APPENDICES

(A) INDIA'S POWER INFORMATION

Table A1—Population Growth in India

Year	*Total population (millions)*	*%Rural population*	*%Average annual exponential growth rate*	*No. of persons per sq. km*
1901	238	89		77
1911	252	90	0.56	82
1921	251	89	– 0.03	81
1931	279	88	1.04	90
1941	319	86	1.33	103
1951	361	83	1.25	117
1961	439	82	1.96	142
1971	548	80	2.20	177
1981	683	77	2.22	216
1991	844	74	2.11	267

Table A2—Consumption of Electric Energy for Different Products

Product	*Consumption of Electrical Energy*
Aluminium	*20,000 kW-hr/ton.*
Copper	*3000 kW-hr/ton.*
Zinc	*4200 kW-hr/ton.*
Coal	*20 kW-hr/ton.*
Petroleum (refining)	*35 kW-hr/ton.*
Nitrogenous fertilizer (electrolytic process)	*16,000 kW-hr/ton.*
Nitrogenous fertilizer (water gas process)	*4200 kW-hr/ton.*
Sulphuric Acid	*250 kW-hr/ton.*
Caustic Soad (Chemical process)	*500 kW-hr/ton.*
Caustic Soad (Electrolytic process)	*4300 kW-hr/ton.*
Plastics	*60 kW-hr/ton.*
Soap	*200 kW-hr/ton.*
Synthetic rubber	*700 kW-hr/ton.*
Papers	*1800 kW-hr/ton.*
Newsprint	*650 kW-hr/ton.*
Cement	*120 kW-hr/ton.*
Cotton Textles	*435 kW-hr/1000 metres.*
Jute	*540 kW-hr/ton.*
Steel	*500 kW-hr/ton.*
Pig iron	*15-20 kW-hr/ton.*
Manganese	*5000 kW-hr/ton.*
Alloy-Steel	*500 kW-hr/ton.*
Rayon	*7000 kW-hr/ton.*
Chemical pulp	*500 kW-hr/ton.*
Woollen	*3000 kW-hr/1000 lbs*
Silk	*300 kW-hr/1000 yards.*
Sugar	*60 kW-hr/ton.*
Vegetable Oil	*125 kW-hr/ton.*
Vanaspati	*250 kW-hr/ton.*
Bicycles	*15 kW-hr/cycle.*
Sewing Machine	*60 kW-hr/Machine.*
Electric Lamp	*150 kW-hr/1000 lamps.*
Matches	*600 kW-hr/1000 gross boxes.*
Plywood	*465 kW-hr/1000 m^2.*
Automobile tyres	*110 kW-hr/tyre.*
Automobile	*3000 kW-hr/car.*
Coke	*25 kW-hr/ton.*

Table A3—Irrigation and Power Development in India since Independence

Irrigation and Power	*Pre-plan upto* 1951	*End of First Plan* 1951-56	*End of Second Plan* 1956-61	*End of Third Plan* 1961-67	*End of Three Annual Plans* 1966-69	*End of IV Plan* 1969-74	*Upto the end of* 1974-77	*Fifth Plan Target* 1974-79
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Irrigation								
Irrigation Potential created from Major and Medium schemes (Million hectares)	9.7	12.2	14.3	16.6	18.1	20.6	23.5	26.4
Area Irri ated from Major and Medium Schemes (Million Hectares)	9.5	10.9	13.1	15.2	16.8	18.7	20.9	23.9
Area Irrigated from all Sources (Million hectares)	22.6	24.9	27.9	31.6	35.8	42.2	47.1	53.4
Flood Control						(upto March 1977)		
Length of Embankments constructed (km)	5280	7274	10122	12152	12231	14406	15540	—
Length of Drainage Channel (km)	—	—	—	8625	9172	15412	17850	—
Town Protected	—	20	80	164	178	219	250	—
Villages raised above High Flood level	—	1200	4300	4582	4582	4683	4700	—
Power								
Installed Capacity including non-utilties (MW)	2301	3418	5654	10173	14296	18456	23664*	—
Total Generation (Gross) (Million kWh)	7514	11872	20123	36825	51641	72796	95280*	—
Per Capita Consumption (kWh)	17.8	26.4	38.2	61.3	78	97.5	118.8*	—
Rural Electrification								
Number of villages and Towns Electrified	4075	8828	23980	47786	76396	159424	236000	—
Number of Pumpsets Electrified	21008	56058	198904	512756	1088804	2426133	3141305	—

*Provisional

Table A4—Regionwise Power Development by 1981 in India

	Northern	*Western*	*Southern*	*Eastern*	*North Eastern*	*Total*
Installed capacity required in the region by 1980-81	14400	12000	13000	10000	1000	50400
Installed Capacity in 1970-71	3700	3800	4100	3300	200	15100
Additional Capacity expected from Schemes under construction	4100	1900	3100	1400	240	10740
Balance Capacity to be added during 1971-81 from new Schemes	6600	6300	5800	5300	560	24560
Total installed Capacity in 1980-81						
Hydro	7000	3500	8400	2600	800	22900
Thermal	6000	7100	3200	7400	200	23900
Nuclear	1400	1400	1400	nil	nil	4200
Total	14400	12000	13000	10000	1000	50400

All the figures are in M.W.

Table A5—Electric Power Supply – Forecast of Power Requirement and Power Availability upto 1983-84 in India

Installed Capacity, Peak availability, Peak Load, Energy availability and Energy Requirement

	Actual			*Provisional*				*Estimated*	
	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84
Installed Capacity, MW	20106	21463	23673	26680	28458	30294	33489	38008	43348
Peak Availability, MW	13452	14197	15097	17027	17402	19188	21142	23976	27401
Peak Load, MW	13452	14197	15097	17027	17402	19188	25190	27712	30372
Surplus (Deficit), MW	—	—	—	—	—	—	(4048)	(3736)	(2971)
Energy Availability, MkWh	74777	83061	85689	96654	98837	104134	127522	142167	161411
Energy Requirement, MkWh	74777	83061	85789	96654	98837	104134	139873	153873	168415
Surplus (Deficit), MkWh	—	—	—	—	—	—	(12351)	(11754)	(7004)

Table A6—Growth of the Power Sector in the Country (Planwise) Utilities (India)

31.12.50	Ist Plan ending on 31.3.56	II Plan ending on 31.3.61	III Plan Plan on 31.3.66	3 Annual Plan ending 31.3.69	IV Plan ending on 31.3.74	V Plan Plan on 31.3.79	Annual Plan ending 31.3.80	CI Plan on 31.3.85	31.3.87	VII Plan ending on 31.3.90
Installed 1713	26595	4653	9027	12957	16664	26682	28448	42585	49265	64823
Capacity (MW)	(57.3)	(72.7)	(94.0)	(43.5)	(28.6)	(60.1)	(6.6)	(49.7)	(15.69)	(52.22)
Gross	5107	8592	16937	32990	47434	66689	102523	104627	156859	280400
Generation (G.M.H.)		(68.2)	(97.1)	(94.8)	(43.8)	(40.6)	(53.7)	(2.1)	(49.9)	(78.8)
Consumption	4157	7111	13847	26735	37352	50246	772933		114068	209730
(G.W.H.)		(71.7)	(97.1)	(94.8)	(43.8)	(40.6)	(53.7)	(1.0)	(46.1)	(83.1)
No. of villages	30611	7294	21754	45148	73739	186729	232770	249799	370332	488332
Electrified ; per capita		(138.3)	(198.2)	(107.6)	(63.3)	(112.50)	(48.8)	(7.3)	(48.2)	(31.9)
consumption (K.W.H.)										
Utility	16.55	2640	3790	61.30	77.88	97.48	130.94	130.49	168.5	LNA
+ Non Utility		(69.8)	(13.6)	(61.7)	(27.0)	(25.2)	(34.3)	(0.3)	(2.9)	

Table A7—Statewise Generating Capacity, Electricity Generation, Sales and Per Capita Consumption During 1982-83

State/Union Territory	*Capacity MW*	*Generation GWh*	*Sales GWh*	*Per Capita consumption, kWh*
Haryana	1214	4911	3326	275
Himachal Pradesh	128	540	330	75
Jammu & Kashmir	206	936	651	106
Punjab	1704	7777	5843	336
Rajasthan	1023	3604	3265	103
Uttar Pradesh	3752	12585	9843	97
Chandigarh	2	neg	196	383
Delhi	276	1077	2759	441
Centre Sector	1970	5648	——	
Total (Northern Region)	10275	37078	26223	141
Gujarat	2576	10775	8428	252
Madhya Pradesh	1841	7681	5865	121
Maharashtra	4862	20138	15442	251
Goa, Daman & Diu	—	—	222	244
D & N Haveli	—	—	9	81
Central Sector	726	1591	—	—
Total (Western Region)	10005	40185	29966	206
Andhra Pradesh	2678	10255	7076	134
Karnataka	1875	7678	6227	166
Kerala	1011	4488	3067	121
Tamil Nadu	2539	7383	8517	480
Pondichery	—	—	144	269
Lakshadweep	2	2	2	44
Central Sector	600	3833	—	—
Total (Southern Region)	8705	33639	25033	153
Bihar	1050	2753	4703	85
Orissa	1143	3185	2667	118
West Bengal	1996	5938	6367	125
DVC	1632	6008	—	—
Andaman & Nicobar Islands	9	12	11	48
Sikkim	17	25	17	48
Total (Eastern Region)	5847	17921	13765	105
Assam	333	896	747	38
Manipur	23	13	20	13
Meghalaya	134	405	73	52
Nagaland	65	2	27	35
Tripura	17	46	38	17
Arunachal Pradesh	11	20	15	23
Mizoram	6	6	10	19
Total (North Eastern Region)	529	1388	930	35
Total (All India)	35361	130211	95917	146

Table A8—Capacity Additions During Eighth Five Year Plan

Plant	Central Sector (All Figures in MW)	State sector	Total
Hydro	2115	7254	9369
Thermal	14875	13197	280972
Nuclear	705		705
Total	17695	20451	38146

Table A9—Expected Capacity Addition in Ninth Plan

Plant	Central Sector	State sector	Total
Hydro	10690	9133	19823
Thermal	14840	12970	27810
Nuclear	7645		7645
Total	33175	22103	55278

Table A10—Growth in the Power Sector (India) in 1990

Description	Unit	Position in 1950	Present position 1989-90	Increase	Annual growth rate
1. Installed capacity	MW	1700	64729	38 times	9.72
2. Annual energy generation	MU	5100	244971	48 times	10.37
3. Village electrification	Nos.	3060	4.7 Lakhs	154 times	13.69
4. Pumpsets energised	Nos.	21000	82.8 Lakhs	394 times	16.45
5. No. of consumers	Lakhs	15	650	43 times	10.08
6. Per capita consumption	Units	15	225	15 times	7.14

Table A11—All India Power Supply Position : 1980-81 to 1989-90 (Energy)

(Million units)

Year	Anticipated requireemnet	Supply	Shortage	
			Million units	%
1980-81	1,20,118	1,04,932	15,186	12.6
1981-82	1,29,245	1,15,274	13,971	10.8
1982-83	1,36,746	1,22,909	13,837	9.2
1983-84	1,45,273	1,29,625	15,648	10.8
1984-85	1,55,432	1,45,013	10,419	6.7
1985-86	1,70,746	1,57,262	13,484	7.9
1986-87	1,92,356	1,74,276	18,080	9.4
1987-88	2,10,993	1,87,976	23,017	10.9
1988-89	2,23,194	2,05,909	17,285	7.7
1989-90	2,49,059	2,30,897	18,162	7.3

Table A12—Al India Power Supply Position : 1985-86 to 1989-90 (Peaking Power)

(MW)

Year	Anticipated requirement	Availability	Shortage	
			MW	%
1985-86	28,090	24,215	3,875	13.8
1986-87	30,850	26,924	3,926	12.7
1987-88	31,990	28,242	3,748	11.7
1988-89	35,560	31,121	3,439	12.5
1989-90	45,455	37,298	8,157	17.9

Table A13—Share of commercial & non-commercial Energy in different sectors (India) % wise

Sector	*Oil*	*Electricity*	*Coal*
Household	29	11	3
Agriculture	10	16	—
Industry	5	62	78
Transport	56	2	13
Others	—	9	6
	100	100	100

Table A14—India's Energy Requirement

	1987	2000 A.D.
	A (5%)	B (8%)
	(MTOE) (In million metric tonnes of oil equivalent.)	
Nuclear	**1.5**	**15**
Hydro	**14**	**30**
Natural Gas	**4**	**18**
Coal	**79**	**113**
Oil	**48**	**177**
	146.5	**373**

In the above table it has been assumed that India will be successful in installing 10,000 MW of Nuclear power as planned by year 2000 A.D. During the last 14 years, hydro-electricity has increased by about 8 to 9 million (MTOE) and it is assumed that we will be successful in adding another 16 million MTOE in the next 13 years. Coal production during the last 14 years has increased by 41 million MTOE and with great investment and improved productivity. We may succeed in increasing coal production during the next 13 years by 34 to 54 million MTOE.

