Making Sweden an

OIL-FREE

Society

Commission on Oil Independence
21 June 2006

Foreword

In December 2005, the Government appointed a commission to draw up a comprehensive programme to reduce Sweden's dependence on oil. There were several reasons for this. The price of oil affects Sweden's growth and employment. Oil still plays a major role for peace and security throughout the world. There is a great potential for Swedish raw materials as alternatives to oil. But, above all, the extensive burning of fossil fuels threatens the living conditions of future generations. Climate change is a fact which we politicians must face. Broad and long-term political efforts are needed.

Interest in the Commission's work is and has been enormous. Many people took part in the hearings which were the start of the Commission's work. In contacts with me or other members of the Commission, very many more took part by presenting proposals, criticising, and analysing problems and solutions.

Since the objective of ridding ourselves of our dependence on oil by the year 2020 is bold, and the issue embraces the whole of society, it was essential that the Commission should have a broad base. Experts from industry, agriculture and forestry, science – and special experts on energy efficiency and district heating – met for the discussions we had. In this way, the Commission was forced to examine conflicts of goals and different aspects of practically all the issues.

The result is a consensus report. No member of the Commission gained a full hearing for his/her standpoints and views. But all were prepared to look for compromises, weigh up the pros and cons and accept not fully achieving their own ideal position on each individual issue.

This openness meant that we were able to agree on the best common denominator in the task we faced: to mark out a path to strengthen Sweden's competitiveness and take a substantial step towards reducing emissions of greenhouse gases. This greatly pleases me.

On only one point were we not able to agree. The question as to whether protection is needed for domestic and EU-produced ethanol divided the group. On the one hand, Christian Azar stated that Sweden should be proactive for the abolition of the European tariff protection of its own production of ethanol. This is a respectable position. On the other hand, most of the members of the Commission supported the view that protection and stimulation of our own ethanol production is needed during the initial phase.

Apart form this, the Commission is in total agreement on the contents of the report.

I hope this spirit can continue to characterise discussions about our dependence on oil. The next stage will now follow. The changes required will not be realised solely by political decisions, nor by market forces in industry alone, nor by individual farmers and forest farmers who see future opportunities for profit. Not until all the positive forces in society aim for the same goals can Sweden achieve independence from oil. In this work, I hope the Commission's report will be an important contribution.

Stockholm, 28 June 2006

Göran Persson

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A vision for Sweden

The nations of the world seem increasingly like neighbourhoods in a shrinking global village. Modern information technology gives us amazing new opportunities for cross-border exchanges of knowledge and hence for insight into one another's distinctive cultural characters and living conditions. And the globalised economy has bound us together in a web of mutual dependency.

Today the human race has better chances than ever before of solving the enormous challenges we face. When we look out over the globe, we can rejoice in several promising trends. Even so, here and there global developments continue to be unsustainable. The major "survival issues", among others energy and climate problems, call for far greater commitment and strong political and industrial leadership, at both national and international levels.

Declining access to conventional oil, in combination with our joint responsibility to stop global warming, will be a test of the world community's readiness to switch to energy systems that are more sustainable in the long term. Basically, it is a question of the will to show solidarity with present and future generations.

Sweden accepts this challenge!

In this document, we propose a number of far-reaching, concrete measures that can end our dependence on oil by the year 2020 and tangibly reduce our use of oil products. Our ambitious objectives are as follows:

- Through more efficient use of fuel and new fuels, consumption of oil in road transport shall be reduced by 40-50 per cent.

- In principle no oil shall be used for heating residential and commercial buildings

- Industry shall reduce its consumption of oil by 25-40 per cent

The fleet of private cars must become more efficient from an energy point of view. The need for physical travel can be reduced by a well built-out IT infrastructure and IT solutions, *inter alia* enabling distance work and travel-free meetings. The Government should contribute to large-scale production of new, domestic biofuels from forests and fields. Public transport should be given the resources to become faster, more convenient and good value.

All this means that we can not only reduce emissions of greenhouse gases. We can also secure our supply of energy, strengthen our economy and promote the development of sound growth driven by technology and environment, with new business opportunities for Swedish industry. In short: the phase-out of oil can further strengthen our position as one of the world's leading nations in sustainable development.

However, our ambitions are not really new. They have a long previous history. And they will obviously need to be followed up and intensified in the decades following 2020.

In the last thirty years Sweden has, for example, reduced its use of oil for heating residential and commercial buildings by seventy per cent. This has been achieved by replacing oil with

biofuel-fired district heating plants, direct electricity and electrically driven heat pumps and, not least, by better insulation of buildings.

We will now continue to reduce our consumption of oil at the same time as we also utilise biofuels in order to replace as far as possible direct electricity for heating buildings.

Since the mid-1970s we have also succeeded in reducing average energy consumption per square metre of living space through new technology facilitating a more efficient use of energy. However, during the same period total living space increased by almost fifty per cent. The saving was eaten up by increased consumption, the so-called rebound effect.

We will now move on, with the lessons we have learnt. As an overall strategy, the Commission proposes extensive efforts to improve the efficiency of society's total energy consumption. It is also essential that the rebound effect be counteracted through the design of the tax system, education, energy counselling and a national campaign to save energy.

2020 is the primary time horizon for the objectives presented in this document. But naturally, efforts to make more efficient use of energy and the phasing out of both oil and other fossil energy carriers will need to continue for decades after that. This is connected above all with climate policy and the already existing objectives and requirements to reduce by 2050 emissions of greenhouse gases by 60-80 percent compared with today's level of emissions.

We are technology optimists and want Sweden to be at the forefront in the gradual use of new, resource-efficient, renewable technology – hybrid vehicles, solar cells, wave energy, fuel cell vehicles, new biofuels, and energy-saving IT solutions and also technology we cannot know anything about yet or can just divine. We prepare for this type of development in our proposals by massive support to research, development and commercialisation of new technology.

We would also like to underscore the need for partly new values and a way of life based to a greater extent on solidarity, at both national and individual levels. The role of homes and schools is therefore important, and we need to support the bearers of ideas, the popular movements, in their ambition to encourage new thinking and a deeper understanding of our world. Democracy can and must therefore be intensified and politics renewed. In this work, information paths such as, for example, the Internet must also be used in order, *inter alia,* to reach the younger generations with knowledge and information.

Sweden is to be sure a small neighbourhood in the global village. But we have great and growing opportunities to contribute to positive change, now and for tomorrow!

The Commission on Oil Independence

The Commission on Oil Independence was set up by the Government in December 2005 and was requested to present concrete proposals for reducing Sweden's dependence on oil by 2020 and, in this connection, also significantly reduce our actual consumption of oil.

For over fifty years oil has been one of the most indispensable physical lubricants in modern welfare societies. It is fuel for most forms of transport and raw material for many everyday products such as, for example, plastics, synthetic rubber, paints, varnishes, medicines and

cleaning products. It is also used in certain industrial processes and to a lessening extent for heating.

The current global oil debate therefore arouses both interest and concern. Will the world's reserves of conventional oil in the long term decrease or even come to an end? Must we count on a less secure supply of oil from the Middle East and other politically troubled areas? If so, how will this affect the cost of heating and transport? How vulnerable are we? At the same time, like other countries Sweden has promised to reduce its climate impact.

Composition of the Commission

The Prime Minister, Göran Persson, was chairman of the Commission which comprised the following eight members from the research world, industry and social life: Professor Christian Azar, Chalmers University of Technology, Lars Andersson, government investigator into bioenergy, Lotta Bångens, Chairman of Sweden's Energy Advisers, Birgitta Johansson-Hedberg, CEO, Lantmännen, Leif Johansson, CEO, AB Volvo, Göran Johansson, former chairman of the Swedish Metalworkers Union, Christer Segersteen, Chairman of the Federation of Swedish Forest Owners, Lisa Sennerby-Forsse, Secretary-General, Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning
The Commission's Staff comprised Stefan Edman, biologist, writer, former Political Adviser to the Prime Minister and Anders Nylander, architect and expert on energy.

Working methods
The Commission worked openly and together with experts in order to spread current knowledge to the media and those interested in the general public. Four public hearings broadcast on television were arranged on different themes and attracted considerable interest in Sweden and around the world:

13 December 2005: Will oil run out – and, if so, when?
20 January 2006: Sweden's green gold – what potential do forestry and agriculture offer for bioenergy now and in the future?
17 February: How can we reduce our dependence on petrol and other fossil fuels in the transport sector?
22 March: How can we reduce our dependence on oil and other fossil fuels for heating and power production?
Material in preparation for and after the hearings was presented on the Government website During the spring, the Staff held many meetings with the actors concerned, the media and other interested parties.

Will oil run out – and, if so, when?

In the earth's interior there are very extensive coal-based energy resources, from methane hydrates deep in the oceans and in northerly permafrost areas to unexploited deposits of oil sands and shale oils. The superficial deposits of coal, oil and gas that man makes use of today are the tip of the planet's enormous energy pyramid.

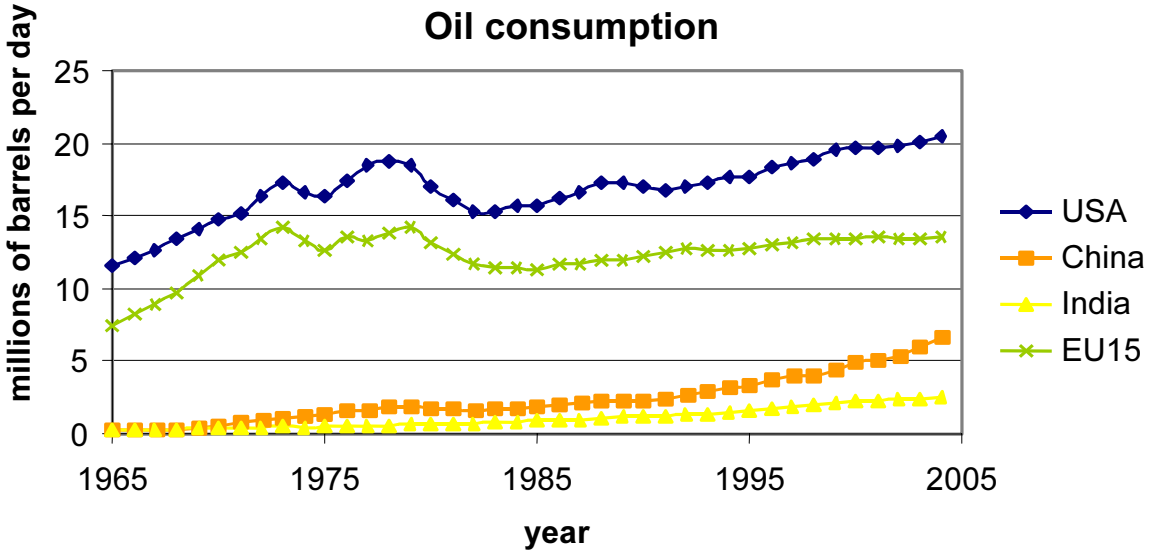
Thus, oil will never run out, neither in a theoretical nor a practical sense. However, how large the amounts that will actually be available for human use in the future is an entirely different matter and more difficult to judge. The answer to a large extent depends on the one hand on the technology that can be used for its extraction and, on the other, on the prevailing

economic and environmental conditions. In general, it may be said that the deeper and more difficult to access the oil deposits lie, the more expensive it will be to extract them and the greater the impact will be on the environment.

The international petroleum industry considers that the amount of conventional oil at the beginning of the industrial revolution was 6 000 – 8 000 billion barrels (1 barrel = 159 litres; the world's current daily consumption is 84 million barrels). With existing technology, it should be possible to extract half of this, 3 000 – 4 000 billion barrels, of these about a thousand billion barrels have already been produced. To this may perhaps be added some thousand billion barrels of non-conventional oil. At the present level of consumption – and deducting what has already been consumed – according to the oil industry's estimate there would be sufficient oil for at least a hundred years.

Assessments of when the global oil peak will occur vary among different actors. The OECD's expert body, the International Energy Agency, considers the peak will come somewhere between 2020 and 2030, while BP, British Petroleum, believes it will occur in the period 2015-2020.

The expert group Aspo, the Association for the Study of Peak Oil and Gas, makes a considerably more pessimistic assessment of the supply of unexploited oil reserves and expects a peak before 2010. According to Aspo, extraction of the conventional oil reserves will decline dramatically in the coming decades.



Oil consumption in some major countries. Source: BP World Energy Statistics

The Commission bases its work mainly on the assessment of future world oil carried out by the energy committee of the Royal Swedish Academy of Sciences (KVA), which may be briefly summarised under the following points:

- New oil deposits that are discovered nowadays in the course of a year, approximately 10 billion barrels, are equivalent to only a third of the world community's current annual consumption, some 30 billion barrels. Demand is increasing by about 2 per cent a year while most oil-producing countries show decreasing production
- Known reserves amount to 900-1200 billion barrels; a total of 1300 billion barrels may possibly remain to be discovered
- The Middle East is a key region with over 60 per cent of the world's oil reserves. Here and in some of the other major oil-producing countries developments are characterised by political unrest
- Oil prices will continue to be high due to increasing use of oil in western industrial countries as well as in China and India and other rapidly growing economies

How dependent on oil is Sweden today?

Sweden's dependency on oil has varied over time. Use of fuel oil for heating, for example, has decreased dramatically from top levels in the 1970s while use of petrol has stood still for the last ten, fifteen years (see figure below).

