Notebook

1991 Carbon Dioxide Fact Sheet

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Notebook is a new ESR feature that will provide data not easily found elsewhere and background descriptions of important aspects of the energy system. Contributions are invited.

In Canada's *Green Plan*, released in December of 1990, the Government's policy was confirmed of stabilizing emissions of greenhouse gases at their 1990 level by 2000. Canada thus joined the growing group of nations (mainly in Europe) to have set targets to deal with the threat of global warming. While no international targets were agreed upon at the recent United Nations Conference on Environment and Development held in Brazil in June of 1992, much of the Conference's attention was focused upon this subject. Greater efficiency in the Canadian energy economy will be encouraged as one means of reaching this goal which, since it is a fixed upper limit, will become ever more difficult to achieve over time. Other means of control will no doubt be required sooner or later (Dept. of the Environment, 1992). For these reasons, there is much interest in world-wide emissions of greenhouse gases. In Canada, there is particular

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interest in the values for 1990, a recessionary year, since it was selected as the base year for reference.

These calculations provide an early review of the world's emissions of carbon dioxide from the three fossil fuels for 1991. They do not include emissions from such sources as the decomposition of limestone in the cement industry, nor any information on the other greenhouse gases, notably methane. One of a series, this note is not intended to displace the detailed sector-by-sector studies needed to determine carbon dioxide emissions accurately either in Canada or elsewhere. The purpose of the series is to provide earlier estimates than are possible with the use of a sectoral approach.

The 1991 issue of the *Carbon Dioxide Fact Sheet* follows the format of previous reports in this series in relying upon the *BP Statistical Review of World Energy*, which is published every June following the year under review. This well-accepted source provides a comprehensive set of energy statistics for the world as a whole, classified by the principal nations and regions, on a timely basis. The data are especially useful for the estimation of carbon dioxide emissions from fossil fuels since they provide a means of comparing these emissions throughout the world on a consistent basis as early as six months after the conclusion of the subject year. Now that the National Energy Board no longer publishes preliminary statistical data in its *Annual Report*, normally released in the April following the year in question, the *BP Statistical Review of World Energy* provides the earliest source of detailed statistical information for Canada available to the public at large.

Internationally accepted coefficients are applied to these energy consumption data to estimate carbon dioxide emissions for Canada, for other leading nations and regions of interest, and for the world as a whole. This overall or 'top-down' approach involves two major inherent errors: non-energy applications for the fossil fuels which may not lead to the emission of greenhouse gases are ignored, as are the internal (or parasitic) use of fossil fuels in the production side of the energy industry, which may be either not reported or under-reported in conventional consumption statistics. (These two errors tend to balance each other.) P.A. Okken has calculated that emissions of carbon dioxide as determined from global fuel statistics should be reduced some 2% to account for non-energy applications (Okken, 1990). Nor are other greenhouse gases taken into account such as the methane released to the atmosphere from natural gas and coal during the production and distribution of these fuels. In 1991, the production of natural gas was reported as exceeding consumption by 2.7% (3.8% in 1990), suggesting there is still significant flaring in some production regions.

In addition to these difficulties, there is an inevitable uncertainty in global statistics dealing as they do with enormous flows of energy among a great many nations, each of which may be in quite different economic circumstances. What is important for the preliminary monitoring of carbon dioxide emissions, however, is the direction of change from year to year and its consistent measurement for both regions and major countries, including the patterns of consumption of the three fossil fuels in the respective individual primary energy balances. Nevertheless, the data reported here cannot be considered a substitute for a 'bottom-up' analysis of emissions; however, such detailed studies inevitably take a good deal of time to conduct.

