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A look at 1983 CO_2 emissions from fossil fuels (with preliminary data for 1984)

By RALPH M. ROTTY*, *Institute for Energy Analysis, Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge, Tennessee 37830, USA*

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ABSTRACT

During 1983, global emissions of CO_2 from fossil fuels continued to decline slightly, to a value of 4932 millions tons carbon compared to 4957 million tons carbon in 1982. This marked the 4th consecutive year that CO_2 emissions from fuel use has declined. Even though cement production has continued to increase very slowly, the annual CO_2 emissions from the combination of fuels and cement showed the relative decline that occurred in emissions from fuels alone. Although preliminary, data for 1984 strongly suggest that the decline is over; CO_2 emissions in 1984 were greater than any previous year other than 1979. Examination of each fuel type reveals that the decline in the total emissions between 1979 and 1983 was a result of reduced use of liquid fuels. Both gas and solid fuels continue to grow, albeit at a very slow pace.

Growth in fossil fuel use and resulting CO_2 emissions has continued in the developing world in contrast to the decline observed in developed countries of the western world in recent years. This could have important implications for growth in global emissions in future years.

1. Introduction

Since 1973, it has been customary to use the energy data published by the United Nations Department of Economic and Social Affairs to estimate the CO_2 emissions from fossil fuels (Keeling, 1973). During the intervening years, both the energy data collection and the procedures for estimating CO_2 emissions have been refined (Marland and Rotty, 1983, 1984). Although recent estimates of CO_2 emissions (and those reported here) are reflective of global economies, they have been useful in efforts to better understand the carbon cycle as well as in providing a basis from which projections can be made.

The compiling and revising of world energy data is a continuing process. Each annual *Energy Statistics Yearbook* published by the United Nations includes not only new data for fuel production and consumption for the most recent year but revised values for earlier years. The revisions are usually minor, but can be as much as a few percent for an individual country. Most of the larger revisions are made during the first year after initial publication; changes made two or three years later are generally quite small. An exception to this occurred in the early 1980s when all of the coal data were more rigorously evaluated and all solid fuels were reported on a coal equivalency basis of 7000 calories per gram "net heating value". This required an adjustment to all earlier emissions calculations, and estimates published in Marland and Rotty (1983) include appropriate corrections for each year back to 1950. Since then only routine revisions have been made to previously published UN energy data. Consequently, the CO_2 emissions calculated here show only some small changes in the estimates for previous years as well as extending the length of the series.

Fuel production data continue to be used in the

* Now at Mechanical Engineering Department, University of New Orleans, New Orleans, Louisiana 70148, USA.

Table 1. *Summary table of CO_2 emissions from fossil fuels, 1950–1984*

Year	Gas fuel production* (10^{12} joules) (thousands)	CO_2 from gas fuel (10^6 t C)	Liquid fuel production† (10^6 t oil)	CO_2 from liquid fuel (10^6 t C)	Solid fuel production‡ (10^6 t coal eq)	CO_2 from solid fuel (10^6 t C)	Gas flared and vented§ (10^9 m^3)	CO_2 from flared gas (10^6 t C)	Total CO_2 from fossil fuels (10^6 t C)
1950	7,193	97	542	423	1,471	1,078	44	23	1,621
1951	8,562	115	613	479	1,552	1,137	46	24	1,755
1952	9,241	124	646	504	1,538	1,127	50	26	1,781
1953	9,772	131	684	533	1,546	1,133	51	27	1,824
1954	10,250	138	714	557	1,533	1,123	52	27	1,845
1955	11,137	150	801	625	1,659	1,215	58	30	2,020
1956	12,019	161	870	679	1,748	1,281	61	32	2,153
1957	13,237	178	915	714	1,798	1,317	67	35	2,244
1958	14,285	192	938	732	1,834	1,344	66	35	2,303
1959	15,969	214	1,012	790	1,898	1,390	69	36	2,430
1960	17,521	235	1,089	850	1,936	1,419	75	39	2,543
1961	18,899	254	1,160	905	1,851	1,356	79	41	2,556
1962	20,614	277	1,257	981	1,853	1,358	84	44	2,660
1963	22,375	300	1,350	1,053	1,915	1,403	90	47	2,803
1964	24,457	328	1,458	1,138	1,968	1,442	97	51	2,959
1965	26,181	352	1,564	1,221	2,003	1,467	104	55	3,095
1966	28,330	380	1,697	1,325	2,026	1,485	115	60	3,250
1967	30,519	410	1,825	1,424	1,985	1,454	126	66	3,354
1968	33,144	445	1,989	1,552	1,986	1,455	139	73	3,525
1969	36,295	487	2,146	1,674	2,038	1,493	152	80	3,734
1970	38,409	516	2,356	1,839	2,177	1,595	167	88	4,038
1971	41,179	553	2,494	1,946	2,176	1,594	171	90	4,183
1972	43,371	582	2,635	2,056	2,200	1,612	180	95	4,345
1973	45,267	608	2,871	2,240	2,214	1,622	213	112	4,582
1974	45,876	616	2,877	2,245	2,211	1,620	204	107	4,588
1975	46,238	621	2,732	2,132	2,341	1,715	183	96	4,564
1976	48,024	645	2,965	2,313	2,394	1,754	210	110	4,822
1977	48,080	646	3,062	2,390	2,473	1,812	206	108	4,956
1978	51,124	673	3,055	2,384	2,495	1,828	201	106	4,991
1979	53,248	715	3,252	2,538	2,592	1,899	142	74	5,226
1980	53,938	724	3,086	2,408	2,626	1,924	149	78	5,134
1981	54,560	733	2,914	2,274	2,632	1,928	111	58	4,993
1982	54,665	734	2,798	2,184	2,707	1,983	106	56	4,957
1983	54,451	731	2,773	2,164	2,710	1,985	100	52	4,932
1984¶	58,384	784	2,906	2,268	2,871	2,103	90	47	5,202

