Energy Resources and Consumption in Fiji: an Overview

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ABSTRACT

Fiji has always relied on imported petroleum products for all its transportation needs as well as for electricity generation and industrial uses. Since 1983, the major island of Viti Levu has been provided with electricity from a hydroelectric power station. Energy for domestic cooking and heating has been dominated by biomass which has also provided energy to four sugar mills in Fiji through bagasse, the waste product of the sugar producing process. Biomass also provides energy for commercial, industrial and agricultural use. The major energy sources are biomass, hydropower and petroleum products.

This paper presents an overview of the energy situation in Fiji. The current supply and end uses of energy in all its forms are examined and the historical trends over the last 15 years are detailed. The locally available resources and imported energy are put in their proper perspective along with the energy consumption pattern and efficiency of generation.

1. INTRODUCTION

Fiji has relied very heavily on petroleum products for transportation, industries and electricity generation. Since 1983, hydroelectricity became the major source of electricity for the country.

The Monasavu hydroelectricity scheme, located in the center of Viti Levu, with a rated capacity of 80 MW, supplies most of Viti Levu with electricity. This leaves Vanua Levu and all the other islands still dependent on electricity from diesel-fuelled power stations. Electricity from the hydropower station is not enough to meet the demands in Viti Levu, with the result that several major industries, including the Vatukoula gold mine, as well as many remote communities still rely on electricity from diesel power plants.

In 1993, around 47% of the population of Fiji had electricity supplies. This consisted of grid electricity from the Fiji Electricity Authority (FEA) as well as village or community-based diesel generated electricity. The total number of domestic consumer of grid electricity was 143,000 households in 1993, representing less than 47% of the total population. Some 8000 consumers have access to electricity from diesel-fuelled power plants, representing 5.5% of the population. Thus as in 1993, around 150,000 household had electricity available.

2. THE CURRENT ENERGY SUPPLY SITUATION

Currently, the major energy sources are petroleum products, biomass, hydropower and coal. Energy from coal contributes less than 5% to the total energy supply. Biomass and petroleum make up over 70% of the total primary energy. Table 1 shows the energy supply since 1981 and Fig. 1 shows a graphical plot of the same. Before the commissioning of the Monasavu hydroelectric power scheme in 1983, electricity was generated by diesel-fuelled power stations. Since 1983, however, electricity has largely been generated from the Monasavu hydropower system, with around 95% of all electricity for the island of Viti Levu coming from it. Electricity for consumers outside Viti Levu comes from diesel power stations operated by FEA.

Biomass, mainly in the form of bagasse from the four sugar mills, and wood bark and chips from the Drasa sawmill, also is used to generate electricity (and process heat), for industry. The Fiji Sugar Corporation (FSC) has a collective electrical generating capacity of 27 MW in its four sugar mills. The mills utilize the combustion of bagasse to generate steam and electricity. In 1993, 43 823 MWh of electricity was generated from 940.5 million kg of bagasse. The Drasa sawmill in Lautoka has a 3 MW power station, which supplied all the energy requirements for the sawmill. The bark and chips-fired boiler consumes 24 000 kg of fuel daily to generate steam for process heat and for electricity.

Table 1 shows energy supply data for Fiji between 1981 and 1992. The mix of imported and indigenous primary energy supply, along with the individual components of each category are shown in energy units as well as in percentage terms. Figure 1 shows the historical trend in the primary energy supply.

Table 1. Energy supply for Fiji: 1981-1992.

		Energy consumption by source: 1981-1992									
Year	Coal	Pet.	%	Electricity					Wood		Total
		Prod.	C + P	Diesel	Hydro	Bagasse	Total				
	TJ	TJ		TJ	TJ	TJ	TJ	%	TJ	%	TJ
1981	485	7762	62.14	881	0	164	1045	7.87	3980	29.99	13272
1982	541	6930	59.17	924	0	179	1103	8.74	4053	32.10	12627
1983	479	7170	59.68	830	114	93	1037	8.09	4131	32.23	12817
1984	535	7165	58.8	87	945	155	1187	9.06	4208	32.13	13095
1985	428	7077	57.99	65	974	129	1168	9.03	4268	32.98	12941
1986	601	7698	59.61	67	1067	151	1285	9.23	4339	31.16	13923
1987	485	6925	56.81	68	1059	129	1256	9.63	4377	33.56	13043
1988	333	6575	54.56	122	1105	111	1338	10.57	4415	34.87	12661
1989	446	7266	56.66	114	1169	162	1445	10.62	4453	32.72	13610
1990	431	7686	57.45	116	1252	153	1521	10.77	4491	31.79	14129
1991	571	8206	59.25	122	1249	138	1509	10.19	4528	30.57	14814
1992	462	8664	59.87	160	1247	144	1551	10.18	4566	29.95	15243

