The IAEA Energy and Economic Data Bank

by Jean-Pierre Charpentier and John E. Russell

In order to ascertain the role which could be played by nuclear power in the developing regions of the world, the IAEA in the past has carried out market surveys for nuclear power in a number of developing countries In 1976, the IAEA established a computerized energy and economic data bank not only on nuclear energy but on other forms of energy as well. The purpose of the data bank is to provide in a unified and systematic way energy and related economic data needed for long-term energy planning. The Agency has now gathered the available data on energy production and consumption in most of its Member States and basic information on the world's energy situation and related economic parameters

Data required for analyses of the role of nuclear power in Member States, for official Agency reports, or for national, regional or world surveys can now be obtained rapidly and automatically A flexible computer program permits the production of a variety of up-to-date tables and graphs Aggregation of results on a regional or world basis, which previously called for individual and time-consuming calculations, are now easily and quickly obtained

There were three main developments that led to the setting up of the computerized data bank. The first was a considerable increase in the volume of information that was being gathered. For a number of years, a variety of energy and economic data have been gathered and classified by the Agency, and management of the continuously growing data base was becoming more and more difficult.

The second, and probably the most important, development was the need for faster selection and retrieval of the basic information With the computerized data bank, it is now possible to provide a quick answer to many questions about energy production, consumption and resources, and about related economic aspects

Thirdly, there was a need for data for making forecasts of energy consumption and production through trend extrapolations, cross-comparison between countries as well as through more sophisticated models It should be nevertheless clear that the data bank will not be a new mathematical energy model but an easily accessible system of energy data that may be used in any model as well as for more general purposes.

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ORGANIZATION OF THE DATA BANK

The setting up of a computerized data bank requires essentially four things.

1. Input data,
2. A computer and a linked magnetic storage system for these data (the hardware support),
3. A computer system (the software) which allows organization and classification of the raw input data and easy retrieval of the output data from the magnetic storage system,
4. A series of additional computer sub-programs to process the raw output data into tables, graphs, statistical analyses, etc

Points 1 and 3, the gathering of data and adaptation of a computer program for the classification and retrieval of raw input data, were the keypoints for the development of the data base. The computer hardware support was already available at the Agency (an IBM 370/158), and the development of sub-programs related to the final uses of data was a "relatively" easy task

Data gathering: As shown in Figure 1, the data sources of the IAEA energy data bank are twofold. either data are sent to the Agency directly on magnetic tape by other international organizations, or the Agency develops its own files

Concerning the data received from outside the Agency, good co-operation has been established, including loans of computerized tapes and data up-dating procedures, with the United Nations Statistical Office in New York, the Statistical Division of IEA/OECD in Paris, the World Bank in Washington D C. and the Statistical Energy Division of EEC in Luxembourg

Contracts have also been initiated with other national and international bodies such as the World Energy Conference in order to set up a similar procedure. These external contracts are essentially oriented toward the gathering of non-nuclear information. Data related to the nuclear field are on the whole gathered directly by the Agency through specific organizations, through perusal of literature from meetings and by staff members on missions.

Figure 2 shows the structure of the content of the data bank. The thick lines on the figure refer to data presently gathered and available, and the thin lines indicate the type of data that are still being collected.

The Computer System: The magnitude of basic information in the data bank is presently close to three million. The derived data such as growth-rate or per capita consumption, etc , which are calculated by sub-programs, are not included in this amount The processing of such a large amount of data, even computerized, is not an easy task. Originally, the data bank used a program that the Agency had developed for library purposes (code LIPSY) But even with modifications, it was clear that this program was very difficult to adapt with sufficient flexibility to the management of information which is essentially numerical

After examination of several possibilities, it was decided to make use of the general data management system recently provided by the Federal Republic of Germany to the Agency. Called ADABAS, this system for computer programs is specially written for the management of data It organizes input data in such a way that they can easily and quickly be retrieved without the user knowing the exact location of the data in the data base There is a simple language which allows one to make simple commands and retrieve data from very large and complicated data bases

