5D

Key Statistics Related to CO₂ Emissions: Significant Contributing Countries

**M. A. Kellogg
J. A. Edmonds
M. J. Scott
J. S. Pomykala**

July 1987

**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute**

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor Battelle Memorial Institute, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government of any agency thereof, or Battelle Memorial Institute. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof, or Battelle Memorial Institute.

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE MEMORIAL INSTITUTE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America
Available from
National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

NTIS Price Codes
Microfiche A01

Printed Copy

Pages	Price Codes
001-025	A02
026-050	A03
051-075	A04
076-100	A05
101-125	A06
126-150	A07
151-175	A08
176-200	A09
201-225	A010
226-250	A011
251-275	A012
276-300	A013

KEY STATISTICS RELATED TO CO₂ EMISSIONS:
SIGNIFICANT CONTRIBUTING COUNTRIES

M. A. Kellogg
J. A. Edmonds
M. J. Scott
J. S. Pomykala

July 1987

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RL0 1830

Pacific Northwest Laboratory
Richland, Washington 99352

EXECUTIVE SUMMARY

This report documents the results of the country selection task in the Carbon Dioxide Energy Systems Research Program being conducted by Pacific Northwest Laboratory (PNL) for the U.S. Department of Energy (DOE), Carbon Dioxide Research Division (CDRD).

Emissions of carbon dioxide (CO₂) and other energy related radiatively important gases (RIGs) may be changing the composition of the earth's atmosphere which, in turn, could lead to atmospheric temperature changes. That is, increasing concentrations of CO₂ and other RIGs could have a "greenhouse effect" on the atmosphere. Since energy production and use are the most important determinants of the level of greenhouse gas emissions, identifying country contributions to this worldwide concern is an important part of the development of a sound energy policy.

This country selection task report describes and applies a methodology for identifying a set of countries responsible for significant present and anticipated future emissions of CO₂ and other RIGs. The identification of countries responsible for CO₂ and other RIGs emissions will help determine to what extent a select number of countries might be capable of influencing future emissions. Once identified, those countries could potentially exercise cooperative collective control of global emissions and thus mitigate the associated adverse affects of those emissions.

The methodology developed consists of two approaches: the resource approach and the emissions approach. While conceptually very different, both approaches yield the same fundamental conclusion. The core of any international initiative to control global emissions must include three key countries: the United States, USSR, and the People's Republic of China. It was also determined that broader control can be achieved through the inclusion of sixteen additional countries with significant contributions to worldwide emissions. The list of countries selected as significant contributors to worldwide radiatively important gas emissions is presented in Table ES.1.

Data are presented for five of the most important determinants of radiatively important emissions: country-specific estimates of CO₂ emissions, economic activity (as measured by gross national product, GNP), population,

head of ruminant livestock, and rice production. Except for methane and the chlorinated fluorocarbons (CFCs), RIGs emissions produced by human activity are primarily energy-related and energy use is related to economic activity and population. Major sources of methane are the digestive systems of ruminant livestock and the anaerobic decay of organic matter, particularly that from the bottom of rice paddies. CFCs are used as refrigerants, propellants for aerosols and for spray-in foam insulation, and in the production of computer chips and other computer hardware.

Table ES.1. Country List of Significant Contributors to Worldwide CO₂ and RIGs Emissions

<u>Country</u>	<u>Country</u>
1.) USA	11.) Italy
2.) USSR	12.) Germany, Democratic Rep.
3.) China	13.) South Africa
4.) Japan	14.) Mexico
5.) Germany, Federal Rep.	15.) Czechoslovakia
6.) United Kingdom	16.) Australia
7.) India	17.) Rumania
8.) Poland	18.) Spain
9.) Canada	19.) Brazil
10.) France	

The data base presented in this report clearly shows the uneven worldwide distribution of these determinants of RIGs emissions. As a group, in 1983 the countries listed in Table ES. 1 accounted for approximately 80% of worldwide CO₂ emissions, 83% of worldwide economic activity (GNP), 64% of the world's population, 62% of the world's head of ruminant livestock, and 64% of the 1980 worldwide rice crop.

Data for other important determinants of RIGs emissions (such as detailed energy use, urbanization, education, and others) are being collected as the next task of this on-going project.

CONTENTS

EXECUTIVE SUMMARY	iii
1.0 INTRODUCTION	1.1
1.1 OBJECTIVE	1.1
1.2 DEFINITION OF TERMS	1.1
1.3 ORGANIZATION OF REPORT	1.3
2.0 METHODOLOGY	2.1
2.1 RESOURCE APPROACH	2.1
2.2 EMISSIONS APPROACH	2.2
2.3 RANKING COUNTRY'S ANTICIPATED EMISSIONS	2.2
3.0 COUNTRY SELECTION RESULTS	3.1
3.1 INTRODUCTION	3.1
3.2 CARBON DIOXIDE DATA	3.4
3.3 ECONOMIC ACTIVITY DATA; GROSS NATIONAL PRODUCT (GNP).	3.4
3.4 POPULATION DATA	3.4
3.5 RUMINANT LIVESTOCK DATA	3.14
3.6 RICE PRODUCTION DATA.	3.14
REFERENCES	R.1

FIGURES

3.1 1975 CO ₂ ; Country Contributions to World CO ₂ Emissions	3.5
3.2 1980 CO ₂ ; Country Contributions to World CO ₂ Emissions	3.6
3.3 1983 CO ₂ ; Country Contributions to World CO ₂ Emissions	3.7
3.4 1975 GNP; Country Contributions to World Economic Activity	3.8
3.5 1980 GNP; Country Contributions to World Economic Activity	3.9
3.6 1983 GNP; Country Contributions to World Economic Activity	3.10
3.7 1975 Population; Country Contributions to World Population	3.11
3.8 1980 Population; Country Contributions to World Population	3.12
3.9 1983 Population; Country Contributions to World Population	3.13
3.10 1975 Ruminant Livestock; Country Holdings of World Herd	3.15
3.11 1983 Ruminant Livestock; Country Holdings of World Herd	3.16
3.12 1975 Rice Production; Country Contributions to World Total	3.17
3.13 1980 Rice Production; Country Contributions to World Total	3.18
3.14 1983 Rice Production; Country Contributions to World Total	3.19

TABLES

ES.1 Country List of Significant Contributors to Worldwide CO ₂ and RIGs Emissions	iii
2.1 Global Coal Resource Base (10 ¹² Tonnes of coal equivalent) .	2.1
2.2 Growth Categories (Annual Rate)	2.4
2.3 Representative Example of Sectoral Composition Effect . .	2.5
3.1 1983 CO ₂ Emissions for Countries of the World (billions of tonnes of carbon)	3.1
3.2 1975 CO ₂ Emissions by country (billions of tonnes of carbon) .	3.5
3.3 1980 CO ₂ Emissions by Country (billions of tonnes of carbon) .	3.6
3.4 1983 CO ₂ Emissions by Country (billions of tonnes of carbon) .	3.7
3.5 1975 GNP by Country (billions of 1985 \$'s)	3.8
3.6 1980 GNP by Country (billions of 1985 \$'s)	3.9
3.7 1983 GNP by Country (billions of 1985 \$'s)	3.10
3.8 1975 Population by Country (millions)	3.11
3.9 1980 Population by Country (millions)	3.12
3.10 1983 Population by Country (millions)	3.13
3.11 1975 Ruminant Livestock by Country (thousands of cattle, buffaloes, and camels)	3.15
3.12 1983 Ruminant Livestock by Country (thousands of cattle, buffaloes, and camels)	3.16
3.13 1975 Rice Production by Country (millions of tonnes, rough basis)	3.17
3.14 1980 Rice Production by Country (millions of tonnes, rough basis)	3.18
3.15 1983 Rice Production by Country (millions of tonnes, rough basis)	3.19

1.0 INTRODUCTION

1.1 OBJECTIVE

The U.S. Department of Energy (DOE), Carbon Dioxide Research Division (CDRD) Program seeks to understand the relationship among energy, carbon dioxide (CO₂), and CO₂'s direct and indirect environmental consequences. Understanding of these relationships requires the scientific basis to make and bound projections of the future emissions to the atmosphere CO₂ and other radiatively important gases (RIGs)(a) with particular emphasis on energy's role.

