Finland's National Report under the United Nation's Framework Convention on Climate Change

CONTENTS

FOREWORD

The United Nations Framework Convention on Climate Change (FCCC) took effect globally on March 21, 1994. Finland ratified the Convention on May 31, 1994. According to the commitments made in the Convention, each industrialized country has to submit a first National Report to the secretariat containing inventories of greenhouse gas emissions and sinks and an account of action taken to implement the Convention.

The Report should also provide detailed information on action taken to implement Articles 4.2a and b of the Convention, and assess their impact on emissions and sinks.

This Report outlines Finnish action and strategies to fulfil the commitments of the FCCC. It strives to follow as far as possible the guidelines drafted by the meetings of the FCCC Intergovernmental Negotiating Committee concerning reporting and calculation methods. Background material related to the Report and other additional information can be obtained from the ministries concerned; the Ministry of Agriculture and Forestry, the Ministry of the Environment, the Ministry of Finance, the Ministry for Foreign Affairs, the Ministry of Trade and Industry and the Ministry of Transport and Communications.

The Report is based on various ministries' programmes and decisions in the '90s that are of significance for climate policy. Some of the programmes were approved specifically to implement climate policies, but equally some have other national justifications. The Report surveys all the action taken by Finland towards meeting the objectives of the Framework Convention, that is, the reduction of emissions and the protection of carbon reservoirs and sinks.

Emissions of greenhouse gases from energy production and consumption are the best inventoried in Finland. The Report also deals with changes in the greenhouse gas balances of the biosphere caused by other human activities, though we as yet lack comprehensive data on this area. Present estimates of these changes demonstrate just how important a role the protection and reinforcement of carbon reservoirs and sinks may play in combating climate change.

The climate strategy described in this Report is Finland's first step towards fulfilment of the Convention. Implementing climate policy is a continuous process, however, and constant work over the next few years is vital.

Helsinki, January 1995
Minister of the Environment

SUMMARY

1. Finland and the greenhouse effect

Finland is an industrialized country with a great deal of forest. Because of the structure of industry and the country's geophysical conditions, large amounts of energy are consumed. In 1990, CO_2 emissions from fossil fuels and peat and from industry totalled 54 million tonnes. Wood burning released another 17 million tonnes of CO_2, but this is not counted in total emissions because even more carbon was bound up in growing stock in the forests. Methane (CH_4) emissions totalled 252,000 tonnes, nitrous oxide (N_20) 23,000 tonnes, nitrogen oxides 295,000 tonnes of nitrogen dioxide, carbon monoxide (CO) 487,000 tonnes and volatile organic compounds from human activities (NMVOC) 219,000 tonnes. Emissions other than carbon dioxide were jointly equivalent to some 29 million tonnes of CO_2 in terms of their greenhouse effect.

2. Finland's climate strategy

The main focus in Finland's climate strategy is to intensify those programmes to reduce greenhouse gas emissions that are already under way, such as efficiency improvements in the energy production and utilization system, and use of energy and carbon taxes. As well as limiting emissions of CO_2 and other greenhouse gases, the Finnish action programme also includes measures to enhance carbon reservoirs and sinks.

In its energy report to Parliament in autumn 1993, the Government adopted the goals of halting growth in CO_2 emissions from energy production and use at the end of the '90s. Finland has been practising sustainable forestry for decades now, and consequently the forests are expected to sequester increasing amounts of atmospheric carbon for at least the next 15-20 years. In 1994, the Government ratified a forestry environment programme concentrating on

protecting the biodiversity of the forest ecosystem. This means that even more carbon will be bound in the forests.

In line with the Convention on Climate Change, Finland is taking action to mitigate climate change by limiting emissions of greenhouse gases and enhancing sinks and reservoirs. The country's potential for doing this is limited by its special geographical and economic conditions, which should be taken into account according to the Convention. Also instrumental here is how extensively other industrialized countries are willing to take action to mitigate climate change. Finland will work with other countries to promote the widespread adoption of measures to this end, with the maintenance of sustainable and balanced economic development as the goal.

3. Carbon dioxide emissions from energy production & consumption and industry in 1990

In 1990, CO_2 emissions from Finnish energy production & consumption and industry, estimated according to the IPCC reporting instructions, totalled some 54 million tonnes. Most of these emissions derived in various ways from energy production and consumption. Emissions from industrial processes, mainly from the cement and lime industry, totalled 1.2 million tonnes.

Other activities connected with energy production, but whose emissions are not counted in the CO_2 total, are bunkers, use of wood-based fuels, and emissions equivalent to imported electricity. Finland has so far imported over 10% of the electricity it needs from neighbouring countries. The CO_2 emissions of bunkers totalled 2.8 million tonnes. Some 17 million tonnes derived from the use of wood-based fuels. In 1990, net imports of electricity accounted for 17% of total consumption of electricity, which would have caused some 11 million tonnes of CO_2 emissions if it had been generated by Finnish condensing power.

CO_2 emissions from Finnish energy production & consumption and industry, 1990

Source	Emissions in 1990 mill. tonnes of CO_2
Fossil fuels and peat	53
Industrial processes	1.2
Bunkers	*2.8*
Wood-based fuels	*17*
Emissions equivalent to imported electricity	*11*

Finnish industrial output rose by a third between 1980 and 1990. During the same period, however, fuel consumption only increased about 10%. In terms of CO_2 emissions, it was beneficial that the increase in fuel consumption stemmed mainly from wider use of natural gas and wood-based fuels. Today's nuclear power capacity came fully on stream in the '80s, and by 1990 accounted for a third of total electricity production. Oil consumption by industry halved during the '80s, and emissions from industry and energy production at the end of the decade were nearly the same as ten years earlier, though the economy and energy consumption had grown.

CO_2 emissions from domestic traffic rose from 8.4 million tonnes to 11.5 million between 1980 and 1990, largely as a result of the increase in passenger and goods traffic consequent to fast economic growth (nearly 40% in 1980-1990). Judged in passenger kilometres, traffic increased 30% in the '80s. During the same period, distances travelled by lorries rose 16%.

4. Biospheric carbon reservoirs and sinks

The forests are Finland's most important natural resource. Of the total land area, 76% is classified as forested. The forests have been managed according to sustainable principles for several decades now, so felling has never exceeded forest growth. As a result, growing stocks in the forest have been rising ever since the '60s. The forests and the timber resources in them are still increasing substantially, thanks to their age structure and efficient silviculture. At the moment, the volume of growing stock in Finland is 1,880 million cubic metres, and the amount of carbon bound up in the forests continues to grow, since the overall amount harvested each year is very much lower than the increment.

According to the current forestry environmental programme, an annual increment of some 5-10 million cubic metres is estimated to be untouched by commercial exploitation, as a result of environmental protection goals such as the conservation of biodiversity. In 1990, the Finnish forest ecosystem had stored 2,700 million tonnes of carbon, with trees - including branches and roots - accounting for 660 million tonnes. The forest carbon dioxide sink in 1990 is put at around 31 million tonnes of CO_2.

Finland also has huge areas of peatland and mire. The carbon stored in the peat is put at 6,300 million tonnes. Virgin mires are estimated to accumulate some 0.4-2.0 million further tonnes of carbon every year. Of the country's original ten million hectares of peatland, some six million have been drained for forestry and farming. The result of drainage is that the peat starts to disintegrate, causing carbon dioxide to be released into the atmosphere. In most of the areas drained, tree growth has improved and carbon absorption has increased, a fact partly reflected in rising forest resource figures. Over about 10% of the drained areas, drainage has not yielded the desired increase in forest growth, however, and because of peat disintegration they have become sources of carbon dioxide. The net emission from these non-viable forest drainage areas is put at 1-5 million tonnes of CO_2.

Peatlands drained for agricultural use have also started to witness peat disintegration not counterbalanced by carbon binding in growing plants; this, too, is a CO_2 source. The annual CO_2 emission from cultivated peatlands is put at 3-10 million tonnes. The above estimates concerning the carbon balance of the peatlands are still rather unreliable, however.

5. Structure of Finnish energy production

Finland's energy production system is diversified and utilizes several energy sources. This reduces the economy's tolerance to problems caused by sudden fluctuations in the price or availability of individual fuels. The most important domestic energy sources are hydro power and biomass, i.e. pulp and paper industry wood waste. This latter accounts for 13% of all use of primary energy.

Over 30% of Finland's electricity is produced in combined heat and power (CHP) systems, i.e. either district heating plants or industrial backpressure utilities. At such installations, 80-90% of fuel energy is exploited, compared with about 40% at condensing power plants. The potential for district heat production combined with electricity and the coverage of the district heating network is already fully utilized. Specific releases of CO_2 from the energy system are therefore already low, at around 42 g CO_2/MJ. About half of the electricity need is met by hydro and nuclear power. Only 11% of the electricity consumed in 1990 was generated at coal-fired condensing power plants.

6. Energy policy

Finland has a long history of measures to save energy and make use of energy more efficient, and several energy reports and programmes have been drawn up since 1973. This action was largely motivated by purely economic reasons.

Because of the cold climate, buildings have always been designed and constructed partly with energy economy in mind. Really effective forms of insulation were introduced in the '60s and triple glazing, for instance, was made compulsory in all new buildings as early as the '70s. Official regulations, energy counselling and financial incentives have succeeded in reducing building-specific heat consumption to the level found in many countries that are very much warmer than Finland. This past action has thus reduced the number of cost-effective options open in the future.

The autumn 1993 Council to State Report to Parliament on Energy Policy aimed to ensure social and economic development and achieve a reduction in harmful environmental effects, while also reconciling energy targets and economic and environmental goals.

As early as 1990, Finland became the first country in the world to introduce a CO_2 tax. Since the beginning of 1994 fuel has been taxed partly on environmental grounds in that a tax on energy content was levied on all primary energy sources. A tax on carbon content is also levied on fossil fuels. This change in the tax structure favours low-emission energy sources, promotes energy conservation and encourages the use of renewable fuels such as biomass to replace fossil fuels. Over the short term the impact is relatively slight, but because the new tax system is meant to be permanent, it already influences decisions on investments and will thus gradually affect the structure of production and consumption. According to the 1995 budget bill, revenues from the tax based on carbon and energy content will contribute 0.5% to GDP. Any chance of raising the tax rate will also depend on international progress in introducing the tax.

In autumn 1992, the Government approved a separate energy conservation programme aimed at rationalizing end uses of energy in individual sectors by cutting 1990-level specific consumption 10-15% by the year 2005, i.e. space heating 10%, household use 15%, services 15% and industry 10%. The Government has launched work to revise the energy conservation programme in 1995.

Research on energy conservation has continued. Improved energy surveys and investment in economy measures have been supported. A special service centre to promote energy conservation, called MOTIVA, has been set up for information purposes. A separate energy conservation programme has been drawn up for the public sector. Voluntary energy conservation agreements have been concluded between the government and industry.

In spring 1994, as one element in the programmes called for by its energy report, the Government decided on measures to encourage the use of biofuels. The aim is for use of bioenergy to increase at least 25% by the year 2005. The goal set by the Government means expanding use of biofuels by 1.5 million tonnes of oil equivalent (Mtoe) by that date. Half of this target will be achieved by further use of peat and half by using wood from the forests.

To ensure that the structure of energy production remains diversified and based on both new technologies and renewable energy sources, the Government has been putting more money into the development of Finnish energy technology, and launching, financing and directing research programmes and development and demonstration projects for the home market and for export. This has been going on for several years now, and in 1993 the Ministry of Trade and Industry launched new energy technology development programmes ranging up to 1998.

7. Transport and communications

Greenhouse gas emissions from transport and communications are relatively high, because the population is scattered and distances are great. Since 1990, a rapid decline in emissions of nitrogen oxide, hydrocarbons and carbon monoxide from traffic has been achieved through technical improvements and granting a tax relief on cars with catalytic converters. Exhaust gas emissions from lorries and buses have been reduced, e.g. by cutting the maximum level of nitrogen oxides by half compared with the end of the '80s, and by ordering heavy vehicles to carry a speed limitation device that prevents excessively high speeds.

The tax on car purchases has always been rather high by international standards, a fact that has curbed growth in the car stock and especially discouraged the purchase of powerful cars. The tax on traffic fuels has also been raised sharply, and this, combined with the recession in the early '90s, has caused a halt in traffic growth. There has been a change-over to unleaded reformulated gasoline because of the steeply graded fuel tax, and this has reduced emissions of carbon monoxide and hydrocarbons by 10-15%.

Other measures adopted include subsidies for public transport (though these subsidies have had to be cut substantially in recent years), investments in the rail network and in electrification, a cut in the right to tax-deduct business travel costs, and a reduction in the transport subsidy to industry in developing areas. Use of gas fuels, bioalcohols and rapeseed methyl esters as traffic fuels has been studied and vehicles developed as far as the production stage.

The Ministry of Transport and Communications has drawn up an action programme of long-range targets and action proposals for reducing the environmental hazards of traffic. The bodies responsible for the programme are the Ministry and the administrative units and public enterprises subordinate to it, the other ministries, the local authorities, companies and organizations. Implementation of the programme is largely voluntary. The Government decision-in-principle in 1993 on measures to promote traffic safety includes steps in line with the action programme, aimed, for instance, at restraining further traffic growth.

Plans for future action are largely targeted at road traffic and a reduction in volumes. Emissions from new working machinery and rail diesels are also being reduced, as are nitrogen oxide emissions from ship engines, through international cooperation. The possible introduction of landing charges for aircraft, graded according to their environmental impact, is also being investigated.

8. Agriculture

Methane emissions from agriculture derive from the digestive processes and manure of domestic animals, and totalled 94,000 tonnes in 1990. The use of chemical fertilizers and manure spreading and, to a lesser degree, the spreading of treatment plant sludge on fields also cause nitrous oxide emissions, totalling 12,000 tonnes in 1990. Reducing these emissions is a key element in action to cut the load on the water system caused by farming. Improvements to cowsheds and manure containers and better manure handling procedures have succeeded in reducing methane emissions somewhat.

The Rural Environment Programme approved in 1992 and the agri-environmental support programme which is an element in Finnish accession to the European Union both include action to reduce greenhouse gas emissions from farming and greenhouse cultivation. It is difficult to predict the changes that will take place in farming and in the number of livestock, but emission estimates assume that there will be no major changes in the next few years.

Closer checks on and reduction in the use of chemical fertilizers and checks on the use of manure will help stabilize nitrous oxide emissions. The clear increase in grass cultivation will act in the same direction. More effective water pollution controls in animal husbandry, combined with the agri-environmental support programme, will also bring a decline in overall emissions of methane.

9. Waste management

In Finland, as in most other industrial countries, waste water is mainly treated aerobically, resulting in low methane emissions. The annual estimate is about 7,000 tonnes. Emissions from industrial effluent in 1990 are put at about 27,000 tonnes.

In 1990, Finland had 680 landfills, and some 1,000 have been closed. The waste management development programme calls for a substantial decrease in the number of landfills; the aim is for only 200 by the year 2000. Reducing the number will make for more efficient management and supervision, and also reduce their harmful environmental effects.

Methane emissions from landfills will decrease substantially in the near future. In the year 2000, emissions are expected to be about 60,000 tonnes, compared with 105,000 in 1990. A few landfills already recover the methane released and use it as a fuel for small-scale energy production.

10. International cooperation

Finland took an active part in the United Nations Conference on Environment and Development and provides financial support for programmes contributing to sustainable development. Finland assists developing countries in furthering the goals of the FCCC through bilateral and multilateral aid programmes that support countries in adopting advanced environmental technology, in increasing general know-how and capacity concerning environmental protection, and in the maintenance of greenhouse gas reservoirs and sinks, especially forests. In 1994-1996 Finland is contributing FIM 105 million to the Global Environment Facility (GEF) in compliance with the agreed burden-sharing. Environmental cooperation with countries in economic transition also began recently.

