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Report on the in-depth review of the second national communication of Norway

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I. INTRODUCTION AND NATIONAL CIRCUMSTANCES

1. Norway ratified the UNFCCC on 9 July 1993. Its first national communication (NC1) was submitted on 21 September 1994 and the second national communication (NC2) on 16 April 1997. The in-depth review was carried out between October 1998 and June 1999 and included a review team visit to Oslo from 5 to 9 October 1998. The team consisted of Mr. Abdoulaye Ouedraogo (Burkina Faso), Mr. Faouzi Senhaji (Morocco), Mr. Magnus Thorstensson (Sweden) and Ms. Tina Dallman (UNFCCC secretariat, coordinator). During the visit, the team met officials from government ministries and agencies, members of environmental non-governmental organizations and industry representatives.
2. Norway, which stretches 1,752 kilometers from a latitude of 57° to 71°, has highly dispersed settlements. Out of a population of around 4.4 million in 1997, about three quarters of a million lived in the capital Oslo and its surrounds, in the south-eastern part of the country. Bergen, Trondheim and Stavanger accounted for around another half million. Average annual temperatures range from 5.7° in Oslo to 1.3° in Vardø, a northern town. Temperatures in Oslo range from an average of 16.4° in July to -4.3° in January when daylight also falls to six hours. Consequently, during winter months, there is significant demand to heat and light indoor spaces, yet winters could be colder still were it not for the warming influence of the Gulf Stream.
3. Of Norway's total area of 306,253 km², agriculture accounts for only 4 per cent. Productive forest, which includes national parks, nature reserves and other protected areas, accounts for 23 per cent, and forms part of the 37 per cent of land area covered by forest.
4. Norway is rich in natural resources, having significant offshore oil and natural gas reserves and also significant hydroelectricity resources. It has been a petroleum-exporting country since 1971 and is now the second largest net oil exporter in the world and amongst the 10 largest gas exporters. In 1997, exports of crude oil and natural gas reached record levels and totalled Nkr 163 billion or 37 per cent of the country's total export earnings, although this figure fell to 29 per cent in 1998. Approximately 10 per cent of the gas consumed in Western Europe is Norwegian and this share is expected to grow. Norway's per capita energy use was about 20 per cent higher than the average of Organisation for Economic Co-operation and Development (OECD) countries in 1995, whereas its energy intensity, measured as energy use per unit of gross domestic product (GDP) was about two thirds of the OECD average, although on a purchasing power parity basis it was more in line with the average. Its electricity consumption per capita is one of the highest of OECD countries.
5. Excluding the use of energy in the energy industries, based on provisional data, total consumption of energy commodities amounted to 813 PJ in 1997 made up of 45 per cent electricity, 33 per cent oil, 9 per cent gas, 7 per cent coal/coke, 5 per cent wood and 1 per cent district heating. Electricity in mainland Norway is almost entirely hydroelectric in origin. In 1998, the mean annual hydroelectric production capability was 113 TWh. Variations in annual precipitation contribute to changing hydroelectricity production levels and hence requirements for imports and exports of electricity. Electricity trade in the 1990s varied from net exports of

15.9 TWh to net imports of 9.0 TWh. The development of a Nordic power market has led to a substantial improvement in the region's transmission capacity and Norway is likely, to an increasing extent, to be a net importer in the absence of new domestic generating capacity.

6. Whilst the oil and gas sector has a major influence on the economy, only around 90,000 people are involved, onshore and offshore, in extraction, transportation and incidental activities, including surveying. Since production began there has been a gradual shift away from manufacturing toward a more service-oriented economy, although Norway still maintains a number of power-intensive manufacturing industries. Considering GDP by activity, in 1996, oil and gas activities accounted for over 29 per cent, various services around 20 per cent, government services 16 per cent and manufacturing 12 per cent, whilst agriculture and fishing accounted for less than 2 per cent, combined. Norway's GDP per capita is amongst the highest in the world.

7. Norway is a party to the European Free Trade Agreement and the European Economic Area Agreement, which means that, in order to have access to the European Community's (EC) internal market, it must follow the same rules and, therefore, implement EC directives. Some of these relate to energy and the environment and hence limit greenhouse gas (GHG) emissions. Norway is a Party to the Convention on Long-range Transboundary Air Pollution; it has complied with its obligations with respect to nitrogen oxides (NO_x) and is on target in relation to sulphur dioxide (SO₂), but it is not likely to meet its obligations for non-methane volatile organic compound (NMVOC) reduction in the required timeframe.

8. In 1989, Norway set a preliminary target to limit carbon dioxide (CO₂) emissions so that they are no higher in 2000 than in 1989. In addition to UNFCCC commitments, this was reiterated in a 1994 White paper to the parliament on policy to mitigate climate change and reduce emissions of NO_x. This report noted, however, that Norway had expected greater international policy cooperation and, in particular, was more isolated in the use of CO₂ taxation than originally envisaged. Norway agreed to limit the net growth of the six GHGs under the Kyoto Protocol to 1 per cent above the 1990 level over the period 2008 to 2012. A White Paper on the implementation of the Kyoto Protocol was presented to the parliament in April 1998 setting out strategies to mitigate emissions of GHGs, in addition to a proposal on 'green taxes'. A number of resulting decisions have created a new policy framework, including a mandate for a commission of experts to draw up proposals for a domestic GHG emissions trading system. The Government also submitted a White Paper on energy policy to the parliament in March 1999 which addresses climate change issues. The ministries have begun carrying out sectoral environmental action plans which also include climate change measures beginning with the transport and defence sectors, and in 1999 a plan for the energy sector was under development.

II. INVENTORIES OF ANTHROPOGENIC EMISSIONS AND REMOVALS

9. Norway's NC2 includes summary tables for emissions of CO₂, methane (CH₄), nitrous oxide (N₂O), perfluorinated hydrocarbons (PFCs), hydrofluorocarbons (HFCs), and sulphur hexafluoride (SF₆), as well as the precursors NO_x, carbon monoxide (CO), NMVOCs and SO₂ for

the period 1990 to 1995 inclusive. In addition to the NC2, several publications are available, in English, covering various issues related to, *inter alia*, methodologies, default approaches and uncertainty. Data shown in this report are taken from a 1999 GHG emissions publication, presented to the review team, and differ from those reported in the NC2.

10. In general, estimation methods, as presented in recent publications, follow the Revised Guidelines for National Greenhouse Gas Inventories of the Intergovernmental Panel on Climate Change (IPCC). National methods are used in some cases. The emission factors are mainly a mixture of own values, based on national research, and 1996 IPCC default values, but for some minor sources default values from the earlier IPCC Guidelines are employed. More than half of the estimated emissions are covered by national emission factors. Norwegian officials noted that, in general, the IPCC default approach tends to underestimate emissions, compared to national values. In addition to comparing the IPCC fuel combustion default approach with the national bottom-up methodology, there are other comparisons to check for errors. For example, some estimates can be compared with measured and directly reported emissions from industrial plants.

11. Emissions of CO₂, CH₄, N₂O, NO_x, CO, NMVOCs and SO₂ are estimated in collaboration between Statistics Norway, which is responsible for activity data, emission models and calculations, and the Norwegian Pollution Control Authority (SFT), which contributes emission factors for all sources and measured emission data from large industrial plants. Combustion emissions are estimated by combining fuel consumption allocated across sources and economic sectors with fuel, source, sector and pollutant-specific emission factors. Measured emissions are used in preference to estimated values, where available and of high quality. Transport emissions are given especially detailed treatment. Non-combustion emissions are estimated either by combining activity data with emission factors or, in some cases, by the application of more complex calculations based on special investigations. Estimates for emissions of PFCs and SF₆ have been provided solely by the SFT with assistance from industry. From 1999 a model for actual HFC emission estimates will operate - in general based on the IPCC tier 2 approach using national emission factors when necessary and activity data such as import statistics.

12. The CO₂ emission estimates for combustion are based on complete statistics for the underlying activity data and emission factors which are generally easy to determine. The statistics used for the activity data are also used for revenue-raising purposes and are therefore of good quality. So, these emissions are rated as having high confidence. As there are few measurements related to CH₄ and N₂O emissions from combustion, the emission factors are uncertain, so emission estimates have a medium quality. Fugitive CO₂ and CH₄ emissions from solid fuels, oil and natural gas sources have medium confidence. Fugitive emissions from the oil and gas industry are based on specific measurements and calculation, although there are some difficulties in measuring CO₂ and CH₄ venting and leakage. CO₂ emissions from industrial processes are mostly based on mass balance calculations for industries where the knowledge of production processes is good and hence these emission estimates have high confidence. Activity data underlying emission estimates in the agricultural sector are based on a 10 year full farm

survey and annual cattle counts, required for agricultural supports, so these data are thought to have an accuracy of within 3 per cent.