Table A15—Power Projection for 1994-95

Surplus (+) Deficit (–)

Region	Maximum Demand (MW)	Energy Requirement (MKWh)
Northern	– 4338	– 6216
Western	– 3528	– 3516
Southern	– 3868	– 17931
Eastern	– 1181	– 2997
Northeastern	+ 273	+ 4924
A & N Islands	40	– 52
Total	– 12679	– 7362

Table A16—All India Utilities (Energy Requirements)

(Million kWh)

	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
Northern region	114876	125861	138028	151395	166088	182239	199997	219526	241001
Western region	109038	118177	128094	138851	150518	163180	176909	191810	207980
Southern region	99164	107713	117015	127139	138158	150153	163211	177428	192915
Eastern region	56097	61290	66995	73271	80177	87777	95824	104653	114345
North Eastern region	5552	6260	7060	7966	8986	10142	11495	12875	14503
Andaman & Nicobar Island	114	134	158	186	219	258	303	357	430
Lakshadweep	13.4	15.1	17.1	19.2	21.7	24.4	27.5	31	34.9
All India	384764	419450	45367	498827	544168	593773	647697	706678	771204

Table A17—Power Demand of Northern States by 2000

State	(MW) Peak Demand		(Billion kWH) Energy Requirement	
	1994-95	1999-2000	1994-95	1999-2000
Harayana	2623	3850	12.95	19.28
H.P.	540	940	2.54	4.58
J & K	990	1608	4.77	7.89
Punjab	4015	5288	21.14	28.37
Rajasthan	3185	5016	18.34	29.08
U.P.	7175	10215	30.05	54.58
Delhi	2150	3180	18.10	28.10
Region (Total)	20895	30295	107.84	171.88

Table A18—Per Capita Rural Energy Consumption in India for Different Fuels (1 kg coal = 28000 kJ)

Fuel	Annual Consumption (kg)	Coal Equivalent
Coke	2.00	1.43
Coal	4.28	3.06
Firewood	326.82	221.77
Dung	121.92	57.48
Other fuels	17.91	5.61
Kerosene	5.35	7.64
Electricity	3.65	0.45

Table A19—Pattern of Commercial and Non-Commercial energy use in Rural India (in percentage)

Sector	Commercial	Non-commercial
Agriculture	23	77
Domestic	2	98
Transport	About Nil	100
Lighting	100	About Nil

Table A20—Sector Shares in Commercial Energy Consumption (India)

Sector	Commercial energy consumption 1984-85	Specific fuels in 1984-85 (in per cent)		
		Oil	Electricity	Coal
Household	18.2%	29	11	03
Agriculture	9.8%	10	16	—
Industry	36.4%	05	62	78
Transport	31.4%	56	02	13
Others	4.2%		09	06

Table A21—Rural Energisation

Sl. No. State/Union Territory	*Total Number Energised By The End of 1984-85*	*Additional Number*		*To Be Energised during*		
		1985-86	*1986-87*	*1987-88*	*1988-89*	*1989-90*
A. States						
1. Andhra Pradesh	644822	88712	81288	85000	85000	85000
2. Arunchal Pradesh	—	—	—	—	—	—
3. Assam	2736	500	500	500	500	500
4. Bihar	192109	9743	20000	80000	50000	50000
5. Goa	3009	250	250	250	250	250
6. Gujarat	292387	20000	20000	20000	20000	20000
7. Haryana	271902	11000	13000	15000	17000	19000
8. Himachal Pradesh	2324	100	100	100	100	100
9. Jammu & Kashmir	1355	40	40	40	40	40
10. Karnataka	441214	48337	45000	45000	45000	45000
11. Kerala	131991	13714	14000	14000	14000	14000
12. Madhya Pradesh	467816	41231	52169	52200	52200	52200
13. Maharashtra	937054	80650	104766	90000	90000	90000
14. Manipur	10	—	—	—	—	—
15. Meghalaya	56	—	—	64	65	65
16. Mizoram	—	—	—	—	250	50
17. Nagaland	—	—	—	—	—	—
18. Orissa	30002	7946	7946	7946	7946	7946
19. Punjab	410519	35684	51511	37805	37500	37500
20. Rajasthan	275290	11000	12000	13000	16000	18000
21. Sikkim	—	—	—	—	—	—
22. Tamil Nadu	1001728	40000	40000	40000	40000	40000
23. Tripura	840	43	43	43	44	44
24. Uttar Pradesh	509165	29267	32183	34850	34850	34850
25. West Bengal	39492	20000	20000	20000	20000	20000
B. Union Territories						
1. A & N Islands	—	—	—	—	—	—
2. Chandigarh	368	15	15	15	15	15
3. Delhi	15705	1000	1000	1000	1000	1000
4. Dadra & Nagar Haveli	351	15	30	30	30	30
5. Daman & Diu		..... Included in Goa				
6. Lakshadeep	—	—	—	—	—	—
7. Pondicherry	8513	200	200	200	200	200
All India	5680764	459447	516041	557043	531989	535790

Table A22—Use of commercial Energy for Inputs to Agricultural Production in 1972 & Projections for 1985 & 2000

Recion	Fertilizers			Farm Machinery			Irrigation			Pesticides			Total		
	1972	1985	2000	1972	1985	2000	1972	1985	2000	1972	1985	2000	1972	1985	2000
Total (Developed Countries)	84.6	168.	375.	122.	157.	211.	4.9	6.0	8.1	4.45	5.08	6.35	216.	33.	601
Developing Market Economies	20.0	68.4	286.	8.8	22.9	72.5	4.6	8.3	17.3	0.32	1.82	13.9	34.	101.	38
Africa	1.3	3.8	13.8	1.0	2.5	7.4	.1	.2	.7	0.04	0.28	2.80	2.5	6.8	2
Latin America	5.2	16.7	58.2	5.0	11.9	32.9	0.4	0.9	2.4	0.18	0.47	1.49	10.9	29.3	9
Far East	10.5	36.6	163.7	1.0	2.8	9.4	2.0	3.4	6.2	0.05	0.79	19.78	13.6	43.6	19
Near East	2.9	32.0	61.3	1.7	5.5	23.8	2.0	3.8	8.0	0.05	0.28	2.30	6.7	21.6	9
Asian Centrally Planned Economies	10.8	23.3	60.0	1.4	3.4	11.7	2.4	2.7	3.0	0.79	1.10	1.28	15.4	30.7	7
Total (Developing Countries)	30.8	91.7	345.5	10.1	26.5	84.2	7.0	11.0	20.0	1.10	2.92	15.17	49.4	132.2	46
World	115.4	259.8	720.8	132.6	183.4	295.3	12.	17.	29.	5.55	8.00	21.52	265.6	467.5	10

Table A23—Commercial Primary Energy Production in India

Million tons (Mt)

Year	*Coal Mt*	*Lignite Mt*	*Crude oil Mt*	*Gas M m^3*	*Electricity TWh*
1953-54	36.05	—	0.28	—	8.68
1960-61	55.70	—	0.45	—	20.10
1970-71	72.94	3.39	6.82	1445	61.20
1980-81	114.01	5.10	10.51	2368	119.11
1982-83	131.61	6.41	21.06	4936	140.50

Table A24—Progress of Electrification of Villages and Energization of Pump-Sets

Year (Ending 31st March)	*No. of Villages electrified (in 10^3)*	*No. of pump sets energized (in 10^3)*
1950	3.06	21.01
1956	7.29	56.06
1961	21.75	198.90
1966	45.15	512.76
1971	104.94	1629.42
1976	184.71	2785.87
1981	272.29	4330.45
1982	294.90	4653.22
1983	320.08	4961.02

Table A25—Trends in Consumption of Commercial Primary Energy

Year	*Coal Mt*	*Lignite Mt*	*Oil Mt*	*Natural Gas Mm^3*	*Hydro power TWh*	*Nuclear power TWh*
1953-54	34.10	—	3.50	—	2.90	—
1960-61	49.90	0.05	6.70	—	7.80	—
1965-66	62.30	2.57	10.49	—	15.22	—
1970-71	71.23	3.37	14.97	704	25.25	2.42
1973-74	77.68	3.32	18.22	866	28.97	2.40
1975-76	92.22	3.01	18.68	1286	33.30	2.63
1980-81	109.42	4.99	26.01	1566	46.53	3.00
1981-82	117.66	6.30	26.75	2311	49.53	3.01
1982-83	124.22	6.40	30.60	2735	48.25	2.02

Note : Consumption for non-energy purposes is excluded.