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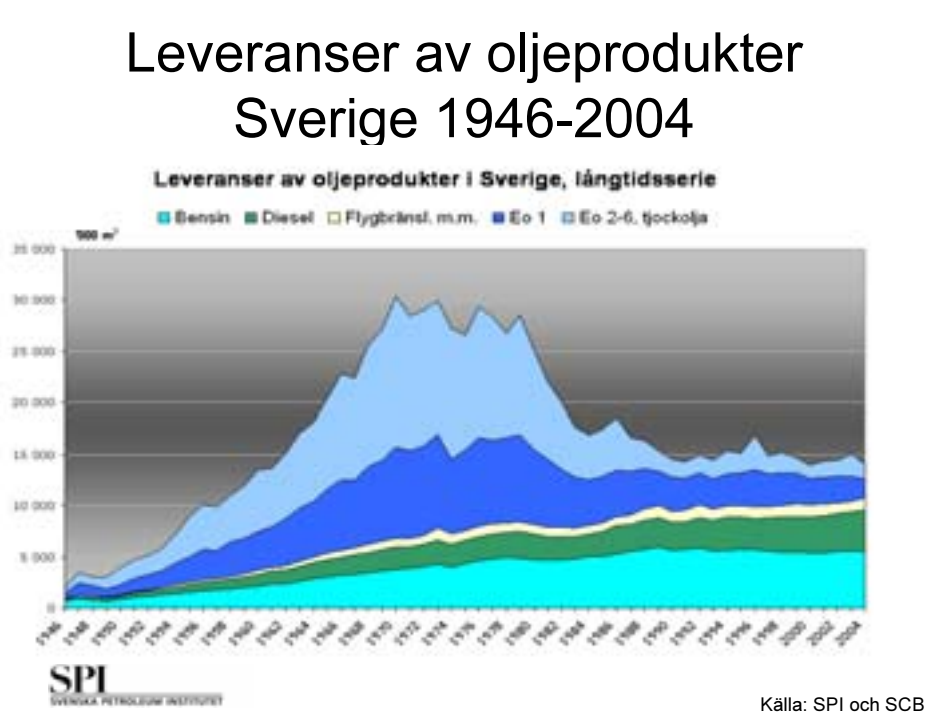
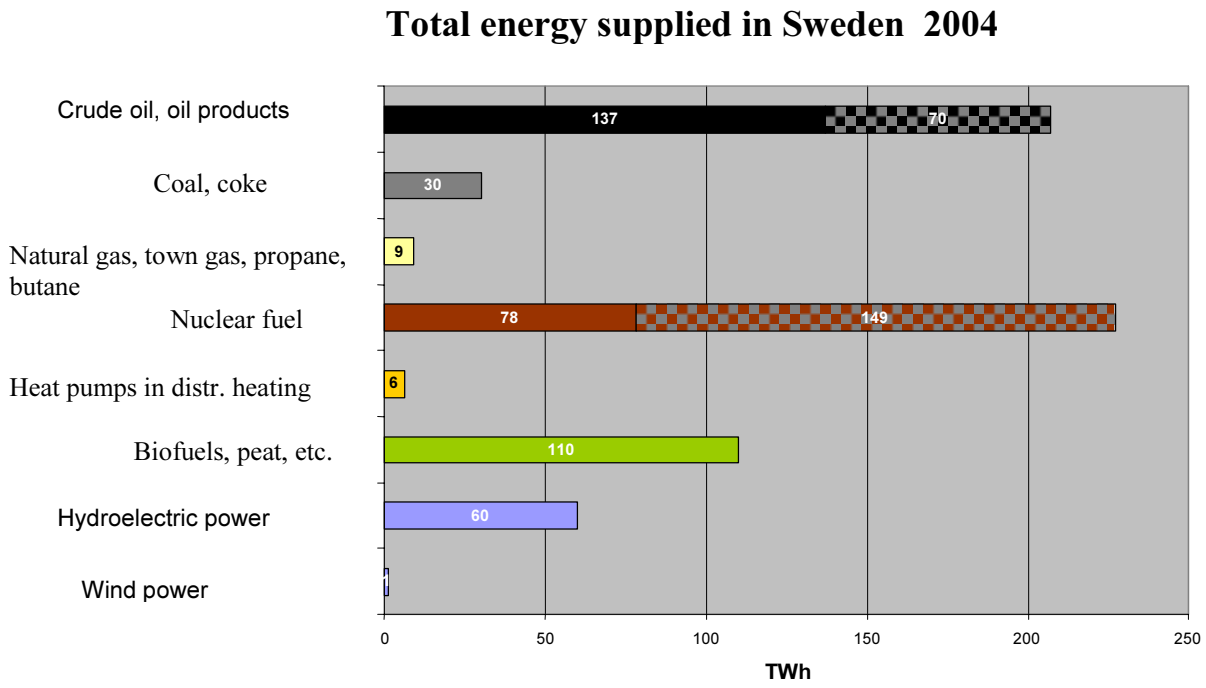
Supplies of oil products
Sweden 1946–2004



Källa: SPI och SCB

Diagram text:

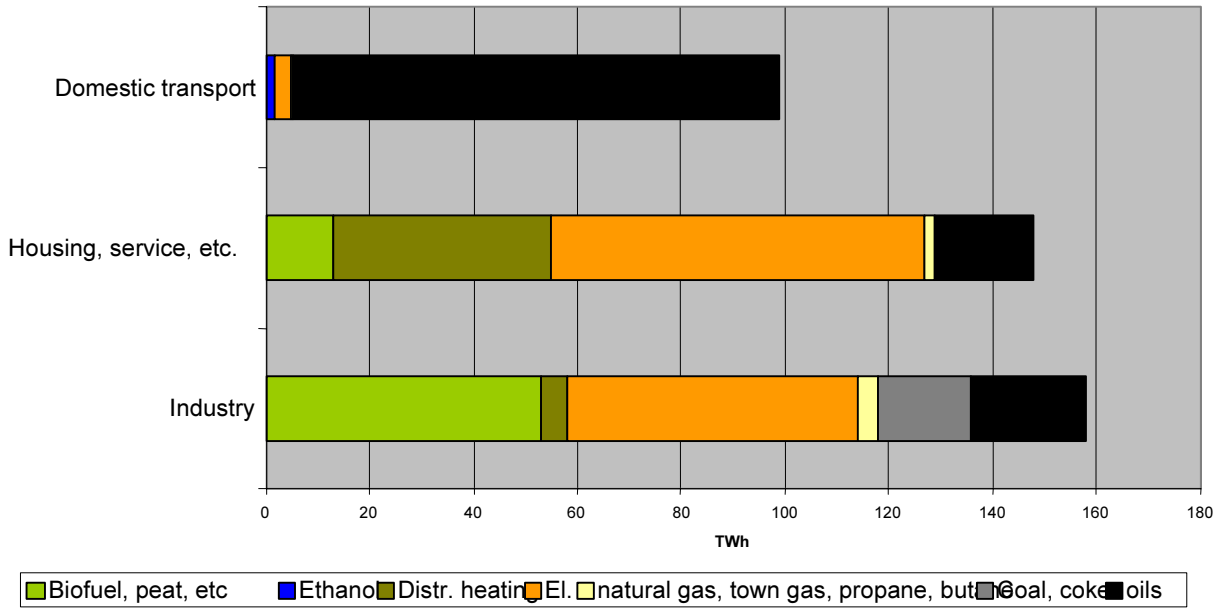
Supplies of oil products in Sweden, long-term series
Petrol Diesel Aviation fuel, etc. Fuel oil 1 Fuel oil 2-6, heavy oil
Source: Swedish Petroleum Institute and Statistics Sweden
We have chosen to illustrate Sweden's dependency on oil in 2004 with the aid of the two diagrams below. The first diagram refers to the total *supply* of energy which amounted to approximately 647 TWh. Crude oil and oil products accounted for 32 per cent and biofuels, peat, etc. for 17 per cent:



The patterned parts refer to heat losses in the form of cooling water regarding nuclear energy, and for oil, foreign shipping, non-energy purposes and refinery losses. Source: Swedish Energy Agency

The second diagram measures so-called end-*use* energy, which is the energy bought for the residential or commercial building or put in the car tank. There are losses here too which, however, are not discussed until later in the text. In end-use, oil products account for about 33 per cent. Bioenergy for direct use and district heating plants, which mainly use biofuel, together account for about 28 per cent, and the share of electricity is 32 per cent.

End-use energy distributed among sectors in Sweden 2004



Source: Swedish Energy Agency

Use of oil in 2004, in percentage terms and absolute terms for each sector:

Sector	Oil use		Areas of use, oil
Transport sector	97 per cent	95 TWh	Motor operation
Agriculture, forestry, Fisheries	70 per cent	7 TWh	Tractors, drying, contractors' equipment, fish processing
Building sector	67 per cent	2 TWh	Contractors' equipment, heating, drying
Residential and commercial buildings	11 per cent	10 TWh	Private heating (i.e. not district heating plants) and hot water
Industry	11 per cent	18 TWh	Heating and process energy
Production of district heating	8 per cent	4 TWh	Peak load, etc.
Service sector	6 per cent	3 TWh	Heating and motor operation, etc.
Production of electricity	1 per cent	3 TWh	Power in industry and district heating plants

The Commission's points of departure

The Commission sees five strong reasons for phasing out Sweden's dependency on oil, improving the efficiency of energy use and in the long term replacing fossil energy sources with renewable energy:

1. We will reduce Sweden's climate impact
2. We will secure Sweden's supply of energy in the long term
3. We can become a leading nation in the development of new technology for sustainable use of energy and more efficient use of energy
4. We will strengthen our international economic competitiveness
5. We will use and develop the energy resources from forests and fields, "Sweden's green gold"

Use of oil and climate impact are two sides of the same coin. They can only be fundamentally changed by regional and international cooperation. In this respect, the EU is Sweden's most important arena. Since we became members over ten years ago, our target-oriented climate policy has been of considerable importance for the development of the Union's common strategies. Sweden will continue to lead efforts to reduce emissions of greenhouse gases. Furthermore, we now want to develop models, control instruments and concrete measures to reduce dependence on oil, and in the long term on coal and natural gas also.

These measures must not obstruct preconditions for sustainable economic growth, including cross-border trade and communications. At the same time, we claim it is reasonable that each nation utilise its own, perhaps unique, preconditions for managing the switch to renewable energy. Several of our proposals for replacing oil are therefore based on Sweden's possibilities of producing biofuels and biopower on forest and agricultural land.

We wish to stress that "use of oil" is not the same as "dependence on oil". Our measures certainly aim to reduce as far as possible actual consumption of oil by the year 2020. We also want to reduce the one-sided dependence on oil in areas where total independence from oil will take much longer to achieve, for example in the transport sector.

All in all, these ambitions will give Sweden considerable opportunities to drive and stimulate a new resource-efficient technical and business development, above all for bioenergy but also to a high degree regarding vehicle, building and industrial technology. This can contribute to further strengthening Sweden's already prominent role on the global market and generate small and large enterprises, employment, export income and a vigorous regional development. As a nation we will utilise our enormous forest holdings, good arable land and our rich supply of fresh water. But we will also make use of the fact that Sweden is strong in the IT area with good competence, extensive infrastructure and a high degree of IT maturity.

How well we succeed will depend to some extent on price trends on the oil market. In our view, the current high oil prices are primarily not due to the start of physical oil scarcity but to a combination of increased demand and disruptions in the form of political unrest and problems in connection with the actual extraction of oil.

However, in the longer term, the situation will probably be different. We have been influenced by the experts who predict that supplies of conventional oil will decline. The reasons for this are the continued substantial and growing oil consumption of the rich countries, including the EU and USA, in combination with greatly increased energy needs in megastates such as China and India. It is also a fact that fewer and fewer new major sources of oil are being discovered. Furthermore, security of supply may be jeopardised by increased political unrest in the Middle East and elsewhere.

An uncertain factor in the analysis is coal, which can already be used for relatively cheap production of petrol and diesel. If this is done on a large scale, the world will move towards a more rapid and extensive climate impact, even though it will be possible to a certain extent to trap and store carbon dioxide. Increased use of coal must therefore be counteracted, both by national policies and in the international climate negotiations.

The Commission was requested to find the best strategies for reducing dependence on oil and actual use of oil in Sweden by the year 2020. The proposals will deliver us from a costly and insecure dependence on oil and thereby unnecessarily large emissions of climate gases and, at the same time, strengthen the international economic competitiveness of this country and our companies.

Our analyses and proposals

The Commission proposes the following national objectives for more efficient use of energy and reduced dependence on oil by the year 2020:

- Swedish society as a whole should be able to make 20 per cent more efficient use of energy by 2020 and thereby at the same time create intensified, cost-effective prosperity that is sustainable in the long term
- By 2020 in principle no oil should be used for heating residential and commercial buildings
- Road transport, including transport in the agricultural, forestry, fisheries and building sectors, should reduce use of petrol and diesel by 40-50 per cent by 2020
- Industry should reduce its use of oil by 25-40 per cent by 2020

Realisation of these extremely ambitious objectives presupposes, among other things, that very powerful investments are made, not least in the three sectors transport, industry and heating. As a result of the increasingly high price levels for oil and oil products, market-economic incentives will also steer us away from consumption of oil. With increased access to alternative technical solutions, for example in the form of vehicles that can also be powered by renewable fuels, actual dependence on oil will end.

Our proposals for measures imply a considerable challenge to the whole of society. They demand above all a large measure of trusting collaboration between politics, industry and research. We wish to point out that our Commission is in itself an expression of precisely this kind of broad consensus. When all is said and done, support and commitment is needed from each and everyone of us, as citizens and consumers in everyday life.

In separate sections below, we present our proposals in the three areas – heating of residential and commercial buildings, transport and industry. Annex 1 briefly presents some of the extensive factual material that has guided us.

The Commission's proposals are based on the following five overall strategies:

1. Radically more effective use of energy by the whole of society

For decades the industrial countries, including Sweden, have built their welfare and modernisation on an abundant supply of electricity and fuel at low prices. This precondition,

which has primarily been regarded as a law of nature, is scarcely likely to remain in a world with a growing demand for energy, incipient oil scarcity and requirements to reduce emissions of carbon dioxide. The cost of energy, including oil, will gradually rise to presumably permanently high levels.

For our common future, it is essential that nations and companies can meet this new situation by making more efficient use of energy, through new technology, utilisation of IT, better planning and creative commitment on the part of citizens and employees.

A more effective use of energy means that the same product value and prosperity gain can be produced at lower cost and with lower energy consumption, which is positive for the finances of companies, households and the public sector.

This means not just reduced emission of carbon dioxide but also better long-term management of renewable energy sources so that they can cover more needs than would otherwise have been the case. Environmental stress, *inter alia* climate impact, will hence also be reduced.

Last but not least, making more efficient use of energy will give impetus to an expanding growth and business sector powered by environmental technology, with products and services for both the domestic market and growing global demand.

It is our firm conviction that the phasing out of Sweden's dependence on oil can only be successful if it is based on vigorous and continual efforts to improve the efficiency of society's total use of energy. Central responsibility for ensuring that this takes place is, however, at present divided among several different public authorities.

The Commission proposes therefore that a "council" or "energy conservation centre" be created. Its task will be to be proactive for a more offensive development with sector objectives, a duty to report to the Swedish Riksdag and Government on developments as well as follow-up and continually raised targets.

The Commission proposes an energy efficiency objective for Sweden that means Swedish society as a whole should improve energy efficiency by 20 per cent by 2020. This implies an average annual 1.5 per cent increase in energy efficiency.

2. Historic investment in forest fuels and energy crops

Sweden and Finland are the EU countries with the largest acreage of woodland per inhabitant, of considerable importance for their economies, jobs and prosperity. Forests do not just produce timber and pulpwood but also substantial quantities of fuel raw material for heating, electricity and propellants.

Our arable land is also of high quality and can yield, in addition to foods, large amounts of energy crops. As a result of the reform of the Common Agricultural Policy, it no longer steers towards food production. This in combination with the introduction of an energy crop premium and other control instruments promoting renewable energy means that more and more acreages will in future be used for the production of energy.

Thus, this country has at its disposal considerable potential for bioenergy (see annex 1)

The Commission proposes that in the next few decades Sweden make major investments in the production of bioenergy from raw materials from forest and field which can greatly help to replace fossil fuels in industry and for heating, electricity and transport purposes. In this way, by fuel replacement we could in principle totally eliminate oil in the heating of residential and commercial buildings by 2020. During the same period, we could also, in combination with energy-saving technology, reduce the total amount of petrol and diesel in the transport sector by 40-50 per cent.