11. Research on climate change

In 1990-1995, the Finnish government will be contributing altogether FIM 90 million or so to the research programme on climate change (SILMU), which includes some 60 research projects and two hundred research workers. The main areas being studied are climate changes expected in Finland, assessment of the effects of climate change on the ecosystem, and strategies for adapting to and combating these effects. The programme focuses on special issues of importance to Finland, such as the carbon balance of the peatlands and adjustment of the forest ecosystem to changes in climate. Basic research on climate change connected with international programmes such as the World Climate Research Programme (WCRP) and the International Geosphere-Biosphere Programme (IGBP) is also included.

12. Trends in emissions and sinks, 1990-2010

Carbon dioxide emissions from energy production and consumption can be limited in future through the measures outlined above. Even so, emissions will probably rise between 1990 and 2000, partly because it is assumed that all the electricity used in Finland in future will also be produced here. In 1990 CO_2 emission equivalent to electricity imports was 11 million tonnes. CO_2 emissions from industrial processes are not expected to change very radically in future.

Estimates of emissions from the biosphere are still very unreliable, but the CO_2 emissions produced as a result of peat disintegration in cultivated peatlands and non-viable drainage areas will presumably decrease in future. There are no grounds at present for maintaining non-viable drainage areas in a condition fit for forest cultivation, and it would be more practicable to let them run wild. Similarly, the area covered by cultivated peatlands is declining rapidly as a result of reforestation or return to the natural state, and consequently their CO_2 emissions are decreasing.

Finnish CO_2 emissions in 1990 and estimates for 2000 and 2010

Source	Emissions in 1990 mill. tonnes CO_2	Estimate for 2000 mill. tonnes CO_2	Estimate for 2010 mill. tonnes CO_2
Fossil fuels and peat	53	69	69
Industrial processes	1.2	1.2	1.2
Cultivated peatlands	3-10	1-3	1-3
Non-viable drainage areas	1-5	0-3	0
Total	**58-69**	**71-76**	**71-73**
Emissions equi-valent to elec-tricity imports	11	-	-
Total	69-80	71-76	71-73

Emissions of methane, nitrogen oxides, carbon monoxide and NMVOCs will decline in future in all probability. Methane emissions from landfills, energy production and traffic will decrease in these sectors merely because of qualitative and technical changes already implemented. Emissions of nitrogen oxides will decline substantially, particularly because of action to limit emissions in energy production and in transport and communications. Carbon monoxide emissions and emissions of NMVOCs will mainly decrease because of lower emissions from road transport. In contrast, emissions of nitrous oxide are likely to increase, primarily because of higher emissions from energy production and traffic, unless radical advances are made in technical means of cutting emissions in these sectors.

Finnish emissions of greenhouse gases in tonnes of CO_2 *equivalent in 1990, and estimates for 2000 and 2010*

Gas	GWP integrated over 100 years	Emissions in 1990 CO_2 Equivalent Mt	Emission estimates in 2000 CO_2 Equivalent Mt	Emission estimates in 2010 CO_2 Equivalent Mt
CO_2	1	58-69	71-76	71-73
CH_4	24.5	6.2	5.0	4.9
N_2O	320	7.4	9.0	9.3
NO_x	40	11.8	9.1	8.0
CO	3	1.5	1.0	0.9
NMVOC	11	2.4	1.5	1.5
Total		87-98	97-102	96-98

Over the decades, increasing amounts of carbon from the atmosphere have been absorbed in the Finnish forests. The net forest sink in 1990 is put at 31 million tonnes of CO_2. In future, developments will depend on how much wood is used. It is assumed that forest industry wood utilization will continue to increase (from 50 million cubic metres in 1990 to about 56 million in 2000), giving an annual CO_2 sink of about 23 million tonnes in 2000. However, the amount of carbon bound up in stemwood, branches and roots in 2000 and 2010 in the scenario based on increasing wood utilization has also grown appreciably on the 1990 level.

Carbon balance and reservoir in total wood biomass in managed forests in 1970, 1980 and 1990, and estimates for 2000 and 2010. The estimates are based on the scenario of increasing wood utilization.

	Million tonnes of CO_2				
	1970	1980	1990	2000	2010
Carbon sequestration	76	91	103	114	121
Carbon emission	75	65	72	91	97
Annual sink	2	26	31	23	23
Carbon reservoir	1940	2141	2420	2633	2842

Economic growth will increase Finnish energy consumption in the 1990s despite the Government's energy conservation programme, because most of the production plants and processes, buildings, vehicles, machinery and equipment in use and under construction today will still be in use in the year 2000. The rate of replacement is insufficient for the reduction in specific consumption achieved thereby to counteract the effects of overall expansion on energy consumption.

In 2000, most CO_2 emissions will be from installations already in use or under construction. Parliament has rejected the application to build a fifth nuclear power plant and has also passed a Rapids Protection Act, so there will be no chance to achieve appreciable structural changes in the energy production system by 2000. Instead, today's substantial imports of electricity will have to be replaced by conventional domestic electricity production. Any fast increase in the amount of natural gas used and the creation of a new pipeline link from the west also depend on decisions in countries other than Finland. In practice, getting new energy production methods operational, thereby substantially improving the efficiency of electricity production and at the same time also making effective use of renewable biofuels using these methods, will only be possible on any major scale after the year 2000.

Achieving a reduction in emissions larger or faster than outlined above, and continuing to reduce emissions in the long term call for several simultaneous additional measures and a consistent strategy. The Government has already launched a reassessment of the energy conservation programme in which even firmer action, including official regulation, non-statutory norms and standards, will be pondered. The new programme should be approved in 1995.

Developments in industry and communities, faster-than-expected advances in technology and changes in attitudes to energy use, together with progress internationally, may all create the future potential for new ways of reducing emissions. Better knowledge about the effects of human activities on biospheric greenhouse gas balances may also yield new approaches, e.g. in agriculture and forestry and in land use. Effective combating of climate change calls for decades of work and successful measures to implement the strategy. The need for new action must thus be constantly reassessed.

1. FINLAND'S POINTS OF DEPARTURE IN COMBATING CLIMATE CHANGE

1.1 Basic facts about Finland

Finland lies between latitudes 60° and 70°N; and a quarter of the country is north of the Arctic Circle. To the west and south, it has some 1,000 km of coastline on the Baltic Sea. With a total area of 338,145 km^2, it is Europe's sixth largest state. Thanks to the warming effect of the Gulf Stream, the climate is relatively mild compared with many other countries at the same latitude. The growth season (temperatures above 5°C) is rather short, however: 175-180 days on the south coast and about 130 days on the Arctic Circle. About 30-40% of the annual precipitation comes in the form of snow, which remains on the ground for about three months in the south and seven months in the north.

In 1992 Finland's population was 5,055,000, making it one of the most sparsely populated countries in Europe, with an average density of only 16.5 people per square kilometre. Population density varies in different areas, however, with 127 people per square kilometre in the southernmost province and only 2.2 in Lapland, and 60% of all Finns live in towns, the six largest having populations of over 100,000.

Nearly the whole of Finland is in the boreal coniferous forest belt, and 76% of the total land area is classed as woodland, while only some 9% is farmed. Finland has 33,522 km^2 of water systems, or about 10% of its total area (Table 1).

Table 1. Land use in Finland in 1960 and 1990.

Land use class	Year	
	1960	1990
		km^2
1. Agriculture	**31,400**	**28,160**
2. Forest and other woodland	**224,400**	**233,665**
3. Built-up land	**3,400**	**9,390**
4. Open wetlands		**20,828**
5. Dry open land with special vegetation cover		**9,642**
items 4 and 5 total	**42,260**	
6. Waters	**32,600**	**33,552**
Unclassified	**3,740**	**2,908**
Total area	**337,800**	**338,145**

Source: Environment Statistics 1994

The last few decades have been a time of great change in the Finnish economy. In the '60s and '70s, people moved increasingly into towns and industrial occupations. With faster industrialization, the need for social and other services also grew. Transport systems were improved, and in the '70s the total distance covered by railways and public roads rose significantly. Trade, transport and services doubled in volume between 1950 and 1990.

Over the decades, changes in economic and social structures have also altered the way land is used. The amount of cultivated arable land has decreased, while peatland drainage has increased the total area used by forestry. Partly as a result of new traffic arteries, the area of built land has nearly tripled.

Finland's most important natural resource is her forest, and most of it is commercially exploited. However, the sustainable use of forest resources is safeguarded under law, and deforestation is extremely infrequent. Regulation of forestry in fact goes back to the 17th century. Later, the 1886 Forest Act actually prohibited the destruction of forest and thus endorsed the principle of sustainable yield. The Private Forest Act passed in 1928 ensured that no woodland can be deforested, that the growing capacity is properly managed and that felling is followed by reforestation.

The forest resources of Finland have grown particularly fast in the last couple of decades (Table 2). In 1990 the total volume of stemwood was assessed at 1,880 million m^3, with annual growth at nearly 80 million m^3. Between the beginning of the '50s and 1990, volume rose 22% and annual increment 43%. Forest growth has been accelerating all the time, and the current assessment is already 85-88 million m^3 a year.

This increase has primarily been achieved because felling has fallen short of the sustainable annual figure originally planned, on the other hand efficient silviculture, forest improvement in areas of low yield and drainage programmes have also enhanced forest growth.

Table 2. Trend in forest resources, 1950s to 1990s.

	1951-53	1964-70	1971-76	1977-84	1990
Area of forest and scrub, mill.ha	22	22	23	23	23
Volume of growing stock, mill. m^3	1,540	1,490	1,520	1,660	1,880
Annual increment, mill. m^3 p.a.	55	57	57	68	79
Total drain, mill. m^3/a	49	55	55	46	55

Source: Yearbook of Forest Statistics 1993

Finland also has some 9 million hectares (90,000 km^2) of peatland (Table 3). Of this total, about 5 million hectares have been drained for forestry use, leaving some 4 million hectares in a natural state. There were extensive drainage programmes in the '60s and '70s, but new projects are now few and far between. The estimate is that, overall, peatland drainage added some 10 million m^3 to annual increment, i.e. 15% of the total. About 0.7 million hectares of peatland have also been drained for agricultural use.

Table 3. Finnish peatland

	Million hectares
Original mires before drainage	10.4
Current mire area	9.0
Virgin peatlands	4.3
Peatland drained for forestry	5.3
Cultivated peatland	0.26-0.42

Source: Geological Survey of Finland 1993

1.2 Economic premises

Over the last three decades the Finnish economy has expanded threefold, a fast rate by any international yardstick. Industrialization and the advance of the tertiary (service) sector came later here than in older industrial countries. There are several reasons for this fast economic growth: favourable bilateral trade with the Soviet Union right up to the late '80s and early '90s, good demand on Western markets and energetic investment in research and development.

Around the end of the '80s, however, the economy plunged into a recession that proved extremely severe compared both with other countries and Finland's own past history. Output dropped for three years in succession (1991-93), and the unemployment rate hit 18%, compared with a mere 3.5% in the late '80s.

Now, in 1994, an upturn seems to be taking place and output is rising appreciably. Prognoses suggest that the Finnish economy has all the preconditions for exceptionally rapid growth in the latter half of the '90s. Fast growth is also an important goal of economic policy, if the unemployment and debt problems caused by the recession and the overheating that preceded it are to be overcome.

Three quarters of all Finland's greenhouse gas emissions derive from energy production and consumption for various purposes. Finnish industry is rather energy-intensive compared with other West European countries. This is particularly true of production for export, though admittedly the trend has been for an increase in highly processed products in the realm of 'high tech'. What is more, the key export industry, wood processing, relies to an appreciable degree on biomass to meet its energy needs. There has, it must be said, been an enormous increase in energy efficiency in the last couple of decades; industry's energy consumption relative to value added has fallen by a third.

Because of the country's northerly location, Finland uses a lot of energy for heating, and this is the source of most CO_2 emissions by households and the public and tertiary sectors. Similarly, because of the sparse and scattered population, the economy is burdened by the long distances goods have to be transported, compared with many other European countries. The markets for our exports also tend to be remote.

Thus, the country's geography, combined with its role in the international division of labour in industry, means that our economic preconditions for effective action to combat the greenhouse effect are not exactly good by international comparison. Further, many measures to increase efficiency that also reduce emissions of greenhouse gases were actually taken here long ago, dictated by our demanding circumstances.

From the economic viewpoint, there are two factors of particular significance for combating measures in the latter half of the '90s. First, achieving fast and sustainable economic growth is a key goal of Finnish society, in order to overcome the problems brought by the recent recession. Second, the cost efficiency of the combating measures available to Finland is deteriorating substantially.

The aim of fast, sustainable growth in order to overcome the recession is founded on an export-driven strategy. The proportion of GDP accounted for by exports declined throughout the '80s, especially towards the end of the decade, and in consequence the net national debt to foreign lenders mushroomed. This decade, high exports and a foreign trade surplus are therefore important ways of reducing the burden of debt servicing. Our exports mainly comprise industrial products, and flourishing industry affects greenhouse gases in two ways. On the one hand, it increases the emissions generated, but on the other it creates the potential for plant modernizations and a larger proportion of new, high-tech products, resulting in less burden on the environment.

In the ideal future scenario, investment will be brisk and exports will rise 6-7% a year at the end of the decade. This export-led growth will gradually spread to the rest of the economy, generating a 5-6% a year increase in GDP. In this vision of the future, unemployment would fall to half its present level (over 18%). Because of this high unemployment rate, government indebtedness might edge up still further, but thereafter a few years would bring it under control. In the choice and use of measures to combat climate change, special care must therefore be taken to ensure that they do not counteract action to overcome recession-related problems and ensure a return to a sustainable and balanced economic path.

The cost of combat measures to the economy is rising appreciably. This is partly due to steps already taken before the FCCC, and partly to action aimed at the rest of the '90s and outlined later on in this Report. There will therefore be more investment in R & D to devise low-cost techniques.

Over the long term, a wide range of ways of reducing emissions will become available. New energy-producing technologies should reduce CO_2 emissions substantially. The new process industry units offer many important ways of cutting energy consumption. The cars of the future will need much less fuel than at present. In just a few decades, technology will offer great potential. This decade, in contrast, the range of viable methods is rather limited in countries like Finland, where CO_2 emissions relative to total energy consumption are already low.

Trends in CO_2 emissions were encouraging in the '80s, and the 1990 figure was roughly the same as in 1980. To meet its obligations under the FCCC, Finland is currently implementing a large number of measures and programmes. Even so, emission trends this decade will not be as favourable as in the '80s, because there quite simply are not enough viable courses of action.

It is not possible to increase the percentage of low-emission or emission-free fuels used in energy production, at least in the short term, because there is hardly any reasonably priced technology available that will raise energy efficiency. At the end of the decade, too, Finland is likely to have to use domestic capacity to replace its present electricity procurement under long-term import agreements. If the new capacity has to be coal-fired, this could well raise CO_2 emissions by a fifth.

In 1990, to guide energy production and consumption in the most desirable direction, Finland introduced a tax based on CO_2 emissions. This tax system was revised at the beginning of 1994 to make it apply consistently to the carbon (and partly energy) content of all primary energy. The system allows for no exceptions or reliefs in the case of energy-intensive industry. The tax is to be raised appreciably at the beginning of 1995, when it will yield government revenues representing an estimated 0.5% of GDP. It is difficult to make the tax on carbon content any higher in Finland alone.

At this level, a combined energy/carbon tax cannot be expected to have much of an effect on emissions, or quickly. However, it does represent a clear signal to economic units that the obligations of the FCCC must be taken into account; it also encourages them to implement any measures that can still reasonably be expected. The carbon tax thus crucially encourages further energy conservation, and in time will make biomass a more competitive energy source, assuming the tax level can be raised further in the future.