(B) WORLD'S POWER INFORMATION

Table B_1. World Energy Production & Consumption in Relation to Population Distribution

Country	*Energy production MTOE*	*Energy consumption MOTE*	*Population millions*
Canada	180	195	23
USA	1365	1727	214
Latin America	281	299	324
West Europe	446	1201	367
East Europe	320	401	106
Middle East	1002	97	109
Africa	306	120	292
USSR (CIS)	1106	1022	255
China	399	388	839
Japan	25	340	111
South & South East Asia	223	259	1306
Australia	78	73	21
Total	5730	6123	3967

MTOE = million tonnes oil equivalent

Table B_2. GNP Per Capita Average Annual Growth Rate & Energy Consumption for few selected Developed & Developing countries

Country	*GNP per capita average annual growth rate (%) (1965-84)*	*Energy consumption*		
		Average annual growth rate (%) (1974-84)	*Per capita (Kg of oil equal)*	
			1965	*1984*
Developed Countries				
Switzerland	1.4	0.9	2501	3777
USA	1.7	−0.1	6536	7302
West Germany	2.7	−0.1	6535	4238
U.K.	1.6	−1.3	3481	3441
Japan	4.7	0.4	1474	3135
Canada	2.4	1.8	6007	9148
Developing Countries India	1.6	6.5	100	187
Nepal	0.2	8.6	6	16
China	4.5	5.3	178	485
Botswana	8.4	8.2	207	409
Korea	6.6	8.4	237	1171

Table B_3. Global Estimated Energy Consumption in Billion kWh

Country	*1975*	*1980*	*1990*	*2000*
U.S.A	15.0	20.0	40.0	80.0
USSR (Now, CIS)	7.5	15.0	35.0	70.0
Germany	3.0	5.0	10.0	20.0
France	2.5	4.0	8.0	15.0
Canada	3.0	5.0	10.0	20.0
Japan	2.5	3.5	7.0	15.0
U.K.	2.0	3.0	5.0	10.0
India	0.5	1.0	4.0	16.0
China	0.1	2.0	6.0	20.0
Other countries	13.9	21.5	35.0	60.0
Total	50.0	80.0	160.0	326.0

Table B_4. Household Requirements of Energy in various countries (1 Kg = 7000 kcal)

Country	*Units Reported*	*Other Remarks*	*Per Person Requirements in Kgce/year*
India	Average of variety of fuels ranging from dung to kerosene	Household survey of 21,000 rural households	300
Kenya	324 kgce/year	Consumption of wood, charcoal and kerosene taken together	325
Tanzania	400 kgce/year	400	
Ivory Coast	1.5 kg of wood/day	352	
Thailand	6 to 7 m^3/family	Heavy use of charcoal means greater losses	450--500
Nepal	0.6 to 1 m^3 wood/year/person	Nepal requires different intensities of heating in different parts of the country.	260-435
China	1800 kg/family	Chinese coal of low quality ; range depends on quality assumptions	250-400

Table B_5. Per Capita Energy Use (in Gigajoules per Capita per year) for selected developing countries

Country	*Commercial Energy(b)*	*Biomass Energy(c)*	*Total*	*Percentage of Energy from Biomass*
Bangladesh	1.2	3.0	4.2	71%
Niger	1.1	8.0	9.1	88%
Gambia	3.1	7.0	10.1	21%
India	5.2	6.0	11.2	54%
Ethiopia	0.6	11.7	12.3	95%
Nepal	0.3	13.5	13.8	98%
Somalia	2.9	15.0	17.9	84%
Bolivia	10.7	8.3	19.0	44%
Sudan	5.0	20.0	25.0	80%
Thailand	9.6	16.5	26.1	63%
Tanzania	1.9	25.5	27.4	93%
China	24.5	10.0	34.5	29%
Brazil	23.2	11.7	34.9	34%
Mexico	40.5	4.0	44.5	9%
Libya	55.3	3.0	58.6	5%
Developing Countries (Average)	17.3	13.1	30.1	43%

Table B_6. Power Consumption of Different Countries as per the data available in 1975

Country	*kW-hr per annum per capita*
U.S.A.	8100
Sweden	7500
U.K.	4900
Australia	4300
France	2400
Yugoslavia	1000
Mongolia	430
India	95 (persent 400)

Table B_7. Summary of Selected National Energy Consumption Surveys

Country	*Commercial Energy (NCE) kW/capita*	*Non-Commercial Energy*	*Total Energy fron NCE sources*	*Percentage of Energy*
Bangladesh	0.038	0.095	0.133	71
Niger	0.035	0.254	0.289	88
Gambia	0.098	0.222	0.320	69
Morocco	0.268	0.073	0.340	21
India	0.165	0.190	0.355	54
Ethiopia	0.019	0.371	0.390	95
Nepal	0.009	0.429	0.438	98
Somalia	0.092	0.476	0.568	84
Bolivia	0.340	0.263	0.603	44
Sudan	0.159	0.635	0.794	80
Thailand0.305	0.524	0.829	63	
Tanzania	0.60	0.810	0.870	93
China	0.778	0.317	1.10	29
Brazil	0.737	0.371	1.11	34
Mexico	1.29	0.127	1.43	9
Libya	1.76	0.095	1.86	5
Developing Countries (Average)	0.550	0.416	0.996	43

Table B$_8$. Global Distribution of Energy Use (Per Cita Energy Use)

	Population	*New Commercial energy*		*Oil*		*Natural gas*		*Coal*		*Hydro & Nuclear*		*Total*	*Total Energy Use*
	(Million)	*Watts*	*%*	*Watts*	*%*	*Watts*	*%*	*Watts*	*%*	*Watts*	*%*	*Watts*	*TW*
World	4371.5	308[b]	15	778	37	397	19	567	27	64	3	2114	9.24[c]
Industrialised market economies	795.1	NA[c]	—	2658	48	1323	24	1356	24	243	4	5580	4.44[b]
U.S.	227.6	220[d]	2	4093	41	3038	31	2249	23	281	3	9881	2.25
Western Europe	372.6	NA[c]	—	2035	52	689	18	979	25	199	5	3902	1.45[b]
Japan	116.8	NA[c]	—	2162	67	268	8	640	20	172	2	3242	0.38[b]
Centrally planned Europe	377.8	NA[c]	—	1559	30	1371	27	2155	42	86	2	5171	1.95[b]
Developing market Economics	2186.2	456[e]	52	272	31	68	8	65	7	20	2	881	1.93
Brazil	123.0	371[e]	34	513	48	12	1	63	6	118	11	1077	0.13
India	662.0	190[e]	52	51	14	2	1	115	31	9	2	367	0.24
Bangladesh	88.2	95[e]	69	22	16	18	13	2	1	1	1	138	0.01
China	939.3	317[e]	36	106	12	19	2	427	49	7	1	876	0.82

Notes to table B$_8$:

(*a*) Unless otherwise indicated, data are from United Nations, 1981.

(*b*) This is the world average value, assuming zero non-commercial energy use in industrialized countries other than the U.S.

(*c*) Not available.

(*d*) This is estmated wood consumption as fuel by the forest products industry plus firewood consumption Source : OTA, 1980.

Table B_9. Following is the Assumed Global Primary Energy Supply Mix for the High Demand Scenario.

	1980	*2020*
Nuclear Power	0.22	0.75
Hydro[c]	0.19	0.60
Wind & Photovoltaic energy	—	0.12
Fossil Fuels		
Coal	2.44	1.95
Oil	4.18	4.46
Natural gas	1.74	4.46
Sub Total	8.36	10.87
Biomass		
Organic wastes	—	1.01
Plantations	1.49	2.00
Sub Total		3.01
Total	10.3	15.34

Table B_{10}. Potential World Primary Energy Production in kW

Resources	*1972*	*1985*	*2000*	*2020*
Coal	66	115	170	259
Oil	115	156	146	125
Gas	46	77	143	125
Nuclear	2	23	44	56
Hydraulic	14	24	34	56
Unconventional Oil & gas	0	0	7	44
Renewable, solar				
Gothermal, Biomass	26	33	56	100
Total	269	418	600	866

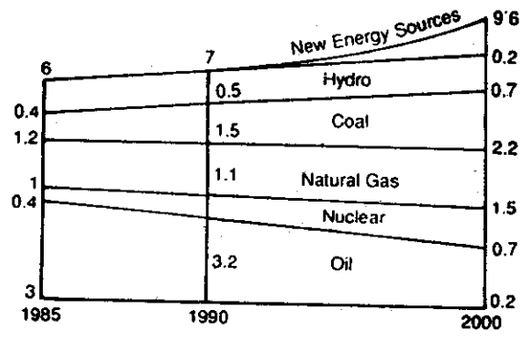


Fig. (A) Energy Consumption Outlook in the Western World

Table B_{11}.

Sources	*1970*	*1975*	*1985*	*2000*
Petroleum	8.79	10.72	14.08	19.63
Natural Gas	6.69	8.51	11.71	15.61
Coal	4.08	4.79	6.61	7.78
Hydro	0.78	0.84	1.04	1.48
Nuclear	0.06	1.43	6.19	12.91

Table B_{12}.

Region	*Number of years*	*Year of Exhaustion*
1. OECD US	89	2067
2. OECD JANZ	81	2059
3. OECD West	90	2068
4. Centrally Planned Europe	76	2054
5. Centrally Planned Asia	61	2039
6. The Middle East	72	2050
7. Africa	89	2067
8. Latin America	81	2059
9. South & East Asia	62	2040
Total World	78	2056

Table B_{13}. World oil, gas and coal reserves*

Billion barrels oil equivalent*	*Crude oil*	*Natural gas*	*Coal*
North America	77	60	937
Caribbean and South America	27	17	22
Western Europe	17	27	438
Africa	58	34	157
Middle East	307	118	1
Far East and Australasia	19	28	253
USSR, Eastern Europe and China	86	195	1492
Total	591	479	3300

*Crude oil and natural gas proven reserves at year end 1980.

1. Billion = thousand million.

Table B_{14}. World energy consumption, 1960-1980

Million barrels a day oil equivalent	**1960**	**1970**	**1980**
Oil	21.2	46.3	61.5
Coal	25.5	28.5	35.0
Natural gas	7.5	17.1	25.0
Hydro	3.9	6.0	8.5
Nuclear	*	0.4	3.5
Other①	0.8	0.9	1.5
Total	58.9	99.2	135.0

*Negligible.

"Non-commercial" use of traditional fuels (firewood, charcoal, agricultural waste etc.) is excluded.

Table B_{15}. The world commercial energy picture.
(consumption : million barrels a day oil equivalent)

	1960	*1965*	*1970*	*1973*	*1975*	*1980*
OECD countries	37.7	47.5	63.1	72.3	68.9	74.8
USSR, Eastern Europe and China	16.1	20.0	25.7	30.1	33.7	41.1
OPEC	0.7	1.0	1.6	2.3	2.6	4.1
Others	4.4	6.1	8.8	10.5	11.3	14.9
Total	58.9	74.6	99.2	115.2	116.6	134.9

Table B_{16}. World supply and demand of oil by region wise (1980)

Million barrels a day	*Indigenous supply**	*Demand*
OECD North America (U.S., Canada)	12.0	18.0
OECD Europe	2.5	14.0
OECD Pacific (Australia, New Zealand, Japan)	0.5	6.0
OPEC	27.5	3.0
Others	5.5	8.5
Communist areas	14.5	13.0
Total	62.5	62.5

*Includes natural gas liquids.

Table B_{17}. OPEC crude oil reserves and production, (1980)

OPEC	*Proven reserves at year end (billion barrels)*	*Production (million b/d)*	*Years remaining*
Saudi Arabia	117	9.9	32
Kuwait	71	1.7	118
Iran	40	1.5	74
Iraq	34	2.6	35
United Arab Emirates	37	1.7	60
Libya	26	1.8	39
Venezuela	20	2.2	25
Algeria	12	1.0	32
Nigeria	11	2.1	15
Indonesia	11	1.5	19
Others	5	0.8	16
Total OPEC	384	26.8	439

Table B_{18}. World nuclear power installation (GWe)

World regional grouping	*1975*	*2000*	*2020*
OECD countries	68	800	2225
Centrally planned	07	560	1850
Developing Nations	01	180	925
Total	76	1540	5000

Table B_{19}. Potential world Primary Energy Production

Resource	*Unit*	*1972*	*1985*	*2000*	*2020*
Coal	Billion Joules	2.2	3.9	5.8	8.8
Oil	Billion Barrels	18	34	31	17
Gas	Trillion ft^3	46	77	143	125
Nuclear	Exajoules	2	23	88	314
Hydraulic	Exajoules	14	24	34	56
Unconventional	Billion Barrels oil equivalent	0.0	0.0	0.6	6.4
Solar, Geothermal & Biomass	Exajoules	26	33	56	100

1 Exajoules = 1 Quadrillion Btus.
= 1 Trillion ft^3 of natural gas
= 34 million tons of coal
= 159 million barrels of oil.