The Commission proposes the following long-term strategies, and assumes that they be implemented so that the objectives for nature conservation, outdoor life and recreation are not jeopardised:
(see page 21 and annex 2, Bioenergy and nature conservation):

1. Forest growth be increased in the long term by 15-20 per cent through more efficient management in the form of clearing, thinning out, refined plant material, ditch clearing and fertilisation as well as through more intensive cultivation of spruce and broad-leaf trees on a few per cent of the acreage.

2. Energy crops and energy broad-leaf trees be cultivated on arable land and disused, non-afforested farmland on a scale of 300 000 – 500 000 hectares.

3. The Government invest funds to stimulate education, plant support, procurement of technology as well as production facilities for the manufacture of fuels (see page 21-22).

3. Electricity for a sustainable supply of energy

Electricity is an efficient and valuable energy carrier. Use of electricity has increased in Sweden over several decades and is, per capita, remarkably high compared with other industrial countries in the developed world. It is uncertain how consumption of electricity will develop in Sweden in the future when historically low Swedish electricity prices are levelled out to the European level.

Very little electricity is produced in Sweden using oil or other fossil fuels. However, the common European electricity market, to which we nowadays belong, is largely supplied by fossil condensing power with a very low degree of efficiency and fuelled by coal. If, by improving efficiency, we reduce our consumption of electricity in Sweden we will be able to reduce emissions of carbon dioxide. The Commission wishes to stress that *inter alia* industry's need of electricity for specific purposes in industrial processes must be accommodated in a secure way.

The Commission proposes that the Government and industry cooperate to achieve the following:

1. More efficient use of electricity in industry. It is assessed that non-energy-intensive industry can in many cases improve electricity efficiency by 40 per cent and residential and commercial buildings by 20 per cent.
2. Increased production of domestic renewable electricity. There are plans to extend wind power by about 10 TWh by 2015. According to Svensk Fjärrvärme AB, the potential for

district-heating-based electricity is about 25 TWh, based on the data for district heating plants that may apply around 2010; with gasification technology it will further increase. In watercourses already harnessed, more electricity can be produced. Support will be given to research and plants for solar cells, wave power and hydrogen gas for fuel cells, the new sources of power that will be of considerable importance in the future (see page 28). The major power companies, not least state-owned Vattenfall, should take additional responsibility for the development of research and demonstration projects, in order to increase investments in commercial, renewable electricity production.

3. Reduced consumption of electricity for heating buildings. This should be achieved by more efficient climate shells and installations, increased use of IT-based systems for more efficient use of energy and by switching above all to biofuel-fired district heating, environmentally approved wood boilers, pellet burners and pellet stoves.

4. The role of energy gases

Energy gases should play an essential role in our ambitions to reduce Sweden's dependency on oil.

The Commission is dubious about a large-scale extension of the natural gas network and, hence, about the Russian natural gas planned to be distributed to Germany in a pipeline on the bottom of the Baltic Sea. Interested parties want to link this fossil gas to our country and, *inter alia* build a gas network to supply the Lake Mälare valley and Bergslagen. There are also plans for a pipeline southwards through Östergötland and Småland in the future.

We are aware that natural gas can replace a certain proportion of coal and oil in industrial processes and thereby contribute to reduced emissions of carbon dioxide from individual plants. And we can also see the positive synergy effects of renewable biogas for vehicle propulsion that may arise in the context of the gas pipeline.

To us the overriding problem is, however – along with the danger of reduced security of energy supply – that a large-scale supply of natural gas could replace and thus risks crowding out domestic biofuels used in many heating and district-heating power plants. In this way, the historically unique investment in bioenergy which we propose in this programme would be obstructed. The large-scale introduction of natural gas will thereby probably also lead to a total increase rather than a reduction in emissions of greenhouse gases in Sweden.

Danish natural gas, about 10 TWh, has long been available in Sweden. It is distributed along the west coast, from Skåne through Halland to Göteborg, and on to Stenungsund. Gas has replaced oil for heating and in industrial processes, among others the petrochemical industry in Stenungsund. The gas pipeline has also functioned as infrastructure for the vehicle gas established in south and west Sweden. A link to Norwegian natural gas is now also planned, via Preemraff's plant in Lysekil, which is thereby expected to strengthen its chances of producing Europe's cleanest fossil diesel fuel from residue oil.

The Commission proposes that the Government does not actively commit itself to increased use of natural gas in Sweden in the future. The gas pipeline along the west coast should on the other hand be used as rationally as possible. Industries with a special need of gas to replace coal and oil in processes should to some extent be supplied with LNG transported by rail, road or boat, that is to say natural gas in liquid form. The advantage of a solution of this type

is that it does not commit us to a fixed natural gas infrastructure that is not sustainable in the long term. On the other hand, the Government should support local and regional infrastructures for biogas from retting and gasifying of biomass, for use in both vehicles and industrial processes.

5. Control instruments at EU level

The EU emission trading system for carbon dioxide entered into force in 2005. Its formulation affects in several ways the conditions for reducing oil and fossil fuels in Sweden, *inter alia* in energy-intensive industry. It is therefore politically difficult to introduce additional control measures that impair the competitiveness of Swedish companies in relation to other companies in the EU. In order to speed up developments towards higher efficiency and other fuels, it is important that the ceiling for the number of emission rights is gradually lowered.

The trading system also concerns the district heating sector. Swedish district heating is a climate policy success story. In the past thirty years we have succeeded in moving from almost a hundred per cent oil in district heating to a predominance of biofuels in combination with small amounts of fossil energy carriers. This was made possible thanks to different types of control instruments such as carbon dioxide tax and now also trade in emission rights.

The remaining oil in district-heating systems is almost exclusively used for what is known as peak production on cold winter days, hence in furnaces that are used for a very short period. The Commission estimates that this oil will also be phased out by 2020, with the present price relations and control measures.

Should the EU emission trading system be weakened, there is the risk of a return to fossil fuels. Should this, contrary to expectation, occur, supplementary national rules will be needed.

If the EU has much more stringent requirements on its industry than other countries, the competitiveness of our companies may be jeopardised. It is therefore essential that a global climate policy system be developed within the framework of the climate agreement that is to supersede the Kyoto Protocol in 2012. Should commitments by the poorer countries be delayed, this should not be taken as a pretext for deteriorated climate policy in, for example, western countries.

The Commission proposes that Sweden contribute to a gradual tightening of the EU emission trading system. A reasonable objective is that distribution of emission rights decreases in the next ten to fifteen years so that total emissions in the trading sector will be 25 per cent lower in 2020 compared with 1990. This would give considerable impetus to reducing emissions of carbon dioxide and thereby consumption of oil.

It is also essential that Sweden more actively pursues the auctioning issue in order to create a better functioning market and lower economic cost for achieving the climate goals. We should also develop well balanced strategies to protect the fiercely competitive electricity and fuel-intensive industry from competition from regions that do not have a climate policy. This may increase opportunities to pursue a more ambitious climate policy in Europe during the period when the rest of the world lags behind.

Objectives for residential and commercial buildings

Remove heating oil by 2020!

The Commission proposes a radical bid to make the use of energy in residential and commercial buildings more efficient, more economical and ecologically sustainable. This means that by 2020 oil should be phased out and the use of direct electricity for heating minimised. New houses must use the best technology to combine energy efficiency with attractive housing. The existing housing stock must be modernised on the basis of the same objective. By means of intelligent control of lighting, heating and ventilation, major energy savings can be achieved in buildings. IT has great potential for creating positive changes in the future.

Since the mid-1970s, Sweden has reduced its use of oil for heating by 70 per cent. There are good chances of reducing our remaining use of oil, about 10 TWh, to in principle no use of oil at all by 2020. Switching to other types of energy is economically interesting, partly due to high market oil prices, but also as a result of an active energy policy that has introduced both oil replacement grants and carbon dioxide charges on fossil fuels.

The Commission wishes to underscore the importance of replacing oil with biofuels, preferably in combination with heat from solar panels. In population centres with district heating, the alternative should be connection to the district-heating network. Biofuel-fired district heating plants are at present available in many more than a hundred municipalities. Domestic fuel assets – wood, chips, pellets – are so extensive (see annex) that they can replace the remaining oil in the heating sector without further ado. The strength of the district heating network is that in extremely resource-efficient systems it can make use of locally available energy resources that would otherwise be lost or be difficult to make direct use of in buildings – waste heat from industries, energy from waste, geothermal energy or different types of less refined or "difficult" biofuels.

We are also of the view that both existing and new heating plants should be supplemented by what is termed power plant technology so that in addition to heat they can also produce electricity. Technology for small-scale heating power production, known as micro-district heating plants, is interesting but needs to be further developed. The green electricity certificates and amended tax rules mean that this will probably take place without additional special control measures. Today, about 6.6 TWh electricity is produced in district-heating plants. According to the district heating industry, with gasification technology, the potential for 2020 is 25-27 TWh, estimated on the district heating data that it is considered will apply in 2010.

Measures to improve efficiency must be applied in the entire chain from extraction, processing and conversion of energy, and not just regarding end use. Today, about half of all primary energy resources are lost before they reach the end consumer. All efforts to improve efficiency must aim to reduce the strain on limited energy resources and the environment.

The Commission proposes the following measures that should constitute the frame for national efforts to achieve more efficient use of energy in residential and commercial buildings:

1. Enhanced efficiency in connection with the construction of new buildings

- *Low energy housing with little or no external heat supply*

The Government and the building industry should jointly formulate incentives that stimulate construction of a high proportion of new low energy houses. By 2020 the share in new housing could be at least 75 per cent. This concept which has spread rapidly on the continent, is based on reliable technology with a tight climate shell, advanced heat exchange, intelligent control systems for use of electricity, clever windows, etc. These houses are slightly more expensive in the construction phase but economically advantageous to run since energy consumption per square metre of living space is halved compared with the best conventional technology.

- *Tightened building regulations*
  Building regulations relating to energy conservation should be tightened. Notification of planned and new tightened regulations should be given early so that the market has time to adjust to the new requirements. Parties to the building process should put effort into verifying that the set requirements have been met or exceeded. Weighting factors should be introduced for different types of energy when a building's energy consumption is estimated so that the gross supply of energy is made visible just as much as the carbon dioxide load. Installation of broadband should be encouraged in order to enable distance work.

- *Energy-related deductions on real estate tax*
  At present all new buildings are entitled to a real estate tax deduction for the first five years. We propose that the size of the deduction be linked to the building's energy performance, related to the weighting factors (see above), and that a similar arrangement also be considered in connection with investments to enhance energy efficiency in existing buildings.

2. Improving energy efficiency in connection with reconstruction
Requirements should be introduced for improvement of energy efficiency in the respective sub-systems, including tightened requirements for follow-up and observance of the framework of regulations.

3. Improving efficiency in existing residential and commercial buildings

- *"The million programme" and other older properties*
  Special efforts are needed to achieve energy efficiency improvements in connection with the extensive renovation and modernisation that will need to be carried out in the years ahead in the large housing stock built in the decades after the Second World War. These include, among others, the apartment blocks in what is known as the million programme which started in 1965. Measures can best focus on bringing the housing companies to carry out in-depth planning for good overall solutions, investments in systems to improve energy efficiency, joint procurement of technology, in combination with demonstration projects in, for example, the areas ventilation and building envelope, that is to say additional insulation and windows. It should be possible to give grants or tax relief to property owners who participate in a Programme for Improving Energy Efficiency (see below).

- *Buildings with direct electric heating*
  Reduction of direct electric heating of buildings should be accelerated. This must be effected by more efficient climate shells and installations and by switching over to heating methods that do not use electricity. A good alternative may, for example, be to provide a well insulated house heated by direct electricity with biofuel heating. Increased

efforts should be made to reduce the cost of changing to waterborne systems, for example by joint local/regional procurement of technology for cost-effective, waterborne systems.

- *Property owners and managers*
  Start a Progamme for Improving Energy Efficiency (PIEE) for property owners. The participants carry out measures in accordance with the Energy Declaration and in exchange receive financial stimulants, for example a temporary tax reduction or, alternatively, a tax reduction for certain environmentally sound installations (ROT). Investments are also made in training for caretakers and management personnel, possibly in the form of training cheques for participants in the PIEE.

- *Spread knowledge about improving energy efficiency*
  A special effort to spread knowledge about energy efficiency improvement, methods, good examples and basic knowledge should be made for all social groups. The prime target groups are schools and preschools, consumers and tenants as well as all the actors in the building sector from purchasers and planners to entrepreneurs and craftsmen. Experience can be gained from the activities and the information campaign carried out by the Delegation for Energy Supply in the South of Sweden during the period 1998-2003.

- *State leads the way*
  State-built, state-owned and state-administered buildings must reduce their energy consumption, *inter alia* on the basis of the measures proposed in the Energy Declaration. Good examples and models should be set by, for example, ministries and authorities. A similar aim should apply for other public premises, among others schools and hospitals.

  The state must also set a good example and promote growth and development of the market for the best products/applications, through public procurement and support to research and development in the area. Procurement should only be from the best performer quartile in energy efficiency.

Objectives for the road transport sector:
Reduce use of oil by 40-50 per cent by 2020!

The Commission proposes measures that can reduce use of fossil petrol and diesel in road traffic by 40-50 per cent by the year 2020. This objective also comprises the machines and transport used in the sectors agriculture and forestry, fisheries and building activities.

In combination with more efficient transport, increased production of renewable fuels, and by changing over to a fleet of vehicles that are not dependent on just fossil fuels, it will be possible to end the road traffic sector's dependence on oil.

A decisive precondition to attain such an ambitious goal is that the fleet of private cars – which today are about twenty per cent "thirstier" than the EU average – use their fuel considerably more efficiently. Freight logistics must also be rendered more efficient with the aid of ITS (intelligent transport systems), by higher loading rate vehicles and more optimal interaction between car, train and boat. What is known as the economic driving method and improved observance of speed limits contribute to reduced consumption of oil, as, of course, does increased travel by public transport.

In addition to all these measures to improve efficiency, large amounts of petrol and diesel must be replaced by biofuels from forest and energy crops. We propose (page 12) a historically unique bid to produce most of these fuels from Swedish agriculture and forestry. In this way, the Commission wants to contribute to greater security of energy supply and create the preconditions for environmentally driven growth, jobs and faith in the future in Swedish rural areas.

How well we succeed in reaching this objective partly depends on how high the price of oil rises and what the alternatives will cost. At the same time, we are of the view that the climate issue in itself justifies implementation of these changes.

The Commission proposes seven interacting measures:

1. Encourage a more energy efficient fleet of private cars!

The Commission considers that by 2020 Sweden's fleet of private cars should be on average 25-50 per cent more energy efficient than they are today. There are several possibilities for achieving this:

- A higher proportion of modern diesel vehicles. Diesel technology is 25-30 per cent more energy efficient than the petrol motor, and should gradually be provided with renewable diesel fuels (see section 3, p21). However, diesel cars at present emit more nitric oxides than petrol cars. This must be remedied. Negotiations in the EU on new exhaust requirements for private cars will lead to improvements.