13. N₂O emissions from nitric acid production are measured as part of emission monitoring required by the self-monitoring programme of the SFT. Plants responsible for about 60 to 70 per cent of emissions from this source are continuously monitored and the rest are monitored randomly. Thus N₂O emission estimates from industrial processes are rated with a medium confidence level. As in other countries, there is a large degree of uncertainty about other N₂O estimates, especially in relation to emissions from soil. PFC emission estimates are plant specific, based on activity data, with uncertainty in the range -25 per cent to +55 per cent. The estimates of SF₆ and HFC emissions are, on the whole, based on consumption data and/or import statistics and so they are rated as having medium to high uncertainty. Aside from improvements to the inventory, there is ongoing work on uncertainty to, *inter alia*, reflect the source of uncertainty for different emission estimates and improve reporting of this issue. The 1999 inventory report notes that the main weaknesses in the accuracy of emission estimation relate to CH₄ from landfills, N₂O from agriculture and PFC from industrial processes and that, overall, the Norwegian GHG emission level is estimated with an accuracy of about ± 10 to 20 per cent.

Table 1. Greenhouse gas emissions, 1990 - 1997, CO₂ equivalent (Gg)

	1990	1991	1992	1993	1994	1995	1996	1997
CO ₂	35 200	33 610	34 250	35 910	37 950	38 200	41 140	41 430
CH ₄	6 660	6 760	6 880	6 990	7 140	7 200	7 250	7 350
N ₂ O	5 420	5 260	4 580	4 930	5 040	5 110	5 110	5 060
SF ₆	2 190	2 070	690	720	840	560	530	510
PFCs	2 550	2 160	1 670	1 750	1 590	1 440	1 270	1 450
HFCs	0	0	0	0	10	30	50	90
Total	52 010	49 850	48 080	50 300	52 580	52 540	55 350	55 900

14. In 1997, total emissions of GHGs, in terms of CO₂ equivalent, were about 55,900 Gg which is about 7 per cent higher than in 1990. Total emissions fell 8 per cent between 1990 and 1992, during a period of economic recession, but then rose by 16 per cent in the period to 1997, mainly as a result of higher CO₂ and CH₄ emissions. CO₂ is the most important GHG in Norway, accounting for 74 per cent of total emissions in 1997. CH₄ accounted for 13 per cent and N₂O about 9 per cent, while the new gases, PFCs, HFCs and SF₆, combined, accounted for less than 4 per cent.

A. Carbon dioxide

15. In 1997, total CO₂ emissions amounted to about 41,400 Gg, around 18 per cent higher than in 1990 (see table 2). To a large extent this was due to emissions from energy and transformation increasing by about 41 per cent, in line with increased oil and gas production. Transport also contributed to the overall increase with emissions growing by around 13 per cent between 1990 and 1997, in particular due to growing diesel consumption. The period also

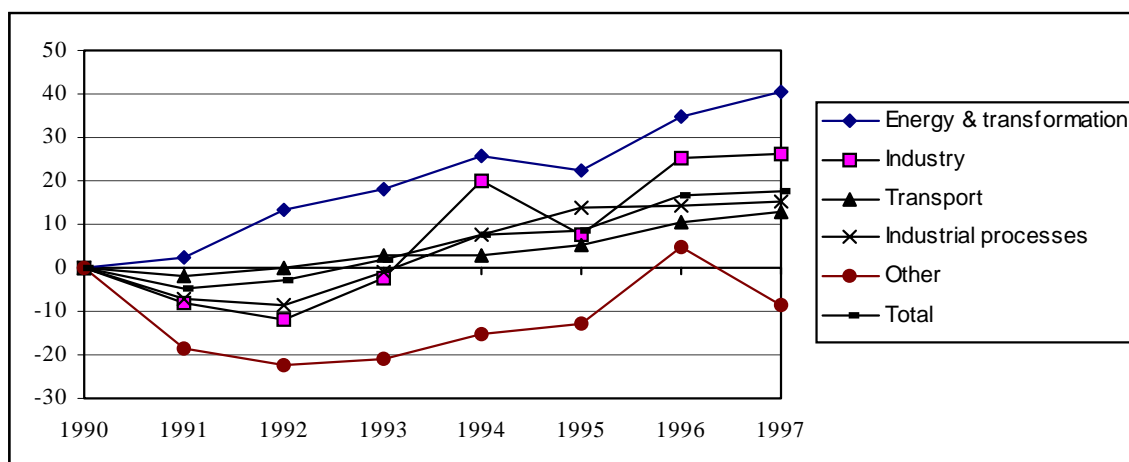
witnessed a significant increase in coastal traffic. 1990 was a relatively wet year which experienced a mild winter, whereas some recent years have been quite dry. Price rises occur during winter months when electricity demand is higher due to the increased need for heating, and water reservoir levels limit the possibilities for increased hydro-electricity production. So, CO₂ emissions, in part, are affected by varying consumption of fuel oil in response to changing electricity prices. Whilst CO₂ emissions increased, there was an increase in CO₂ removals of 72 per cent between 1990 and 1997. Preliminary data for 1998 indicate a 0.5 per cent increase on 1997 underlying which emissions from oil and gas production were lower, whilst emissions from diesel vehicles and metal production increased.

Table 2. Carbon dioxide emissions, by source, 1990-1997 (Gg)

	1990	1991	1992	1993	1994	1995	1996	1997
Energy & transformation	7 396	7 574	8 386	8 751	9 294	9 044	9 953	10 404
Industry	3 043	2 791	2 681	2 966	3 650	3 278	3 816	3 847
Transport	13 533	13 306	13 511	13 948	13 935	14 274	14 964	15 296
Industrial processes	6 718	6 245	6 150	6 656	7 216	7 654	7 684	7 750
Solvent & other product use	144	125	130	129	136	135	143	137
Other	4 332	3 525	3 356	3 419	3 678	3 772	4 540	3 957
Waste	37	37	37	38	39	39	40	40
Total	35 203	33 603	34 251	35 907	37 948	38 196	41 140	41 431
International bunkers	2 083	1 794	2 123	2 301	2 449	2 809	3 142	3 832
Land-use change & forestry	-9 590	-11 700	-13 250	-13 510	-15 680	-13 640	-17 611	-16 499

16. Stationary combustion and mobile sources accounted for 42 per cent and 37 per cent, respectively, of the CO₂ total in 1997. The oil and gas industry accounted for about 23 per cent of the emissions, whilst road traffic accounted for about 21 per cent and coastal traffic and fishing, combined, a further 9 per cent. Industrial processes, including the production of metals, carbides and cement, but excluding the oil and gas industry, accounted for 19 per cent of overall CO₂ emissions. All CO₂ emissions from gas, coal, coke and petroleum coke used as feedstock in the iron and steel, non-ferrous metals and chemical and petrochemical industry are included in the industrial process category. It is assumed that all carbon in feedstock used in the production of primary plastic is absorbed in the product and emitted when plastic is burned in waste incineration plants. Natural gas from the Sleipner Wes gas field offshore in the North Sea contains more CO₂ than the sales specifications allow, CO₂ is therefore removed from natural gas produced at the field then injected into geological formations below the sea bed and, therefore, is not counted in the inventory.

17. In accordance with the reporting guidelines, emissions from international aviation and marine bunker fuels are not included in the national totals, but emissions from Norwegian domestic marine traffic, total fishing fleet operations and offshore oil and gas activities are incorporated. In 1997, CO₂ emissions from international bunkers amounted to approximately 3,830 Gg, an increase of around 85 per cent compared to 1990 and corresponding to about 9 per cent of total CO₂ emissions. The increase was mainly attributable to higher emissions from ships.

Figure 1. Carbon dioxide emissions, percentage change from 1990, by source

18. The area of managed forest in Norway is around 7 million hectares. The net anthropogenic sink of CO₂ in the Norwegian forests in 1997 was estimated at around 16,500 Gg, equivalent to around 40 per cent of total CO₂ emissions in 1997. This accumulation is due to the larger annual increment in the standing volume than the amount of wood harvested for industrial and fuel use. The net sink of CO₂ increased by about 6,900 Gg in the period 1990 to 1997.