The objective of this country selection task is to identify a set of countries responsible for significant present and anticipated future emissions of carbon dioxide (CO₂) and other radiatively important gases (RIGs). Once identified, the countries selected could potentially form a key group that in concert could exercise cooperative collective control of global RIGs emissions.

1.2 DEFINITION OF TERMS

Responsible: In this report, responsibility for emissions is defined in two ways. Either a country can be said to be responsible as the site of emissions of CO₂ and/or RIGs or as the source of the energy or resource that is eventually transformed into an emission. If there were no imports or exports then both types of responsibility would yield the same result. If a country exports fossil fuels its responsibility is greater under the second definition than under the first. Similarly, importers (such as Japan) that import fossil fuels and burn them would have greater emissions attributed to them under the former definition than under the latter. In combination, these two definitions of "responsibility" lead one to consider both where fossil fuel burning (or other resource use) is expected to take place and where fossil fuels (or other resources) to be extracted (or otherwise harvested).

(a) The major non-CO₂ radiatively important gasses are; CO (carbon monoxide), CH₄ (methane), O₃ (ozone), NO_x (nitrogen oxides), N₂O (nitrous oxide), and CFCs (chlorinated fluorocarbons).

Significant: In this report, those countries considered to be "significant" contributors to the emission of CO₂ or of RIGs are defined according to a criterion of 80 percent cumulative responsibility for world CO₂ emissions.(a) Using the most recent and best country specific emissions data available and ranking the countries from the largest to the smallest emitting countries, a few of the largest emitters alone may be the only countries considered "significantly" responsible for emissions. This criterion may be considered necessary but not sufficient for a country to be defined as "significantly" responsible for emissions.

Additional criteria may or may not be deemed relevant considerations in the selection of countries "significantly" contributing RIGs emissions. For example, geographical balance may be important. That is, at least one representative from every major continent may be desired. Alternatively, groupings of several countries may be considered desirable on political grounds. That is, such countries may be considered as client states of other organizations or countries (e.g., Eastern Europe and the USSR) and could be expected to act as a group rather than as individual countries exercising independent foreign policies.

Collective Control: If a select set of countries found the scientific evidence to conclusively demonstrate that the burning of fossil fuels had sufficiently adverse consequences, then that group could conceivably agree to "collectively control" emissions. That is, by collectively or individually putting measures into place which would reduce emissions to the point where the atmospheric composition would stabilize, they could control the situation.

Anticipated Emissions: In this report, anticipated emissions are defined to be each country's cumulative emissions over a specific period of time which, for present purposes, is arbitrarily set for a period of 67 years (1983 to 2050). The methods used to anticipate emissions are described in our methodology section but depend critically on three components; initial emissions rates, the rates of change of the emissions rates, and the time frame under consideration.

(a) Insufficient data are available at this point to estimate the equivalent values for non-CO₂ RIGs emissions. Research is being done in DOE's carbon dioxide research program to improve the RIGs data base.

1.3 ORGANIZATION OF REPORT

The remainder of this report consists of Section 2.0 that describes the details of the methodology and Section 3.0 that presents the country selection results along with graphical and tabular data used in the selection process.

2.0 METHODOLOGY

Country selection will be based on the actual and anticipated emissions of individual countries. Two approaches will be utilized, the Resource Approach and the Emissions Approach. Each will be given equal consideration.

2.1 RESOURCE APPROACH

The resource approach focuses on the source of carbon that can be vented to the atmosphere. The combined carbon weight of resources of conventional oil and gas remaining is less than 300×10^{15} gC with an airborne fraction (a.f.)^(a) at 0.58. Hence, upon the combustion of all known reserves of oil and gas, less than 175×10^{15} gC could be added to the atmospheric store of carbon which currently stands at 720×10^{15} gC. It is the approximately 4000×10^{15} gC of coal resource and $40,000 \times 10^{15}$ gC in the form of oil shale deposits that have the potential to dramatically change the atmosphere's burden of carbon.

We ignore the shale oil resource on the grounds that its economics are contested and that significant production capacities cannot be anticipated before the year 2025. The resource of coal is not evenly distributed throughout the world:

TABLE 2.1. Global Coal Resource Base^(a)

<u>Country</u>	<u>Resource</u> ^(b)	<u>Percent</u>	<u>Cumulative Percent</u>
USSR	4.9	44	44
USA	2.9	26	70
PRC	1.4	12	82
Australia	0.7	6	88
Canada	0.4	4	92
Others	0.9	8	100
<u>World</u>	<u>11.2</u>	<u>100</u>	<u>100</u>

(a) Source: Edmonds, 1985.

(b) 10^{12} Tonnes of coal equivalent.

Three countries, USSR, USA, and PRC account for over 80 percent of the coal resource base. There is enough carbon residing in 25 percent of that resource base to double the atmospheric carbon content if that coal was burned along with the conventional oil and gas resource (with a.f. = 0.58).

(a) That fraction of the resource's carbon weight that enters the atmosphere upon combustion of the resource.

Hence, to prohibit the doubling of the atmospheric carbon content would require that more than 75 percent of current carbon based energy related resource must remain uncombusted.

2.2 EMISSIONS APPROACH

Another perspective is the emissions approach in which countries can be ranked by their contributions to emissions. This ranking, detailed in Section 3, shows that the same three regions which are responsible for 80 percent of the coal resource are also responsible for the direct combustion of 50 percent of all fossil fuels. Because energy use is more evenly dispersed than are the world's fossil fuel resources, the number of countries required to account for 80 percent of global CO₂ emissions is 19 (see Table 3.1).

2.3 RANKING COUNTRY'S ANTICIPATED EMISSIONS

While highly uncertain, anticipated emissions can be bounded. For any country future cumulative emissions depend on three factors; initial emissions (CO₂(0)), the rate of growth of the rate of emissions (r), and the time frame of (t) future years being considered. For any year t, these factors are related by the equation

$$CO_2(t) = CO_2(0) * (e^{rt} - 1) / r$$

so that a country's cumulative emissions can be obtained by

$$\sum_{1}^t CO_2(t).$$

The initial rate of emissions is a historical value. The uncertainty all lies in the value of anticipating r.