Figure 1. Data sources of the IAEA Energy Data Bank

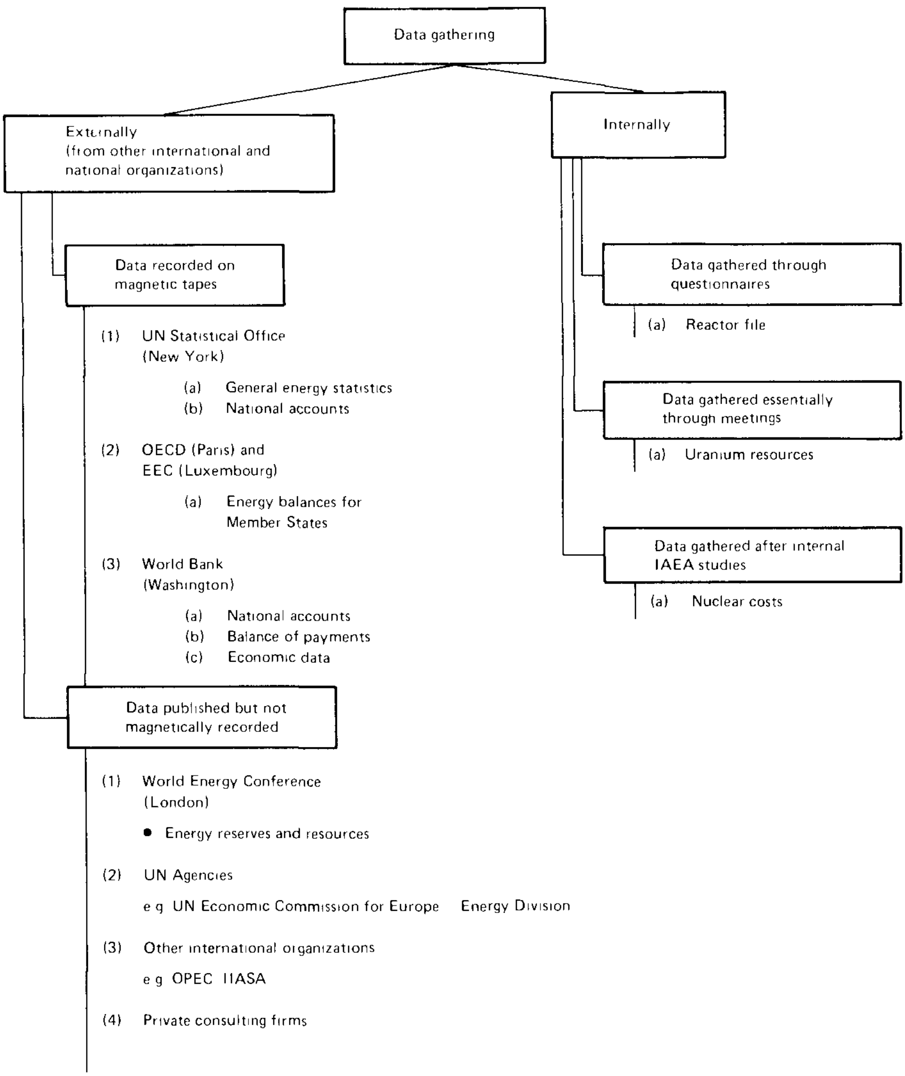
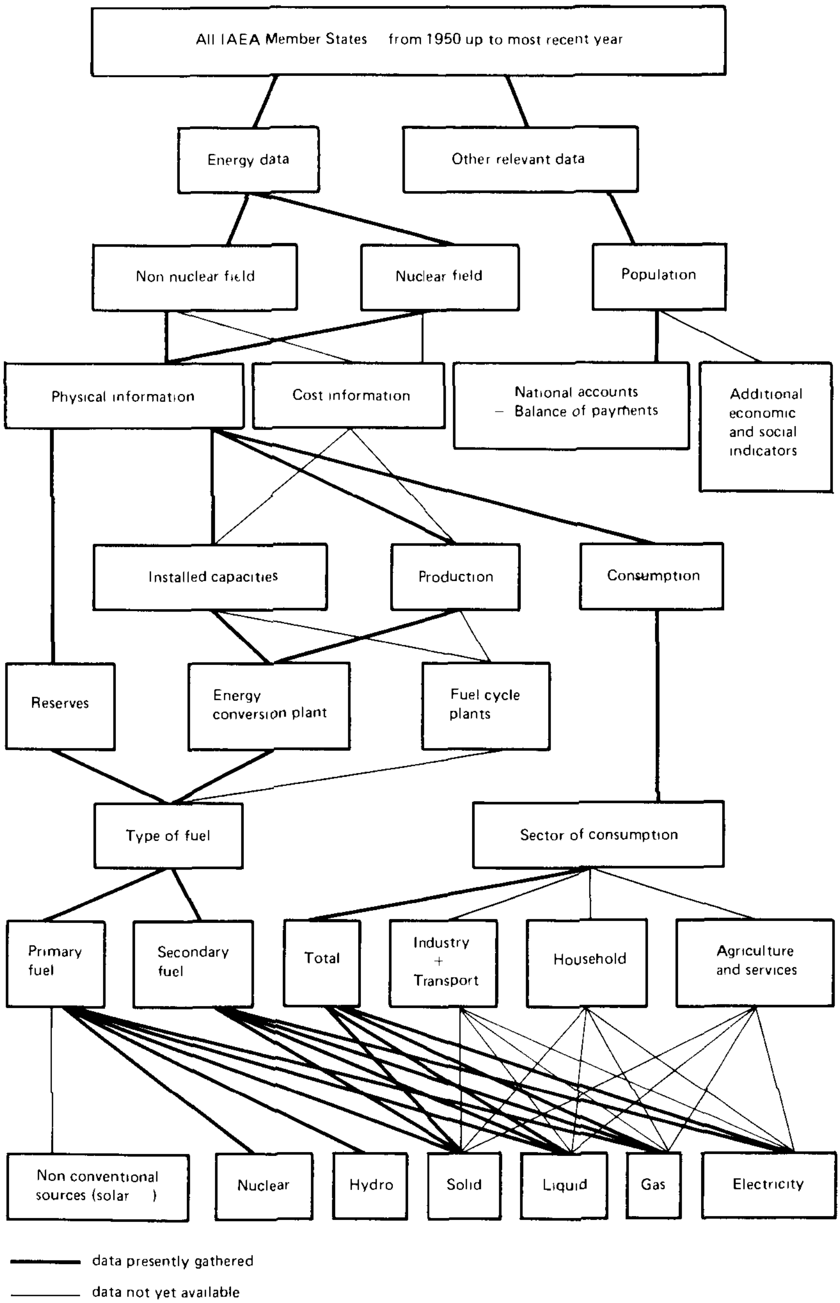