Economic and other preconditions for achieving a fast reduction in CO_2 emissions in the 1990s are, exceptionally, rather limited. On the other hand, the carbon reservoirs in Finland's forests will probably grow by around 10% by the end of the century, and then go on growing even if the economic revival depends on a substantial increase in use of wood. This is no minor consideration, thinking of the CO_2 in the atmosphere, as 15% of the forest area in Europe is in Finland, which has been pursuing a policy of sustainable forestry to maintain its growing stock reserves for decades now.

1.3 Planning climate policy

The Finnish Government has set up two committees to work out alternative strategies and measures to limit and reduce emissions of CO_2 and other greenhouse gases and to lay down a basis for goal-setting in international negotiating processes. The first committee was appointed in October 1990, with the brief of examining ways of cutting emissions by both technical and structural means. The other committee was set up in 1991, to draw up a proposal for an action programme to limit greenhouse gas emissions and preserve carbon sinks.

The main targets of the action programme to reduce greenhouse gas emissions are energy conservation and ways of increasing efficient energy production and use of low-emission fuels. Emissions of greenhouse gases can also be reduced through measures affecting certain areas of farming, forestry and waste management.

An increase in forest resources will in turn reduce the impact of our emissions on the atmosphere. Forestry must ensure that carbon reservoirs are augmented and that the carbon stored in our forests and peatlands is not released into the atmosphere. Conversely, every effort must be made to preserve the viability and growth of our forests through silviculture, so that this renewable natural resource can be used more widely as a raw material and energy source in industry. Estimates concerning biospheric emissions and sinks are still unreliable to some extent, and it is important to continue research in these areas.

The action programme is reflected in the various official decisions outlined in what follows. The aims of Finnish climate policy have to be reassessed at regular intervals and adjusted to the country's technological, economic and social potential, changes in international agreements, and implementation of them in different countries.

2. ENERGY PRODUCTION AND INDUSTRY

Because of the structure of Finnish industry and natural conditions here, energy is extremely important. Further, the export industry is highly specialized, and raw-material-intensive (Figure 1). Energy is therefore a key production input in the export industry, and its price and availability will remain crucial in the future. This fact has in turn provided the motive for efficient production methods and energy economy. The energy economy of Finnish buildings and many industrial processes is in fact among the best in the world. In terms of oil equivalent, total energy consumption in 1990 was about 5.8 tonnes per capita. This is nearly double the OECD European average, but highly typical of countries at northern latitudes.

2.1 General features of the Finnish energy economy

Total use of energy in Finland has risen steadily practically throughout this century, as a result of industrial and social change. Oil consumption increased rapidly from the mid '40s onwards, but slowed down somewhat during the 1973 oil crisis. Between 1960 and 1990 total use of energy rose nearly threefold, and during the same period use of electricity increased more than sixfold.

Finland's lack of energy resources of its own led to great dependency on imported energy, and today about 70% of all raw energy comes from abroad. The input of domestic energy has remained at a steady 30% or so, even as total energy generation has risen, meaning that its volume has also increased.

The energy production system is diversified and utilizes several sources. The most important source of domestic energy is hydro power and combustion of biomass by the paper and pulp industry in the form of waste sludge (Figure 2).

Nearly half of all the wood recovered from the forests, including wood from management of young stands, is used for energy production.

Industry is the biggest user of energy (Figure 3), accounting for 46% of total consumption in 1990. Total consumption by the forest, basic metal and chemicals industries accounts for over 90% of industrial use. Some 21% of total consumption in 1990 went into heating buildings, 14% into transport and 19% into other uses. Industry is also the biggest user of electricity, accounting for something over 50% (Figure 4).

The special features of Finnish energy production are combined heat and power (CHP), district heating and the use of biofuels.

COMBINED HEAT AND POWER PRODUCTION

In combined heat and power (CHP) production the waste heat produced when electricity is generated is utilized in industrial processes or for heating, greatly boosting the efficiency and economy of energy production. Though heat remains the main product at many existing plants, there, too, the principle is to utilize the hot steam produced in the electricity generating process. Over 30% of all electricity produced in Finland is generated at CHP plants.

The utilization rates of condensing power plants using fossil fuels are around 40% (including the removal of sulphur and nitrogen oxides), while those of backpressure plants are around 80-90% or even higher. This cuts the amount of fuel needed by as much as half (Figure 5). The saving can be 10-40% in the case of CHP production.

The efficiency of CHP production in reducing CO_2 emissions depends on the fuel used (fossil fuels or renewable energy sources), the balance between heat and power produced, and the capacity for exploiting the waste heat.

At the moment, CHP technology is available for natural gas, but in the case of biomass techniques are still being developed. In the long term, use of CHP plants based on pressurized gasification could double output of CHP.

DISTRICT HEATING

Buildings in Finland need a lot of heat because of the climate, but have always been constructed to use energy economically. A substantial proportion of the building stock is also supplied with efficient district heating (Figure 6).

In modern systems, district heating reaches the consumer through insulated transmission networks where the water temperature is 60-90°C or 70-120°C and the return temperature 50-70°C. The heat losses are very much less than in systems based on steam (which operate at 150-200°C), and the potential for electricity production is greater. In urban transmission networks, insulation losses range from a few per cent to 10-15%.

WOOD AND PEAT AS FUELS

Some 13% of all primary energy is produced from wood and wood waste, and firewood and peat jointly account for 18% of total energy production. Industry uses wood waste from production processes to generate energy, and firewood or woodchips are also used to heat buildings. Two thirds of all the wood waste used by industry is black liquor from the chemical pulp production process and one third bark.

Table 4. Use of wood, wood waste and peat as fuel, 1990.

	Wood and wood waste Mtoe/a	Peat Mtoe/a
Separate power production	0.02	0.19
District heating	0.12	0.64
Industry	3.10	0.40
Heating buildings	0.7	0.02
Farming, etc.	0.16	-
Total	4.10	1.38

The above-mentioned fuels call for special combustion techniques. Black liquor is burned in recovery boilers and other fuels in fluidized-bed boilers. These methods have replaced conventional grates and PF-firing systems. In the new methods the fuel input ranges from 10-20 megawatts right up to 300 megawatts. They have the advantage that several fuels, including coal, can be burned at once and waste paper, for instance, can be burned at the same time as wood and peat.

Biomass and peat are mostly used in Finland for CHP production. Government-subsidized research is concentrating on increasing power yield using IGCC (Integrated Gas Combined Cycle) technology. The first demonstration plant using Finnish gasification technology is starting up in Sweden. Its thermal input is 20 MW, and it will produce electricity and district heat. Even bigger plants will go on stream in the Finnish paper industry in another five years time.

Energy is produced efficiently in Finland, and by modern methods. The specific release of CO_2 is also relatively low (Figure 7). There are several factors at work here. For instance, energy is generated using several energy sources, and by a number of competitive methods. Generating utilities are also efficiently operated; for instance, the availability record of our nuclear power plants is over 90%. Hydro power and nuclear power jointly account for some 60% of domestic power production, leaving 30% to CHP and only 10% to condensing power. Biomass is also widely used as fuel, especially wood waste in the forest industry.

2.2 Emissions from energy production and industry

Emissions of greenhouse gases related to energy production (extraction and burning of fuels, transportation, storage and distribution) have been inventoried according to IPCC guidelines up to 1990. Component activities and the emissions from them have been divided into two categories: emissions from combustion and fugitive emissions. The latter include the evaporation of greenhouse gases, leaks, and biological formation in the extraction, refining, storage and distribution of fuels.

Combustion emissions include those deriving from all fuel uses, i.e. fossil fuels such as coal, oil and natural gas, and man-made fuels such as blast furnace, coke-oven and town gas. The inventory also includes emissions from the burning of firewood, peat, industrial waste wood, pulping spent liquors and municipal waste. Oil combustion accounts for a major proportion of all greenhouse gas emissions (Figure 8). Burning of coal and biomass constitutes a substantial source of CO_2 and use of biofuel for much of the emission of methane, carbon monoxide and NMVOCs.

Biofuels include wood, peat, agricultural biomass and biowaste. The speed of their renewal varies from a few months to several thousand years. The fastest are various forms of agricultural biomass and what is called 'short-cycle wood', the age of which ranges from a few months to a few years. Typically, the age of wood biomass in Finland varies from a few years to over a century. The CO_2 released when renewable fuels are burned is bound back into new fuel as the biomass grows. For this reason, CO_2 emissions from wood-based fuels are not included in total emissions, as they are considered to 'find their way back' into forest growth.

Geologically speaking, peat is not a fossil fuel, but a slowly renewable soil component formed from plant decomposition. Depending on the speed and stage of this process, peat renews itself in different types of mire within a few thousand years, sometimes within a few centuries. Emissions from peat-burning are included among total CO_2 emissions.

Table 5. Greenhouse gas emissions from energy production and industrial processes in 1990, by main sector.

Greenhouse gas source categories	Emissions of greenhouse gases					
	CO_2 Mt/a	CH_4 kt/a	N_2O kt/a	NO_x kt/a	CO kt/a	NMVOC kt/a
1 All Energy	**52.6**	**19**	**8**	**291**	**484**	**156**
Fuel Combustion	*52.6*	*19*	*8*	*291*	*484*	*142*
Energy and transformation industries	19.5	1	1	64	9	0
Industry (ISIC)	13.7	2	1	41	32	0
Internal transport	11.5	8	5	160	368	79
Bunkers [1]	(2.8)	(1)	(1)	(22)	NE	NE
Commercial/Institutional [2]	IE	IE	IE	IE	IE	IE
Residential	5.8	6		8	61	51
Agriculture/Forestry	2.1	2		18	14	12
Other	NO	NO	NO	NO	NO	NO
Wood and waste wood [3]	(17.1)					
Fugitive Emissions	*0.1*	*0*				*14*
Oil and Natural Gas Systems [4]		0				14
Coal mining		NE				
Peat Production	0.1	NE				
2 Industrial processes	**1.2**	**NE**	**3**	**4**	**3**	**15**
Iron and Steel	0.1					1
Non-Ferrous Metals						
Inorganic Chemicals			3			
Organic Chemicals						12
Non-Metallic Mineral Products	1.1					
Other	0					2

[1] Marine and air bunkers are are not included in the totals.
[2] Heating of commercial /institutional buildings is included in "Residential"

[3] Wood and waste wood burned for energy is reported separately for CO_2 emissions and is not is not included in the CO_2 emission totals. For emissions of other gases, biomass burned for energy is included in the sectorial subtotals.
[4] NMVOC emissions include NMVOC from refineries and oil distribution and also methane from refineries.
NE not estimated
IE estimated but included elsewhere
NO not occurring

Thus, nearly all Finland's CO_2 emissions are from energy production and consumption. Combustion of fossil fuels and peat generated altogether 53 million tonnes of CO_2. A further 2.8 million tonnes derived from fuels used in bunkers. In 1990, 1.2 million tonnes of CO_2 came from outside the energy sector, primarily cement and lime works. Use of rapidly renewable biofuels caused some 17 million tonnes of CO_2 emissions. These are not included in the total emissions figure, however, as they are bound up in new growth of forest biomass reservoirs.

Total per capita consumption of primary energy in Finland is higher than the OECD average. In contrast, CO_2 emissions per primary energy unit are rather low (Figure 8). The main reason for this is the energy production structure (use of CHP production, hydro power, nuclear power, bioenergy and peat). Only 11% of all the electricity consumed in 1990 was produced by coal-fired condensing power plants. As a result, the CO_2 specific release coefficient in electricity production is relatively low.

Industrial output rose by a third in 1980-1990. During the same period, consumption of fuels only rose some 10%, however. In terms of CO_2 emissions it is a good thing that the higher fuel consumption mainly affected natural gas and wood-based fuels. Most of Finland's present nuclear power capacity also went on stream during this period.

Table 6. CO_2 emissions from energy production and consumption using fossil fuels and peat, 1980s and '90s.

Year	CO_2 emissions Mt
1980	54.0
1981	44.7
1982	42.8
1983	42.4
1984	43.4
1985	49.5
1986	48.1
1987	51.9
1988	51.6
1989	51.9
1990	53.1
1991	53.2
1992	51.1
1993	53.0

Between 1980 and 1990, CO_2 emissions from domestic traffic rose from 8.4 million tonnes to 11.5 million, largely as a result of higher passenger and goods traffic volumes deriving from fast economic growth. Measured in passenger kilometres, the overall rise was 30%.

2.3 Action to reduce emissions

2.3.1 Energy policy report

In autumn 1993, the Government made an energy policy report to Parliament. This aimed to reconcile the primary targets for Finland's energy, economic and environment policies so as to ensure steady socio-economic development while also reducing harmful environmental impact. Energy availability was viewed as a crucial factor for the future of the economy and reliable energy supply as one of the energy economy's most important goals.

Energy policy is designed to stabilize emissions of greenhouse gases as laid down in the Rio Climate Convention. In the near future, CO_2 emissions will increase as utilities currently under construction are completed, so the goal at this phase is to halt any further increase in CO_2 emissions from energy production and consumption at the end of the '90s. Whether or not the goal is attained earlier than that depends on how intensively the methods outlined in what follows are used, and here the country's economic development and programmes adopted internationally both constitute certain limits.

2.3.2 Premises for energy measures

Since the early '70s and the first oil crisis, changes have taken place in the structure of Finnish energy production which have also had an impact on CO_2 emission trends. Policy-based energy programmes to date since that period also provide one premise for future action and our potential for influencing CO_2 trends.

Oil accounted for the highest proportion of Finnish energy use in 1973, at over 55%. By 1990 the figure had fallen to 30%. Over the same period use of coal rose, reaching about 15% in 1980 and thereafter declining as nuclear power capacity went on stream. Coal consumption again increased with rising energy consumption towards the end of the '80s, reaching a steady 11-12%. Use of natural gas also rose steadily, reaching about 7% in 1990, as did use of peat, at nearly 5%.

Depending on the rainfall, the amount of hydro power used ranged from not quite 15% to something over 8% in 1990. Nuclear power accounted for nearly 17% of total energy use in the early '80s and has since held steady at around 15%.

Imported electricity has compensated for the shortfall in domestic production. These imports peaked in 1990, and now account for 4-9% of total energy consumption.

Use of rapidly renewable domestic biofuels (wood, chips, spent liquors) fell by several percentage points between the '70s, when it was about 18%, and the mid '80s, since which time the figure has gradually started rising again.

CHP's contribution to electricity production using various fuels (excluding hydro power) declined in the '70s, but started increasing in the '80s, reaching 40% or so in 1990.

Energy efficiency has been effectively promoted throughout the economy, or by some 20 percentage points since 1973, when low-cost energy conservation measures were introduced.

The various changes outlined above have made Finland's present energy production system both up-to-date and efficient. It also fulfils many energy policy objectives, meaning that in the '80s in particular, environmental discharges, including emissions of greenhouse gases, decreased prior to the comparison year 1990, which was exceptional in many respects.

Because of the large contribution made by CHP and district heating, extensive use of wood-based biofuels, and the relatively new technology in utilities using fossil fuels and peat, the specific CO_2 release of the Finnish energy production system is already low, at around 42 g/MJ. The figure had risen to around 55 g/MJ by the end of the '70s, but fell to 42 g in the early '80s, remaining at this level for the rest of the decade. An increase looks inevitable during the '90s, admittedly.

2.3.3 Energy taxation

In a market-oriented energy economy, society aims to promote efficient use of energy and to reduce environmental emissions by manipulating the price of energy that the consumer pays through energy taxation. One precondition is that changes in this taxation take industrial competitiveness into account and are combined with other action programmes concerning use of energy. **As an adjunct to the 1994 budget, the Finnish Parliament approved an amendment of the Fuel Tax Act that partly based the tax on environmental grounds,** i.e. a tax determined according to energy content was levied on all primary energy sources. A further tax according to carbon content is also now levied on fossil fuels. No tax is charged on wood, wind power or waste used to produce energy. The tax on electricity generated by hydro or nuclear power is only based on energy content. Further, a basic fiscal tax is levied on electricity produced by nuclear power and on oil products.