For the world as a whole, the anticipated rate of growth of future emissions is generally bounded between 0.03 and -0.005, (though values as low as -0.02 have been put forward) (Edmonds, 1985). For a ranking of countries according to anticipated cumulative emissions to vary from a ranking based on initial emissions alone, at least some countries with initially low emissions must have relatively high rates of growth of emissions. To see how this relationship works, we construct a simple model of CO₂ emissions:

$$CO_2 = C \cdot F \cdot G \cdot Y \cdot N$$

where, C = average emission of CO_2 per unit of fossil fuel
 F = share of all energy in the form of fossil fuels
 G = the energy/GNP ratio
 Y = per capita GNP
 N = population size.

The rate of growth of CO_2 emissions (r) can be calculated as the simple sum:

$$r = r_c + r_f + r_g + r_y + r_n$$

where, r_c = the rate of growth of CO_2 emissions per unit fossil fuel burned
 r_f = the rate of growth of fossil fuel burned per unit energy consumed
 r_g = rate of growth of energy consumed per unit GNP
 r_y = rate of growth of GNP per capita
 r_n = rate of population growth.

We will ignore changes in C and F and assume both r_c and r_f are zero. This leaves three factors to consider. Population growth and the growth rate of per capita income are significant and will vary by country. The rate of growth of the energy consumed per unit GNP (r_g) is a more complex phenomenon which must be broken down into constituent effects. We identify three:

1. energy price effect (r_p)
2. exogenous energy productivity effect (r_t)
3. sectoral composition effect (r_u)

Thus we have:

$$r_g = r_p + r_t + r_u$$

The energy price effect reflects the direct effects of changing energy prices. This effect is anticipated to improve energy productivity as the price of energy is anticipated to rise over the next seventy-five years as inexpensive fossil fuel resources are used up.

The exogenous energy productivity effect represents the effects of changing energy productivity as the direct consequence of either technological change or policy measures which affect energy productivity. This term assumes that other things, such as the relative price of energy and product composition, remain unchanged. While this factor can in principle either enhance or detract from energy productivity, evidence does exist that the sign of r_t is negative.

The sectoral composition effect reflects the fact that the energy intensities of different activities vary and that shifts between these activities can affect the overall energy-GNP ratio. In developing countries these shifts are most pronounced. There the development process corresponds to a process of urbanization in which labor and population move out of the rural agricultural sector with low purchased fuel use per unit GNP produced to an urban, manufacturing-oriented economy in which purchased fuels are used more intensively. Developed economies face the reverse phenomenon. Continued urbanization and economic development leads to a shifts in the labor force out of energy intensive manufacturing activities and into service sectors with lower energy intensities. Urbanization tends to lower the overall energy intensity of developed economies and raise the overall energy intensity of developing economies.

We can therefore break the rate of change of the energy-GNP ratio, r_g , into the sum of r_p plus r_t plus r_u . This latter effect, the sectoral shift effect of urbanization, is generally represented via the income elasticity of demand for energy, u . Thus, we may also write $r_u = u(r_y + r_n)$, and

$$r = r_p + r_t + u(r_y + r_n)$$

In the example that follows we assume high (A), mid (B), and low (C) categories of values for four variables: $(r_p + r_t)$, u , r_y , and r_n . The values given in categories A, B, and C are meant to represent the range of reasonable values, values that countries are anticipated to be able to maintain over the course of 67 years, for each variable category.

TABLE 2.2. Example Values for Components of CO₂ Emissions
(Annual Rate, 1983-2050)

CATEGORY	ENERGY PRODUCTIVITY ($r_p + r_t$)	URBANIZATION SECTORAL SHIFT ^(a) u	GNP PER CAPITA r_y	POPULATION r_n
A HIGH	- 0.03	0.40	0.03	0.02
B MID	- 0.02	0.19	0.02	0.01
C LOW	- 0.00	-0.10	0.01	0.00

(a) Dimensionless multiplicative factor.

To examine how this scheme might work we next take three countries, the United States, USSR and China and select representative values for each.

TABLE 2.3. Representative Example of Sectoral Composition Effect

<u>Country</u>	<u>Energy Productivity</u>	<u>Urbanization Sectoral Shift</u>	<u>GNP Per Capita</u>	<u>Population Growth</u>
USA	B	C	B	B
USSR	B	B	B	B
PRC	B	A	A	C

This yields values of r as follows:

$$\begin{aligned} \text{USA} &= 0.007 \\ \text{USSR} &= 0.015 \\ \text{PRC} &= 0.022. \end{aligned}$$

From Section 3.0 of this report we know that 1983 CO₂ emissions for these countries were:

$$\begin{aligned} \text{USA} &= 1.14 \\ \text{USSR} &= 0.91 \\ \text{PRC} &= 0.44 \end{aligned}$$

Using the cumulative emissions equation yields cumulative emissions for the period 1983 to 2050 as follows:

$$\begin{aligned} \text{USA} &= 97.5 \\ \text{USSR} &= 105.1 \\ \text{PRC} &= 67.3 \end{aligned}$$

This methodology yields a change in ranking although we note that the PRC's cumulative emissions, despite its high rate of growth of CO₂ emissions, does not surpass either the USA's or the USSR's. This is in spite of the fact that PRC year 2050 emissions have overtaken those of the USA which has the third highest rate of emissions.

The point of this exercise is not to produce country energy-CO₂ emissions forecasts but rather to demonstrate the power of this mode of analysis. In any case, the results for out-years would be speculative and uncertain, but not significantly different than using the most recent CO₂ ranking. Therefore, the most recent CO₂ ranking is an appropriate basis for the selection of countries on which to place emphasis, especially as related to the collection of additional data for further characterization of worldwide emissions.

3.0 COUNTRY SELECTION RESULTS

3.1 INTRODUCTION

In this section, results are presented on the emissions contributions of nineteen countries responsible for a major portion of world CO₂ emissions or emissions of other radiatively important gasses (RIGs). The nineteen countries of this presentation were selected on the basis of their being the top nineteen CO₂ emitters of 1983 as listed on Table 3.1 (ORAU, 1986). Both graphical and tabular data are shown for country rankings of CO₂ emissions (metric tonnes of carbon), economic size (constant dollar GNP), population, number of ruminant livestock (head count), and rice production (metric tonnes of rice) for the years of 1975, 1980, and 1983.