Table B_{20}.

World Energy Availability	*U.S. Energy Availability*
Known Reserves = 31 Q % solids=50% Ultimate Resources = 220 Q Gas = 12 Q Oil = 20 Q Solids = 170 Q Uranium = 18 Q (non-breeder) = 900 Q (breeder) Consumption = 0.25 Q/year	oil + gas = 2 Q Coal = 13 Q Uranium (breeder) = 130 Q Thorium (breeder) = 21 Q Uranium 238 = 13 Q LWR = 1.8 Q Consumption = 0.08 Q/year

$Q = 10^{18}$ Btu.

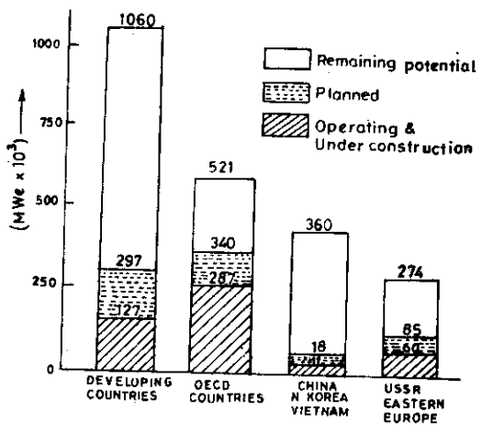


Fig. B. World total installed and future planned hydraulic capacity.
1 EJ = 10^{18} Joules

Table B_{21}. Total & Thermal Power Production in 11-countries

Country	*Total Production kWh × 10^9*	*Thermal Production kWh × 10^9*	*Thermal Capacity MW (e)*
U.S.A.	1317.32	1092.4	239353
U.S.S.R.	556.9	469.2	106914
Japan	237.2	168.2	32421
U.K.	196.2	191.0	53573
West Germany	172.2	150.0	40904
Canada	165.6	32.9	9613
France	111.6	66.5	18020
Italy	93.5	50.8	14158
East Germany	56.7	55.7	10855
Poland	47.4	46.5	10560
Czechoslavakia	35.7	32.0	8050
Total	2990.2	2361.2	544421

Table B_{22}. Total Fuel Consumption in 11 countries.

Country	*Coal Tons × 10^6*	*Lignite Tons × 10^6*	*Fuel Oil Coal Tons Eq. × 10^6*	*Gas in m^3 × 10^6*
U.S.A.	439.1	1.3	202.7	1262.5
U.S.S.R.	197.4	236.4	117.3	378.5
Japan	76.3	0.1	69.4	12.8
U.K.	163	—	49.3	31.2
West Germany	97.4	29.6	59.7	33.6
Canada	21.7	0.6	29.8	85.0
France	60.3	1.8	39.0	23.3
Italy	12.8	1.1	41.4	24.0
East Germany	11.0	72.6	3.0	3.8
Poland	97.7	7.2	3.1	12.4
Czchoslavakia	25.7	42.8	3.9	8.9
Total	1202.4	393.5	618.6	1876

Table B_{23}. Comparison of Energy Consumption in a few countries

Sector	*Energy Consumption (%)*				
	USA	*UK*	*Sudcn*	*Sweden*	*India*
Industrial	25	36	07	49	36
Domestic	19	26	61	24	18
Transport	25	23	20	13	31
Agricuture	02	03	07	—	10
Others	25	—	05	—	—

Table B_{24}. Forecast of energy demand for the period 1982-2000

Energy	*1982-83*		*1987-88*		*1992-93*		*2000-2001*	
	RLF	*OLF*	*RLF*	*OLF*	*RLF*	*OLF*	*RLF*	*OLF*
Coal (million tonne)	96.8	96.8	131.5	128.0	186.6	170.4	308.0	266.0
Oil (million tonne)	25.4	25.2	33.4	30.4	44.7	37.0	74.2	54.8
Electricity (TWh)	128.3	128.3	191.2	173.6	282.0	241.0	471.0	395.6
Non-Commercial	204.1	—	202.9	—	195.8	—	163.5	—

(C) HYDEL POWER INFORMATION

Table C_1. Development of Irrigation Potential

Period	*Expenditure in the Plan (Rs. crores)*	*Irrigation potential created (million hectares) (cumulative)*	*Irrigation potential utilised (million hectares) (cumulative)*
1. First Plan	442.86	26.2	25.0
2. Second Plan	541.58	29.1	27.8
3. Third Plan	1019.10	33.6	32.2
4. Annual Plans (1966-69)	990.74	37.1	35.8
5. Fourth Plan	2415.64	44.2	42.1
6. Fifth Plan	3925.76	52.0	48.5
7. Annual Plans (1978-80)	3060.48	56.6	52.6
8. Sixth Plan	10785.65	67.5	60.6
9. Seventh Plan	17327.42	78.8	70.3
10. Annual Plans (1990-92)	8897.96	84.6	75.7

Table C_2. Planwise Hydro : Thermal Mix

At the end of	*Total installed capacity-MW*	*Hydro %*	*Thermal % including nuclear*
1. (1950-51)	1713	32.66	67.34
2. I Plan (1951-55)	2695	34.86	65.14
3. II Plan (1956-61)	4653	41.19	58.81
4. III Plan (1961-66)	9027	45.88	54.32
5. Three Annual Plans (1966-69)	12957	45.59	54.41
6. IV Plan (1969-74)	16664	41.80	58.20
7. V Plan (1974-79)	26680	40.60	59.40
8. Annual Plan (1979-80)	28449	40.02	59.98
9. VI Plan (1980-85)	42585	33.95	66.05
10. VII Plan (1985-90)	63290	28.93	71.07
11. VIII Plan (1990-95)*	101659	25.32	74.68
12. IX Plan (1995-2000)*	166624	31.03	68.97

(Anticipated)

Table C_3. Statewise Distribution of Hydro-Power Potential in India

State	*MW at 60% load factor*	*Installed capacity in Jan. 79 in MW*
1. Andhra Pradesh	2477	826
2. Assam, Meghalaya, Nagaland and Mizoram	11600	107
3. Bihar and West Bengal	632	217
4. Gujarat	677	300
5. Jammu and Kashmir	3590	140
6. Kerala	1540	1012
7. Madhya Pradesh	4582	115
8. Tamil Nadu	708	1369
9. Maharashtra	1910	1264
10. Karnataka	3373	1117
11. Orissa	2062	630
12. Punjab and Haryana	1360	1802
13. Rajasthan	149	271
14. Uttar Pradesh	3764	1068
15. Himachal Pradesh	1868	105
16. Manipur	865	0.6
Total	38757	10344

Table C_4. Installed Power in January 1979 in India

Thermal	13400 MW	54.9%
Hydel	10344 MW	42.4%
Nuclear	640 MW	2.7%
Total	24384 MW	100%

Table C_5. Hydel Power Plants in India

S. No.	*Name of Power Plant*	*Capacity, MW*
1.	Nizamsagar	15.00
2.	Tungabhadra	36.00
3.	Hampi	36.00
4.	Mackhund	114.75
5.	Upper Sileru	120.00
6.	Umtru	11.20
7.	Umiam	36.00
8.	Bhakra, Kotla and Ganguwal	1204.60
9.	Ganderbal	15.00
10.	Neriamanglam	45.00
11.	Penniar	30.00
12.	Poringakuthu	32.00
13.	Pallivasal	36.00
14.	Sengulam	48.00
15.	Sholayar	59.00
16.	Sabirigiri	300.00
17.	Gandhi Sagar	115.00
18.	Rana Partap Sagar	129.00
19.	Purna	22.50
20.	Koyna	540.00
21.	Khapoli	72.00
22.	Bhivpuri	72.00
23.	Bhira	132.00
24.	Shimshopur	17.20
25.	Munirabad	27.00
26.	Sivasamudram	42.00
27.	Jog	120.00
28.	Bhadra	33.00
29.	Sharavati	534.60
30.	Hirakud-I	198.00
31.	Hirakud-II	72.00
32.	Shanan	48.00
33.	Kundah	445.00
34.	Papanasam	28.00
35.	Moyar	36.00
36.	Mettur	240.00
37.	Pykara	70.00
38.	Periyar	140.00
39.	Sakarapathi	30.00
40.	Matatila	30.00
41.	Pathri	20.40
42.	Dhakrani	22.50
43.	Khatina	41.40
44.	Dhalipur	34.00
45.	Rihand	300.00
46.	Jaldhaka	18.00
47.	Panchit Hill	40.00
48.	Maithon	60.00

Table C_6. Some Pelton Turbine Installations in India

Scheme	*No. of Turbines*	*Turbine Specifications*				
		Power in H.P. each	*Head in metres*	*Discharge litres per sec. in each*	*Speed in r.p.m.*	*Other Details*
1. Mahatma Gandhi Hydro Electric	4	17,000	367	—	428.5	Sharavati River
Power (Jogfall)	4	32,500			428.5	
2. Tata Hydro-electric	6	17,100	1685	104	300	Khopoli
Co. Ltd.	5	15,000	1655			
3. Simla Hydro-electric	3	370	167.5	218	—	Sutlej River
scheme	2	590	167.5	340		
4. Nainital Hydro-electric scheme	3	172	290	615	—	Natural Lake
5. Mussoorie Hydro electric scheme	2	675	305	240	750	Kiarkuti River
6. Darjeeling	2	135	168.5	—	1000	
Hydro-electric	2	368	173	190	1000	Mountain Streams
Scheme	2	294	198	139	715	
7. Govt. of Mysore Elect. Dept.	6	1,450	117	—	—	Cauvery River
8. Satara Hydro.	2	70	—	—	1000	
electric Scheme	2	11,000	940	—	600	Krishna River
9. Mohora Power Station Kashmir	4	812	122	782	500	Jhellum River
10. Koyna	4	87,000	475	—	300	
Hydro-electric	4	100,000	—	—	—	Koyna River
Project	2	27,000	360	—	—	

Table C_7. Some Francis Turbine Installations in India

Scheme	*No. of Turbines*	*Turbine Specifications*				
		Power in H.P. each	*Head in metres*	*Discharge m^3/sec. each*	*Speed in r.p.m.*	*Other Details*
1. Bhakra Dam Project (Punjab)	5	150,000	120	100	166.7	Sutlej River
	5	170,000	—	—	—	(vertical)
2. Damodar Valley Corporation (W.B. & Bihar)	2	2500	15—23.5	—	—	Basakar River (vertical)
3. Hirakud Dam Project (Orissa)	2	32,000	25 to 40	17.5	250	Mahanadi
4. Gokak Hydro-electric Scheme (Bombay)	3	900	60	—	—	Gorkaprabha
	1	1500	—	—	—	River
5. Ranbir Canal Scheme (Jammu & Kashmir)	4	700	8	—	300	Chenar River (horizontal)
6. Cauvery Hydro-electric Scheme (Mysore)	4	900	120	—	75	
7. Chambal Hydro-electric Scheme (Rajasthan)	3	900	60	—	—	Chambal
	1	1500	—	—	—	River
8. Tungabhadra Hydro-electric Scheme (Andhra)	1	680	27	—	—	Tungabhadra
	2	12,500	33.5	31	214	River
9. Periyar Hydro electric Scheme (Madras)	3	50,000	374	11.38	750	Periyar River
10. Rihand Dam Project (U.P.)	5	77,000	68.5	—	150	Rihand Dam (vertical)