In 1990, Finland became the first country in the world to adopt a CO_2 tax, and the system has gradually been improved since then. As of the beginning of 1994, the tax based on carbon content has been FIM 22.10 per tonne of CO_2, and the tax based on energy content FIM 2.10 per megawatt hour. The Government also proposes a tax increase in 1995 to FIM 38.30 per tonne of CO_2 and FIM 3.50 per megawatt hour. Revenues from this tax would then represent about 0.5% of GDP.

The system allows for no exceptions, rebates or reliefs to energy-intensive industries. It is to remain in force on these principles, within the limits permitted by international competitiveness.

Analyses already made indicate that such taxes have to be rather high to achieve any appreciable and relatively rapid cuts in emissions. Other action is thus also needed, its effectiveness being boosted by taxation.

The present tax system favours low-emission energy sources less harmful to the environment. It also promotes energy conservation and supports the use of renewable fuels such as biomass to replace fossil fuels. It likewise influences investments, and thus gradually alters production and consumption patterns.

The tax on carbon would have a major impact on emissions if it were also adopted widely in other countries. It would then be possible to levy very much higher taxes than any single country can manage without serious economic consequences.

ENERGY AND CARBON TAXATION IN FINLAND

Fuels and energy products are mainly subject to two kinds of taxes. **Excise duty** is levied on fuels and energy products, and they are also subject to **value added tax** (VAT). Also, a **'contingency reserve charge'** and an **'oil protection charge'** are imposed on some fuels.

Excise duty

The excise duty on fuels and certain sources of energy consists of **a basic tax** and **an additional environmentally based tax**.

The basic tax is primarily a fiscal tax determined annually in the State budget proposal. The basic tax is, however, **differentiated** to promote environmental protection. In the case of gasoline, there is a lower tax on unleaded and reformulated grades, and in the case of diesel oil on the desulphurized grade. The basic tax is also levied on light and heavy fuel oil and nuclear power. Tax revenues derive primarily from liquid traffic fuels, however.

Basic fuel tax and its environmentally related differentiation in 1994		
Gasoline, leaded basic grade, basic tax, penni/l	**281**	
Basic tax relief on unleaded grade penni/l		45
Basic tax relief on reformulated grade penni/l		5
Diesel oil, basic grade, basic tax, penni/l	**165**	
Basic tax relief on desulphurized grade penni/l		15
Light fuel oil, basic tax, penni/l	**4.2**	
Heavy fuel oil, basic tax, penni/kg	**2.5**	
Nuclear power, basic tax, penni/kWh	**1.5**	

According to the Government budget bill, the basic tax is to be increased by 2% in 1995. For gasoline, however, the increase would be about 10%.

The additional environmentally based tax is determined according to the energy and carbon content of the fuel. As a rule, the tax is imposed on primary energy, thus encouraging improvements in energy efficiency and production techniques. The yardstick for the system is heavy fuel oil: 75% of the tax on this comes from carbon content and 25% from energy content. In 1994, the tax component on carbon content was FIM 22.1 per tonne of carbon dioxide, and that on energy content FIM 2.1 per MWh. The additional taxes on all fuels are determined according to unit taxes worked out in this way.

For nuclear and hydropower, the additional environment tax is levied only on energy content. The energy tax component for nuclear power is the same as for electricity generated in coal-fired condensing plants, where the efficiency coefficient is about 38%. The tax on hydropower is worked out by applying the unit tax for energy content directly to the amount of electricity generated. As a general rule, no additional tax is levied on renewable energy sources. Thus, for example, wind power and use of waste and wood-based biomass are not taxed. Peat is only slowly renewable, however, and the full energy content tax and a reduced carbon content tax (30% of the corresponding tax on fossil fuels) are levied on it.

According to the Government budget bill, the additional tax will be raised substantially in 1995. The carbon content component would rise to

FIM 38.3 per tonne of carbon dioxide and the energy content component to FIM 3.5 per MWh.

The system provides for no refunds, reliefs or compensation for any economic agent. Only the use of a fuel for purposes other than energy production (e.g. as a raw material) is exempt from tax.

Environmentally based tax on carbon and energy content of different fuels in 1994

	Additional tax component on $C0_2$ *(FIM 22.1/tonne of $C0_2$)*	Additional tax component on energy *(FIM 2.1/MWh)*	Total additional tax	Ratio of $C0_2$ and energy components *%*
Gasoline, penni/l	5.25	1.85	7.1	74/26
Diesel oil, penni/l	5.77	2.04	7.8	74/26
Light fuel oil, penni/l	5.89	2.08	8.0	74/26
Heavy fuel oil, penni/kg	6.91	2.35	9.3	75/25
Coal, FIM/tonne	52.46	14.75	67.2	78/22
Natural gas, penni/m^3	4.37	2.08	6.5	66/34
Fuel peat, FIM/MWh	2.22	2.08	4.3	52/48
Nuclear power, penni/kWh	-	0.6	0.6	0/100
Hydro power, penni/kWh	-	0.2	0.2	0/100

Estimated revenues from the excise duty on fuels and energy products in 1994 were FIM 10.0 billion, representing 2% of GDP. The basic tax accounts for FIM 8.5 billion and the additional tax for 1.5 billion. About 60% of additional tax revenues come from the carbon dioxide component and 40% from the energy component. In 1995, revenues from the whole tax system are expected to amount to FIM 12.5 billion. Revenues from the environmentally based additional tax would then be FIM 2.5 billion, i.e. 0.5% of GDP.

Value added tax (VAT)

The normal tax rate for the VAT levied on products and services is 22%. A lower tax of 6% or 12% applies to certain commodities. The lower tax rates do not apply to fuels, electricity or heat, and these are subject to the full 22% tax. VAT is also levied on that part of the commodity's price made up of excise duty on fuels or energy sources.

Although the Finnish VAT system does not generally favour the consumption of energy, it does promote the use of some energy sources. A special tax deduction has been granted to wood- and peat-based biomass; the primary energy component of biomass is thereby tax-exempt at all stages of production and use. A similar reduction also applies to natural gas.

The Government has submitted a proposal to Parliament on amending the Value Added Tax Act. The aim is to make the Act comply with the Community regulations and the provisions of the EU. The amendment will remove the support given to natural gas and bioenergy through the value added tax system. The intention is to partly compensate for this in excise duty, as the EU has no provisions on environmentally motivated use of this tax. It is proposed that only 50% of the additional tax on natural gas based on carbon and energy content would be levied for a period of three years, starting from 1995. The plan is not to levy tax on the carbon content component of the additional tax in the case of slowly renewable biomass (peat) for the time being. The lower price competitiveness of wood-based biomass cannot be totally compensated for in this way, however. No tax in the form of excise duty is levied on wood-based fuels at the moment, so their relative position would only be improved in future if the taxes on fossil fuels could be raised further.

Contingency reserve charge

This charge is levied on certain commodities vital to maintaining supplies during an emergency, such as liquid fossil fuels. Revenues go into a special fund. The purpose of the charge is to transfer the costs accruing to the State from maintaining a contingency reserve for the economy as a whole to users of these commodities. The charge in 1994 was

4.3 penni/l for gasoline, 2.3 penni/l for diesel oil and light fuel oil and 1.9 penni/kg for heavy fuel oil.

Oil protection charge

An oil protection charge is levied on imports of oil. The charge depends on the safety category of the transport tanker. The charge in 1994 was FIM 2.2 per tonne of oil if the tanker had a double bottom, but was doubled if the vessel had only a single bottom. The charges are paid into a special fund, which is used to provide oil damage prevention and to compensate for the cost of such damage.

2.3.4 Energy conservation programme

In autumn 1992 the Finnish Government approved a separate energy conservation programme aimed at more efficient end use of energy in individual sectors; this would reduce specific consumption by 10-15% on the 1990 level by the year 2005. To back up the programme, a study was made of existing efficiency levels. Detailed technical and financial means of raising efficiency were sought in various use sectors, and an assessment was made of their economic and environment effects.

The term 'energy conservation' here means using energy more efficiently. The aim is to generate a given product, service or performance with a lower consumption of energy. The programme does not strive to influence the volume of output, living standards or the structures of production. Its targets concern more efficient energy use, i.e. a cut in specific consumption of energy, by the year 2005, as follows: building heating 10%, household electricity 15%, electricity in the tertiary sector 15%, industry 10% and transport and communications 10% (comparison year 1990).

The main action areas covered by the energy conservation programme are information, energy surveys and analyses, and commercialization and demonstration of new technologies. A special project organization, the energy conservation service centre MOTIVA, has been set up for the provision and dissemination of information and to develop new modes of operation. This organization is launching and carrying out information and energy survey programmes and promoting the introduction of new energy-efficient products and systems on the market. Energy awareness among consumers is being increased, e.g. by adopting a new 'energy label' for household appliances and by increasing the amount of feedback on energy consumption given on power invoices. The new energy label on appliances will be adopted early in 1995. Energy surveys by experts will aim to find and utilize energy conservation potential in SMEs and real estate.

Because of the cold climate, buildings in Finland have always been built to use energy efficiently. Finland has practically no need for air conditioning. Various forms of insulation and double glazing were already in use here in the 19th century. It was, however, the 1960s before the first really effective insulation was adopted, and the '70s before the first official regulations connected with energy economy were issued; these resulted in the widespread introduction of triple glazing and sufficiently thick insulation layers. After the 1973 energy crisis, a start was also made on improving the energy economy of the existing building stock, e.g. by making government grants for structural and mechanical improvements and by providing municipal advisory services on energy economy. Thanks to these measures, better information about energy conservation and other programmes, building-specific energy consumption has in fact fallen, and despite its cold climate Finland does not consume any more energy per cubic metre of space than many much warmer countries. In the '80s, stricter and more detailed requirements were laid down for new buildings, e.g. heat recovery was made compulsory in large ventilation units and the regulations on insulation were tightened. Ways of reducing consumption of heating in buildings by laying down temperature standards are being investigated, as is apartment-specific energy invoicing.

Various research programmes are studying possible ways of saving energy in households. Commercial exploitation of the findings of such research will be furthered by subsidizing demonstrations of new technology.

Implementation of the energy conservation programme presupposes that all spheres of government put it into effect. A special programme has been drafted for the public sector. Circles outside the State administration will be encouraged to commit themselves to the programme's targets - for instance, through energy conservation agreements. Such voluntary agreements have already been signed with industry and the municipal sector.

An important role in the success of the programme will be played by better methods of monitoring specific energy consumption. Systems have already been worked out for the energy-intensive pulp and paper industry and for the basic metal industry, and the first results are currently being assessed.

Various energy conservation measures have been initiated in 1994. The basic premise of the programme - more advanced energy taxation - has not made the hoped-for progress internationally speaking, however. Similarly, it does not look likely that the international community will start implementing energy and environment taxes very rapidly, at least in the near future. This could well reduce Finland's chance of achieving its goals.

2.3.5 More use of biofuels

In spring 1994, as part of its report to Parliament on energy policy, the Government decided on measures to promote the use of bioenergy. The aim is to increase use of bioenergy by at least a quarter on the present level by the year 2005. This target will mean raising consumption by 1.5 Mtoe from the present 5.1 Mtoe. About half of this increase will stem from wider use of rapidly renewable biofuels and about half from peat.

The biofuels concerned include wood, peat, agricultural biomass and biowaste. Various products can be made from these materials, such as charcoal, wood chips, sod peat, ethanol, rapeseed diesel oil and the gasoline additive ETBE.

Geologically, peat is not a fossil fuel, but rather a slowly renewable soil component made up of decomposed plants. Overall, more peat is produced in Finland than is used to produce energy.

The background report assessed the untapped potential for biofuels at around 7-8 Mtoe. However, the chances of actually exploiting this potential are much more limited. Considering economic viability and real government potential for promoting use of biofuels, the officially adopted target for extended use poses a challenge in terms of the correct allocation of government support, the development of technology, more extensive advisory services and guidance, and changes in the legislation.

2.3.6 Energy technology development programmes

To maintain a diversified energy production structure relying also on new technology and renewable energy sources, the Government promised in its report to Parliament to **provide more funding for the development of Finnish energy technology** by launching, financing and guiding research programmes and development and demonstration projects aimed at finding new solutions both for the home market and for export. Such programmes have actually been under way for several years now, and in 1993 the **Ministry of Trade and**

Industry launched new energy technology development programmes for 1993-1998.

(picture)

Eight national energy technology programmes for 1993-1998 are under way in cooperation with companies and other expert bodies. The main emphasis in these research programmes is on environmentally sustainable technologies. Aspects covered include the development of new combustion techniques and research aimed at increasing use of biofuels and other renewable energy sources and raising the efficiency of energy production. The programmes involve considerable international collaboration. The total funding input is around FIM 1,500 million.

2.3.7 Industrial advances

Environmental considerations will change the industry of the future. Gradually, the market will come to demand products and services that promote sustainable development. National aspects such as our own know-how and natural resource base will, however, continue to constitute their own restraints. The environmental viewpoint will be integrated into all Finnish technological research and its funding and permeate all development.

New products and new production technology will as a rule be more acceptable environmentally than their predecessors, because being environmentally sound is known to be a crucial element in quality and competitiveness. As there has been more funding of technology in the last few decades, this has also meant faster technological advances, and hence the faster adoption of less polluting technologies.

Social choices concerning energy production, environmental regulations and the traffic infrastructure are also shaping the structure of industry. If industry's investment choices are to be efficiently implemented, it is important for society's administrative and economic control systems to be consistent and to disturb the markets as little as possible. In future, industry will be relying on fields in which Finland has both know-how and natural resources.

Natural resources will be used more economically once industry acts on its own initiative to take environmental considerations into account, e.g. through internal eco-auditing and eco-management. In product development and the renewal of production processes, life-cycle thinking and life-cycle analysis will promote more economical use of raw materials. On the same principles, use of renewable materials will increase. Use of harmful substances will decrease and harmful emissions and wastes will also decline in volume.

The Environmental Impact Assessment (or EIA) Act, the revised Waste Act and the Eco-Audit system will work in practice to further the goals outlined above. Product life-cycle analyses, eco-labelling and voluntary eco-audits will all contribute to the same process. The aim is in fact to develop methods for reducing the environmental impact of industry and products on a basis of voluntary independent action.

2.3.8 Reducing the harmful environmental effects of traffic

Because of its small population and large area, Finland is a sparsely-populated country with long distances from place to place. We are also rather far away from our main markets. These factors, combined with the distinctive structure of industry, tend to increase traffic volumes and thus greenhouse gas emissions from traffic. The distances driven by heavy goods traffic are about double the European average, and though the actual car density is around the European average, people drive about one and a half times more kilometres.

As pointed out earlier, dealing with our unemployment problem calls for fast economic growth. Traffic volumes are bound up with economic development. If traffic and the greenhouse gas emissions it causes are not to increase in the '90s at the same rate as economic growth, there must be both structural changes and economic controls. By themselves, the technical means normally resorted to in order to eliminate the causes of environmental pollution are insufficient to reduce greenhouse gas emissions from traffic.

Since 1990, a rapid decrease has been achieved in emissions of nitrogen oxide, hydrocarbons and carbon monoxide by traffic, thanks to technical improvements and tax reliefs on cars with catalytic converters. Since the same year, Finland has also been applying US-standard exhaust gas limits to new cars.

Exhaust gas emissions from lorries and buses have also been cut rapidly in the last five years, in line with EU directives. The maximum nitrogen oxide emission permitted for new heavy diesel engines is only half what it was at the end of the '80s.

On the other hand, the adoption of catalytic converters in private cars will increase nitrous oxide emissions from traffic. Lambda-regulated exhaust gas control based on a stoichiometric fuel mixture has also reduced the potential for cutting fuel consumption.

Heavy lorries and buses are now required to have a speed limitation device which prevents them from travelling at very high speeds. This is expected to cut fuel consumption by about one per cent.