TABLE 3.1. 1983 CO₂ Emissions for Countries of the World
(billions of tonnes of carbon)

COUNTRY	WORLD RANK	CO ₂ EMISSIONS (a)	PERCENT OF WORLD EMISSIONS (b)	CUMULATIVE PERCENTAGE OF EMISSIONS (c)
USA	1	1.1384	22.31%	22.31%
USSR	2	0.911806	17.87%	40.18%
China	3	0.441021	8.64%	48.83%
Japan	4	0.223773	4.39%	53.21%
Germany, Federal Rep.	5	0.179212	3.51%	56.73%
United Kingdom	6	0.141438	2.77%	59.50%
India	7	0.112907	2.21%	61.71%
Poland	8	0.112248	2.20%	63.91%
Canada	9	0.106597	2.09%	66.00%
France	10	0.103032	2.02%	68.02%
Italy	11	0.090604	1.78%	69.80%
Germany, Democratic Rep.	12	0.082580	1.62%	71.42%
South Africa	13	0.069987	1.37%	72.79%
Mexico	14	0.068598	1.34%	74.13%
Czechoslovakia	15	0.064775	1.27%	75.40%
Australia	16	0.055636	1.09%	76.49%
Rumania	17	0.051987	1.02%	77.51%
Spain	18	0.046627	0.91%	78.42%
Brazil	19	0.042516	0.83%	79.26%
Korea, Rep. of South	20	0.036859	0.72%	79.98%
Netherlands	21	0.036063	0.71%	80.69%
Bulgaria	22	0.030727	0.60%	81.29%
Yugoslavia	23	0.030530	0.60%	81.89%
Iran	24	0.027571	0.54%	82.43%
Belgium	25	0.026895	0.53%	82.96%
Argentina	26	0.025934	0.51%	83.46%
Indonesia	27	0.023449	0.46%	83.92%
Venezuela	28	0.022753	0.45%	84.37%

(continued)

TABLE 3.1. 1983 CO₂ Emissions for Countries of the World (cont.)
(billions of tonnes of carbon)

COUNTRY	WORLD RANK	CO ₂ EMISSIONS (a)	PERCENT OF WORLD EMISSIONS (b)	CUMULATIVE PERCENTAGE OF EMISSIONS (c)
Hungary	29	0.022220	0.44%	84.81%
Turkey	30	0.021551	0.42%	85.23%
Algeria	31	0.018385	0.36%	85.59%
Egypt	32	0.015691	0.31%	85.90%
Sweden	33	0.015395	0.30%	86.20%
Greece	34	0.013237	0.26%	86.46%
Columbia	35	0.012952	0.25%	86.71%
Austria	36	0.012615	0.25%	86.96%
Denmark	37	0.012441	0.24%	87.20%
Finland	38	0.010720	0.21%	87.41%
Singapore	39	0.010533	0.21%	87.62%
Switzerland	40	0.010446	0.20%	87.82%
Pakistan	41	0.010295	0.20%	88.02%
Thailand	42	0.009374	0.18%	88.21%
Philippines	43	0.009270	0.18%	88.39%
Nigeria	44	0.008600	0.17%	88.56%
Malaysia	45	0.007785	0.15%	88.71%
Portugal	46	0.007339	0.14%	88.86%
Norway	47	0.006640	0.13%	88.99%
Hong Kong	48	0.006431	0.13%	89.11%
Israel	49	0.006244	0.12%	89.23%
Peru	50	0.006233	0.12%	89.36%
Ireland	51	0.006142	0.12%	89.48%
Trinidad & Tobago	52	0.005998	0.12%	89.59%
Chile	53	0.005362	0.11%	89.70%
Iraq	54	0.005277	0.10%	89.80%
Syria	55	0.005186	0.10%	89.90%
New Zealand	53	0.005064	0.10%	90.00%
Ecuador	57	0.004119	0.08%	90.08%
Morocco	58	0.004102	0.08%	90.16%
Tunisia	59	0.002454	0.05%	90.21%
Cameroon	60	0.002437	0.05%	90.26%
Bangladesh	61	0.002254	0.04%	90.30%
Luxembourg	62	0.002135	0.04%	90.35%
Zimbabwe (Rhodesia)	63	0.002077	0.04%	90.39%
Dominican Republic	64	0.001855	0.04%	90.42%
Jordan	65	0.001835	0.04%	90.46%
Jamaica	66	0.001788	0.04%	90.49%
Burma	67	0.001412	0.03%	90.52%
Kenya	68	0.001078	0.02%	90.54%
Ivory Coast	69	0.001053	0.02%	90.56%
Bolivia	70	0.001023	0.02%	90.58%
Zaire	71	0.000990	0.02%	90.60%
Sudan	72	0.000977	0.02%	90.62%
Uruguay	73	0.000974	0.02%	90.64%
Guatemala	74	0.000925	0.02%	90.66%
Angola	75	0.000873	0.02%	90.68%

(continued)

TABLE 3.1. 1983 CO₂ Emissions for Countries of the World (cont.)
(billions of tonnes of carbon)

COUNTRY	WORLD RANK	CO ₂ EMISSIONS ^(a)	PERCENT OF WORLD EMISSIONS ^(b)	CUMULATIVE PERCENTAGE OF EMISSIONS ^(c)
Zambia	76	0.000840	0.02%	90.69%
Mozambique	77	0.000747	0.01%	90.71%
Cyprus	78	0.000715	0.01%	90.72%
Ghana	79	0.000675	0.01%	90.74%
Costa Rica	78	0.000617	0.01%	90.75%
Gabon	80	0.000615	0.01%	90.76%
Senegal	81	0.000576	0.01%	90.77%
Nicaragua	82	0.000515	0.01%	90.78%
Tanzania	83	0.000514	0.01%	90.79%
Papua New Guinea	84	0.000507	0.01%	90.80%
Surinam	85	0.000484	0.01%	90.81%
Honduras	86	0.000479	0.01%	90.82%
Afghanistan	87	0.000476	0.01%	90.83%
Ethiopia	88	0.000473	0.01%	90.84%
El Salvador	89	0.000459	0.01%	90.85%
Liberia	90	0.000437	0.01%	90.86%
Guyana	91	0.000434	0.01%	90.86%
Iceland	92	0.000403	0.01%	90.87%
Madagascar	93	0.000393	0.01%	90.88%
Paraguay	94	0.000342	0.01%	90.89%
Somalia	95	0.000316	0.01%	90.89%
Botswana	96	0.000284	0.01%	90.90%
Malta	97	0.000268	0.01%	90.90%
Guinea	98	0.000243	0.00%	90.91%
Sierra Leone	99	0.000225	0.00%	90.91%
Niger	100	0.000190	0.00%	90.92%
Barbados	101	0.000184	0.00%	90.92%
Haiti	102	0.000174	0.00%	90.92%
Mauritania	103	0.000170	0.00%	90.93%
Uganda	105	0.000168	0.00%	90.93%
Togo	106	0.000163	0.00%	90.93%
Mauritius	107	0.000155	0.00%	90.94%
Malawi	107	0.000145	0.00%	90.94%
Nepal	108	0.000126	0.00%	90.94%
Upper Volta	109	0.000116	0.00%	90.94%
Mali	110	0.000114	0.00%	90.95%
Swaziland	111	0.000109	0.00%	90.95%
Benin	112	0.000096	0.00%	90.95%
Congo	113	0.000084	0.00%	90.95%
Chad	114	0.000055	0.00%	90.95%
Central African Empire	115	0.000051	0.00%	90.95%

(a) Source: ORAU Worldwide CO₂ data base.

(b) Percent of total world emissions from a country. Percents do not sum to 100 as they are based on a 1983 world total of 5.102 tonnes of carbon as reported in DOE/ER-0239 and not on the sum of the countries as listed.

(c) Cumulative percentage of total world emissions accounted for by the summation of a country's percent of world total emissions with that of all other countries with greater emissions.