19. The Norwegian method of calculating CO₂ sinks does not distinguish between CO₂ removal resulting from changes in forest and other biomass stocks, from forest and grassland conversion or from abandonment of managed lands. Basic data are available from the national forest inventory, which involves the collection of annual field observations from each of the counties as well as permanent observation fields visited on a five-year cycle. Data on forest harvest and related industrial statistics are available from a number of sources. Data for deforestation are more certain than for reforestation. Research by the Norwegian Forest Research Institute shows that 47 per cent of the carbon in a tree is stored in roots, stumps, branches and bark. An expansion factor of 1.9 is therefore used on all entries that are based on roundwood cut. Natural losses are assumed to be 0.6 per cent of the total tree numbers annually. It is assumed that all carbon is emitted in the year when the biomass is harvested. Export and import of wood has not been taken into account when calculating the net sink. The estimated factor for annual average above-ground biomass uptake by natural regeneration, based on field measurement, is 2.6 tonnes dry matter/hectare, compared to an IPCC default value for boreal forest of 1.0 tonne dry matter/hectare. The large difference may be explained by the extensive investment in reforestation, particularly during the period 1960 to 1985.

B. Methane

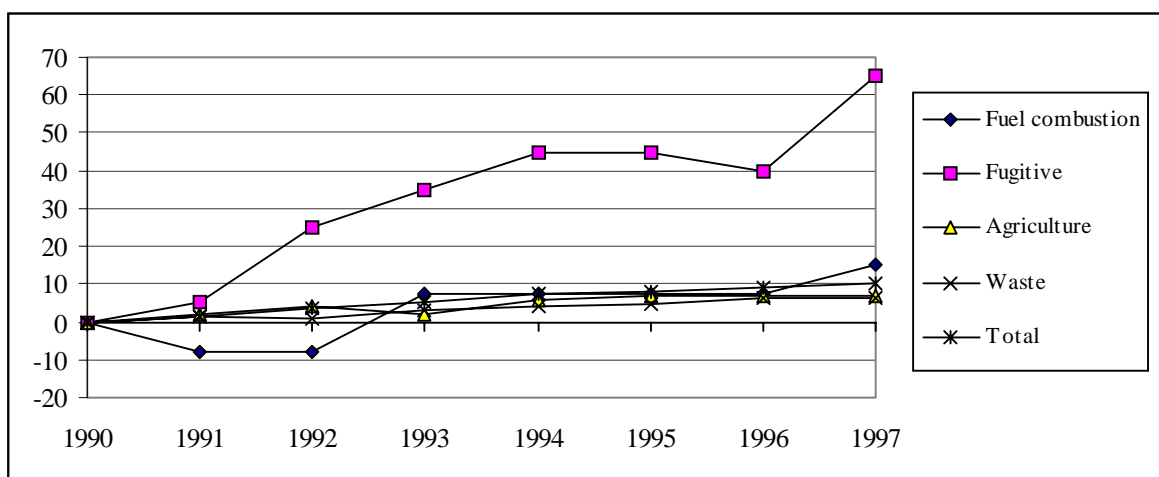
20. In 1997, CH₄ emissions totalled approximately 350 Gg, about 10 per cent higher than in 1990 (see table 3). The main sources are landfills and livestock which accounted for 55 per cent and 31 per cent of the emissions, respectively. CH₄ emissions from oil and gas production, accounting for about 8 per cent of the total, are relatively low in Norway, compared to other

significant producers, owing to low levels of venting and low leakages. Rising waste volumes have led to higher emissions from landfills. There has been an increase in emissions, in the 1990s, from livestock, landfills, and oil production. Preliminary data for 1998 indicate a slight decline of total CH₄ emissions owing to increased waste recycling and CH₄ recovery at landfills.

Table 3. Methane emissions, by source, 1990-1997 (Gg)

	1990	1991	1992	1993	1994	1995	1996	1997
Fuel combustion	13	12	12	14	14	14	14	15
Fugitive	20	21	25	27	29	29	28	33
Industrial processes	1	1	1	1	1	1	1	1
Agriculture	101	103	105	103	107	108	108	108
Waste	182	185	184	188	190	191	194	194
Total	317	322	328	333	340	343	345	350

Figure 2. Methane emissions, percentage change from 1990, by source



21. Due to a change in the methodology for calculating CH₄ from landfills, emission figures for total emissions of CH₄ for the period 1990 to 1996 are 25 to 30 per cent lower than those presented in the 1998 emissions report. The new methodology presented and used in the 1999 inventory submission has been developed in accordance with a higher tier of the IPCC Guidelines and should, therefore, provide more accurate estimation. The reduction in the emission estimates is explained by a change in the CH₄ correction factors related to local and operational conditions, a lower estimate of the volume of industrial waste landfilled, owing to improved data, and changed assumptions about oxidation of CH₄ in the surface layer of landfills.

C. Nitrous oxide

22. Emissions of N₂O were estimated to total around 16 Gg in 1997 around 7 per cent lower than in 1990 (see table 4). Emissions from the use of nitrogen-based fertilizer and manure

accounted for 57 per cent of the total, whilst the production of nitric acid was responsible for around 29 per cent.

23. Since the publication of the NC2, the method for estimating emissions of N₂O has changed. Figures were based on the first IPCC default methodology and excluded source categories for ammonia and secondary emissions of N₂O. The method used is not consistent with the 1996 Revised Guidelines. Due to this revision, the general level of N₂O emissions has increased; for example, the emissions in 1990 are 13 per cent higher than reported in the NC2.

Table 4. Nitrous oxide emissions, by source, 1990-1997 (Gg)

	1990	1991	1992	1993	1994	1995	1996	1997
Fuel combustion	1	1	1	1	1	1	2	2
Industrial processes	7	6	5	5	6	6	6	5
Agriculture	9	10	9	9	9	9	9	9
Total	17	17	15	16	16	16	16	16

D. New gases (HFCs, PFCs and SF₆)

24. The latest IPCC methodology for estimating HFCs, PFCs and SF₆ has been employed. Work has been undertaken to improve the methods for calculating actual emissions of HFCs and PFCs by consideration of, *inter alia*, information on equipment and products containing these gases, and on the bulk import of chemicals, emission factors and lifetimes of the products involved. The 1999 emission inventory report contains information on both actual and potential emissions of HFCs and PFCs used to replace ozone depleting substances.

25. Consumption of HFCs has increased significantly in the 1990s as a result of the phasing-out of chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) in cooling equipment (see table 5), but in 1997 they still accounted for only 0.2 per cent of total GHG emissions. About 96 per cent of CO₂ equivalent HFC and PFC emissions in 1997 were from the refrigeration and air-conditioning category. The emissions of PFCs from refrigeration and air-conditioning are negligible. Approximately 0.14 Gg of PFCs were produced from Norwegian aluminium plants in 1997, a reduction of about 44 per cent compared to 1990, primarily due to improved technology and process control. Foam and foam blowing were the second most important source of HFC emissions.

26. Use of SF₆ as a cover gas in the magnesium and aluminium industries accounted for around 85 and 5 per cent of emissions in 1996, respectively, whilst about another 10 per cent came from gas-insulated electric switchgear and other sources. Where used as a cover gas it is assumed to be inert, so the emissions are assumed to equal the level of consumption. Emissions of SF₆ were estimated at about 0.02 Gg in 1997, a reduction of 77 per cent compared to 1990. This reduction was a result of improved magnesium production, in addition to improved processes. Whilst SF₆ is known to be contained within double glazing imported in recent years, it is assumed that these products are still in place and emissions will not occur until future years.

SFT has initiated a project to measure and calculate the actual SF₆ emissions more accurately from sources such as gas-insulated switchgear and double glazing. The results will be available by autumn 1999.

Table 5. Potential emissions of HFCs, PFCs and SF₆; CO₂ equivalent basis, 1990-1997 (Gg)

	1990	1991	1992	1993	1994	1995	1996	1997
Potential HFCs	0	2	3	41	97	245	432	440
Actual HFCs	0	0	0	2	9	26	52	88
PFCs	2 546	2 163	1 674	1 752	1 595	1 437	1 270	1 448
SF ₆	2 188	2 065	691	719	845	564	526	512

III. POLICIES AND MEASURES

27. Since the early formulation of climate change policies, action across most sectors has been considered and implemented. From 1989 onward, work has been facilitated by inter-ministerial cooperation resulting in a first report in 1991. At the time of the review, a number of government proposals were being formulated to implement commitments under the Kyoto Protocol and to provide early incentives to carry out the least costly domestic action to mitigate GHG emissions. Taxation has been the main instrument to curb CO₂ emission since 1991. The CO₂ tax at present covers about 65 per cent of the emissions. As of 1999 there is also a tax on final waste disposal of waste, partly motivated by climate change considerations. The Government proposed widening the CO₂ tax base to include currently exempt sectors, although at the time of the review some of these proposals had been rejected by Parliament. As an alternative to taxation, the parliament called for a domestic emissions trading scheme which should, at a minimum, include the industrial activities (mainly process industries) which are currently exempt from the CO₂ tax. Policy evaluation has estimated that non-CO₂ measures could save 4,000 to 5,000 Gg of CO₂ equivalent emissions before the marginal cost of further measures exceeds the current level of the CO₂ tax applied to mineral oils. Despite these recent developments in policy formulation, the review focused mostly on existing measures.

