.

[1] There are new forms of bioenergy under development, which do not make demands on arable soil, such as blue biomass (algae), or biomass that stems from waste products such as manure or straw. However, if the aim of making Denmark fossil fuel free by 2050 is to be attained, it will be necessary to build upon techniques that require biomass from arable land for some time to come.

In a context of global economic crisis it may seem naïve to claim that economic considerations should be subject to deliberations about how to live, and which regards should be taken for other people, nature, and animals. However, on a slightly longer time scale, the present economic situation may turn out to be only a small shudder. As regards the state of the planet and the conditions for life in the longer run, it may be unfeasible to continue allowing short-sighted economic concerns to determine political decision-making.

The current situation is unprecedentedly serious for humanity: developments in greenhouse gas emissions follow worst-case scenarios from the UN Climate Panel (IPPC); the average global temperature increase is expected to be more than 2ºC, which will have an adverse effect on farming and the eco-system. The consequences of climate change are already visible many places in the world, while the consequences for our descendants are generally not known yet. However, with greater knowledge comes a better understanding of the serious consequences that will be brought about by climate change. Swift degradation of ecosystems constitutes an immediate threat to human living conditions and to animals, the rest of nature, and future generations. Global energy and food production is far from sustainable, which is aggravated by rapid growth in the global population. This means that there will be a need for food, energy, and other products for a population, which has grown by 40% in 2050. At the same time, it is expected that the world's middle class will grow more rapidly and living standards will improve, implying greater consumption, wherefore – all things being equal – there will be significant extra pressure on resources and climate.

The Council suggests that ethical considerations should have greater weight than previously, when it comes to decisions concerning: production, consumption, interaction with the natural world, and prioritising scarce resources. Obviously this also applies to the theme taken up in the present report about decisions to introduce bioenergy. **Emphasis in the report will be on the ethical concerns, which should determine the choices made to counter the enormous challenges, which confront the world.**

The concept of sustainability was introduced in the UN report *Our Common Future* from 1987. This held that a sustainable development is "a development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

The definition is therefore rather vague and is often used with different interpretations in different contexts, for example:

A. Environmental sustainability
B. Economic sustainability
C. Social sustainability

Actions may therefore be economically sustainable in the short run, but destructive for the biosphere and hence not sustainable in the environmental sense.

When we discuss the ethical concerns that should determine our actions as individuals and as a nation, it often turns out that we are not always able to live up to out ethical ideals in practical terms. That it is arduous to attain these requirements does not mean, however, that they do not express the right values. It may make a big difference if one strives to live up to them, over and against not thinking there is a regard to be taken to those who, for instance, are affected by climate change. The Council wishes to debate various views of which ethical concerns we should have as individuals and as society. Also, we encourage people to take a stand on our ethical ideals and follow up on them.

The main focus of the report is at the ways bioenergy competes with food production and nature for scarce resources. One obvious approach to this is by looking at the possibility of feeding the world's population on a smaller area, such that it frees arable land for energy crops. A related issue is the large and growing consumption of meat, since it is possible to feed more people on the same land, if food is made directly from the primary production, vegetarian, rather than being fed to animals first.[2] In addition, fewer farm animals would mean fewer emissions of greenhouse gasses, which in itself would have a beneficial effect upon the climate. The Council is aware that the carbon footprint from meat and meat products in Europe only constitutes around 4-12% of global warming,[3] and that other variables such as heating for homes and transport are equally or more important. When we emphasise food composition, it is because it also – in addition to amplifying the climate crisis – has an effect upon the food crisis and the nature/natural resource crisis and thereby comes into conflict with the concern for the world's poor, future generations, animal welfare, and the use of scarce resources. The field of work for the Ethical Council is exactly ethical questions concerning bio- and gene-technological developments in food production, environment, and nature.

The Council is aware that the production of bioenergy may have social implications, which are partly dependent upon local conditions. This applies to Denmark (for instance in regard to job creation and energy conservation), but also the developing countries may experience highly invasive, positive and negative consequences. Especially job creation, but also access and rights to land (cf. "land-grabbing" in developing countries) are relevant issues here. Although the Council recognizes that it is necessary to take into account people who are affected by these social consequences, these will not be at the core of the report. For reasons of delimitation, it will only concern the situation in Denmark and the consequences of Danish actions.

[2] Some calculations show that arable land in Denmark could feed approx. 11 million people if 30% of their food intake was meat, and approx. 20 million if they could make do with 15% meat, while it – in principle - could feed 80 million people if they were willing to live with a purely vegetarian diet (Kristian Thorup-Kristensen, Professor at the Department for Plant and Environmental Sciences at the University of Copenhagen, personal message)

[3] European Commission. 2006. *Environmental Impact of Products - Analysis of the life cycle environmental impacts related to the final consumption of the EU-25.* Bruxelles: European Commission. p. 15.

Bioenergy is often produced through biotechnological processes and may eventually be based upon genetic modification of crops and microorganisms. This gives rise to questions concerning the role of technology in solving the challenges, which confront us. In European societies this is often met with great scepticism. Indeed, also the members of The Ethical Council have differing views concerning the role of technology as a problem solver. Some hold that technology is a part of the problem, rather than a part of the solution, while others - in general – view technology as an important part of the response to the present situation, if it is put to proper use. This means that introducing new technology takes into account an acceptable balance concerning basic ethical variables.

Either way, it is possible to introduce bioenergy in many different ways and with methods of production having varying degrees of sustainability. It is decisive that short-term economic gain and ensuring supply does not come to determine implementation. The Council therefore considers it necessary to work towards developing a wider concept of growth, which is able to ascribe value to the environment and resources in economic modeling. However, the actual development of such models is not within the purview of the Council's activities, wherefore it should be left to the experts in that field.

Bioenergy is often presented as a "green" energy, which will replace the fossil fuels, which are a substantial cause of global warming. To the extent that the technologies are environmentally sustainable their usage will be in correspondence with the important ethical concern for future generations, distant people who are affected by climate change, and to nature. There are, however, a multitude of techniques for producing bioenergy and a plethora of biomass sources that may supply bioenergy production. Indeed, it is far from all of them that live up to the aim of being carbon neutral or being a carbon sink. To this must be added that a substantial part of bioenergy production is based upon crops and therefore take up scarce resources such as arable land, water, and plant nutrients, thereby increasing the global market price of food to the detriment of the world's poor and nature.[4] These questions are therefore at the core of decisions about using bioenergy.

[4] This only applies to the poor with no land. The landed poor may actually benefit from increasing food prices, since they are paid more for their goods. Thus, higher prices may give an incentive to produce more food and thereby improve their economic situation. However, the tendency is towards ever-more poor urban inhabitants. Higher food prices may be an incentive towards greater productivity in farming and food production in general.

Guide for readers

The report sets out with a description of the four global crises: the energy crisis, the climate crisis, the food crisis, and the crisis concerning nature/natural resources. Introducing various kinds of bioenergy may affect the crises positively or negatively, which gives rise to dilemmas, for instance when one kind of bioenergy is introduced to counter climate change, all the while it aggravates the other crises.

Chapter two reviews the various kinds of bioenergy and their effects upon the climate, environment and biosphere, food production, and the economy. The different kinds of bioenergy have very diverse effects upon these matters. Biomass is set to play an important role in our future energy supply. A complete phasing out of fossil fuels by 2050 is predicated upon 12% of Denmark's total land surface being laid out for energy crops. In addition to which the remaining arable land must produce the same amount of biomass by-product as today.[5] The consequence of setting off this arable land for bioenergy depends very much upon how the land is presently being used.

It should be mentioned that one often hears about great scientific disagreement concerning whether climate change is real and whether it is anthropogenic. However, the occurrence of anthropogenic climate change is an area with an unusually high degree of scientific consensus. This will be the theme for Chapter three. Scientific consensus regarding climate change does not mean that there is agreement about the scope of future change. Uncertainty is a condition for research, wherefore – as in other situations – we must base our reasoning upon the best knowledge available.

As mentioned, bioenergy and other efforts to alleviate the four crises, gives rise to ethical dilemmas. For instance, concerns for the environment and climate speaks in favour of ceasing all non-sustainable exploitation of resources, such as clearing rainforests for farmland to be used in food production and bioenergy. However, the concern for the world's growing population presents an argument for increasing the production of food and energy, so there is enough for everybody. In order to determine how to act in the face of such dilemmas, it is necessary to weigh who should be considered in the various situations. In Chapter four, it will be discussed which ethical regards should be considered for various ethical approaches in terms of animals, nature and humans - both those close to us and those that are distant in time and space.

[5] Klimakommissionen. 2010. *Grøn Energi - vejen mod et dansk energisystem uden fossile brændsler*. Danmark: Klimakommissionen.

Chapter five sets up three scenarios that illustrate how the dilemmas may be expressed in practical terms and which strategies for introducing bioenergy and mitigating the crises results from the choice of ethical outlook. We have named the three scenarios: 1) *An economically sustainable introduction of bioenergy - consumer-oriented vision*; 2) *A climatically and environmentally sustainable introduction of bioenergy – technology oriented vision*; 3) *An environmentally sustainable degrowth vision.* The purpose of these scenarios is to show how certain actions, everything else being equal, express certain values and that they are also ethical choices.

Chapter 6 concerns The Ethical Council's recommendation for using bioenergy in Denmark. The outset is that there are many kinds of bioenergy with very different, positive, and negative effects upon climate, environment, biosphere, and food production. The question is therefore not *whether* we should use bioenergy, but *which* values should determine our position on the various kinds of bioenergy.

1. Bioenergy and the four global crises

This chapter will look at the role of bioenergy in regard to four contemporary and closely connected crises related to using land and resources: the energy crisis, food crisis, climate crisis, and the crisis concerning natural resources. These crises are serious threats to humanity and related in such a manner that they reinforce each other since attempts to solve one crisis can aggravate the others. This gives rise to ethical dilemmas which necessitates prioritizing various conflicting values and aims:

- Bioenergy may potentially be one of the solutions to the energy crisis and could at the same time reduce the global warming that stems from burning fossil fuels. However, energy crops may take up limited resources such as arable land, water, and plant nutrients and destroy natural eco-systems, hereby worsening the food crisis and crisis concerning natural resources;
- If Denmark reduces its food production and uses the area for growing energy crops, it may reduce the supply of foodstuffs on the global market hereby contributing to higher food prices. This may aggravate the food crisis and would probably lead to conversion of non-cultivated areas for agriculture other places in the world, which has an adverse effect on the climate;
- If we choose a policy, which leads to the consumption of natural resources and cultivation of woodland, in order to manage the energy- and food crises, it would lead to a worsening of the climate crisis because of the carbon (C), which is locked in the trees and soil, that would be released as greenhouse gasses following deforestation. Depending on the mode of production, there is also a risk of increased erosion and pollution for the newly cleared area;
- Greater focus upon long-term environmental-, biosphere-, and climate aims may reduce food production for this generation, but probably increase the possibility for improved living standards for future generations;
- The climate crisis amplifies the food crisis, because it will lead to the destruction of arable land - especially in the poorer countries, which themselves emit very few greenhouse gases. However, a large percentage of emissions stem from farming, which through its activities aggravates the climate crisis;
- The type of production, which leads to lowest emissions per produced unit, is often the most intensive. If one therefore wishes to promote intensive and efficient husbandry to counter climate crisis and food crisis, one risks crossing important principles of animal welfare and land stewardship;
- Climate change is a threat to human living conditions. However, many of the bioenergy efforts that can be introduced to the benefit of humanity will damage nature and/or other beings.

Four central challenges

> *We must grasp the dimensions of the challenge. We must recognize that the drivers of that challenge include unsustainable lifestyles, production and consumption patterns, and the impact of population growth. As the global population grows from 7 billion to almost 9 billion by 2040, and the number of middle-class consumers increases by 3 billion over the next 20 years, the demand for resources will rise exponentially. By 2030, the world will need at least 50 per cent more food, 45 per cent more energy and 30 per cent more water — all at a time when environmental boundaries are throwing up new limits to supply. This is true not least for climate change, which affects all aspects of human and planetary health. The current global development model is unsustainable. We can no longer assume that our collective actions will not trigger tipping points as environmental thresholds are breached, risking irreversible damage to both ecosystems and human communities.* (United Nations secretary-General's high-level panel on Global sustainability. 2012)

This quote is from a UN high-level panel on global sustainability report[6] – a follow-up to the Brundtland-report from 1987,[7] which introduced the concept of 'sustainability' as an aim for global development. The new report notes that the current situation is, in many ways, more serious than in 1987 and that we are confronted with a number of global crises, which are each a serious threat to humanity, all the while they are connected in a manner whereby they amplify each other. The wish to introduce bioenergy, which is - in many cases - a sustainable energy, must be seen in relation to how it affects these four contemporary, global crises in energy, food, climate, and nature.

The energy crisis

> *The world's energy system is at a crossroads. Current global trends in energy supply and consumption are patently unsustainable — environmentally, economically, socially. But that can — and must — be altered. (*IEA, 2008*)*

This is how the International Energy Agency introduces its 2008 report about the global future of energy. The world's energy consumption is expected to grow 45% by 2030, not least because of an expanding population and an increasing demand for energy in China and India.[8]

[6] United Nations secretary-General's high-level panel on Global sustainability. 2012. *Resilient People, Resilient Planet – A future Worth Choosing.* New York: United Nations.
[7] United Nations World Commission on Environment and Development. 1987. *Our Common Future*. Oxford: Oxford University Press. (Se: http://www.un-documents.net/ocf-02.htm#I)
[8] International Energy Agency. 2008. *World Energy Outlook 2008.* Paris: IEA. p. 38.

Fossil fuels are currently the dominant source of energy and thereby one of the main culprits in regard to greenhouse gas emissions. For this reason the use of fossil fuels is obviously not sustainable. In October of 2009, the heads of government in the EU therefore confirmed the goal of limiting global warming to 2 degrees, which implies that emissions in industrialised countries should be reduced by 80-95% in 2050, as compared to 1990. In 2010 the Danish Climate Commission suggested how Denmark could live up to the aim of reducing emissions by 80-95% by 2050.[9] The primary approach is to reduce the use of fossil fuels. The premise here, and in the Energy Act of 2012, is to transition all of Denmark's energy supply to sustainable energy by 2050.[10] The purpose of establishing independence from fossil fuels is not just to reduce emissions, but also to ensure energy security, since fossil fuels are becoming scarcer with higher prices as a consequence.[11] A complete transition to sustainable energy will reduce emissions by 75% by 2050. Whether this goal is attainable will depend upon how one goes about it. Not all bioenergy can be viewed as sustainable if all inputs for its production are included. Furthermore, most would probably hold that it is equally important that transitioning to bioenergy will reduce pressure on nature.

The Climate Commission points out that the last 5-15% reductions of climate gas emissions has to be attained by looking at things other than energy consumptions. It points to agriculture as the second largest contributor to emissions after fossil fuels.[12]

According to the Climate Commission, a 80-95% reduction of emissions will require a total restructuring of the Danish energy system: away from oil, coal, and gas (currently 80% of energy consumption) and over to green energy with windmill and bioenergy as the most important components.[13]

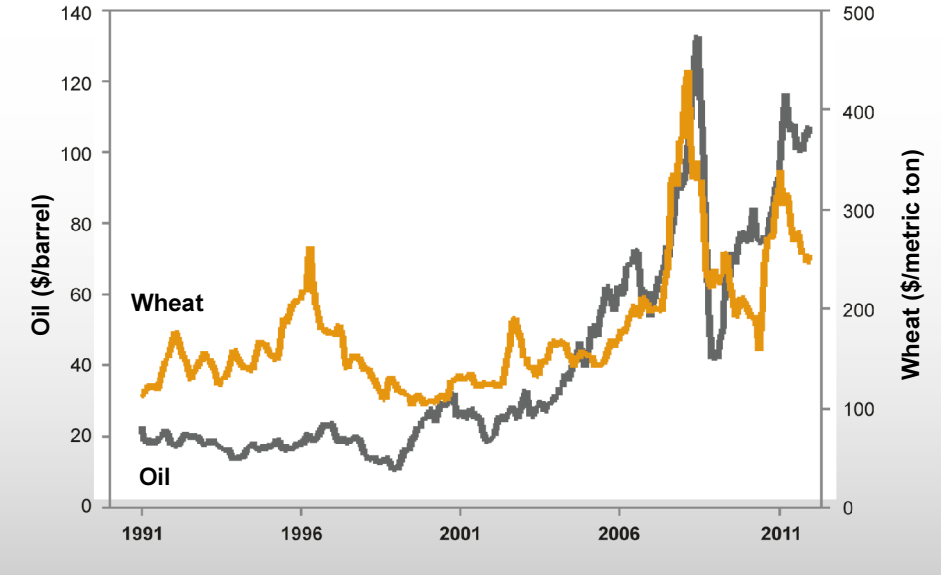
The Climate Commission therefore ascribes biomass an important role in regard to transitioning Denmark away from the use of fossil fuels; although it also points out that there are limits to how much biomass can be produced in Denmark and in the world. Even a comprehensive restructuring of Danish farmland for energy crops would be far from sufficient in covering future demand.[14] One strategy may be to import biomass, but this exports the problem to other countries, since there are globally no surplus areas which can be converted to biomass production (we will expand upon this issue in the section

[9] Klimakommissionen. 2010. *Grøn Energi - vejen mod et dansk energisystem uden fossile brændsler*. pp. 12-13.
[10] Agreement between the government parties (Social Democrats, The Danish Social-Liberal Party, and The Socialist People's Party), The Liberal Party, Danish People's Party, The Red-Green Alliance and The Conservative People's Party concerning Danish Energy policy 2012-2020, from March 22nd, 2012.
[11] Klimakommissionen. 2010. *Grøn Energi - vejen mod et dansk energisystem uden fossile brændsler*. p. 3.
12 Ibid., p. 45.
[13] Ibid., p. 8.
14 Ibid., p. 25.

below about the food crisis), wherefore demand for biomass from Denmark could reduce food production and negatively affect the environment in other places.

The International Energy Agency assumes that 27% of the world's transport fuel will stem from biomass in 2050, against the 2%, which is currently the case. In addition to resulting in a substantial reduction of emissions this could also contribute to energy security and socio-economic development, as can be read in their report from 2011.[15]

Development in wheat and oil prices 1991-2011



Source: Jørgen E. Olesen, data from Index Mundi, www.indexmundi.com

However, there is a clash of crises here, since while biofuels may contribute to a reduction of emissions and thereby counter climate change, it will at the same time take up arable land in competition with food production. Indeed, this was a part of the dynamic in the 2008 food crisis, as we shall see in the section thereon. The soil, which is used for energy crops, may be existing farmland, but it may also be land currently covered by forests that is converted into cultivation. This will release CO_2, which was bound as C in the plants, and possibly in the soil, thereby putting additional pressure on the climate, while simultaneously putting a strain on the bio-diversity and eco-system balances in these habitats.[16] There is also the risk that pollution of the environment increases, because of fertilizer and pesticide use in the production of energy crops.

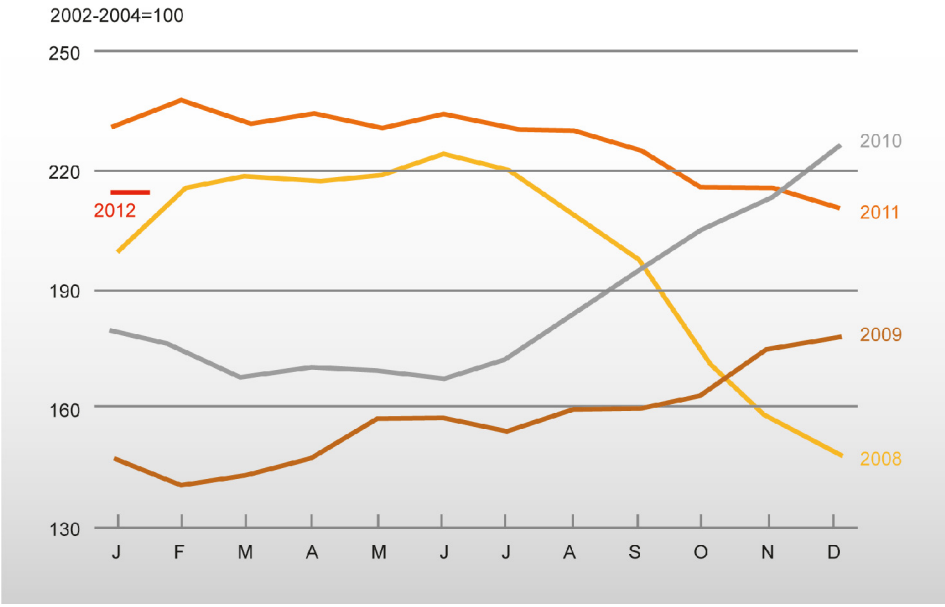
[15] International Energy Agency. 2011. *Technology Roadmap – Biofuels for Transport*. Frankrig: OECD/ IEA.
[16] European Commission. 2010. *Report from the Commission on indirect land-use change related to biofuels and bioliquids*. Bruxelles: European Commission. p. 3.

Bioenergy increases the correlation between energy and food prices. For instance, if demand for energy is expected to increase, its price will go up, which will affect food prices in several ways. Production of artificial fertilizer is for instance very energy intensive, just as higher energy prices result in greater costs for the fishing industry.[17]

The food crisis

> *The case for urgent action in the global food system is now compelling. We are at a unique moment in history as diverse factors converge to affect the demand, production and distribution of food over the next 20 to 40 years. The needs of a growing world population will need to be satisfied as critical resources such as water, energy and land become increasingly scarce. The food system must become sustainable, whilst adapting to climate change and substantially contributing to climate change mitigation. There is also a need to redouble efforts to address hunger, which continues to affect so many."* (Professor Sir John Beddington, The Government Office for Science. 2011).

FAO Food Price Index



Source: FAO, http://www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en/

[17] The Government Office for Science. 2011. *Foresight. The Future of Food and Farming*. London: The Government Office for Science. p. 15.

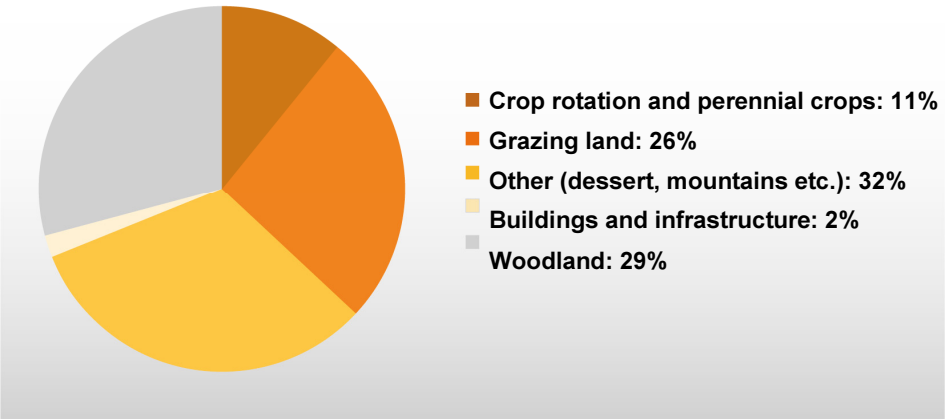
According to the FAO (Food and Agriculture Organisation of the United Nations) price index, global food prices for a time reached new heights in February 2011.[18] This was two years after having gone through a similar food crisis in the first half of 2008.[19] Both instances had serious consequences for the world's poor and resulted in riots in several countries.[20] This can be viewed as the beginning of the challenges that confront us over the coming years, in regard to producing sufficient food to feed the global population.

The two food crises had many causes, but were fundamentally the results of a very precarious balance between supply and demand in global markets over the last years. There is an increasing demand from developing countries for basic foodstuffs as for more advanced products such as meat (especially in the developing countries with greatest economic growth); growth in global food production declined as a result of an increasing proportion of arable land being set off for biofuels mainly destined for the transport sector. The OECD-FAO expects global farm output to grow by only 1.7% annually until 2020, compared with 2.6% in the previous decade.[21] Also, rising energy prices as well as legal requirements for use of biofuels, has increased demand for energy crops, which influences the supply of food negatively and therefore makes the prices go up.

In this vulnerable situation, single events may cause huge price increases. In 2007, most analysts considered the price level a result of high oil prices, which created an incentive for farmers to switch to energy crops. In addition to this switch the harvest failed in a number of countries.[22] The price hikes in 2010 were primarily caused by extreme weather in many places, which resulted in declining wheat harvests caused by drought in Russia combined with lower rice yields following flooding in Pakistan.[23]

[18] FAO. 2011. *Food Price Index (05-05-2011)*. New York: United Nations. (Se: http://www.fao.org/-worldfoodsituation/wfs-home/foodpricesindex/en/)
[19] IMF. 2008. *World Economic Outlook*. Washington, DC: International Monetary Fund. p. 60.
[20] Petherick, Anna. 2011. Food and the future. *Nature Climate Change.* Vol. 1.
[21] OECD/ FAO. 2011. *OECD-FAO Agricultural Outlook 2011-2020*. OECD Publishing and FAO. (Se: http://www.keepeek.com/Digital-Asset-Management/oecd/agriculture-and-food/oecd-fao-agricultural-outlook-2011_agr_outlook-2011-en)
[22] FAO. 2009. *How to feed the world in 2050*. FAO. pp. 23f. ; IMF. 2008. *World Economic Outlook*. pp. 60ff.
[23] FAO. 2010. Wheat sends food prices up. *FAO*. (Se: http://www.fao.org/news/story/en/item/45006/icode/)

Present Land Use



Source: Ministry of Food, Agriculture and Fisheries of Denmark

Food production is vulnerable, not least because global population is expected to increase by 40% from 6.7 billon in 2008 to 9.3 billion in 2050 and 10.1 billion in 2100.[24] Most of this demographic growth will happen in developing countries, where there is a great need for voluntary family planning. The United Nations Population Fund, UNFPA, estimates that at least 200 million women wish to use safe and efficient family planning, but are prevented for various reasons. The organisation points to the uncovered need for prevention growing by 40% over the next 15 years.[25] Perhaps the most important variable in reducing population growth is the education of women. The striking growth in the number of people with climate detrimental behaviour is one of the main causes of the problems concerning depletion of resources and lack of food, but population growth will not be the main theme for the report and will not be treated in detail.