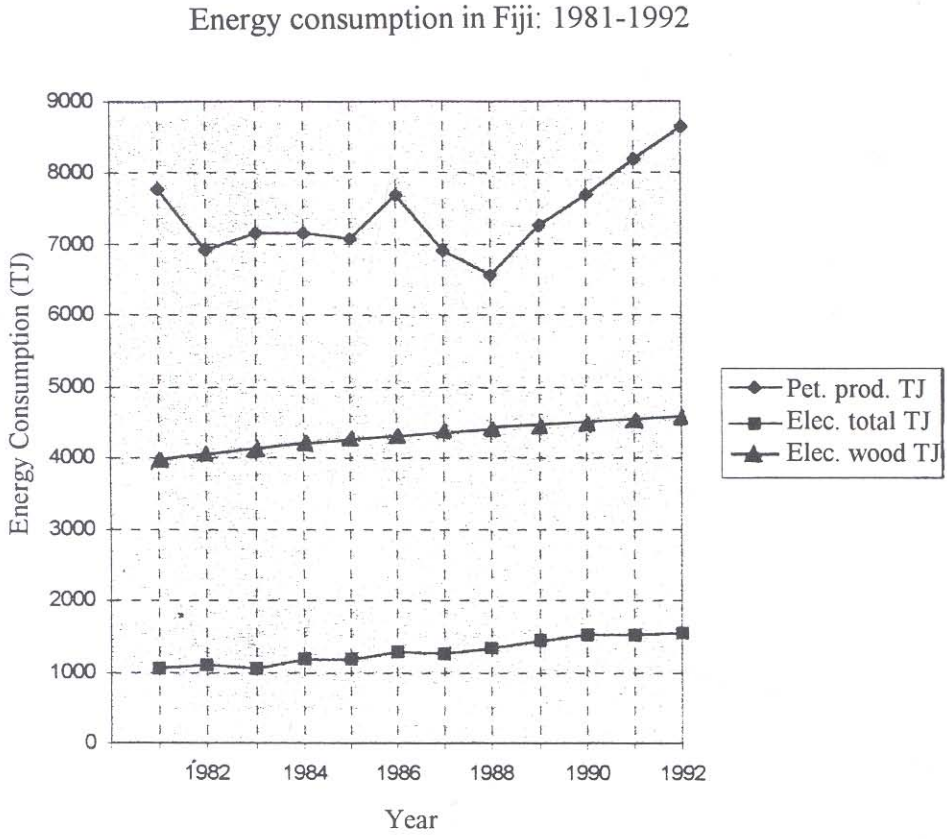

Fig. 1. Historical trend in energy consumption.

3. CONVERSION TECHNOLOGIES

Industrial energy supply consists of electricity, thermal energy (hot air and steam) and mechanical energy (from electricity, biomass, oil, gas and coal). The basic conversion technology is combustion of fuel to produce electricity, mechanical and thermal energy output.

3.1 Electricity Generation

Electricity is generated mostly through three methods, namely, hydroelectricity generation, generation from diesel-fuelled power stations and biomass-fuelled electricity (sugar mills, sawmills). Apart from the sugar mills and a large sawmill, electricity is generated by the Fiji Electricity Authority either through the Monasavu hydroelectricity generating system (for most of Viti Levu) and through its thermal power plants fuelled by diesel fuel. The Public Works Department, a government department, is charged with the responsibility of generating electricity, through small and medium scale diesel generating plants for remote and rural communities.