The Finnish tax on new cars has always been rather high by international standards. It has also acted to discourage the purchase of high-powered cars, though this might otherwise have seemed natural considering the long distances that have to be travelled. The high car tax has also helped to restrain growth in the overall number of cars.

The Finnish tax on traffic fuels is around the average West European level. At the moment, the tax on gasoline is slightly below the EU average, and that on diesel oil just above the EU minimum, though well below the average. The tax on both fuels has been raised sharply in recent years, and this, together with the recession in the early '90s, has halted growth in traffic volumes. The tax on gasoline will again be raised, by over 10%, as of the beginning of 1995.

The taxes on fuels are graduated according to environmental principles, and as a result reformulated gasoline has practically displaced the 'normal' grades. Very low sulphur (max. 0.005% S) diesel oil is also widely used for the same tax reasons. The change-over to reformulated gasoline rapidly reduced total CO and HC emissions from Finnish car traffic by 10-15%. The tax on fuel CO_2 and energy content is also levied on traffic fuels.

The other economic instruments used include subsidy for public transport (though this has had to be cut sharply in recent years), investments in upgrading the rail network, a reduction in the tax deductibility of business travel expenses and a cut in the transport subsidy granted to industry in developing areas.

The use of alternative gas fuels containing less carbon and of bioalcohols and rapeseed methyl esters as fuel has been studied and gas-powered lorries and buses have been developed as far as the production stage.

Emissions from trains have been reduced by electrifying rail traffic. This process and basic improvements continue.

In autumn 1994, the Ministry of Transport and Communications approved its own action programme to reduce the harmful environmental effects of traffic. This programme is based on the recommendations of the Second Parliamentary Traffic Committee. The 1993 Council of State decision-in-principle on improving the safety of road traffic includes measures in line with this programme. The primary target - of restraining traffic growth - is common to both lines of action.

The action programme proposes long-range goals and targets up to the year 2000, plus measures to achieve these goals so that they harmonize with Agenda 21, for instance. In the case of greenhouse gases, the aim is to promote attainment of the objectives of the Climate Convention.

The bodies responsible for implementing the programme are the Ministry of Transport and Communications and its subordinate agencies and public enterprises, the other ministries, local authorities, companies and organizations. Much of the programme is on a voluntary basis.

Most of the measures in the programme concern road traffic, because its environmental impact is on the whole more controllable than with other forms of transport. However, action is also proposed to reduce the environmental impact of rail, water and air traffic, and working machinery.

To ensure that traffic systems develop in a sustainable manner, it is proposed that traffic growth should be restrained through socially acceptable structural and financial means. Like the proposal of the Parliamentary Traffic Committee, this programme recommends that the necessary transportation should be provided efficiently and economically, while involving the minimal amount of traffic.

Economic controls will support the chosen social and traffic policy strategies. They will affect, for instance, trends in transport technology and fuels, use of means of transportation and location of functions. Planning of these measures will take the whole life cycle of traffic systems into account and the whole transportation chain, including related functions. The environmental impacts of building, managing and maintaining traffic systems will be assessed early enough in the planning system to allow the assessment to contribute to better solutions.

Cooperation between the various spheres of government will be increased, especially when measures are being harmonized, and in order to make research, monitoring, information and training more effective. Development of environmental technology in the traffic sector will be promoted.

The programme includes plenty of practical measures to reduce both greenhouse gas emissions and other environmental hazards. In terms of the FCCC, the most important measures are:

- maximum limits for greenhouse gases and other emissions coming into effect in the EU, or economic instruments will be adopted;
- the necessary national measures to promote the sale of low-consumption cars and to restrain traffic growth will be worked out, together with the effects on community structure and transport needs of possible taxation practices promoting the use of environmentally more acceptable cars, of the right to tax-deduct business travel expenses and of transport subsidies in developing areas: the necessary changes will then be made;
- the operating potential of public transport and non-vehicular traffic will be improved, for instance by improving the price and service competitiveness of public transport; to this end a working group has been set up to draw up a public transport programme;
- the competitiveness of rail traffic will be improved through cooperation between the State Railways and other interested parties, e.g. in physical planning, public transport system planning and improvement of the rail network;
- control of land use planning will pay special attention to changes in transport needs and choice of means of transport; new developments will be located in the areas best placed in terms of public transport services;
- pedestrian and cycle paths in town centres will be increased and parking arrangements planned so as to reduce traffic volumes,
- use of IT will be promoted as a replacement for physical traffic;
- projects promoting logical efficiency will be supported in order to reduce traffic growth;

- in transit traffic through Finland into Russia, efforts will be made to make the railways more competitive, e.g. by adjusting freight rates.

The economic instruments included in the programme will restrain growth in car traffic and speed up replacement of technology. The specific consumption of private cars can be cut about 20% by technical means if their fuel economy is improved or people start using lighter, lower-powered cars. In the 21st century, the specific consumption of new private cars could be very much lower, e.g. 5 l/100 km by 2005.

Land use planning, economic controls to back it up and improvements in the operating potential of public transport could reduce energy consumption 5-15% over the next 10 years. Over the longer term, the effects would be much greater.

As of 1995, in order to reduce other greenhouse gases from traffic, such as nitrogen oxide and hydrocarbon emissions, supervision of exhaust emissions from motor vehicles is being extended to include diesel-powered in addition to gasoline-powered cars. Research material will be produced to actively influence future EU rules on exhaust gases insofar as these deal with problems concerning cold starting and use.

Emissions from new working machinery and diesel trains will be reduced and electrification of rail traffic will continue. Efforts will be made to reduce nitrogen oxide emissions from ships' engines in international cooperation, so as to ensure that emissions from new engines are 30-40% lower than at present.

The future EU emission limits for aircraft will be put into effect. The adoption of landing charges graded according to the aircraft's environmental impact will be considered. In fuel distribution, recovery of VOCs in line with EU directives will be implemented. The use of cleaner fuels will be further promoted through economic instruments.

2.4 Estimate of future carbon dioxide emissions by the energy sector

Assessments of future energy consumption and emission trends are usually based on detailed economic and other social goals and analysis of the consequent energy demand. Assumptions also have to be drawn regarding energy production and consumption technology, the price of energy, and the quality and effectiveness of energy policy measures. The following presents an assessment of trends in energy sector CO_2 emissions up to the year 2010, based on general assumptions about economic and social development and taking the potential effect of the emission reduction programmes outlined earlier into account.

2.4.1 Trend according to the basic scenario

The basic scenario, which was drawn up in 1990, mainly depicts a course of events in which no special action is taken to influence developments. It is then assumed that the Finnish economy will develop in line with the growth targets set. GDP is expected to rise 95% between 1988 and 2025. The structure of the economy would then change slowly, as lower wood availability starts to limit the forest industry's growth potential, while the other sectors would expand appreciably.

It is assumed that the population structure will change as indicated by present birth and mortality rate trends. At the end of the period, the population would gradually start dropping from the present 5 million, reaching not quite 4.8 million by 2025. Even before this, an important factor holding back economic growth would be the decline in the number of people of working age. Even so, material well-being (i.e. GDP) per capita would be roughly double the present level by 2025.

New construction is expected to make the building stock more low-rise dominated. The size of homes will grow and per capita floor space (net) will rise from 35 m^2 to 50 m^2. The predominance of electric heating as the choice for new low-rise housing will continue. The specific consumption of heating systems will only improve insofar as recovery of free heat is successful (50%). The competitiveness of district heating will remain roughly unchanged.

The number of motor vehicles is expected to rise throughout the period, with the car stock increasing 65%, though total distances driven would rise less than 20%. In 2025, the number of motor vehicles would top 3.1 million, 2.1 million being cars. The basic scenario assumes that car fuel consumption in 2025 would average 7.5 l/100 km, and that the percentage of electric cars would hardly rise at all.

Industry expects its present production structure to remain the same. Timber consumption by the forest industry would rise about 50% between 1985 and 2025. No important sudden changes are likely in the world market for energy commodities. Prices are expected to rise steadily, reflecting the drain on energy resources. The availability of imported energy is expected to remain at least at the present level during the period reviewed.

The basic scenario embodies the key assumption that energy demand will not be manipulated more energetically than at present; on the other hand, present approaches such as investment subsidies and support for energy research will remain much at today's level. Energy taxation is also presumed to stay as it is now.

Technical improvements that reduce energy consumption would be adopted within a normal machinery and equipment replacement schedule. It is assumed that energy prices will have little influence on individual consumers' purchasing decisions and energy consumption habits.

In the basic scenario, CO_2 emissions from fossil fuel and peat without any special energy conservation action would be about 78 million CO_2 tonnes in 2000 and over 90 million tonnes in 2010. Energy consumption would thereafter rise at the same rate as economic growth and the structure of energy production would remain the same, meaning that a substantial proportion of the new electricity production capacity would be covered by increasing coal consumption. If electricity imports were abandoned once the present agreements end, this shortfall, too, would be compensated with coal-fired condensing power.

This scenario was, as noted, drawn up in 1990, and takes no account of the severe recession that came in the early '90s. CO_2 emissions so far this decade have in fact not followed its forecasts. The recession upset earlier patterns of dependency between energy consumption and economic growth. Contrary to expectations, total energy consumption did not rise, though neither did it fall because of the recession; instead, it remained roughly static in 1990-1992. As a result, CO_2 emissions in recent years have also remained much the same. However, this situation is not expected to continue. Energy consumption (30.8 Mtoe) already started rising in 1993, and was a good 2% higher than the year before.

Total output has been reduced most by the services and the home market industry, which make a large contribution to GDP but only account for a small share of energy consumption. In turn, the rise in total energy consumption was caused mainly by the rapid increase in energy-intensive export industry production. Use of energy increased in both the forest industry and the chemicals industry.

The fast growth in exports in the last couple of years is gradually yielding an upturn in GDP, but overall energy consumption and use of electricity actually started rising earlier, as a result of the upswing in export industry output. This rise is expected to continue in the near future.

Electricity consumption did not in fact reflect the decline in total output, unlike the trend in the '80s, but after a slight fall started rising again. Electricity consumption in 1993 was 65.6 TWh, up 4% on the previous year. Electricity consumption by industry as a whole rose a good 7%, and by nearly 9% in the forest industry. Another factor, apart from economic growth, likely to increase electricity consumption in the next few years is the structure of the economy, which will continue to be dominated by energy-intensive sectors throughout the '90s.

2.4.2 Effect of action programmes on carbon dioxide emissions

Figure 9 surveys the effect of the measures outlined above on CO_2 emissions from energy production and consumption up to the year 2010. In the most likely option, emissions in both 2000 and 2010 would be 69 million tonnes. This option takes account of cuts brought about by energy taxation, energy conservation, more use of bioenergy and the adoption of new technology. Depending on arrangements concerning the base-load capacity and the amount of electricity imported, annual CO_2 emissions could well decline further, reaching some 65 million tonnes in 2000 and about 64 million in 2010.

Effect of energy taxation on CO_2 emissions

Boosting the price of carbon-based fuels by raising the tax on them will make them less competitive and encourage the energy industry to develop new production methods based on renewable fuels. Because the energy industry is rather slow to change, taxation will only take effect gradually, and it will only be possible to point to distinct effects over a 10-20 year period.

Energy taxation also means that rising energy prices will motivate more efficient use of energy and make previously non-viable energy conservation investments more attractive. Thus the total amount of energy used would be lower than in the situation without taxation.

The effects of the CO_2 tax depend on several component factors which are not sure to materialize. They include the overall scale on which an energy tax is adopted internationally and how the tax revenues in different countries are used or consumers compensated, and also whether the system allows for many exceptions. The question of whether more nuclear power plants are built will also greatly influence developments.

The CO_2-based energy tax currently levied in Finland is expected to reduce CO_2 emissions about 4-5% by the year 2000, i.e. by 2 million tonnes, if it proves possible to pursue this policy consistently. In 2010 the reduction would already be in the 10% class. This estimate is based on a substantial increase in the price of carbon-based fuels by the year 2000 through a tax applied internationally.

Effect of the energy conservation programme on CO_2 emissions

The aims of the energy conservation programme up to the year 2005 are to reduce electricity consumption by 5.2 TWh and consumption of primary energy by 2.8 Mtoe compared with a no-action situation. This would mean a cut of some 6-8 million tonnes of CO_2 by the year 2000, though with the provision of a gradually rising energy tax. By 2005, the effect of the present programme would be a cut of around 9 million tonnes.

The additional investments in the energy economy called for by the most efficient modern technology would be a good FIM 2 billion a year. If more efficient techniques were also adopted in space heating, the annual additional investment would be close to FIM 8 billion. This comes pretty close to Finland's annual bill for imported energy (FIM 11 billion). It is therefore obvious that these investments cannot be realized very rapidly, and time must be allowed for creating the technical potential for emission cuts.

The estimates made of the reductions in emissions that can be achieved through energy taxation and energy conservation overlap to some extent.

Effect of wider use of bioenergy on CO_2 emissions

More extensive use of wood under the programme to promote use of biofuels will help to achieve the CO_2 reduction targets. By 2000, it would cut about 3 million tonnes (6-7%) off total emissions at installations where wood replaced coal.

Further use of peat, where emissions are already included in the total, will also replace coal, so here the effect will be unchanged. Emissions from peat extraction can be reduced through careful choice and post-management of extraction sites.

More advanced technology to reduce CO_2 emissions

Intensive investment in research, test and demonstration projects concerning new technologies has already yielded solutions, some of which are commercially competitive already, and will continue to do so. As energy taxation gradually alters relative fuel prices, new techniques will come onto the market.

Natural gas is already utilized in CHP production. This 'backpressure production' is economically viable where gas remains available at the current price. Achieving real potential for emission cuts would mean extending the natural gas network.

A large proportion of the hydro power potential as yet unbuilt cannot be commercially exploited for environmental reasons. It is, however, to some extent possible to build small hydro power plants, and to modernize or add generating units to existing ones.

The biggest potential user of bioenergy is the forest industry, which already accounts for the bulk of total bioenergy consumption. The preconditions for more extensive use are competitively-priced wood, integrated harvesting methods for both wood raw material and firewood, and new power plant technologies. If the new techniques work in practice, they will reduce emissions substantially, but not until around 2010. The plants are combination utilities based on pressurized gasification, using waste wood as the energy source. The first power plants based on gasification of black liquor could well go on stream around the year 2005, when their heat load would be utilized by solid fuel gasification plants.

Coal gasification techniques are also being developed to increase electricity generation at CHP plants even if no additional heat is needed. The same amount of fuel would then yield more energy.

Overall, the cut in emissions permitted by new technologies ranges from 1 to 5 million tonnes of CO_2 in 2000, while the variation in 2010 could be as great as 5-15 million tonnes, or even higher. Some of the technology development measures are the same as have been adopted under the bioenergy promotion programme and the energy conservation programme.

Of all the individual technical means available, more use of nuclear power in separate electricity production would actually be the most effective means of reducing CO_2 emissions. However, as Parliament has decided against a fifth nuclear power plant, no additional nuclear power is likely to be generated in Finland on a time scale that would influence the situation in the year 2000.

Electricity production capacity choices and the importance of imported electricity for CO_2 emissions

In the next few years, Finland must decide how it is going to produce the base-load capacity needed. Some of the capacity needed up to the year 2000 will possibly be covered with CHP production in towns and industry, a small amount by more hydro power, and some by wind power. The rest will be covered by wider use of bioenergy and natural gas, and finally possibly through coal-fired utilities. Depending on the choices, CO_2 emissions in 2000 will vary by some 3-4 million tonnes.

The Government has placed a bill before Parliament for an Electricity Markets Act. This is designed to improve the functioning of the electricity market, ensuring that the overall system of Finnish electricity generation, transmission and distribution remains efficient and competitive in future. It also aims to prepare the Finnish electricity market for integrating Nordic markets and any European markets that may open up. The reform would reduce obstacles to competition and eliminate unnecessary regulation in the part of the market where competition is possible, i.e. in the production and sale of and foreign trade in electricity.