3.2 CARBON DIOXIDE DATA

The CO₂ data (see Figures 3.1 - 3.3 and Tables 3.2 - 3.4) show that the USA, USSR, and mainland China account for about half of all world emissions of CO₂ for the years 1975, 1980, and 1983. Another fifteen countries account for the next 30 percent of all world emissions, which leaves the rest of the countries of the world account for the remaining 20 percent (ORAU, 1986). By comparing the rankings of CO₂ emissions in 1975 and 1983 one notes several things. First, there is no change in the order of the first six (largest) emitters. Second, there is no change in the countries that compose the top 19 on each list. Third, all currently developed countries on the list become less important while India moves from 12th to 7th and both South Africa and Mexico move considerably up the list. Finally, there is a slight tendency toward a more even distribution of emissions. The top six countries account for two percent less of world CO₂ emissions in 1983 than in 1975 while the next nine countries cumulatively account for three percent more of world emissions in 1983 than in 1975.

3.3 ECONOMIC ACTIVITY DATA; GROSS NATIONAL PRODUCT (GNP)

The USA, USSR, and Japan account for over half of all world economic activity in terms of GNP (see Figures 3.4 - 3.6 and Tables 3.5 - 3.7). The GNP rankings remain relatively unchanged between 1975 and 1983 and the first 11 countries account for approximately 75 percent of the world GNP in 1983 (CIA 1986). The country rankings for CO₂ and GNP are very similar.

3.4 POPULATION DATA

The population rankings (see Figures 3.7 - 3.9 and Tables 3.8 - 3.10) indicate that of the nineteen countries listed, the four most populous countries are China, India, USSR, and the USA. They alone account for about 48 percent of 1983 world population (CIA 1986). Note that the relatively less developed countries of Brazil and Mexico gain greater prominence in this ranking and that they both moved up in the world population rankings between 1975 and 1983.

FRACTION OF WORLD TOTAL

FIGURE 3.1. 1975 CO₂; Country Contributions to World CO₂ Emissions^(a)

TABLE 3.2. 1975 CO₂ Emissions by Country^(a)
(billions of tonnes of carbon)

COUNTRY	RANK	CO ₂ EMISSIONS	PERCENT OF WORLD EMISSIONS ^(b)	CUMULATIVE PERCENTAGE OF EMISSIONS	ABR
USA	1	1.166192	25.20%	25.20%	USA
USSR	2	0.767343	16.58%	41.79%	USSR
China	3	0.309722	6.69%	48.48%	PRC
Japan	4	0.223730	4.84%	53.32%	JAP
Germany, Federal Rep.	5	0.217560	4.70%	58.02%	FRG
United Kingdom	6	0.160667	3.47%	61.49%	UK
France	7	0.117689	2.54%	64.04%	FR
Canada	8	0.105378	2.28%	66.31%	CAN
Poland	9	0.099239	2.14%	68.46%	POL
Italy	10	0.087953	1.90%	70.36%	ITLY
Germany, Democratic Rep.	11	0.074486	1.61%	71.97%	DRG
India	12	0.066381	1.43%	73.40%	IND
Czechoslovakia	13	0.059791	1.29%	74.69%	CZK
Australia	14	0.044516	0.96%	75.66%	AUS
Spain	15	0.043527	0.94%	76.60%	SPN
Rumania	16	0.040739	0.88%	77.48%	RUM
South Africa	17	0.037783	0.82%	78.29%	SA
Mexico	18	0.032659	0.71%	79.00%	MEX
Brazil	19	0.032085	0.69%	79.69%	BRA

(a) Source: ORAU Worldwide CO₂ data base, 1986.

(b) Percentage of total world emissions accounted for by the individual country and based on the 1975 world total (4.627 tonnes of carbon) as reported in DOE/ER 0239, page 70.

FIGURE 3.2. 1980 CO₂; Country Contributions to World CO₂ Emissions^(a)

TABLE 3.3. 1980 CO₂ Emissions by Country^(a)
(billions of tonnes of carbon)

COUNTRY	RANK	CO ₂ EMISSIONS	PERCENT OF WORLD EMISSIONS ^(b)	CUMULATIVE PERCENTAGE OF EMISSIONS	ABR
USA	1	1.247997	23.60%	23.60%	USA
USSR	2	0.871024	16.47%	40.07%	USSR
China	3	0.395465	7.48%	47.55%	PRC
Japan	4	0.240130	4.54%	52.09%	JAP
Germany, Federal Rep.	5	0.199015	3.76%	55.86%	FRG
United Kingdom	6	0.154901	2.93%	58.78%	UK
France	7	0.127992	2.42%	61.21%	FR
Poland	8	0.122927	2.32%	63.53%	POL
Canada	9	0.115472	2.18%	65.71%	CAN
Italy	10	0.092842	1.76%	67.47%	ITLY
India	11	0.092641	1.75%	69.22%	IND
Germany, Democratic Rep.	12	0.082443	1.56%	70.78%	DRG
Mexico	13	0.065994	1.25%	72.03%	MEX
South Africa	14	0.065291	1.23%	73.26%	S A
Czechoslovakia	15	0.064660	1.22%	74.49%	CZK
Australia	16	0.053724	1.02%	75.50%	AUS
Rumania	17	0.051934	0.98%	76.48%	RUM
Spain	18	0.051895	0.98%	77.47%	SPN
Brazil	19	0.44761	0.85%	78.31%	BRA

(a) Source: ORAU Worldwide CO₂ data base, 1986.

(b) Percentage of total world emissions accounted for by the individual country and based on the 1980 world total (5.288 tonnes of carbon) as reported in DOE/ER 0239, page 70.

FRACTION OF WORLD TOTAL

FIGURE 3.3. 1983 CO₂; Country Contributions to World CO₂ Emissions^(a)

TABLE 3.4. 1983 CO₂ Emissions by Country^(a)
(billions of tonnes of carbon)

COUNTRY	RANK	CO ₂ EMISSIONS	PERCENT OF WORLD EMISSIONS ^(b)	CUMULATIVE PERCENTAGE OF EMISSIONS	ABR
USA	1	1.1384	22.31%	22.31%	USA
USSR	2	0.911806	17.87%	40.18%	USSR
China	3	0.441021	8.64%	48.83%	PRC
Japan	4	0.223773	4.39%	53.21%	JAP
Germany, Federal Rep.	5	0.179212	3.51%	56.73%	FRG
United Kingdom	6	0.141438	2.77%	59.50%	UK
India	7	0.112907	2.21%	61.71%	IND
Poland	8	0.112248	2.20%	63.91%	POL
Canada	9	0.106597	2.09%	66.00%	CAN
France	10	0.103032	2.02%	68.02%	FR
Italy	11	0.090604	1.78%	69.80%	ITLY
Germany, Democratic Rep.	12	0.082580	1.62%	71.42%	DRG
South Africa	13	0.069987	1.37%	72.79%	S A
Mexico	14	0.068598	1.34%	74.13%	MEX
Czechoslovakia	15	0.064775	1.27%	75.40%	CZK
Australia	16	0.055636	1.09%	76.49%	AUS
Rumania	17	0.051987	1.02%	77.51%	RUM
Spain	18	0.046627	0.91%	78.42%	SPN
Brazil	19	0.042516	0.83%	79.26%	BRA

(a) Source: ORAU Worldwide CO₂ data base, 1986.

(b) Percentage of total world emissions accounted for by the individual country and based on the 1983 world total (5.102 tonnes of carbon) as reported in DOE/ER 0239, page 70.