- An investment in hybrid vehicles, which can use fuel or electricity can speed up the development towards oil independence. Hybrid technology, which for buses and lorries is most suitable for traffic in built-up areas, can reduce fuel consumption by up to 35 per cent. Fossil diesel can be phased out more rapidly, and tomorrow's biodiesels from forests and energy crops will last longer. With hybrid vehicles that can also be charged via the electricity network, known as plug-in-hybrid technology, probably half or more of a private car's fuel needs can be replaced with electric power. A breakthrough in the near future for hybrid vehicles of this type will tangibly improve our chances of phasing out the use of oil in the transport sector in the long term. For the system as a whole to be sustainable, electricity should be produced from renewable energy sources.

- A rejuvenation of the fleet of private cars and also a development towards reduced weight could play a major role to bring down energy consumption. One of the reasons why recently sold Swedish cars emit about 20 per cent more carbon dioxide per km than the EU average is the low proportion of diesel cars in Sweden. Other factors are also important. The average for new petrol cars sold in Sweden (194 g carbon dioxide/km) is above the average for other north European countries (Finland 181; Denmark 178; Germany 179; Holland 176; UK 175; Belgium 165). We also note that Sweden's somewhat heavier fleet of cars are among the safest in Europe.

The Commission calls for considerably more effective legislation regarding the three main components that steer towards fuel-efficient vehicles: carbon dioxide based vehicle tax, preferential taxation of company cars where fuel–efficient alternatives are encouraged and energy and carbon dioxide tax on fuel.

We are also of the opinion that fuel efficiency should be included as an essential requirement in connection with environmental classification of cars. To be classified as an environmental car, it is reasonable that the car's energy efficiency is better than that of the corresponding conventional alternative. Energy consumption should be defined in a way that takes into account the conditions of all size groups. This is in order to secure development of technology for all types of vehicle. A requirement of this nature is needed to make it clear to consumers and producers that there will hardly be a sufficient supply of biomass if the majority of all the world's cars are to be powered by biofuels at today's consumption levels.

In connection with choosing a vehicle, consumers should also be made aware that petrol and diesel prices are expected to rise, on the one hand due to oil price development on the world market and, on the other, through tax rates for managing environmental problems. For this purpose, Sweden should try introducing a consumer-adapted energy labelling system for cars of the type nowadays applied in the Netherlands and the UK.

We also consider that more efficient use of the fleet of vehicles should be encouraged by improved traffic planning and route optimisation, *inter alia* with the aid of ITS (intelligent transport system), GPS and a bonus system for car sharing (which could reduce fuel consumption by 10-20 per cent). Since 1 March 2006, an economic driving method, known as ecodriving, has been a compulsory part of driving school training and should also comprise heavy traffic, tractors, contractors' equipment, etc. A follow-up should be carried out with so-called sparcoach programmes.

Public procurers of vehicles should be able to assist in the development of technology by buying at an early stage demonstration vehicles with special qualities if necessary at higher prices than commanded by the simplest standard vehicle that can manage to meet the transport requirement in question. Authorities should procure vehicles with new technology to the extent judged necessary to speed up the phase-out of fossil fuels and introduction of efficient vehicles.

2. Improve the efficiency of goods traffic and reduce its share on the roads!

The Commission would like to point to the decisive role for industry and economic growth that fast transport with delivery security plays in a country like ours with substantial distances to one another and long distances to the markets on the continent.

The Government must therefore make sure that the transport sector's dependence on oil is ended and that this is effected in a way that does not damage Swedish companies and the Swedish economy. A method that promotes both the economy and oil reduction is to continuously increase lorries' loading rates and to upgrade both logistics and engine technology so that oil consumption in goods traffic can be reduced. At the same time there should be a gradual changeover from fossil fuels to biofuels.

The Commission also proposes positive control measures that put a premium on goods transport in energy-efficient combinations of road, rail and sea.

We want the Government together with municipalities and other local actors to contribute to building and improving the efficiency of transshipment terminals and equipping ports. In connection with large flows of goods, a higher share of sea transport is often an interesting alternative with on average six times lower oil consumption per tonkilometre. Municipalities

with rail connections have a special responsibility to utilise the synergy potential between goods transport on road and rail.

The Commission considers that it should be considerably easier in connection with public procurement to demand energy-efficient and environmentally adapted goods transport. The state sector should lead the way by procuring transport within the best performance quartile on the market and by creating good logistics for its own goods transport. A similar policy should apply for municipalities and county councils.

The state sector should also support the development and use of ITS (intelligent transport system) in order to help the transport industry to improve logistics and transport efficiency.

3. Increase the share of fuels from agriculture and forestry

The Commission proposes that, to replace petrol and diesel, Sweden should produce 12-14 TWh biofuel annually from forest and arable land by 2020. This country has excellent soil and climate conditions to achieve this. At the same time, new impetus will be created and a broad platform for development of technology and business in the green industries.

The EU has tariff protection for imports of ethanol which diminishes opportunities for, for example, Brazilian ethanol derived from cane sugar to compete on the European market. The tariff, which is part of EU agricultural policy, is motivated today by the need to protect the EU market during the build-up of its own, domestic biofuels. The negotiations now in progress in the World Trade Organisation, WTO, will probably move in the direction of a dismantling of this protection and a liberalisation of the global market. Biofuels will thereby be a commodity like all other commodities, which is, of course, desirable and in line with free trade principles.

In the present situation, imports of Brazilian ethanol would be economically advantageous for Sweden. However, with increased demand on the world market, we can expect higher prices and an "upward price adjustment" in relation to our own domestic production. The Commission's view on ethanol is that as a first generation of biofuels, it has increased interest on the market for alternatives to fossil fuels in a meritorious way. To accommodate the market's rapidly growing needs, continued development of acreage- and energy-efficient fuels, the second generation of biofuels, is required.

The Commission would also like to underscore that it is the conditions on a cross-border market that ultimately determine how the production and flow of raw material and end-use biofuel respectively will appear in reality. In certain situations we will perhaps import forest raw materials for production of fuel which we subsequently export, *inter alia* to other nations' fleets of cars. The price of forest for energy in relation to other areas of use will play a part, as also differences in the cost of fuel production in the different countries.

The Commission proposes the following measures:

- The Government contribute to the initiation of a number of pilot and demoplants that produce "second generation biofuels" such as DME, FTD, methanol and biogas – produced by gasification of the bio-based raw material – forest-based ethanol as well as biogas from bio-based raw materials that are most efficient from the point of view of

acreage, cost and energy efficiency. These biofuels present considerable differences in efficiency between different raw material alternatives, production process and fuel. The Government's contribution should focus on the alternatives that appear to have the best long-term preconditions for high energy-efficiency and financial strength.

Support should also be given to the development of high efficiency bio-refineries that can produce both gaseous and liquid fuels as well as electricity and heat from a mix of the most expedient raw materials from forest and field. Likewise, the Government should engage in the construction of the partly new infrastructure that will be needed for fuel distribution and possibly also for linking up major regional heat networks in order to make use of the entire energy content of the bio-based raw material.

- The Government should promote biofuel by means of economic control instruments such as tax relief and fuel certificates. Sweden should also continue to be proactive in the EU to bring about rules that enable a higher admixture of ethanol and RME (rape methyl ester) in petrol and diesel respectively. The Government's involvement should be based on a uniform definition of an environmental car that also includes energy efficiency (see above).

- The Government should supplement EU grants for cultivation of energy crops with funds from the national Regional Development Programme.

- The effects of investment in bioenergy on land use, the landscape and nature conservation should be analysed in a study based, *inter alia,* on region-based impact assessments. The Commission would like to stress how important it is that energy production in fields and forests takes place as far as possible in harmony with food production and existing forestry, as well as societies' other general objectives, including biodiversity, nature conservation and outdoor life in forest and cultivated countryside (see annex 2, Bioenergy and nature conservation).

4. Make public transport cheaper and more attractive!

The Commission has been influenced by the Swedish Public Transport Association's assessment that travel by public transport could grow by about thirty per cent during the period 2006-2020, chiefly in population centres. If this is the case, it will be a considerable contribution to the transport sector's oil reduction.

With rising oil and petrol prices this development will accelerate. In order to be sustainable in the long term, however, it needs to be supported and encouraged by investments that promote comfort, speed, availability, and hence make travel by public transport an alternative worth its price.

The Commission proposes the following measures:

- The Government should support pilot and development projects with public transport in a number of municipalities, focusing among other things on comfort, speed and biofuels.

- The Government should encourage use of public transport to and from workplaces. A possible method currently being investigated is that employers be able to offer their employees free public transport without social charges and benefits tax.

- A uniform, convenient pay system for all public transport should be introduced.

5. Strengthen the role of the train!

The current share of journeys longer than 100 kilometres by long-distance trains is about 14 per cent. Continued high oil prices may contribute to more people choosing rail travel which, in its turn, will lead to reduced oil consumption. However, to systematically increase travel by long-distance train at the expense of travel by air and private car, vigorous measures are required.

The Commission proposes the following measures:

- The Government should make a strong investment in the railways for new fast train connections between major cities.
- The Government should build away the bottleneck in the centre of Stockholm.
- The Government should guarantee in the long term a low VAT rate on train journeys.

6. Air travel

The Commission judges that high oil prices will in the long term impair profitability. Fast trains should be capable of winning over air passengers, thereby increasing their share of medium-distance travel. Trains have a competitive advantage by being able to offer more space and service. However, time and price are decisive competitive factors for the future of the railways.

Society should promote alternatives to air travel where possible. It may be a question of encouraging the use of IT in the form of tele-, video- and webconferencing at companies and authorities and/or encouraging travel policies that put a premium on rail travel. It is also a matter of improving rail services between population centres at medium distances so that the train may become the chief alternative for private journeys on these routes.

Air travel urgently needs to be included in the EU's trade in carbon dioxide emissions but presupposes tightened goals for the Union's trading system. Together with other countries, Sweden should support research and development of more efficient aircraft engines and new fuels of the hydrogen gas and bio-based aviation kerosene type.

7. Distance work

It is an indisputable fact that IT offers completely new opportunities to reduce environmental stress from passenger transport. But it is not yet used to a sufficiently large extent to produce noticeable effects. Where possible, mobility should be replaced by accessibility. The technology already exists, it is relatively easy to count in the environmental and financial gains and there are also possibilities of utilising innovative control instruments.

The Commission considers that the public sector should lead the way in this area in order to speed up the development and use of alternative methods for passenger transport which will

then impact on the private sector also, both regarding use and development. One condition is accessibility to flexible modes of work. If employers enable more distance work to take place than is the case today, the daily commute to work can be reduced. Another area that may involve major reductions in transport is the use of virtual meetings that offer an alternative to costly, environmentally stressful and time-consuming official journeys.

Objectives for industry:
Reduce consumption of oil by 25-40 per cent by 2020!

The Commission proposes that measures be taken so that by 2020 Swedish industry can improve efficiency and reduce its consumption of oil for heating and processing purposes by 25-40 per cent.

Industry's total oil consumption today is about 20 TWh. Roughly half is used for heating and half for various production processes.

It should be possible to replace at least half of the share of heating oil – thus, 25 per cent of industry's total oil consumption – with biofuels and/or district heating. The heating networks provide an opportunity to locally link up industries with heat needs and excess heat respectively, and also efficient system solutions with, for example, district-heating plants. A control measure working in this direction is the EU carbon dioxide trading system (however, all of industry does not participate in this). The Commission proposes (see pages 15-16) that Sweden should contribute to gradually tightening this system. In certain industrial processes where replacing oil with solid biofuels is problematic, electricity is a possibility. However, imported coal combustion power represents about three times higher emissions of carbon dioxide than if oil had been used and therefore is not an attractive alternative. Furthermore, it tends to be more expensive. But in the long term the share of electricity from renewable sources of energy will increase. Irrespective of how electricity is produced, considerable energy efficiency improvements should be made (see our proposals below).

For other industrial processes, oil needs to be replaced by energy gases. Initially these could be (fossil) natural gas with a gradually increased admixture of renewable gases, for example upgraded biogas and synthesis gas produced from biomass. The Commission previously (see page 14) gave its views on the use of natural gas in the Swedish energy system. It should, however, to some extent be possible to provide industries with a special need of gas as a replacement for coal and oil in processes, with LNG transported by rail, road or sea, that is to say natural gas in liquid form. The advantage of this type of solution is that it does not commit us to a fixed gas infrastructure that is not sustainable in the long term.

We propose the following measures:

- Control measures may need to be strengthened so that oil used for heat and steam in industry is replaced by biofuels or connection to district heating.

- Supplement the "Programme for Improving Energy Efficiency" so that it also comprises oil. Small and medium-sized companies should be given supplementary support through energy offices or energy consultants.

- Develop cooperation between basic industry and the Institutes of Technology. This could be done, *inter alia,* by doctoral candidates in the field of "technology for improving energy efficiency".

- Encourage measures to improve electricity efficiency.
  Non-energy-intensive industry is judged in many cases to have a potential for improving the efficiency of electricity by about 40 per cent. There are several successful examples of management and employees together reducing their company's dependence on energy and oil; one of the projects was called "Stop unnecessary use". Additional incentives are needed for a detailed review of energy consumption and possibilities of improving energy efficiency in companies.

R&D and commercialisation of new knowledge – to make Sweden an oil-free, energy-efficient society

The Commission would like to point out how decisively important continued development of knowledge is for the improvement of efficiency and the phase-out of oil. We want to see new strong investment in applied research and different demonstration projects and also further government involvement, together with industry, to commercialise technology and service systems that can speed up the changeover to more sustainable energy in the future.

There are, of course, many areas and projects that deserve our interest and support. In the following section, pertaining to the sectors we have discussed in this report, we present a selection of examples of what we consider should be given high priority in the short and medium term.

Residential and commercial buildings

Sweden has built up considerable knowledge, often in international cooperation, regarding energy technology and energy systems relating to buildings. It is now a matter of implementing this knowledge and bringing about collaboration between different areas and actors. The previous focus on buildings and technical systems needs to be supplemented by research into user participation and other so-called soft issues.

Building system issues
Continued research is needed into interaction between the regional system and the buildings, and interaction between the different subsystems in a building, and how technology can be better adapted to the users. Knowledge about measurement and feedback can strengthen the behaviour of residents as regards reducing their consumption of energy.

Order, own, administer
Use of energy in a building depends on how the various roles have been played, from placement of the order to the administrative phase. It is about incentives and control systems, contract terms and administrative organisation.

Industry

We see ahead of us several areas where research and development in cooperation between universities/colleges and industry can have a positive impact on the phase-out of oil. Here are some examples:

Improving energy efficiency
The Government should support research into applied industrial energy efficiency. With higher oil prices, the need for research support is more necessary than previously in order to contribute to enhanced competitiveness for Swedish industry. Research must show how Swedish industry can improve its energy efficiency and reduce its dependence on oil and electricity through a system view and by converting both industrial processes and support processes to, *inter alia,* district heating and biofuels.