A. Energy and transformation

28. The energy sector in Norway accounted for about 30 per cent of Norwegian CO₂ emissions in 1996. In recent years, emissions from this sector have grown more than emissions in other sectors because of the growth in oil and gas extraction, as shown in figure 1.

29. The main policy instrument affecting CO₂ emissions is the CO₂ tax. In general, it applies to the use of petrol, auto diesel, fuel oil, natural gas, coal and coke. The tax level varies both by fuel type and by economic sector. As a result of exemptions, particularly for sectors affected by international competition, about 43 per cent of CO₂ emissions were not covered by the tax, based on 1995 data. As a result of parliamentary agreed tax extensions, this should fall to about 36 per cent in 1999.

30. In 1997, about 20 per cent of Norway's energy use occurred in the energy sector including, *inter alia*, hydropower production, oil and gas extraction and oil refineries. The use of natural gas in the extraction of crude oil and natural gas accounted for over two thirds of this. Almost all of the gas is used for energy purposes; only 1 per cent is flared. Flaring of CH₄ beyond what is necessary for safety reasons under normal operations is not permitted under the Petroleum Act without the approval of the Ministry of Petroleum and Energy. Particularly large amounts of energy are needed to generate power on oil platforms. The CO₂ tax now covers about 97 per cent of emissions offshore. The CO₂ tax applies to flaring and burning of natural gas and diesel. The level was increased by about 20 per cent in 1998, but reduced again in 1999 to previous levels, the rate being 89 øre/ Sm³ for natural gas (Nkr 381/ tonne CO₂) and 89 øre/litre for diesel (Nkr 336/ tonne CO₂). CO₂ emissions per unit, on a combined measure of oil and gas produced, fell by about 30 per cent from 1990 to 1996 owing to general improvements in technology, the influence of the CO₂ tax and changes in the maturity of various fields. Norway's emissions of CO₂ from the production and transportation of oil offshore on a per unit basis are considerably lower than for other major producers. Similarly, its emissions of CH₄ from the production and transportation of natural gas are lower than for other countries.

31. The review team were informed about a number of petroleum industry initiatives to improve energy efficiency in gas turbines, use heat from turbine exhaust gas and waste heat from power production and remove CO₂ from flue gas. The first plant to separate CO₂ from produced natural gas is in operation at the Sleipner West gas field and could save 800 Gg of CO₂ per annum. The MILJØSOK is a committee initiated by the industry and the Ministry of Petroleum and Energy with a mandate to investigate an effective environmental strategy to ensure that extraction, transport and processing of oil and gas in the Norwegian continental shelf meet the highest possible environmental standards and to improve the industry's cost-effectiveness and competitiveness. In a report to the Ministry of Petroleum and Energy in December 1996, the MILJØSOK indicated that the offshore petroleum sector might be able to achieve a 30 to 40 per cent reduction in CO₂ emissions, per kWh generated, in the 15 years to come. No dramatic reduction is expected in the near future, but continuous technological development, in conjunction with application of the best available and most cost-efficient technology, should gradually produce results. In 1998, Statoil, the state oil and gas company, launched a Nkr 600 million technical programme to cut its CO₂ emissions by almost a third over 10 years.

32. In 1997, petroleum operations contributed about 8 per cent of national emissions of CH₄ and 17 per cent of NO_x emissions. NO_x is not currently explicitly regulated offshore. Low-NO_x burners are, however, installed on new turbines where technologically feasible. The petroleum sector is the main source of emissions of NMVOCs, accounting for about 56 per cent of national emissions of those gases. The first NMVOC recovery plant was installed in 1996 at a crude oil terminal. To promote the installation of coupling equipment, lower port fees are offered to ships with such equipment. Technology for NMVOC recovery from offshore oil loading (accounting for about 50 per cent of national emissions) is expected to be made commercially available by the Norwegian oil industry during 1999. A voluntary agreement is under discussion with the petroleum industry to limit emission of NMVOCs in oil production.

33. The Energy Act of 1991 resulted in deregulation and introduced competition into the electricity sector. The state and municipalities retained ownership of electricity transmission and generation, but the law provided greater scope for private sector activities. The reform allowed both firms and householders to purchase electricity from any supplier. Competition initially led to a general reduction in prices, reflecting also conditions of supply, which is likely to have increased demand, but may also have influenced consumers' choice of fuel for heating, in particular. About 60 per cent of households heat using electricity. Fluctuations in temperature and precipitation have major influences on the supply and demand of electricity such that prices can change through the year and between years. Electricity consumption grew steadily from the late 1980s to 1996 and declined somewhat in 1997, owing to the relatively mild weather and higher electricity prices. As electricity prices rise, some industries are able to switch from electric to oil-based heating. It is estimated by officials that about 10 TWh of industry and household electricity demand, combined, could be substituted by oil annually. There has been little expansion of generating capacity during the 1990s and without new investment the expectation of officials is that Norway will be a significant net electricity importer in normal years, depending on price developments.

34. Norway's gas fields are located far from the mainland and it lacks an effective infrastructure for the distribution of gas. Two combined cycle gas turbine plants with a capacity of 350 MW each have been under consideration since 1996, but it was unclear, at the time of the review, whether these would be constructed. Evaluation is underway as to whether the plants could incorporate CO₂ extraction and disposal. If no new gas-based power generation is constructed in Norway and no measures are introduced to establish new gas pipelines in the Nordic region, then economic analysis shows that new investments could be made in coal-fired electricity generation capacity in Sweden, Denmark and Finland, although that would depend on energy policy in these countries. Development could include some additional construction of hydropower, windpower and additional use of biofuels in Norway. The construction of new gas pipelines to transport Norwegian gas to the other Nordic countries is likely to result in lower overall CO₂ emissions than otherwise. The demand for gas in this region has so far not been sufficient to justify such a pipeline.

35. As practically all electricity production is based on hydropower, renewables already account for a large proportion of energy supply. Of 178 TWh of economically exploitable yearly hydropower, in 1998, 63 per cent was already developed, 4 per cent under construction, 20 per cent permanently protected and 13 per cent available for licensing. The further technical potential for certain other types of renewable energy in Norway may be significant. Currently, about 5 per cent of total energy consumption consists of bioenergy. Firewood burnt in private homes or buildings represents around 5 TWh annually and another 7 TWh of biomass is generated and used by the wood processing industry, which satisfies around 30 per cent of its energy needs this way. It has been estimated that the annual bioenergy potential could be in the range of 25 to 30 TWh over the course of 10 years. Norwegian wind power resources are relatively large as there are many sites along the coast with sufficient wind and favourable topography, but the costs of related infrastructure such as road access and grid connections limit the economic potential. Wind farm capacity increased from 4 MW in 1997 to 8 MW in 1998 and

the Government recently announced a target to have 3 TWh of wind power by 2010 and an increase of 4 TWh in the use of renewables combined with central heating systems. Several projects are in the planning stage, mostly by the energy utility companies, although independent power producers are also getting involved.

36. Government funding of renewables covering research, development and market penetration has fluctuated greatly during the last 20 years. From 1990 funding in real terms increased in the subsequent two years, but then fell steadily each year to 1996. However, in the subsequent two years funding increased substantially and exceeded Nkr 110 million in 1998, with the expectation that bioenergy could make a more significant contribution to domestic hot water and space heating. Additional funding has been and should continue to be available from industry. Low electricity prices, in combination with limited use of central heating systems, have hindered the expansion of renewables other than hydropower. Windpower production is only required to pay half of the electricity tax and also benefits from exemptions from investment taxation.

37. Pursuant to the Energy Act, energy utilities with a local area licence are required to implement certain energy efficiency measures. Almost every county has a regional energy conservation centre set up in cooperation with electric utilities and financed through a kilowatt-hour surcharge on consumer's bills. These centres regularly distribute energy saving information and every household is offered an energy efficiency audit. The Industrial Energy Efficiency Network was established in 1989 and its members account for around 80 per cent of energy used by industry. Since 1996, it has offered its members voluntary agreements on energy efficiency. Under the terms of such agreements, the authorities will offer advisory services and training for key personnel in return for the companies involved agreeing to implement energy efficiency measures. A recently established organization for the building industry should establish a similar network. Greater application of energy efficiency technologies and renewables may be encouraged by a recent requirement to use flexible heating systems in all new buildings owned or rented by the government.