Figure 2: Structure of the Content of the Data Bank



The data are grouped by homogeneous topic and separately stored on magnetic support which is called file Six different files are presently in use.

- General energy information on production, consumption, trade and plant capacities
- Energy resources
- Nuclear reactors and fuel cycle facilities
- Cost information on investment and management for energy facilities
- National accounts
- Forecasts

ADABAS contains in its internal structure features which allow the easy coupling of files containing at least one common keyword For example, since every data in each of the files always refers to the name of the country, a country's name could be used as the keyword With such feature it is also possible to couple the general energy file with the national account file in order to find the energy consumption of all countries where the Gross National Product (GNP) per capita is a certain value

SERVICES SUPPLIED BY THE DATA BANK

The data bank has been structured so that it can fulfill three main services

1 **The "day to day" service,** which consists of being able to answer quickly any question on energy consumption, production, trade, resources and their related economic aspects

In the near future, on-line video-terminals will be available so that users of the data bank will be able to make simple queries by themselves and the answers will be displayed directly on the screen

Example of a simple request "Find all countries which, in 1975, had an average load factor of their electrical plants greater then 50%"

The computer query was formulated as follows. "FIND ALL RECORDS IN WORLD-ENERGY-STATISTICS WITH YEAR EQUAL 1975, IF ELEC-CAP NOT EQUAL O THEN COMPUTE ≠ UTIL = ELEC-PROD * 114/ELEC-CAP ELSE SET ≠ UTIL = 0 END IF ≠ UTIL LT 500 THEN REJECT RECORD END DISPLAY COUNTRY ELEC-PROD ELEC-CAPA ≠ UTIL 10 'LOAD/FACTOR/%' "

A list of countries and output data appeared on the screen from which the following were selected in order of decreasing electric energy production

COUNTRY	ELEC-PROD GIGAWATT-HOURS	ELEC-CAPACITIES MEGAWATT	LOAD FACTOR %
USSR	1 038 625	217 484	54.4
Canada	272 624	59 886	51 8
Poland	97 168	20 057	55 2
German Democratic Republic	84 505	16 929	56 9
Norway	77 564	17 090	51 7
South Africa	74 914	13 990	61 0
Romania	53 720	11 577	52.8
Yugoslavia	40 040	9 043	50.4
Venezuela	21 179	4 705	51.3
Hungary	20 465	4 291	54.3

Figure 3: Basic Energy and Economic Information for VENEZUELA – Basic Energy Situation