Many developing countries are experiencing ever-greater prosperity and therefore demand more processed food and meat. Overall, according to FAO, these trends generate the need for a 70% increase in food production by 2050.[26] At present there are already very few "available areas", which can be put to use in increasing agricultural output.

Worldwide there are 13 billion hectares of land, of which 1.5 billion hectares are arable land and 3.5 billion hectares are for grazing animal husbandry. The remaining approx. 8 billion hectares are made up of 3.9 billion hectares of woodland and 4.2 billion hectares ice, mountain, desert, and so forth. Although there - in theory - are considerable areas that could be cultivated, FAO estimate

[24] United Nations. 2011. *World Population Prospects. The 2010 Revision*. New York: United Nations. (Se: http://esa.un.org/unpd/wpp/Other-Information/Press_Release_WPP2010.pdf)
[25] UNFPA. Reproductive Health – Ensuring that Every Pregnancy is Wanted. *United Nations*. (Se: http://www.unfpa.org/rh/planning.htm)
[26] FAO. 2009. *How to feed the world in 2050*. p. 2.

that this can only be done to a limited degree: partly because most of these areas are found in South American and African countries, where infrastructure poses a hindrance in the short run; and because it would require educating farmers. Perhaps more important is that these uncultivated areas have important ecological functions and making farmland of them would involve felling forests or including other natural areas, which would constitute a substantial climatic burden because of the C, which is bound in soil and vegetation thus released as CO_2 due to the clearing. Besides the new vegetation will not be able to capture as much CO_2 as the previous vegetation, to which it must be added that preserving woodland may have a value in and of itself. Because of these limitations, the FAO only expects arable land to expand by app. 5% by the year 2050.[27]

Furthermore, the FAO points to many areas already under cultivation showing disturbing signs of land degradation and exhaustion, because they are not managed sustainably. Food production often causes exhaustion of the soil, desertification, depletion of aquifers, loss of rain forest and bio-diversity. Without investment in sustaining and regenerating the threatened areas and without introducing sustainable agricultural methods, these areas will no longer be able to support cultivation.[28] The European Environment Agency Scientific Committee points out that monoculture has caused enormous loss of habitats by affecting perhaps 75% of the worlds ice and dessert free land areas, using aquifers and emitting large amounts of greenhouse gasses into the atmosphere.[29] We will return to this in the section below on the crisis concerning nature/natural resources below.

FAO expect it to be possible to expand global farmland areas by 5% or 70 million hectares, if a number of preconditions are fulfilled. The most important precondition is that exhaustion by the global food production of plant nourishment, soil erosion, desertification, depletion of aquifers and loss of tropical forests are halted and that sustainable agricultural methods are employed. The organisation expects that 90% of crop output growth will stem from intensification of agriculture in developing countries. Such a process should make it possible to cover global food requirements in 2050.[30] However, requirements concerning sustainable use of resources are not being followed at present time, wherefore it seems very doubtful that the goal will be reached.

Also, the FAO adds that these projections do not take into account intensive competition for limited land and water resources between food- and energy crops. The last food crisis demonstrated that higher oil prices and state

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[27] Ibid., p. 9.
[28] Ibid., pp. 8ff.
[29] EEA Scientific Committee. 2011. *Opinion of the EEA Scientific Committee on Greenhouse Gas Accounting in Relation to Bioenergy*. European Environment Agency Scientific Committee. p. 1.
30 FAO. 2009. *How to feed the world in 2050*. pp. 8ff.

subsidised first-generation bioenergy technology could swiftly add to higher prices, but also lead to food and animal feed shortages.[31]

The production of meat constitutes a different and very substantial obstacle to increasing food production. The last years' economic growth in China and other prosperous developmental countries has resulted in higher income for the populations, wherefore they are given the opportunity to eat meat, rather than their previous, largely vegetarian diets. The global production of meat is expected to rise from 229 million tonnes in 1999/01 to 465 million tonnes by 2050.[32]

The extensive consumption of meat in the West and increasing consumption in the rest of the world is problematic, since it requires more resources to produce such carnivorous rather than vegetarian diets.

This can be seen from the acreage requirements for producing meat as compared with the land area needed for vegetarian diets. This shows that it is possible to produce 1 kg of grain on around 1.5 m^2 of arable land in Denmark. In comparison, 1 kg of pork requires around 8 m^2 and 1 kg of beef around 24 m^2. However, the areas required may be much larger in other countries.[33]

Since there is approx. twice the energy in 1 kg of grain (approx. 17.000 KJ), in comparison with meat (approx. 8.000 KJ), an additional calculation shows that for eating pork and beef one needs about 20 and 40 times the agricultural land respectively, that is required for eating bread, grains, or pasta.[34] With a diet made up of 70% vegetarian products and 30% meat (15% pork and 15% beef), food production in Denmark requires around 2300 m^2 of farmland per person. If the consumption of meat were merely 15%, 1300 m^2 would suffice per person. This means that Denmark could produce food for 11 million people, if their diet were 70% vegetarian and 30% carnivorous, while halving the consumption of meat would make it possible to feed 20 million people. If production were purely vegetarian, Denmark could feed 80 million people.[35]

One could also examine how many kg of grain or other feed units were needed to produce beef, pork, or chicken. That calculation would show that a bullock needs approx. 5.81 Feed Units (where one feed unit is equal to the energy in 1 kg of barley) per kg of weight gain. A pig requires approx. 2.84 Feed Units per kg of weight gain and a chicken approx. 1.72 Feed Units for 1 kg of weight

31 Ibid., p. 14.
32 Steinfeld et al. 2006. *Livestock's long shadow*. Rome: FAO.
33 This is based upon the total weight of the animal, subtracted the parts not used.
34 This calculation is based on data that varies a little from the above, because of different methods of compilation, for instance how much energy from animal fat should be included as edible flesh.
35 Kristian Thorup-Kristensen, Professor at the Department for Plant and Environmental Sciences at the University of Copenhagen, personal message

gain.[36] It is worth noting that these numbers apply to whole animals and not just the parts that are edible. Thus, bones and innards are included. The numbers are therefore higher when one looks at the energy required for producing 1 kg of edible meat. It is also worth noting that not all energy found in animal feed could have been used for human consumption. This applies particularly to cows that in addition to grain also eat grass, which cannot be consumed by humans. As a rule of thumb, however, it is the case that one can feed substantially less meat eaters than vegetarians on the same farmland. The growing number of meat eaters is therefore a hindrance to increasing the amount of food. All the while, animal husbandry also affects the climate and the environment. We shall return to this is the section on the climate crisis.

Feeding the growing population will therefore be a substantial challenge - indeed it may even be impossible. In either case the International Food Policy Research Institute (IFPRI) expects prices to go up by 40 – 72% for the most important foodstuffs by 2050, because of population growth and increased demand for meat and energy crops. To this we must add that climate change will have an adverse effect on agriculture. IFPRI's calculations show that the effects of climate change will mean an additional increase in prices of between 12-111% for the most important crops such as rice, maize, soya beans and wheat.[37]

Biofuels may constitute a barrier to growing enough food for everybody. According to FAO, the production of biofuels was tripled between 2000 and 2008. Also, if biofuels are still to be based upon food crops, it may have serious implications for food security.[38] It has also been claimed that the production of energy crops may be a source of income for farmers in developing countries, but this may have complicated repercussions, since the subsequent competition with food production may affect the landless poor.[39] However, to the extent that bioenergy replaces fossil fuels and reduces pressure on the climate, it will in the long run contribute to countering the challenges to agriculture generated by climate change.

The climate crisis

Over time a consensus has been reached that climate change is a reality and that our daily activities are a contributing cause. All the while emissions cause increasing temperatures, the changed climate also changes precipitation patterns, causes more extreme weather, desertification, and increasing water

36 Poulsen, Hanne Damgaard. 2011. Normtal for husdyrgødning. (Se: http://agrsci.au.dk/fileadmin/-DJF/HBS/HEM/Normtal_2011_med_NH4_pdf.pdf)

[37] International Food Policy Research Institute. 2009. *Climate Change Impact on Agriculture and Costs of Adaptation*. IFPRI. p. 16.

[38] FAO. 2009. *How to feed the world in 2050*. p. 3.

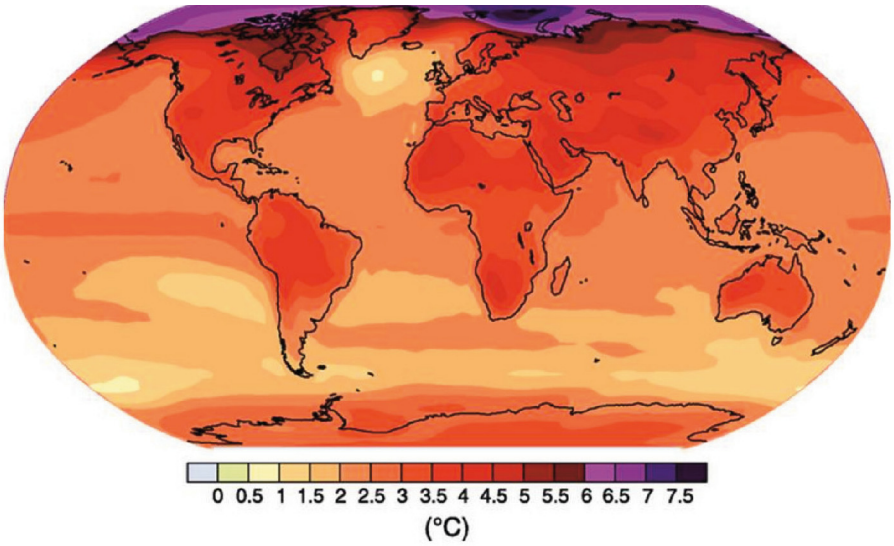
[39] Gamborg, C. et al. 2011. Bioenergy and Land Use: Framing the Ethical Debate. *Journal of Agricultural and Environmental Ethics.*

levels in the oceans, which can bring about flooding of low-lying areas.[40] For this reason, climate change will reduce the opportunity for agriculture, especially in the many developing countries that have vulnerable soil usage.[41] Climate change is thus one of the biggest challenges ever facing mankind because of the enormous consequences it will have for the globe's ecosystems and human living conditions.[42]

As mentioned, the EU countries must reduce their emissions by 80-95% before 2050 as compared with 1990. The Climate Commission report from 2010 was a suggestion as how to attain such a target.[43]

There is a direct connection between the food crisis and the climate crisis, since global warming destroys arable land, particularly in developing countries in tropical and sub-tropical zones.[44]

Expected changes in surface temperature 2090-2099 (relative to the period 1980-1999)



Source: IPCC Fourth Assessment Report: Climate Change 2007

[40] Intergovernmental Panel on Climate Change. 2007. *IPCC Fourth Assessment Report - Synthesis Report*. UNEP. p. 26.
[41] International Food Policy Research Institute. 2007. *The World Food Situation - New Driving Forces and Required Actions*. Washington, DC: IFPRI. p. 11.
[42] Olesen, Jørgen E. 2010. Fødevarernes andel af klimabelastningen. In *Vores mad og det globale klima – Etik til en varmere klode*. Danmark: Det Etiske Råd.
[43] Klimakommissionen. 2010. *Grøn Energi - vejen mod et dansk energisystem uden fossile brændsler*.
[44] International Food Policy Research Institute. 2009. *Climate Change Impact on Agriculture and Costs of Adaptation*. p. vii.

There are enormous regional differences when the consequences of global warming will manifest themselves. They are already felt in the poor countries of the world, while the industrialised countries, which emit by far the most greenhouse gasses, are in the short run the least vulnerable to the effects of climate change. Either way, equatorial countries are already experiencing declining yields and more extreme weather. Also, it is expected that the negative effect of climate change – all else being equal – will reduce the output from African farming by 15-30 % in 2080-2100.[45]

In our part of the world, it is likely that the coming generations will feel the worst effects, since the effects occur far later (decades and centuries) than the emissions.[46] Since publication of the last report from the Intergovernmental Panel on Climate Change (IPCC) in 2007, it has been demonstrated, however, that climate changes affect the world sooner than predicted in earlier models and emissions continue at a pace, which is located among the pessimistic predictions.[47]

There is a dual climate challenge when it comes to food production, since a large fraction of the emissions, which lead to climate change, stem from agriculture. Farming must therefore adapt to changes as well as reduce emissions. The Climate Commission has pointed out that agriculture is the second largest emitter of greenhouse gasses in Denmark, so if we wish to live up to the goal of reducing domestic emissions by 80-95% by 2050, it is absolutely essential to focus upon the contribution from food production.[48]

In Denmark, agriculture is responsible for 16% of all emissions, but this only includes actual production, not the emissions from transport of produce to processing, processing per se, distribution, waste, etc.[49] Emissions from import of feed, fertilizer, and other materials used for sustaining production are not included either. Around 20-30% of the EU countries' total emissions stem from the production and use of food.[50] A very large part of this is related to livestock.[51] However, there is some uncertainty concerning the exact amount because of the uncertainty regarding the cultivation of woodland for feed production.[52]

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[45] FAO. 2009. *How to feed the world in 2050*. p. 3.
[46] Olesen, Jørgen E. 2010. Fødevarernes andel af klimabelastningen.
[47] The Government Office for Science (ed. John Beddington). 2010. *Food, energy, water and the climate: a perfect storm of global events?* London: The Government Office for Science.
[48] Klimakommissionen. 2010. *Grøn Energi - vejen mod et dansk energisystem uden fossile brændsler*. p. 45.
[49] Fødevareministeriet. 2008a. *Landbrug og Klima*. Danmark: Fødevareministeriet. p. 12.
[50] European Commision. 2006. *Environmental Impact of Products - Analysis of the life cycle environmental impacts related to the final consumption of the EU-25.* IPTS/ESTO project (EIPRO) studies siger 31% (pp. 15-16).
[51] Steinfeld et al. 2006. *Livestock's long shadow*.
[52] Olesen, Jørgen E. 2010. Fødevarernes andel af klimabelastningen.

For Europe the total consumption of meat and meat products is responsible for around 4-12% of the contribution to global warming.[53] However, at the global level the emissions from animal production amounts to 18% of emissions, which is a larger contribution than emissions from the transport sector on land, in the air, and at sea combined.[54] Beef's contribution is 4-8 times that of pork and chicken. This is because the emission of methane from ruminant mammal (cattle and sheep) digestion is far greater than emissions from mono-gastric digestion (pigs and chickens).[55]

It should be mentioned, that there is a dilemma here, since the type of livestock production, which has least emissions is also often the most intensive production and uses the lowest amount of feed per kg meat. All the while, the most intensive industrialised agriculture is currently being criticised for utilising methods of production, which disregards animal welfare.[56]

However, this is a complex situation. It is not given that intensive land use results in overall less emissions. This is because organic farming has an advantage in using less fossil fuel and storing a relatively large amount of carbon in the ground. Organic farming is, on the other hand, less efficient, in that is has a lower output: smaller yields per hectare and organic husbandry has animals that grow slower and produce less than in conventional and intensive production. In this context it is interesting that some studies show a tendency for those who buy organic food to eat less meat-based products, which therefore reduces the environmental footprint. One reason may be that organic meat is more expensive, which thus suggests that a tax on meat products could result in less consumption of meat.[57]

Over the last decades Denmark has become one of the biggest per capita meat consumers in the world. As can be seen in table 1, Denmark consumes far more that in Africa and Asia. There is, however, a tendency even in regions such as Asia and South America towards greater meat consumption.

[53] European Commision. 2006. *Environmental Impact of Products - Analysis of the life cycle environmental impacts related to the final consumption of the EU-25.* p. 15.
[54] Steinfeld et al. 2006. *Livestock's long shadow*. p. xxi.
[55] Det Jordbrugsvidenskabelige Fakultet (Institut for Jordbrugsproduktion og Miljø). 2008. *Notat om Fødevarernes klimaaftryk*. Aarhus Universitet (upubliceret).
[56] See for instance Foer, Jonathan Safran. 2010. *Om at spise dyr*. Købehavn: Tiderne Skifter.
[57] Sandøe, Peter et al. 2011. Kød og klima – bør vi blive vegetarer for at modvirke den globale opvarmning, eller er det godt nok at spise økologisk? In *Klima og etik*, ed. Søbirk og Ryberg. Danmark: Roskilde Universitetsforlag.

Table 1. Development in gross annual per capita consumption of meat (kg meat per year) for selected countries and regions in the period 1980 to 2007

	1980	1990	2000	2007
Denmark	79	98	114	98
Sweden	64	59	69	79
USA	109	113	120	123
Argentina	111	84	98	91
China	15	26	50	53
Africa total	14	14	15	16
Asia total	11	17	26	28
Europe total	73	80	70	77
America total	69	69	82	85

Source: FAO-stat: http://faostat.fao.org/default.aspx [58]

As can be seen in table 2 below milk, butter, and cheese also leave a large environmental footprint, while plant based food such as free range vegetables, flour, grains, and bread are least detrimental to the environment, insofar as they are not transported by plane. [59]

[58] Various methodologies are used, depending on which organisation compiles the meat consumption data. For Denmark, methodology was changed in 2005, such that the destruction of heads and hooves was not included after, which results in lower numbers.
[59] Carlsson-Kanyama, Annika. 2010. Fødevarernes klimabelastning – hvordan kan en klimavenlig kost se ud? In *Vores mad og det globale klima – Etik til en varmere klode*. København: Det Etiske Råd.

Table 2. Climate footprint of food according to energy content, kg CO_2-equiv. per 1 MJ.

Food stuffs in the supermarket	kg CO_2-equiv. per 1 MJ
Beef	1,47
Cheese	0,84
Skimmed milk	0,59
Pork	0,46
Chicken, whole and uncooked	0,41
Egg	0,31
Onion	0,20
Rye bread, fresh	0,09
Wheat flour	0,08
Carrots	0,08
Wheat bread, fresh	0,07
Potatoes	0,06
Oats	0,05

Source: Olesen, 2010

It should be mentioned that food waste is a global problem. It is a huge problem when so many starve, but it is also a sustainability problem when the production of food emits greenhouse gasses and uses scarce resources. Around one third of all food produced – or 3.1 billion tons – is wasted every year. [60]

Developing and industrialized countries waste the same amount, but at different stages in the in the production/consumption process. Low-income countries loose most food during or shortly after harvest or during processing, while there is very little loss among the consumers. In high-income countries 40% of goods are lost in retail or by consumers, although the food is still suitable for human consumption. Food waste among the consumers in industrialised countries (220 million tons) is almost equivalent to food production in sub-Saharan Africa (230 million tons).[61] There is no data for Denmark concerning the extent of food waste, but a memorandum developed by the University of Aarhus for the

[60] Gustavsson et al. 2011. *Global Food Losses and Food Waste*. Rome: Food And Agriculture Organization Of The United Nations. p. 5.
[61] Ibid.

Ministry for Food, Agriculture, and Fisheries in 2010 estimates that it constitutes 13.5% of the total carbon footprint of all food. [62]

The crisis concerning natural resources

> *Damage to global ecosystem services and biodiversity is acute and accelerating. In the last century we have lost 35% of mangroves, 40% of forests and 50% of wetlands. 60% of ecosystem services have been degraded in fifty years. Species loss is 100 to 1000 times higher than in geological times and will get worse with climate change. 80% of the world's fisheries are fully- or over-exploited. Critical thresholds are being passed: for example, coral reefs risk collapse if CO_2 emissions are not urgently reduced.* (TEEB. 2009)

The destruction of bio-diversity resulting from human activity has been greater over the last 50 years than at any other time in human history. [63] Recognition of this led to the UN environmental programme developing the bio-diversity convention in 1992. 168 countries have currently signedthe agreement. Alas, it is very difficult to see any effect from the convention, and at least species and

> In the report we do not by the term 'natural resource crisis' wish to imply that the natural world is merely a resource for humans to exploit without any inherent value.

habitat extinction continues at an alarming rate.
The most important cause of declining biodiversity is human changes in soil use, river flows, damming, loss of coral reefs, damages to the seabed from trawling, climate change, invasive species, overexploitation, and pollution.[64]

In 1987 the UN published the Brundtland-report, which contains the following definition of sustainability: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".[65] Elsewhere the report adds: "The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities."[66] The report mentions the essential needs of the

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[62] Mogensen et al. 2011. *Notat vedrørende: Madspild i fødevareproduktionen – fra primærproduktion til detailled*. Det Jordbrugsvidenskabelige Fakultet (Institut for Jordbrugsproduktion og Miljø). p. 22.
[63] Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-being: Biodiversity Synthesis*. Washington, DC: World Resources Institute.
64 Ibid
[65] United Nations World Commission on Environment and Development. 1987. *Our Common Future*. Kapitel 2.
[66] Ibid., Overview, bullet 27.

poor and the limitations set by technology, social organization, and the environment. The concept of sustainability can, as mentioned in the introduction, be defined in different ways, for instance one can distinguish between environmental, the economic, an social sustainability. There may be a tendency for the choice of definition to reflect the status the user ascribes to the environment. Currently many agricultural systems are not sustainable according the Brundtland definition, but rather contribute substantially to the environmental problems that threaten biodiversity[67] and other goods, which we receive from the ecosystem.[68]

People as well as the rest of nature depend completely upon well functioning ecosystems, where biodiversity is one of the preconditions as well as an indicator for the state of the ecosystem. However, the value of biodiversity is often overlooked, because it is 'invisible' in economic calculations.[69]

That which is sometimes termed *ecosystem services* is the basis for economies, societies, and individual welfare. Ecosystem services comprise *supporting services*, (soil nutrients dispersal and cycling, photosynthesis, primary production, and water cycles), which is a precondition of all other 'ecosystem services', such as *provisioning services* (food, fibres, fuel, fresh water, genetic resources, or bio-chemical materials); *regulating services* (processes that regulate climate, flooding, diseases, water quality, and pollination) and *cultural services* (such as recreation, aesthetics, inspiration, reflection, landscape values, and cognitive development).

It is important to understand that the opportunity to find a replacement for water, fuel, timber, food, or water purification is very limited. In some cases, as that of species extinction, there are no substitutes.[70] However, in many cases there will be some overlap between species, when it comes to ecosystem function. Species extinction need not affect ecosystem function fatally. It is far more serious if human actions or anthropogenic environmental change results in the disappearance of a certain kind of ecosystem.

Globally speaking, agriculture uses vast amounts of non-renewable resources and it utilizes many renewable resources at a much faster rate than they can replenish. These activities cover forestry, conventional farming and horticulture, which take up around 70% of global fresh water use from rivers and ground water. The demand is set to grow by 30% by 2030.[71] Cattle play an important

[67] The Government Office for Science. 2011. *Foresight. The Future of Food and Farming*. p. 10.
[68] Power, Alison G. 2010. Ecosystem services and agriculture: tradeoffs and synergies. *Philosophical Transactions Of The Royal Society B-Biological Sciences*. Vol. 365, no. 1554.
[69] TEEB. 2009. *The Economics of Ecosystems and Biodiversity for National and International Policy Makers – Summary: Responding to the Value of Nature*. TEEB. p. 4.
[70] TEEB. 2009. *TEEB for Policy Makers Draft Chapters. Chapter 1: The global biodiversity crisis and related policy challenge*. pp. 4ff.
[71] The Government Office for Science. 2011. *Foresight. The Future of Food and Farming*. p. 12.

role here, since 8% of human water usage is spent on animal husbandry - primarily for irrigation of feed cultivation.[72]

It is estimated that 24% of cultivated land has been reduced in quality by humans, particularly though erosion. To this must be added that agriculture emits greenhouse gasses, nutrients, and other pollutants to the environment that damage the natural ecosystems and reduces biodiversity. There is a direct influence upon ecosystems through these variables, but to this we must add the conversion of fallow land to cultivation. This situation must change if the conditions and requirements needed for feeding the world are not to be destroyed.[73]

Because of ever-greater meat production large woodland areas are being cleared for grazing areas and for feed production. The carbon, which is bound in the forests, is thus released as for instance CO_2, when the trees are cut down. Also, the regular crops are unable to bind as much CO_2 as did the trees. This development can be seen particularly in Latin America.[74]

The effect of energy crops upon biodiversity depends upon a number of variables. One is whether they are cultivated on soil that was previously used for farming or whether it was recently cleared forest. Another factor is which cultivation methods are to be used and a third, which crop is planted. Oil palm, soybeans, sugar cane, maize, and rapeseed are all very detrimental to biodiversity. Oil palm is often planted in place of rain forest, and all the mentioned crops are cultivated as monoculture using artificial fertiliser. Most grasses, willow, poplars, and eucalyptus are second-generation energy crops that have a neutral or moderate effect upon biodiversity, if they are cultivated in soil that was already employed for agriculture.[75]

Often it is argued, of latest in the report for the UN General Secretary's High-Level Panel on global sustainability,[76] that the weak effort to counter the loss of biodiversity and ecosystem degradation is based on the fact that traditional economic models cannot capture the value of ecosystems. The panel notes that it is necessary to include the sustainability paradigm in economic thought. The reason for this is that – for instance in regard to climate change – the ability to price environmental and natural resources is deficient. Thus, most goods and services currently sold do not reflect the environmental and social costs that went into making them.

[72] Steinfeld et al. 2006. *Livestock's long shadow*. p. xxii.
[73] The Government Office for Science. 2011. *Foresight. The Future of Food and Farming*. p. 12.
[74] Steinfeld et al. 2006. *Livestock's long shadow*. p. xxi.
[75] Fischer et al. 2009. *Biofuels and Food Security*. Vienna: IIASA. pp. 78ff.
[76] United Nations secretary-General's high-level panel on Global sustainability. 2012. *Resilient People, Resilient Planet – A future Worth Choosing*. Overview, pp. 5ff.