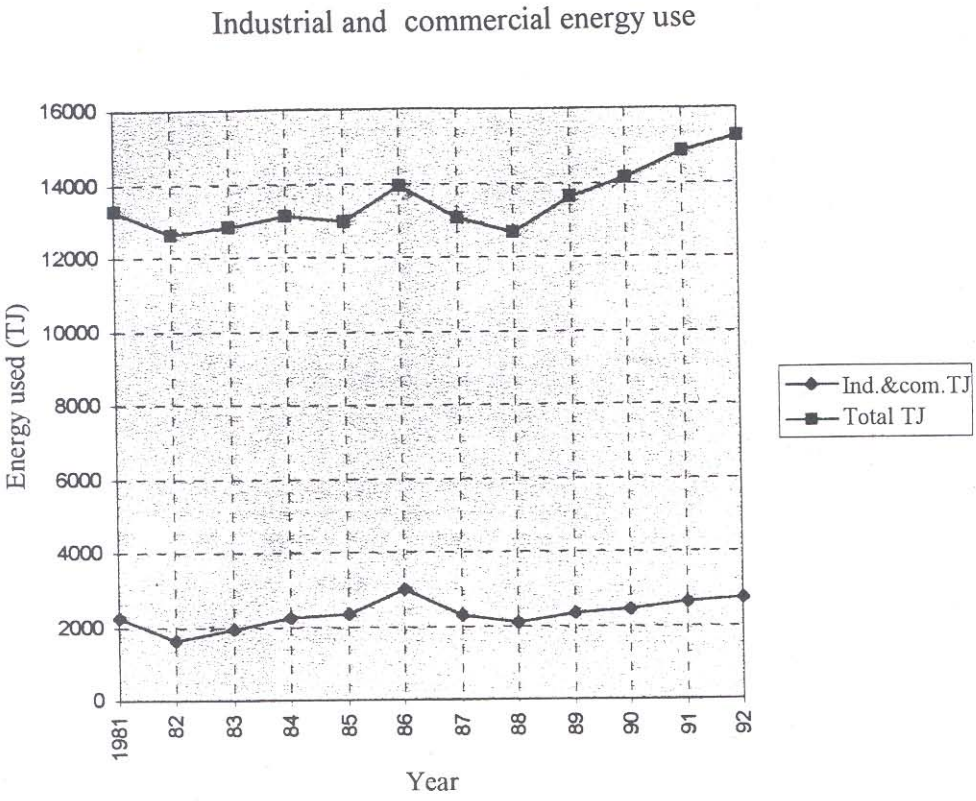

Fig. 2. Electricity generated from various sources: 1981-1982.

Figure 2 shows electricity generated by various sources since 1981. Electricity generated from the rural diesel power systems are not included; nor is that generated by the Vatukoula gold mine. The latter generates its own electrical power requirements through diesel power sytems.

4. ENERGY USE

4.1 Energy for Industry

While Fiji is not heavily industrialized, compared to its developed neighbors such as Australia and New Zealand, it does have several mainly light industries and expends a considerable amount of energy on these. These industries include manufacturing ones such as sugar, cement, building materials (timber, nails, concrete blocks, etc.), coconut oil, soap, food processing and packaging, cooking oils, vehicle assembly; agricultural, fisheries and forestry-related industries and others.