* Data from UN (1985a) and corresponding Data Tape of UN Energy Statistics.

† Data from UN (1985a) and corresponding Data Tape of UN Energy Statistics. Numbers are the sum of crude oil and natural gas liquids, both in mass units.

‡ Data from UN (1985a) and corresponding Data Tape of UN Energy Statistics; in 10^6 t of coal equivalent where coal equivalent means net heating value of 29.31×10^9 j/t (7,000 cal/g).

§ 1950–70 data from Rotty (1974). 1971, 1972 data from US DOI (1974). 1973 data from US DOE (1979). 1974–1978 data from US DOE (1980). 1979–1982 data are estimates from incomplete data in International Energy Annual (e.g., US DOE 1984). 1983–1984 data are estimates by author.

¶ Data for gas, liquid and solid fuels are estimates by author based on data from May 1985 UN Monthly Bulletin of Statistics (UN 1985b).

estimation of the global annual CO_2 emissions "standard" series. The procedures used have been documented in Marland and Rotty (1983, 1984). To study where the emissions are being produced or to study the distribution of growth rates among the world regions, it is necessary to use fuel consumption data and this presents some problems not immediately evident. Especially with liquid fuels it is frequently difficult to reconcile the sum of the consumption of all liquid fuel products, i.e., gasoline, refined fuel oil, diesel fuel, jet fuel, etc. with the balance of production of crude oil, imports and exports of crude oil and oil products, and refinery production and usage.

Thus, to maintain an up-to-date file on global annual emissions, it is necessary each year to

examine and check all fuel data and then apply the Marland and Rotty (1983, 1984) procedures to the fuel production data. For regional studies, the techniques of Rotty et al. (1984), Rotty and Marland (1986), and Marland et al. (1985) are used with the less reliable fuel consumption data.

2. An update of global annual CO_2 emissions

Table 1 is given in the same format as fossil fuel emissions in other recent compilations (Marland and Rotty, 1983, 1984). The calculation for CO_2 quantities from gas fuels, liquid fuels, and solid fuels is straightforward, applying the techniques developed earlier to the latest UN energy statistics. The estimates for gas flaring show a pronounced downward trend in recent years (DOE, 1979, 1980, and 1984) and this trend has been used in calculating CO_2 emissions from flaring for 1983 and 1984.

During 1983 the global release of CO_2 from fossil fuel combustion continued to decline slowly from the peak year of 1979, but the rate of decline became very small between 1982 and 1983. Preliminary data indicate that the decline is over and the production of all three fuel types increased during 1984. Even liquid fuel production which had declined 14.7 percent between 1979 and 1983, increased an estimated 4.8% in 1984. Now that the decline in global CO_2 emissions appears to be over, a renewed rise can be expected over the next few years, although probably at a rate less than the 4.4%/year that was prevalent prior to 1973 (Rotty, 1978).