For this reason it is necessary to introduce a much wider concept of growth that prices the environment and natural resources. It is no longer sufficient to merely calculate growth in GDP, where production and consumption - which harm the environment - count as value adding activities. Not till the cost of a given activity and the cost of not performing that activity are taken into account will the political system be able to implement the necessary policies to ensure a sustainable future.[77]

A similar problem concerns the ability of economic models in pricing the value of long-term investments. When economists calculate the value of pay-offs that only occur in the far future, they use what is known as the discount rate. They do this to translate future value into present value. The discount rate for public investment is a political choice and it is absolutely essential for the outcome: a high discount rate means that the costs and gains in the future – for instance the pay-off from lowering emissions - is ascribed a low value.[78] Denmark uses a discount rate of 6%. This means that if we invest 100.000 dkr, which will not pay-off until 50 years from now, the value at that time must be 1.85 million dkr for it to be a sensible investment. If a discount rate of 2.2% is used as in Germany, the value 50 years from now need only be 300.000 kr. The Danish discount rate is very high compared to other similar countries and in regard to EU recommendations.[79] By setting the discount rate so high, there is an implicit choice to prioritise the present generations and short-term gains over the future and the concern for the coming generations.

[77] Ibid.
[78] De Økonomiske Råd. 2010. *Økonomi og Miljø*. Danmark: De Økonomiske Råd. pp. 375ff.
[79] Concito. 2011. *Den samfundsøkonomiske kalkulationsrente – fakta og etik*. Danmark: Concito. (Se: http://www.concito.info/sites/concito.dk/files/dokumenter/artikler/notat-den_samfundsoekonomiske_kalkulationsrente_-_fakta_og_etik__10._feb_2011pressemeddelelser---statens-gr-nne-beregninger-under-al-kritik_3_2008165469_0.pdf)

2. Bioenergy as a resource

The use of energy from biomass from Danish agriculture in the shape of by-products such as liquid manure, wood, and straw, but also from energy crops such as rapeseed and willow, have the potential to limit society's carbon dioxide emissions substantially and improving energy security. Biomass has therefore been selected to play an important role in future energy supply.

In order to attain a complete phasing out of fossil fuels by 2050, an area of around 12% of Denmark's land surface will have to be cultivated with energy crops, according to one scenario. In addition, existing agriculture must generate the same amount of biomass by-products as today. The consequence for the climate, environment, biosphere, food production, animal welfare, and for the economy will depend upon the specific use of the given acreage. The consequences of this strategy are also coupled to the choices made about which resources – including energy crops – are to be used, but also which current soil usage is to be phased out, where the crops are located, and which role technology, such as genetics, will play.

There are great expectations for the production of transport fuel from plant fibres. These are also known as second generation (2G) fuels. While the technologies require some development before 2G fuels can compete in the market, there are indicators that if areas with traditional crops such as barley or rapeseed are exchanged with for instance willow or grass, 2G fuels will be able to attain certain climate, biosphere, and environmental improvements as well as a by-product, which can be used as feed.

It is estimated that an area corresponding with 12% of arable land may be released through more efficient usage in farming, i.e. without a reduction in food production. However, whether the 12% should be used for bioenergy purposes, rather than converted into open countryside for wildlife, or if there should even be greater efficiency in agriculture are ethical and political questions.

Summary Table[80]

Biomass	Livestock manure	Straw and wood		Energy crops (2050)				
				Rape seed	Willow / poplar	Willow / poplar	Maize	Maize
Energy format	Power station (biogas)	Power station (for burning)	Ethanol (2. gen.)	Biodiesel (1. gen.)	Power station	BTL-diesel (2. gen)	Bio-SNG (2. gen)	Ethanol (1. gen.)
Estimated potential Gross energy (% of 2010 production)	2	5-8	3-4	3-4	12	7	14	8
Area requirements in comparison with 2008	No change, but maintains the current production of livestock	No change, but maintains the current production of soil		520.000 ha arable land in 2050 (i.e.: 520.000 hektares rape seed could cover 3-4 % of current Danish energy needs, while willow and poplar could cover 12 or 7 %, depending upon whether it is used for power stations or diesel production. See more about the premises for these calculations below in the table				
Estimated climate in comparison with fossil fuels (+ = better)	++	+++	++	+	++	++	++	+
Weighted score, climate, e-crops (potential x climate effect)				+	+++	++	++	+
Technological level/ Present cost efficiency	+++ / +++	+++ / +++	+ / +	+++ / +	+++ / +++	+ / +	+ / +	+++ / +
Effects on environment and biosphere	See area requirements. Indirect area requirements from existing agriculture	Indirect area requirements from existing soil use and given that wood is not collected in pristine forests		Requires plant nutrients and pesticides	Requires water; willow/poplar require less nutrients and pesticides than most annual plants		As for existing agriculture, maize requires nutrients and pesticides	
Food supply	Unchanged	Contributes to exhaustion		Stagnation in food production; Contributes to exhaustion	Stagnation in food production; Fixes carbon in the soil, unlike many other crops		Stagnation in food production; Contributes to exhaustion	

The table summarises the approximate outcomes for some of the possible resources in terms of bioenergy (gross values, i.e. before loss from conversion etc., about which more can be read below), as well as the consequences in terms of area utilisation, climate, environment, biosphere and food production.

[80] Calculating the energy output for energy crops is based upon the Climate Comission's data, where a crop that uses 4.8 hectares per TJ can deliver 110 PJ on 520 hectares *(tera joule corresponds to 10^{12} J, peta joule to 10^{15} joule). Via Ha/TJ these are converted into units for various energy resources in Miller (2010), which in return must be viewed as very dependent upon various assumptions in the calculations. The data can therefore be viewed as giving an indicator for the relative contributions among various resources, rather than precise data. Evaluation the effect upon emissions in comparison with fossil fuels is based upon LCA-analyses in Rettenmeier (Baggrundsnotat ref 62) and (Baggrundsnotat ref 64).*

At the top is found the percentage of current Danish energy usage that a given crop can contribute. It is assumed that an area of 520.000 hectares is cultivated with an energy crop, while the remaining energy sources are based upon by-products from farming and forestry. Further down the table, one sees the efficiency of the particular crop in absorbing greenhouse gasses, which is very much related to energy requirements in production and losses at conversion to electricity, liquid fuel etc. The best crop is thus the one that delivers a lot of energy all the while it hinders emissions of CO_2. However, energy crops must take variations in carbon loss or carbon fixing in soil into account. All the figures must be viewed as indicative rather than precise values.

The various resources are very different in terms of cost efficiency (i.e. how cheaply they reduce climate gas emissions), which among other things depends upon the price of the fossil energy source being replaced and CO_2 quotas. Especially 2G technologies are at a lower stage of development, wherefore they lack competitiveness, while 1G technologies are very sensitive to food and feed price variations. As an indication of this, scores are shown for levels of technological sophistication and present cost efficiency (more stars equal more advanced/ lower price relative to reduction of emissions).

The production of bioenergy

Bioenergy denotes energy made from biomass using technological or bio-technological processes.[81] The plant generates biomass by converting energy from the sun and storing it in organic matter (chemical-compounds). From there the matter can be reconverted into other kinds of energy such as heat, electricity and transport. Fossil fuels such as coal, oil, and natural gas are, in reality, bioenergy. However, these bio-chemical compounds were made millions of years ago. When we speak of bioenergy we therefore view it as being formed or re-formed within a given number of years. Bioenergy can therefore be described as a sustainable energy insofar as the CO_2, which is released from combustion of the plant, is balanced by the absorption of CO_2 by plant photosynthesis during growth. However, not all kinds of bioenergy have an equal benefit for the climate, since emissions that stem from cultivation of biomass (production of fertilizer, pesticides, mechanisation etc.) along with emissions from converting biomass into energy may outweigh the CO_2, which the plant has absorbed. Biomass from plants such as trees, straw or algae can be used as biomass. Plant-biomass is used for solid bio-fuel, which may be burnt, or submitted a process of gasification[82]; liquid biofuel (such a bio-

[81] There are several bioenergy technologies that are not bio-technological, such as burning biomass for electricity or gas. Diesel from rapeseed or palm oil are not bio-technology either. There are, on the other hand, kinds of bio-energy that use biotechnology to produce liquid fuel, such as 1st and 2nd generation bio-ethanol.

[82] Gasification is combustion at very high temperatures, which generates gas and for instance oil, and bio-charcoal. This is not a kind of biogas in the usual sense of the word.

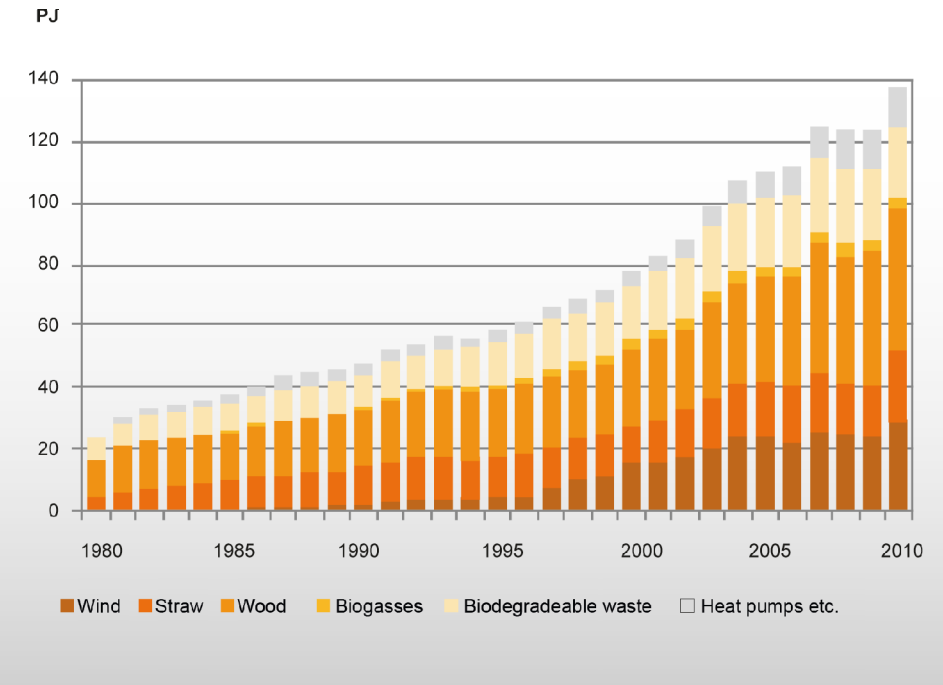
ethanol/alcohol or bio-diesel); or bio-diesel. Much of the waste that is burned at the power stations is also considered bio-fuel/biomass in the following, but this is subtracted the fraction, which is made from fossil fuel, such as some kinds of plastic.

The background for the heightened interest in bioenergy is climate change, but also energy security. It is predicted that Denmark is faced with declining production of fossil fuels in the coming years and prices are expected to go up and exhibit greater fluctuation. At the EU level this challenge is even greater yet and EU policy guides developments in Denmark.[83]

Historical consumption and aims

A large part of the energy we consume already stems from the production of bioenergy, for instance from burning straw, wood, waste, and biogas from livestock manure.

Production of sustainable energy distributed on energy goods



The production of sustainable energy in Denmark is today five times bigger than 30 years ago, while the total energy consumption has practically remained constant, such that sustainable energy now contributes 20% of the total energy

[83] This report is primarily based upon the Climate Commission's work and further studies made for the ethical Council by Niclas Scott Bentsen, Skov & Landskab, Det Biovidenskabelige Fakultet, Københavns Universitet. This is available on the Ethical Council's site.

consumption. Bioenergy currently contributes 14% of the total energy production (see figure 1). Around 20% of the biomass used is imported.

As a part of the EU climate and energy package from 2008, Denmark has committed itself to reducing emissions from the non-quota sectors (agriculture, transport, households etc.) by 20% before 2020 in comparison with 2005. The sector is responsible for 60% of all emissions. In addition to this, emissions from power/heating stations and energy intensive industries are regulated through a combined emissions ceiling for all of EU in the Carbon credit trading system.[84]

The Danish energy agreement for the period 2012-2020, which was adopted in March of 2012, initiates efforts to ensure a 12% reduction of the gross energy budget by 2020 in comparison with 2006.[85] A further 35% of energy production must be sustainable in 2020 and almost 50% of electricity consumption must be from wind farms, against the current 25%. The long-term goal is to transition all of Denmark's electricity production (electricity, heating, industry, and transport) to sustainable energy by 2050.

Producers and consumers of district heating-power plants are given a tax advantage if they change from fossil fuels to biomass. At the same time there will be an analysis of bioenergy usage in Denmark scheduled for 2013. This analysis is to look at "whether the right conditions are in place for an efficient and environmentally sustainable use of biomass resources in the Danish energy sector. The analysis will furthermore shed light on CO_2 displacement." In extension of this, a decision will be made about which sources the biomass will stem from. However, the agreement has already determined initiatives for promoting the use of biogas.

The aim for the transport sector is in the longer run to attain "a radical transition from fossil fuels to new propellants such as electricity and biomass." By 2020 transport fuel will be made with a 10% mix of biofuels. However, this requires a study of which materials should be used to live up to EU requirements concerning sustainable energy in transport, which must be ready by 2015.

Requirements and limitations

The overall calculation of what kind of emission reduction is possible for the various kinds of sustainable energy, must consider the fact that different levels of energy are used in producing energy and in transforming it into energy services such as heating, refrigeration, illumination, and transport. The result is

[84] Klima- Energi- og Bygningsministeriet. 2012. *2020-målsætningen*. Danmark: Klima- Energi- og Bygningsministeriet. (See: http://www.kemin.dk/da-DK/KlimaogEnergipolitik/danmark/reduktionafdrivhusgasser/Maalsaetninger_og_rammer/2020-målsætningen/Sider/Forside.aspx)

[85] Agreement between the government parties (Social Democrats, The Danish Social-Liberal Party, and The Socialist People's Party), The Liberal Party, Danish People's Party, The Red-Green Alliance and The Conservative People's Party concerning Danish Energy policy 2012-2020, 22nd march 2012.

that a given resource delivers less energy than merely its actual energy content. In principle it can even be an overall energy sink.

Biomass may have special relevance for use in heat/power plants. This allows for better use of the energy in that particular fuel, since the excess heat from producing electricity is used for heating. When the biomass is converted into electricity, heating, and fuel, energy is lost. In pure electricity production, where the residual heat is not used, exploitation is only 25-50%. From a climate-perspective wind-energy is therefore more suitable for the production of electricity. The production of liquid fuel for the transport sector involves a much greater energy loss than in direct combustion at a power station where the electricity is used in electric cars and heating for homes. If biomass is burnt directly in a power station and excess heat is used for heating, 90% of the energy is put to use. If bioethanol is made from biomass, only 50-75% is exploited, depending on the composition of the biomass. However, we may expect on-going technological improvements, although it may take some time before efficiency reaches that found in heat/power stations.

However, there are other considerations that must be taken into account for bioenergy than merely climate effects. The problem with solar and wind power is that they are weather dependent. There is only a limited leeway for adjusting for variations in sun and wind intensity, which result in substantial fluctuations in power output. The challenge is to store surplus energy in a viable manner. The chemical energy, which is bound to the carbon molecules of these fuels lasts for a long time without degrading.

When biofuels are ascribed a particular role in regard to the transport sector this is because there are no alternatives, in the short span, to fossil fuels, since the majority of cars cannot run on electricity. They can run on bioethanol, biodiesel, or biogas however, so if it is produced in the correct manner this will displace fossil fuels and result in a reduction of emissions. Particularly air travel and shipping pose serious obstacles to battery technology.

A general distinction is usually made between first- and second-generation biofuels. First-generation biofuels are made from the sugar, starch, or oil content of a given plant, wherefore it only uses the particular part of the plant, which in some cases could have been used as food or feed. Danish rapeseed and Brazilian sugar cane are for instance currently being used for the production of biodiesel and bioethanol respectively. This is then blended into transport fuel. Second-generation biofuels are made from plant fibres, which are found in large quantities in straw or wood, which is typically not used in food. All things being equal, one could therefore say that second-generation biofuels do not compete with food production in the same way. There may however be a number of indirect effects, which will be taken up below. Also, the use of acreage for cultivating second-generation energy-crops, such as willow or poplar, will compete for space needed for food production.

At the global level the transport sector is responsible for approx. 25% of CO_2 emissions and around 50% of oil consumption. The production of biofuel has increased substantially over the last few years, but most of this is from first-generation production, i.e. crops such as sugar cane, rapeseed, sunflower seed, and maize. Second-generation production has been established as prototypes, but must be implemented on a very large scale to be economically and climatically efficient. The fuel production plants are expensive to build and the products are still more expensive than fossil fuels, wherefore first-generation biofuels are dependent upon subsidies.[86] There are three dominant second-generation technologies for converting plant fibres into biofuels, the first of which is BTL-diesel, the second being bio-SNG (a kind of gas), and thirdly the biochemical production of ethanol.[87] It is at present not possible to say which of the three technologies will be dominant in the future. This depends very much upon who can best reduce costs at certain expensive stages in the process, such that biofuels can be produced in a cheap and efficient way.[88]

It has been claimed that Denmark should move towards second-generation biofuel production in spite of the high costs, since while power stations are subjected the quota system for CO_2 reduction, which makes the real effects in this sector unclear, this is not the case for the transport system. Accordingly, there is a higher probability that efforts in the transport sector will have a real effect upon the global greenhouse effect.

DONG energy built the prototype Inbicon in Kalundborg, which tested the production of second-generation bioethanol from straw. In 2011 the company suggested expansion to a full-scale second-generation plant, but also asked for subsidies worth 9 billion kroners (1.21 billion euro) as well as a guarantee against deficits. In November of 2011 the government stated that it considered second-generation bioethanol too expensive and would not take up such endeavours.[89]

Requirements concerning acreage

One overall limitation to the production of bioenergy concerns the requirements for acreage. Areas used for energy crops are of course lost opportunities for other uses. However, this consideration should take into account that the productivity of Danish agriculture is expected to increase. The Climate Commission uses a scenario where there is 520.000 hectares or 12% of Danish arable soil free for energy crops in 2050, insofar as current food production

[86] International Energy Agency. 2010. *Sustainable production of second-generation biofuels.* IEA.
[87] BTL is the acronym for "biomass-to-liquid". This is a process that has been known for many years and comprises two steps of which the first is gasification of plant fibres to more than 700 C^o while adding oxygen or vapour, which gives syn-gas or bio-SNG, while the second step transforms the gas to a diesel, BTL-diesel.
[88] International Energy Agency. 2010. *Sustainable production of second-generation biofuels.*
[89] Østergaard, Christian. 2011. Regeringen dropper bioethanol i Danmark. *Ingeniøren.* (Se: http://ing.dk/artikel/124541-regeringen-dropper-bioethanol-i-danmark)

remains stable.[90] It is estimated that 100.000 hectares of low quality farmland could be used for other purposes without significant consequences for food production, which thereby exploits that many energy crops, unlike traditional annual crops, have low requirements regarding soil quality.[91]

The improvement in productivity is to be attained through improvements in efficiency concerning land use, which requires research, development, education and the development of new technology. The estimate concerning efficiency builds upon projections from historical developments in plant production, which involves an increase in 0.7% per year for both conventional as well as organic crops. Freeing 520.000 hectares of farmland for energy crops is thus attained by greater efficiency in crop production. The yield of farm animals is expected to increase. While a sow, on average, had 19 piglets per year in 1984, that number is now 28. A sow is expected to have 35 piglets per year in 2050. A cow's milk yield was 6 tons per year in 1984 and 9 tons today - it is expected to be 13.5 tons in 2050.[92]

Denmark has an intensive agro-industry and a large production of dairy, meat, and livestock products. Out of the country's 4.3 million hectares, about 61% is used for farming.

Table 3. Acreage in Denmark.

Use	Distribution (%)
Farming	61
Open countryside	9
Woodlands	12
Housing, construction, and roads	10
Lakes and waterways	2
Other/unknown	6

Source: Landbrug og Fødevarer, 2011, DMU, 2009.

[90] Klimakommissionens dokumentationsdel i Klimakommissionen. 2010. *Grøn Energi - vejen mod et dansk energisystem uden fossile brændsler*. p. 35. As well as the background report: Tommy Dalgaard et al. 2010. *Landbrugets drivhusgasemissioner og bioenergiproduktionen i Danmark 1990-2050*. Danmark: Aarhus Universitet. The estimate of 520.000 ha includes the effect of other planned efforts such as additional woodland etc.

[91] Fødevareministeriet. 2008a. *Landbrug og Klima*.

[92] Landbrug og Fødevarer. 2011. *Fakta om Erhvervet 2011*. Danmark: Landbrug og Fødevarer. ; Tommy Dalgaard et al. 2010. *Landbrugets drivhusgasemissioner og bioenergiproduktionen i Danmark 1990-2050*. Since milk production happens by quotas, greater efficiency will result in fewer cows.

Around 80% of farmland is used for growing feed, and this corresponds to 49% of Denmark's land surface.[93] To this must be added that a large amount of feed is imported. In terms of protein, about one third of all feed is imported, wherefore Danish agriculture takes up quite a large area of farmland abroad also.[94] Most of the meat produced in Denmark is however exported, wherefore overseas demand for Danish meat has a great impact upon land use.

The inclusion of farmland for bioenergy will, all else being equal, result in a lower production of food. A demand for sustainable soil use may also limit the maximal production of energy crops. Further consequences will, however, depend on prioritisation. For instance, intensive agriculture may result in higher yields for food and energy crops, but result in corresponding environmental problems such as leaching of nutrients.

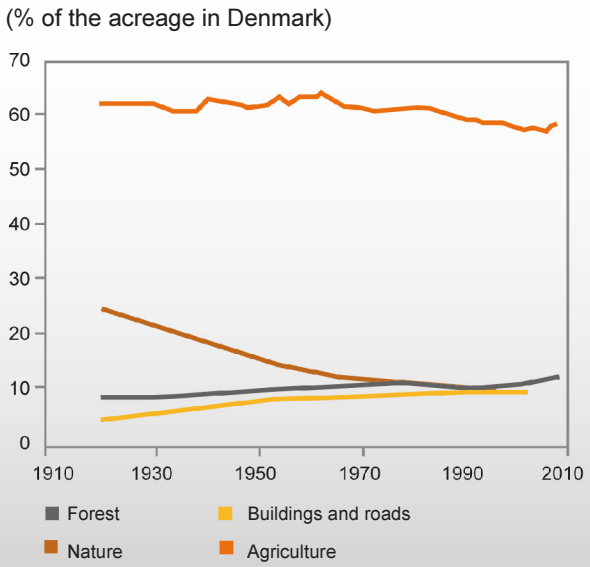
Agriculture is currently, along with urbanisation, the greatest threat to Danish nature. Farming, because nature is thereby burdened with nutrients and pesticides; cities and roads, because they result in a fragmentation of the countryside. Nutrients lead to well-known problems such as oxygen depletion in seas and waterways, algae blooms and the destruction of low-nutrients habitats, where high-nutrients plants such as nettles and raspberries invade and replace the original flora. Pesticides affect countryside areas that neighbours monoculture and some fear that it may seep into the soil and pollute the ground water.

Woodland areas are expanding in Denmark, while open countryside (moor, tundra, and meadow) is in reversal (see figure below).[95] Around half of woodland areas are intensive use, wherefore the quality of wildlife etc. is limited. Only 1.6% of all woodland is protected as pristine.

[93] Danmarks Statistik. 2011. *Statistiske efterretninger: landbrug og fiskeri*. Danmark. p. 2. Notes that 30% of farmland is used for grass and maize for feed. To this is added that ¾ all grain grown in Denmark, the equivalent of 1.100.000 ha per annum, is used for feed (personal communication with consultant Ole Olsen, Danmarks statistik as well as head of department at Videncenter for Landbrug Jon Birger Pedersen)
[94] Danmarks Statistik. 2011. *Landbrugets foderforbrug 2009/2010*. Danmark: Danmarks Statistik.
[95] DMU. 2009. *Natur og Miljø 2009*. Danmark: DMU. (Se: http://www2.dmu.dk/webmtr/pdf/FR750_A.pdf)

The development in the acreage in Denmark

Lakes and watercourses (approx. 2%) as well as areas of unknown usage/acreage (close to 10%) have not been included. In the figure, the agricultural acreage has been calculated in a historic perspective, the reason why the figures are a little more reduced than the present calculations from Danmarks Statistik.
Kilde: Levin & Normander



Although there are no upheavals in the use of the acreage, the quality of the Danish wildlife is in decline because of the mentioned effects. In 2008, the state of Danish nature was uncertain or in decline for 59% of the wildlife and 48% of the species that Denmark is required to protect in accordance with the EU habitat directive. The number of wild countryside birds and hares is in serious decline. The aquatic environment is improving however.[96]

How the cultivation of energy crops will affect fauna and flora depends on whether the areas put to use will be cultivated more or less intensively than at present. Conversion of existing farmland for bioenergy may thus have a positive effect on the environment and biosphere, as will be seen in the next section.

The potential for increasing the use of bioenergy

According to the Climate Commission, the proportion of energy production that should stem from bioenergy in 2050 depends on whether the aim is total phasing out of fossil fuels, and how much biomass is to be imported. This last point is in particular dependent upon how ambitious a climate policy is pursued abroad, since the greater the ambition there, the greater the price of biomass. One could say that the import of biomass exports problems concerning acreage use, since deforestation may put pressure on pristine nature abroad.