COMMODITY		1950	1960	1970	1973	1974	1975	AVERAGE ANNUAL GROWTH RATE 1950 TO 1970	AVERAGE ANNUAL GROWTH RATE 1973 TO 1975
ENERGY CONSUMPTION	- TOTAL	7.88	17.83	33.39	40.66	38.94	45.21	7.49	5.46
	- SOLID FUELS	0.00	0.43	1.49	3.05	2.81	2.44	39.69	-10.51
	- LIQUID FUELS	6.19	10.77	17.85	19.69	17.60	25.01	5.44	12.69
	- GAS	1.63	6.60	12.73	15.94	16.19	15.07	10.83	-2.77
	- PRIMARY ELEC.	0.06	0.03	1.31	1.97	2.34	2.70	17.12	16.88
PRIMARY ENERGY PRODUCTION	- TOTAL	104.51	204.57	272.89	254.36	228.46	183.17	4.92	-15.14
	- SOLID FUELS	0.00	0.03	0.04	0.05	0.05	0.06	20.25	9.54
	- LIQUID FUEL	102.82	197.91	258.80	236.40	209.87	165.35	4.72	-16.37
	- GAS	1.63	6.60	12.73	15.94	16.19	15.07	10.83	-2.77
	- URANIUM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	- HYDRO + GEO	0.06	0.03	1.31	1.97	2.34	2.70	17.12	16.88
ENERGY BALANCE (EXP-IMP)	- TOTAL	96.62	183.45	235.08	208.71	186.03	135.89	4.55	-19.31
	- PRIM. SOLID	-0.00	0.0	-0.03	-0.01	-0.00	-0.00	0.0	0.0
	LIQUID	85.09	138.11	168.40	146.40	122.03	101.27	3.47	-16.83
	GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	- SEC. SOLID	0.0	-0.40	-1.42	-2.99	-2.75	-2.39	0.0	0.0
	LIQUID	11.54	45.75	68.13	65.32	66.75	37.01	9.28	-24.72
	GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY PRODUCTION	- TOTAL	0.39	1.49	4.07	5.14	5.89	6.78	12.43	14.78
	- THERMAL	0.33	1.46	2.75	3.17	3.55	4.08	11.11	13.45
	- HYDRO-ELECTRIC	0.06	0.03	1.31	1.97	2.34	2.70	17.12	16.88
	- NUCLEAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	- GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAPACITIES OF ELEC. PLANTS	- TOTAL	350.00	1353.00	3172.00	3357.00	4391.00	4705.00	11.65	18.39
	- THERMAL	315.00	1220.00	2264.00	2390.00	3043.00	3137.00	10.36	14.57
	- HYDRO	35.00	133.00	908.00	967.00	1348.00	1568.00	17.68	27.34
	- NUCLEAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	- GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL ENERGY CONSUMPTION PER CAPITA		1.48	2.30	3.21	3.60	3.35	3.77	3.96	2.28
TOTAL ELEC. CONSUMPTION PER CAPITA		0.07	0.19	0.39	0.46	0.51	0.57	9.74	11.31
REFINERY CAPACITIES		12990.00	46310.00	67720.00	68015.00	62450.00	44950.00	8.61	-18.71

ALL ENERGY VALUES IN MILLION KILOWATT-YEAR THERMAL
ALL PER CAPITA VALUES IN KILOWATT-YEAR THERMAL PER HEAD
ELECTRICAL CAPACITIES IN MEGAWATTS

REFINERY CAPACITY IN MEGATONNES
ALL GROWTH RATES IN PER CENT

0.0 INDICATES VALUE NOT AVAILABLE
0.00 INDICATES VALUE LESS THAN 0.005

Figure 4: VENEZUELA – Additional Energy Information

LATEST AVAILABLE ESTIMATED FOSSIL ENERGY RESERVES

MILLION KILOWATT-YEAR THERMAL

SOLID	LIQUID	GAS	URANIUM	TOTAL
10.53	8854.55	1504.80	0.0	10369.88

LATEST AVAILABLE ESTIMATED HYDRO-ELECTRIC RESERVES

MEGAWATTS

UNDER CNSTR	PLANNED	POSS. SITES	TOTAL
2620.0	13565.0	0.0	16185.0

ENERGY RATIOS

	1950	1960	1970	1975
RESERVES/CURRENT CONSUMPTION	1316.5	581.6	310.6	229.3
ENERGY DENSITY KW-YR/SQ KM	8.6	19.6	36.6	49.6

2 **The regular supply of statistical bulletins and booklets** summarizing in standardized tables and graphs the past and present energy situation in the different IAEA Member States. Four standardized pages of energy and economic data on Venezuela are shown in Figures 3, 4, 5 and 6

Figure 3 shows energy production, consumption, energy trade and electrical plant capacities. All information is given in a unified unit – kilowatt-year thermal. In addition, two growth rates and two ratios are mentioned: the long-term energy and electricity growth rate, that is to say, the growth rate calculated since 1950 and the new growth rate since the energy crisis at the end of 1973; the two ratios given are the energy and electricity consumption per capita.