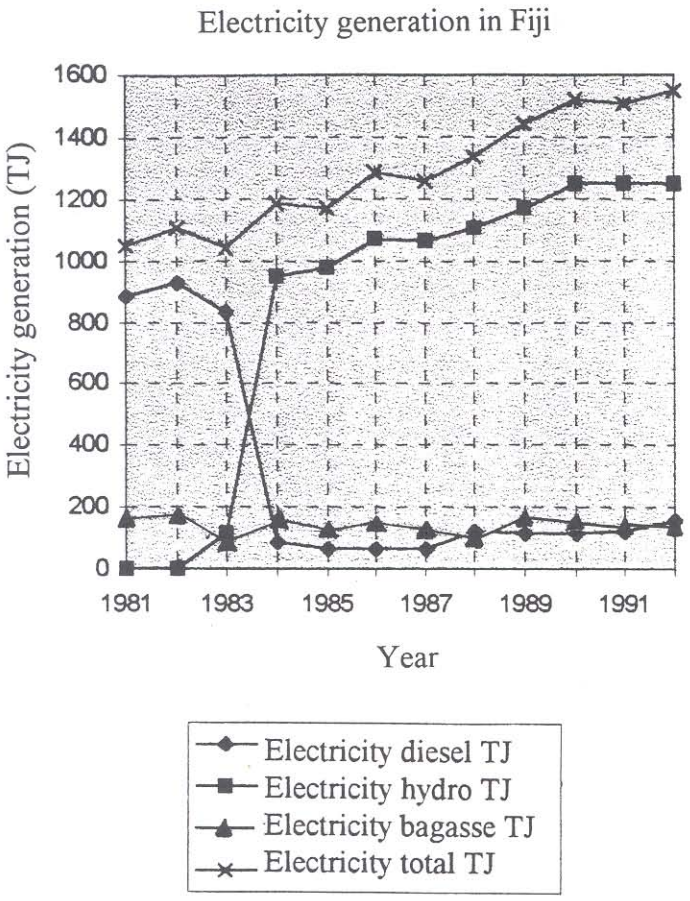

Fig. 3. Industrial and commercial energy utilization.

Figure 3 shows the use of energy for industrial and commercial activities since 1981, with the total energy used as a comparison. The commercial and industrial consumption does not include energy used for transportation for these sectors, which would be significant.

4.2 Agricultural and Household Energy Use

Almost a third of the total energy consumed in the country goes towards domestic or household activities. This is a reflection firstly of the relatively low level of industrial activity and secondly of the increasing availability of electricity to the domestic sector, particularly in the rural areas through the extension of the national electricity grid.

Energy used in the agricultural sector includes agriculture, fisheries and forestry activities, particularly large-scale government and private projects. These include rice schemes, copra plantations, pine plantations, and fisheries projects such as PAFCO, the Pacific Fishing Company.

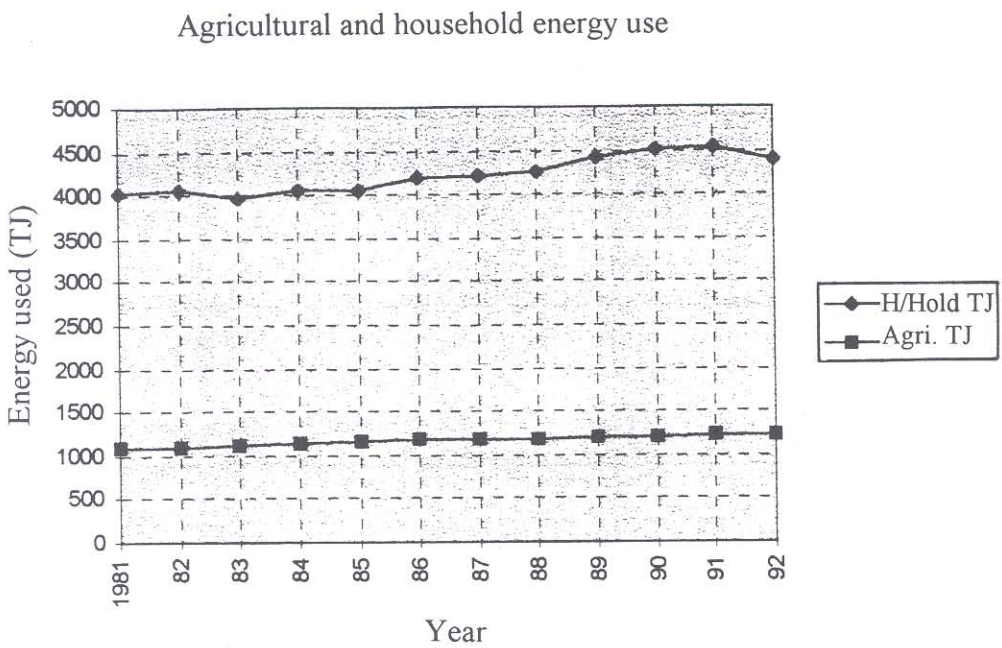

Fig. 4. Household and agricultural energy consumption: 1981-1992

Figure 4 shows the energy consumed by the agricultural and domestic sectors since 1981. The energy consumed by these two sectors has remained relatively stagnant even though, in the case of the agricultural sector, the economy of the country was growing between 1981 and 1987. The energy used by the agricultural sector is around a quarter of that consumed by the households.