FIGURE 3.4. 1975 GNP; Country Contributions to World Economic Activity^(a)

TABLE 3.5. 1975 GNP by Country^(a)
(billions of 1985 \$'s)

COUNTRY	GNP	Percent of World GNP ^(b)	Cumulative Percent	ABR
USA	3008.1	28.65%	28.65%	USA
USSR	1660.5	15.81%	44.46%	USSR
Japan	858.7	8.18%	52.64%	JAP
Germany, West	497.5	4.74%	57.38%	FRG
France	410.1	3.91%	61.28%	FR
United Kingdom	374.6	3.57%	64.85%	UK
Italy	284.6	2.71%	67.56%	ITLY
Canada	254.8	2.43%	69.99%	CAN
Poland	224.7	2.14%	72.13%	POL
China	169.9	1.62%	73.75%	PRC
Brazil	146.8	1.40%	75.15%	BRA
Germany, East	142.3	1.36%	76.50%	DRG
Spain	141.5	1.35%	77.85%	SPN
India	130.7	1.24%	79.09%	IND
Australia	115	1.10%	80.19%	AUS
Czechoslovakia	113.3	1.08%	81.27%	CZK
Mexico	96.6	0.92%	82.19%	MEX
Rumania	93.1	0.89%	83.07%	RUM
South Africa	63	0.60%	83.67%	SA

(a) Source: Central Intelligence Agency, 1986, "Handbook of Economic Statistics"

(b) Percentages based on a 1975 world GNP total of 10500 billion 1985 \$'s.

FIGURE 3.5. 1980 GNP; Country Contributions to World Economic Activity^(a)

TABLE 3.6. 1980 GNP by Country^(a)
(billions of 1985 \$'s)

COUNTRY	GNP	Percent of World GNP ^(b)	Cumulative Percent	ABR
USA	3557.3	28.46%	28.46%	USA
USSR	1860.2	14.88%	43.34%	USSR
Japan	1096.2	8.77%	52.11%	JAP
Germany, West	587.3	4.70%	56.81%	FRG
France	481.5	3.85%	60.66%	FR
United Kingdom	407.3	3.26%	63.92%	UK
Italy	343.6	2.75%	66.67%	ITLY
Canada	297.1	2.38%	69.04%	CAN
Poland	232.7	1.86%	70.91%	POL
China	228	1.82%	72.73%	PRC
Brazil	203.7	1.63%	74.36%	BRA
Germany, East	159.6	1.28%	75.64%	DRG
India	156.1	1.25%	76.88%	SPN
Spain	155.9	1.25%	78.13%	IND
Mexico	133.5	1.07%	79.20%	AUS
Australia	131.3	1.05%	80.25%	CZK
Czechoslovakia	126.1	1.01%	81.26%	MEX
Rumania	112.9	0.90%	82.16%	RUM
South Africa	71.7	0.57%	82.74%	SA

(a) Source: Central Intelligence Agency, 1986, "Handbook of Economic Statistics"

(b) Percentages based on a 1980 world GNP total of 12500 billion 1985 \$'s.

FIGURE 3.6. 1983 GNP; Country Contributions to World Economic Activity^(a)

TABLE 3.7. 1983 GNP by Country^(a)
(billions of 1985 \$'s)

COUNTRY	GNP	Percent of World GNP ^(b)	Cumulative Percent	ABR
USA	3658.3	28.14%	28.14%	USA
USSR	1970.7	15.16%	43.30%	USSR
Japan	1209.5	9.30%	52.60%	JAP
Germany, West	590.7	4.54%	57.15%	FRG
France	496.1	3.82%	60.96%	FR
United Kingdom	421.4	3.24%	64.21%	UK
Italy	341	2.62%	66.83%	ITLY
Canada	302.9	2.33%	69.16%	CAN
China	282.5	2.17%	71.33%	PRC
Poland	228.9	1.76%	73.09%	POL
Brazil	188.9	1.45%	74.55%	BRA
India	175.7	1.35%	75.90%	IND
Germany, East	165	1.27%	77.17%	DRG
Spain	161.9	1.25%	78.41%	SPN
Mexico	138.5	1.07%	79.48%	MEX
Australia	138	1.06%	80.54%	AUS
Czechoslovakia	129.8	1.00%	81.54%	CZK
Rumania	116.1	0.89%	82.43%	RUM
South Africa	72.7	0.56%	82.99%	SA

(a) Source: Central Intelligence Agency, 1986, "Handbook of Economic Statistics"

(b) Percentages based on a 1983 world GNP total of 13000 billion 1985 \$'s.

FIGURE 3.7. 1975 Population; Country Contributions to World Population^(a)

TABLE 3.8. 1975 Population by Country^(a)
(millions)

COUNTRY	Population	Percent of World ^(b)	Cumulative Percent	ABR
China	917.9	22.35%	22.35%	PRC
India	621.0	15.12%	37.47%	IND
USSR	255.1	6.21%	43.68%	USSR
USA	216.0	5.26%	48.94%	USA
Japan	111.6	2.72%	51.66%	JAP
Brazil	108.7	2.65%	54.30%	BRA
Germany, West	61.8	1.50%	55.81%	FRG
Mexico	61.5	1.50%	57.31%	MEX
United Kingdom	56.2	1.37%	58.68%	UK
Italy	55.6	1.35%	60.03%	ITLY
France	52.8	1.29%	61.31%	FR
Spain	35.6	0.87%	62.18%	SPN
Poland	34.0	0.83%	63.01%	POL
South Africa	25.5	0.62%	63.63%	SA
Canada	22.7	0.55%	64.18%	CAN
Rumania	21.2	0.52%	64.70%	RUM
Germany, East	16.8	0.41%	65.11%	DRG
Czechoslovakia	14.8	0.36%	65.47%	CZK
Australia	13.8	0.34%	65.80%	AUS

(a) Source: Central Intelligence Agency, 1986, "Handbook of Economic Statistics"

(b) Percentages based on a 1975 world population of 4107 million.

FIGURE 3.8. 1980 Population; Country Contributions to World Population^(a)

TABLE 3.9. 1980 Population by Country^(a)
(millions)

COUNTRY	Population	Percent ^(b) World	Cumulative Percent	ABR
China	983.4	21.96%	21.96%	PRC
India	689.0	15.39%	37.35%	IND
USSR	266.5	5.95%	43.30%	USSR
USA	227.7	5.08%	48.38%	USA
Brazil	123.0	2.75%	51.13%	BRA
Japan	116.8	2.61%	53.74%	JAP
Mexico	70.1	1.57%	55.30%	MEX
Germany, West	61.6	1.38%	56.68%	FRG
Italy	56.5	1.26%	57.94%	ITLY
United Kingdom	56.3	1.26%	59.20%	UK
France	53.9	1.20%	60.40%	FR
Spain	37.5	0.84%	61.24%	SPN
Poland	36.6	0.82%	62.06%	POL
South Africa	28.4	0.63%	62.69%	SA
Canada	24.1	0.54%	63.23%	CAN
Rumania	22.2	0.50%	63.72%	RUM
Germany, East	16.7	0.37%	64.10%	DRG
Czechoslovakia	15.3	0.34%	64.44%	CZK
Australia	14.6	0.33%	64.77%	AUS

(a) Source: Central Intelligence Agency, 1986, "Handbook of Economic Statistics"

(b) Percentages based on a 1980 world population of 4478 million.