Figure 4 indicates the energy reserves of the country, also in the same standardized energy unit. Figure 5 is concerned with the population, its historical evolution as well as its distribution by age and by geographical zones. Figure 6 is devoted to the macro-economic situation of the country: gross national product (GNP) and its breakdown along the various economic sectors.

3. **Support for energy forecasts.** Several mathematical models have been developed and systematic series forecast have been carried out through a computerized link between the data and the models. Figure 7 shows an example of an extrapolation exercise based on the data of Japan. For this example, a logistic function (also called saturative function) has been fitted on the data of electricity production per capita since 1950 and extrapolated up to the year 2000.

Let us recall that a logistic function has the following mathematical form

$$y = \frac{L}{1 + \exp - (at + b)}$$

where y is the electricity consumption per capita

L is a fixed asymptotic limit which, in this example is 15 000 kWh per capita

t is the time

a & b are constants computed through regression. The regression coefficient for Japan is very good: 0 99. The results are given within a confidence interval of 95%.

The forecasts thus obtained for Japan were:

YEARS	ELECTRICITY PER CAPITA (kWh)
1985	between 7875 and 9198
1990	between 9756 and 10 974
2000	between 12 600 and 13 350

CONCLUSION

A worldwide energy data bank has now been created. It is hoped that the services offered by the data bank will assist individual States and international organizations in planning future power systems. However, there remains much to be done. It goes without saying that the development of an energy data bank is a long-range undertaking requiring constant additions and improvements.

Figure 5: VENEZUELA – Population Information

	1950	1960	1970	1975	AVERAGE ANNUAL GROWTH RATE 1970 - 1975
POPULATION IN MILLIONS	5.3	7.7	10.4	12.0	2.9
POPULATION DENSITY PER SQ KM	5.8	8.5	11.4	13.1	-----
PRESENT POPULATION GROWTH RATE					3.4
SURFACE AREA IN 1000 SQ KM					912.0

POPULATION STRUCTURE IN 1970

BY AGE				BY LIVING AREA		BY EDUCATION	
0-14	15-64	65+	TOTAL	% URBAN	URB GROWTH	SEC ENROL	LITERACY
47.0	50.5	2.5	100.0	76.0	5.0	33.0	77.0

Figure 6: VENEZUELA – Economic Information

COMMODITY	1950	1960	1970	1973	1974	1975	AVERAGE ANNUAL GROWTH RATE 1960 TO 1970	AVERAGE ANNUAL GROWTH RATE 1973 TO 1975
GNP IN BILLIONS OF 1975 $	3.95	8.89	16.28	18.53	19.74	21.25	6.23	7.08
GNP PER CAPITA IN 1975 $	796.48	1213.11	1584.44	1642.83	1697.37	1771.49	2.71	3.84
BREAKDOWN OF GNP IN %								
SUPPLIED BY :								
- INDUSTRY	39.43	23.11	42.08	47.27	57.81	0.0	12.80	0.0
- AGRICULTURE	6.81	6.47	7.42	6.55	5.33	0.0	7.69	0.0
- TRANSPORT	0.0	0.0	10.62	10.57	8.26	0.0	0.0	0.0
- OTHERS	59.94	77.83	45.16	40.73	30.86	0.0	0.61	0.0
CONSUMED BY :								
- INVESTMENT	30.87	22.10	29.39	30.80	22.27	27.66	9.30	1.48
- PRIVATE EXPEND.	56.58	56.50	56.24	49.28	41.34	50.85	6.19	8.76
- GOVRNMT EXPEND.	14.66	14.94	14.05	14.02	11.79	13.10	5.58	3.52
- TRADE BAL. (EXP - IMP)	10.21	13.86	5.60	11.02	26.86	9.31	-2.97	-1.55
EXPORTS IN BILLIONS OF 1975 $	1.34	3.05	4.18	5.79	9.13	7.35	3.20	12.65
IMPORTS IN BILLIONS OF 1975 $	0.94	1.82	3.27	3.75	3.83	5.38	6.04	19.68

Figure 7: Electrical Energy Forecast for Japan