Systems research
Technical conditions, economic factors and other conditions in the surrounding world affect the energy system. Research into systems analyses can improve methods for realising sustainable overall solution. Other research areas of a systems nature concern, for example, biofuels and waste and special niches such as district cooling and district-heating-powered absorption cooling.

Transport

The Green Car
The Green Car, phase 2, is an R&D programme to reduce total exhaust emissions from motoring. The focus is on engines, alternative fuels and electric and hybrid systems. This programme should be supplemented by substantial investment in applied vehicle research, the production of prototypes and demosystems in order to develop hybrid technology as well as improve the technology for use of alternative fuels in vehicles.

Investment in technical development for "greener" aircraft
One of the major challenges regarding future energy supply concerns air transport. A vision for the year 2020 of future air traffic that has been established by the European organ ACARE means that fuel consumption and emissions of carbon dioxide should decrease by 50 per cent. The Swedish aviation industry holds a strong position in several of the areas that require further technological development to achieve this target. A development programme for a "Green Aircraft" could put Sweden in a strong position internationally and complement other efforts well. The programme should focus on technical development and what are termed demonstrators, chiefly regarding engine components and aircraft structures and systems.

Technology and plants for biofuels
Research and demonstration of biofuels from "well to wheel", focusing on the development of efficient technical and distribution systems as well as economy and infrastructures, needs to receive strong government support and involvement.

The Government should strongly support demo- and full-scale plants for synthesis gas production of methanol, DME, FT diesel from solid biomass and black liquor. Continued support should be given to the development of ethanol from forest raw material. We also propose that the Government invest in the development of a complete infrastructure both for these fuels and for biogas/biomethane in some suitable areas, possibly the Lake Mälare valley, Skåne and on the West Coast.

Biorefinery is the term for a facility that produces electricity, heat and gaseous and liquid fuels, and in some cases chemical raw materials too, as efficiently as possible. The Government should support research into the development and implementation of several biorefineries of this nature, for example connected to local or regional district heating networks.

Plant biology research
Rapid developments in the biosciences will in future contribute to both increased growth and plant material with "designed" properties for different purposes. Among other things, the potential of biomass as an energy raw material may thereby increase.

Today, basic molecular technology research primarily contributes to increasing our understanding of how properties can be regulated, controlled, inherited and find expression in different environments. In the future, new knowledge in this field will gradually increase the efficiency of plant improvement programmes. An example is the promising work in progress at the Umeå Plant Science Centre (UPSC), one of northern Europe's foremost environments for plant biology research.

Fuel production in agriculture and forestry

The contribution of agriculture
R&D is needed in several areas to increase knowledge about agriculture's potential as a producer of energy raw material; here are some examples:

- Cultivation techniques for different crops in different soils, *inter alia* for hemp and other "new" energy crops.
- Continued plant breeding and bio-technical research into energy broad-leaf trees and agricultural crops in order to obtain the desired properties
- Logistics and technology for handling and transport of waste products and different types of plant material
- Economy, control instruments, job opportunities, rural development issues
- Effects of energy crop cultivation on surrounding environments, biodiversity, soil and water, as well as the role of the countryside for recreation and outdoor life

The contribution of forestry
R&D is needed in several areas to increase knowledge about forestry's potential as a producer of energy raw material; here are some examples:

- Increased production of forest raw material by sustainable management methods in conventional forestry
- The preconditions for intensive cultivation of forest that is sustainable in the long term
- Best use of different parts of the forest raw material; development of environmental technology for biofuels , improved logistics and management, transport of takeoff
- Nutritional balance and acidification risk in connection with extraction of logging residue
- Continued genetic refinement of plant material with an opportunity to implement new techniques

Development of the public transport system

The Government should support R&D and local pilot projects for transportation efficiency in town planning and public transport and R&D concerning advanced car-sharing schemes and telematics for private cars (see page 21)

Tomorrow's energy technology

- **Solar cells**

Solar cells are already available but at the same time they are an example of tomorrow's technology for producing clean, renewable electricity. Intensive research work is in progress to, *inter alia,* create cells with improved efficiency and economy. Through the Ångström laboratory in Uppsala, Sweden is a leading nation in solar cell research. We have northern Europe's largest production of solar cell modules, in the form of two companies in Gällivare, and an important plant in Arvika. It is essential to link up research and production in pilot projects, among other things, in order to develop new thin film technology.

- **Wave power**

Research into ways of utilising the energy of ocean waves can be developed into promising technology for renewable electricity production. Practical experiments are ongoing at present at a test facility on the West Coast.

- **Hydrogen gas**

Hydrogen gas is an energy carrier that, above all in fuel cell vehicles, has great potential to reduce dependence on oil in the transport sector in the long term. The major vehicle actors (Toyota, Ford, Daimler, Chrysler, GM/Opel and Honda) nowadays estimate that the fuel cell car may be commercialised some time during the period 2012-2020.

Sweden currently invests SEK 30 million annually in fuel cell research and about SEK 10 million in hydrogen gas research. It is essential that the Government and industry assist in developing demonstration projects around fuel cell buses with the appurtenant infrastructure in Stockholm, Göteborg and Malmö. In this connection, SamVäte i Väst, which is aiming for the introduction of hydrogen gas in Western Götaland, may be an interesting partner,

Annex 1

Factual background

The Commission bases its standpoints on extensive factual background material, on the one hand from sectors where we ourselves are active and, on the other, from the Commission's hearings and through material placed at our disposal from various trade organisations and interest groups. The figures in brackets refer to the respective pages in the proposals section.

Sweden's bioenergy potential (p. 12)

Sweden has excellent climate and soil conditions for producing considerable amounts of bioenergy for heating, transport and certain industrial purposes.

The biofuel market has strongly expanded from 40 TWh in the 1970s to 110 TWh today. In recent years, annual growth was 4-5 TWh. Growth was previously strongest in the distance heating sector but is now considerable in other sectors too. An example that may be mentioned is use of pellets, which in 2005 was 7 TWh with a growth of 19 per cent in total and 33 per cent in sales to private houses.

To try to estimate both the use of biofuels and the potential for bioenergy production that may be available on Swedish agricultural and forestry land in the long term and in the management of waste flows, etc. is a difficult task. Assessments vary depending on the criteria set. And basic Swedish statistics need to be greatly improved.

The Commission had access to basic data from the Swedish Energy Agency, the Swedish Board of Agriculture, the National Board of Forestry, the Federation of Swedish Farmers, the Swedish Bioenergy Association (SVEBIO), the Swedish University of Agricultural Sciences (SLU), the Swedish Forest Industries Federation, etc. The tables below are an attempt to sum up on the one hand the acreages that can be used for biofuel production and the waste product flows and, on the other, an assessment of how great a supply and use respectively may be outlined for the future, compared with the present. Roughly estimated, production in fifty years time could very well be twice as large as today.

Biofuels, supply and use* (TWh)

*including import/export opportunities within the respective sector

	2005	2020	2050
Gross supply			
Firewood, logging residues, stumps	20	40	52
Industrial by-products for sale	16	22	35
Industrial by-products for internal use	19	20	35
Spent liquor, etc.	44	45	45
Waste, pine tar pitch, peat, demolition wood, etc.	8	15	31
Fuels from energy crops (incl. waste products and energy wood)	1	10	32
Miscellaneous, etc.		2	8
	108	154	228
Gross use excl. conversion losses			
Housing	11	16	20
Distance heating	20	26	36
Electricity production	18	22	34
Forestry industry, internal incl. spent liquor, etc.	57	59	65
Transport (gas, liquid, electricity for plug-in-hybrid, etc)	2	26	63
Miscellaneous, etc.	1	5	10
	108	154	228

Source: The Commission's summary

Naturally, the market will have a decisive impact on developments regarding which products will be available and how and to what extent they will be used in the various sectors.

Regarding an assessment of which land could be used for which production, the table below shows a possible development. It is too early to say anything about which of the biofuel products will be produced on the different lands. But it may be seen that the land and opportunities are available.

	2005		2020		2050	
Acreages for biofuel	ha	TWh	ha	TWh	ha	TWh
Agricultural land in total	3 215 600		3 215 600		3 215 600	
comprising agricultural land for energy crops	80 000	0.5	160 000	2	400 000	11
fallow acreage	320 000	0.0	320 000	4	320 000	10
waste products, straw, fertiliser, etc.		0.5		4		11
previous agricultural land	400 000	0	400.00	2	400 000	12
Forest land in total	23 000 000		23 000 000		23 000 000	
Production		94		94		94
comprising increased productivity in existing forest land				23		30
intensive afforestation	0	0	200 000	2	1 150 000	27
other biofuels, waste, peat, etc.		13*		23		33
Total biofuel acreage ha/energy TWh	26 615 600	108	26 615 600	154	26 615 600	228

* including imports assessed to be 7-9 TWh in 2005

Source: The Commission's summary

Agricultural land

Bioenergy production from agricultural land today amounts to over 1 TWh, distributed by about 0.5 TWh from straw, 0.3 TWh from corn ethanol, 0.2 TWh from Salix and 0.1 TWh from corn as solid fuel. In addition, there are limited volumes of fertiliser and ley and pasture for biogas as well as oil plants for RME.

In the longer term, the bioenergy potential of agriculture, including waste products and fallow is assessed at about 32 TWh according to the Federation of Swedish Farmers' energy scenario. It comprises cultivated crops such as corn, sugar-beet, oil plants, Salix, hybrid aspen/hybrid poplar but also by-products such as straw, fertiliser and waste from the food production chain. The potential of waste products greatly depends on the production of traditional vegetables and meat and dairy products. Utilisation of these waste products by means of retting – fertiliser, plant waste, organic waste, etc. – produces additional positive effects in the form of reduced methane seepage and closed nutrient ecocycles.

Sweden's agricultural land, that is to say arable and pasture land, in 2005 amounted in total to 3 215 600 ha. Of this, fallow acreage comprised 321 300 ha, an increase by 20 per cent compared with the previous year.

However, added to this there is the acreage of "previous agricultural land" which, according to Statistics Sweden, amounts to about 400 000 ha. Over half of this is arable land and half pasture land which to varying degrees is becoming overgrown with forest.

Forest land

Sweden's very extensive forest acreage, 23 million ha, today produces about 94 TWh of energy. It may be possible to increase this by about 30 TWh, primarily biofuel, through more efficient forestry and improved silviculture.

For example, 1.1 million ha acreage (5%) could be used for intensive cultivation of spruce. The Swedish University of Agricultural Sciences experimental data for spruce with a rotation period of about 45 years suggests that production could amount to approximately 27 TWh.

Other biofuels – waste and peat

Waste burning at present comprises 5 TWh and is expected to increase up to somewhere in the region of 18 TWh. However, gradually reduced flows of material and increased recycling may change this prognosis. Today, combustible waste is mainly used for heat and to some extent for electricity but, in the long term, may even be gasified into vehicle fuel, etc.

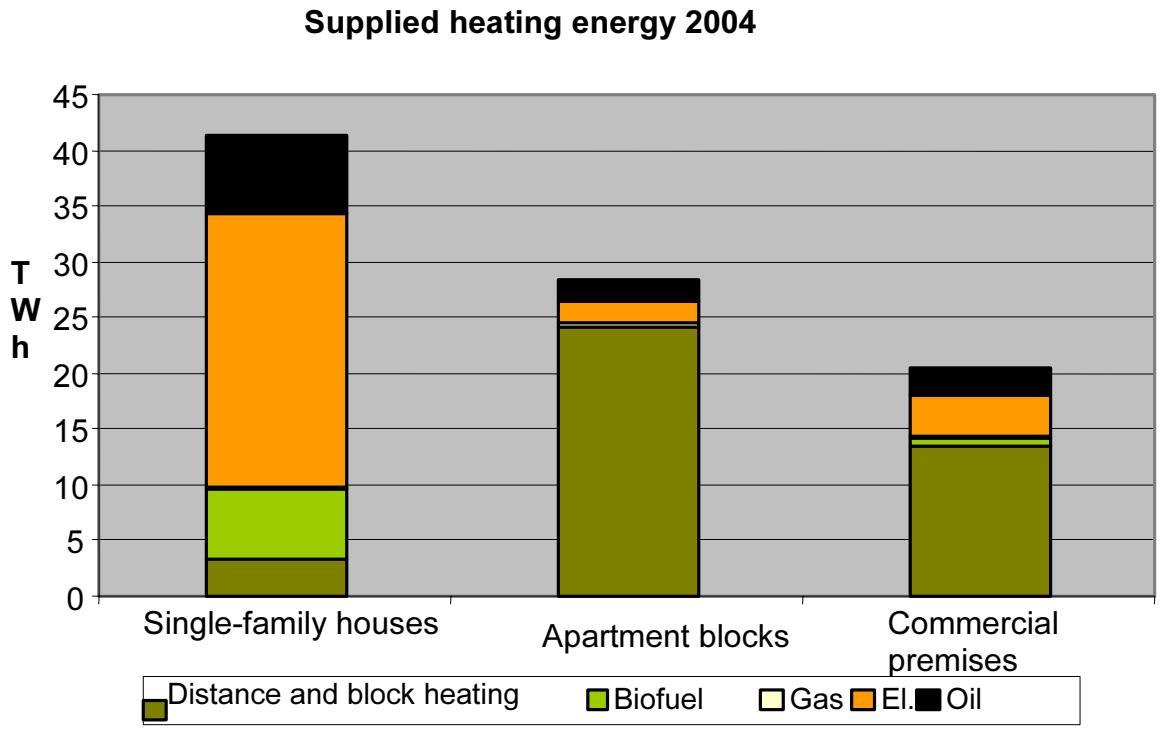
Peat has long been included in Sweden's energy system although the volume has decreased in relative terms. It may be an important complement to wood fuels through joint combustion and by releasing biomass for the production of cellulose-based fuels. Since conventional peat has so far been classified as a fossil fuel, the economic control instruments required to make it interesting for the production of heat and electricity do not exist. In 2004, 2.4 TWh peat was used in Sweden.

Current scientific studies indicate that unused ditched, organogenic peatland leaks carbon dioxide and methane. Harvesting and burning this peat could counteract climate impact and provide a positive contribution to Sweden's energy supply. This applies in particular if, after harvesting, forest can be planted and the growing crop absorbs more carbon. Naturally, when suitable areas for peat harvesting are selected, serious attention must be given to the other environmental values.

Residential and commercial buildings (p. 16-18)

Since the mid-1970s Sweden has succeeded in reducing the amount of heating oil in residential and commercial buildings by about 70 per cent.