The reform would improve market access in the case of renewable energy. The present status of this bill means that it is difficult to estimate exactly what the structure of our electricity production capacity will be in future, or the amount of electricity that will be imported.

Finland has consistently imported over 10% of the electricity it needs from Russia, Sweden and Norway. In 1990, the figure was 17% of the total, and if this had been produced in Finland, resulting CO_2 emissions would have been 11 million tonnes. Current import agreements come to an end in the late '90s or early next century. There are major uncertainties and conditions attached to merely continuing with the present level of imports, not to mention raising it. As a result, the calculations allow for the construction of Finnish electricity production capacity to replace current imports. This also results in some uncertainty about CO_2 emission trends.

3. FORESTRY AND CHANGES IN LAND USE

3.1 Carbon reservoirs in the forest ecosystem

The Finnish national well-being is largely based on export revenues from the forest industry. We have purposefully aimed at augmenting our forest resources and ensuring their sustainable use. Private individuals own about two thirds of the forested land area. Sustainable use of these resources is based on legislation, supervision, resource inventories, forestry plans and advisory services. To a large extent, corresponding procedures also apply to state- and company-owned forests. This ensures that fellings cannot exceed the sustainable harvesting plan or endanger yield. Regional forestry planning supports the management and use of about 430,000 privately-owned woodlots in terms of timber yield, and nowadays also in terms of the various objectives of environmental protection and multiple-use forestry.

Sustainable forestry involves systematic national inventory of forest resources, including surveillance of the state of the forest environment. Forest inventories are carried out at 8 to 10 year intervals, and we have a good view about how the forests are developing. The growing stock in Finnish forests is now the largest since 1917, when inventories started, and the growth-boosting effect of efficient silviculture, drainage and forest improvement in areas of low yield will continue for a long time to come. Although the structure of wood use has changed, volumes have remained largely at the same level.

From the point of view of preventing climate change, forestry aiming at maximum wood yield means that the Finnish forests have sequestrated more and more carbon from the atmosphere. In 1990, the amount of carbon stored in the Finnish forest ecosystem was 2,700 million tonnes. Of that, trees, including roots and branches, accounted for an estimated 660 million tonnes. Above-ground wood biomass contained 500 million tonnes of carbon. However, most of the carbon, i.e. over 2,000 million tonnes, is stored in the ground in litter, humus and soil organic matter.

The amount of carbon in the entire forest ecosystem and the proportion in stemwood is expected to grow at least for the next 15-20 years. It has been estimated that if the use of wood remains at the present level, forest resources will grow at least until the year 2030. Forests are a long-term carbon reservoir under forestry practices, since the length of rotation in commercial forestry is 60-120 years depending on the species, site and geographical location.

Existing nature reserves (approximately 1.3 million hectares) and the areas in Lapland protected through the Wilderness Act (approximately 1.4 million hectares), which together cover about 8% of the country's land area, comprise a substantial volume of forest functioning as a stable carbon reservoir. These forests mostly comprise old trees that have finished or are about to finish growth, but in any case, they form a stable carbon reservoir.

More extensive use of wood in building and more extensive production of building materials from wood has been investigated in Finland. Owing to the long life cycle of wooden buildings, building materials and furniture, greater use of wood in this respect would not mean a significant increase in CO_2 emissions, but rather a long-term carbon sequestration.

Forest fires are rare and very limited in Finland due to dense coverage of the forestry road network and efficient fire prevention. This implies that only small amounts of carbon is emitted from the forest ecosystem into the atmosphere through fires, contrary to the situation in a large part of the boreal coniferous forest zone in general.

Most of the wood raw material is used by the pulp and paper industry, a smaller share going to sawmills and other mechanical wood-processing plants. The life cycles of mechanical wood-processing industry products are substantially longer than in the paper industry. Although most of the production based emissions occur in Finland, a high proportion of the products are exported (approximately 80%)and the carbon is released into the atmosphere outside Finland.

Due to the production structure and the use of wood raw material in the forest industry, about 6.6 million tonnes of carbon per year was bound in the products at the end of the 1980s. The carbon in the wood raw material amounted to 9.9 Mt C/a, and 3.3 Mt C/a was released during the production process in the form of burned by-products.

Carbon is also stored in the peat in Finnish mires. Peat is incompletely decomposed plant matter with high carbon concentration. The estimated amount of carbon in the peat of Finnish mires is 6,300 Mt. There are still about four million hectares of mires in their natural state, and an estimated 0.4-2.0 Mt of carbon accumulate in them annually.

On the other hand, methane is released into the atmosphere from natural mires; estimates on the amount vary widely, from 0.05 to 2.4 Mt.

Drainage and forest improvement have affected the carbon balance of peatland forests. Since the beginning of the 1950s, about 6 million hectares of mires have been drained for forestry and about 0.7 million hectares for agriculture. As a result, tree growth has improved in most of the drained areas, increasing the amount of carbon stored in the trees as can be seen in forestry statistics illustrating the development of the growing stock. When the peat layer in the drained areas begins to thin out, the resulting decomposition releases CO_2 into the atmosphere. Methane emissions, on the other hand, seem to diminish.

In terms of the national carbon balance of drained mires, the important factor is whether the enhanced tree growth is able to compensate for the emissions from the decaying peat layer. Reliable emission estimates are lacking yet. It is estimated that in about 10% of the drained areas, i.e. 500,000 hectares, draining has not resulted in the desired increase in forest growth. According to the present criteria, it is not feasible to maintain these non-viable areas in a productive condition; rather, it is more reasonable to let them return to the natural state, also from the nature conservation point of view. The extent of new areas drained annually has declined substantially throughout the '90s, and the CO_2 emissions from drained mires will, in any case, decrease.

In fields drained for agricultural use, carbon emissions from decaying peat exceeds the carbon uptake of the cultivated plants, resulting in carbon flow from the field into the atmosphere. According to estimates, 0.2-0.4 million hectares of mires drained for agricultural use are cultivated peatlands in which decomposition of peat and emission of CO_2 are still continuing.

3.2 Programmes affecting forestry

3.2.1 The Forest 2000 Programme

Use of forests and the required forestry activities in Finland are outlined in the Forest 2000 programme. This programme assesses the development and use of forest resources and the factors affecting them, such as air pollution, the consideration of nature conservation objectives in forestry, and the multiple-use of forests. Finnish Forest Research Institute has dated forest inventory results and estimated felling potentials and trends. If fellings remain at the level of the late 1980s, i.e. about 50 million m^3 per year, Finland's forest resources could be doubled by 2030. This would gradually result in over-stocked and over-mature forests with degenerated growth.

According to the Forest 2000 programme, fellings are most likely to increase up to 60 million m^3 by the year 2000 and up to 70 million m^3 by 2010. Despite this increase, forest resources could grow by a third by the year 2030. The use of forest resources of this extent allows to keep the forests in good productive condition under sustainable forestry concept. Nature conservation considerations can also be taken into account. The anticipated increase in the use of wood presupposes new investments in the forest industry or a substantial increase in the use of wood in energy production.

3.2.2 Forestry Environmental Programme

In July 1994, the Ministry of Agriculture and Forestry and the Ministry of the Environment jointly confirmed the Forestry Environmental Programme as Finland's strategy for sustainable forestry for the near future. The programme especially emphasizes the protection of biodiversity in the forests, but the target state of the forests for 2005 also implies that they are managed and used as efficiently as possible, and that trees grow well, ensuring that the forest effectively sequestrates CO_2 from the atmosphere, mitigating climate change. The programme also acknowledges that maintaining tree growth and uptake of CO_2 is both a long- and a short-term prerequisite if Finland is to be able to fulfil its obligations under the FCCC.

The Forestry Environmental Programme, with its emphasis on nature-related, environmental and multiple-use considerations in commercially exploited forests, will mean that some 5-10 million m^3 of the total annual increment is left unused.

3.3 Emissions and sinks deriving from forestry and changes in land use

As commissioned by the Ministry of Agriculture and Forestry, the University of Joensuu has made an inventory of emissions and sinks deriving from changes in land use and forestry according to IPCC guidelines.

Greenhouse gas emissions of land use changes and forestry have been divided into forest clearing, conversion of grasslands into cultivated lands, use of managed forests, and the restoration of managed land (i.e. land previously used for agriculture) to the natural state. In Finland, as in most industrialized countries, use of wood from managed forests is the most important category for emissions and sinks.

The assessment is based on the national forest inventories made by the Finnish Forest Research Institute and on the statistics of use of wood. Estimates for annual increment and total drain (industrial use, fuelwood, logging and silvicultural waste, natural mortality) are based on the statistics from the periods 1965-1969, 1970-1974, 1975-1979, 1980-1984 and 1985-1989. Two different future trend estimates, or scenarios, have also been made for the years 2000 and 2010.

The first scenario assumes that the use of wood will remain at the present level, i.e. at about 50 million m^3/a. This can be regarded as a sort of 'minimum wood use' scenario. The second scenario, for increased wood use, is based on the assumption that the wood processing industry will continue to grow and that the chemical wood-processing industry will continue to be a major element in maintaining economic growth. Under this scenario industry's demand for wood will be 62 million m^3 in 2000. Domestic wood will account then for 56.5 million m^3; in 2010, the figure will be 66 million m^3, with domestic wood at 61.5 million m^3. This scenario is compatible with the basic scenario for energy consumption discussed in section 2.4.1 above, and can well be considered the most likely alternative.

Table 7. Carbon balance and reservoir in the total wood biomass in managed forests in 1970, 1980 and 1990, and estimates for 2000 and 2010, according to two wood use scenarios.

				Unchanged use scenario		Increased use scenario	
	1970	1980	1990	2000	2010	2000	2010
Carbon sequestration, Mt C/a	20.6	24.8	28.0	31.7	35.1	31.2	32.9
Carbon emission, Mt C/a	20.0	17.6	19.6	20.7	20.9	24.7	26.5
Annual sink, Mt C/a	0.5	7.2	8.3	11.0	14.2	6.4	6.4
Annual sink, Mt CO_2/a	2.0	26.3	30.6	40.4	51.9	23.5	23.5
Carbon reservoir, Mt C	529	584	660	789	916	718	776

From 1970 to 1990, the carbon reservoir in the wood biomass of the forests rose by about a fifth (Table 7). The annual sink increased about fifteen fold during the same period. The main reason for this is increased growth, while use of wood has remained almost the same, despite structural changes. The substantial increase in the carbon reservoir and sink over the years is the result of efficient forest management, and partly also because of the increase in area of productive forest land. However wood growth may have increased by the higher atmospheric CO_2 concentrations and by nitrogen depositions deriving from air pollutants, which have sofar a fertilizing effect on the forests.

Development of the carbon sink in future is largely dependent on wood use. If wood use remains at about the present level, the carbon reservoir and annual sinks will continue to grow substantially. The increased wood use scenario, however, indicates an annual sink of about 23 million tonnes of CO_2 for 2000 and 2010, which is 7 Mt less than in 1990. But even under this scenario, the carbon reservoir in stemwood, branches and roots in 2000 and 2010 is substantially bigger than in 1990. The possible effects of climate change on forest growth have not been included in these estimates for 2000 and 2010.

4. EMISSIONS FROM AGRICULTURE

Nine per cent of Finland's land area is cultivated. In practice, no new arable land is being cleared any more. Agricultural production in Finland is mainly based on livestock, and over 80% of the arable land area is under grass, silage and fodder cereal production. The most important harmful environmental impacts caused by agriculture are increased leaching of nutrients into water systems, and ammonia, methane and nitrous oxide emissions into the atmosphere. Up to now, environmental protection in agriculture has mainly taken the form of voluntary measures by farmers, and there has been no specific environmental legislation concerning agriculture, apart from the prohibition on pollution in the Water Act. Improved cattle sheds and better manure handling have succeeded in reducing methane emissions somewhat.

In the autumn of 1992, the Ministry of Agriculture and Forestry and the Ministry of the Environment ratified the Rural Environment Programme aimed at combining the attempts made by the authorities and agricultural producers to reduce the harmful effects of agriculture. Promoting the good agri-environmental practise is the essential part of this programme.

One element in Finnish accession to the European Union is the development of an agri-environmental support programme. The programme will not only promote measures to improve water protection but also make for more efficient use of chemical fertilizers and manure so as to reduce emissions of methane and nitrous oxide into the atmosphere.

The methane emissions from agriculture mainly derive from the digestive processes and manure of domestic animals. Methane emissions from livestock digestion have been estimated in accordance with the method suggested by the OECD (Estimation of greenhouse gas emissions and sinks. Final report from the OECD experts' meeting 18-21 February, 1991). Emissions from manure have also been estimated using the method recommended by the OECD and taking the latest published research results into account. Emission trends up to 2010 have also been estimated.

These emission trend estimates are based on the assumption that the number of livestock will remain at the present level, although the size of stocks may grow. Adjustments called for by EU membership make smallholdings less profitable, and the size of farms will grow. Investments will increase and the sludge method will gain popularity in manure handling, meaning that 50% of cow and 80% of pig manure will be handled in sludge form. These changes will increase emissions.

Table 8. Methane emissions from agriculture in 1990, and estimates for 2000 and 2010.

Emission category	Emissions in 1990 kt CH_4	Estimate for 2000 kt CH_4	Estimate for 2010 kt CH_4
Digestion of domestic animals	83	83	83
Manure of domestic animals	11	15	15
TOTAL	94	98	98

Nitrous oxide is formed in the ground and in water bodies through biological processes. Human activities affect emissions mainly by changing the natural circulation of nitrogen. Such activities include changes in land use and added nitrogen load on the soil. In Finland, the most important factor is added nitrogen load (use of chemical fertilizers, waste sludge and manure on the fields). The nitrogen load on the soil is further increased by nitrogen deposition caused by anthropogenic nitrogen oxide and ammonia emissions. The estimate is that nitrogen deposition is causing an annual nitrous oxide emission of about 2,000 tonnes in Finland. The formation of nitrous oxide and its release into the atmosphere stem from numerous factors, and estimates are as yet very uncertain.

Agriculture's nitrous oxide emissions have been estimated for 1990 and the future trend for the years 2000 and 2010 (Table 9). The estimate assumes that the total arable area will remain the same throughout the period, but that grain growing will decline by 20%, while grass cultivation increases by the same amount. The use of chemical fertilizer is estimated to remain at the present level, and no major changes are expected in the volumes of sludge spread over the fields. According to the estimate, no major changes will occur in agriculture's nitrous oxide emissions in the near future.

Table 9. Nitrous oxide emissions from agriculture in 1990, and estimates for 2000 and 2010.

Emission category	Emissions in 1990 kt N_2O	Estimate for 2000 kt N_2O	Estimate for 2010 kt N_2O
Arable land	6	5	5
Artificial fertilizers	4	4	4
Manure of domestic animals	2	2	2
Waste sludge	0.1	0.1	0.1
TOTAL	12	11	11

5. EMISSIONS FROM WASTE MANAGEMENT

The annual amount of community waste produced in Finland is over three million tonnes. About 2.5 million tonnes is dumped in landfills, the rest being burned or recovered.

The disintegration of organic matter in oxygen-free conditions generates methane emissions into the atmosphere. These emissions have been estimated using the method recommended by the OECD, excluding recovery and burning of landfill methane, which as yet is only on a minor scale. The estimate merely includes emissions deriving from community waste dumped in landfills.

In 1990, the volume of community waste water was around 560 million m^3. In Finland, as in most industrialized countries, waste waters are treated in aerobic conditions, when methane emissions are low. The annual methane emission estimate is 7000 tonnes. Methane emissions from industrial effluents in 1990 are estimated at 27,000 tonnes.