4.3 Sectoral Energy Use

In this section sectoral energy use as well as final end-use are considered. Sectors that need energy include household (domestic), industry, commerce, institutions, agriculture, government, and others. Final end-uses include what energy is actually used for in terms of the final output. Thus cooking, heating, crop drying, cooling, refrigeration, air-conditioning, lighting, running machinery, and transportation are all inclusive of energy end-use. Table 2 shows the final energy consumption by energy source from 1981 to 1992.

Table 3 shows energy used in Fiji by sectors from 1981 to 1992. Figure 5 shows sectoral energy use for three sectors, namely, industrial and commercial, transport, and household, between 1981 and 1992. It is noted that transportation consumes the largest amount of energy, with over 39% of primary energy used in 1992. For this time period, the highest energy consumption for transportation was in 1981 with 42%. The fraction of energy for transportation has been decreasing since 1981 up to 1988 whereafter it has shown a steady increase. Household energy has been more or less steady between 1981 and 1986, has increased thereafter until 1988 and has been decreasing steadily since then.

Table 2. Final energy consumption by energy source.

				Final energy consumption by energy source														
								Electricity										
Year	Coal			Petroleum products				Diesel		Hydro		Bagasse		Total		Fuelwood		Total
	TJ	% Imports	%	TJ	Total Imports	% Imports	%					TJ		TJ	%	TJ	%	TJ
1981	485	5.9	3.7	7762	8247	94.1	58.5	881	84.3		0	164	15.7	1045	7.9	3980	30.0	13272
1982	541	7.2	4.3	6930	7471	92.8	54.9	924	83.8		0	179	16.2	1103	8.7	4053	32.1	12627
1983	479	6.3	3.7	7170	7649	93.7	55.9	830	80.0	114	11.0	93	9.0	1037	8.1	4131	32.2	12817
1984	535	6.9	4.1	7165	7700	93.1	54.7	87	7.3	945	79.6	155	13.1	1187	9.1	4208	32.1	13095
1985	428	5.7	3.3	7077	7505	94.3	54.7	65	5.6	974	83.4	129	11.0	1168	9.0	4268	33.0	12941
1986	601	7.2	4.3	7698	8299	92.8	55.3	67	5.2	1067	83.0	151	11.8	1285	9.2	4339	31.2	13923
1987	485	6.5	3.7	6925	7410	93.5	53.1	68	5.4	1059	84.3	129	10.3	1256	9.6	4377	33.6	13043
1988	333	4.8	2.6	6575	6908	95.2	51.9	122	9.1	1105	82.6	111	8.3	1338	10.6	4415	34.9	12661
1989	446	5.8	3.3	7266	7712	94.2	53.4	114	7.9	1169	80.9	162	11.2	1445	10.6	4453	32.7	13610
1990	431	5.3	3.1	7686	8117	94.7	54.4	116	7.6	1252	82.3	153	10.1	1521	10.8	4491	31.8	14129
1991	571	6.5	3.9	8206	8777	93.5	55.4	122	8.1	1249	82.8	138	9.1	1509	10.2	4528	30.6	14814
1992	462	5.1	3.0	8664	9126	94.9	56.8	160	10.3	1247	80.4	144	9.3	1551	10.2	4566	30.0	15243

Table 3. Energy consumption by sectors.