In 2004, in total approximately 10 TWh oil was used for heating and warm water in residential and commercial buildings (see figure below)



Source: Energy statistics for single-family houses, apartment blocks, commercial premises 2004, Statistics Sweden, Swedish Energy Agency

Apartment blocks (total consumption of oil 1.8 TWh) often lie in areas where distance heating is the best system alternative. The same applies to commercial premises (total oil consumption 2.4 TWh). Single-family houses (total oil consumption 7 TWh) often lie outside the distance heating networks. This is often property built during the period 1950-1974, with a relatively low standard of insulation in the climate shell, however, equipped with a boiler-room and chimney.

Buildings are almost always unique systems as regards technology and use. All energy efficiency measures and oil conversion must therefore regard every individual building as a system and analyse how that system will function with a larger energy supply system. Oil consumption in this sector is very unevenly distributed across Sweden.

In connection with the oil crises in the 1970s, many and rapid improvements were carried through regarding energy consumption in Swedish single-family homes and apartment blocks. But since the 1980s the rate of improvement has waned. The figures below also show that houses with optimised performance are much better (50-80 per cent) than newly built houses in the present situation.

Consumption of energy in single-family houses 1970-2002

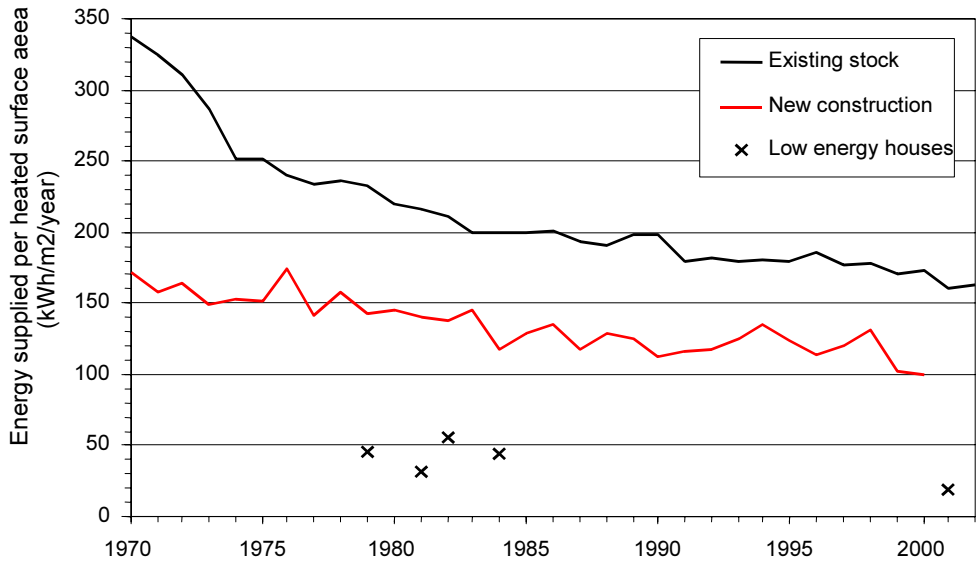


Figure 1 Energy consumption (energy supplied) for heating and warm water per heated surface area in single-family houses between 1970 and 2002. The curve for the existing stock represents all heated surface area during the current year and the curve for new houses shows energy consumption at the time of completion. Examples of values measured from newly built low-energy houses illustrate the gap to the best technology available (BAT). All data are corrected for normal year.
Source: Jonas Nässén and John Holmberg, Department of Physical Resource Theory, Chalmers University of Technology

Consumption of energy in apartment blocks 1970-2002

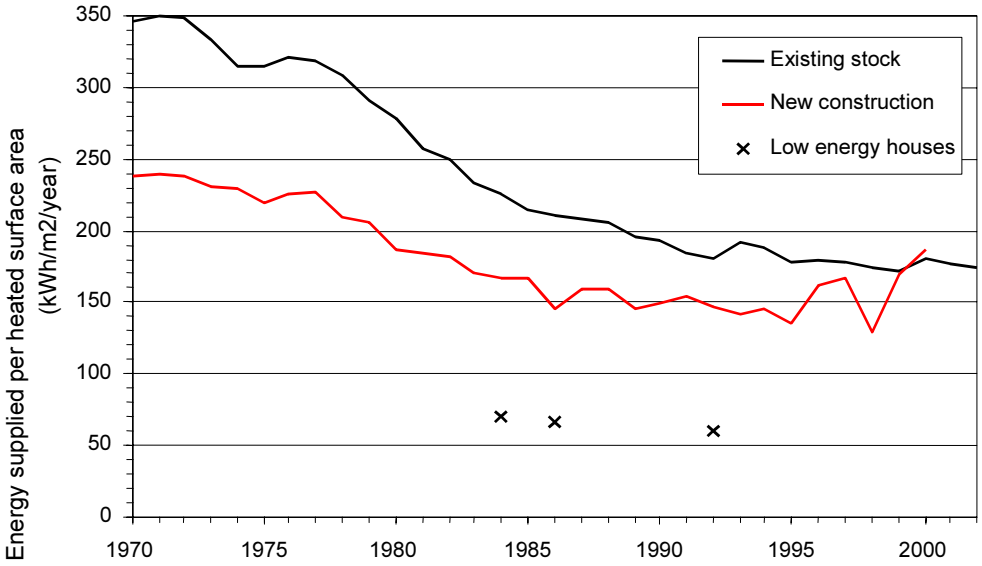


Figure 2. Energy consumption (energy supplied) for heating and hot water per heated surface area in apartment blocks between 1970 and 2002. The curve for the existing stock represents all heated surface area during the present year and the curve for new buildings shows energy consumption at the time of completion. Examples of measured values from newly built low-energy houses illustrate the gap to the best available technology (BAT). All data are corrected for normal year.
Source: Jonas Nässén and John Holmberg, Department for Physical Resource Theory, Chalmers University of Technology

Transport (p 18-24)

The transport sector as a whole is approximately 94 per cent dependent on oil-based fuels. 3 per cent is electricity for most of the trackbound traffic. Aviation is fuelled exclusively by paraffin oil and shipping by bunker oils.

Petrol and diesel make up more than 97 per cent of road traffic fuel, about 8 billion litres of petrol and diesel. 2.7 per cent are biofuels: 250 million litres of ethanol for low admixture and 32 million litres for E85 and bus fuel, a further 19 million normal m3 natural gas (fossil gas), 16 million normal m3 biogas and 11 thousand m3 RME (rape ethyl esters).

The total number of vehicles in Sweden is at present made up of 4.2 million private cars, about 70 000 lorries and 8 000 local buses. Fuel consumption for private cars is at present on average 20 per cent higher than in the 15 EU member states. This is due to the fact that cars in Sweden are older and on average slightly heavier, and there is a low proportion of diesel vehicles (which are 25-30 per cent more energy efficient than the corresponding petrol vehicle).

In the last ten years, transport of passengers increased by 14 per cent and goods transport by 26 per cent.

From base year 1990, the road sector's emissions of carbon dioxide have so far increased by 9 per cent, almost exclusively from heavy lorries. To achieve the Government's intermediate goal, a stabilisation of CO2 emissions at the 1990 level by 2010, these must in continuation

decrease by 1.4 per cent per year. However, the prognosis points more to an *increase* in emissions by an average 2 per cent per year.

More energy-efficient vehicles

The effects of hybrid technology are greatest for refuse lorries and urban buses producing 20-25 per cent fuel saving and for wheel loaders 20-40 per cent fuel saving. There is less potential for long-distance lorries, 5-8 per cent, as their energy efficiency is already relatively high today. In 2020, all new buses and 50 per cent of new lorries are expected to be provided with hybrid technology. This means in total 17 000 heavy hybrid vehicles with a reduction of over 600 million litres of diesel.

Motor-vehicle taxes differentiated by carbon dioxide emissions will be introduced for private cars as from 1 October 2006. Light lorries may be included in the system when information on the carbon dioxide emissions of these vehicles is available in the road traffic register, based on the EU Directive recently issued by the European Commission. There are also plans to draw up a common EU method for measuring and reporting fuel consumption for heavy vehicles, with the aim of introducing control measures differentiated by carbon dioxide emission for these vehicles too.

Biofuels from soil and forest

The first generation of biofuels is produced in relatively simple processes and comprises ethanol, biogas and rape methyl esters:

- 0.3 TWh ethanol is produced annually from corn by the Agroetanol company in Norrköping, owned by Lantmännen and the Federation of Swedish Farmers. By 2008 capacity will have quadrupled compared with today's level.

- 0.1 TWh RME, rape methyl ester, is produced annually in Sweden. Two new factories will start production in 2006 in Karlshamn and Stenungsund. The preconditions for producing RME in Sweden are limited because of the climate and due to opportunities to sell the rape fodder meal.

- 0.2 TWh biogas as vehicle fuel is produced annually from sludge, food waste and household waste. It is estimated that by 2020 production will be 3-5 TWh. Many different by-products and crops are suitable for biogas production. The rotted residue can be returned to the field. In some quarters, regional biogas networks are planned that will connect producers of organic residual products (farms, sewage plants, food industries) with retting facilities and filling stations.

In the years ahead, it will also be possible to produce biogas as a second generation fuel by gasification of biomass (wood), see below.

The second generation of biofuels is usually produced by more advanced technology. A process of this type, which *inter alia* is under development at facilities in Örnsköldsvik, is hydrolysis of wood cellulose for sugar, followed by fermentation of the sugar into ethanol. Another process involves gasification of biomass (wood) and black liquor into gas mixtures which, in their turn, can be synthesised into DME (dimethyl ester) methanol, methane and FTD (Fischer-Tropsch diesel).

To optimally economise with the acreages of forest and arable land that could be used for energy purposes, which are after all limited, a considerable share of tomorrow's biofuels should be made up of synthesis-gas-based products. Research facilities for gasification processes are available in Piteå and Värnamo. Demo plants are planned and subsequently several commercial full-scale plants will probably be built.

Gasification technology has the potential to produce excellent total efficiency.

Gasification	**Ethanol combinations**
70% biogas	21% ethanol
20% distance heating	16% electricity
10% loss	35% distance heating
	28% loss

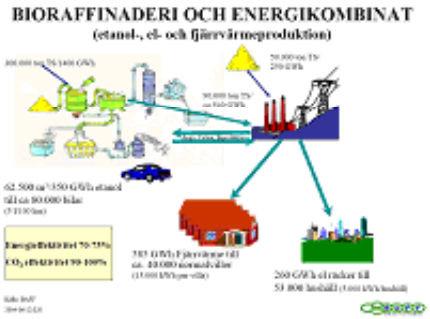
OBS! THAT THE DIAGRAM STILL ARE IN SWEDISH TEXT AND THAT YOU FIND THE ENGLISH TRANSLATION UNDERNEATH THE DIAGRAM (WILL BE UPDATED).

Förgasning

70% biogas
20% fjärrvärme
10% förluster

Etanolkombinat

21% etanol
16% el
35% fjärrvärme
28% förluster



Source: BAFF, Göteborg energy

Diagram text:
BIOREFINERY AND ENERGY COMBINATIONS
(ethanol, electricity and district heating production)
300 000 ton TS/1400 GWh
90 000 ton TS/approx. 540 GWh
50 000 ton TS/250 GWh
Steam, Water, By-products
62 500m ^{3}/350 GWh ethanol
for approx. 80 000 cars
(51/100km, 18 kWh/100km)
Energy efficiency 70-75% 585 GWh distance heating for 260 GWh electricity

CO_2 efficiency 90-100% for households kWh/household)	about 40 000 normal private houses (15 000 kWh per house)	sufficient 53 000 (5 000

For production of fuels, agricultural crops require more input energy than forest-based raw materials. According to what is termed the well-to-wheel analysis – which specifies the number of possible transport miles per hectare cultivated energy crop – DME from broad-leaf plantations is most efficient. Ethanol/biogas from sugar-beet also has relatively good values while ethanol/biogas from corn and biogas from field crops produce half as much transport service. Rape for production of RME for admixture to diesel fuel has lower efficiency. What makes it economically viable to produce corn ethanol and RME from oil plants is not just the energy part, which like other biofuels receives tax relief, but also the by-products that are generated at the same time for, among other things, fodder. This explains why substantial investments are made in this area.

However, the technical systems will in all probability gradually improve, and also different combinations of crops and technology may increase efficiency.

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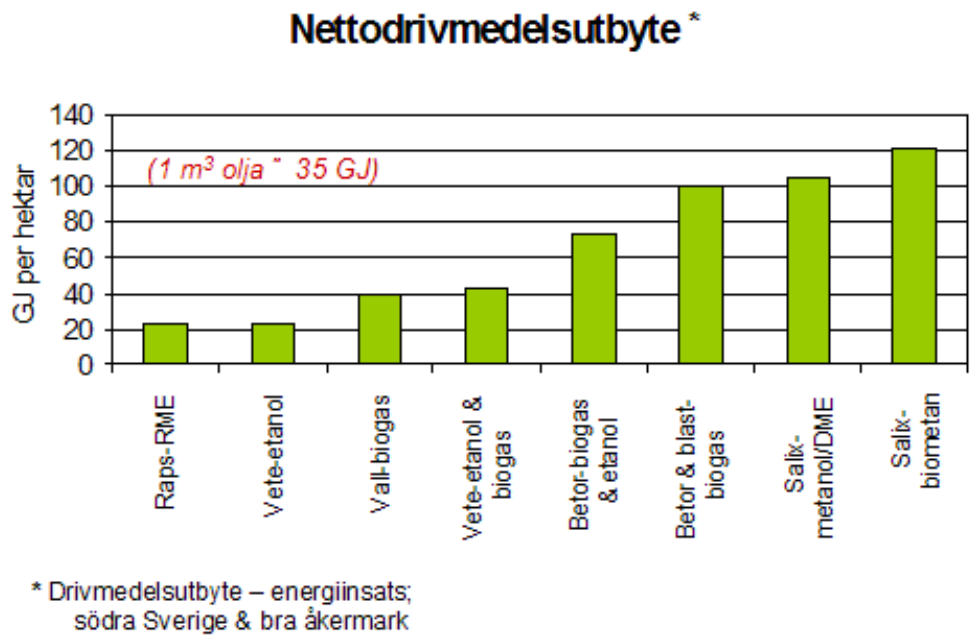


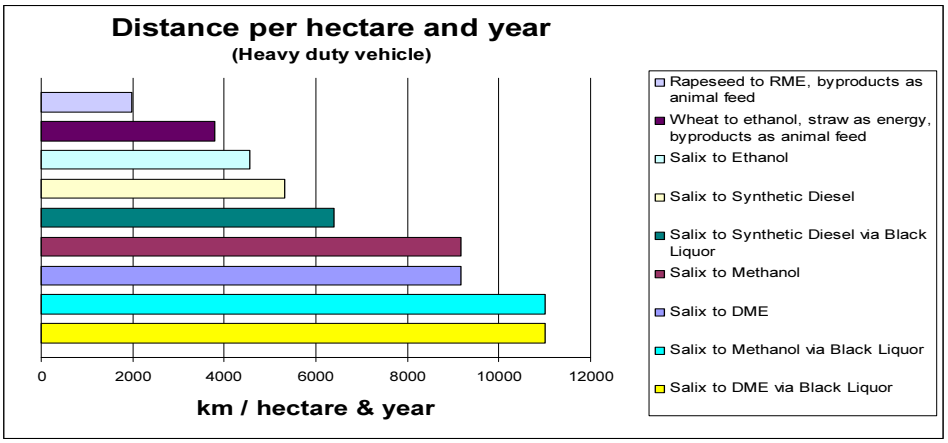
Diagram text:
GJ per hectare
Rapeseed RME
Wheat-ethanol
Straw-biogas
Wheat-ethanol & biogas
Beet-biogas & ethanol

Net fuel exchange*

Beet & tops biogas
Salix-Methanol/DME
Salix-biomethane
* Fuel output – energy input;
south Sweden & good agricultural soil

The diagram shows how much net energy (J or KWh) that can be extracted per hectare through different production systems (after deduction of the energy used for cultivation and processing).
Source: Pål Börjesson, LTH 2006-07-01

Distance per hectare for a heavy vehicle with diesel engine efficiency



The diagram shows how many kilometres a heavy vehicle can run per hectare and year on fuels produced by different production systems (after deduction of the energy used for processing).
Source: AB Volvo

Full-scale fuel cell vehicles and admixture

Biofuels can be used on the one hand for admixture with fossil fuels (RME and FTD in diesel, ethanol in petrol) or as full-scale fuel (ethanol in E85 vehicles, RME, DME and FTD in diesel vehicles). Biogas can be used in engines for fossil gas/biogas.