An estimate indicating the trends in methane emissions from waste handling by the year 2010 has also been made. In 1990, Finland had 680 active landfills, and about 1000 had been closed. The waste management development programme calls for a rigorous reduction in the number of landfills with the aim of a mere 200 landfills in the year 2000. By reducing the number, it will be possible to put more effort and resources in management and supervision of the existing landfills, and thus reduce their harmful environmental effects. Another aim is to reduce the volume of waste dumped in landfills. The estimate is that in 2000 the present amount of community waste will still be produced, but the volume dumped at landfills will go down from the present 2.5 million tonnes to 1.4 million tonnes. This reduction will be achieved by increasing the level of recovery and reuse of waste, and through efficient waste disposal utilities.

Like emissions in the reference year, the methane emissions for the emission trend estimate have been calculated from the waste volumes stated in the waste management development programme. After 2000, emissions are expected to remain at the same level. No major changes affecting methane emissions in any way are expected in waste water management.

According to the estimate, methane emissions from landfills will fall substantially in the near future. According to the basic scenario, emissions in 2000 will be around 59,000 tonnes, compared with about 105,000 tonnes in 1990.

Table 10. Methane emissions from waste management in 1990, and estimates for 2000 and 2010.

Emission category	Emissions in 1990 kt CH_4	Estimate for 2000 kt CH_4	Estimate for 2010 kt CH_4
Landfills	105	59	59
Community waste waters	7	7	7
Industrial waste waters	27	27	25
TOTAL	139	93	91

6. EMISSIONS AND SINKS BY GAS 1990-2010

6.1 Carbon dioxide

The most important factors affecting CO_2 emissions and sinks in Finland are CO_2 from energy production and consumption, release of carbon from use of forests, and binding of CO_2 in forest growth.

The most important source of CO_2 emissions is energy production using fossil fuels and peat. Burning of biomass also releases substantial amounts of CO_2, but that is included in the carbon balance of forest use discussed below. In 1990, the carbon emissions from the burning of fossil fuels and peat were 53 million tonnes CO_2 (Table 11). According to the most probable prognosis, CO_2 emissions from the energy sector will keep on growing, reaching the 69 million tonne level by the year 2000. After that, measures to reduce emissions would begin to have an effect and further growth would be halted, remaining at the same level in 2010. The CO_2 emissions from industrial processes were about 1.2 million tonnes in 1990, and are expected to remain at that level in the future, too.

Finland imports over 10% of its electricity from Russia, Sweden and Norway. In 1990, the figure was 17%; produced in Finland, this would have generated 11 million tonnes of CO_2 emissions. The present agreements expire at the end of the '90s, and any extension as such, let alone any increase in volumes, is uncertain and subject to conditions. This also causes some uncertainty in emission prognoses. In the estimates for 2000 and 2010 it is assumed that all the electricity used in Finland will also be produced here.

Table 11. CO_2 emissions from energy production and industry in 1990, and estimates for 2000 and 2010.

Source	Emissions in 1990 Mt CO_2	Estimate for 2000 Mt CO_2	Estimate for 2010 Mt CO_2
Fossil fuels and peat	53	69	69
Industrial processes	1.2	1.2	1.2
Emission equivalent to imported electricity	11	-	-

The net sink of the forests in 1990 is estimated at 31 million tonnes CO_2 (Table 12). If the use of forests remains at the 1990 level, the net forest sink will be around 40 million tonnes in 2000 and 52 million tonnes in 2010. Increased use of the forests could, however, reduce the sink to a mere 23 million tonnes in both 2000 and 2010. The carbon reservoir in the forests will nonetheless continue to grow up to 2000 and 2010, even according to the increased wood use scenario.

CO_2 bound in forest growth and released as a result of felling is the most important and best known factor in the CO_2 balance. In Finland, draining of mires has also contributed to the total balance. Over most of the 5 million hectares of drained mires, added tree growth has resulted in added a further reservoir of CO_2. The estimate is that the annual increment in forest growth caused by drainage is about 10 million m^3, i.e. about 15% of the total growth.

Over about 10% of the drained areas, however, drainage has not brought about the desired results. The net emission from such non-viable drained areas is estimated at 1-5 million tonnes of CO_2 in 1990. It is not economically feasible to maintain these areas in a condition fit for forest growth, and it is more reasonable to let them return to a natural state. Once in the natural state, CO_2 emissions from these areas will stop, and they will eventually start to absorb carbon again.

About 0.7 million hectares of peatland have been drained for agricultural use. Some 0.3-0.4 million hectares of this area are counted as cultivated peatland where the peat is still disintegrating and CO_2 is emitted into the air. In 1990, this emission is estimated at 3-10 million tonnes CO_2. The area covered by cultivated peatlands is decreasing, and at the moment about 100,000 hectares are out of use. If these fields are reforested or paludified, CO_2 emissions will decrease and the areas will again begin to absorb carbon.

There are many significant uncertainties still associated with the greenhouse gas balances of peatlands and mires.

Table 12. CO_2 emissions (+) and sinks (-) associated with land use changes and forestry, together with carbon reservoirs in wood biomass in 1990, with estimates for 2000 and 2010.

	Emission/sink in 1990 Mt CO_2	Estimate for 2000 Mt CO_2	Estimate for 2010 Mt CO_2
Forest sink	-31	-23-40	-23--52
Cultivated peatland emission	+3-+10	+1-+3	+1-+3
Emission from non-viable drainage areas	+1-+5	0-+3	0
Mt C			
Forest carbon reservoir	660	720-790	780-920

6.2 Methane

Finnish methane emissions in 1990 were about 250,000 tonnes (Table 13). The most significant sources were landfills (about 100,000 tonnes) and agriculture (about 90,000 tonnes). Moreover, about 20,000 tonnes methane is released from combustion and about 30,000 tonnes from waste water treatment. The estimates are highly uncertain. Trends in methane emissions will be determined by developments in agricultural production and waste volumes, and small-scale use of bioenergy. Finnish methane emissions will probably decline in the future.

Emission from landfills, energy production and traffic will decrease owing to changes in volume and technology already decided on and partly realized. The impact of these changes on emissions in 2010 is shown in the estimate below. Ways of reducing methane emissions further by different methods look promising and as much as a 50% reduction in total emissions is possible by the year 2010.

Table 13. Finnish methane emissions in 1990, and estimates for 2000 and 2010.

Emission category	Emissions in 1990 kt CH_4	Estimate for 2000 kt CH_4	Estimate for 2010 kt CH_4
Energy production and consumption	19	13	13
Agriculture	94	98	98
Landfills	105	59	59
Waste water	34	34	32
TOTAL	252	204	202

6.3 Nitrous oxide

Finnish nitrous oxide emissions totalled about 20,000 tonnes in 1990 (Table 14), and the trend is rising. Emissions from arable land are not expected to grow, but those from energy production and transportation will. The increasing use of fluidized bed boilers in energy production and the growing number of cars with catalytic converters will add to emissions. The calculation assumes that no new advances that might reduce nitrous oxide emissions take place in fluidized bed combustion or catalytic converter technology.

Table 14. Nitrous oxide emissions in Finland in 1990, and estimates for 2000 and 2010.

Emission category	Emissions in 1990 kt N_2O	Estimate for 2000 kt N_2O	Estimate for 2010 kt N_2O
Energy production and consumption and industry	11	17	18
Agriculture	12	11	11
TOTAL	23	28	29

6.4 Nitrogen oxide

Nitrogen oxide emissions in Finland totalled 295,000 tonnes NO_2 in 1990. Of this, 55% originated from traffic and the rest mainly from energy production. Only some 4000 tonnes is released in industry from sources other than energy production.

Finland signed the Protocol on Reduction of Nitrogen Oxides Emissions in Sofia under the auspices of the UN-ECE in 1988. The parties to the Protocol undertook to keep their emissions of nitrogen oxides and their transboundary fluxes after 1994 at or below the level in 1987.

In addition to the actual Protocol, 12 nations, including Finland, signed the declaration, according to which the signatories will strive to reduce their nitrogen oxide emissions by about 30% by 1998 at the latest.

The maximum permitted levels for exhaust gases from motor vehicles laid down in a Government decision-in-principle in 1988 mean that emissions of nitrogen oxides, hydrocarbons and carbon monoxide from new cars will drop by 80-90%. As a result, nitrogen oxide emissions from traffic have already dropped during the early '90s. By 2000, the decrease is expected to be 30%.

In 1989, a commission set up by the Ministry of the Environment prepared a Finnish programme for reducing nitrogen oxide emissions. The commission stated that a 15% reduction on the 1997 emission level could be achieved by the year 2000 if new combustion technology was adopted in new and existing plants, flue gas scrubbing in new plants, new techniques in heavy diesel engines, and catalytic converters in new gasoline engines. These measures would make it possible to cut emissions down to 228,000 tonnes by the year 2000 and to 200,000 tonnes by 2010 (Table 15).

Table 15. Nitrogen oxide emissions in 1990, and estimates for 2000 and 2010.

Emission category	Emissions in 1990 kt NO_2	Estimate for 2000 kt NO_2	Estimate for 2010 kt NO_2
Energy production and industry	135	104	108
Traffic	160	124	92
TOTAL	295	228	200

6.5 Carbon monoxide

Carbon monoxide emissions totalled 487,000 tonnes in 1990, with traffic accounting for 75%. The largest source of emissions is road traffic, where developments will have a decisive impact on the overall trend in these emissions. Measures taken to reduce emissions include improving engine technology, adopting catalytic converters and changing the composition of fuel. As a result of these measures, carbon monoxide emissions from traffic will take a downward turn during the 1990s. The estimate is that carbon monoxide emissions from road traffic will fall to 220,000 tonnes by the year 2000 and to 190,000 tonnes by 2010.

Table 16. Carbon monoxide emissions in Finland in 1990, and estimates for 2000 and 2010.

Source	Emissions in 1990 kt CO	Estimate for 2000 kt CO	Estimate for 2010 kt CO
Energy production and consumption	116	116	116
Stationary sources	368	220	190
Traffic			
Industry	3	3	3
TOTAL	487	339	309

6.6 NMVOC

Anthropogenic NMVOC emissions totalled 232,000 tonnes in 1990. The largest sources were energy production and industrial use of solvents.

Table 17. NMVOC emissions in Finland in 1990.

Source	Emissions in 1990 kt NMVOC
Energy production	
Stationary sources	63
Traffic	79
Fugitive emissions	14
Industrial processes	15
Use of solvents	48
TOTAL	219

In 1991, Finland signed the Protocol on Control of Volatile Organic Compounds under the auspices of the UN/ECE. In this protocol Finland undertook to reduce its annual emissions of NMVOCs by at least 30% on the 1988 level by 1999.

A reduction of about 35% in NMVOC emissions will be achieved as a consequence of decisions already taken or measures most probably to be implemented, including tighter limits for emissions from petrol-driven cars, further reductions at plants required to notify their emissions, and the adoption of more environmentally sound products to replace the more harmful ones. The recovery of gasoline vapours from distribution systems has also begun. Compared with the 1988 level, emissions from stationary sources will decrease by about 25% and those from traffic by about 40% by the year 2000. Total emissions of NMVOCs at that time would thus be 140,000 tonnes.

6.7 Summary of greenhouse gas emissions in 1990, 2000 and 2010

Table 18 is a summary of greenhouse gas emissions in Finland in 1990 and estimates on trends for 2000 and 2010.

The CO_2 emissions from Finnish energy production and consumption can be reduced in future by the measures outlined above. Nevertheless, emissions will probably grow from 1990 to 2000, partly because of the assumption that all electricity used here will also be produced in Finland in future.

Estimates of biospheric emissions are still very uncertain, but emissions due to disintegration of peat in cultivated peatlands and non-viable drainage areas will probably decrease in future.

Table 18. Finnish greenhouse gas emissions in CO_2 equivalents in 1990, and estimates for 2000 and 2010.

Gas	GWP integrated over 100 years	Emissions in 1990 CO_2 Equivalent Mt	Emission estimates in 2000 CO_2 Equivalent Mt	Emission estimates in 2010 CO_2 Equivalent Mt
CO_2	1	58-69	71-76	71-73
CH_4	24.5	6.2	5.0	4.9
N_2O	320	7.4	9.0	9.3
NO_x	40	11.8	9.1	8.0
CO	3	1.5	1.0	0.9
NMVOC	11	2.4	1.5	1.5
Total		87-98	97-102	96-98

7. INTERNATIONAL COOPERATION IN FUNDING AND TECHNOLOGY TRANSFER

7.1 Developing countries

Finland has been implementing development aid programmes financed out of public funds for nearly thirty years. In 1991 we reached the quantitative target of 0.7% of GDP recommended by the UN. Irrespective of some recent decline owing to the extensive savings measures called for by the state of the country's economy, the level of assistance is still above the OECD average. The Government has announced its intention to restore the level to 0.7% of GDP by the year 2000.

The overall principles and priorities of Finland's development co-operation strategy are:

- to reduce widespread poverty;
- to mitigate global threats to the environment by helping the developing countries to solve their environmental problems; and
- to promote social equality, democracy and human rights in developing countries.

Environmental enhancement criteria have been included as one of the main principles of Finnish aid policy since the 1970s.

The Framework Convention on Climate Change is the basis on which co-operative efforts to combat changes in the global atmosphere can be built. Development co-operation is one of the major tools Finland can provide to assist countries in need to enhance the objectives of the Convention.

In multilateral co-operation, Finland underlines the need to integrate sustainable use of natural resources and environmental enhancement into the programmes of UN operational organizations. We also emphasize this approach in international financing institutions - the World Bank and regional development banks, in particular.

Finland participated actively in the preparations for the United Nations Conference on Environment and Development (UNCED, 1992) and in the conference itself. The UNCED decisions and recommendations agreed on by the international community marked strong endorsement for sustainable development. During the negotiations process Finland contributed roughly FIM 5 million to the UNCED preparations, and has subsequently supported UNDP's Agenda 21 programme with FIM 6 million as a follow-up to the Conference. Finland has also supported the Trust Fund for the negotiation process and the Special Voluntary Fund for the participation of developing countries in the Climate Change Convention to the tune of FIM 500,000 and 550,000 respectively.

In response to the need to allocate additional new resources for the solution of global environmental problems, Finland has contributed FIM 105 million during the first phase of the Global Environment Facility (GEF). An equal commitment has been made to support the second phase of GEF in 1994-96. Finland is among the major donors to the United Nations Environment Programme (UNEP) and firmly supports the role of UNEP in implementing Agenda 21. In 1993, our voluntary contribution to UNEP was FIM 20 million.

In 1990, Finland was actively involved in the establishment of the Multilateral Fund for the implementation of the Montreal Protocol, which provides financial resources targeted for phasing out ozone-depleting substances which also contribute to the greenhouse effect. Finland provided FIM 10 million for the prompt launch of the fund. In 1994 our share of the contributions was FIM 5.5 million.

Within the bilateral co-operation programmes financed by Finland, the focus will increasingly be on high-priority areas, including environmental protection, conservation of nature and sustainable use of natural resources. A major principle in Finnish development aid policy is to integrate environmental considerations in each stage of project design. Environmental Impact Assessment (EIA) therefore forms an integral part of planning a project's life cycle.

Transfer of technology and reduction of GHG emissions

Finland has specific programmes and financial arrangements for transferring environmentally sound technology - in particular, technologies aimed at reducing greenhouse gas emissions.

Finland has supported cleaner generating options with grants, concessional credit and development credit financing. Greater efficiency in the use of coal and other fossil fuel has been achieved by introducing and developing new technologies in electricity generation and combined heat and power generation. These technologies include the circulating fluidized bed (CFB) boiler, district heating and advanced diesel power plant technologies, which all help reduce carbon dioxide and sulphur dioxide emissions.