38. As a follow-up to local Agenda 21, the Ministry of the Environment has conducted a dialogue with regional authorities and municipalities and formulated national guidelines for the consideration of cost effective GHG mitigation measures in all sectors. The guidelines focus on measures related to energy consumption and the use of renewable energy at the regional and local levels.

39. In line with other European countries, Norway introduced a regulation in 1996 related to the energy labelling of refrigerators, freezers, tumble driers and washing machines. It is planned that other types of electrical consumer goods will have labelling in future.

B. Transport

40. About 37 per cent of CO₂ emissions came from transport in 1996 and, of that, about two thirds was from road transport, with the remainder dominated by domestic coastal shipping and

air transport. Rail was a very small proportion of the total as traction is mostly electric, based on hydropower. The number of motor vehicles reached over 3 million in 1997, of which over 1.7 million were passenger cars. This is equivalent to about 38 cars per 100 of population in line with the OECD average. The number of private cars and miles driven has been growing for the last three decades. Norway has 4,021 km of railway, a figure which has remained almost static for decades as the combination of geography and population dispersal result in relatively high costs per passenger, whilst the public road network has expanded to reach 91,346 km in 1996. In that year, 87 per cent of domestic passenger kilometres were travelled by road, 5 per cent by rail and 7 per cent by air transport. Total passenger kilometres travelled by scheduled buses have remained almost unchanged since 1970. Freight transport by road, measured in terms of tonne-kilometres, increased only modestly in the early 1990s, but rose sharply from 1994 to 1997 as less was carried by domestic sea transportation. Lorries have developed a clear advantage in deliveries over distances of less than 150 km, especially given industries' trend to deliver smaller consignments more frequently. Demand for rail freight has been around the same modest level since 1970. From 1979 onward, there has been growing transportation associated with offshore oil and gas production.

41. The CO₂ tax is the main instrument for limiting CO₂ emissions in the transport sector. In 1998 the rates were NKr 380 per tonne of CO₂ from petrol and NKr 170 per tonne of CO₂ associated with auto diesel and other mineral oils. There were several exemptions, but as of January 1999 a tax equating to NKr 100 per tonne of CO₂ emissions was applied to fuels used for air traffic, domestic shipping, supply ships and installations in the petroleum industry offshore. In addition to the CO₂ tax, there are taxes of NKr 4.11 per litre of petrol, NKr 3.43 per litre of auto diesel and a mineral oil tax graduated by sulphur content. Norwegian taxes on transport fuels are amongst the highest in the world. Based on delivery statistics, gasoline consumption fell almost 7 per cent between 1990 and 1997, but auto diesel consumption, which has been taxed at a lower rate, increased by approximately 38 per cent, so gasoline consumption was 165 million litres lower in 1997 than 1990, but auto diesel consumption was 485 million litres higher. Furthermore, there is a tax on the purchase of vehicles which is not related to usage, but differentiated according to three categories of weight, four categories of engine volume and four categories of engine capacity which may influence choices toward more fuel efficient cars. There are annual taxes for both cars and lorries. Lorries pay a further annual weight tax which, in 1998, ranged from zero for vehicles below 12,000 kg to NKr 6,239 for those in excess of 25,000 kg. Economic incentives are provided to recycle scrapped cars. In 1996, the financial incentive was substantially increased for a one-year period to scrap the oldest, most polluting cars, but a cost-benefit analysis of the environmental and financial aspects showed that this was not a profitable scheme.

42. National policy guidelines for coordinated land-use and transport planning decreed in 1993 that 'planning of the spatial pattern of development and of the transport system should be coordinated, to promote forms of transport that are as effective, safe and environmentally friendly as possible, and to limit the need for transport'. Responsibility for implementing the guidelines lies with the national authorities, counties and municipalities.

43. Toll rings operate around the largest towns in Norway, which may contribute to lower car usage or reduced congestion. The resultant revenue provides funding mostly for road building, but also infrastructure for public transport. The Government, in 1997, presented a road pricing strategy, which received the support of the parliament, whereby drivers would pay for each journey. The Ministry of Transport and Communications should present the necessary legislative proposals in 1999.

44. Research is being conducted into the use of alternative fuels in the transport sector and there are pilot projects on the use of natural gas in buses and ferries, and on electric vehicles. The Ministry of Transport and Communications has provided annual support of around Nkr 10 million per annum since 1991, with more than half the funding going toward natural gas projects. Electric cars have been exempted from various taxes and city tolls in Oslo. In 1998, there were approximately 180 electric vehicles, 40 compressed natural gas (CNG) taxis or vans, 12 CNG buses and 150 liquefied petroleum gas taxis or passenger cars in operation.

45. Support is given to the provision of public transport, but this has not halted the growth in the popularity of the car as the main means of travel. The Ministry of Transport and Communications has a special programme to support the construction of infrastructure for public transport in the four largest cities, with a budget of Nkr 144.5 million in 1998. Subsidies provided by regional authorities for local public transport have been fairly stable during the 1990s and totalled about Nkr 2.8 billion in 1997. The State budgeted Nkr 930 million for railways, Nkr 246.8 million for rural air transport and Nkr 199.7 million for coastal shipping support in 1998.

C. Agriculture

46. Norway has about 80,000 farms, yet only a small proportion of the country's area is devoted to agriculture. The agricultural sector is responsible for significant emissions of CH₄ and N₂O, in particular, such that about 9 per cent of Norway's total GHG emissions are generated from agricultural activities. No policies were in place specifically to reduce GHG emissions in this sector, but a number of measures to reduce nutrient runoff from land and use manure more efficiently should have some effect in practice.

47. Agricultural CH₄ emissions, which constituted about 31 per cent of the total CH₄ emissions in 1997, are mainly attributable to enteric fermentation from ruminants with 26 per cent, while manure management accounted for 5 per cent in 1997. Livestock numbers are adjusted in line with domestic demand and there have been no significant trends during the 1990s. Regulations relate to animal density per hectare and how and when manure is spread, which may assist in limiting CH₄ emissions.

48. Research is being conducted on how best to apply fertilizer in order to reduce emissions of N₂O from soil. As of 1998, farmers must have a fertilizer plan, which should lead to its more efficient usage. Furthermore, there is a fertilizer tax, adding about 20 per cent to the price of nitrogen fertilizer. Subsidies for leaving fields untouched over the winter, in order to reduce

run-off and for the drainage of cultivated land, which reduces the area of anaerobic soil conditions, may both have a limiting effect on N₂O emissions. The Ministries of Agriculture and the Environment, together with the Farmers' Union, promote organic farming. This includes additional subsidies per hectare and subsidies during the transition period before which products cannot be sold as organic. Organic farming should reduce the use of nitrogen fertilizer.

D. Forestry

49. Ever since the first forest inventory in 1925, the annual increment has been larger than the harvest. As a result, the volume of the growing stock has more than doubled since 1925. The most recent data from inventories carried out by the Norwegian Institute for Land Inventory show that the total volume of the growing stock, without bark, below the coniferous forest line was on average 648 million m³, in the period 1994 - 1997. This consisted of 46 per cent spruce, 33 per cent pine and 21 per cent broadleaved trees. In 1996, the net increment in the growing stock was about 11.6 million m³ or 1.8 per cent of the total volume. In recent years the net annual uptake of CO₂ by productive forests has been rising, to correspond to more than 40 per cent of Norway's CO₂ emissions in 1997. This includes CO₂ assimilated in bark, roots and other biomass.

50. About 80 per cent of the forest is in private ownership and only around 1 per cent is protected by the State. The economic importance of forestry has been declining during the 1990s as a result of low timber prices and moderate harvesting. The registered level of silviculture activities has been dropping for several years. This may be partly explained by the fact that thinning accounts for a rising proportion of roundwood cut, and partly by the fact that clear-cutting and replanting are, to some extent, being replaced by logging techniques that ensure a larger degree of natural regeneration.

51. Forest policy consists of regulations, including certain requirements for reforestation in particular, economic support schemes, research and information programmes. The Forest Protection Act prohibits the cutting of growing forest. State funding is provided for planting and other silviculture activities. The average support for planting amounts to around 30 per cent of total costs, but support can vary from nothing up to 80 per cent of project costs.