Dong Energy is currently working on determining a set of requirements for sustainable import.[97] From a national perspective, and insofar as climate,

[96] Ibid.
[97] Wittrup, Sanne. 2011. Dong Energy klar med klima-krav til træpiller i 2012. *Ingeniøren*. (Se: http://ing.dk/artikel/124654-dong-energy-klar-med-klima-krav-til-traepiller-i-2012)

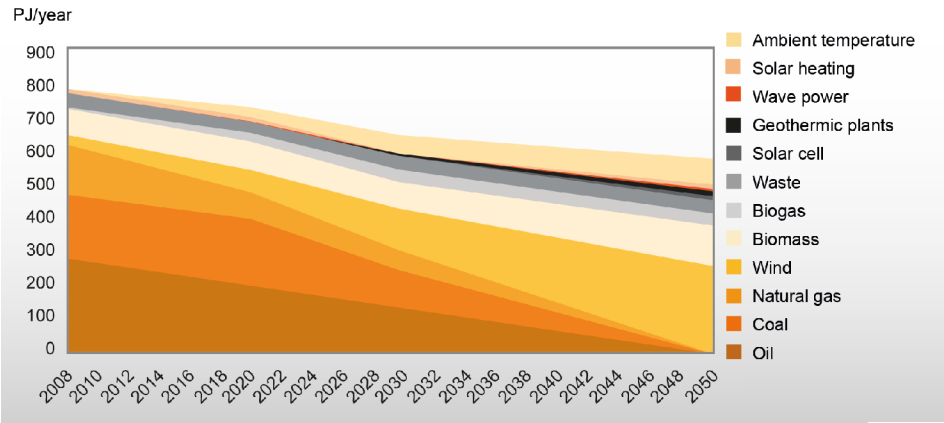
environment and wildlife drawbacks can be avoided, the import of biomass can be an advantage from a climate perspective, all else being equal, insofar at it allows and cheapens a swifter phasing out of fossil fuels in Denmark.

In the following, for simplicity, we take an outset in a scenario, where fossil fuels are phased out, and there is no biomass import, corresponding to the Climate Commission "Future scenario A".[98] Here the production of energy will look as follows in the future:

- Wind power and possibly photovoltaic will deliver most electricity, which will also cover the majority of the energy needs in the transport sector;
- Biomass delivers energy for peak hours on the electrical net, for instance when there is little sun and wind, as well as for certain parts of the transport sector (especially planes and ships);
- Biomass, including the burning of biogas and waste delivers heat. Also, heat pumps, which use the heat in the air and ground (geothermal heat), and central heating will see wider usage;
- The total consumption of energy will decline as a result of fewer losses in converting heat to electricity, since a greater proportion of energy will be delivered by windmills.[99]

According to the Climate Commission Future Scenario A, a total phasing out of fossil fuels in energy production and transport by 2050, requires biomass to

Potential for Danish Bioenergy



Source: The Climate Commission 2010

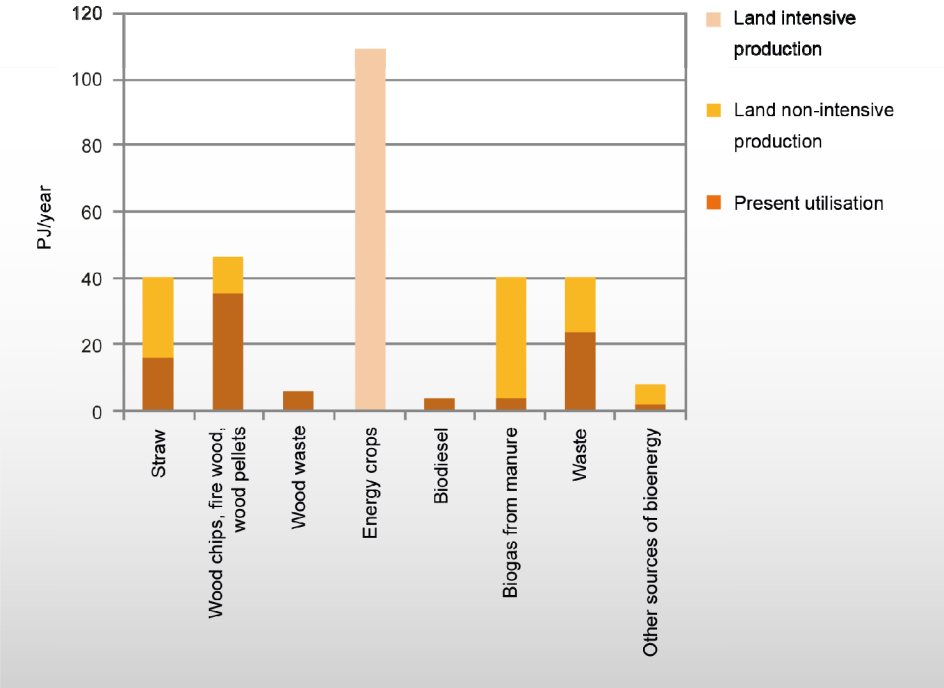
[98] Whether the targets set up in this scenario are correct, may of course be debated. *Future scenario A* is used as an out set for this discussion.
[99] This scenario builds mainly on wind energy, but there is openness towards solar providing some electricity, depending on developments within that technology.

deliver the equivalent of 25% of current energy consumption, which is around one third of expected energy consumption in 2050. This also involves **an additional 11% of current energy needs to be covered by biomass**.

If it is decided to use foreign biomass, for instance because it is cheap, biomass may deliver 70% of total energy consumption. If the transport sector's current consumption of petrol and diesel were to be replaced by domestically produced bioethanol (from straw and grain) and biodiesel (from rapeseed), it would require an area that corresponds to approximately all present Danish farmland.

A number of different strategies for increasing the contribution from bioenergy have been studied. Examination of the various potentials for future increases of bioenergy in Denmark may be difficult to compare however, since they are each based upon very different assumptions. Some studies look at the possibility for economically profitable production, while others look at theoretical or technical possibilities and others again at environmental sustainability. In 2050, biofuels will - according to the Climate Commission – be able to deliver 38% of current energy usage. Indeed, in this scenario, the acreage granted by increased productivity is used for bioenergy and the production of food is hereby kept at a constant. A more efficient collection of by-products is estimated to grant an additional 7% energy in itself.

Potential for producing biofuels



The following will describe the options for increasing the proportion of bioenergy through domestic production, which seem to have the greatest potential. In addition to the possible contribution to bioenergy, the review will look at cost

efficiency and the most important implications for climate, environment, the biosphere, and food production in regard to each resource at various levels of exploitation.[100] The individual contributions are, in the following, given as a percentage of current gross energy consumption (815 peta-joule in 2010, of which around 25% went to the transport sector). As mentioned, the goal of living up to Future scenario A from the Climate Commission report, depends upon the total contribution from these resources reaching 11%. Gross energy consumption includes the loss of energy from energy-production itself, wherefore the possibility for energy savings may be related to a more efficient use of biomass.

The values describing effect of emissions upon the individual resource are coupled with great uncertainty. In general though, the climate effect can be seen in: 1) how much energy the resource provides per hectare minus the energy that is needed to produce and transport it; and 2) the amount of energy that is lost in converting the resource into electricity, heat or fuel (degree of efficiency). Both fossil- and biofuels result in much higher emissions if the waste energy from producing electricity is not used for heating.

Crops that yield a lot of energy per hectare (low area intensity) typically require a lot of nitrogen (high nitrogen intensity) and can therefore result in nutrients pollution. Since this added nitrogen itself requires energy, the climate calculation for nitrogen-intensive crops such as rapeseed deteriorates.

The two best measures of biofuel climate effects are: *to what degree a given fuel replaces fossil fuels;* and *what kind of reduction in emissions a given biofuel results in*. Both measures should include all relevant life cycle processes. The latter measure is preferable, which can be illustrated by degassing of manure. Not only does it replace a fossil fuel, it also reduces emissions of the powerful greenhouse gas methane. Lifecycle analyses are very sensitive to premises for the calculations and particularly for overall estimates concerning the reduction of emissions. In the following this estimate is therefore given in more qualitative terms. Finally, it should be mentioned that the ability of a given bioenergy resource to reduce CO_2 emissions also depends upon, which fossil fuel resource it replaces. Natural gas gives far more energy per emitted unit of CO_2 than coal for instance. Often the substantial differences in emissions or ability to bind carbon in the various kinds of soil and crops are not included in the climate account for various energy crops.[101]

[100] Estimates are based upon: Bentsen, Niclas Scott. 2011. Bioenergi – udvikling, anvendelse og miljømæssige forhold (notat udarbejdet til Det Etiske Råd). *Det Etiske Råd*. As well as a number of other documents, including: Fødevareministeriet. 2008b. *Jorden – en knap ressource*. Danmark: Fødevareministeriet. ; Fødevareministeriet. 2008a. *Landbrug og Klima*.

[101] Jørgensen, Uffe and Jørgen E. Olesen. 2011. Biomasse til energi – bæredygtig løsning eller molbohistorie. *Aktuel Naturvidenskab.* Vol. 4.

Farm animal manure

Potential contribution to bioenergy supply and acreage requirements
Currently around five per cent of all farm animal manure is used for biogas. When the manure has been degassed, it can be spread on the fields as fertiliser. It is considered technically feasible to use around 75% of all manure for biogas. At current livestock levels it is projected that the method can contribute the equivalent of two per cent of current energy consumption. This can be used very efficiently for heating and electricity.

Exploitation of biogas from manure does not take up additional acreage, since it is an existing, underexploited resource. Bio-degassing can make nutrients more accessible, which improves the efficiency of the subsequent fertiliser. In the long run, however, biogas production from manure may result in a small decline in soil carbon content.

On the other hand, one could say that livestock production, which is a precondition for biogas from manure, is an activity, which already takes up three quarters of Danish farmland and itself constitutes a substantial contribution to emissions. This is not least the case for cattle, which in addition to regular CO_2 emissions from tilling the soil for feed, puts pressure on the atmosphere with methane from the cattle's digestive systems, which is 20 times more powerful as a greenhouse gas than CO_2. Manure from cattle is also the kind that has the poorest yields in terms of biogas, while sewage from waste treatments plants and gut contents from butcheries are more productive. If these effects are not included, biogas production from liquid manure is considered one of the cheapest methods for Danish agriculture to limits its effect on the climate.[102]

Effects upon climate, environment, and nature
As mentioned, limiting climate gasses through degassing of manure depends upon the composition of the manure and whether one includes livestock production in climate accounting for biogas. Taking an outset in present livestock production, biogas is possibly able to displace 2% of current fossil energy, since more energy is used in production than is the case for fossil fuels. To this must be added that degassing also reduces the methane emissions that normally occur during the storage of manure. However, the precondition of this is that great care is exhibited to avoid methane emissions in the movement from stable to field. *Overall climate accounting in replacing fossil fuels with manure is very positive, but only if livestock production itself is not included*.

Biogas production from manure does not in itself lead to substantial environmental problems. Rather, biogas may solve some of the odour issues

[102] The economic profitability for various uses of the resources build upon calculations that also include the effect of for instance limiting the leeching of nutrients and carbon storage relative to overall Danish commitments (Fødevareministeriet. 2008a. *Landbrug og Klima*.).

that are associated with this particular resource. The environmental problems of intensive agriculture are mentioned earlier in this chapter.

Exploiting biogas from manure need not have any direct consequences for nature and wildlife. However, this assumes that one can control the leeching of nutrients from manure that occurs in the biogas plants. The comprehensive and intensive Danish feed production furthermore constitutes a substantial effect upon natural habitats.

Effects upon food production
The production of biogas from manure does not reduce the plant nutritional value of the manure – quite the contrary - wherefore it does not have a detrimental effect upon food production.

Straw and wood

Potential contribution to bioenergy supply and acreage requirements
It is considered technically possible and perhaps also economically feasible to increase the use of straw, i.e. primarily straw from grain and leftovers from rapeseed production. This could be used for producing energy equivalent to between four and six per cent of present energy consumption, deduced the 20% straw for feed and bedding. However, the contribution will only be a third if surplus heat is not used for central heating. There is considerable uncertainty about how much biomass is currently used from forestry (firewood and waste from industry) and how much will be available if forestry remains unchanged. At full use of firewood, wood from thinning, waste from gardens and hedges and so forth, the potential may be two per cent of current energy use. All in all, straw and wood may therefore contribute **five to eight per cent** of current energy consumption, if it is used in plants for electricity and heating.

Using second-generation techniques, straw and wood may be converted into ethanol for the transport sector, whereby around half the energy is lost. If all straw was used for ethanol, it is estimated that 15% of current petrol consumption could be replaced, but the technology is not currently economically sustainable.[103]

Since straw and waste-wood are both by-products, the usage does not in itself result in additional pressures on acreage. The calculations assume the continuation of present agricultural production, with the acreage this involves. If too much straw is harvested, rather than being ploughed into the ground, it may have a detrimental effect upon carbon content in the soil and thus give long term problems concerning soil productivity. Most likely it will not be possible to

[103] However, the cost efficiency of lowering emissions from the transport sector may – in practical terms - be greater than for power plants, since the latter are currently subjected to a quota system, which makes the reductions in emissions difficult to determine.

increase the amount of straw removed from the fields, without altering agricultural practices by for instance planting cover crops. Firewood from intensively run forests or waste wood does not require additional acreage.

Without including the agricultural production, which creates straw, it is considered – in terms of economy - one of the cheapest agricultural methods of lowering emissions.

Effects upon climate, environment, and nature
In itself, existing agricultural production emits greenhouse gasses, but if this is not included in calculations, the use of straw and wood in power and heating plants may cover five to eight per cent of the total energy consumption, while the contribution is significantly lower for particularly straw when only producing electricity. *Overall, the climate account for waste-wood and straw for replacing fossil fuels is excellent (power/heating plants and second generation biofuels in the longer run), but only if the plant production in itself is not included.*

By converting straw into bioethanol one attains a 74-81% reduction of emissions in comparison with fossil fuels. By converting wood into biodiesel, it is possible to attain a very high degree of efficiency, if the plant is sufficiently large. Both technologies are at early stages of development and energy prices therefore relatively high. Exploitation of existing straw and wood production has a moderate direct effect upon environment and wildlife, insofar as they are burned in centralised power and heating plants, while the production itself is coupled to the well-known environmental and biosphere problems of agriculture and forestry. Insofar as fire and waste wood is taken from the 44% or woods that are pristine, but not protected, it should be expected to have a considerable effect upon the wildlife. Decaying wood is, for instance a substratum for the insects, which feed many other woodland animals.

Effects upon food production
The use of straw and wood is not expected to have an effect upon food production, except if there is decay in soil quality because of declining carbon content, following insufficient return of organic matter.

Energy crops

Potential contribution to bioenergy supply and acreage requirements
As mentioned, expected increases in agricultural productivity by 2050 will release an area of 520.000 hectares, which is large enough to grow energy crops to cover **seven to eight per cent of current energy needs** without a decline in food production. In the following we will consider the effects upon climate, environment, biosphere, and food production from the scenario.

The amount of energy produced depends upon the choice of crops and whether the biomass is to be burnt or converted into liquid biofuel. We here present two

examples: Rapeseed is an instance of an annual energy crop for the production of diesel (first generation) and willow/poplar an example of a perennial energy crop that may be burnt in a power plant or used in second generation BTL-biodiesel production. The examples are not selected because they necessarily represent the most promising approaches from a climate perspective, but as instances of energy crops currently being used. Most of the rapeseed currently grown in Danish fields is converted into biodiesel. However, this fuel is then exported to for instance Germany and Sweden that unlike Denmark are exempt from energy and CO_2-taxes.

Many annual energy crops are characterised by producing a lot of energy per hectare.

First generation technologies are generally so advanced that they may be profitable without subsidies, but are often expensive instruments to use for lowering emissions. Second generation technologies are not as mature and are therefore more expensive when it comes to reducing emissions, although they show promise in the long run.

Effects upon climate, environment, and nature

The effect upon the environment and the biosphere will also depend upon which crops are cultivated, use of acreage displaced by these crops and on which soil, as well as which effect this has if other farming is to maintain constant food production under these circumstances though additional intensification. The European Environmental Agency has estimated the potential for environmentally sustainable production of energy crops in Denmark to attain under one per cent of current usage in 2030, i.e. far below the estimates given by the Climate Commission.[104] On the other hand, many observers note that shifting from annual crops in rich loam to perennials such as willow, poplar or grass may have a substantial and positive effect upon the environment, climate and the biosphere, because far less nutrients are leached from the soil and less carbon released. This is because these plants develop a deeper and more permanent system of roots and because tilling the soil is no longer necessary. It thus becomes possible to store three tons of carbon annually for one hectare of such crops.[105]

Intensification of other agriculture, which is to free acreage, will as mentioned require plant breeding to improve qualities and thereby yields.

Rapeseed: Biodiesel made from rapeseed is considered to limit emissions by 59-90% in comparison with fossil fuels. Rapeseed still leads to substantial loss of carbon from the soil however. If rapeseed is cultivated in rich loam, it is

[104] Bentsen, Niclas Scott. 2011. Bioenergi – udvikling, anvendelse og miljømæssige forhold. Reference 16.
[105] Jørgensen, Uffe and Jørgen E. Olesen. 2011. Biomasse til energi – bæredygtig løsning eller molbohistorie. pp. 37-39.

thought that the overall CO_2 effect may be negative.[106] *The overall effect of rapeseed diesel in replacing fossil fuels is viewed as quite moderate; there are, as mentioned, annual crops with a substantially better energy pay-off per hectare. However, the cost of conversion in the engines is lower for rapeseed diesel than for instance ethanol.*

As with other annual energy crops, rapeseed has a less favourable environmental profile in regard to emissions and pesticides and therefore has a markedly negative effect on the biosphere and environment.

Willow and poplar: Biomass from willow or poplar, which is used for heating and electricity, will displace as much fossil fuel as is contained in the biomass. There are, furthermore, techniques that in large-scale plants may convert wood into BTL-biodiesel. This involves such a high rate of efficiency that every litre of biodiesel completely saves the CO_2, which would have been emitted in a litre of fossil diesel. To this is added that perennials may reduce CO_2 emissions without limiting the production of food. This is because conversion to biofuel results in a by-product, which may be used as feed, containing around a third of the biomass. Furthermore, such energy crops grow much faster than barley or wheat. However, the technology requires further development. Overall, it is estimated that the climate effect of willow and poplar in replacing fossil fuels is excellent, both in connection with heating/electricity and fuel production in the long run.[107]

In comparison with annual crops, perennials like poplar and willow have a good environmental profile in terms of nutrients requirements and pesticide use. However, if there were to be intensive use, it would be unrealistic to imagine that it is possible to avoid fertiliser and pest control. It is calculated that laying out certain intensive-use fields for perennials, which are fertilised, leaching would be reduced by a third. However, this would still involve twice the leaching than in a fallow field, wherefore converting fallow land to such energy crops would result in increased leaching.[108]

There are currently only very few fallow fields in Denmark.

Like forests, willow and poplar use a lot of water, wherefore these crops may put pressure on ground water levels. This may be a problem for areas with lower precipitation.

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[106] See ibid. However, this is refused by calculations in: Fødevareministeriet. 2008a. *Landbrug og Klima*.

107 Note however, that the loss in conversion is generally larger in producing biofuels, but in comparison with other kinds of bio-fuel, such as ethanol from annual crops, BTL-diesel from willow/poplar has a better effect on the climate, for instance since the crop fixes rather than removes carbon from the soil.

[108] International Energy Agency. 2010. *Sustainable production of second-generation biofuels.*

Finally, extensive production of willow and poplar, which grow tall, bring substantial changes to the landscape, since there will be an obstruction of the view across fields. An alternative in some locations may thus be lower crops with a smaller yield.

Effects upon food production

In this scenario, which does not use other areas than those currently cultivated, the Danish food production will be stable until 2050, since - as mentioned – 520.000 hectares may be set off for growing energy crops as a consequence of increased efficiency. Perennials may have some positive effects upon soil quality, because of less tillage than for annuals, which reduces compression of soil and erosion.

Biotechnology and bioenergy

Globally huge investments are being made in research into biotechnological solutions, which may contribute to making energy crops more competitive.[109]

Biotechnological methods may contribute to the bioenergy supply in various ways. For instance, researchers hope that genetic modification can be used to attain a greater yield of biomass per hectare. One example is genetic modification of fast growing but frost sensitive eucalyptus trees, such that they may grow in temperate zones.

However, focus will here be upon genetic modification in an attempt to: 1) make energy crops easier to convert into fuel within the framework of first generation technology; and 2) ensuring the competitiveness of techniques used to convert plant fibres into transport fuel by using genetically modified organisms, i.e. second generation production of biofuel.

GM Maize (first generation ethanol production)

'Enogen' is the name of a genetically modified maize plant (GMO: genetically modified organism), in which has been placed a gene that makes the corn develop the enzyme amylase. This enzyme breaks down corn-starch into sugars, while the plant is growing. It is necessary to convert starch into sugar, before it can be fermented into ethanol. Normally, one would add the amylase as preparation of the corn as a part of the ethanol production process. This step can now be left out with 'Enogen'.

The overall advantages of this are, according to the developer, that water and electricity can be saved, which results in a slightly improved ethanol production. This is the background for genetically modified maize having a slightly better

[109] Franke, A.C. et al. 2011. Sustainability of current GM crop cultivation. *Plant Research International, part of Wageningen UR*.

climate profile than conventional maize. Also, this requires that the farmer follow the developer's instructions carefully.

However and for now, results have been uncertain for 'Enogen' as such and many researchers have been critical of claims about the advantages of GMOs. Advantages in yields and environmental effects have often turned out to depend upon the specific circumstances of cultivation and the payoff – if there was any - has turned out to be rather limited. Research suggests that this also applies to genetically modified energy crops.[110]

However, small gains may be important in determining whether crops will actually be grown in a highly competitive market. GMOs are thus currently grown on ever larger areas outside Europe and Africa, in spite of limited documentation for them resulting in higher yields per hectare. The advantage is rather in this type of crops having a more stable yield. In the US production of energy maize, it has been important to develop a kind of maize that lives up to federal minimum requirements for new ethanol plants.[111]

Ethanol production from maize is not viable for Denmark with its current climate, where the plant does not mature sufficiently. However, second generation techniques can convert maize into a gas (bio-SNG), which can be used to replace regular biogas. The technique is viewed as promising, but as with other second-generation technologies, it is not yet sufficiently mature and therefore not price competitive. It is therefore not unlikely that genetic modification will be used in different ways to cut costs.

Potential contribution to bioenergy supply and acreage requirements

In general, maize is a crop that delivers a large yield of energy per hectare.[112] Ethanol from maize is an example of first generation technology that puts stress on the use of acreage. In terms of climate, maize may have advantages, insofar as it displaces fossil fuel. However, it is not yet clear how much genetic modification can contribute to making biofuel production more efficient in comparison with alternatives. Some studies indicate that it may be difficult for annuals – genetically modified or not – to compete with perennials in terms of climate advantages. This in return will depend on technological breakthroughs for second-generation technologies (if the biomass is to be converted into fuel) or battery technology (if the biomass is converted into electricity at the power plants and thereby supply the transport sector).

[110] Urbanchuk, John M. et al. 2008. Corn Amylase: Improving the Efficiency and Environmental Footprint of Corn to Ethanol through Plant Biotechnology. *AgBioForum.* Vol. 12, no. 2.
[111] Bentsen, Niclas Scott. 2011. Bioenergi – udvikling, anvendelse og miljømæssige forhold.
[112] Urbanchuk, John M. et al. 2008. Corn Amylase: Improving the Efficiency and Environmental Footprint of Corn to Ethanol through Plant Biotechnology.

Effects upon climate, environment and nature

'Enogen' can, as mentioned, "only" lower emissions a little more that conventional maize, and even this is an optimistic estimate. According to studies, using 'Enogen' reduced emissions about five per cent compared to non-GM energy maize.[113] As with rapeseed, which is also an annual crop, maize released carbon - especially from rich loam. *Overall, the climate effect of maize as a replacement for fossil fuel, genetically modified or not, ranges from limited (ethanol) to very good (bio-SNG).*

Annual crops have been mentioned as being generally environmentally detrimental. Just as for rapeseed, maize must be given large quantities of nitrogen and pesticides, which put pressure on the environment and are energy intensive. To this is added the risk of genes in the GMO spreading to wild flora. However, this is not a problem for maize in Europe, where there are no wild species. There may also be economical risks insofar as inserted genes spread to non-modified maize in for instance organic production.

Effects upon food production

In the scenario, it is assumed that 520,000 hectares can be released through intensification of agriculture without this resulting in a decline in food production. This will not mean the inclusion of other areas, unless the production of bioenergy is to be initiated faster than agriculture can attain the necessary intensification. As with other annuals, cultivating maize leads to problems concerning compacting of soil and erosion. According to the European Environmental Agency, maize is especially problematic in this regard.[114]

GM-microorganisms (second-generation ethanol production)

Genetic modification of microorganisms does not, as in the examples above, concern the production of biomass, but the techniques used to convert the biomass. Production of the straw for biofuel takes up arable land and affects the environment etc., while the conversion per se does not require acreage as such. However, the techniques do pose a risk in terms of GMO leaks, which will be taken up in the following.[115]

As mentioned above, the biochemical conversion of biomass is viewed as a promising second-generation technique for producing bioenergy. Biochemical conversion of plant fibres happens in two stages, each of which is connected

113 For technical reasons 'Enogen' is only used in a 25% mix with non-modified maize Ibid.
114 Bentsen, Niclas Scott. 2011. Bioenergi – udvikling, anvendelse og miljømæssige forhold. Reference 16.
115 Læs mere om risikovurdering af GM mikroorganismer på: http://www.mst.dk/Virksomhed_og_myndighed/Genteknologi/

with certain challenges researchers are working to overcome. Already now genetic modification plays an important role here.

In the first stage, plant fibres (straw or wood chips/pellets) are converted into sugar. Plant fibres are mostly made up of closely woven strings of carbohydrate molecules or starches that are chemically bound to each other. These carbohydrate molecules can be broken into ethanol if they can break into individual sugars.