The data of Table 1 are plotted in Fig. 1 on a linear scale of estimated emissions. Because the steady exponential growth that is evident in the data for total emissions and for liquid fuels for the period prior to 1973 has clearly been disrupted, the value of the semi-logarithmic plots used earlier (Rotty, 1979; Marland and Rotty, 1984) is much reduced. Exponential growths in CO_2 emissions from gases and liquid fuels as well as the total emissions for the pre-1974 period are still evident in Fig. 1 and the trends since 1974 are more easily seen on the linear plot. The temporary slowing in the global use of oil following the 1973 OPEC embargo is shown along with a resumption of growth during 1975–1979. The steady decline in oil consumption from 1979

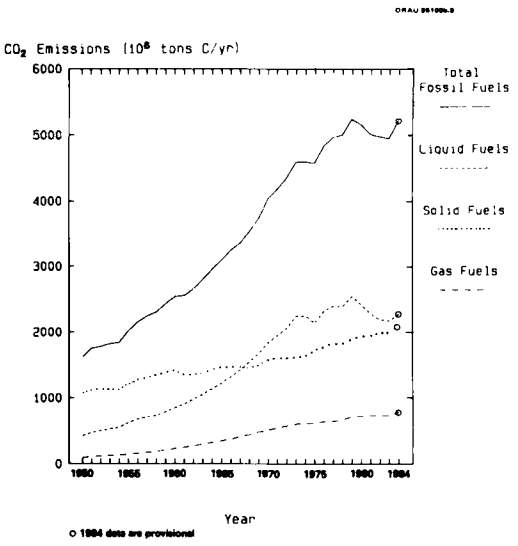

Fig. 1. Annual CO_2 emissions from fossil fuels.

through 1983 resulting, at least in part, from higher petroleum prices appears to have been reversed with an appreciable increase in 1984. Gas and solid fuels show a more nearly continuous growth although at rates below those of the pre-1973 years (especially for gas). The linear plot of Fig. 1 also suggests that solid fuels have experienced a continuous growth characterized as much by linear expansion as by exponential growth. Preliminary estimates for 1984 show substantial increases in use of gas and coal (as well as the turn-around for oil) as the global economy begins to grow after several depressed years.

Table 2 gives an update on the CO_2 from the production of cement. Even during the 1979–1983 period of declining fuel use, cement production has continued to grow. The carbon dioxide production from cement manufacture was about 1% of the CO_2 emitted from fossil fuels in the early 1950s, but it has grown faster than fossil fuel use, reaching 1.6% of the fossil fuel CO_2 by 1960, and about 2% by the early 1970s. In 1983 the CO_2 produced in the manufacture of cement was 122×10^6 tons C, equivalent to 2.5% of the CO_2 produced by fossil fuel combustion that year. The data for cement production have been taken from *Minerals Yearbook* (US Bureau of Mines [BOM], each

Table 2. *CO_2 emissions from cement and total from fuels + cement, 1950–1984*

Year	Cement production* (10^6 t cement)	CO_2 from cement (10^6 t C)	Total CO_2 from fuels + cement (10^6 t C)
1950	133	18	1,639
1951	150	21	1,776
1952	161	22	1,803
1953	178	24	1,848
1954	195	27	1,872
1955	218	30	2,050
1956	236	32	2,185
1957	247	34	2,278
1958	262	36	2,339
1959	294	40	2,470
1960	317	43	2,586
1961	334	46	2,602
1962	358	49	2,709
1963	377	52	2,855
1964	415	57	3,016
1965	434	59	3,154
1966	464	63	3,313
1967	480	66	3,420
1968	515	70	3,595
1969	543	74	3,808
1970	572	78	4,116
1971	617	84	4,267
1972	657	90	4,435
1973	702	96	4,678
1974	703	96	4,684
1975	702	96	4,660
1976	746	102	4,924
1977	797	109	5,065
1978	853	117	5,108
1979	872	119	5,345
1980	885	121	5,255
1981	892	122	5,115
1982	892	122	5,082
1983	894	122	5,054
1984	932	128	5,330

* Cement production data from US BOM Minerals Yearbooks, except 1983 and 1984 estimated for the BOM sequence from data in UN Monthly Bulletin of Statistics, February 1985.

year) because this was the most consistent and regularly updated data set available. Values for 1983 and 1984 were estimated from data in the UN Monthly Bulletin of statistics, February 1985, by adjusting UN cement data to be consistent with the BOM published values for earlier years.

3. Emissions in several parts of the world

In the US Department of Energy Report (DOE/OR/21400-2, Rotty et al., 1984) and in Rotty and Marland (1986), it was demonstrated that during the period from 1950–1980, the 3-fold growth in CO_2 emissions was accompanied by a change in the relative amounts of CO_2 produced in developed and developing parts of the world. With the slowed economic growth of the early 1980s and the increasing debt problems of some of the developing countries, it seems appropriate to again examine the distribution of CO_2 emissions and the rates of change in several parts of the world.