E. Waste

52. In 1997 CH₄ from landfills accounted for around 55 per cent of CH₄ and 7 per cent of GHG emissions in Norway, 85 per cent coming from municipal landfills and 15 per cent industrial. The environmental authorities' strategy is firstly to minimize waste generation, secondly to promote the re-use and recovery of useful material and the extraction of energy from any waste generated and, thirdly, to ensure sound management of the residual waste. Waste management strategy is, in part, governed by the requirement to fulfil the EC waste directive. Work is being conducted on the environmental impact of different types of waste management and it is not clear whether recycling is always beneficial from the GHG standpoint. Much of the responsibility for implementing waste policy lies with the municipalities.

53. In relation to the waste goals, the amount of household waste has been rising ever since the first surveys were made in the early 1970s. Figures for recent years show a steep increase in the amount of waste recycled. By 1996, sorting and collection at source was available to more than one million households or just over half the population. In that year, 63 per cent of municipal waste was landfilled, 20 per cent delivered for material recovery, 16 per cent incinerated, and 1 per cent treated biologically. The proportion of waste from manufacturing industries delivered for material recovery or re-use also rose substantially in the 1990s to reach 44 per cent in 1996. Simultaneously, the proportions incinerated and landfilled fell, reaching 19 per cent and 23 per cent respectively in 1996.

54. The recycling of waste should accord with guidelines associated with municipal landfill permits. At some sites there are bans on the type of waste deposited and a variety of schemes exist for the collection and recycling of various types of waste. In some cases these were established because this was more cost-effective than normal refuse collection, but in other cases it has been necessary to promote recycling through the use of taxes or agreements with particular industries. From January 1999, a landfill tax of NKr 300 per tonne applies to organic waste or mixed organic waste, payable by landfill owners, with the aim of deterring the delivery of such waste to landfills. Many landfills will not accept food or garden waste; instead this receives biological treatment or is composted.

55. During the 1990s there has been a significant reduction in the number of landfills and increased use of gas collection. In 1996, at 15 facilities, an estimated 13.5 Gg of CH₄ from landfills was flared or used for energy purposes, or about 5.5 per cent of CH₄ from this source, compared to 0.8 Gg in 1990. At the time of the review 34 facilities had gas collection amounting to about 21 Gg of CH₄ annually. By 2000 it is expected that there will be fewer landfills, and that 70 per cent of the deposited waste will end in landfills with gas collection. This is in accordance with the guidelines for municipal landfill permits issued by the SFT, which state that municipal landfills emitting significant amounts of combustible gas should be equipped with a gas extraction and flaring system. In 1997, 63 per cent of the 1,400 GWh of district heating produced was from waste incineration. Other sources included waste heat from industry, wood chippings, gas from landfills, electricity and oil. As of January 1999, incinerators will pay a basic charge of NKr 75 per tonne of waste, with an additional charge varying according to the degree of energy recovery from NKr 0 to 225 per tonne.

F. Industry

56. The CO₂ tax applies to energy use of fossil fuels for most industries. In 1997 an agreement was entered into between the Ministry of the Environment and each of the Norwegian aluminium producers to limit emissions of CO₂, tetrafluorocarbon (CF₄) and hexafluoroethane (C₂F₆) resulting from electrolysis and anode effects. It includes three reduction targets. Compared to 1990, CO₂ equivalent GHG emissions should be reduced by 50 per cent per tonne of primary aluminium produced by the end of 2000 and 55 per cent by the end of 2005, noting that in 1990 GHG emissions, on a CO₂-equivalent basis, were 5.5 tonnes per tonne of primary aluminium produced. The aluminium industry is to base its actions on a joint plan for the

implementation of this agreement. The agreement requires annual reporting of emissions on the basis of agreed methodologies. Arrangements will be made for the Pollution Control Authority to check on the implementation of measures and report progress to the Ministry of the Environment. The agreement is based on an assumption that production will not exceed 1,036 million tonnes of aluminium annually, otherwise adjustments will need to be agreed. In 1997, GHG emissions under this agreement, on a CO₂ equivalent basis per kg of output, were 40 per cent lower than in 1990.

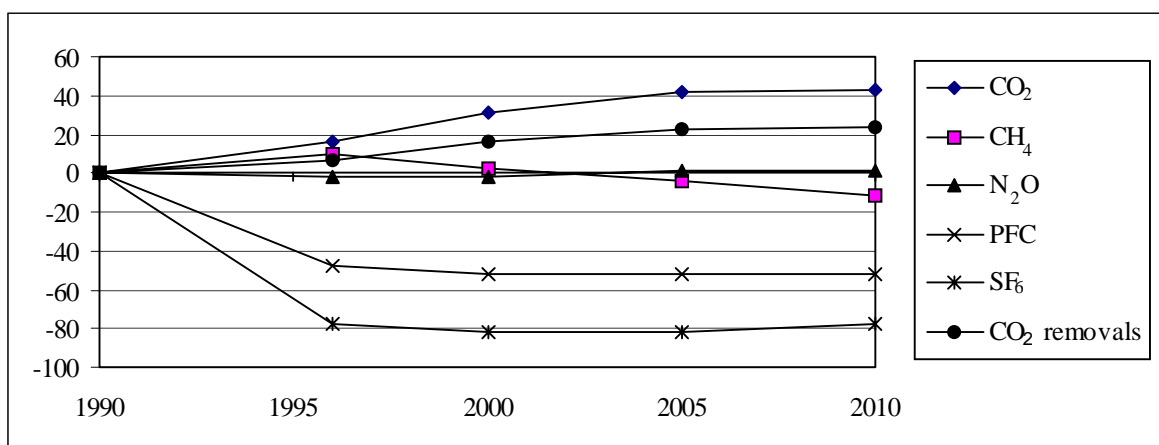
57. A number of industries, including the aluminium industry, will be required to apply best available technology in production under the Integrated Pollution and Prevention Control Directive, which had yet to be implemented in Norway at the time of the review, but which should be incorporated into Norwegian legislation by October 1999. This could result in GHG emission reductions.

58. Measures to limit emissions of SF₆ from magnesium production, N₂O from nitric acid production and HFC consumption are under consideration.

IV. PROJECTIONS AND THE EFFECTS OF MEASURES

59. There is no quantified information in the NC2 about the effects of measures incorporated in the projections, other than for the waste sector. It contains ‘business as usual’ projections of the six direct GHGs up to 2020 as well as net CO₂ removals in forests and the indirect GHGs CO, NO_x, NMVOCs and SO₂ over the same period. Modified projections for the period up to 2010 were provided during the review. The NC2 usefully contains a brief description of both the underlying assumptions for the projections and the methodology employed. This section of the in-depth review report does not take into account revisions to historic data presented in Norway’s 1999 emission inventory report.

Figure 3. Projections of GHG emissions, percentage change from 1990



60. Compared to the NC1, projections of CO₂ in 2000 were revised upward from 39,000 Gg to 44,000 Gg in the NC2, a figure which has subsequently been revised upward to 46,400 Gg or 31 per cent higher than actual emissions in 1990. By 2010, CO₂ is projected to reach 50,600 Gg and be 42 per cent higher than in 1990, as shown in figure 3. Since the NC2 there has been no revision in projections other than for the petroleum sector, which was responsible for 23 per cent of CO₂ emissions in 1995, so it is still possible to consider information in the NC2 for other sectors to 2020. CO₂ emissions from domestic transport are expected continually to trend upwards and double over the period 1990 to 2020. Compared to 1990, manufacturing emissions increase by around a quarter in 2010 and thereafter stabilize to 2020. Household emissions are expected to increase after 2005, to be about 17 per cent higher in 2020 than in 1990. Up to 2000 there are no emissions from electricity generation, but thereafter about 2,100 Gg of the annual projected increase in CO₂ emissions is attributed to electricity generation from two combined-cycle gas turbines with a total capacity of 5.6 TWh. This is because there is limited scope for further exploitation of hydroelectricity. However, it is possible that these plants will not be constructed or will incorporate CO₂ recovery systems such that the projections become overstated. Petroleum-activity-related CO₂ emissions were, in the NC2, expected to continue on an upward trend, as witnessed in the 1990s, to reach peak levels of 12,000 Gg in the period 2000 to 2010, before trending downward. Revised CO₂ projections show a much more rapid increase in emissions, with a peak around 2005 at about 16,000 Gg or twice the 1990 level. By 2015 emissions from this sector are expected to fall back to current levels of around 11,000 Gg.