The bond between the carbohydrate molecules and the various fibres must be dissolved as cheaply and efficiently as possible. One uses enzymes as an initial treatment to do this. Enzymes are a kind of proteins that have a catalytic effect. By fastening themselves to the fibres, one reduces the amount of energy needed – such as heat – to dissolve the bonds. The research is very focused upon identifying enzymes that are efficient in this process. To attain this there has been some genetic modification of fungi. Many fungi have a natural ability to produce enzymes which can break up the bonds in plant fibres, as is known in for instance dry rot. By changing such enzyme genes a little and reinserting them into the fungi, researchers attempt to produce enzymes, which efficiently break down plant fibres for industrial use.

The result of enzyme and heating is a mass made up of partially released sugar molecules and more resistant fibrous parts that can be removed and burnt. Finally there is a fraction of this material, which can be recycled to a certain extent.

In the second stage, the sugar molecules from the enzyme and heat treatment are fermented into ethanol. Fermentation is a process performed by yeast, where sugar and water is converted into CO_2 and ethanol. One of the more substantial problems has been that the biomass that results from the first stage generates two kinds of sugar: pentose and hexose (sugars with five and six carbon atoms respectively). There are no known living organisms that can convert both kinds of sugar into ethanol efficiently. This drastically reduces the payoff from the conversion process and thereby makes the ethanol much more expensive. For this reason much research is being conducted into genetically modifying yeast so that it may convert these sugars.[116]

Both the production of enzymes and the conversion of sugar to alcohol hereby depend upon genetically modified organisms. The process takes place in closed

[116] Matsushika, A. 2009. Efficient bioethanol production by a recombinant flocculent Saccharomyces cerevisiae strain with a genome-integrated NADP+-dependent xylitol dehydrogenase gene. *Appl. Environ. Microbiol.* Vol. 75, no. 11: pp. 3818-22.

vats, where the product is separated from yeast or fungi by centrifuge for instance.[117]

Consequences for health and nature

The concerns for safety, which are particular to GMO production relate to the risk of accidental release, such that the GM organisms escape the closed system and thereby have harmful consequences. In the risk assessment it is considered whether the individual organism could have such a detrimental effect. The applications for approval are taken up on an individual basis with emphasis upon accidental release and the specific risk that stems from the genes inserted into the organism.

An overall principle in evaluating GMOs concerns whether the organism can be said to be substantially and relevantly different from the corresponding non-modified variant. This is termed 'the substantial equivalence principle'. The breeding criteria used for breeding both crops and microorganisms typically promote features, which weaken their competitiveness against natural organisms. Commercial cultivars are highly specialised organisms that fare badly outside the artificial conditions of the field or laboratory. For this reason considerations are not on whether the organism can survive in the wild than about whether the inserted genes will take hold and constitute an ecological advantage over its wild relatives.

A fungus with a heightened capacity for decomposing cellulose does not as an outset pose a health risk for animals and humans. However, it may be that the property could alter the competitive relations between fungi, since the capacity for decomposition is an important quality among organisms that live of plant fibres. The fungus that is typically used however cannot flourish in the Danish climate and biosphere and has no natural relatives that could absorb the inserted genes. Sometimes genetically modified bacteria, which do have wild relatives in Denmark, are used. However, in spite of spills there has never been a single registered finding of a wild organism with the artificial genes.[118]

The ability to convert several kinds of sugar may however be an important, competitive quality to posses in all kinds of yeast. This being said, it also depends upon the organism living where the pentose is available and whether there are wild relatives that may absorb the inserted gene.

In addition to these genes there are typically also marker genes. Here it has been debated whether the use of markers, which make the genetically modified organism resistant to antibiotics, enhances existing problems with pathogenic

117 Read more at for instance: http://www.novozymes.com/en/innovation/our-technology/production-processes/Pages/default.aspx

118 Finn Bech, Miljøstyrelsen, pers. kom.

organisms. There has therefore been some resistance to approving activities where the organism is given a gene that is resistant to antibiotics.

Production using genetically modified yeast strains goes back to the 1980s, wherefore there is a lot of experience with ceiling off labs. Especially the production of enzymes for decomposing fibre is considered well tested, while the practicalities of working with modified yeast for fermenting sugar is less advanced. It may become lucrative to implement quite far-reaching genetic modifications for the production of second-generation biofuels. One of the world's leading research groups is working on producing diesel-producing bacteria with nine genes from various organisms.[119]

Denmark has never approved a GMO where negative effects were likely. All production is therefore approved as so-called risk class 1. Although harmful effects are viewed as unlikely, companies and researchers are normally not permitted to release GMO, since it is considered relatively easy to avoid, for instance by heating waste water to boiling point such that the organisms die.

Release is permitted in mass production if the concentration of organisms is sufficiently low, since it is not considered realistic to demand complete avoidance. There is, however, an accordingly greater demand for surveillance and documentation.

[119] Sample, Ian. 2011. Jay Keasling: 'We can use synthetic biology to make jet fuel'. *The Guardian*. (Se: http://www.guardian.co.uk/technology/2011/feb/27/jay-keasling-synthetic-biology-diesel)

3. Scientific uncertainty and scientific disagreement – the case of climate change

This chapter takes up the widespread claim that there is great disagreement among climate researchers, whether anthropogenic global warming actually takes place. In fact there is a high degree of consensus among climate researchers that human activities affect the climate and thereby, for instance, increase the average global temperature.

Perhaps the fact that all science, as with any other form of knowledge, is associated with a certain level of uncertainty, contributes to the impression of lack of confidence in the idea about humans causing climate change. Although a certain degree of uncertainty is a condition for all research, there is not reason to consider knowledge about climate change as being particularly uncertain. Normally we base our actions on the best available information and this should also be the case here. This points towards a need for immediate action to reduce emissions.

No scientific disagreement about climate change

> *Without substantial disagreement scientists find human activities are heating the Earth's surface (..) Politicians, economists, journalists, and others may have the impression of confusion, disagreement, or discord among climate scientists, but that impression is incorrect.*
>
> (Naomi Oreskes. 2004)[120]

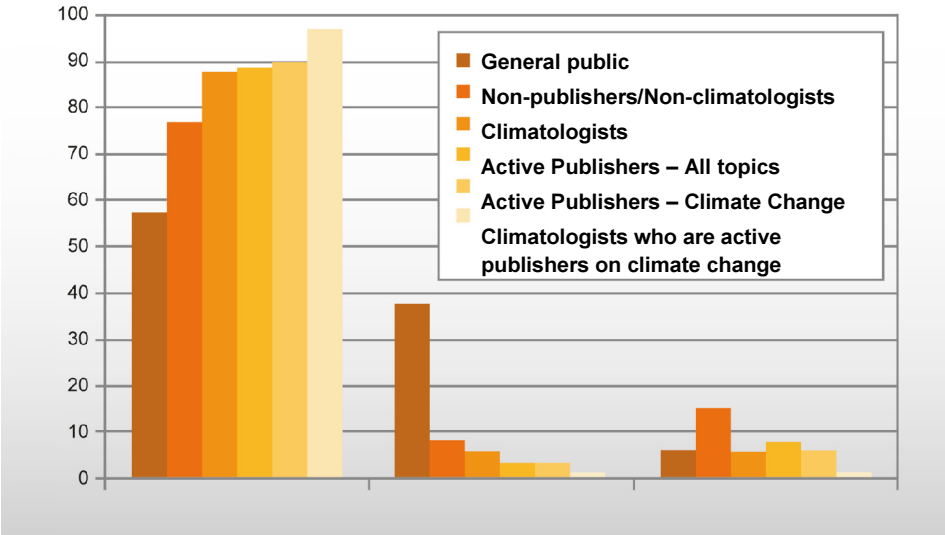
There are few areas of science with such a degree of consensus as climate research and the claim that the climate is getting ever warmer and that the cause of this is human activities, which result in the accumulation of greenhouse gasses in the atmosphere. In a famous article in *Science* from 2004, the American Professor of History and Science Naomi Oreskes sums up her analysis of 928 peer-reviewed articles about climate change from the period 1993 and 2003. She concludes that none of the articles disagreed and none argued the case that climate change is caused by natural phenomena.

In another study from 2009, 90% of 3,146 researchers responded that the earth's average temperature had risen since the 1800s and 82% gave human activities as a primary cause. As can be seen in the data, these numbers are even more pronounced in the group of climatologists and reveal an unusually large – albeit no quite complete – agreement among experts about the question. However, the study also shows that the population in general had a

[120] Oreskes, Naomi. 2004. The Scientific consensus of Climate Change. *Science.* Vol. 306, no. 5702.

very different view of these issues. A contemporary US Gallup questionnaire revealed that only 58% of Americans found human activities to be the cause of global warming. A recent Danish study showed that 71% of the population agreed completely or agreed that the average global temperature is rising, while 60% agreed completely or agreed that warming was anthropogenic.[121] This therefore reveals a significant discrepancy between expert and popular perspectives.

Response distribution to our survey question 2. The general public data come from a 2008 Gallup poll
(see http://www.gallup.com/poll/1615/Environment.aspx).



Source: Kilde: Doran and Zimmerman, 2009.

An important question is whether agreement among experts guaranties that the conclusions they reach are true? As Oreskes points out, it is – of course – possible that all the experts are wrong, since if there is one thing science has taught us, it is humility. No one can claim that new knowledge will not surface at some point, and reveal a very different explanation of these phenomenons. Indeed, this is a condition for all the knowledge we possess and it could be said that if knowledge required absolute certainty, we could not know anything – not even that knowledge required certainty. There will always be scientific uncertainty, since science merely grants us an interpretation of the world, and this interpretation is always limited by human knowledge being incomplete. For this reason science can never prove anything definitively. Most people have, for instance, noticed how certain findings reported in the news about the healthy

[121] Minter, Michael. 2012. Klimabarometeret Januar 2012. *Concito*. (See: http://www.concito.info/sites/-concito.dk/files/dokumenter/artikler/klimabarometeret_januar_2012_0.pdf)

effects of some foodstuff that everyone had trusted, might later be refuted in another study. This may give the impression that science cannot be used as a source of secure information.

Does this mean we should doubt all science and that any piece of information is just as good as any other, because none of them represent certain knowledge? Of course not! There are huge differences in how substantiated a study may be, how competently it was executed and therefore what kind of reasons one may have for viewing its findings as facts. However, the circumstance that we must view our knowledge about the world as limited and preliminary, gives us reason to be humble as Oreskes writes. Every time science comes to a new finding, it likewise discovers how much it does not know. For this reason, it should always include doubt and challenge existing knowledge. Indeed, in cases where there are conflicting findings of a comparable quality, it should include them all.

In an open letter to Science in 2010[122], 255 members of the US National Academy of Sciences wrote:

> *There is always some uncertainty associated with scientific conclusions; science never absolutely proves anything (..) But when some conclusions have been thoroughly and deeply tested, questioned, and examined, they gain the status of "well-established theories" and are often spoken of as "facts." (..) Climate change now falls into this category: There is compelling, comprehensive, and consistent objective evidence that humans are changing the climate in ways that threaten our societies and the ecosystems on which we depend.*[123]

Science can never definitively prove anything and there are various causes for this uncertainty. Initially, however, it is important to note the 255 researchers' second proposition above: when some conclusions have been comprehensively and stringently tested, challenged and examined, they attain the status of well-established theories, and one therefore refers to them as facts. For instance they mention that there are overwhelming scientific proof of the theory that earth is 4.5 billion years old and the theory that the universe came into being at the big bang 14 billion years ago. In this same category they mention the proof of the theory concerning anthropogenic global warming.

So, although uncertainty is an existential condition for science it is important not to view all scientific results as similar and to view them as fundamentally doubtful. If a theory is studied in depth and by many different and independent researchers, and their findings submitted to tests and challenges by groups of different researchers, and all results point in the same direction, then there is - all else being equal – good reason to view it as indicative. Likewise, if a theory

[122] Gleick, P. H. et al. 2010. Climate change and the integrity of science. *Science.* Vol. 328, no. 5979.
[123] Ibid.

has been tested in a single, limited study, which has not been through peer-review, then there is reason to be careful about credibility. Finally, one must also be careful in subject matters, which are marred by disagreement among researchers, and there are contradictory findings.

In this report we have sought to only include scientific data that enjoys wide consensus within the given areas of study. However, all results should only be used carefully and the given reservations should be taken into account. There may be many variables of uncertainty involved and they may have factual/empirical as well as theoretical causes. Furthermore, there may be cases of seemingly scientific uncertainty, which are caused by non-scientific variables. Indeed, this is the case for anthropogenic global warming. In a book from 2010, Oreskes shows how political actors and interests with no support in the world of science have deliberately planted the impression shared by large parts of the public that disagreement prevails in the scientific community about the existence of anthropogenic climate change.[124]

Scientific uncertainty as a condition for all research

In the question concerning global warming there is therefore no scientific controversy about the conclusions. However, this does not mean that there is nu uncertainty coupled with climate research, since scientific uncertainty is a condition for all research. A part of this uncertainty may have to do with the difficulties in generating sufficient data. For instance, but not only, when measuring a highly complex research object such as determining the climactic pressure generated by some foodstuff, for instance one kilogram of beef. In order to compare it with other foodstuffs, it is necessary to include the same and all pertinent variables in both cases.

In comparing the cost and effect of products on the environment, it is therefore necessary to employ Life Cycle Assessments. If we take the example of the climate pressure held in one kilogram of beef, then one looks at the whole process from the production of feed in the field, which involves fertiliser and pesticides, over the life of the animal, where it lives in a heated stable, eats a certain amount of feed and emits a certain amount of methane etc., over transport to the butchery, processing and distribution in shops and supermarkets, where it is refrigerated. This is a very complicated calculation and requires attention to all details, which may include regional variations. If the various researchers do not employ the exact same method of accounting, by for instance some eliding the climate pressure of using artificial fertiliser, their results may differ and introduce a number of uncertainties in the final result. Scientists are usually very attentive to such issues and therefore seek to identify them and manage them as a part of the research process.

[124] Quoted from an article on the book. *Nature*: Oreskes, Naomi and Erik M. Conway. 2010. Defeating the merchants of doubt. *Nature.* Vol. 465, no. 10.

A different kind of uncertainty stems form the theoretical models used by the researchers to structure the collected data in order to determine their mutual relations. Without such models they would merely have eclectic observations. In practical terms there will always be some kind of theory about how things relate, which the data either confirms or refutes.

One may for instance have a theory about which factors result in women having fewer children leading to declining birth rates for a certain region. This could be based upon experiences from countries where the birth rate had declined previously. Birth rates went down in most industrialised countries after mortality rates had been declining for some time, women had entered the labour market and the welfare state took over many of the functions traditionally held by the extended family. It is therefore possible to develop a theory that these factors are decisive for declining birth rates and this theory can be tested by examining whether countries with high birth rates have conditions similar to western countries before the demographic transition: high child mortality rates, low employment for women, and the extended family as only support in old age. However, one hereby risks that the theory comes to control the observation of developments in other countries and lead to the explanation of high birth rates being a result these same factors.

The risk is that by focusing upon these circumstances, one comes to overlook that other variables may enter and even be more decisive for high birth rates: these issues could be the woman's position in the family, her legal status, the possibility for receiving an education, lack of access to birth control or other local circumstances. Often it is possible to adjust the theory one was working from, so that it also captures these additional features. However, a theory may be fundamentally flawed when it comes to explaining complex phenomena such as demographic growth, because it 'constricts' the way one gathers data. There is therefore a risk of overlooking important issues that do not immediately fit into the model. This may be another source of scientific uncertainty and yet another reason for always being careful about and critical towards scientific findings.

It is important to be attentive to the fact that there will always be scientific uncertainty, but this does not mean that one cannot be justified in assuming the veracity of scientific findings. In practical terms, we base our actions upon the best accessible information, and of course this must be the case. As Naomi Oreskes writes: "If the history of science teaches anything, it is humility, and no one can be faulted for failing to act on what is not known. But our grandchildren will surely blame us if they find that we understood the reality of antropogenic climate change and failed to do anything about it." .[125]

[125] Oreskes, Naomi. 2004. The Scientific consensus of Climate Change.

4. Ethical considerations in a globalised world

As mentioned, bioenergy may be a tool for countering the energy and climate crises, but also risks aggravating the crises concerning food and nature/natural resources. Ethical dilemmas appear because different regard and interests collide.

It is necessary to weigh the regard to various actors: people near and distant, animals and the natural world. For this reason it is necessary to begin with some basic considerations about what kind of responsibility we may have for those who are affected by our choices. In the following, we describe some of the various ethical approaches and their view of who deserves special moral regards. It is not necessary to speak of attitudes, which are shared by the Council members. The review will show that:

- Most described approaches will admit that, all else being equal, one is obliged to not damage other people's most vital interests. For this reason we should arrange our acreage such that the overall damage to the biosphere and environment results in the least possible damage as well as the least possible emission of greenhouse gasses, because this will threaten people's subsistence.

- Many will grant that Denmark is committed to producing foodstuffs as a response to increasing global demand, and/or contribute towards improving the possibility for these to be produced in proximity to where they are consumed.

- Many are of the opinion that our use of arable land and interaction with nature should consider the interests of animals. Thus we should not degrade the natural habitats of fauna. Applied to food production the principle will require methods of husbandry with low concern for animal welfare to be replaced with modes of production that result in greater welfare or a transition to vegetable production.

- Some hold that we have obligations to nature or to elements in the natural world. This at least implies that farming is pursued in a manner that does not contribute to climate change, pollution, and over-consumption of scarce resources such as water and phosphates. In a stronger formulation this concern requires that human influence on nature be diminished. New technologies should thus be evaluated upon whether using them constitutes an inadmissible manipulation of the biosphere and the conditions that reign there.

To whom do we owe ethical consideration?

Most would probably respond to this by indicating other people and especially those in ones community and nation as deserving special consideration. However the question is whether it is possible to defend a position, which defines ethical responsibility so narrowly. We live in a globalised world, where we have ever more relations with people that live far from us. The world's hungry are more prominent because of the media and it is clear that our actions – for instance in changing the climate – have consequences for distant people and their ability to grow food and acquire basic necessities. In the long run, the consequences of our actions will also affect our descendants. This raises the question of whether we should give a broader definition of our ethical responsibility than we are used to, either because a globalised world generates relations with people in other countries as when our actions affect them, or simply because we owe other people consideration in force of them being people - not because we enter into a relation with them.

There have been periods is western history when groups such as slaves, foreigners or other ethnic groups, women, sexual minorities etc. were not viewed as having a similar moral status and thereby rights as others. However, the development has been - at least in the west – towards equality: there are no viable criteria for excluding people from the moral community.

However, if all people are of equal moral worth, how can this cohere with the fact that most people are of the opinion that they have a special moral responsibility to some people, for instance family?

Should there be special considerations for animals? In our part of the world there has, until recently, been a view of animals as being similar to machines that cannot feel. As this perspective has lost terrain, many have begun to ask whether there should be a greater moral regard for animals than is currently the case in food production.

Many also hold that there should be considerations for wildlife and the biosphere and that the contemporary problems with the depletion of nature stems from us not respecting it as we should. This is viewed as caused by anthropocentric, western ethics, which only includes man and views nature as gratification mere resource for humans to utilize as they please. If nature is not owed respect for its own sake, then it is only wrong to exploit it if doing so harms other people. Some would add that higher orders in the animal kingdom may have ethical value and that it is wrong to harm nature if one hereby damages habitats for these animals. However, according to environmental ethics, these attitudes are wrong and only express a lack of human recognition for nature's inherent value. Indeed this value does not depend upon Man needing the biosphere and wildlife or not. We will return to these issues after having looked at how the main schools of thought in western philosophy since the enlightenment have viewed man as requiring special ethical consideration.

The special moral status of human beings

One may ask where the idea of human beings as having a special status originates? Why has man ascribed himself such a unique position in comparison with all other beings? In this part of the world two reasons are normally offered.

The situation may firstly be traced to Christianity, which holds that humans have a special status, since God made Man in his image. God has provided Man with rationality and required us to manage his creation on earth. A secular version of this perspective has gained foothold since the enlightenment. This position views rationality and other qualities particular to Man as the basis of their special moral status. Different features are emphasised with the commonality that they result in humans having certain interests or certain rights, which other people are required to take into consideration. The list of qualities is not set in stone, but most would point to various combinations of higher consciousness and social capabilities, among them the ability of autonomous behaviour, self-consciousness and hereby the ability to have wishes for the future, which may be frustrated; the ability to relate to self and others; moral acts; view one's own existence as valuable; the ability to act responsibly and freely etc.[126]

However, if one agrees that all humans have a special moral status, it must – all else being equal - mean that every individual has the same commitment to every other person in the world. Since (nearly) all people have the qualities listed above and thereby a moral status other people must take into consideration. However, this view may have wide reaching implications, which run counter to many people's intuitions about how the world is. Some will reject the idea that one can determine our commitments to other people from a universal principle that applies to all situations. In the following we will look at the discussion between various perspectives on commitments to distant people.

All people are of equal value –cosmopolitanism

As mentioned, both Christianity[127] and the main schools of thought in western philosophy since the Enlightenment, hold that all people – no matter which coincidental circumstances of birth – demand the same consideration. One could say that these considerations are universal. Because all people have the same status, they have the same demand to be treated as ends in themselves,

[126] A problem arises here, since when we do not explain Man's special status with membership of Homo Sapiens, but with possession of special abilities, how do we view people who are severely mentally handicapped or infants. These are neither rational nor self-conscious. Do these not deserve similar considerations as other people? Many would respond that we should, but not for their own sakes, since they cannot relate to their lives and futures. Rather we should do this out of consideration for other people who care for them and whom we would hurt if we treated the handicapped or infants badly.

[127] This is the most widely held interpretation of Christianity, but it should be held that some theologians argue that Christian charity only requires actions for people who are close to us.

or to have their interest in having a good life protected. Another important principle here is impartiality, which means that everybody should look beyond their immediate interests and understand that other people have the same value as themselves.

Conceived in this way ethics cannot grant different considerations to different people. It is pointed out that there are only bad experiences from history with singling out groups of humans on the basis of their race, gender, or religion, and cutting them off from the moral community by not granting them the same consideration as other people. Adherents of this view are often termed (moral) cosmopolitans and although is sounds like a modern term, the ideas behind this position can as mentioned be traced far back in history.

When all people are of equal moral worth, one has the same commitment to prevent evil to all others, if it is in one's power to do so without thereby sacrificing something of equal importance. This principle is illustrated in a famous thought experiment developed by the Australian Philosopher Peter Singer. Imagine that you are passing a shallow pond and see a small child drowning in it. Then you should save the child, even if this comes at the price of the expensive new shoes you were wearing and being late for work. The reason is simply that these sacrifices are not of the equal value to the life of a child.[128]

Most would probably agree with the conclusion reached in this example. It is clear that one cannot stand passively by while a child drowns, just because one does not want to ruin a pair of new shoes. If this is correct, then a similar argument must apply in similar cases, which implies that it is wrong to let people die of hunger or illness in a poor country, if we are able to save their lives through a small donation - for instance the equivalent of a new pair of shoes. One has an obligation to give something unimportant up, if it can save the life of another person.

This view has been criticised extensively, because we have to do with a demand so extensive that nobody could live up to it. Perhaps it even seems insurmountable, wherefore most people would draw back from even trying to live by that rule. However, cosmopolitans still hold that there are no good ethical reasons to treat people differently because of accidental factors such as place of birth, whether we know them, or they look like us. One should aim towards ideal goals, even if they are not fully attainable. This also applies in the case of near and distant people. According to this argument, it makes no difference if a person is a member of the family or lives on the other side of the world, since all people have the same demand for concern.

[128] Singer, Peter. 2009. *The Life You Can Save: How to play your part in ending world poverty.* New York: Random House. pp. 3-4.

The outcome of cosmopolitanism is that there are no ethical reasons for putting family, relatives, or friends ahead of others that are geographically distant. Although there seems to be an intuitive commitment to people one knows, intuitions are not good proxies for moral actions. Consequentialist cosmopolitans may, however, recognise a sort of division of labour for moral activities, which in practical terms brings about a particular commitment to those who are close to you and with which you enter into special relations. We typically have a better idea of what is good for members of the family than we do for strangers, and likewise strangers have friends and family that will feel especially committed to them. In this manner a certain limited partiality may overall lead to better consequences than if one were to enforce a very strict requirement of treating everybody equally.

Although one must make the same considerations for all people, and that is a responsibility held by all individuals, it does not mean that one cannot leave it to the state to manage this responsibility, because it would be more efficient. The individual may view it as an insurmountable task to, for instance, do something about global warming or world hunger. It may even be demoralising to take up such gigantic tasks, when it is clear that one person's efforts does not make any detectable difference. For this reason, cosmopolitans may be adherents of indirect nationalism, in the sense that they view the state as the best suited institution for ensuring basic human rights, enter into binding climate agreements or implement taxes that makes us choose less damaging lifestyles. This does not mean that politicians should solve our problems for us, but that it is more efficient if such tasks are taken up communally in a coordinated political effort. This, however, does not alter the fact that fundamentally individuals have obligations to choose the right actions.

Both of these claims: that the responsibility for distant individuals is held by individuals and that our relation to other people is not of substantial ethical importance are rejected by some. We shall take up their arguments in the following section.

We do not have the same ethical commitments to all people

Cosmopolitans only view nation-states as having indirect ethical relevance by being the best and most efficient institutions for taking up the responsibility held by all individuals. However, national borders are without relevance in determining which ethical considerations people owe each other.

Others disagree by claiming that national borders are ethically important. They hold that the principles for, say, individual justice, do not apply to societies. Nor is it that principles that apply to one kind of society will also apply to all other societies in the world. There are different principles is different contexts. The problem thus becomes to determine which principles apply to which situations and why there are different principles. Out of the many accounts that exist, we shall view two.