Table C_8. Some Kaplan Turbine Installations in India

Scheme	*Total number of Turbines & H.P. (total)*	*Head in metres*	*R.P.M.*	*Other Details*
1. Bhakra Project in Punjab	2 with 34000 H.P.	29.8	166.7	Run away speed is 458 r.p.m.
2. Ganga Hydro-electric Scheme in U.P.	10 & 4000 H.P. to 40,000 H.P.	5.3 to 9.62	125	D = 5.3 metres
3. Sarda Hydel Project in U.P.	3 with 57600 H.P.	—	—	—
4. Hirakud in Orissa	3 with 208,000 H.P. and 2 with 73,400 H.P.	2.7	150	Q = 127.5 m^3/sec D = 4.48 m
5. Nizamsagar in Andhra	3 with 21,150 H.P.	—	—	—
6. Tungabhadra in Madras	2 with 27,400 H.P.	20	214	—
7. Radhangari Peroject in Bombay	4 with 6,880 H.P.	14 to 36	600	—

Table C_9. Different Power Potentials in India Regionwise
(As per data available in 1982)
(*a*) Hydro-Electric Potential

Region	*Annual energy potential TWh*	*Annual energy potential developed TWh*	*Annual energy potential under development TWh*
Northern	147.39	14.88	11.13
Western	36.95	6.36	1.65
Southern	68.31	21.10	11.45
Eastern	37.81	3.07	4.64
N-Eastern	105.86	0.73	1.56
Total	3396.32	46.14	30.43

Table C_{10}. Details of Irrigation & Hydel Plants in Maharashtra

Particulars of the plants	*Jayak Wadi Stage-I*	*Jayak Wadi Stage-II*	*Purna*	*Bhima*	*Koyana*	*Penganga (Isapur)*	*Penganga (Sapli)*	*Pocha-mpad (Nagar)*	*Sun-Sagar*	*Tung-Bhadra*	*Bhadra*	*Hirakund*	*Bhakra Nagal*
Reservior $10^6 \times m^3$	2850	440	964	3114	2780	1254	119	3170	11315	4040	2022	8110	9868
Live storage $10^6 \times m^3$	2150	311	820	1440	2690	951	61	2290	6800	3310	1780	5836	7760
Dam Length (metres)	10200	6350	3270	2331	805	3870	235	13401	4863	2440	4403	4800	518
Max Height (metres)	41.82	30	51	56	103	48	1.9	23	124	49	72	61	226
Earth work $10^6 \times m^3$	12.82	4.66	1.56	0.14	—	6.9	1.0	8.2	2.35	0.17	0.4	17.1	4.22
Masonary $10^6 \times m^3$	0.34	0.077	0.14	0.76	—	200	35	0.68	4.9	0.93	0.79	0.4	—
Concrete $10^6 \times m^3$	0.07	0.04	0.06	0.05	—	14	17	—	0.71	0.08	0.01	0.76	4.13
Power (MW)	12	—	22.5	—	860	—	—	—	—	126	—	270	1204
Canal Length (kilometres)	208	297	44.8	587	—	366	—	112	379	768	176	147	237
Irrigation Area (Hactares)	142000	136000	61538	122956	—	104207	—	231000	832000	353175	99054	496761	145749
Cost in Crores	125	123	18.7	43	94	35	—	146	312	102	35	83	242

(D) THERMAL POWER INFORMATION

Table D_1. Consumption of Commercial Energy in Selected Developing Countries 1978 to 1990

Country	*Coal%*	*Oil contribution*	*Natural Gas*	*Nuclear and Hydro*	*Per capita consumption GJ/Year*
Nepal	6%	81%	–	13%	0.3
Ethiopia	–	92	–	8	0.6
Mali	–	97	–	3	0.9
Bangladesh	10	51	36	2	1.2
Tanzania	–	94	–	6	1.9
Somalia	–	100	–	–	2.9
India	65	28	2	5	5.2
Guatemala	–	97	–	3	7.6
Indonesia	1	84	14	1	8.1
Bolivia	–	87	8	5	10.7
Zambia	29	42	–	28	13.9
Peru	2	85	1	7	1.9
Brazil	9	75	2	14	23.3
China	80	18	1	1	24.4
S. Korea	38	61	–	1	39.8
Mexico	8	68	20	3	40.6
Venezuela	1	49	46	4	87.6
Developing countries (average)	46%	43%	8%	3%	16.8

Table D_2. India ranks fourth in the production of coal in the world as is evident from Table D_2.

Country	*Tonne per capita*
USSR	23,112
USA	13,747
China	1,060
India	201

Table D_3 Different Power Potentials in India Regionwise (As per data available in 1982)

(a) Hydro-Electric Potential

Region	*Annual energy potential TWh*	*Annual energy potential developed TWh*	*Annual energy potential under development TWh*
Northern	147.39	14.88	11.13
Western	36.95	6.36	1.65
Southern	68.31	21.10	11.45
Eastern	37.81	3.07	4.64
N-Eastern	105.86	0.73	1.56
Total	105.86	46.14	30.43

(b) Coal Reserves in Million tons

Region	*Coking coal*	*Non-coking coal*	*Total*
Western	437	20297	20734
Southern	–	8505	8505
Eastern	22969	58778	81747
Others	–	892	892
Total	23406	88472	111878

(c) Lignite Reserves in Million tons.

Region	*Total Reserves*	*Proven Reserves*
Northern	23.57	12
Western	45.00	45
Southern	3300.00	2000
Total	3368.57	2057

(d) Crude Oil and Natural Gas

Region	*Oil Million tons*	*Natural Gas in Million m^3*		
		on-shore	*off-shore*	*Total*
Western	378	17.57	331.00	348.57
N-Eastern	93	71.00	–	71.00
Northern	–	0.43	–	0.43
Total	471	89.00	331.0	420.00

Table D_4. Trends in Consumption of Commercial Secondary Energy

Year	*Coal Mt*	*Oil Mt*	*Electricity TWh*
1953-54	28.7	3.7	7.6
1960-61	40.4	6.7	16.9
1965-66	51.8	9.9	30.6
1970-71	54.1	12.5	48.5
1973-74	56.5	15.2	55.6
1975-76	65.5	15.6	66.0
1980-81	70.3	22.2	89.7
1981-82	74.1	22.7	98.0

Note. Coal and oil consumption excludes coal and oil used for power generation and non-energy purposes and refineries.

Table D_5. Regionwise Availability of total coal Resources in Million tons in India

Region	*Non-coking coal*	*Coking coal*	*Lignite*
North Eastern	828	–	–
Eastern			
West Bengal	17139	2480	–
Bihar	17862	17365	–
Orissa	5186	–	–
Central Region			
M.P. and U.P.	15174	309	–
Western Region			
Maharashtra	2622	–	–
Gujrat	–	–	78
Southern Region			
Andhra Predesh	2055	–	–
Tamil Nadu	–	–	1919
Northern Region			
Rajasthan	–	–	20
Kashmir	–	–	8
Total	60796	20154	2025

Table D_6. Estimated future production of coal of different major countries

Country	*Coal production in 10^6 TCE*			
	1975	*1985*	*2000*	*2020*
Australia	69	150	300	400
Canada	23	35	115	200
Czechoslovakia	80	93	100	110
Germany (Rep)	126	129	145	155
GDR	76	80	90	100
U.K.	129	137	173	200
India	73	135	235	500
Poland	181	258	300	320
South Africa	69	119	233	300
Other countries	224	330	449	561
Sub-total	1049	1466	2140	2846
China	349	725	1200	1800
USA	581	842	1340	2400
USSR	614	851	1100	1800
Big three sub-total	1544	2418	3640	6000
Total world population	2593	3884	5780	8846

Table D_7. World nuclear power installation (GEw)

World regional grouping	*1975*	*2000*	*2020*
OECD countries	68	800	2225
Centrally planned	07	560	1850
Developing Nations	01	180	925
Total	76	1540	5000

Table D_8. Potential World Primary Energy Production

Resource	*Unit*	*1972*	*1985*	*2000*	*2020*
Coal	Billion Joules	2.2	3.9	5.8	8.8
Oil	Billion Barrels	18	34	31	17
Gas	Trillion ft^3	46	77	143	125
Nuclear	Exajoules	2	23	88	314
Hydraulic	Exajoules	14	24	34	56
Unconventional	Billion Barrels oil equivalent	0.0	0.0	0.6	6.4
Solar, Geothermal & Biomass	Exajoules	26	33	56	100

1 Exajoules = 1 Quadrillion Btus.
= 1 Trillion ft^3 of natural gas
= 34 million tons of coal
= 159 million barrels of oil.

Table D_9. Chemical Analysis of India Coal

Constituent	*%*
Fixed Carbon	30.74
Ash	37.53
Volatile matter	29.12
Moisture	2.61
Iron in ash	7.45
Total S	2.03
CaO	0.23
MgO	0.12

Table D_{10}. Ash Fusion Temperatures of Slag forming and Non-Sag forming Compounds

(a) Slag Forming

Chemical Compound	*Ash Fusion Temp. (°C)*
Vanadium Pentoxide (V_2O_5)	690
Sodium Sulphate (Na_2SO_4)	888
Nickel Sulphate ($NiSO_4$)	841
Sodium Meta vanadate ($Na_2O \cdot V_2O_5$)	629
Sodium Pyrovanadate ($2Na_2O \cdot V_2O_5$)	654
Sodium Orthovanadate ($3Na_2O \cdot V_2O_5$)	866
Nickel Orthovanadate ($3\ NiO \cdot V_2O_5$)	399
Sodium Vanodyl Vanadate ($Na_2 \cdot V_2O_4 \cdot 5\ V_2O_5$)	624
Sodium Iron Trisulphide [$2\ Na_3\ Fe\ (SO_4)_3$]	621

(b) Non-Slag Forming

Chemical Compound	*Ash Fusion Temp, (°C)*
Magnesium Oxide (MgO)	2800
Aluminium Oxide (Al_2O_3)	2030
Calcium Oxide (CaO)	2570
Magnesium Aluminate ($Mg\ Al_2O_4$)	2135
Manganese Oxide (MnO_2)	1649
Nickel Oxide (NiO)	2090
Vanadium Tetroxide (V_2O_4)	1967
Magnesium Vanadates ($MgO\ .\ V_2O_5$)	1074 to 1243
Sodium Magnesium Trisulphate [$Na_2\ Mg_2\ (SO_4)_3$]	1126

Table D_{11}. Typical Analysis of Indian Coal

Moisture	7 – 20%
Carbon	21 – 50%
Hydrogen	2.3 – 3.5%
Nitrogen	0.7 – 1.3%
Sulphur	0.3 – 0.9%
Ash	30 – 50%
Oxygen	1.7 – 11%
Volatile	15 – 26%
Calorific value	3000 – 5000 kcal/kg

Table D_{12}. Typical Ash Analysis of Indian Coal (1)

SiO_2	35 – 65%
Al_2O_3	13 – 30%
Fe_2O_3	3.4 – 20%
TiO_2	0.9 – 3%
CaO	0.46 – 3%
MgO	0.2 – 2.5%
SO_3	0.1 – 2%
P_2O_5	0.22 – 3%
MnO	0.05 – 0.10%
K_2O	0.64 – 0.96%
Na_2O	0.50 – 1%
Li_2O	0.01%
Resistivity	$10^8 - 10^{13}$ ohm cm
Bulk density	800 – 1840 Kg/m^3
Ash softening temperature	1130° – 1400°C