61. CO₂ removals by sinks have been estimated under different assumptions for natural losses and also the wood harvest, which depends on world timber prices. Compared to removals of 9,400 Gg in 1990, the range could be 13,400 Gg to 15,600 Gg in 2010 and 12,800 Gg to 16,800 Gg in 2020. The so-called 'best estimate' within this range is shown in figure 3. Whilst forestry policies will affect CO₂ removals, the time lag between actions and actual growth is substantial, so over the next few decades the level of harvest will have the biggest influence in this sector.

62. Both the NC1 and the NC2 reported an approximate 4.5 per cent reduction in the expected level of CH₄ emissions in 2000, compared to the level of 432 Gg in 1990, but this has subsequently been modified as a result of revised petroleum sector expectations, such that an increase of 2 per cent is now expected. Thereafter, emissions of CH₄ are expected to decline. Emissions from waste are expected to decline from about 302 Gg in 1990 to 200 Gg in 2010 and then stabilize. This assumes the implementation of existing and new policy instruments. Without new measures, the CH₄ emissions from this source would be expected to increase by 15 per cent.

63. Emissions of N₂O are likely to increase slightly over the projection period, mainly due to higher emissions from transport. Emissions of PFCs and SF₆, having already declined rapidly to date, are projected to stabilize. Conversely, emissions of HFCs, although small today, are expected to grow quickly, as their role in substituting ozone-depleting substances in cooling equipment increases. Over the forecast period, 1990 to 2020, CO emissions are projected to

decline by around 35 per cent, NO_x emissions to be broadly stable, NMVOC emissions to decline by about 28 per cent and SO₂ emissions to fall by approximately 32 per cent.

64. Overall, compared to 1990, emissions of the six direct GHGs are projected to increase by 16 per cent in 2000 and 23 per cent in 2010. In terms of total GHG emissions, the proportion from petroleum activities is projected to grow from 14 per cent in 1990 and 18 per cent in 1996 to 22 per cent by 2010.

65. GHG emissions are projected by the Ministry of Finance on the basis of macro-economic models maintained by Statistics Norway, covering different time horizons, supplemented by separate studies for transport and for the petroleum sector. There is cooperation between various ministries in order to supply assumptions for the various models. Emissions of non-CO₂ gases are projected by SFT. The CO₂ projections incorporate the expected effect of current policies at the time of the NC2 and do not incorporate any policies to which the Government was not committed. Only economic instruments, which dominate Norwegian policy, are included in these model-based analyses, but the effect of other measures may be picked up by the assumed 1 per cent annual improvement in energy efficiency. The state power company supplies more than 50 per cent of industry's electricity needs. Most energy-intensive companies have long-term contracts at relatively low prices and, whilst there may be some developments toward more market-based contracts for such industries, it was assumed in the modelling that these would, on the whole, remain intact. It was further assumed that it would not be profitable for such industries to expand production involving the purchase of additional electricity.

66. The Ministry of Petroleum and Energy carries out projections of future Norwegian petroleum activities. These include, among other things, projections of oil and gas production and associated emissions of CO₂, CH₄ and NMVOCs. The emission projections are partly based on data submitted by the oil companies and controlled by the authorities, and partly on the Ministry's expectations of future production levels and technology. Effects of the existing policies are included in the projections. Changing production levels are not the only factor affecting emissions, as the stage of a field's development affects its energy demands related to water and gas injection. After 2005, there are significant uncertainties about when different fields go off plateau production levels, how fast their output declines, when fields under construction come on stream, technology employed and the recovery factor and hence energy requirement for each field.

67. The petroleum sector projections incorporate a tax of \$60 per tonne of CO₂ emitted, in line with existing policy. It is therefore assumed that all mitigation measures costing less than this are employed and technology development is enhanced. A price of \$18 per barrel of North Sea oil is assumed. Lower oil prices would not affect production for some time because there are major sunk costs involved in developing oil fields, whilst the short-run marginal costs of production are low. So, whilst sensitivity analysis has been conducted for different oil prices this was not found to have much impact on the emissions projections in this sector in the short to medium term. However, a reduction in the oil price will have a significant impact on

government revenues, which can fall by 20 per cent or \$3 billion in 2010 if the oil price drops from \$18 to \$13 per barrel, as well as on export earnings amounting to around 2 per cent of GDP.

68. The Government's long-term programme for transport uses projections drawn up by the Institute of Transport Economics. In the period 1980 to 1995, the average rate of growth for private cars and public transport was 2.2 per cent and 1.3 per cent, respectively, but this is assumed to drop to 1.3 per cent and 1.0 per cent respectively in the period 1995 to 2010. The estimates are based on slower assumed growth in the number of people holding driving licences, a slower increase in the number of cars and slower growth in the labour force. The projections show that growth in goods transportation in mainland Norway will be substantially lower in the period 1995 to 2010 than in the previous 15-year period. For this period, the projected average annual growth rate for road transport is 1.9 per cent, slightly lower than for sea and rail at 2.0 per cent. The slower growth is explained by the imposition of a CO₂ tax, in addition to existing taxes.

69. There are several uncertainties in the CO₂ emissions projections. As these are based on historic econometric relationships it is possible that future behaviour does not follow the same patterns, for example as a result of technological progress. Assumptions about petroleum activities, world fuel prices and energy efficiency improvements could differ from reality, which all affect economic growth and hence emissions. Furthermore, whether future increases in electricity demand are met by natural gas and whether this is with or without CO₂ recovery systems could have a significant impact on the future path of emissions.

70. Projections of gases other than CO₂ carried out by SFT are based on a combination of trend analysis, information from companies and knowledge about the expected impact of policies and measures. Separate analysis is provided on different scenarios of CH₄ emissions from waste, according to degree of policy implementation. On the basis of recycling schemes and gas recovery facilities in operation or under construction and assuming the development of new methods of disposal for increasing volumes of municipal waste, CH₄ emissions could increase from 302 Gg in 1990 to around 365 Gg in 2020. If new policy is implemented involving increased gas flaring, enhanced recycling activities, including voluntary agreements between the Government and various industries, then emissions could fall compared to 1990 and be in the range of 170 to 230 Gg by 2010 and beyond, despite forecasts of increasing waste volumes.

71. Around 45 per cent of N₂O emissions have been from nitric acid production and in making the projections, expected production levels of the two Norwegian producers have been taken into account. In making the projections, no changes in current agricultural policy were assumed and hence no significant changes are expected in the consumption of fertilizer, so most of the increase in emissions is due to increased penetration of catalytic converters in the car market. The PFC projections are partly based on the views of industry, which expects a small growth in output and does not believe that significant improvements in technology or processes are now possible, but the projections did not take into account the possible effect of the voluntary agreement signed in 1997. At the time of the review, there were no plans for further reduction of SF₆ use in the magnesium industry. It has been harder to make the projections of HFCs because

there are many consumers, so, instead of detailed analysis, simple assumptions have been made about the rate at which substitutes are phased out. By 2010 it is assumed that 0.68 Gg of HFCs will be used as refrigerants, 0.32 Gg as foam blowing agents, 0.12 Gg as solvents and a small amount in fire extinguishing agents. This represents potential emissions of 1,800 Gg of CO₂ equivalent in 2010 (IPCC default method, tier 1). Chemicals stored in imported products are not included in this number.

V. EXPECTED IMPACTS OF CLIMATE CHANGE AND ADAPTATION MEASURES

72. Between 15 and 20 per cent of the funds from the Norwegian Climate and Ozone Research Programme went toward climate impact studies over the period 1993 to 1997. The NC2 contains a description of how climate change might impact on the Norwegian environment, but does not discuss the possible impacts on physical systems, including hydroelectricity. There is great uncertainty surrounding possible climate change variation at a regional level. Currently, models suggest that warming could result in a 5 to 15 per cent increase in precipitation, especially on the western coast in spring.

73. Sea-level rise is not a particular concern for Norway as the country is still lifting, in some places faster than the sea level, but increasing storm frequency could be damaging, especially to fish farming. This could also increase the risk of shipping accidents and oil spills along the coast. Spring tides could be higher and flooding could occur in some areas if increased rainfall led to river bursts. Flood prevention measures have been in place for many years, so adaptation should continue to occur autonomously over time.

74. Changing temperatures and higher CO₂ concentrations could affect forest and plant life, although the outcome of countervailing effects is unclear. Furthermore, temperature rise could affect the composition of vegetation at different altitudes and latitudes. Given that plants migrate slowly, many species could be exposed to climates to which they are unsuited, thereby changing the overall composition. There will be consequent effects on animal life. More climatic variability could also alter the ecosystem. Some species will be able to migrate short distances to higher altitudes in response to a changing climate, whereas others native to alpine forests may diminish. It is believed that climate change could have particularly adverse consequences for the flora and fauna of marshes in eastern Norway and Finnmark. Most marine species are capable of moving quickly and so should be able to adapt to changing temperatures, but there could be a change in the distribution and size of different fish stocks.