Ethical commitments to distant people is a concern for nation-states – the contractarian view

One position holds that ethical norms should be understood as a kind of rules or contracts, which are mutually advantageous for everybody. Hereby, it becomes possible to view the question about what is owed other people within nations and internationally as political issues that can be regulated by contracts which only apply within the political field. Within a society citizens have certain commitments towards each other in terms of the social contract they share through their societal institutions and laws. But these commitments are not the same as commitments towards those who live in other nations. Different principles apply for the two relations, wherefore nations have an important role to play in determining what people owe to each other.

From such a contractualist perspective, some argue that political justice does not comprise everything and that we should not expect it to. The principles that apply in the political sphere within nations cannot be employed to the management of institutions such as churches or universities, or to types of societies, which are not liberal or to cooperation between nations.

Contractualism views international collaboration as primarily an affair for nations, wherefore citizens do not as individuals – or as societies -have the same obligations to individuals with whom they do not share the same nation and welfare institutions, as they have to their countrymen. Different principles of justice apply in different contexts, depending on whether these are relations between individual people, between individuals and nations, or between states. Of course this does not mean that Danes own nothing to people in other countries. There may, for instance, be mutual commitments for disaster relief aid and recognition of basic human rights. However, these are not so much commitments between individuals, but commitments between states.

Where cosmopolitans could be criticised for being so idealistic, as to become unrealistic, these contractualist perspectives could be viewed as the practise currently employed in the world. They explain why our relations to people in other countries are primarily coordinated by states and why our options for helping people who live in undemocratic and repressive regimes, that are not willing to enter into international agreements, are so limited. The critics of contractualism do not see any good reasons why the considerations owed to other people should be determined by arbitrary circumstances such as whether they were lucky enough to be born in a well-ordered and affluent country. If one is obliged to help the worst off within the nation – as is recognised by contractualists - then it is hard to see why one is not obliged to help the worst off in a global context.

Ethical commitments depend on relations – communitarians

Another way of rejecting the cosmopolitan claim that we owe all people the same ethical commitments is to point out that it would be wrong to ignore the social circumstances in which people meet other people, or the kind of relations

people have – or perhaps do not have – to each other. Adherents of this view are often called *communitarians* and they argue that we should view nations as communities, where individuals have special commitments toward each other because of their special cohesion. This is because it is the social relations between people that determine which ethical commitments they owe to each other. People can have many relations with each other: they can be related in family, share a local community, be colleagues, be members of the same sports club, share a profession, or be completely alien to each other. These relations are decisive for determining the ethical commitments that apply to them.

Moral values come about through the relations and traditions, which are formed and shared in various communities, wherefore there also exist different principles of justice in different communities. For instance, close communities should follow a principle of distributing goods according to needs, while national communities should have a principle of equal rights for all citizens. Often different principles will come into conflict, in those situations the parties must decide which principles to apply in the situation.

Communitarians may hold, though, that there are ethically committing relations to people one is not acquainted with, for instance countrymen are committed through their common political system. However, such social commitments belong in a society, where the members identify with each other and therefore recognise the special commitments they have to each other. For this reason the commitment do not apply to people in other countries, which one does not share a state or culture with.

Although individuals do not have *the same* commitments to foreigners, many communitarians recognise, that certain basic human rights apply to everybody. However, they will typically not consider all rights in international conventions, such as the Universal Declaration of Human Rights, as genuine human rights, only the most basic necessities for survival can be considered as rights that apply to all humans.

Many have criticised the idea of using relations as the basis for ethical status, since it excludes foreigners and other 'outsiders', such as the unwanted and those without relations to others from the ethical community. Cosmopolitans will for instance view it as unacceptable to ascribe value to people on the basis of relations, which they view as arbitrary. Another point of criticism is that the approach bases ethical concern for others on communities, which tend to be postulates, rather than realities in complex, modern societies, which are increasingly made up of many different cultures that live side by side. One could ask, whether one is then committed only to those countrymen with whom one shares a cultural bond? and whether one have obligations to people in other countries with whom one shares the same culture? Finally, we must ask how it is possible to determine if one shares a culture to a sufficient degree to grant ethical commitments and how this question is to be settled in case of disagreement?

The concern for future generations

It is often taken for granted that one has ethical commitments to future generations. For instance, the United Nations defines sustainable development as fulfilling current generations' needs without endangering the fulfilment of needs for future generations. But there is some controversy in claiming a responsibility for future generations understood as those who live in the deep future, whom we will never know and whose circumstance may not even be imaginable.

From a contractualist perspective there is no commitment to future generations, since it is not possible to enter into agreements with them and thereby draw a mutual advantage. At best the future generations will benefit, but not us. However, this argument goes against the common sense of ethics in other situations. For instance, we agree that we cannot treat animals as we please, but rather have ethical commitments to them although we cannot enter into contractual agreements that involve reciprocity.

Others have pointed to the paradox that to do damage to a person, it is ordinarily necessary to treat them in a way that leaves them worse off than would otherwise have been the case. However, when it comes to those who are not yet born, our actions may not only harm them, but result in them not being born at all.

That exactly those people actually come into existence depends on all the actions that we take now. If we had taken other actions, other people would – genetically speaking – come into existence. Thus the alternative of being born under those circumstances - event if they are bad circumstances because they inherit a world of altered climate – would be that exactly those people would not be borne at all. Since in this way of thinking the alternative to being born under those circumstances is not being born at all, we have not harmed them, because they are no worse off than if we had acted differently.

Many have responded that it does not make a moral difference exactly which future people are harmed. The ethical commitment does not depend upon genetic identity, but the fact that they are persons. It would therefore be more correct to evaluate possible future outcomes from as many as possible living good lives in that outcome. It seems a better yardstick than whether the individuals that live in the future would be better of if they had not existed at all.

It gives rise to a new problem if one accounts for the amount of welfare by adding the quality of life for all people who exist at any given time. This could result in a world in which a huge amount of people led lives that were barely worth living was better than a world with only a few people living really good lives. This has been termed the repugnant conclusion and, and it is broadly refuted, that the argument would have such implications. One argument here is that it is possible to harm people by bringing them into the world, if their lives

will fall below some standard for what a good life must include. For this reason we should select a policy, which leads to least possible people coming to lead lives that fall below such a standard.

For this reason, most agree that is difficult to reject a moral concern for future generations. We should not degrade the environment, the climate, and use the earth's resources if it leads to the destruction of the foundation of life for future generations.

The ethical concern for animals

Going back in western history, animals have been viewed as brutes that were not – in the Christian tradition – comprised by love of one's neighbour, but rather delivered to man who dominated them. Neither were animals in the secular tradition considered equals in any way. By way of example it was a widely held view right up till the Enlightenment that animals could not feel pain, because they did not have a soul. So, to the extent that it was wrong to be cruel to animals, this was not based a concern for the animal, but only that the cruelty towards animals could develop into cruelty towards people. It was therefore not for the sake of the animal that it must not be mistreated, but for the sake of other people.

This view of animals has been abandoned, because research has shown that animals are not only able to feel pain and happiness, but that many species are able to experience complex emotions such as empathy. This challenges the basis for the moral and legal separation of animals from humans, since this, as mentioned, is based on the assumption that humans have special cognitive faculties - which were considered absent in animals – that gives rise to special demands.

Many therefore argue that the implication of animals having some of those particular qualities creates the need for special ethical considerations concerning their interests, for instance that they should not be subjected to pain. But the extent of this consideration and the question of whether the same considerations apply to all animals, gives rise to disagreement.

Utilitarian ethicists insist that there is ethical importance in beings having an interest in their lives and that they may hereby be harmed or benefitted. Adherents of so-called sentientism hold that all sentient beings have an equal right of regard for their interest. However, not all sentient beings have the same interests, since these depend upon characteristics of that particular species as well as various physiological needs and mental capacities. For this reason animals and humans should not be treated in the same manner, nor should different animals: there are differences between the cognitive capacities and needs of a monkey, a chicken, and a worm. There may also be differences in the needs among humans, depending on their capacities, e.g. a myopic person will have a greater demand for glasses than somebody with normal eyesight.

In general there should be greatest concern for the beings that are self-conscious and able to reason – those who can anticipate the future and have a conscious desire to continue living. If it is correct, as many hold, that humans – but not the higher orders of non-human animals – may have plans for the future: that they feel sorrow if they know they are to be killed before they fulfil the plans, then there is a moral concern that applies to people, but not to the higher orders of animals.[129] Properly, most would intuitively hold that it is more tragic for a person to die at 25 than 90 years of age, because the 25 year old has many more plans for the future, which will not come to fruition than the geriatric. To this is added that humans have relations to others who can mourn their deaths and who can fear that they would be killed if murder were permitted. The sum of suffering is, all else being equal, greater for killing a human than a higher ranking animal. For this reason it is worse to kill a person than an animal. However, it is not worse to inflict pain on an animal than a person; both are equally wrong, since the capacity for pain is the same in animals and humans.

Traditional deontological ethics has assumed that only rational beings are able to act morally, wherefore only humans count ethically. However, there are adherents of duty ethics who hold that rationality is not required to count morally. All beings who has a life which is meaningful to that being – which at least most regular mammals have – has a claim to ethical consideration.

Some virtue ethicists[130] point out that the motives for action are the fundamental ethical matter. We should ask ourselves what kind of people we wish to be and which traits of character should control our actions. Many in this school of thought will hold that caring, moderation, gentleness, attention, and responsibility are virtues, which should characterise our interaction with people and animals and, indeed, the biosphere in general. Some go even further and claim that if these virtues guided our actions, it would become necessary to focus upon the empathy held for animals, wherefore this would mean that we should treat many animals - for instance those in agro-industry - far better than is currently the case.

Ethical considerations to nature

These ways of considering our relation to animals can be seen as a challenge to what is known as anthropocentrism. This has to do with man's tendency to view everything in the world from the perspectives of human interests and only recognise the characteristics that are valuable from a human perspective as deserving of moral concern. Characteristics such as rationality and self-consciousness are important for people and are therefore used to explain why people deserve a special status in the world. However, if one takes an outset in

[129] New research questions whether there are substantial differences between animals and the higher orders of animals in this regard. To the extent that some animals have the same capabilities that sentienists consider as having moral relevance , it means that we should take their interests into greater consideration than has been the case hitherto.

130 However, many virtue ethicists – including Aristotle – have been anthropocentrists.

animals and plants instead, one will come to see the characteristics that are important to them.

There are different kinds of environmental ethics that emphasise man's lacking recognition of the biosphere and hereby also animals as having independent value. They view this attitude as having resulted in the destruction of nature through our self-centred behaviour.

We must first, however, determine what ascribing value to the biosphere or the natural world means. There are at least three meanings involved:

> *Nature* might be understood as all that which is not *supernatural*: If one uses this definition and rejects all that is supernatural, everything is natural, including humans and animals. However, this is not how most people understand the meaning of 'natural'.
>
> *Nature* may be understood as *all that is not influenced by human existence:* If one uses this definition then one excludes everything except rain forests and other areas outside the scope of human influence. This means there is practically no nature in Denmark. So perhaps what most people understand by 'nature' is rather:
>
> *Nature, understood at that which is not influenced by man in some particular way*: perhaps many hold that cultural landscapes such as fields and woodlands belong to nature. That which is not nature then comprises structures such as buildings or roads – areas, which have been shaped by man in a special way. However, if nature is made up of areas that are cultivated and affected by man, it becomes a pressing question why we cannot use these areas in other ways? What is the limit of what man may do to nature, given that we live off it and affect it with most of our activities?

It is furthermore important to be precise about what specifically has an inherent value, when one speaks of nature as having inherent value. Is it the mere fact that nature exists that has value in itself? Most would probably reject this claim, since this value would be retained even if one for instance fells a rain forest. It could also be every individual object in nature, which has inherent value. But what counts as an object or a part? Does the Amazon rain forest (6.8 million km^2) count as one part and a 400 km^2 jungle in Malaysia as another part of the natural? And do the two have equal inherent values?

In addition to clarifying what is understood by nature, it is important to define 'inherent value'. 'Traditional' ethics only views people as having value, in the sense of having a moral status, which demands consideration. A person may not be sacrificed, even if it serves a higher purpose. Doctors may for instance not choose to kill a patient in order to extract organs that could save five others.

In this line of thinking nature and natural areas are not viewed as having this kind of value. If one could imagine that felling a rain forest could save five other rain forests, many would probably hold that considerations of this one rain forest would oblige us to protect it. So, although we value the forest, it does not mean that it has morally relevant value *in it self*, which would demand moral considerations. At least the value of the forest is not of a kind that would generate obligations on us to respect it the same way we would respect human beings.

In the last decade, environmental ethics has put forth various arguments that nature or parts of nature actually have value in the sense that deserves consideration for its own sake.

Some adherents of what is known as *biocentrism*, argue that all living things have a good-of-their-own, which means that their being is guided towards sustaining their existence and attaining a biological purpose. This need not be a conscious effort, since also living organisms without consciousness have things they seek to attain (namely that which is found in their genetic code). The fact that an organism can seek out its biological purpose is in this view just as good a reason to deserve consideration as human rationality and self-consciousness is a reason for us to count morally.

Others argue that not only living things, but also all of the ecosystem and nature has value; not just living things or individual humans and plants. These so-called *eco-centrists* do not least think that meta-entities such as species, ecosystems and the world as such have a value that must be protected. There are different accounts of why we must respect these and take them into consideration. One suggestion is that the relations we have to humans as well as nature are ethically relevant. Others think that we have an intuitive cognition that all parts of the biosphere have an equal right to live and that mankind can only realise itself by identifying with the organic whole of which we are a part.

However, a problem appears when one attempts to live by these considerations, since if one accepts the reasons for all these natural units having value then the number of individuals and biological entities that deserve consideration becomes so large that it becomes practically impossible to take them all equally into consideration. It is clear that even if one only recognises that human beings deserve ethical considerations, it becomes impossible to avoid ethical dilemmas where it is everybody's interests cannot be met, and some interests must be weighed against others. Adding even more interests merely aggravates the problem. All living beings must eat others to survive and thereby violate these living beings vital interests. If carrots, rabbits, and humans had the same ethical status, it would become necessary to violate vital interests every time somebody ate to survive. It therefore becomes necessary to prioritise between survival interests, wherefore we – as humans – must chose to violate the rights of others many times every day.

Many environmental ethicists have therefore set up a system of priority to ensure that we can select the actions that cause least harm. Here basic interests of for instance survival count more than minor interests, no matter who holds these interests. Mankind does not have a special status or right to put its interests ahead of others. On the other hand we must eat to survive, and we must act according to the principle of doing least harm.

This corresponds well with virtue ethics, which holds that one should behave respectfully towards nature and animals, and in daily choices consider the value held by the rest of the ecosystem to a greater degree than is currently the case. This could happen in regard to choosing which kind of food to eat. All people should reflect upon their individual choices and ask which kind of person they want to be in relation to animals, the rest of nature and climate change. If one did this consistently, it would give rise to demands about how to treat nature and its parts, and this would probably be incompatible with how we act today. This attitude may also include considerations on the use of modern technology, chemicals, antibiotics, hormones, and genetic manipulation as being incompatible with a respectful interaction with nature.

It should be added that one may share the view that nature and its balances should be given far more concern than is currently the case, although one does not hold that nature or its individual parts have any claims upon us to do so. Many would hold that we out of concern for humans and perhaps animals need to take better care of nature and use it less to cover our short term needs. Our current resource consuming behaviour demolishes nature and hereby our own basis for living. So, although we are not obliged to take any considerations of nature for its own sake, we should do it for the sake of other people.

The duty not to do harm

There is disagreement about what we as individuals and society owe people who are distant from us and with whom we do not share institutions or communities, as well as what we owe future generations, animals, and to nature. However, most people would recognise that we have at least some responsibility in ensuring that also people who live far away are guaranteed basic human rights, although some view this as a limited responsibility, which rests upon states rather than individuals. It also looks as though there is a basic agreement that animals have at least some interests, which must be taken into consideration. There is disagreement whether nature has value in itself, but less disagreement that it should be used far more responsibly, although some are of the opinion that this is ultimately out of concern for people, future generations, and higher orders of the animal kingdom (whether this agreement in principle is reflected in our actual actions is a different issue).

In general the degree of responsibility on has for a situation is connected to one’s responsibility for the appearance of that situation. There is, as mentioned previously, consensus among climate scientists that the climate changes, which

can already be seen and which are escalating, are caused by emissions of climate gasses primarily from populations in wealthy countries. It is also clear that the climate changes will first threaten people's subsistence in very poor areas of the world. It looks like there is a connection between Danish emissions and the deterioration of conditions among the world's poorest, which have not contributed to those emissions. We therefore enter into a relation of sorts with these people, because they are affected by our actions.

Normally, even those who do not admit to a general responsibility for helping distant people would admit a moral commitment not to hurt others. This commitment does not depend upon the proximity of those who are affected. Distance is not an issue here; if we have contributed to a critical situation, then we have a responsibility to mitigate damages caused and to cease the damaging behaviour.

It would seem that almost no matter which view one has of moral considerations pertaining to distant people it must be admitted that we have at least some responsibility to ceasing climate degrading behaviour in consideration of those who are affected.

Whether we are also required to help feed the world's hungry – and not least the many additional inhabitants on the planet over the next 40 years primarily in the poorest countries – is probably a more controversial question. Often there will not be any clear causality between behaviour in rich countries and the fact that people in poor countries starve. So, even though most agree that we ought not do harm to others, for instance contractualists and communitarians will not hold that we are required to actively help people with whom we do not have agreements or enter into communities with. Cosmopolitans will argue that we have a responsibility to help produce more food for instance, because we are in a position to do so. However, if there are even a few basic human rights, and among them the right to be able to sustain ones existence, then there will be a wide consensus that if people in distant countries are unable to produce enough food and risk dying from starvation, we should help cover their basic needs.

Other than that, many hold that it is too narrow to look only at which considerations we owe other people, when we speak of climate change and consumption of non-renewable resources. For many it is relevant to discuss whether or not there is a moral concern for animals and nature.

5. Three hypothetical scenarios for introducing bioenergy to Denmark

As mentioned in the previous chapters, the introduction of bioenergy may lead to ethical dilemmas insofar as the positive effects upon the energy and climate crises are countered by energy crops taking up scarce resources such as arable land, water, and nutrients. There is a risk that cultivation of energy crops will result in cultivation of natural resorts and have negative implications for food production and the food crisis. Furthermore, the cultivation of some energy crops may put additional pressure on nature and the climate. In some cases, energy crops may be genetically modified, which gives rise to further ethical dilemmas. Various ethical concerns may therefore collide and the question therefore becomes how to balance these considerations against each other.

This chapter sets up three hypothetical scenarios to illustrate how various ethical concerns, which arise when introducing bioenergy, should be balanced from the different ethical approaches. These represent three suggestions on how to act, depending on how one answers the question about who deserves ethical consideration. Is it only people – perhaps only or mainly people in close proximity? Do animals also count? How about nature and natural entities? Also, do these require as great a concern as is granted people?

These scenarios illustrate how the ethical positions we choose imply a commitment to some overall socio-political choices. The choices made by politicians must necessarily be based upon far more detailed analyses and calculations and include more detailed assumptions than those employed here. The scenarios are not based upon technical or economical calculations, just as they disregard that Denmark is a small country that in and of itself cannot prevent climate change. However and as mentioned, these examples can be used to show how certain possibilities express ethical choices. They can hereby be used to open our eyes to whether our socio-political attitudes actually correspond with our basic ethical values.

Three scenarios on the use of biofuels and crisis management

The three scenarios set up by the council may be viewed as the political choices that follow from certain ethical positions. This does not mean that to each specific ethical point of view there can be only one single related policy. Taking the stance for example that we ought to be more considerate towards the natural environment is not only compatible with promoting the use of sustainable biofuels, but also with recommending the reduction of energy consumption, or even favouring the use of other sustainable energy technologies. However, it is incompatible with proposing the use of cheap but

unsustainable biofuels. Thus the scenarios express possibilities within a spectrum of related actions that support certain ethical positions.

The three scenarios are:

1. **An economically sustainable introduction of bioenergy- consumer-oriented vision**
2. **A climatically and environmentally sustainable introduction of bioenergy – technology oriented vision**
3. **An environmentally sustainable degrowth vision**[131]

The first scenario builds upon the notion that our ethical responsibility in relation to others varies according to our mutual involvement, such that acquaintances and compatriots have greater priority for us than those at a distance, or perhaps who are yet to be born.[132] In this approach, our duty to others vary according to the particular circumstances and are not universally the same to all human beings. One does not owe the same duty of care to those physically or temporally at a distance, as to those with whom we have personal dealings or political relations. More is needed before we are morally obliged to help to those with whom we have little or nothing to do.

This scenario is anthropocentric in that ethical duty is considered as something one has exclusively towards other people. Since animals and the natural environment are unable to enter into agreements with us or engage in the sort of relationships one can have with human beings, we cannot have strong commitments towards them. We do not have moral obligations to nature or to animals on equal footing with people. They are considered resources humans can utilize and which we should take care of because we depend on them as our basis of living. We can interfere with nature or with animals provided no humans are threatened by it, or if it even serves good causes.

The second scenario considers ethical commitments as owing to all human beings, because they spring from certain qualities all humans have in common. We are all rational, able to behave morally, and are interested in how our lives play out, wherefore we are entitled to other people's consideration. The scenario is therefore Universalist, because it holds that all people share the same value or interests, and therefore in principle are entitled to the same considerations. Nonetheless, this is only the case in principle, because we actually have stronger relationships with those closest to us, and from time-to-time and in certain connexions will show them extra consideration.

[131] Notice that one or more of the scenarios are a compound of various ethical standpoints that need not be related. The third scenario for example mainly reflects a virtue ethical approach which is also eco-centrist approach, which is not the case for all virtue ethical approaches.
[132] That ethical commitments stem from relations between people is sometimes compatible with commitments towards distant people. This stems from the empathy and engagement in the relation to other people, which stems from close relations.

This scenario is not strictly anthropocentric, since it involves the idea that to the extent that some highly developed animals posses some of the characteristics, that grant moral considerations, we have ethical duties towards them too. Natural entities, however, such as plants, mountains, or landscapes, do not deserve consideration in their own right. It does not harm a carrot if we eat it and we do no harm to woodland by cutting down its trees. But even if we do not have moral obligations to nature as such, it does not follow that our present treatment of it is ethically defensible; we ought to show far more consideration to the complexities of nature and ecology than is presently the case. Nature is invaluable for the subsistence of humans and animals, and our present treatment of that upon which we are reliant harms those that actually deserve ethical consideration.

The third scenario builds upon the notion that ethics is a question of acting from the right motives and the kind of people that we want to be. If we consistently promote desirable characteristics and allow them to guide our actions, we will show far greater consideration not only to other people, but also the whole of nature. We do this for the sake of other people but also because self-improvement brings with it a better life. This scenario also builds upon universalism; all human beings are held to be of equal value and entitled to the same consideration. Hence, it follows that all people should be shown respect, compassion, and justice.

Furthermore, this viewpoint is eco-centric, because it is held that we ought to respect not only other people, but also animals and the wider aspects of nature. Our present conduct is wrong, since regarding the world merely as a warehouse full of resources that we can utilize at our pleasure serves to destroy that upon which we depend. However, it is also wrong because we ought to empathize with and show care to animals and nature. We ought to ask ourselves what kind of people we would like to be and act in accordance with the desirable characteristics.

Most of us will find that there are features of which we approve in all three scenarios. They can therefore be used to reflect upon whether or not our values correspond with the choices we make in specific situations. For example, if a person holds that on the one hand we ought to use biofuels in order not to exacerbate climate changes that are detrimental to distant people, but at the same time holds that he or she is entitled to drive a car with high fuel consumption, then that person might take time to reflect whether or not his or her energy consumption is commensurable with a value of being morally obligated toward those affected by climate change. If not, then perhaps either a revision of values or a change of behaviour would be called for.

In some cases, one will remain assured about ones values but find it impossible to live up to them. The ideal that we ought not contribute to anthropogenic global warming could mean that we never should drive a car, and moreover

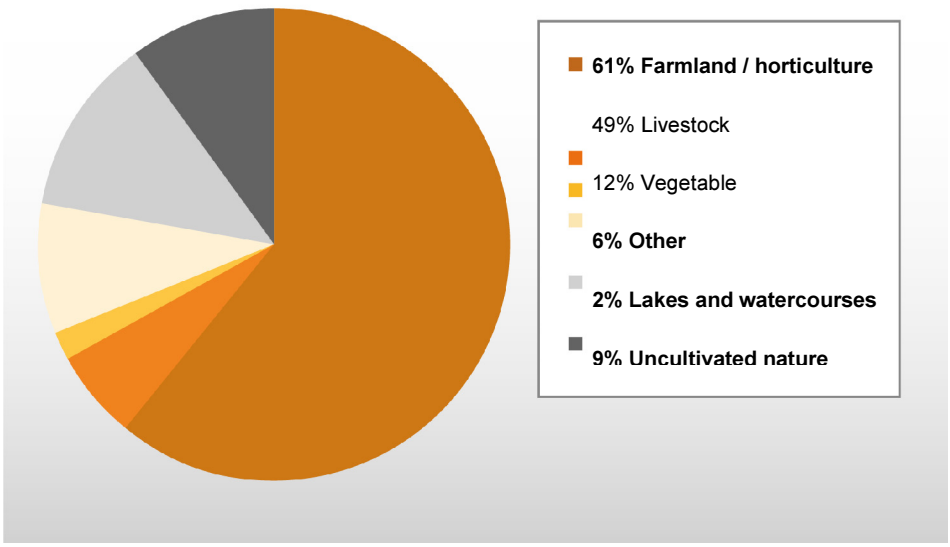
reject many other actions such as eating energy-intensive foodstuffs like meat. In reality, though people seldom live entirely in accordance with their ethical values, it nonetheless makes a difference whether we have ideals and all the time try to move toward them, or whether we hold that we owe nothing to for instance distant people.