The same conversion factors were used as in previous years. The conversion of one million tonnes of oil equivalent (MTOE), the basic energy unit adopted in the *BP Statistical Review*, was taken as 42 petajoules, the value also used by the World Energy Council. The specific factors applied to the three fossil fuels were those employed by the International Energy Agency: for oil — 19.9 million tonnes of carbon (not the dioxide) per exajoule (MTC/EJ); for natural gas — 13.8 MTC/EJ; and for coal — 24.1 MTC/EJ, all calculated on the basis of the higher heating value (HHV). The greatest uncertainty in the selection of

appropriate conversion factors centres on coal, which may vary from one production region to another. Should it be desired to express emissions in terms of carbon dioxide rather than the carbon convention used in this note, the factor is 3.67.

The method of calculation of primary electricity (hydro and nuclear), and thus primary energy, was changed in the *BP Statistical Review* in the report for 1991 to be consistent with the system adopted by the International Energy Agency, the World Energy Council, and some other such bodies, and which has also been adopted by the Department of Energy, Mines and Resources. Energy derived from hydraulic sources is now reported as its thermodynamic equivalent of 3.6 MJ/kWh rather than the energy content of an estimated quantity of fossil fuel which would have been required to generate it. (Typically a conversion factor of 10.5 MJ/kWh was used previously for primary electricity.) For nuclear power, the factor adopted is 10.9 MJ/kWh, which is equivalent to the 33% efficiency of conversion of heat to electricity characteristic of a modern nuclear power plant. Though this change in methodology does not affect the calculation of carbon emissions in this note, ratios of carbon emissions to such important parameters as primary energy consumption will change substantially in a country such as Canada which has major generation of hydraulic energy and not negligible nuclear power. Care must thus be taken in applying data from past years. Also, as in previous years, the *Review* does not report the substantial consumption of non-commercial energy around the world, such as that derived from biomass sources. In the case of Canada, however, some of the biomass energy consumed may be reported as 'solid fuel' in certain statistical sources and thus this energy may appear ultimately counted in part in the coal tables. On the new reporting basis, 90.9% of the world's commercial energy was derived from the three fossil fuels in 1991. This high proportion is an indication of the difficulties that will be encountered if it proves necessary to reduce carbon dioxide emissions substantially in the coming years.

The recent world political changes have also necessitated new regional classifications in the *BP Statistical Review*. Europe is now divided into two major groups: OECD Europe, which includes the European Community and such nations as Austria, Finland, Sweden and Switzerland as well as Turkey; and Non-OECD Europe, which includes the republics of the former USSR together with the nations of eastern Europe — Bulgaria, Czechoslovakia, Hungary, Poland, Romania and the former Yugoslavia. A separate classification was also established for the developing countries (termed in the *Review* "LDCs"), but unfortunately the exact membership in this group of growing importance for carbon dioxide emissions is not specified. The increase in CO_2 emissions from the LDCs was 4.2% in 1991 over 1990, the greatest increase reported by any group, and these countries now account for 30.1% of the world's total emissions of this gas. There is every reason to believe these countries will account for a steadily rising proportion of the total as the years go by.

In 1991, world emissions of carbon from the three fossil fuels were 5.9 gigatonnes C in the form of carbon dioxide, an increase of 0.4% from the previous year. Total primary energy consumption reached a new high of 7807.6 MTOE, an increase of 1.0% over 1990. Reliance upon oil remains high at 40.2% of the primary energy consumed, but there are signs of an increase in the share of natural gas in the world energy balance. Aside from the LDCs, whose increase in primary energy consumption on the year was 4.3%, increases were modest in most countries except Non-OECD Europe, where there was a marked decline of 4.0%, no doubt due to the current economic dislocation in that region.

Two advanced European nations, France and Sweden, are following quite different energy strategies. France relies heavily upon nuclear power, which in 1991 accounted for 72.7% (IAEA statistics) of its electrical generation; nuclear generation increased 4.8% over 1990. Sweden, on the other hand, has

Table 1: Carbon Emissions (MT) from Fossil Fuels — World

	1990	%	1991	%
Oil	2620.2	44.9	2625.6	44.8
Natural Gas	993.5	17.0	1025.7	17.5
Coal	2227.3	38.1	2212.4	37.7
Total	5840.8	100.0	5863.7	100.0

Increase — 1991 over 1990: 0.4%
World per capita emissions from the three fossil fuels: 1.1 tonnes C/person/year (1991).