75. In the early 1990s a study was conducted to consider possible climate impacts on hydroelectricity. It was found that increased rainfall could increase electricity production and that some changes to the infrastructure may be required. Warmer temperatures could also result in lower heating requirements.

VI. EDUCATION AND PUBLIC AWARENESS

76. Officials believe that public awareness about climate change is fairly high in Norway, especially as it has become one of the most important environmental issues for the Government, thereby sparking media interest. Non-governmental organizations also play an important role in raising awareness.

77. The Ministries of Education and the Environment are involved in planning the teaching of environmental issues in primary and high schools. The focus of these studies is on energy and the environment. A national programme has been instigated to reduce energy consumption in schools through active pupil participation. Various materials are available on request to schools, including the Norwegian Pollution Control Authority annual report on the state of the environment, which incorporates data on emissions of various pollutants. This information is also accessible via the Internet.

78. Energy efficiency campaigns targeting households have been conducted through the mass media. There are also energy efficiency centres in most counties, allowing customers to find out about energy-saving measures and get information on state energy efficiency programmes. The Norwegian Information Centre for Energy Efficiency has run training courses, primarily targeted at caretakers, maintenance personnel and architects.

79. In 1990, the Government established the Centre for International Climate and Environmental Research (CICERO) as a private non-profit organization with the aim of developing research on climate change policy and also of keeping various 'stakeholders', including Government, industry, the media, schools and the public, informed about international climate change policy developments. It is partly funded by the Norwegian Government and various international bodies. It organizes quarterly meetings of a 'climate forum' group to bring together representatives of industry, Government and academia to share information on international climate research and policies. CICERO publishes a quarterly newsletter covering international policy developments and research findings related mainly to economics, political science, sociology and natural science. It also translated the IPCC Second Assessment Report Summary for Policymakers into Norwegian in 1996. CICERO is developing a 'climate encyclopaedia' which will be launched in 2000 on the Internet.

VII. FINANCIAL ASSISTANCE AND TECHNOLOGY TRANSFER

80. For the period 1994 to 1997, Norway provided an extra grant of around Nkr 55 million annually, in addition to its assessed annual share of Nkr 54 million for the Global Environment Facility (GEF). It also exceeded the United Nations' target of 0.7 per cent development assistance in relation to gross national product (GNP). Due to a change in the method of calculating GNP, the estimate of overall ODA as a percentage of GNP has been reduced from around 1 per cent of GNP to about 0.8 per cent. The Government has a declared goal to increase this to 1 per cent. Whilst most ODA is focused on alleviating poverty, some projects may have an impact in improving technology transfer and reducing GHG emissions.

VIII. ACTIVITIES IMPLEMENTED JOINTLY

81. Funding for activities implemented jointly (AIJ) is separate from overseas development assistance (ODA). The 'Climate Fund' has been used to finance AIJ projects and capacity-building through workshops, studies etc, in particular in developing countries. The Norwegian AIJ portfolio covers a number of different regions and activities. It includes four projects implemented in cooperation with the World Bank in Burkina Faso, India, Mexico and Poland, and bilateral projects in Costa Rica and Slovakia. Agreements with China and Romania were subject to finalization at the time of the review. The projects mainly relate to the energy sector and cover fuel switching, energy efficiency, and power sector development, but there is one reforestation project. In total, they involve a commitment of about \$18 million. Officials noted that, in terms of the environmental impacts, energy efficiency projects tend to involve so-called 'rebound effects' which reduce the expected gains, hence projects which also involve fuel switching are likely to be more successful. In addition to ODA, technical assistance amounting to NKr 1,277 million over the period 1994 to 1997 was given to Annex I Parties with economies in transition, with an emphasis on technology transfer.

IX. RESEARCH AND SYSTEMATIC OBSERVATION

82. The NC2 contains a good description of the varied activities related to research by a large number of organizations. Much of the climate and technology research conducted in Norway involves close cooperation at either the Nordic, European or international level. Funding of relevant activities is provided directly by the State and the private sector to research institutions (universities, institutes etc) and through targeted programmes through the Research Council of Norway. A commission for coordination of climate change related research was set up in 1998.

83. In addition to NKr 100 million for technology research in 1998, the Research Council of Norway provided NKr 40 million for the natural sciences and NKr 10 million for socio-economic research. From the technology budget, the Research Council operates an initiative of several ministries related to the enhanced use of technology for GHG mitigation, focusing mainly on the petroleum and processing industries. About 80 per cent of relevant funds are directed toward technology demonstration projects and 20 per cent toward long term research and development. As part of the success criteria, options are sought which allow for cost-effective implementation and no additional adverse environmental impacts. A five-year programme began in 1997 with an annual budget of NKr 120 million, of which NKr 25 million came from the Research Council and a significant contribution from industry. One of the most important projects relates to the separation of CO₂ from exhaust gas and natural gas. Other projects include studies on new processes for industry in several sectors and technological options to reduce transport emissions.

84. As of 1997, from its technology budget, the Research Council was providing an annual amount of NKr 24 million for research related to technology with the potential to reduce GHG emissions and renewable energy sources. Objectives include the development of products which have the prospect of becoming profitable within a five-year period and work is being conducted,

inter alia, on bio-energy, photovoltaic electricity, solar heating, wind energy, wave energy, flexible heating systems and heat pumps.

85. Work on natural sciences covers improved understanding of the causes of climate change, predicting future climate change and the environmental impacts of climate change. The climate and ozone programme, which received Nkr 22 million in 1997, includes work on regional climate modelling, atmospheric studies, ocean studies, paleoclimatology and impacts on biodiversity. In 1999 a monitoring system for the concentration of CH₄, CFCs, HCFCs, HFCs, halons, PFCs and SF₆ will be established at Ny-Ålesund on Spitsbergen, funded through SFT. Socio-economic activity focuses on policy-oriented research, in particular related to energy, and the impacts of climate change on society. Basic funding of CICERO is additional to the funding through the programmes of the Research Council.

X. CONCLUSIONS

86. The team formed a favourable impression about the work on inventories. It appears that good quality activity data are available for all the key sources and that underlying more than half of total estimated emissions are national emission factors. The team noted that Norway had compared the IPCC default approach with their own methodology for the whole time series since 1990. Additional approaches were employed to check the consistency of the methodologies. The team also noted the work being conducted to improve understanding of uncertainties associated with emissions inventories.

87. The Norwegian Government has pursued a gradual strengthening of policies and measures which mitigate GHG emissions, even though this is not always their primary goal. Despite this, by 2000, GHG emissions are projected to be 16 per cent higher than in 1990. CO₂ emissions are expected to be about 31 per cent higher than in 1990, whilst CH₄ emissions are projected to be around 2 per cent higher and N₂O to remain unchanged, compared to 1990. The latest projections indicate that GHG emissions may be 23 per cent and CO₂ emissions 42 per cent higher than the 1990 level by 2010 and that N₂O emissions could be 2 per cent higher, whilst CH₄ emissions could decline by around 12 per cent. To a large extent the trends in Norwegian CO₂ emissions will reflect activities in the petroleum sector.

88. The main instrument to mitigate CO₂ emissions has been a cross-cutting carbon tax, although there are exemptions to maintain the international competitiveness of industry. Petroleum activities account for a significant share of GHG emissions. Through various measures Norway has achieved lower emissions per unit of output than other major offshore producers and continues to promote the development and implementation of new technology. Nevertheless, increasing production and maturity of the fields is expected to lead to rising emissions from this sector.

89. Hydroelectricity dominates electricity generation in Norway, but due to technical and environmental reasons, it is unlikely to expand to meet growing demand. It was unclear at the time of the review whether Norway would build combined cycle gas turbine plants, more fully exploit other types of renewable energy or become a net importer of electricity. Despite

relatively high petrol and diesel prices, toll rings and other measures, transport growth continues to be a problem in terms of growing emissions.

90. Norway invests significant resources in research covering, *inter alia*, inventory improvement, technology development, climatology and the social sciences. There is also a strong commitment to ODA.

91. Awareness about climate change issues is relatively high. This was best illustrated to the team when informed that public protests had occurred focusing on possible climate impacts if gas-fired power generation plants are constructed in Norway. Climate change and energy efficiency issues appear to be promoted in all relevant groups. However, the effectiveness of energy efficiency campaigns has been somewhat limited to the extent that electricity was, historically, relatively inexpensive and consumers became accustomed to a high level of comfort in household heating.