Clearly then, none of the three scenarios can justify the way in which we presently emit greenhouse gasses into to the atmosphere, consume non-renewable resources, or damage the environment. Even those who maintain we have very limited responsibility towards the world's poor and future generations will surely concede that we have no right to harm others through our actions.

Seeing how most scientific experts agree that anthropogenic global warming is a fact, and that the consumption of fossil fuels by the western nations of the world is a significant contributing factor, we have a moral responsibility to reduce our emissions, no matter which ethical standpoint we adhere to. This is a strong argument in favour of introducing biofuels, provided that it is the sorts that reduce CO_2 emissions and are sustainable. The counter-argument would be that land useful for food production must be allocated to biofuels, and that the production of certain biofuels is *not* environmentally sustainable.

How Denmark's available land should be utilized is one of the central dilemmas that the scenarios address. As mentioned, the Climate Commission's proposal that Denmark eliminate its use of fossil fuels by 2050 requires that 12% of the country's area is cultivated with energy crops. Seeing how there is presently no un-utilized land, where is this soil to come from? Below the present allocation of spaces in Denmark is depicted. The Climate Commission assumes that the 12% required for biomass can be found by intensifying present production methods.

Denmark's Land Use 2011



Source: Statistics Denmark, 2011, Agriculture and Food Production 2011

One means by which the impact on the climate can be lessened is to reduce those agricultural activities most responsible for the release of climate gasses – the foremost of which is livestock production – and reallocate the land to vegetable production, or energy crops or leave the land uncultivated. The number of livestock kept depends not only on Danish demand but also that from demand abroad, wherefore a reduction of Danish demand might not necessarily result in less area used for livestock. To achieve a reduction in livestock keeping, regulation would be needed, and perhaps the payment of subsidies for alternative uses of the land.

Unless such regulation is applied internationally there is of course the risk that livestock production simply moves abroad. This is just one of many dilemmas in a global economy. Should Danish people change their ways and live up to the values that we endorse, the effect might well be insignificant if the rest of the world does not follow suit. To what extent this dilemma should prevent us from following our convictions is a subject discussed in the Council's recommendations.

The three hypothetical scenarios that illustrate the various ethical approaches:

First scenario: An economically sustainable introduction of bioenergy – consumer-oriented vision

This scenario builds upon the following assumptions:

- **Total energy consumption**
  Aggregate demand determines how much energy is consumed, but attempts should be made to minimize consumption through cost-effective measures of efficiency in the energy sector.

- **Land use**
  Market demands dictate the response of agriculture and livestock production. As hitherto, a reasonable balance between animal welfare, environmental issues, and competitiveness should be aimed at. Concern for energy security might encourage more intensive agricultural and husbandry methods, thus allowing the allocation of land for the cultivation of energy crops. This may include the use of arable and woodland areas for the cultivation of high yielding energy crops.

- **Electricity and heating**
  Electricity and heating shall partly come from domestic or imported biomass by 2050 and partly from other kinds of sustainable energy that may be advantageous to Denmark in terms of economy and reliability in the long term. The transition to alternative energy sources is to occur such that it is not be detrimental to Danish economic competitiveness. Similarly, the costs for consumers must be balanced with other socio-economic concerns.

- **Transport**
  If the most prudent and cost effective long term course of action is to convert to non-fossil fuels, the shortfall in energy might be satisfied during the interim with liquid biofuels from energy crops and other organic by-products, and yet further in the future by electricity, should that technology become economically competitive. The transition must however occur at a pace that allows us to ensure long-term economical sustainability. We ought not convert unilaterally from fossil fuels before 2050 if more profitable alternatives are available to us.

- **Technology**
  There ought to be continuous investment in new solutions – including technological innovation – with the aim of securing for Denmark not only reliable supplies of energy and food, but also competitiveness and employment. Denmark's sole criterion for investment in technology should be financial, and any investment must occur at a pace that ensures acceptable returns rather than rushing to costly environmental protection measures, unless such steps are thought to be in Denmark's best interests.

The primary aim in this scenario is to forestall financial threats to Danish people's welfare and living conditions. Its premise is that ethical duty in political affairs is first and foremost to one's compatriots, those with whom one shares institutions and laws. Government shall nonetheless collaborate with other nations concerning broader issues such as climate change and the unsustainable consumption of natural resources. We cannot all together disregard the concerns of future generations of Danes, though our relationship with them is one-sided, as we can benefit them but they can do nothing for us. For this reason it is unreasonable to over-burden the present generations with deprivations since we cannot predict future circumstances. Most likely new

technologies will be designed that utilize other resources than those that might be depleted by present generations. Indeed, these technologies may compensate for wear and tear on nature and climate in other ways. It is therefore not given that our conduct will put future generations at a disadvantage despite consuming resources or causing climate change.

According to this point of view, nations have very limited responsibility to those living in societies whose ruling classes are disdainful of their people's welfare, as is the case in many of the world's poorest countries. Responsibility for a nation's citizens is a domestic matter, and it is up to them to agree between themselves how to arrange their common affairs of policy. Outsiders have limited means in interfering with undemocratic regimes that ignore citizens' interests, and though we might think them wrong, we must to a great extent accept prevailing standards in other cultures. Nonetheless, people everywhere are entitled to certain minimal human rights; not least food sufficiency and other commonplace necessities, and wealthier nations have a duty to assist in acute situations and to offer a degree of foreign aid, provided it benefits the citizens of that country. Notwithstanding all this, when a conflict of interest must be resolved, compatriots have priority over foreigners.

Climate

The scenario implies that despite limited duty to assist foreigners, there is nonetheless a duty not to actually do harm to harm others by for instance damaging their basis for living. It must be conceded that to the extend that emissions eradicate the basis for cultivation of the land in places where the inhabitants themselves do not significantly discharge greenhouse gasses, then all have a duty to lessen anthropogenic global warming that brings climate change. It is however debatable whether or not emitting those gases is the main cause of hunger around the world. Many problems can be put down to dysfunctional societies, i.e. conditions in which we cannot interfere and are not responsible for. Furthermore, Danish emissions are insignificant in a global context and do not contribute in any meaningful degree to anthropogenic global warming. There is therefore no pressing reason to use biofuels, but should we do so to some extent, it ought to be done with economic prudence, efficiency, and with due regard to the security of Denmark's own energy supply. Though the proposals in question would introduce biofuels in a way that combines economic growth with a degree of reduction in the emission of harmful gases, measures that cause Danes unreasonable privations should not be accepted.

Another feature of this ethical standpoint is that while the food industry's climatic impact should be reduced to some extent, due regard should be given to farmers' earnings and agricultural exports. It follows that agriculture's emissions be reduced through more intensive and efficient farming methods. It is often assumed that emissions from intensive farming are less than from traditional agriculture, and that intensifying production might make space available for the cultivation of biomass. Intensive agriculture is therefore thought beneficial with

respect to climate change, given that agriculture must produce the same in future as it does today.

Foodstuffs

In this scenario more climate-friendly methods are welcome, always provided they do not disadvantage farmers' competitiveness or consumer purchasing power. Most likely this assumes that Danish agriculture constantly increases efficiency. Any necessary behavioural change should be achieved by appealing to personal responsibility, and not through bureaucratic meddling, moralizing, or introduction of surcharges. Any attempt by the State to interfere with citizens' eating habits – such as placing surcharges on polluting foodstuff production – would be unacceptable interference with the individual citizen's right to self-determination.

The export of foodstuffs must also be considered, as unilaterally introduced national surcharges would increase Danish costs and hurt competitiveness. Danish farmers can probably not survive by producing foodstuffs and biomass merely for the domestic market. Taxes on foodstuffs with high climate impact will only promote imports from other countries that have not taken similar measures. Furthermore, food production and exports are valuable in the trade balance and generate many jobs, which would be lost and thereby create hardships for Danish families.

Since, ethical duty is primarily towards compatriots and our children, this approach views our commitments towards helping the poor people around the world improve their lives as quite limited. There is therefore no duty to maintain high levels of food production simply to keep world market prices low for the benefit of people in places beyond Denmark's influence. Should the production of bioenergy become commercially attractive, farmers ought not to face difficulties in changing from the production of food to energy crops. The government might through formal international organizations seek to influence poor countries, for example by encouraging the control of demographic growth, but the responsibility of feeding people in those places remains with their own governments.

Rearing livestock

Intensive methods of rearing and keeping livestock are important to the country both commercially and for employment. Animal welfare in Danish agriculture is currently satisfactory. However, there is a need for further intensification of animal husbandry by using manure in the production of biofuels. For manure to be a significant energy source, a very considerable number of animals are required though.

The introduction of tighter animal welfare regulations would be wholly acceptable provided such a move took place internationally and Danish farmers were not put at a commercial disadvantage. Unilateral measures on the other hand would not be commercially viable for Danish farmers. If meat is to be

produced using less intensive methods, then consumers must be prepared to pay more for it.

Nature and the environment

Since we have a certain relationship to our descendants, we ought not in principle disadvantage them by using up vital non-renewable resources or bringing other species to extinction. On the other hand it is important not to exaggerate the importance of all species surviving or no resources being depleted. Many species of animal and plant can be considered non-essential to people, both now and in the future, and many resources are replaceable or new technologies can make them re-collectable.

Natural surroundings understood as those areas not used for roads or buildings are recreationally important, and should be protected from destruction. But from this ethical standpoint there is no duty toward animals or plants for their own sake; therefore consideration for them must never be put above that of other people, e.g. by protection measures that put farmers at a disadvantage.

Genetically modified organisms

The use of genetically modified plants, algae, or microorganisms in the manufacture of biofuels is not an ethical problem, as it is not viewed as particularly disrespectful towards nature. There is nothing wrong in changing nature. Selective breeding of plants goes far back in history, so there is nothing dubious about accelerating the process by gene modification or other methods, always provided that doing so is safe for humans. All genetically modified organisms should therefore be subject to a detailed risk analysis before they are released for general use. Clearly, such analysis cannot guarantee the identification of all long-term problems and there may be unforeseen risks, but that is not only the case for genetically modified organisms, but also numerous other technologies or practices we engage in.

Possible undesirable consequences

This scenario in many ways represents the ethical standpoint behind the predominant lifestyle and common priorities in Denmark today. Criticisms raised by those opposed to continuing as we do are likewise well known.

The many opponents of this scenario claim that the serious situation in which we find ourselves today is a direct result of the scenario's ethical standpoint. If all that really counts is contemporary Danes there is probably nothing wrong with policies that aim to maximize their prosperity. The objection is however that there are significant reasons for being considerate to those at a distance, to nature and the climate (regardless of whether nature is considered valuable as our basis of living or whether it is seen to have value in its own right). Global warming, the destruction of natural environment and the depletion of natural resources are all consequences of policies promoted by the western

democracies in particular, which solely consider living compatriots' short-term interests.

Critics will argue, that since these actions have landed us in the present, serious situation, it would be fatal to continue along that course. The crises concerning the climate and the environment/nature plainly show that "business as usual" is not an option open to us. If global warming continues, a tipping-point will be reached for many sensitive ecological systems in just a few years, where they can no long be re-established. Large-scale changes of this kind will alter living conditions around the planet. Moreover, many species have already fallen extinct, and many more will follow unless something is done to prevent it. A whole range of natural resources, such as water, are consumed thoughtlessly and to such an extent that they will vanish or acute shortages will occur.

Adherents of this ethical standpoint adhere to market forces and technological development in the defense of their position as the best strategy to counter future challenges. But market mechanisms seem faulty in that they cannot include the cost of natural resources and are unable to prevent excessive consumption and depletion. Furthermore, the objection can be raised that faith in technological solutions to these problems is excessively optimistic. Arguments in support of technological possibilities should build upon that which is already under development and which appears likely to work. To speak of non-existing future technologies as though they are certain to become realities is irresponsible and even selfish.

Second scenario: A climatically and environmentally sustainable introduction of bioenergy – a technology oriented approach

This proposal involves the following preconditions:

- **Total energy consumption**
  Even if it involves completely phasing out fossil fuels, Denmark must aim at CO_2-neutrality by latest 2050. Energy consumption must be restricted and more efficient than at present. The State ought to promote this development by paying subsidies and applying surcharges until the aim is achieved, even if this means some sections of society are financially disadvantaged while others are not. Nonetheless, Danish business competitiveness may, however, not be significantly disadvantaged. Surcharges and subsidies should be gradually introduced in order to stimulate consumers to choose fossil free energy sources.

- **Land use**
  Biomass is to make a considerable contribution to the supply of energy. A substantial part of the energy supply must stem from the cultivation of energy crops on arable land within as short a timespan as possible. Efforts should be made to do this as benignly as possible towards the environment. Any imported biomass must be suitably certified so that Denmark does not simply export its problems.

A State surcharge on food production with negative climate impact might partially cover the cost of subsidizing energy production from biomass. Such subsidies aim to make it attractive for farmers to shift from production of feed to cultivating energy crops. Surcharges encourage Danes to reduce their consumption of meat and dairy products so that land currently used in connection with the production of animal foodstuffs can be used to grow energy crops. The overall production of foodstuff will remain unaltered since a mainly vegetarian diet requires less space to produce than a carnivorous diet.

Ideally such policies should have several positive effects: firstly, the cultivation of biomass does not put strain on world food production compared to the present moment; secondly, the environmental pressure from keeping livestock will be reduced as land is allocated to the cultivation of energy crops, which replace fossil fuels; thirdly, as livestock keeping declines there will be opportunities to improve animal welfare; and finally, as the cost of products made by climate degrading processes increases it is likely that there will be less food waste than presently is the case in our part of the world. This may lead to people using all the food purchased. There is of course the mentioned risk that should Denmark take unilateral steps the intended benefits might be lost, or in the worst case the situation might even worsen if animal husbandry merely moves to countries with no such taxes. For these reasons, Denmark should encourage the introduction of taxes on climate degrading foodstuff production (and indeed other climate degrading processes) across the whole of the EU and ideally even world-wide.

- **Electricity and heating**
  Sustainable energy technology as described in the Climate Commission's Future Scenario A – wind turbines, biofuels, heat pumps, and an extended district heating network – shall provide household electricity and heating by 2050.

- **Transport**
  Burning of fossil fuel for transport purposes is to be reduced. Initially by mixing biodiesel with conventional diesel oil, then by a transition to electrical propulsion as the wind turbine capacity increases. The transition should be promoted by a gradual introduction of taxes and subvention.

- **Technology**
  Vast investment into bioenergy power stations ought to result in cost savings and reduced energy use. Denmark should be unprejudiced in pioneering novel energy technology, while weighing up benefits and drawbacks from case-to-case, including the use of bio-technological methods.

Under this scenario it is recognized that our problems require a far bolder response to the crises than is currently the case. We presently consume resources and damage ecological systems to the detriment not only of both distant people and animals, but also our successors. While this approach does not necessarily involve a rejection of the predominant idea of growth, it does seek a new perspective that takes valuable natural resources and nature itself into account. Failing this, over-exploitation will continue, leading to the destruction of viable living conditions for humans and animals

The ethical approach behind this scenario is Universalist, in principle the same obligations are owed to all people, since no matter their geographical or temporal distance, they are like us. In a globalised world this becomes ever more obvious. We can easily see that there are no fundamental differences between people, and there is not justification for the position that we may be selective in whom we care for, or worse still, be entitled to act to other people's detriment.

Adherents of this standpoint do not restrict their concerns to people. They maintain it is increasingly clear that many higher ranking animals have rather sophisticated mental faculties. They are able to use implements, have emotional bonds to other animals, and feel sorrow and pain. This means that we have moral obligations toward them and that they should be treated decently and in correspondence with their mental capacities. At the very least we are obliged not to harm them.

The gravity of the situation requires simultaneous responses to many and various problems. Biofuels ought to be introduced to the extent that it is environmentally sustainable and does not affect the production of food negatively, which would harm the world's poor. Energy crops should, for example, be cultivated immediately on the most marginal agricultural land. Denmark may lead the way in this despite possible economic drawbacks, but simultaneously we should be cautious of measures that merely result in climate degrading activities moving elsewhere without improving the overall situation.

Climate

Since this scenario builds upon the idea that there is a duty not to harm the basis for living for other people and animals, it follows that the negative effects of anthropogenic climate changing activities should be ameliorated by – for example – phasing out the burning of fossil fuels and instead using biofuels. However, the criterion for adopting a specific procedure in the manufacture of biofuels ought to be that comprehensive lifecycle analysis indicates the method contributes less to anthropogenic global warming and is more benign to the environment than burning fossil fuels. Additionally, efficiencies should be sought wherever possible in order to reduce the overall consumption of energy.

In failing to bring about effective action to reduce anthropogenic global warming, governments around the world are in fact favouring their own citizens by

prioritizing short-term policies of economy rather than concern for those most affected by climate change. Ethically however, materialism does not have the same weight as contemporary and future people's life essentials, and this political neglect is indefensible. Here, Denmark ought to pioneer the introduction of measures to reduce anthropogenic global warming by reducing the consumption of food and fuel with negative climate impacts, and for a while, subsidize the sustainable cultivation of energy crops.

Foodstuffs

Yet another basic idea behind this scenario is consideration towards the world's poor, and it follows that Danish foodstuff production levels ought not decrease, since that might serve to reduce world food supply and thereby raise prices for the poor. Assurances are therefore required that allocating land to the cultivation of energy crops will not reduce the production of food in Denmark. In the long term it is of course preferable that poorer countries produce more food, and we ought to actively participate in training farmers and improving infrastructure in developing countries.

However, while there are so many hungry people in the world, Danish foodstuff production ought not to diminish. If agriculture must become more sustainable, while increasing the cultivation of energy crops, one strategy to maintain the current level of food production could be to reduce the very substantial Danish meat production. From the perspective of climate and land utilisation, livestock keeping is a very inefficient mode of food production and - as mentioned - Denmark is able to feed approximately eleven million people with a diet comprising 70% vegetables and 30% meat, while halving the meat consumption to 15% makes possible to feed twenty million people. Such reduction would mean fewer Danish meat exports, which is difficult unless global demand for meat declines. Denmark should therefore work toward international initiatives in this area.

A very coarse estimate suggests that if Danes ceased eating food of animal origin, around 12% of agricultural land could be re-allocated to the cultivation of biomass, which incidentally is the area required for energy crop cultivation if Denmark is to phase out fossil fuels by 2050. Moreover, there would be no further import of animal fodder concentrates, which would have a positive impact on the environment and the climate to the extent that animal feed is cultivated in areas of cleared forests.

It is however unrealistic to assume that not only all Danes, but also the entire world might convert to vegetarianism or almost so. It is therefore worth considering meat products grown from animal stem cells. This technology is under development. Researchers are working on cultivating animal cells in tanks with the aim of having meat products without the pollution from livestock, and without taking up agricultural land for pasture and growing fodder. Such technologies should be welcomed to the extent that they counteract the deep crises we face.

Rearing livestock

We owe considerations to animals who are able to live better or poorer quality of life. Much intensive Danish agriculture offers livestock such poor conditions that it does not meet the ethical standard the animals deserve. Consequently, to the degree that livestock keeping is to continue in the future, it shall take animal welfare and instinctive behaviour far more into account than has been the case in recent years, which in turn presumably means moving back towards less intensive production, leading to smaller yields and higher meat prices. However, intensive keeping of livestock is considered detrimental to global warming, which merely adds weight to the argument for discouraging the consumption of meat. In practice, applying taxes on climatically detrimental foodstuff production or allocating subsidies in accordance with the climatic and environmental footprint of farming activities could be ways of reducing meat consumption.

To the extend that livestock keeping will continue in the future, there is nothing wrong with using manure in the production of biogas, as it is a sustainable biofuel provided one ignores the climate problems involved with keeping livestock in the first place. It is however a by-product and the proportion of biogas in future energy supplies should not dictate the number of livestock to be kept for the sake of making gas.

Nature and the environment

Out of regard for our descendants we ought not use up non-renewable resources or bring other species to extinction. Such considerations ought to outweigh the desire to produce food cheaply and efficiently, and incentives ought to be offered to farmers to reduce their consumption of resources and cease their impoverishment of the natural world. We should do this even if current generations might have to spend more to buy the food they eat – but to the extend that green technologies could be developed to make food production cheaper and more efficient without adverse affects to climate or the environment, they should be taken into use.

More room for uncultivated nature is likewise desirable in Denmark as such places are recreationally valuable for people and provide natural habitats for wild animals, plants, and other organisms that are part of ecosystems. All else being equal, and though the complexities of such considerations make it difficult to draw simple conclusions, recreational requirements must be balanced with the essential requirements of distant people. Another aspect to this is whether or not Danish land should be used for cultivation of foodstuffs while less fertile and inaccessible places elsewhere around the globe should be left as pristine wilderness.

Genetically modified organisms

Adherents of this scenario understand that it brings with it certain deprivations relative to the present levels of consumption, such as regarding energy and

resource-demanding foodstuffs which we now have access to. However, it might be possible to find less problematic ways of maintaining our lifestyles, for example through technological inventions, energy-savings and behavioural changes such as altered diets. Technology – when properly applied – is a significant factor in solving our problems.

Cultivation of genetically modified energy crops is in principle compatible with this scenario, provided those techniques offer greater productive efficiency without exacerbating nature and environment issues. Whether or not that is the case must rest with comprehensive analyses of the risks and of sustainability assessments to secure that the negative impacts on climate and the environment are reduced. Clearly, such deliberation is never infallible, or able to exclude unanticipated, long-term risks by using specific GMOs, but this is equally the case for most technologies or practices we engage in. There is a degree of risk in everything, even with restraining from implementing technologies under the current grave situation, and these risks must be weighed against the possible benefits of a particular choice. Should it turn out that a genetically modified plant produces more energy on a given acreage, then that plant should be grown because the positive effect on climate and the production of foodstuffs outweighs the risk of unknown consequences.

According to the ethical standpoint behind this scenario, genetic manipulation of plants does not constitute an impermissible violation of nature. This does not mean, however, that there are no other objections to generically manipulating plants. For example, it could be held that even a small risk of rampant GMOs in the wild is unacceptable. Likewise, since patents and proprietary licenses held by multinational corporations are particularly significant in regulating GM technology, the question of whether or not the world's poor will be able to afford it is also reason for scepticism. These objections are not exhaustive, and more objections that do not relate to the gene modifying process itself, but to circumstances associated with the technology's implementation, could be added in accordance with the fundamental premises of the scenario.

Possible undesirable consequences

This scenario shifts perspective from retaining that ethical obligations primarily are owed to compatriots and those with whom one shares a community to claiming that in principle we have the same commitments towards *all* human beings, and that we should take the interests higher ranking animals into consideration. However, the question must be raised; does the scenario live up to this ideal?

Should we actually treat everyone in the world as equals – not least millions of hungry people – the effect upon us would not be slight, but most considerable. It would make demands, which in point of fact few are actually willing to meet. It follows that this ethical standpoint can be criticised for making claims that are so high that its adherents would have to make many compromises, which in fact is apparent in the scenario. To this objection it can be held that ethical standpoints

might well be correct even if living according to them might take on a character of ideal goals that one attempt to achieve well knowing that one might never be able to fully realise them.

The scenario represents one shot at a policy that attempts to show consideration to the world's poor and future generations, as well as to preserve the natural foundation of life. If it is necessary, then Danes should be prepared to accept reduced standards of living in order to live up to their duty. Yet the scenario is not a fundamental confrontation with the current Danish lifestyle, as it for example welcomes "green" technology that may to some extent allow a continuation of contemporary lifestyles in a less resource-depleting way. Some critics will view this as simply trying to alleviate the consequences of a fundamentally unsustainable lifestyle, thereby solving nothing, but simply postponing the inevitable, while the anticipated technological development may in some cases even make matters worse.

Since this ethical standpoint sees nothing essentially wrong with interfering in nature, there is nothing wrong with introducing technologies that enable people to adapt to the effects of anthropogenic global warming – such as genetically modified plants that are drought-resistant and therefore able to grow in places that have become arid because of climate change – rather than make drastic reductions in consumption so that anthropogenic climate change might be halted altogether. If technology is able to improve living conditions for human beings, they should make use of it. However, those who consider nature inherently valuable will often find that the natural order is valuable and should be preserved, thus finding such technology very problematic and unacceptable.

Third scenario: An environmentally sustainable degrowth vision

- **Total energy consumption**
  Denmark must achieve CO_2 neutrality as quickly as possible and no later than by 2050. The total consumption of energy must be greatly reduced, primarily by being abstemious. Essential energy ought to be from sustainable sources, including biofuels provided they are produced sustainably. The use of climate friendly energy should be supported by economic incentives not least by applying taxes and subsidies.

- **Land use**
  Acreage for the cultivation of biomass can be provided in part by keeping less livestock. This can be brought about by applying taxes the production and consumption of foodstuffs of animal origin. Vegetarian choices should simultaneously be promoted and campaigns mounted to direct public attention to the cost of continuing with intensive agriculture.
  The land thus becoming available should not only be used for cultivating energy crops, but parts should also be left uncultivated. Furthermore, more land should be set aside to allow agricultural production to be reconverted to more extensive production that is more benign towards nature, environment, and animals. Surcharges and subvention shall be put in place

to ensure that the price of specific foodstuffs reflects the impact their production has upon nature, the environment, and livestock, such that by making choices favourable to the community and our surroundings we are not punished by having to pay higher prices.

- **Electricity, heating and transport**
  Energy shall primarily come from renewable sources and from sources that do not require extensive cultivation, such as wind turbines, photoelectric cells, wave generators and geothermal heat.

  Energy crops for biomass production or import of certified biomass – have only a temporary role to play, and even then only if it can be demonstrated the processes are environmentally sustainable. Manure and slurry from livestock should not be used to produce biogas, as that would create a discouragement for farmers to switch over to less intensive production with fewer livestock, as would be desirable both in terms of lowering the climate impact from husbandry and of improving animal welfare. In the long term a reduction of emissions shall be achieved either by using less energy, or by producing enough from self-sustaining sources that do not involve the destruction of natural habitat.