DME and FTD can only be used in diesel engines. DME gives extremely low emissions of particles and nitric oxides and is also better than FTD regarding utilisation of raw material. Since it is gaseous it is best suited for vehicles that can be tanked up at depots, that is to say delivery cars, buses and refuse lorries. Vehicles of this type will be manufactured both in Sweden and other countries in the coming decade. With the normal rate of exchange of vehicles and assuming good accessibility and competitive fuel prices, the Swedish Public Transport Association estimates that all local buses in the country could be fuelled by DME in 2020.

FTD is less efficient and slightly more expensive to produce than DME, but, on the other hand, is a liquid diesel fuel that can be made available at ordinary filling stations.

Public transport

Travel by public transport will probably increase in pace with the anticipated increase in petrol prices. This applies in particular if the benefits tax on free public transport is removed, and if public transport succeeds in offering greater comfort, timetables with more frequent service and simpler ways of paying.

The Swedish Public Transport Association believes there will be a 30 per cent increase by 2020, primarily in metropolitan areas, equally distributed among bus and rail traffic. In this connection, consumption of oil-based fuels may decrease by almost half a billion litres, provided that 70 per cent of the additional passengers are motorists and that all buses in county and local traffic are fuelled by biogas or biodiesel (DME, FTD) by 2020.

Several interesting local pilot projects are ongoing around the country, relating to transport efficient town planning and more efficient public transport, for example the KomFort project in Jönköping and the travel experience project in Mölndal.

Electrically powered train journeys contribute to reduced dependence on oil when they replace road and air transport. At present trains account for 14 per cent of passenger journeys over 100 kilometres.

Air transport

Aviation is an important part of the transport sector:

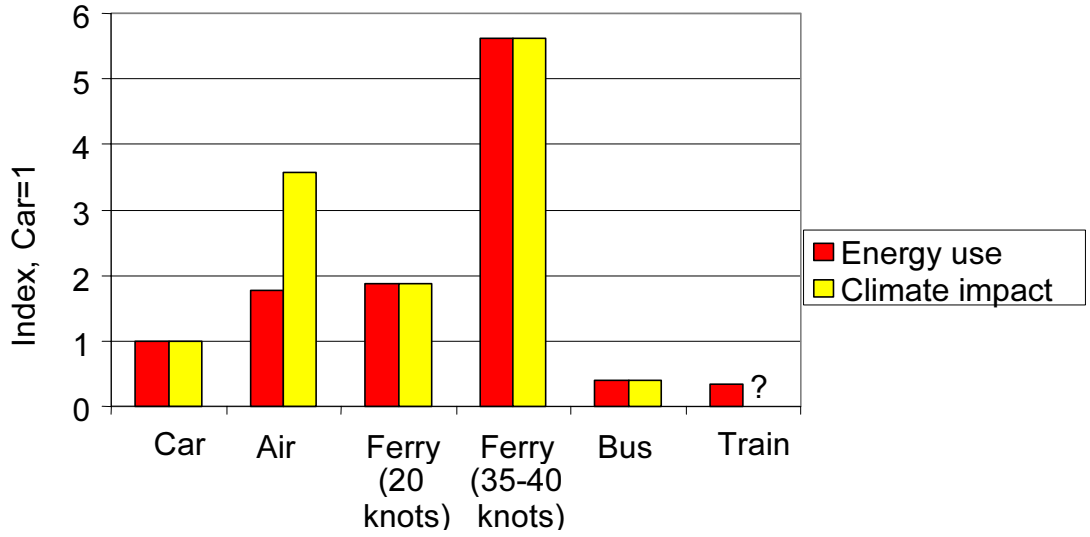
- The average Swede flies about 300 miles per year which is equivalent to a return journey Stockholm-London. This is six times more than the global average. Over 10 per cent are domestic journeys
- The Swedes' air travel consumes about 15 TWh fuel (2006)
- Air travel increased between 1990 and 2001 by more than 5 per cent a year (measured as passenger-km)

Aircraft mainly use aviation kerosene, in private aviation what is termed aviation petrol. Even with considerably more fuel-efficient aircraft, in a few decades air travel may be responsible for greater climate impact than motoring.

It may be possible in the long term for liquid hydrogen and bio-based aviation kerosene to replace oil-based fuels. However, these fuels do not solve the problem of emissions of nitric oxides and steam which are responsible for half of aviation's climate impact. Access to primary energy may also be problematic; to produce the volume of hydrogen (or biokerosene) for Swedish air transport assessed for 2050 would require the equivalent of the whole of today's Swedish nuclear power.

Aviation is at present free from carbon dioxide tax, energy tax and VAT (except 6 per cent on domestic flights). This means that a litre of aviation fuel costs about SEK 4 compared with a litre of petrol which costs SEK 11-12 (in the case of USD 60/barrel for raw oil). If climate impact from Swedes' air travel were valued according to the current Swedish carbon dioxide tax of SEK 0.92 per kg, the sum would be about SEK 7 billion a year, which is equivalent to an extra cost of SEK 600 for a return flight Stockholm-London.

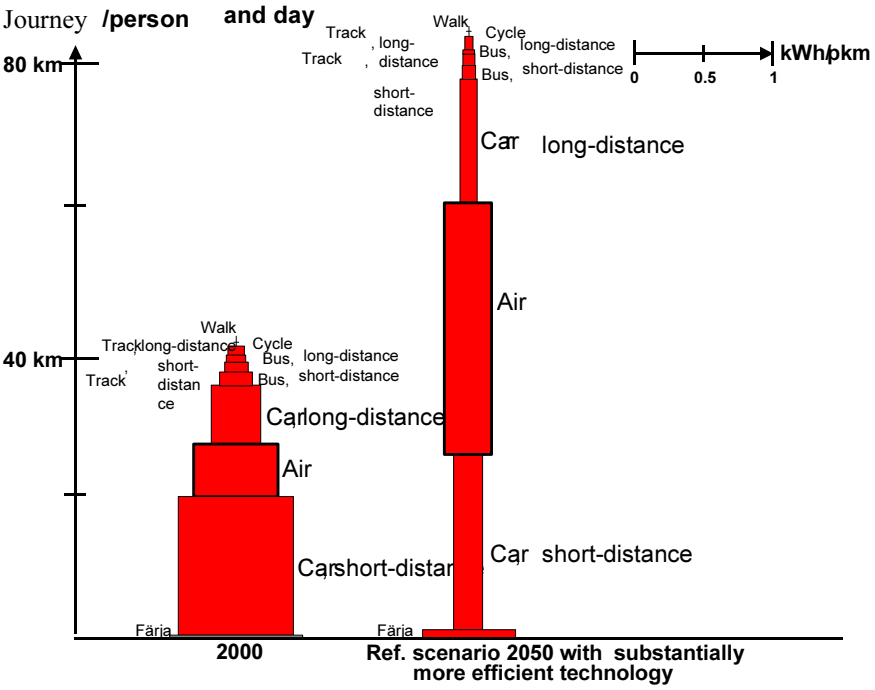
Energy consumption and climate impact respectively for different forms of transport



The diagram shows energy consumption per passenger kilometre for different forms of transport. The question-mark on the column for trains indicates that the climate impact of rail travel depends on whether trains are powered by electricity or diesel.
Sources: Åkerman, Jonas & Höjer, Mattias, How much transport can the climate stand? – Sweden on a sustainable path in 2050, Energy Policy (in press). Sousen, Robert et al., Aviation radiative forcing in 2000:An update on IPCC (1999), Meteorologische Zeitschrift, Vol. 14, No. 4, 555-561, August 2005.

Length of journey and energy consumption, air transport compared with other types of transport

(height of column equal to length of journey, width of column equal to energy/person-km)



The diagram shows travel per person and day in 2000, followed by a scenario for the situation in 2050, with today's development but with substantially improved energy efficiency.

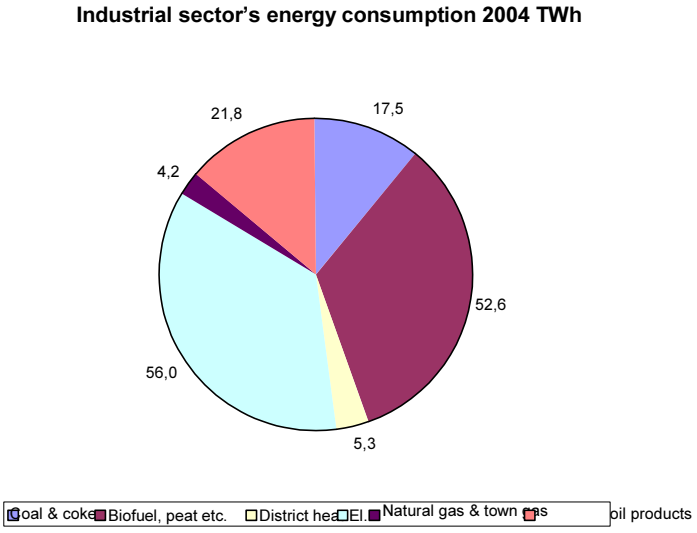
Source: Åkerman, Jonas & Höjer, Mattias, How much transport can the climate stand? – Sweden on a sustainable path in 2050, Energy Policy 34 (2006) 1944-1957.

Sea transport

8 per cent of the volume of goods in Sweden is conveyed by ship, despite the fact that sea transport of goods is more energy efficient than any other alternative. The challenge, however, is to make ships' bunker oils cleaner and more environment-friendly. In May 2006, new tightened international requirements entered into force regarding sulphur and nitric oxides. In total, 22 TWh bunker oil was used in 2004, most of which, over 20 TWh consisted of heavy fuel oils. Diesel fuel oil and light fuel oils amounted to just under 2 TWh.

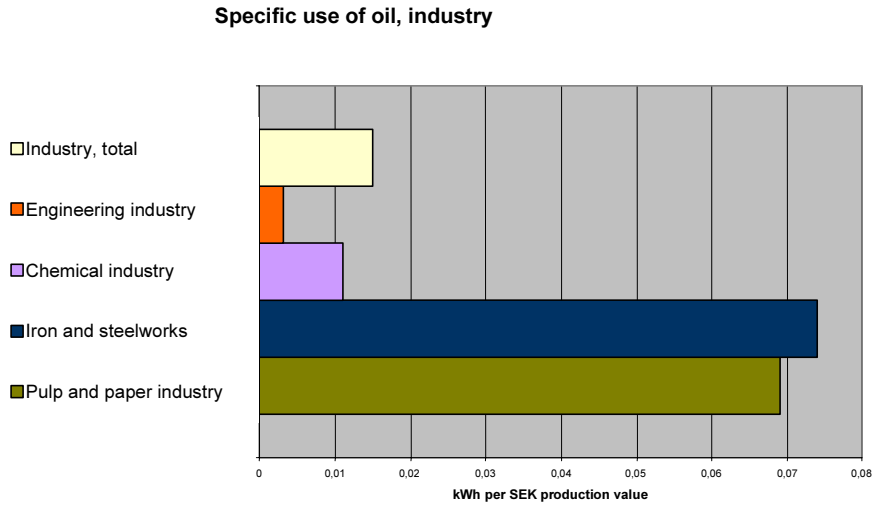
Industry (p. 24)

In 2004, Swedish industry used a total of 157.4 TWh, 21.8 TWh (14%) of this was oil in end energy usage. Energy will remain one of the most important production factors in the iron, steel, paper and pulp industries; access to energy is a key precondition for other industries too.



End use of energy in the industrial sector 2004, in total 157.4 TWh
Source: Swedish Energy Agency

Oil has different importance for different industries. If you measure oil use per production value, the sensitivity to oil energy costs of basic industry becomes evident.



Industry's specific use of oil, kWh per SEK production value at 1991 prices
Source: Swedish Energy Agency

Pulp and paper industry
A dramatic change in use of oil in the pulp and paper industry took place from the 1970s and twenty years on. Today, just under 25 per cent oil is used in the process compared with thirty years ago. What are termed mesa furnaces for lime-burning require high energy intensity. At present oil cannot be replaced by solid biofuel, some form of energy gas, natural gas and in the long term biogas is required; experiments are also being made with bark powder.

Petrochemical industry
In the petrochemical industry fossil oil is used as a raw material, for example for pharmaceuticals, waterborne paints and mobile telephone cases. It will continue to be the most important raw material, however chemical products based on vegetable and animal oils are already available. In the future, ethanol may also become an important raw material for plastics and other chemico-technical products. For this industry, access to natural gas is essential, both as raw material and energy supply.

The refining industry
For a long time ahead, diesel and petrol will remain essential products in the transport area. International consultant studies show that the Scandinavian refineries are among the most energy efficient in the world. There are further possibilities here of improving efficiency with natural gas as raw material for hydrogen gas.

Steel industry
This industry is well ahead in the use of the best process technology. New processes can give major savings as far as use of raw materials and energy is concerned. Developments are at present at the trial or demonstration stage and it will therefore take a decade before they are of importance. The majority of energy-saving efforts are made in connection with new investment or radical reconstruction.

From the energy viewpoint, ore-based (integrated) works predominate. This is because coke for reducing agents and alloyers is included in the energy balance.

It is characteristic of the steel industry that most of the energy-intensive processes occur at high temperature. The energy is mainly used in processes where the operating temperature exceeds 1 000 ˚C. The steelworks therefore need access to high-quality energy carriers such as coal and oil products, gas (liquefied petroleum gas or natural gas) and electric power. Low-grade biofuels cannot be used for energy reasons and also because burning of oil or gas takes place in the same “space” as material that is to be heated.