Table 2: Carbon Emissions (MT) from Fossil Fuels — Canada

	1990	%	1991	%
Oil	64.9	53.3	62.5	51.5
Natural Gas	32.2	26.4	33.2	27.4
Coal	24.7	20.3	25.6	21.1
Total	121.8	100.0	121.3	100.0

Decrease — 1991 over 1990: 0.4%
Canada as a percentage of the world's total: 2.1% (1991).
Canadian per capita release of carbon: 4.5 tonnes C/person/year (1991).

Table 3: Carbon Emissions (MT) from Fossil Fuels — US

	1990	%	1991	%
Oil	653.2	46.0	647.2	45.4
Natural Gas	281.9	19.8	294.3	20.7
Coal	486.7	34.2	483.6	33.9
Total	1421.8	100.0	1425.1	100.0

Increase — 1991 over 1990: 0.2%
US as a percentage of the world's total: 24.3% (1991).
US per capita release of carbon: 5.6 tonnes C/person/year (1991).

announced plans to phase out its twelve reactors, which accounted for 51.6% (IAEA statistics) of its electrical generation in 1991, although these are now running very well with an increase in generation of 10.7% reported over the past year. In fact, Sweden actually obtained more of its total primary energy supply from nuclear power (45.1%) in 1991 than

Table 4: Carbon Emissions (MT) from Fossil Fuels — Non-OECD Europe

	1990	%	1991	%
Oil	428.4	34.6	407.2	34.6
Natural Gas	362.3	29.3	359.3	30.5
Coal	446.9	36.1	410.7	34.9
Total	1237.6	100.0	1177.2	100.0

Decrease — 1991 over 1990: 4.9%
Non-OECD Europe as a percentage of the world's total: 20.1% (1991).
Non-OECD Europe per capita release of carbon: 3.0 tonnes C/person/year (1991).

Table 5: Carbon Emissions (MT) from Fossil Fuels — OECD Europe (including Turkey and the former East Germany)

	1990	%	1991	%
Oil	519.8	53.3	527.6	54.1
Natural Gas	133.0	13.7	142.2	14.6
Coal	321.6	33.0	305.3	31.3
Total	947.4	100.0	975.1	100.0

Increase — 1991 over 1990: 0.1%
OECD Europe as a percentage of the world's total: 16.6% (1991).
OECD Europe per capita release of carbon: 2.3 tonnes C/person/year (1991).

Table 6: Carbon Emissions (MT) from Fossil Fuels — China

	1990	%	1991	%
Oil	92.2	14.8	98.5	15.0
Natural Gas	7.7	1.2	7.8	1.2
Coal	525.1	84.0	550.3	83.8
Total	625.0	100.0	656.6	100.0

Increase — 1991 over 1990: 5.1%
China as a percentage of the world's total: 11.2% (1991).
China per capita release of carbon: 0.5 tonnes C/person/year (1991).

did France (30.7%). This unusual situation may, however, be an artifact of the statistics in that the extensive energy from biomass sources consumed in Sweden is not counted in the *Review*. Nevertheless, the latter country expects

to reduce its already low per capita emissions of carbon by relying more extensively upon biomass, by increasing its imports of natural gas, and by strengthening its already diligent conservation measures, all the while increasing economic output. French per capita emissions of carbon from the fossil fuels were 2.0 tonnes C/person in 1991, while those in Sweden have now fallen to 1.7.

Canadian carbon emissions declined for the second straight year, but less sharply than last year, at 0.4%. This decline was mostly due to the current prolonged recessionary period, and, though oil remained the largest source of carbon emissions, accounting for 51.5% of the total, the shares from both natural gas at 27.4% and coal at 21.1% increased over 1990. Canada continued to be responsible for 2.1% of the world's emissions of carbon from the fossil fuels and, with per capita emissions of 4.5 tonnes C/person, remained very high in the international rankings.

References

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