- **Technology**
  Looking for technological solutions for technologically induced problems, will only create new problems. There are cheaper and better responses to the situation that are more benign and respectful towards nature, such as simply using less energy.

As under scenario 2 this scenario assumes that bold responses are needed in order to resolve the crises and that our present lifestyle is very dubious, because it is centred on the short-term economic and financial interests of contemporary Danes. Our lifestyle is questionable, partly because we ignore our duty of care to those far away and those who are not yet born, though that is not all. It is equally reprehensible to hold that only people have any ethical value, while other species and the natural world are treated solely as resources at people's disposal to be utilized as we alone see fit. Consequently, we violate not only their rights, but transgress against ourselves, since it is impossible to live a good life without behaving respectfully towards our surroundings.

This scenario sets out with the view that we ought to acquire certain characteristics or virtues such as honesty, generosity, courage, and justice and endeavour to live up to them in our commonplace dealings. In point of fact this applies not only to interaction with people, but also animals and the natural world. This way, we will see that radical changes are needed in our lifestyle, because the challenges we face are the result of fundamental shortcomings in all our with other people as well as with nature. It follows that attempting to prolong our present lifestyle is not only futile, but will in fact exacerbate the situation.

Looking for external solutions, which solves problems by retaining production and lifestyles by changing nature is no way to put matters right. Instead we should choose an inner strategy, we should aim at solving the problems by changing our attitudes to the rest of nature. This does not mean that natural resources are not to be utilized at all, but that we must use them with far greater respect than is presently the case.

Climate

Given this scenario's principles, it follows that anthropogenic global warming must be minimized, for example by replacing fossil fuels with sustainably produced biofuels. Obviously only sustainable bio-energy which substantially reduce CO_2 emissions must be used. Equally important however, is that there be a critical review of energy consumption, as the present high level of consumption is a symptom of an untenable lifestyle. Energy savings must be found and there must be a radical reduction of detrimental energy-demanding activities that harm nature and overexploit resources. One approach to this could be the imposition of taxes on polluting foodstuff production as a collective effort to benefit the climate, though it is equally important that individuals reflect upon their own ideas and how one ought to live to attain harmonious living.

It is necessary to alter the predominant perception of 'the good life' as involving habitual overconsumption of natural resources. Instead, the aim should be to bring about common understanding of the necessity in seeking other goals in life than materialism. We have put ourselves in a situation with no prospects and continue destroying the only planet we have. It is therefore essential that we realize we *can* reduce our consumption, and that changing our high energy lifestyles can be done without deprivation and poverty, provided we revise our attitude toward ourselves. It is necessary to dismiss the idea that the good life results from material goods, and instead build communities with more meaningful relations to nature as well as to other people. When we exist as a part of nature and not apart from it, we respect its value while we develop our own character and bring meaning to our lives.

Danes must change their climate depleting behaviour, not only because we have a duty to care for human and animal life, but also because climate is a significant factor in the balance of nature. Mankind has no right to disturb this balance in the pursuit of luxury. It is important not to attempt maintaining the current energy consumption by introducing various technologies such as bioenergy.

There should be less livestock, not only because of its detrimental impacts on climate and the environment, but also because other living creatures are valuable in their own right, and should not be treated merely as potential food.

Foodstuffs

Responsibility to the world's poor requires that production of Danish food ought not decrease while there are people who starve. Denmark should therefore maintain production levels to avoid increasing food prices on the world market. The aim should be however that agriculture shifts its emphasis away from producing foodstuffs of animal origin, not least because it is inefficient use of land, but also because the conditions under which animals are held under intensive farming are objectionable.

Rearing livestock

Agroindustry regards animals merely as a resource to be utilized as efficiently as possible. This notion is incompatible with the ethical view that nature's living creatures have value in their own right. Merely showing consideration for animals' experience of pain and pleasure is insufficient, since animal welfare also takes into account ideas such as integrity and freedom to live in accordance with nature, which ought also to be respected. Ideally, since according to this ethical standpoint killing animals is objectionable, we should cease eating meat altogether.

Nature and the environment

Our destruction of ecosystems should be halted, not only because we thereby destroy the basis of living for human beings, but also nature is more than just the source of people's life essentials. Widespread attitudes towards nature must change and people should accept that it is entitled to respect, while at the same time recognizing that living in harmony with nature is a pre-condition for the good life. It is not nature that must be changed, but our culture that should be adjusted in accordance with the limits that nature and climate impose on our actions.

These cultural changes must necessarily be toward lower consumption; we must not be driven solely by the hunt for ever increasing growth and wealth. Living in harmony with our surroundings is incompatible with mass consumption where goods are abundant and cheap because they are manufactured out of very short-term economic and financial considerations. Though this scenario must result in lower consumption, it does not follow that quality of life will decline – on the contrary. Less focus on material objects makes room for relationships with other living species, and the realization that there is more to life than just using products.

Genetically modified organisms

It is generally unacceptable to develop technologies in order to make possible the continuation of our present ways. Technologies are often representations of values that are ad odds with natural balances. For example, modern agriculture makes use of synthetic chemical compounds, antibiotics, hormones, and in some places genetic modification, all of which are so radically unnatural that they contribute substantially to the problems we face today, including soil degradation and over consumption of scarce resources.

The way ahead is therefore not to develop genetically modified energy crops, despite them possibly having higher yields than conventional varieties. It is disrespectful to nature to alter its balance so fundamentally merely to meet people's requirements – and even worse what concerns luxurious goods and extravagant activities. The way ahead is therefore to bring about farming methods that show more respect for nature's own balance, not less.

Possible undesirable consequences

This scenario takes an outset in the view that ethics concerns acting on the right motives, from asking ourselves which people we wish to be. Consistently cultivating the right characteristics and allowing them to guide our actions will result not only in us showing greater consideration to other people, but also to our natural surroundings.

Having gone through this process, it becomes clear that quality of life cannot be measured in material terms. The road toward a happy and fulfilling life goes through acting from the right motives, and not through possessing more of everything, while ignoring the ill consequences of avarice on the world around us – and in the final instance on ourselves. It is of course not certain that these considerations will persuade a sceptic, who is convinced that material possessions are important for a good life.

Critics will no doubt point out that it is not plausible that the majority of people should willingly forfeit their western lifestyles with a high regard for consumption. To the degree there is little or no support for the ideal that these other values constitute acceptable substitutes for materialism in guiding our lives, it is hard to see how the scenario may be brought about in practice, since it builds on the idea that individuals should act out of inner convictions rather than from a their sense of duty or from which actions have the best consequences for the common good.

It may also be objected that it is not altogether clear what it implies to live in respect of nature having a value in itself. It does not mean we cannot eat at least the plants or that we cannot use at least some forms of technology such as for example conventional plant breeding. It is hardly possible to lay down criteria that allow us to determine when a technology is excessively unnatural and therefore inadmissible. So, seeing how we do it all the time, where is the limit for manipulating nature? What if it were possible to develop a genetically modified plant that raises the nitrate level in soil, and that plant could be cultivated to the benefit of the environment - would that be inadmissible? Most likely such matters would be left to individual choice, so that no broadly accepted criterion could be applied regarding what is and what is not permissible with respect to manipulating nature.

6. Recommendations concerning the introduction of bioenergy in Denmark

There are many kinds of bioenergy with positive as well as negative effects upon the climate, environment, nature, and food production. The relevant question is therefore not whether bioenergy should be introduced, but rather what the criteria should be for introducing a given kind of bioenergy.

If the criterion is a primary commitment to the present generation of Danes and their living conditions, any form of bioenergy should be introduced, if it is profitable in economic terms, does not constitute an immediate risk, and ensures supplies.

If the criterion also encompasses commitments to future generations and people in other countries, the issue of immediate economic profitability cannot be the only one, nor is it even the most important. Here techniques with a positive effect on climate and environment and which do not substantially take up arable land, thereby decreasing food production or threatening natural habitats, should be introduced. However, it is necessary to view the competition for utilisation of acreage in a wider perspective. For instance, it should be considered whether energy crops can replace other uses of land, which are problematic themselves when it comes to solving the global crises, such as animal husbandry.

One could furthermore hold that considerations are owed to animals. If this is the case, it would constitute a further argument for reducing the consumption of animal products that intensive types of agriculture rarely allows animals to unfold their natural behaviour, because of the high pressure to maximize production outputs.

Some take the outset that considerations are owed to nature because it is valuable in itself and not merely because it harms humans and animals if it is degraded. If this is the case, then only environmentally sustainable types of bioenergy should be introduced and emphasis should be upon reducing the overall consumption of resources.

In an evaluation of whether or not it is ethically acceptable to employ energy crops, it is necessary to look at the overall footprint of the crop for various parameters, such as its effect on the climate, environmental implications (including the uses of non-renewable resources, pesticides and its effect on biodiversity etc.), its utilisation of acreage, its economic profitability, and its social consequences. The different kinds of bioenergy rank differently on these factors.

The Ethical Council is contended to learn that the agreement for Danish energy policy for 2012-2020 includes the development of a report on the conditions for efficient and environmentally sustainable use of biomass resources in the Danish energy sector. The Council suggests that the recommendations below, that environmental sustainability should be the criterion for taking up a given bioenergy technology, will be included in this work. Analysis of the sustainability for a given biotechnology should as far as possible be systemic and comprise all derived effects.

The members of the Ethical Council recommend the following concerning the introduction of bioenergy in Denmark:

1. Should sources of bioenergy that benefits distant people, animals or nature be introduced even at the expense of reduced short-term economic profitability?

The members are divided in regard to what should be the most important principle for accepting bioenergy technology and which emphasis should be placed on whether a given kind of bioenergy technology is economically profitable.

All members of the Council find that it is problematic to base decisions concerning the implementation of a given kind of bioenergy on considerations of its profitability in the very short term. They find that it is necessary to apply a long-term perspective on the issue of profitability. One-sided emphasis upon very short-term economic gain risks having a detrimental effect upon long-term profitability and thereby threatens the living conditions for our children and their descendants. If this generation emits large amounts of greenhouse gasses or depletes non-renewable resources, it may in the long term lead to impaired conditions of life, social unrest, and economic decline.

For this reason all members of the Ethical Council agree on the need for introducing a wider concept of growth than GDP, which is currently used. Here production and consumption – which degrade the environment and climate – count as adding value. A wider concept of growth must place value on the environment and on resources, as suggested by many economists and recently by the United Nations Secretary-General's High-Level panel for global sustainability. The members note the panel's identification of "market failure" in terms of the environment and natural resources, i.e. there is a deficient mechanism for determining a cost for these variables. Denmark should join the efforts to develop a new economic paradigm, which views growth in a new perspective. One should for instance not only tax labour, but also behaviour and consumption, which is not sustainable, wherefore it in the long term constitutes a threat towards living conditions of humans and the rest of nature. In extension of this line of thought there should also be other improvements to economic modelling and its ability to ascribe value to investments in sustainable solutions. This could be by lowering the discount rate for investments in sustainable

bioenergy substantially when calculating socio-economic profitability. This would increase the incentive to invest in the living conditions of future Danes.

Introducing a concept of growth that includes the cost of natural resources and the environment would be a step in the right direction, but it would not be a sufficient criterion for introducing bioenergy.

Some members of the Council (Jacob Birkler, Niels Jørgen Cappelørn, Jørgen Carlsen, Gunna Christiansen, Søren Peter Hansen, Lotte Hvas, Rikke Bagger Jørgensen, Ester Larsen, Anne-Marie Mai, Edith Mark, Peder Mouritsen, Jørgen E. Olesen, and Christina Wilson) hold that the most important principle for implementing a type of bioenergy is that it leads to an overall and an immediate reduction of climate gasses and lessens pressure on the environment, resources, and nature in comparison with alternative options. Man's influence upon climate, natural resources, and environment is already so comprehensive and serious that only solutions that are immediately sustainable should be put to use.

Thus the members do not find that economic profitability is the most important criterion in determining whether it is acceptable to implement a given kind of bioenergy, and they consider it problematic that present policies continue to emphasize profitability at the expense of environmental, climatic, and social sustainability.. We should be willing to accept certain deprivations, which on the whole must be viewed as limited, in order to acquire sustainable energy. So, although we should strive for long-term economic sustainability, it is more important that a given biotechnology's climatic and environmental pressure is less than or equal to that of fossil fuels, for introduction to be acceptable.

Other members (Lillian Bondo, Mickey Gjerris, and Thomas Ploug) do not find the aim of developing a new paradigm for growth to be relevant to decisions of whether to introduce bioenergy. The most substantial concern in the present situation is to avoid harming other people, also those who are spatially and temporally distant, as well as other species and ecosystems. For this reason we must adapt out lifestyles, such that they become more environmentally, climatically, and socially sustainable, wherefore it is not relevant whether a given type of bioenergy is economically profitable.

Although some bioenergy may put less strain on the environment and climate than the same amount of energy produced by burning fossil fuels, it can still constitute an unacceptable strain. The relevant consideration must therefore be whether we, by altering our lifestyles, could use less energy and therefore damage the climate and environment to a lesser degree. The energy it would be necessary to produce even after introducing energy saving measures and transitioning our lifestyles, should be produced as sustainably as possible. If the overall most sustainable method would be applying certain types of bioenergy, and it is not possible to get by using other even more sustainable types of

renewable energy, we should use bioenergy – even if it were not economically profitable in the long or short term to do so.

The ethical dilemmas deepen in regard to the introduction of bioenergy that takes up arable land that could be used for growing food for humans, or granting more space to nature. Here too, the Council members are divided:

2. Is it ethically defensible to use arable land for growing energy crops?

One group of members (Jacob Birkler, Niels Jørgen Cappelørn, Jørgen Carlsen, Gunna Christiansen, Søren Peter Hansen, Rikke Bagger Jørgensen, Peder Mouritsen, Jørgen E. Olesen, and Christina Wilson) find it necessary to use arable land for growing energy crops, insofar as it concerns crops that are environmentally sustainable and lead to a reduction of climate gasses and less environmental pressures than is currently the case for fossil fuels. This would benefit us and our descendants as well as distant people who are already affected by climate change.

It would be desirable if the technologies in question are economically profitable, but environmental sustainability should be the principal criterion. The members find that we should in general be attentive to whether our behaviour is too detrimental to the climate and environment. We should be willing to transition our lifestyles in a more climate friendly direction and use fewer resources; for example by eating fewer products of animal origin, avoiding food-waste, and reducing energy consumption.

Some of these members (Jacob Birkler, Niels Jørgen Cappelørn, Jørgen Carlsen, Rikke Bagger Jørgensen, Jørgen E. Olesen and Christina Wilson) further find it to be a precondition for a transition of arable land to bioenergy production to be ethically acceptable that we find other ways of retaining the current volume in global food production. If this is not the case, we risk contributing to rising global food prices by reducing supply in a situation where demand for food is increasing. The members recognise that this gives rise to a dilemma since there is no certainty that high Danish food output will benefit the world's poor. However, it is evident that if large areas of agricultural land are redistributed to growing energy crops, without compensation for the thereby lost food production, this will contribute to a greater lack of food and thus to higher prices. There are already signs that food prices are coupled to energy prices through the introduction of biofuels.

Some of these members (Niels Jørgen Cappelørn, Rikke Bagger Jørgensen, and Christina Wilson) consider a reduction of the very high consumption of meat among Danes, as well as a reduction of the expansive livestock industry in Denmark and around the world, to be obvious possibilities when looking for ways of compensating for lost food production. If the consumption of animal products would be reduced, this would release acreage for cultivating energy

crops as well as food, while also resulting in health benefits, less problems with animal welfare, and a reduction of the climatic and environmental effects from livestock.

This also involves a dilemma since even if Danes were to reduce their consumption of meat it is not given that Danish livestock production would decline, because most of its output goes to export. We risk that the rest of the world would continue to increase its meat consumption and thus the result of reducing Danish production and export of animal products could well be that problems with animal welfare, climate, and environment would be exported to other countries – and these countries often have more substantial problems in this field than do Denmark. The result may be a worse situation globally than had Denmark continued as present. However, these members finds that a lack of confidence in the importance of individual actions appears to be a contributing factor in bringing us in the present situation with several simultaneous and serious crises going on. So this is another area where the time is ripe to act according to our values in confidence that others will choose to do the same.

Finally, a number of these members (Jacob Birkler, Niels Jørgen Cappelørn, Jørgen Carlsen, Gunna Christiansen, Søren Peter Hansen, Rikke Bagger Jørgensen, Peder Mouritsen, Jørgen E. Olesen, and Christina Wilson) find that efforts should generally be made to develop green technologiescapable of countering the crises we are faced with. The members do not find it inherently problematic to change nature. For this reason there is nothing wrong with employing technology, which makes it possible to adapt to the effects of global warming. This could for instance be the case if genetically modified plants could be developed that where able to grow in areas that had been made arid as a consequence of climate change. Also, these could be technologies that made more sustainable production possible, for instance genetically modified plants that were able to improve the conversion from biomass to energy, or result in a greater yield per hectare. If it could ensure better conditions of life, then we should employ technology, insofar as these technologies do not constitute a threat to environment or health.

A second group of members (Lillian Bondo, Mickey Gjerris, Lotte Hvas, Ester Larsen, Anne-Marie Mai, Edith Mark, and Thomas Ploug) do not find it acceptable to utilise arable land for cultivating energy crops, if these crops compete with food production or nature. In a situation with increasing global population more food - not less – should be produced. Not only that, the cultivation of energy crops will put additional pressure on a natural world that is already endangered. It is further not acceptable if the cultivation involves clearing of areas that bind large amounts of carbon in vegetation and the soil.

Some of these members (Lillian Bondo, Mickey Gjerris, Lotte Hvas, Anne-Marie Mai, Edith Mark, and Thomas Ploug) find that there are already many indications that the production of bioenergy has caused global food prices to

increase and that food prices are coupled to energy prices with the introduction of biofuels. This means that when energy prices go up, it becomes more advantageous to produce energy crops, wherefore food prices go up to the detriment of the poor. This development harms the effort to feed the growing global population and should therefore be stopped.

To this must be added that many kinds of bioenergy are neither environmentally nor climatically sustainable: the reason for introducing bioenergy looks more like an attempt to attain energy security than climate improvement. Finally, these members note that insofar as we merely use bioenergy to uphold a high-energy expenditure, rather than reduce consumption necessary to attain a fundamentally sustainable lifestyle, the use of bioenergy is not an acceptable solution.

To the extent that the problems of using biofuels and bioenergy are not solved, the use of these energy forms should be limited, in order to reduce their affect upon climate, environment and nature. This may happen through greater efficiency and changes to behaviour, while on-going development and research in environmentally or climatically sustainable technologies is sought out.

3. With whom does the responsibility for implementing these changes lie?

The members agree that we are at a decisive moment in history in regard to preventing irreversible collapse of living conditions on earth caused by anthropogenic activities. The knowledge we now have about these issues should make us all act in a way that at least does not aggravate the situation.

The council wishes to emphasise the need for schools, media, and authorities to intensify their efforts to inform all Danes concerning the global crises, and the connection between our actions and how the crises develop. Everybody should, for instance, be aware of the area needed to retain livestock production and which activities are particularly detrimental to climate, nature, and environment.

In general for the recommendations given here, it holds that the positive effects of changes in behaviour by individual Danes or the Danish nation in order to live according to the values, we find important, will become insignificant, if the rest of the world does not choose to act similarly. It is, for instance, a condition of global warming that the contribution of individual Danes as well as that of the entire nation only contributes insignificantly. This may lead to many giving up efforts to follow their ethical values.

The Ethical Council recognises that this presents a serious ethical dilemma, but that given the present grave situation we are non the less required to act from a conviction that our actions will make a difference. The Council admits that any solution to the problems must be political and global, given the extent of the crises. All the while however, it is important to note that the political will to

implement the necessary actions will not appear until a sufficient number of people or nations collaborate in identifying solutions.

The members therefore agree that this situation requires reflection on how collaborative action ameliorates or aggravates the current crises. This can be viewed as a desire for a new ethical consciousness, which one seeks to abide by in everyday living. There is a need for all to take up a greater responsibility for their contribution to the current state of the world; this includes states, authorities, companies, organisations, and individuals. One could stress that some people acting in correspondence with ethical consideration may give rise to a domino effect. It will bring others to do the same thing and thereby generate a real positive effect in the world. Furthermore, it is possible to insist that all people should seek to acquire desirable virtues such as 'moderation' in the consumption of resources and 'gentleness' in in the usage of nature, and 'persistence' in following these maxims in everyday choices. If one truly puts in an effort to attaining these qualities, there will be a desire to act in accordance with the ones values and taking responsibility without asking whether others do the same thing. Finally, emphasis could be put on the obligation to always act as one would wish others to act. Indeed, if everybody did this, it would be possible to find solutions to the serious crises we find ourselves in.

Some of the members (Peder Mouritsen) hold that the responsibility to improve the environment, climate, and food production must primarily be held by the state, rather than individuals, since states are more efficient than individuals in tackling climate change or acquiring food for the world's hungry. This member holds that it is legitimate for the state to impose measures to support sustainable energy and production thus making it less attractive to choose climate detrimental goods and food. This recommendation does not imply that politicians should solve our problems for us, but that it is more efficient for the state to initiate regulation.

Some of the members (Jacob Birkler, Lillian Bondo, Niels Jørgen Cappelørn, Jørgen Carlsen, Gunna Christiansen, Mickey Gjerris, Søren Peter Hansen, Lotte Hvas, Rikke Bagger Jørgensen, Ester Larsen, Anne-Marie Mai, Edith Mark, Jørgen E. Olesen, Thomas Ploug, and Christina Wilson) agree on the necessity of collective action at the national or international levels and point to the individual also having a responsibility towards more sustainable behaviour. The importance of individual ethical responsibility should not be underestimated, but retained as a condition for moving the collective towards action.

The situation is, according to these members, so grave that it is necessary to appeal to collective institutions as well as personal responsibility, if developments are to be reversed. However, it is clear that governmental efforts in promoting sustainable development have been inefficient and characterised by difficulties in attaining consensus on common agreements, but also a lack of will to comply with agreements actually reached. For this reason, responsibility

cannot be left to the states alone. Governments as well as individuals – for instance organised in popular movements – must take up responsibility to act in ways that counter the crises that constitute a real threat to life on earth.

Minority Report

One member, Lene Kattrup, has elected to stand outside the report for reasons of principle: there are fundamental premises, conditions, approaches, and conclusions she cannot condone.

This member of the Council has two recommendations concerning bioenergy or the introduction of new types of bioenergy. Lene Kattrup has the following recommendation all the while she understands that animal ethics falls outside the mandate of the Ethical Council.

Introduction of a given kind of bioenergy, including the cultivation of energy crops, is only acceptable if it includes a novel conceptualisation of sustainability and in calculations of profitability think long-term and include the cost of detrimental effects on the environment and nature, pollution, health risks, declining animal welfare and loss of amenity assets etc. according to the actual value they pose to society. This member finds that this concept of sustainability, in addition to the Brundtland definition mentioned earlier, should include expanded and precise regards for nature, which reflects the idea that nature has value in itself (i.e. that it is not merely a resource for humans). There should thus be requirements that woodland areas as well as vulnerable, pristine natural habitats must not be infringed upon. Uncultivated wilderness, fallow fields, meadows, grass fields, peat bogs, commons, marshes etc. should not be cultivated to produce bioenergy, but should be retained in size and condition without pollution, washing out, or other substantial changes. Also, biodiversity must be retained.

In addition, the member finds that animal welfare should be included in the concept of sustainability and be defined by farm animals and livestock being treated with care and in accordance with their physiological, behavioural, and health requirements. In the member's opinion, current conditions are such that e.g. intensive, conventional pork-production is deficient on a number of counts that are counter to animal welfare. For instance many animals through extensive periods of their lives are restrained from being able to move around and unfold important natural behaviour such as foraging and curiosity. Also, the sows are unable to sufficiently unfold their rearing and nesting behaviour. 25% of the sows die or are put down because they are so ill that they cannot be slaughtered for meat. It should also be mentioned that a large part of conventional poultry production prevents the animals' mobility, unfolding of wings, and the foraging behaviour that is of great importance to the species. The member finds that if the concern for climate, economy, or market in the introduction of bioenergy should results in additional pressure upon farm animals, then animal welfare considerations should carry the greatest weight, since there are substantial concerns for animals that cannot be disregarded. It should also be emphasised that the majority of conventional farm animals are

already exploited beyond reasonableness. There is, as pointed out by some researchers, no clear connection in regard to climate effect between intensive animal production over against extensive and ecologically sound animal production (which requires areas for grassing and straw for animal welfare purposes)

If, for instance, cattle are kept on sustained and managed paddocks at low density (and if such paddocks do not require felling of woodland) such areas may collect such large amounts of carbon that it in some cases balances the emissions of methane from the animals. If these are dairy cattle, the climate pressure will be less that for the production of cattle for beef.[133] The member of the Council does not find that grassing areas for animals should be abandoned in favour of growing energy crops, or that animal in need of straw should be prevented in this because grassing areas are utilized for energy production.

Lene Kattrup furthermore wishes to point out the possibility of the individual citizens voicing an opinion and assuming responsibility for what kind of society is considered good - also for future generations. This could be through changes in lifestyle and consumption. Also, this assumes more thorough labelling of food and other goods concerning sustainability. This could be attained if there was a political demand for this to happen or economical incentives that made this the norm. If all goods: food, firewood, wood chips, flowers, furniture, clothes, travels, and fuel were labelled, such that the citizen were able to easily understand the climatic, environmental footprint, but also energy efficiency, resource use, transport distance between place of production and place of consumption, and level of animal welfare for meat or fur, it would be much easier to for citizens to act in accordance with one's conscience. This is currently difficult. It should be done using a transparent and well-defined labelling system, which included on-line access to further information about the product in question.

[133] Sandøe, Peter et al. 2011. Kød og klima – bør vi blive vegetarer for at modvirke den globale opvarmning, eller er det godt nok at spise økologisk? p. 104 & 07-12.

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