Other manufacturing industries
Some oil is used in other industries too. Here, distance heating and biofuels can play a major role. Through improved efficiency and saving, a company can normally reduce its use of energy by 30-60 per cent.

Annex 2

Bioenergy and nature conservation

The Commission wishes to underscore how important it is that energy production on arable land and in forests take place in as much harmony as possible with society's other general goals for, *inter alia,* biological diversity, nature conservation and outdoor life in forest and countryside.

We have therefore requested Urban Emanuelsson, PhD, Director of the "Centre for Biological Diversity" at Sweden's University of Agricultural Sciences and Uppsala University, to describe a strategy for this purpose.

Text: Urban Emanuelsson

Sweden is a relatively sparsely populated country with vast forest acreages and many farms which, in spite of EU grants and environmental compensation, find themselves on the brink of unprofitability. At the same time, there is considerable awareness here of the negative environmental impact of continued use of fossil fuels. It is therefore completely logical to invest in a substantial increase in Swedish biofuel production.

To begin with, it should also be mentioned that, since the early 1990s, Sweden has been strongly committed on the international arena to preserving biological diversity both in this country and at the international level. This work has received positive international attention. Without making too detailed a presentation of what biological diversity is, in this context it may be said that it concerns variation both at the gene, species, biotope/landscape level and regarding ecological processes. Today, for example, it is apparent that there is considerable awareness of the importance of the species for upholding several vital functions of human society.

A few decades ago, production of biofuels already came to be considered a potential danger to nature conservation, a threat to biological diversity. An increase in this type of production may indeed be a major nature conservation problem if this production is laid in the traditional way "on top of" the existing production of food, timber and pulpwood. But this is exactly what must not happen; the fight against two major environmental problems, that is to say the threat to biological diversity and the threat from greenhouse gas impact should not need to compete for resources and priority. There is a great danger that totally different researchers, politicians and administrators will be engaged in one or the other issue. We therefore need to launch a strategy based on the following four main lines:

1. Firstly, use of land can be roughly planned so that areas that are particularly suitable for biofuel production are given major opportunities to pursue **efficient production** of this type. In an equivalent way, the landscape can be roughly planned so that areas with **valuable biodiversity are not utilised for biofuel production** if it damages biodiversity. A number of control instruments should be produced to enable a strategy of this kind.

2. Secondly, there must be a continued adaptation of food and wood production so that a further step can be taken towards these "normal" industries **becoming better in relation to the preservation and sustainable utilisation of biological diversity.** This continued adaptation may mean a certain decrease in production but, at the same time, this decrease may be easier to bear if there is the possibility of higher biofuel production on other acreages. This part of the strategy is presumably a fairly "cheap" way for the forest and agricultural industries to leave more space in the landscape for biofuel production.

3. A third sub-strategy would mean starting from **existing biofuel cultivation systems and subsequently develop these in a target-oriented way** so that they become of considerable value for biological diversity. It may, for example, be a question of modifying cultivation systems for quick-growing broad-leaf trees.

4. The fourth and last sub-strategy primarily concerns **creating new cultivation systems or modifying systems** so that they produce both fuel and a more desirable biodiversity compared with that which existed before modification took place. This may, for example, be of importance regarding areas of wetlands type.

These four sub-strategies demand extensive development work but also research. In this context, the major challenge is to ensure that this work does not just fall within an existing part of the world of authorities or research. The researchers and authorities that have been engaged up to now in biofuel production have had an aim and direction very similar to that of traditional production researchers in agriculture and forestry. Thus, biodiversity has usually been discussed only superficially by these people. The equivalent applies to traditional nature conservation research. Biofuel systems have only been studied by a few individual nature conservation researchers. What is needed is therefore not just the development of intensive cooperation; **development and research work is also needed that is expressly engaged in "discovering" systems that produce both substantial biodiversity and energy.** This is a challenge researchers and authorities have not previously faced.

Designing **concrete land use systems and management systems** is a challenge to researchers. Designing **systems of control instruments** is largely a challenge to authorities, but in cooperation with user organisations and researchers. This is very complicated work. One difficulty lies in our sectorised legislation in which systems of control instruments, for example regarding forest land and arable land respectively, vary greatly. Moreover, control instruments often focus on a specific purpose, something which is already a major disadvantage today, for example when it comes to coordinating leakage control, stimulating biodiversity, cultural environment and recreation. If, in addition, control instruments are to be produced in the future that aim for increased biofuel production without a reduction of biodiversity, a great deal of creativity is required regarding coordination of the various systems of control instruments. Today's environmental work in Sweden is governed overall by 16 environmental objectives. The system has proved successful and gives environmental work a clear focus. To question these 16 environmental objectives may therefore not be a particularly constructive strategy. On the other hand, conflict situations arise between different environmental objectives, above all between those comprised of climate impact or biodiversity. Thus, it is of great importance for continued credible environmental work that considerable efforts be made to develop the control instrument side and the actual land use side.

In concrete terms, it is above all in the forest and agricultural landscape that a coordination of biofuel and biodversity efforts needs to be achieved. Today, there is a discussion in forestry about intensive forest cultivation on certain areas of the landscape. This discussion concurs with the biofuel discussion. So far, both non-profit nature conservation associations and the Swedish Environmental Protection Agency have in principle opposed a development of this type. The reason being that areas of intensive cultivation would mean a deviation from the principle of giving reasonable consideration to nature conservation everywhere in the forest. So why applaud the fact that some forest areas risk becoming even more depleted of biological diversity than they are today. If, on the other hand, a system had been available to **"exchange" increased production on certain areas for higher levels regarding biological diversity on other areas**, the system could presumably be tried out with an ambition for maintained and even increased biological diversity in the total landscape at the same time as total production could be increased. A concrete problem that strongly counteracts the realisation of such a system is that it is often not the same owner who manages the presumptive areas for intensive cultivation and the areas that are interesting for biodiversity. There is reason to investigate more closely through concrete scenario work the possibility of exchanging increased production in really trivial forests for increased protection and consideration in other forests.

Another complex problem that should be studied concerns south and central Swedish forests stemming from a pasture and agricultural landscape. Forests of this nature often contain actual or potential nature conservation values. The simplest nature protection solution here has mainly been **"free development".** This solution is questioned today in many contexts by both nature conservation researchers and culture-historical researchers. Lost biological diversity and diminished culture-historical value may in many cases, but absolutely not in all cases, be the consequence of "free development". A certain timber takeoff may presumably in some cases result in forests being better able to maintain their biodiversity, culture-historical value and recreational value. Some research into this is already ongoing today, however, the nature conservation side and the production side should be better coordinated. It should also be mentioned in this context that very trivial forests that have long been exposed to "tough" forestry **may be restored** to some extent with directed efforts. Research of this nature is in progress and could be combined with studies of the changeover to energy-focused forestry.

In the agricultural landscape the issues are rather different compared with forest land. In some cases, it is so much clearer here that energy production with the right aim can produce several other positive environmental effects. For example, different experiments have been ongoing for about twenty years, albeit on a small scale, to **combine nutrient salt reduction with energy production and an increase in the landscape's biodiversity.** It is a question of wetlands, existing or newly established, where hay-cutting regimes can produce shore meadow environments which are valuable for several threatened wetlands organisms, not least wading birds and ducks. The art is to find the right sort of grass or sedge vegetation that can be used for both a reduction of nutritive substances and for biofuel production and also be positive for biological diversity. In these contexts it is perfectly clear that the system of control instruments has not yet managed to encourage the right combinations of energy, reduction and biodiversity functions.

Also in farms with a more conventional focus carrying on beef production based on natural pastures, **pasture production** could have a concertina effect. In years with weak pasture and grazing production, the "energy pasture" could be included in meat production while, in productive years, this pasture could be used for biofuel production.

Various alternatives and combinations of agricultural crops and wetlands crops involve problems when it comes to **harvest, storage and extraction of energy.** Tree crops have therefore a short-term advantage. However, in their utilisation, products from agricultural land and wetlands have an inherent flexibility that may be of great value for nature and culture conservation. Harvest, storage and conversion methods are therefore of major interest outside the narrow biofuel sector.

A concrete problem that concerns management of arable land for biofuel production is where fast-growing trees such as **Salix and Populus should be placed in an agricultural landscape.** More in-depth studies are needed into both environmental optimisation and possibilities of finding adequate control instruments for their location in the landscape.

Cultural values and recreational values are very important landscape values, often combined in some way with nature conservation values. It is essential that these values are also clearly included in any investigation work and scientific studies that need to be carried out in order that biofuel production and biological diversity can be combined in the landscape.

The international connection should also be mentioned in this context. A special effort in Sweden, on the one hand regarding biofuel production and, on the other, concerning the interplay between other environmental aspects may lead to considerable future exports of services. There is probably every reason to initiate as soon as possible international research cooperation with countries with warmer climates.

Plan but protect private initiative!
This is probably a main issue as regards responsible management of biofuel production in this country in relation to biodiversity values but also to cultural and recreational values. Thus, systems for physical planning are needed and relatively strong control instruments linked to these. But, at the same time, private initiative must be protected and encouraged. This is not an easy equation to solve. Ecological forest landscape planning may be seen as one of several sources of inspiration, as also several successful municipalities where town-country planning has worked well. Kristianstad with its Vattenrike may be mentioned and Örebro with its extensive restoration project. A number of rural development projects may also be seen as sources of inspiration, for example Bråbygden in the county of Kalmar.

Separate statement of opinion to the Commission on Oil Independence

Christian Azar, Chalmers University of Technology

I share the Commission's conclusions and objectives in most areas. However, I would like to express some dissentient views. I refer on the one hand to the issue of international trade in ethanol and, on the other, to views on corn-based ethanol and RME.

Tariff-free imports of ethanol from tropical countries

A considerable share of the biofuels used in Sweden today is supplied through imports. In the light of this, it is important to review the trade situation. However, the Commission has chosen not to side with tariff-free imports of ethanol from countries outside the EU.
I am of the view that the Commission should have clearly supported free trade for ethanol and biofuels in general. This issue is important for several reasons:

1. It is important in principle. Sweden has traditionally advocated free trade. We participate in the WTO negotiations where we demand that the developing countries open their markets. There is broad agreement that our prosperity is partly based on free trade, and this should be so in this case too, particularly since it is the developing countries that have a great deal to gain from the issue. We cannot expect Brazil to buy our lorries without tariffs and at the same time insist on tariffs on fuel which they can produce at lower cost.

2. Production costs for Brazilian ethanol based on sugar-cane are considerably lower than for corn ethanol (which probably applies to production in other tropical countries too).

3. Sugar-cane ethanol in tropical countries has a much better area efficiency than corn ethanol or RME in Sweden/EU. It may be a question of three to six times higher net yield from biofuels per hectare.

4. Sugar-cane ethanol in tropical countries has considerably better energy efficiency than corn ethanol or RME. This means that the indirect CO_2 emissions linked to production will be lower if we choose to open up for free trade. When opportunities for Swedish imports of ethanol from countries outside the EU became considerably limited, it led to extensive imports of ethanol from Europe instead, whose CO_2 emissions are half as great or even equally as great as if petrol had been used. (The exact figures vary a great deal depending on system limits, which energy system there is in the background and how by-products are counted. It should be noted in this context that the ethanol factory in Norrköping has considerably lower CO_2 emissions than wine ethanol and corn ethanol in the US since the energy for production of ethanol in Norrköping comes from bioenergy.)

Thus, it is not just a question of fundamental principles of trade policy but also the fact that regarding ethanol free trade can make it easier, cheaper and more environmentally friendly to achieve the Commission's ambition for reduced CO_2 emissions and oil independence than if we develop support systems that lead to investments in corn-based ethanol and RME.

From this perspective, there is also reason to feel some hesitance about the Commission's objective for *domestic production* of biofuels of 12-14 TWh/year. Given that the first generation of domestic fuels can scarcely reach this goal (half of Sweden's acreage of arable

land would be required), of which the Commission is aware, and that it is still unclear how efficient (regarding both costs and technology) the second generation of fuel will be, there is no reason to bind ourselves to this objective. It would have been better to have an objective of 12-14 TW/year use of biofuels in Sweden. If it subsequently proves more efficient for Sweden to import ethanol from the tropics and export pellets to the continent for heating and power production, there is no reason to counteract this.

Lastly, it should be noted that sugar-cane ethanol will also require large acreages, if not just Sweden but most of the world were to aim for biofuels. For example, if the entire European fleet of private cars were to be run on ethanol today, it would require roughly ten times more land than the whole of Brazil's sugar-cane production uses today (half of which is used for ethanol production). Thus, in the long term there may be considerable problems with environmental protection and nature conservation. The problem does not just concern sugar-cane ethanol but also the fact that demand for bioenergy at the global level may be expected to be many times greater than potential supply in the next fifty to a hundred years.

Measures may already need to be introduced to protect nature and poor farmers in the third world, although a tariff at the present time is not the right instrument. It is the overall demand for land for food, timber and bioenergy that is the decisive driving force and a tariff on ethanol imports is not a good solution to this much larger complex of problems, especially bearing in mind that sugar-cane ethanol is energy-efficient use of land. A detailed analysis is required of the control instruments that could be used but it might be a question of certification systems, national frameworks of rules for protection of sensitive ecosystems and for protection of poor farmers in the South, and in a much longer perspective possibly energy tax on bioenergy.

Views on corn ethanol and RME

The other matter on which the Commission and I have somewhat different opinions concerns biofuels from traditional agricultural crops in Sweden (above all corn ethanol and RME based on rape-oil). I am of the view that the Commission should have made it explicitly clear that corn ethanol – or RME plants – are not an attractive strategy from the climate and oil replacement point of view. These fuels have neither sufficiently good energy and area efficiency nor sufficiently low production costs to be able to compete with other biofuels in the long term.

I have no objection to building a few plants in the initial phase – these plants could be regarded as part of a strategy to start a market, etc. – but a continued expansion of such plants as we are now seeing is not a sustainable path forward. Furthermore, the build-up of an industry of this type would strengthen the forces lobbying for continued high subsidies and tariffs on ethanol from tropical countries.

There is also the risk of a backlash affecting all biofuels, particularly if we continue to import and *subsidise* biofuels from the *EU* with CO_2 emissions that are half as high or even almost equally as high as emissions from petrol.

Biofuel policy is complicated and there are risks of impasses. These must be explicitly discussed. The Commission would like to see higher admixture of RME. A possible alternative strategy would be to reduce the admixture of RME and increase imports of ethanol from the tropics to the corresponding extent. This would lead to the same reduction in the use of oil, reduced CO_2 emissions and resources left to develop the second generation of fuels.

Sweden's strategy for production of domestic biofuels should mainly focus on these second generation fuels, that is to say ethanol from cellulose or biofuels produced through gasification, for example DME or methanol, and it is then a question of support to demonstration and protoype facilities and measures to enable market introduction. Thus, in these respects I share the Commission's assessment.