Table D_{13}. Flammability temperature for various coals

Serial No.	*Coal-Source*	*Flammability Temperature °C*
1.	Singareni	605
2.	Chanda Mine	465
3.	Bhojudhi Sink	645
4.	Swang Sink	530
5.	Kathara middling	560
6.	Kathara rejects	660
7.	Jamodoba middlings	575
8.	Jamadoba rejects	665

Table D_{14}. Analysis of coal fuels tested in prototypes FBC Boiler Sources

	Singareni non-coking raw coal	*Bojudih washery middling (coking)*	*Chanda mine non-coking raw coal*	*Swang washery middlings (coking)*	*Jamadoba washery rejects (coking)*	*Kathara washery rejects (coking)*
Proximate Analysis :						
Moisture %	6.85	1.25	4.68	0.92	0.75	0.9
Volatile matter %	27.05	19.22	24.99	23.33	22.74	14.2
Ash %	25.80	54.61	35.50	37.63	61.55	72.6
Fixed Carbon %	40.3	24.92	34.83	38.83	14.96	12.3
HHV Kcal/Kg	4892	3140	4340	4760	2238	1900

Table D_{15}. Steam Power Plants in India

Zone	*Name*	*Capacity, MW*
East Zone	1. Calcutta	407.5
	2. Bandel	300
	3. Naihati	28.75
	4. Durgapur	315
	5. Chandrapur	280
	6. Patratu	350
	7. Barauni	105
	8. Bokaro	255
	9. Talcher	240
Central Zone	10. Harduaganj	540
	11. Kanpur	72.50
	12. Obra	1150
	13. Amarkantak	60
	14. Korba	290
	15. Satpura	180
	16. Panki	284
North Zone	17. Delhi	278.5
	18. Rajasthan	90
	19. Ahmedabad	180
	20. Badarpur	700
	21. Faridabad	15
	22. Bhatinda	640
West Zone	23. Dhuvaran	200
	24. Bhusawal	60
	25. Akola	90
	26. Khaparkheda	120
	27. Chola	118
	28. Trombay	187.5
South Zone	29. Kothagudiam	120
	30. Ramagudam	97.5
	31. Nellore	30
	32. Madras	87.5
	33. Neyvelli	400
	34. Madurai	10

Table D_{16}. Comparative Cost of Power Generation by Thermal and Nuclear Power Plants

Cost	*Tarapur*	*Rajasthan*	*Thermal of 200 MW (with coal cost Rs. 60 per ton)*
Capital cost per kW installed	Rs. 1850	Rs. 3150	Rs. 2000
Fixed cost (N.P./kW-hr)	2.687	4.38	3.34
Fuel cost (N.P./kW-hr.)	2.04	0.34	3.30
Total production cost (N.P./kW-hr.)	4.727	4.72	6.64
Profit at 3% (N.P./kW-hr.)	0.885	1.44	0.91
Total selling price (N.P./kW-hr.)	5.61	6.16	7.55

The prices are given on the basis of prices in 1969.

Table D_{17}. Allowable SO_2 Emissions in Thermal Power Station in Various Countries

Country	*Typical % of Sulphur in coal*	*Typical SO_2 level without removal ppm Volume*	*Allowable SO_2 emission ppm-volume*	*In mg/NM^3*
U.S.A.	6.5	6000	Max. 580	1660
	6.5 – 3.25	4350	435	1245
	3.25 – 1.08	1900	Max. 290	830
	1.08 – 0	500	150	430
Japan				
Rural		1305	500	1430
Urban	1.5	1305	100	280
Tokyo		1305	50	140
West Germany	3	2610 pp.	140 ppm	400
	1	870		
Austria	3	2610 App.	140 ppm or	400
Sweden	3	2610 App.	200 ppm or	560
	1	870		
Holland	1.5	1305 App.	230 ppm	650
	1	870		

Note : In India, these are no specific SO_2 emission standard.

Table D_{18}. Environmental Needs of Energy Systems

	Hydroelectric 1974 MW Grand Coulee (USA)	*Coalfired 804 MW Willington (USA)*	*Nuclear station 1750 MW Hinkley Point (USA)*
Total site area	34000 ha (hacter) including lake	115 ha	24 ha
Water Usage	11700×10^8 litres/day	28×10^8 litres/day	54×10^8 litres/day

Table D_{19}. Power Station Fuels and Wastes

	Coalfired 804 MW Willington	*Nuclear station 1750 MW Hinkley*
Max. Fuel quantity on site	2,50,000 tons	1200 tons
Rate of Fuel usage	52,000 tons per week	9 tons/week
Output of Solid waste	4,70,000 tons per week	0.7 tons/year

Table D_{20}. Typical Data for Various Type of Boilers (2)

Type of boiler	*Rating*	*Gas flow* m^3/sec	*Gas temp. °C*	*Dust conc.* gms/Nm^3	*Moisture content % by volume*
Pulverised coal fired	15 MW	39.6 – 41.9	132 – 140	14.7 – 20.9	11 – 12
	35 MW	54.44	130 – 135	18 (avg)	6
	62.5 MW (measured)	127 (av)	120	37	–
	62.5 MW (design)	125.28	152	61.08	–
	120 MW (Unit-A)	252.78	185	53.50	–
	120 MW (unit-B)	314.00	130	27.00	4
Stoker fired boiler	15 TPH	19.40	225	20.00	5.3
	40 TPH	31.10	195	15.00	5.3
FBC Boiler		22.23	140	8.00	9.1

* TPH (tons per hour).

Table D_{21}. Details of Super-Thermal Power Stations in India

Name of Plant	*State*	*Installed capacity (MW)*		*Approved cost in Rs. crores (1985)*	*Other Details of the Plant*
		Ultimate	*Aproved*		
Singrauli	U.P. Northern	2000 Stage I – 3 × 200 = 600 Stage Ii – 2 × 200 + 2 × 500 = 1400	2000	1000.2	Located at Shaktinagar in Dist. Mirzapur Coal pit is 7 km from mines, Chimney 220 m height "Merry GO Round" railway is used for coal transport.
Korba	M.P. Western	2100 Stage II 3 × 200 + 1 × 500 = 1100 Stage-II 2 × 500 = 1000	2100	1138.5	Located on Wested on Western Bank of river Hasdeo in Dist. Bilaspur coal is supplied from Kusmunda mines once through and cooling tower combined system is used for cooling.
Ramagundam	A.P. Southern	2100 Stage-I 3 × 200 + 1 ×500=1100 Stage-II 2 × 500 = 1000	2100	1702.2	Located in Dist. Karim Nagar coal is supplied from South Godawari coal field, 15 km away cooling towers are used and compensating cooling water is supplied from Pocham Irrigation Plant.

Contd....

Name of Plant	*State*	*Installed capacity (MW)*		*Approved cost in Rs. crores (1985)*	*Other Details of the Plant*
		Ultimate	*Aproved*		
Farakka	W.B. Eastern	2100	1600	1110.2	Located in Dist. Murshiadabad coal is supplied from Hurra coal fields, 50 km away and cooling water is taken from Farakka canal with once through system. Merry GO round is used for coal transport.
Vindhyachal	M.P. (Western)	2260 Stage-I 6 × 210 = 1260	1260	1110.2	Note.In all the plants, care has been taken to ensure that these are no detrimental effects on the residents by providing electrostatic precipitators of 99% efficiency.
Rihand	U.P. Northern	3000 Stage-I 2 × 500 = 1000	1000	1614.7	
Talcher	Orissa				Located at Haldia a tower type Boiler of 500 MW capacity is used for the first time in India, which is supplied by BHEL.

Table D_{22}. Water Quality for High Pressure drum type Boiler (> 120 bar)

Water Use	*Parameter*	*Maximum Concentration*
Boiler make up	TDS	0.1 mg/L
	Conductivity	0.5 μΩ/cm
	Sodium mg/L	0.02
	Silica	0.005 mg/L as SiO_2
	Iron	00.01 mg/L
	Copper	0.005 mg/L
	CO_2	0.0 mg/L
	O_2	0.0 mg/L
	pH	8.8 – 9.2
Boiler water	Total dissolved Solids	15 mg/L
	Silica	0.25 mg/L
	pH	8.8 – 10.0

Table D_{23}. Water Quality of Cooling Water

Parameter	*Maximum Concentration (mg/L)*
Calcium	700
Magnesium	300
Silica	150
Suspended Solids	150 – 200
Iron/Manganese	< 2

Table D_{24}. Maximum Cooling System Flows (Gallons/min)

Circulating water flow cycles of Concentration	*Power Plant Size MWe*		
	100 *57500 gpm*	*360* *153000 gpm*	*600* *245000 gpm*
Cooling Tower evaporation	1263	3358	5377
Cooling Tower Blow down	132	353	560
Cooling tower drift	7	23	37
Total System Make up	1402	3734	5974

1 gpm = 0.63 litres/s.

Table D_{25}. Water Requirements for FGD System

Water Types (gpm)	*Power Plant Size in MWe*				
	100	*200*	*360*	*500*	*600*
Operation water	95	190	330	450	550
Service water	85	160	230	320	380
Total	180	350	560	770	930

Table D_{26}. Power Plant Max. Water Demands in Millions of Callons/day when wet cooling Towers are used

Water Needs	*Power Plant Capacity in MWe*				
	100	*200*	*360*	*500*	*600*
Cooling system Make up	2.02	3.29	5.38	7.35	8.61
Boiler water Make up	0.23	0.46	0.83	1.15	1.39
Ash handling Make up	0.04	0.07	0.13	0.18	0.22
FGD – requirements	0.14	0.27	0.48	0.65	0.79
Portable water	0.12	0.14	0.17	0.20	0.20
Plant Service water	0.32	0.47	0.67	0.91	1.06
Total	2.87	4.70	7.66	10.44	12.27

Table D_{27}. Some Hints for the Students

(1) O_2 in feed water is limited to 5-7 μ gram/liter or 0.0005 ppm. This is done by deaeriator.
(2) 3.5 MW capacity feed pump is required for 120 MW capacity plant which develops 500 m head of water.
(3) Low pressure boiler 60 ata – 500°C.
High pressure boiler 167 ata – 567°C.
(4) Specific steam consumption for low capacity plant (< 10 MW) is 5 tons/MW-hr and 3 to 5 tons/hr for high capacity plant.
(5) Minimum temp. of exhaust gases is limited to 110°C to avoid the condensation of H_2SO_4 vapour.
(6) Furnace temp. is limited to 1400°C to avoid the fusion of ash and deposit on heat transfer surfaces.