FIGURE 3.9. 1983 Population; Country Contributions to World Population^(a)

TABLE 3.10. 1983 Population by Country^(a)
(millions)

COUNTRY	Population	Percent of World ^(b)	Cumulative Percent	ABR
China	1020.7	21.62%	21.62%	PRC
India	735.6	15.58%	37.20%	IND
USSR	273.7	5.80%	43.00%	USSR
USA	234.5	4.97%	47.97%	USA
Brazil	132.9	2.82%	50.78%	BRA
Japan	119.3	2.53%	53.31%	JAP
Mexico	75.7	1.60%	54.91%	MEX
Germany, West	61.4	1.30%	56.21%	FRG
Italy	56.8	1.20%	57.42%	ITLY
United Kingdom	56.4	1.19%	58.61%	UK
France	54.6	1.16%	59.77%	FR
Spain	38.3	0.81%	60.58%	SPN
Poland	36.6	0.78%	61.35%	POL
South Africa (NO	30.2	0.64%	61.99%	SA
Canada	24.9	0.53%	62.52%	CAN
Rumania	22.6	0.48%	63.00%	RUM
Germany, East	16.7	0.35%	63.35%	DRG
Czechoslovakia	15.4	0.33%	63.68%	CZK
Australia	15.3	0.32%	64.00%	AUS

(a) Source: Central Intelligence Agency, 1986, "Handbook of Economic Statistics"

(b) Percentages based on a 1983 world population of 4721 million.

3.5 RUMINANT LIVESTOCK DATA

Ruminant livestock and rice production are important criteria to consider together since they are the major non-energy related contributors to radiatively important world methane (CH_4) emissions. The 1975 and 1983 (1980 data were not available at the writing of this report) world rankings for ruminant livestock (Figures 3.10 - 3.11 and Tables 3.11 - 3.12) give greater emissions importance to the less developed countries of India, Brazil, and Mexico than what would have been the case if CO_2 emissions alone were considered. The top six countries (India, Brazil, USA, USSR, China, and Mexico) account for over half of all the world's ruminant livestock in 1983 (FAO 1984).

3.6 RICE PRODUCTION DATA

During 1975, 1980, and 1983, China, India, and Japan accounted for nearly sixty percent of all world rice production (Figures 3.12 - 3.14 and Tables 3.13 - 3.15). The People's Republic of China alone produces approximately thirty-eight percent of all the world's rice. In contrast, the entire set of nineteen countries listed account for only about 64% of all world rice production. It is also important to note that total world rice production has increased by over thirty percent between 1975 and 1983 (FAO 1984).

FIGURE 3.10. 1975 Ruminant Livestock; Country Holdings of World Herd^(a)

TABLE 3.11. 1975 Ruminant Livestock by Country^(a)
(thousands of cattle, buffaloes, and camels)

COUNTRY	Ruminant Livestock	Percent of World ^(b)	Cumulative Percent	ABR
India	240398	18.15%	18.15%	IND
USA	129272	9.76%	27.91%	BRA
USSR	109481	8.27%	36.18%	USSR
Brazil	95132	7.18%	43.36%	USA
China	75014	5.66%	49.02%	PRC
Australia	32335	2.44%	51.46%	MEX
Mexico	28636	2.16%	53.62%	FR
France	23939	1.81%	55.43%	AUS
Canada	15334	1.16%	56.59%	FRG
United Kingdom	14694	1.11%	57.70%	UK
Germany, West	14429	1.09%	58.79%	SA
Poland	13052	0.99%	59.77%	CAN
South Africa	12591	0.95%	60.72%	POL
Italy	8420	0.64%	61.36%	ITLY
Rumania	6002	0.45%	61.81%	RUM
Germany, East	5533	0.42%	62.23%	DRG
Czechoslovakia	4559	0.34%	62.58%	CZK
Spain	4412	0.33%	62.91%	SPN
Japan	3672	0.28%	63.19%	JAP

(a) Source: FAO Production Yearbook, 1984, Table 88, pp. 220-222.

(b) Percentages based on a 1983 world herd of 1,324,516,000 head count.

FIGURE 3.11. 1983 Ruminant Livestock; Country Holdings of World Herd^(a)

TABLE 3.12. 1983 Ruminant Livestock by Country^(a)
(thousands of cattle, buffaloes, and camels)

COUNTRY	Ruminant Livestock	Percent of World ^(b)	Cumulative Percent	ABR
India	247400	17.64%	17.64%	IND
Brazil	124888	8.91%	26.55%	BRA
USSR	117746	8.40%	34.95%	USSR
USA	115207	8.22%	43.16%	USA
China	76810	5.48%	48.64%	PRC
Mexico	37522	2.68%	51.32%	MEX
France	23656	1.69%	53.00%	FR
Australia	22478	1.60%	54.61%	AUS
Germany, West	14992	1.07%	55.67%	FRG
United Kingdom	13290	0.95%	56.62%	UK
South Africa	13086	0.93%	57.56%	SA
Canada	12638	0.90%	58.46%	CAN
Poland	11269	0.80%	59.26%	POL
Italy	9126	0.65%	59.91%	ITLY
Rumania	6246	0.45%	60.36%	RUM
Germany, East	5773	0.41%	60.77%	DRG
Czechoslovakia	5131	0.37%	61.13%	CZK
Spain	5070	0.36%	61.50%	SPN
Japan	4590	0.33%	61.82%	JAP

(a) Source: FAO Production Yearbook, 1984, Table 88, pp. 220-222.

(b) Percentages based on a 1983 world herd of 1,402,252,000 head count.

FIGURE 3.12. 1975 Rice Production; Country Contributions to World Total^(a)

TABLE 3.13. 1975 Rice Production by Country^(a)
(millions of tonnes, rough basis)

COUNTRY	Rice Production	Percent of World ^(b)	Cumulative Percent	ABR
China	123.904	37.32%	37.32%	PRC
India	59.428	17.90%	55.21%	IND
Japan	15.365	4.63%	59.84%	JAP
Brazil	7.000	2.11%	61.95%	BRA
United States	5.098	1.54%	63.48%	USA
USSR	1.912	0.58%	64.06%	USSR
Italy	1.047	0.32%	64.38%	ITLY
Mexico	0.487	0.15%	64.52%	MEX
Australia	0.387	0.12%	64.64%	AUS
Spain	0.367	0.11%	64.75%	SPN
Rumania	0.052	0.02%	64.77%	RUM
France	0.044	0.01%	64.78%	FR
United Kingdom	0	0.00%	64.78%	UK
Germany, West	0	0.00%	64.78%	FRG
Poland	0	0.00%	64.78%	POL
Canada	0	0.00%	64.78%	CAN
Germany, East	0	0.00%	64.78%	DRG
South Africa	0	0.00%	64.78%	SA
Czechoslovakia	0	0.00%	64.78%	CZK

(a) Source: USDA Data Base, contact Sara Schwartz, Agricultural Economist USDA/ERS, 202-786-1693.

(b) Percentages based on a 1975 world crop of 332.04 million tonnes, rough basis.