Fuel consumption data for each of 6 world regions were analyzed by fuel type and the CO_2 emissions for each region estimated. Time sequences of the regional emissions are given in Table 3. After 1973, the CO_2 emissions from North America, Western Europe, and the Pacific levelled off after two decades of sustained growth. Furthermore, between 1980 and 1983 the CO_2 emissions declined by 8.7% in North America and by 11.2% in Western Europe. However, during the same period CO_2 emissions continued to rise at rates of almost 4% per year in the planned economy countries of Asia (dominated by China) and in the developing countries of South Asia, Africa, and Latin America.

These changing patterns are evident in Fig. 2. The continued growth in Eastern Europe and the

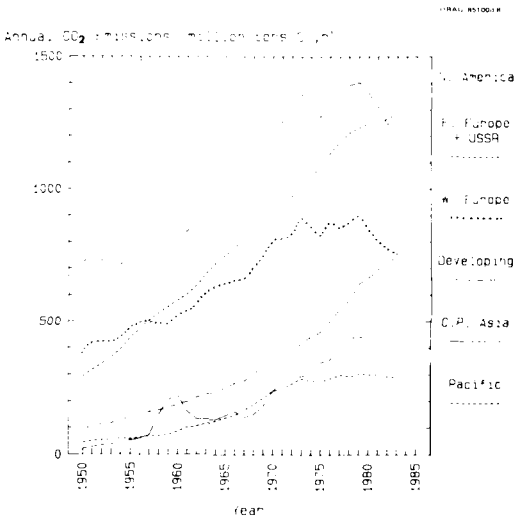

Fig. 2. Annual CO_2 emissions by world region.

Table 3. *Regional distribution of annual CO_2 emissions*

Year	North America	Western Europe	Eastern Europe*	Pacific	Developing	CP Asia†	World
1950	723	377	291	45	95	22	1,621
1951	747	419	316	52	106	29	1,755
1952	726	421	339	54	113	36	1,781
1953	742	418	362	58	117	38	1,824
1954	710	439	392	59	126	46	1,845
1955	775	473	434	60	140	55	2,020
1956	813	498	468	65	151	62	2,153
1957	807	503	506	72	160	74	2,244
1958	782	488	533	71	166	149	2,303
1959	816	486	556	76	175	205	2,430
1960	835	523	581	87	188	222	2,543
1961	839	536	605	102	198	161	2,556
1962	873	567	637	106	214	132	2,660
1963	918	610	679	116	224	131	2,803
1964	963	627	719	127	235	132	2,959
1965	1,003	643	748	138	251	146	3,095
1966	1,055	652	780	147	268	162	3,250
1967	1,099	659	806	167	276	139	3,354
1968	1,144	699	832	188	304	151	3,525
1969	1,197	743	873	213	326	183	3,734
1970	1,239	803	892	239	335	238	4,038
1971	1,252	809	932	246	364	273	4,183
1972	1,311	830	971	265	382	283	4,345
1973	1,358	892	1,006	285	419	295	4,582
1974	1,318	854	1,037	276	441	301	4,588
1975	1,271	820	1,088	275	459	346	4,564
1976	1,355	878	1,132	285	501	355	4,822
1977	1,367	849	1,173	298	544	393	4,956
1978	1,391	872	1,210	293	581	435	4,991
1979	1,403	902	1,229	302	640	443	5,226
1980	1,364	847	1,247	300	662	435	5,134
1981	1,310	801	1,242	298	694	431	4,993
1982	1,244	770	1,266	292	723	453	4,957
1983	1,245	753	1,279	287	738	482	4,932

* Including the USSR.
† Centrally planned economies in Asia.

USSR is striking, as is the growth in the developing countries. In the struggle to meet minimal energy demands of the large and growing masses of people, fuel use must continue to grow in the over populated/under industrialized parts of the world even when the economies of the more industrialized nations are depressed.

Fig. 2 shows that collectively the developing nations with market economies had nearly caught up with the nations of Western Europe in the emission of CO_2 from fuels by 1983, while only 3 years earlier Western Europe was releasing 185 million tons C/year more than the developing nations. By now (1985) it is probable that the CO_2 release from fuels used in developing countries is exceeding that from Western Europe. CO_2 emissions from China also showed continued growth between 1980 and 1983, and because growth rates in China continue to be very high, the CO_2 emissions from China will also soon overtake the emissions from Western Europe. The changes in the global pattern of CO_2 emissions noted in the reports a few years ago have continued even with a depressed global

economy and acute fiscal problems in many developing countries.

4. Acknowledgement

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