Table D_{28}. Generating cost of Gas Turbine with different Fuels

Type of Fuel	*Clean fuel*	*Coal Gas*	*Natural Gas*	*Napatha*	
Generating cost Rs./kWh	0.83	0.25	0.45		Free turbine
	0.45	0.10	0.23		Duel cycle reheat

Table D_{29}. World top 10 Power Stations in 1975

Country	*Name of power station*	*Unit size*	*Steam conditions (bar/°C)*	*Fuel used*	*Load factor %*	η %
Japan	Shinsendai	600	241/538	Oil	87.1	38.42
USA	Bullrun	950	241.538	Coal	74.9	38.28
USA	Belews Greek	1100	241/538	Coal	57.5	38.21
USA	Marshall	650	241/538	Coal	58.8	38.07
Denmark	Stigsnaes	143 270	184/540	Oil	57.4	37.84
Japan	Kudamatsu	156 375	166/566	Oil	73.8	37.50
USA	Canal	560	253/538	Oil	78.2	37.47
Japan	Shinsendai	350	166/566	Oil	85.3	37.31
France	Lehaure	585	163/565	Oil	63.0	37.20
	Lamaxe	250		Coal	56.0	
Ireland	Poolbeg	120	125/535	Oil	84.1	38.00

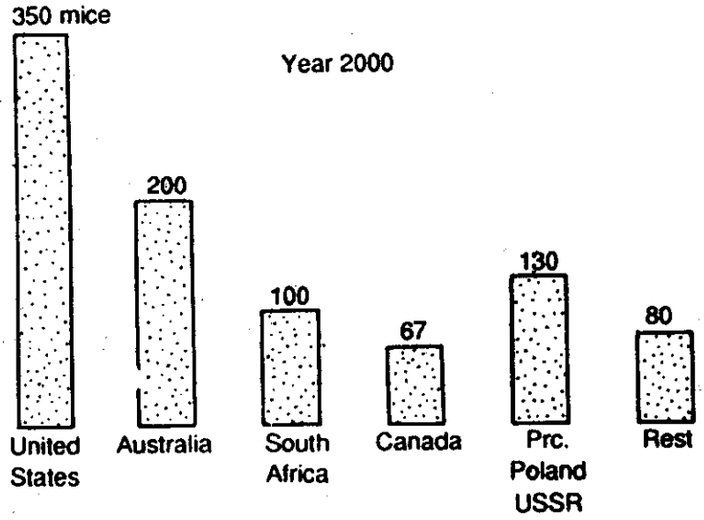


Fig. (C). Coal Exporter Potentials.

Coal's Role in Energy

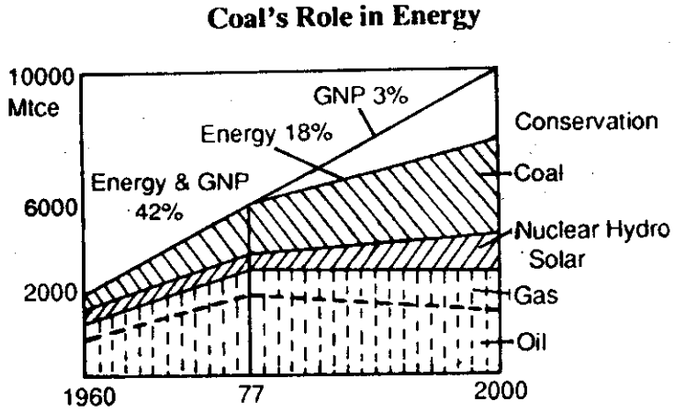


Fig. (D). Coal's Role in Energy.

Required Coal Expansion

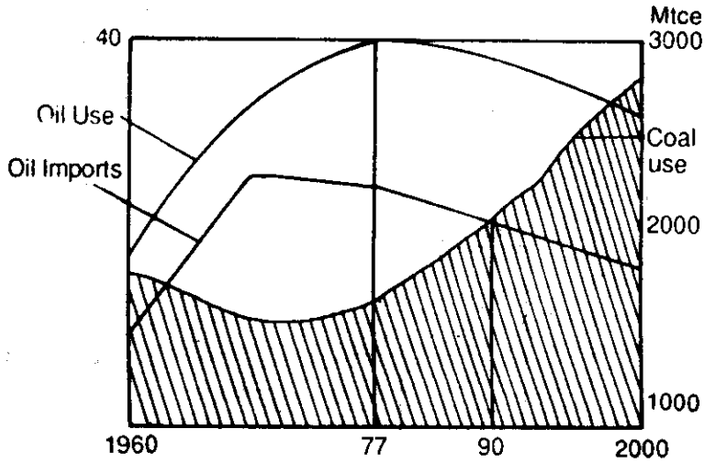


Fig. (E). Required Coal Expansion.

(E) NUCLEAR POWER INFORMATION

Table E_1. Resources of Uranium as on January 1975

Country	*Reserve in 1000 tons*
Algeria	28.0
Argentina	20.6
Australia	243.0
Brazil	10.4
Canada	166.0
Central Africa	8.0
Denmark	6.0
Finland	1.9
France	55.0
Gabon	20.0
Germany	1.0
Italy	1.2
Japan	7.7
Korea	2.4
Mexico	6.0
Niger	50.0
Portugul	6.9
South Africa	276.0
Spain	103.5
Sweden	300.0
Turkey	3.1
U.K.	0.5
USA	454.0
Yugoslavia	6.7
Zaire	1.8
India :	
(*a*) Meghalaya-Kasi Hills	92.3 million tons
(*b*) M.P.	125000 tons
(*c*) Singbhum	52000 tons

Table E_2.

1. *Energy Release of U^{235}*
   (*a*) Per atom of U^{235}
   3.2×10^{-4} ergs = 198 Mev = 1.93×10^3 watt-sec.
   (*b*) Per gram of U^{235}
   1 MW-day = 2.3×10^4 kWh or equivalent to (1,40,000 tons of coal)
   (*c*) Per kg of U^{235}
   1000 MW-day = 10^{10} kcal (equivalent to 20,000 tons of TNT)
2. *Energy Distribution*

(*a*) Fission Fragment (KE)	162 Mev
(*b*) Radio activity (decey)	21 Mev
(*c*) Neutron energy	6 Mev
(*d*) Gama energy	6 Mev
Total	195 Mev

3. *Cost*

Uranium as U_3O_8	Rs. 3.5 lakhs/tons
2.4% enriched uranium	Rs. 1.04 crores/ton.

1 MW plant requires 2 tons uranium for its life time and 1 ton of D_2O_2 for its working.

4. *Uranium Enrichment process*
   (*a*) Gaseous diffusion (USA, USSR, France, China) 3 plants
   (*b*) Gas Centrifugal (U.K., West Germany, Netherland)
   (*c*) Bakers Nozzle Process (West Germany, Brazil)
   (*d*) Laser Encrihcment (USA in 1975)
5. *Production*
   (*a*) Enriched uranium in 1975 17500 tons (world)
   (*b*) Enriched uranium in 1985 72500 tons (world)
   USA production is 95% of world enriched uranium.
   Power consumption for diffusion plant.
   (*a*) Per kg
   (*b*) % of total consumption of power in USA on enrichment
6. *Requirement of U_3O_8 in decade 1970*
   (*a*) America 206,000 tons
   (*b*) World 430,000 tons
7. *Content of U^{235} in various geological locations*
   (*a*) Low silicon rocks 1 p.p.m.
   (*b*) High silicon rocks 4 p.p.m.
   (*c*) Sedimentary rocks 2 p.p.m.
   (*d*) Ground water 0.0002 p.p.m.
   (*e*) Ocean water 0.002 p.p.m.
   (*f*) Petroleum 0.1 p.p.m.

Table E_3. World Nuclear Power Capacity in Operation in December 1976

Country	*No. of Reactors*	*Total power capacity in (MWe)*
USA	57	29590
Japan	13	7067
USSR	20	6616
Germany F.R.	8	4855
U.K.	28	4300
Sweden	5	3244
France	10	2723
Canada	7	2535
Belgium	3	1663
Spain	3	1073
Switzerland	3	1006
German D.R.	3	879
Bulgaari	2	837
India	2	603
Italy	2	543
Netherland	2	499
Argentina	1	319
Pakistan	1	126
Czechoslovakia	1	110
Total 19 countries	173	78589

Cost of installation of 1000 MW plant is Rs. 868 crores (1975 cost basis).

Table E_4. Features of Research Reactors in India

	Apsara	*Cirus*	**Zerlina*	**Purnima-I*	*Purnima-II*	*Dhruva*
Type of reactor	Pool type	Tank type	Tank type	Fast	Solution	Tank type
Fuel	Enriched uranium	Natural uranium	Natural uranium	Plutonium	Uranium-233 as uranyl nitrate	Natural uranium
Moderator	Light water	Heavy water	Heavy water	None	Light water	Heavy water
Coolant	Light water	Light water	Heavy water	Air	Light water	Heavy waer
Power level	1 MW	40 MW	Negligible	Negligible	Negligible	100 MW
Maximum neutron flux	1.26×10^{13}	6.7×10^{13}	—	—	—	1.8×10^{14}
Date of criticality		August '56	July '60	May '72	May '84	August '85

*Zerlina was decommissioned in 1983, conversion of Purnima I into Purnima II was started in 1976.

Table E_5. The World nuclear capacity in 1987

In 1987, 23 nuclear power reactors in 8-countries were newly connected to the grid bringing world total nuclear plants to 417. Nuclear power now accounts for more than 16% of world electricity production. 26 countries generate electricity from nuclear power plants and some countries, the nuclear share is in the range of 50-70%. Total world electrical generating capacity of nuclear plants grew by 23000 MW in 1987, approaching 297000 MW.

The latest world status of nuclear power plants in 1987 is listed below :

Country	*No. of reactors*	*Total Generating capacity in MWe*
Argentina	2	925
Belgium	7	5477
Brazil	1	626
Bulgaria	5	2585
Canada	18	12142
Czechoslovakia	8	3207
Finland	4	2310
France	53	49378
German Democratic Rep.	5	1694
German Fed Rep.	21	18947
Hungary	4	1645
India	6	1154
Italy	3	1273
Japan	36	26877
Korea Rep.	7	5380
Netherland	2	507
Pakisthan	1	125
South Africa	2	1842
Spain	9	6529
Swedan	12	9646
Switzerland	5	2932
Tiwan (China)	6	4918
U.K.	38	10214
USA	106	92982
*USSR	55	32919
Ygoslavia	1	632
Total	417	296876

Nuclear Power Status 1998

- A total of 434 nuclear power plants were operating around the world. Total number of nuclear reactors under construction was 36.
- 18 countries relied upon nuclear power plants to supply at least a quarter of their total electricity needs.
- Worldwide, total nuclear generated electricity increased to 2291.4 terawatt-hours in 1998 and 2400 TWh in 1999.
- Overall nuclear power plants provided approximately 16 percent of the world's electricity production.
- Cumulative worldwide operating experience from civil nuclear power reactors at the end of 1998 exceeded 9000 reactor-years and approached 9400 reactor years in 1999.
- Additionally, construction of seven new nuclear reactors started in 1999—one in China (plus two in Taiwan, China), two in Japan and two in the Republic of Korea, bringing the total number of nuclear reactors reported as being under construction to 37.
- The ten countries with the highest reliance on nuclear power in 1999 were : France, 75% ; Lithuania, 73.1% ; Belgium, 57, 7% ; Bulgaria, 47.1% ; Slovak Republic, 47% ; Sweden, 46.8% ; Ukraine, 43.8% ; Republic of Korea, 42.8% ; Hungary, 38.3% and