Advanced diesel power plant technology has replaced old, less efficient thermal generation capacity at relatively low unit costs, for example in Egypt. In Zambia an efficient power distribution system has been constructed to reduce the loss of energy in transmission and distribution. Advanced diesel power plant technologies have been financed in Nepal to increase the efficiency of energy use. A demonstration boiler plant investment with CFB technology and the development of district heating technology have been supported in China.

Energy-related pollution is still rather minor in many parts of the developing world. It is, however, rapidly increasing so a great deal of attention must be paid to reducing energy-related pollution in these countries in the future. Finland supports national policies to improve the efficiency of energy conversion, distribution and use since this also reduces total energy consumption. Finland has financed projects that are highly related to the problems of power transmission and distribution lines, diesel power plants, and fuelwood plantations (as a part of the forestry sector).

Similarly, it is important to avoid unnecessary energy use and to promote conservation of energy. The correct pricing of electricity is therefore one of the most important preconditions for Finnish participation in energy investments. Indirect measures, such as proper urban planning and several other methods, also promote conservation. Finland therefore supports the global shelter strategy implemented by the UNCHS, for instance. Support for UNCHS was FIM 2.7 million in 1993.

Greenhouse gas sinks

In order to also enhance the objectives of the Climate Change Convention, Finland gives bilateral assistance to promote sustainable management of forests i.e. greenhouse gas sinks and reservoirs. These activities include afforestation and community forestry programmes, adoption of sustainable agricultural practices, comprehensive forestry planning and watershed management.

The reforestation and afforestation projects and forest conservation accounts for FIM 32 million and research, institutional support and capacity building for FIM 61.5 million out of the total amount of FIM 140 million contributed to the forestry section in 1992. Sustainable management of biomass resources will remain high on the Finnish development cooperation agenda in the future, too.

Finland has supported national reforestation and afforestation programmes in Sudan, Kenya and Zambia, for example; improved management capacity of rain forests in Indonesia, Thailand and Tanzania; and community afforestation programmes in Senegal and certain OAS Countries (El Salvador, Guatemala and Honduras).

Table 19. Development projects in forestry and the forest industries supported by the Ministry for Foreign Affairs, Department for Development Cooperation (FINNIDA) in 1992.

Region and country	Grants by project type1 1000 FIM					Interest subsidies 1000 FIM	Grand total 1000 FIM
	1	2	3	4	Total		
Africa	**10 459.9**	**21 251.5**	**3 832.3**	**13 535.1**	**49 078.9**	**1 304.5**	**50 383.3**
Kenya	8 513.4	8 287.9			16 801.3		16 801.3
Mozambique				8 910.3	8 910.3		8 910.3
Namibia				494.1	494.1		494.1
Zambia			3 832.3		3 832.3		3 832.3
Senegal		3 135.0			3 135.0		3 135.0
The Sudan				938.1	938.1		938.1
Tanzania	1 946.5	9 828.6			11 775.1		11 775.1
Zimbabwe						1 304.5	1 304.5
Unspecified				3 192.6	3 192.6		3 192.6
Asia	**3 805.9**	**8 010.6**	**2 884.9**	**18 918.3**	**33 619.7**	**24 384.4**	**58 004.0**
Fiji			743.6		743.8		743.8
Philippines	2 242.5				2 242.5		2 242.5
Indonesia				2 688.1	2 688.1	443.6	3 131.7
China						21 434.6	21 434.6
Laos	560.3				560.3		560.3
Myanmar			2 141.1		2 141.1		2 141.1
Nepal		8 010.6		9 494.9	17 505.5		17 505.5
Sri Lanka				4 335.3	4 335.3		4 335.3
Thailand	1 003.1				1 003.1	2 506.2	3 509.3
Unspecified				2 400.0	2 400.0		2 400.0
Latin America		**2 610.6**		**11 196.0**	**13 806.6**		**13 806.6**

Least developed countries				**17 824.5**	**17 824.5**		**17 824.5**
TOTAL	**14 265.8**	**31 872.6**	**6 717.2**	**61 474.0**	**114 329.6**	**25 688.6**	**140 018.4**

[1]Project types
1 Forestry and forest industries planning
2 Forest conservation and reforestation
3 Forest industries development
4 Research, institutional support and development
Source: Ministry for Foreign Affairs, Department for Development Cooperation

Cross-sectoral linkages between forestry and climate change require lot of further study and research. To this end, the European Forestry Institute (EFI) and the WIDER Institute of the UN, both located in Finland, are carrying out a research project on the role of forests in the north and south in the implementation of international conventions on climate change and biological diversity.

Renewable energy sources

Over the long term, it is important to gradually introduce modern renewable energy sources. Finland's involvement in this field has mostly been directed at developing the use of hydro power (e.g. in Tanzania) and biomass. Finland has also supported the establishment of appropriate data records on wind and solar energy through the meteorological development programmes.

With regard to the use of biomass, an increase in fuelwood production is currently emphasized in a number of forestry projects. In future, emphasis will be on comprehensive schemes, such as agroforestry programmes. Innovative ways of using biomass have been supported through research. To this end, the use of coffee waste as a renewable source of energy has been studied in Kenya, for instance.

Capacity building and adaptation to climate change

Since the early '70s, Finland actively participated in the building-up of a global network to observe and monitor the physical and chemical properties of the atmosphere by providing systems for measuring the basic variables. These produce the necessary data on climate change, ozone depletion, natural disaster prevention and transboundary dispersion of pollutants relevant to the implementation of UN global conventions and programmes. Major programmes have been launched in cooperation with WMO. Finland has provided FIM 148 million for the WMO/SADC Programme, the Meteorology Programme in the Central American Isthmus, the Meteorology Programme in Sudan, and for the WMO's global Voluntary Contributions Programme (VCP).

The above programmes will not only accumulate information on changes in the local and global climate but also contribute to preparedness for the adverse impact that climate change may have. Furthermore, Finland provides funding for CGIAR institutions that could play an important role in assisting agriculture in developing countries to adapt to the impact of climate change. The valuable role of national and international non-governmental organisations in the debate on strategy and policy orientation in reconciling environmental and development objectives is also acknowledged.

7.2 Transitional economies

Owing to its geographical location, Finland has always carried out extensive commercial, technological and scientific cooperation with its eastern neighbours. Nowadays, this cooperation also covers environmental and climate questions of mutual interest. Total funding from Finland for cooperation with CEE countries is about FIM 260 million.

Particularly in the area of environmental protection, Finland has made cooperation agreements and actively supported environmental protection projects. There are now environmental cooperation agreements with Russia, the Baltic countries and Poland.

The questions of energy policy and environmental policy are interrelated. Finland's energy cooperation focuses on the Baltic countries, especially Estonia, and western parts of Russia. The major fields of cooperation are nuclear safety and boosting the efficiency of energy production. Several analyses and trial projects concerning the latter have been launched. With Russia, an energy plan for Karelia and energy conservation studies in nine industrial and energy production plants have been made.

In 1991, the Ministry of the Environment launched a special project aimed at promoting environmental protection in Estonia, Latvia, Lithuania, northwestern Russia and Poland. The Ministry has granted a total of FIM 185 million for environmental protection and energy conservation investments in these areas during the last three years. In addition, 190 technological assistance projects have been supported.

Greenhouse gas emissions have been reduced in a number of projects supported by Finland. A joint venture producing district heating pipes has been built in Warsaw (FIM 9.9 million). If the plant's total potential capacity is installed in Poland over the next ten years, this will reduce CO_2 emissions by a total of 4.8 million tonnes. In Tallinn, the Iru power plant has been converted to burn natural gas (FIM 0.8 million). This change will yield a 100,000 tonnes reduction in CO_2 emissions.

8. FINNISH RESEARCH PROGRAMME ON CLIMATE CHANGE

8.1 Climatic observations

In Finland, meteorological observations have been made at several stations for more than a hundred years now. At the moment, observations are made at three meteorological observatory stations, 46 synoptic stations, 87 climatological stations and 57 automatic stations. Long climatological time series form a necessary basis not only for the actual climatological research but also for estimates on the impacts of climate change. Finnish climate observations have been included in the international North Atlantic Climatological Data Set (NACD) database, which is a collection of reliable long-term climatic observations for climate change research.

Finland also participates in the Global Atmosphere Watch (GAW) programme of the World Meteorological Organisation (WMO). The GAW observes greenhouse gas concentrations and long-range transport of pollutants in the atmosphere. In 1994, the WMO accepted the Pallas-Sodankylä station in Finnish Lapland as a part of the global GAW network. The station measures air composition and measurable meteorological quantities, focusing on greenhouse gases such as CO_2, CH_4, N_2O and O_3. Furthermore, pollutants conventionally associated with regional air pollution are measured continuously in Finland at 20 background stations in different locations.

The Finnish Meteorological Institute is also involved in various development cooperation projects in meteorology, the most important ones being regional projects with the African SADCC countries and the Central American Isthmus. During the last ten years, Finland's total contribution to cooperation projects concerning meteorological technology has totalled about USD 30 million. Projects have been carried out in some 40 countries all over the world.

8.2 Finnish Research Programme on Climate Change

The first research projects on climate change were started in Finland at the beginning of the '80s as individual projects carried out by universities and research institutions. By the end of the decade, research on climate change had gained an important standing in the activities of international communities, and Finland also acknowledged the need to put effort into the study of climate change and the development of alternative models for adaptation and prevention.

An interdisciplinary research programme called the Finnish Research Programme on Climate Change (SILMU) was initiated in 1990 to coordinate the majority of all climate change research in Finland. The principal goals of SILMU are to increase our knowledge about climate change, its causes, mechanisms and results; to promote research on climate change; to further opportunities for Finnish scientists to participate in international research projects; and to prepare and disseminate information to form a basis for decisions on adaptation to and prevention of climate changes.

The key research areas in the programme are the climate changes anticipated in Finland, estimation of the effects of changing climate on ecosystems, and the development of adaptation and prevention strategies.

The programme is scheduled to take six years (1990-1995), and the annual budget is FIM 12-15 million. At present, the programme comprises over 60 research projects and involves some 200 researchers. The fields of research have been grouped into four subgroups: atmosphere, water bodies, forest ecosystem and human actions.

The central aim of atmospheric research is to determine the magnitude of past and future climate changes, with a special focus on northern Europe. In addition, research is being conducted on air chemistry and physics.

Research concerning the water ecosystem focuses on the impact of climate change on the hydrology and ecology of Finnish lake, river and marine ecosystems, and also covers interaction between the atmosphere, hydrosphere and biosphere.

Forest ecosystem research involves studies on the effects of climate change on agriculture and forestry, and on the biochemical cycling of carbon in peatlands.

Studies on the social and economic impacts of climate change are also under way, and assessments on how to limit greenhouse gas emissions and how to reduce or adapt to the effects of climate change are being made.

Many research projects under SILMU are included in international research programmes on climate change, such as the World Climate Change Programme (WCRP) and the International Geosphere-Biosphere Programme (IGBP).

9. EFFECTS OF CLIMATE CHANGE IN FINLAND

The greatest potential climate changes induced by the enhanced greenhouse effect are expected to occur at high latitudes. However, due to the great natural climatic variability in these areas, signals of change are difficult to detect. According to climatic observations recorded over the past hundred years, the Finnish climate has remained basically unchanged, and any variation can be regarded as natural climatic variability. It has not yet been possible to detect the enhanced greenhouse effect.

A factor making it especially difficult to assess coming changes is the uncertain behaviour of the Gulf Stream. Should the stream lose its power or change its course, temperatures in Finland would go down substantially. This could have a dramatic effect on the national economy, especially agriculture and forestry, which already operate on the fringe of viability as far as climatic conditions are concerned.

Finland is located in the area where climate simulation models predict a rise of 3-4°C in temperature and 3-15% in rainfall if the CO_2 concentration doubles. Such changes would have both favourable and unfavourable effects on our ecosystems. The crucial question regarding the ecosystems' capability to adapt is the speed of change. If the change is slow enough, the ecosystems have a chance to adjust. This is a complex situation, and it is very difficult to draw unequivocal conclusions on the overall impact of climate change. At this stage, it is impossible to estimate the magnitude of the changes, but some trends can be outlined.

If greenhouse gas emissions are not limited, the sea level is expected to rise by about 20 cm over the next hundred years. In Finland, land elevation following the ice age is still continuing, especially in low-lying areas around the Gulf of Bothnia susceptible to sea level rise. A rise in the sea level would thus not face Finland with any particular threats.

Climatic warming would move the climatic zones one or two steps north. In principle, warming, a longer growing season, an increase in CO_2 concentration and added humidity would have a positive effect on the growth and reproduction of forest trees. On the other hand, leaching of nutrients from the soil due to excessive rainfall, disturbances in winter dormancy and the resulting frost, storm and snow damage, and new plant diseases and pests would have an opposite effect. The length of daylight important to growth would not change as a result of climate changes, so plants would in any case have to adapt to circumstances not previously experienced in Finland. Studies so far suggest, however, that the changes might not be as drastic as anticipated earlier. A moderate and sufficiently slow rise in temperature could even be advantageous for forest growth.

Organic carbon has accumulated in natural mires over many millennia, and the process still continues. The mires are thus sinks binding carbon from the atmosphere to form a long-term reservoir in the peat. A temperature rise could slow down this accumulation. On the other hand, the types of mire most effective in their carbon uptake could well spread northwards, compensating for some of this change in carbon balance.

The mires are a natural source of methane and probably also of nitrous oxide. Temperature rise and prolongation of the period with no permafrost could result in higher methane emissions, whereas a lowering of the groundwater level would decrease them. No estimate on the changes in the total substance balances of Finnish mires induced by climatic warming can be provided at this stage, however.

The most significant change resulting from climate changes in the Baltic Sea would be the shortening period of ice cover. For winter seafaring, this would be a definite asset. It is, however, probable that large variations in ice cover duration would continue, even in warmer conditions. Temperature changes would also affect the ecology and ecosystems of the Baltic Sea. Algae, plants and fish have adapted to the sea's present conditions, such as its salt and nutrient content, and would have to adapt further.

Great changes would take place in the ice conditions of lakes and rivers, too. Thermal stratification would increase and this could add to the oxygen deficit. Leaching into water bodies would also change, and this, together with warming, would cause biological changes in the lakes. Different species react to change differently, and there could be variations in the number and species of fish. Fisheries may face difficulties.

As the rainfall during the winter season increased, water flow in the rivers would also increase. The hydro power industry would benefit from this. On the other hand, the time and volume of floods could change, causing problems with flood protection.

Changes in the atmosphere affect agriculture in two ways. A higher CO_2 concentration improves the growing potential and possibly the pollution resistance of plants. Warming will also improve growing potential. Climate change would result in a lengthening of the growing season and an increase in the sum of effective temperature, which would naturally be an advantage in northern arable areas. On the other hand, higher rainfall in the winter, more leaching of nutrients, and new plant diseases and pests could bring fresh problems. New varieties of cultivated plants would have to be chosen, but this should not be a problem, as many varieties have been developed for different climatic conditions.

The estimated degree of warming would make the Finnish climate more temperate. The typical snowy winter season would be very short in most of Finland. People's habits and lifestyles, especially their outdoor recreation and leisure pursuits, would change considerably. Winter tourism in southern and central Finland would suffer substantially, whereas in the north the tourist industry might even benefit from the change. Summer-time tourism, on the other hand, could be boosted, as the heat elsewhere in Europe could be excessive.

All in all, the effects of climate change would seem to be less harmful in Finland than in many other regions. The greatest risk is how the forests would adapt to the change, as the national economy is so dependent on the well-being of the forests. If the warming process is faster than anticipated, or if the forests cannot adapt to the change, the results could be dramatic.

The greatest problems in Finland would therefore be the indirect effects of changes elsewhere in the world. These could include refugee problems, lower food production due to desertification, a general decline in the world economy, participation in the funding of environmental projects elsewhere, etc. As one of the developed industrialized countries, Finland must be prepared to bear part of the load in preventing global problems and also part of the costs.

FIGURES:

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