FIGURE 3.13. 1980 Rice Production; Country Contributions to World Total^(a)

TABLE 3.14. 1980 Rice Production by Country^(a)
(millions of tonnes, rough basis)

COUNTRY	Rice Production	Percent of World ^(b)	Cumulative Percent	ABR
China	143.750	37.86%	37.86%	PRC
India	63.559	16.74%	54.59%	IND
Japan	14.948	3.94%	58.53%	JAP
Brazil	9.638	2.54%	61.07%	BRA
United States	5.986	1.58%	62.64%	USA
USSR	2.394	0.63%	63.27%	USSR
Italy	1.127	0.30%	63.57%	ITLY
Mexico	0.480	0.13%	63.70%	MEX
Australia	0.613	0.16%	63.86%	AUS
Spain	0.428	0.11%	63.97%	SPN
Rumania	0.060	0.02%	63.99%	RUM
France	0.031	0.01%	64.00%	FR
United Kingdom	0	0.00%	64.00%	UK
Germany, West	0	0.00%	64.00%	FRG
Poland	0	0.00%	64.00%	POL
Canada	0	0.00%	64.00%	CAN
Germany, East	0	0.00%	64.00%	DRG
South Africa	0	0.00%	64.00%	SA
Czechoslovakia	0	0.00%	64.00%	CZK

(a) Source: USDA Data Base, contact Sara Schwartz, Agricultural Economist USDA/ERS, 202-786-1693.

(b) Percentages based on a 1980 world rice crop of 379.735 million tonnes, rough basis.

FIGURE 3.14. 1983 Rice Production; Country Contributions to World Total^(a)

TABLE 3.15. 1983 Rice Production by Country^(a)
(millions of tonnes, rough basis)

COUNTRY	Rice Production	Percent of World ^(b)	Cumulative Percent	ABR
China	161.240	38.35%	38.35%	PRC
India	70.681	16.81%	55.17%	IND
Japan	12.838	3.05%	58.22%	JAP
Brazil	7.800	1.86%	60.08%	BRA
United States	6.969	1.66%	61.73%	USA
USSR	2.400	0.57%	62.31%	USSR
Italy	0.954	0.23%	62.53%	ITLY
Australia	0.548	0.13%	62.66%	AUS
Spain	0.401	0.10%	62.76%	SPN
Mexico	0.510	0.12%	62.88%	MEX
Rumania	0.046	0.01%	62.89%	RUM
France	0.026	0.01%	62.90%	FR
United Kingdom	0	0	62.90%	UK
Germany, West	0	0	62.90%	FRG
Poland	0	0	62.90%	POL
Canada	0	0	62.90%	CAN
Germany, East	0	0	62.90%	DRG
South Africa	0	0	62.90%	SA
Czechoslovakia	0	0	62.90%	CZK

(a) Source: USDA Data Base, contact Sara Schwartz, Agricultural Economist
USDA/ERS, 202-786-1693.

(b) Percentages based on a 1983 world rice crop of 420.392 million tonnes,
rough basis.

FIGURE 3.14. 1983 Rice Production: Country Contributions to World Total (a)

TABLE 3.15. 1983 Rice Production by Country (a)
(Millions of tonnes, rough basis)

COUNTRY	Production	Percent of World (b)	Cumulative Percent
China	181.750	38.352	38.352
India	70.681	15.812	54.164
Japan	12.839	2.763	56.927
Brazil	7.400	1.592	58.519
United States	6.088	1.304	59.823
USSR	5.400	1.157	61.000
Italy	0.954	0.207	61.207
Australia	0.858	0.185	61.392
Spain	0.401	0.086	61.478
Mexico	0.310	0.066	61.544
Russia	0.088	0.019	61.563
France	0.080	0.017	61.580
United Kingdom	0	0	61.580
Germany, West	0	0	61.580
Poland	0	0	61.580
Canada	0	0	61.580
Germany, East	0	0	61.580
South Africa	0	0	61.580
Czechoslovakia	0	0	61.580

(a) Source: USDA Data Base, contact Data Services, Agricultural Economics
USDA, 1983, 202-706-1000.
(b) Percentages based on a 1983 world rice crop of 450.395 million tonnes, rough basis.

REFERENCES

- Edmonds, J.A., J.M. Reilly, R.H. Gardner and A. Brenkert. 1986. Uncertainty in Future Global Energy Use and Fossil Fuel CO2 Emissions 1975 to 2075. TR036, DOE/NBB-00B1, U.S. Department of Energy, Washington, D.C.
- Edmonds, J.A. 1986. User's Guide to the IEA/ORAU Long-Term Global Energy Economic Model with Carbon Dioxide Emissions: Personal Computer Version A84PC. Institute for Energy Analysis, Oak Ridge Associated Universities, Oak Ridge, Tennessee.
- Edmonds, J.A. and J. Reilly. 1985. Global Energy: Assessing the Future. Oxford University Press, New York.
- Edmonds, J.A., et. al. 1984. An Analysis of Possible Future Atmospheric Retention of Fossil Fuel CO2. TR013, DOE/OR/21400-1, U.S. Department of Energy, Washington, D.C.
- Oak Ridge Associated Universities. 1986. "Worldwide CO2 Emissions Data Base", mimeograph available from Oak Ridge Associated Universities, Oak Ridge, Tennessee.
- Trabalka, J.R. 1985. Atmospheric Carbon Dioxide and the Global Carbon Cycle. DOE/ER-0239, Carbon Dioxide Research Division, U.S. Department of Energy, Washington, D.C.
- U.S. Central Intelligence Agency. 1986. Handbook of Economic Statistics. U.S. Government Printing Office, Washington, D.C.
- U.S. Food and Agricultural Organization. 1984. Production Yearbook. U.S. Government Printing Office, Washington, D.C.

DISTRIBUTION

No. of
Copies

No. of
Copies

OFFSITE

ONSITE

30 DOE Technical Information
Center

DOE RICHLAND OPERATIONS OFFICE

J.J. Sutey/P.K. Clark

10 F.A. Koomanoff
Carbon Dioxide Research
Division ER-12
Office of Basic Energy Sciences
Department of Energy
Washington, DC 20545

35 Pacific Northwest Laboratory

W.J. Bair
J.W. Currie
J.A. Edmonds (10)
C.E. Elderkin
M.A. Kellogg (10)
M.S. Klan
R.J. Nesse
J.S. Pomykala
M.J. Scott
W.G. Slinn
Technical Report Files (5)
Publishing Coordination (2)

2 M. Farrell
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37831

2 M. Steinberg
Brookhaven National Laboratory
Upton, NY 11973

M. McCracken
Lawrence Livermore National Laboratory
700 East Avenue L-262
Livermore, CA 94550

DISTRIBUTION

No. of Copies	Office	No. of Copies	Office
30	DOE Technical Information Center		DOE RICHMOND OPERATIONS OFFICE
10	F. A. Knaus California Research Division 18-12 Office of Basic Energy Sciences Department of Energy Washington, DC 20545	25	DOE Pacific Northwest Laboratory 3601 Sandway P.E. 1 Richmond, WA 99401
2	M. S. G. G. G. Oak Ridge National Laboratory P.O. Box 1 Oak Ridge, TN 37831		W. J. G. G. J. W. G. G. J. A. G. G. (10) J. E. G. G. M. A. G. G. (10) M. S. G. G. J. S. G. G. M. J. G. G. V. S. G. G. Technical Report Files (2) Publishing Coordination (2)
	M. S. G. G. Lawrence Livermore National Laboratory 700 East Avenue 1-525 Livermore, CA 94550		