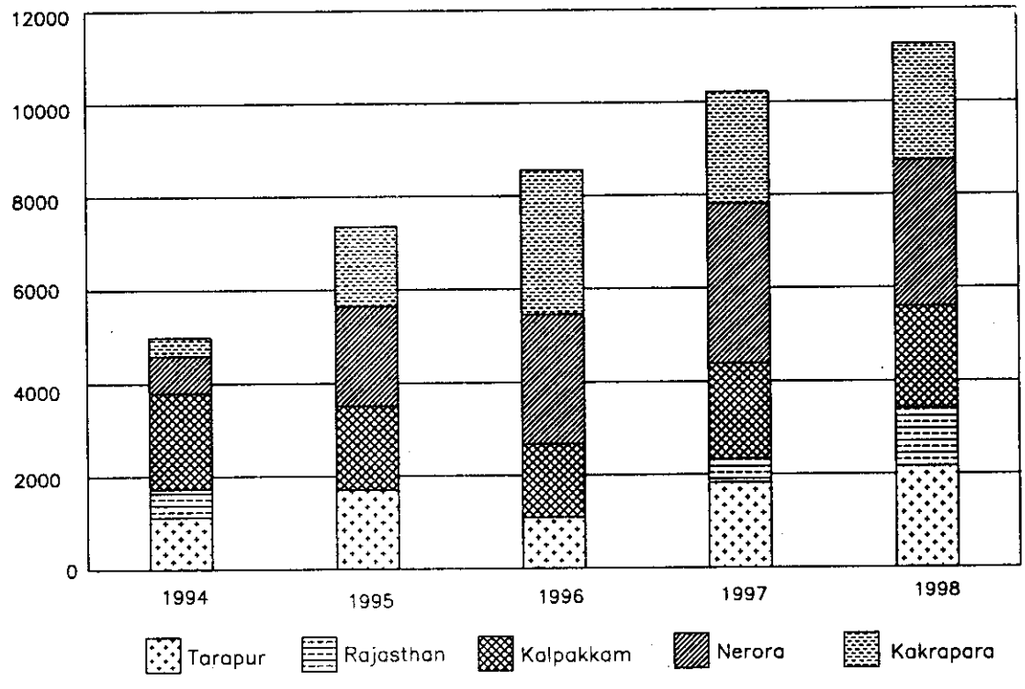
Nuclear Power Reactors in 1998

Country	*Reactor Units*	
	in operation	*under construction*
Agrentina	2	1
Armenia	1	
Belgium	7	
Brazil	1	1
Bulgaria	6	
Canada	14	
China	3	6
Crech Rep.	4	2
Finland	4	
France	58	
Germany	20	
Hungary	4	
India	10	4
Iran	2	
Japan	53	2
Kazakhstan	1	
Korea, Rep. of	15	3
Lithuania	2	
Mexico	2	
Netherlands	1	
Pakistan	1	1
Romania	1	1
Russia	29	4
South Africa	2	
Slovak Rep.	5	3
Slovenia	1	
Spain	9	
Sweden	12	
Switzerland	5	
UK	35	
Ukraine	16	4
USA	104	
TOTAL	434	36

EU Nuclear Share

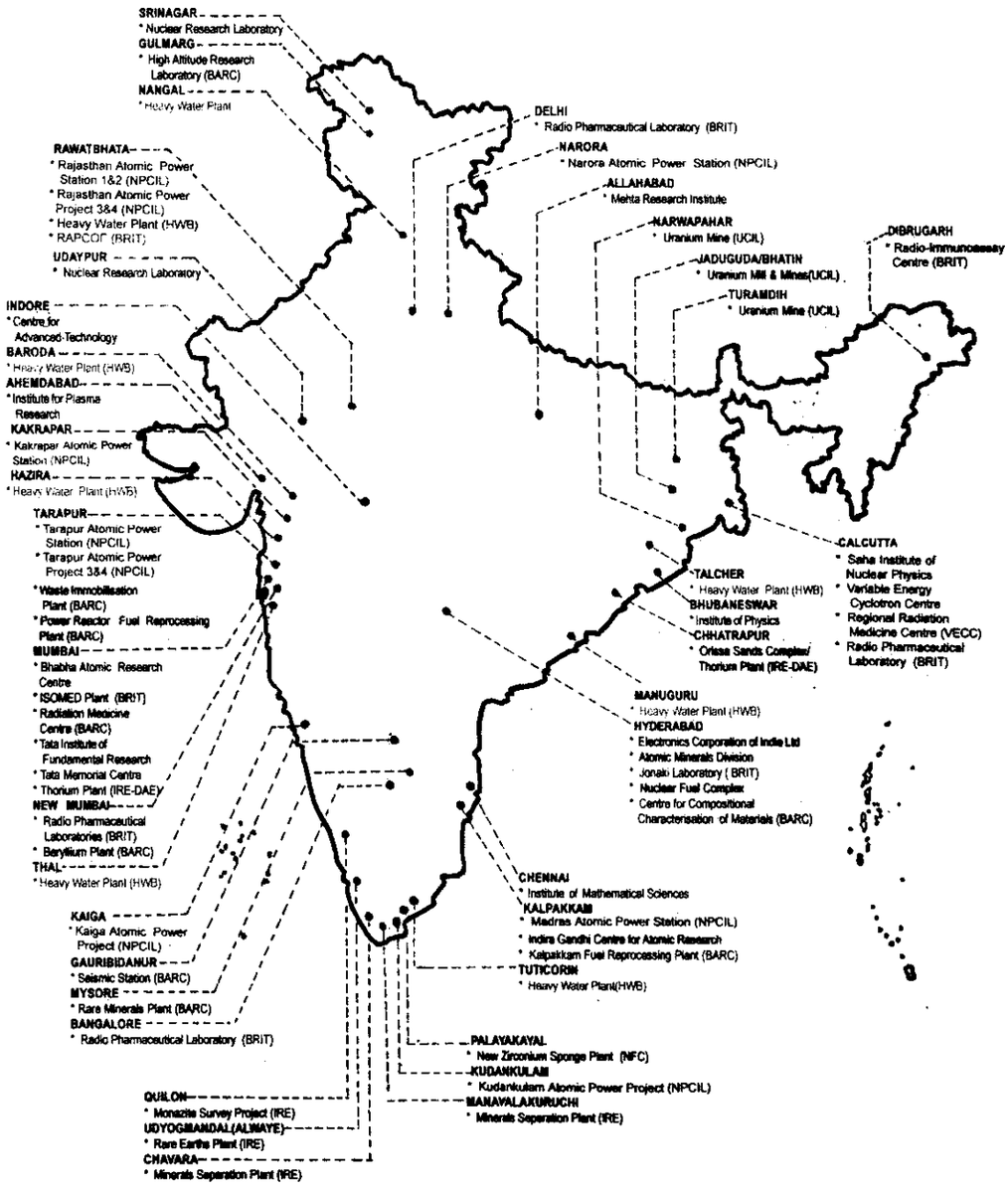
Nuclear power plants in the 15 European Union (EU) countries produced a total of 808 billion kilowatt-hours last year 1997 giving nuclear a 35% share in total EU electricity generation.

Country	*1998 share*	*1997 share*
France	76%	78%
Belgium	55%	60%
Sweden	46%	46%
Finland	31%	30%
Spain	30%	32%
Germany	30%	32%
UK	29%	29%
Netherlands	6%	3%
EU total	35%	36%



Growth in Nuclear Power Generation (1994–98)

Atomic Energy Installations in India



With 10 nuclear power reactors in operation, the total installed capacity of nuclear power generation in the country is now 1840 MWe. The gross generation from all the reactors since commencement of commercial operation till Feburary 28, 1999 is about 131 billion units. During the period from April 1, 1998 to Feebrurary 28, 1999, the gross generation is 9,795 million units with capacity factor of 73%.

(F) GENERAL INFORMATION FOR POWER PLANTS

Table F_1. Characteristics of Generating Plants

Charateristics	*Hydro*	*Thermal*	*Nuclear*	*Diesel*	*Gas Turbine*	*Tidal*
Capital cost Rs./kW	1000—2000	1000	2500 – 4500	1000	1000	1500—3000
Running cost N.P. per kW-hr.	0.5	2.5	2	6	3	0.5
Output kW-hr per kW/year	1000—8000	8000	8000	8000	8000	8000
Percentage availability	10—90%	80—90%	80—90%	80—90%	80—90%	30%
Usual type to load	Base or Peak	Base	Base	Peak or Standby	Peak or Standby	Fortuitous
Time to start	10 minutes	2 to 3 hours	2 to 3 hours	10 minutes	15 minutes	10 minutes
Response to varying load	Very good	Poor	Very poor	Good	Good	Very Good
Location	Topographical	Availability of fuel & cooling water	Safety & availability of cooling water	Anywhere	Anywhere	Topographical
Capacity of the unit	Up to 100 MW	Up to 100 MW	Up to 100 MW	Up to 10 MW	Up to 50 MW	Up to 100 MW

Note : The cost given on the basis of money value in 1966.

Table F_2. Countribution of Biomass Energy in Developing Countries.

Country	*Commercial energy*	*Biomass energy kW/Capita*	*Total Energy*	*% of energy from biomass*
Bangladesh	0.038	0.095	0.13	71
Niger	0.035	0.25	0.29	86
Zambia	0.098	0.22	0.32	69
Morocco	0.27	0.073	0.34	21
India	0.17	0.19	0.36	53
Ethiopia	0.019	0.37	0.39	95
Nepal	0.0095	0.43	0.44	98
Somalia	0.092	0.48	0.57	84
Bolivia	0.34	0.26	0.60	44
Thailand	0.30	0.52	0.83	63
China	0.78	0.32	1.1	29
Brazil	0.74	0.37	1.1	34
Developing countries (average)	0.549	0.416	0.956	43

Table F_3. Transmission Losses in Selected Countries

Country	*USA*	*UK*	*USSR*	*France*	*Germany*	*India*
Loss in Percentage (%)	7.85	7.75	7.95	7.10	5.90	*21

*The losses which were 26.6% in 1980-81 were reduced to 21.6% in the year 1989-90.

Table F_4. Capital and Generating costs of Different Plants

Type of Plant	*Thermal*	*Hydel*	*Nuclear*	*Gas Turbine*	*Direct Generation*
Capital Rs./kW	30,000	20,700	35,000	15,000	15,000 to 20,000
Generating Cost Rs./kW-hr	1	1.5	.2	0.75	1 to 2

Table F_5. Per unit cost of power generation for different plants

Sources	*Cost per Unit (in paise)*
Wind	80 to 100
Gasification Biomass	21.2 to 39.8
Rich Straw and bagasse	42.2 to 57.4
Coal	60 to 70
Hydro conventional	30 to 50
Diesel	120 to 160
Nuclear	60 to 70
Gas	175
Urban waste	125

Table F_6. Global Energy Potential of Land-Based Biomass : Agricultural Waste and Energy Farms.

Region	*Land Equivalent (10^6 hectares)*	*Use of Agricultural Waste*	*Energy Farms*	*Energy Content (10^5 Btus)*
Use	925	1,203	17,113	22.6 — 320.9
OECD Weste	365	0,475	6,753	8.9 — 126.6
JANZ	229	0,298	4,237	5.6 — 79.4
EUSSR	1,238	1,609	22,903	30.2 — 429.4
ACENP	593	0,771	10,970	14.5 — 205.7
MIDEST	75	0.098	1,388	1.8 — 26.0
LA	2,558	3,325	47,323	62.3 — 887.3
AFR	2,292	2,980	42,402	55.9 — 795.0
SEASIA	1,452	1,888	26,862	35.4 — 503.7
Total	9,727	12.647	179,951	237.2 — 3374.0

Table F_7. Comparative Health Hazards associated with alternative Energy Sources (For 1000 kWh Electric power)

Fuel	*Deaths*	*Disabilities*
Coal	10—200	300—500
Oil	3—150	150—300
Gas	0.2	20
Nuclear	1—3	8—30

Table F_8. Plant Load Factor All-India basis (Thermal Power Stations).

Year	*P.L.F. (%)*
1975-76	52.10
1976-77	55.47
1977-78	50.98
1978-79	47.99
1979-80	44.30
1980-81	44.21
1981-82	46.42
1982-83	49.43
1983-84	47.94
1984-85	50.15
1985-86	52.46
1986-87	53.27
1987-88	56.28

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