Year	Ind. & Com.	%	Trans	%	H/Hold	%	Agri.	Govt.	Non. Eng	%	Total
		I + C		T		H				I+C+T+H	
	TJ		TJ		TJ		TJ	TJ	TJ		TJ
1981	2240	16.88	5582	42.06	4025	30.33	1078	0	347	89.26	13272
82	1625	12.87	4947	39.17	4059	32.14	1097	598	302	84.19	12628
83	1946	15.18	5065	39.52	3962	30.91	1117	515	211	85.62	12816
84	2214	16.90	4929	37.63	4044	30.88	1138	491	281	85.42	13097
85	2308	17.84	4591	35.48	4062	31.39	1153	621	205	84.71	12940
86	2986	21.45	4678	33.60	4199	30.16	1171	642	245	85.22	13921
87	2271	17.41	4527	34.71	4202	32.22	1181	631	231	84.34	13043
88	2094	16.54	4246	33.54	4267	33.70	1191	610	252	83.78	12660
89	2333	17.14	4741	34.84	4418	32.47	1201	653	262	84.45	13608
90	2451	17.35	5031	35.61	4513	31.95	1211	660	261	84.91	14127
91	2646	17.87	5480	37.00	4547	30.70	1221	639	278	85.56	14811
92	2735	17.94	5980	39.23	4401	28.87	1231	634	263	86.04	15244

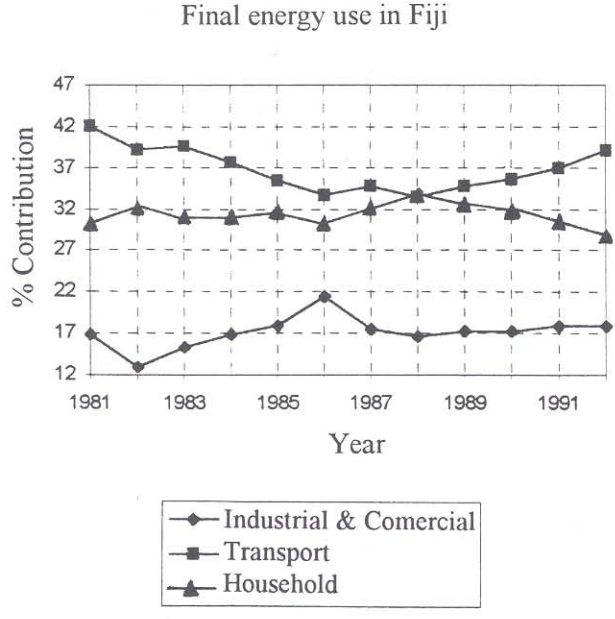

Fig. 5. Sectoral energy consumption: 1981-1992.

Energy for industry and commerce shows some interesting variations. Between 1982 and 1986, there has been a steady increase, peaking to almost 22% in 1986. Since 1987, there has been a slight increase in consumption, reaching a value of 18% in 1992.

4.4 Final Energy End-Use

Due to the unavailability of data for energy end-use on a national scale, it is impossible to comment on energy end-use. However, on the basis of several studies on energy end-use for particular situations, some general observations can be made.

For the household sector, the most common end-use include lighting, cooking, cooling, refrigeration, entertainment, operation of appliances other than for the above (e.g., power tools) and, to a limited extent, air-conditioning.

For the industrial sector, energy end-use is dominated by the running of electrical machinery (motors, pumps, compressors and many other special machinery and tools), lighting, air-conditioning, cooling, process heat and refrigeration. The commercial sector uses the above but to a different extent, particularly for machinery.

For transportation, the end uses are the same in that energy is used for running engines for vehicles, aeroplanes, ships, trains and other means of transportation.

5. ENERGY EFFICIENCY

In this section, the efficiency of electricity generation, in particular, and energy conversion, in general are considered. Four categories of energy systems are considered: the hydroelectricity generation, the FSC mills, the FEA diesel power systems taken as a whole and the rural electrification system, using small and medium diesel gensets.

It is instructive to compare the efficiency of the rural diesel power systems to large scale electricity generation systems. In Fiji, there are three major ways of generating electrical power: thermal power systems using diesel fuel, hydroelectric power generation and electricity generation using biomass (wood or bagasse).

Figure 6 shows the efficiency of these systems for the years 1981 to 1992. The efficiency of rural diesel power plants is compared to those of the FSC thermal power generation, the Monasavu hydroelectric scheme and the FEA thermal power systems as a whole.

It is noted that the efficiency of the rural diesel power systems is the lowest. The average efficiencies of the other systems are 24% (FSC thermal systems), 27.5% (Monasavu hydroelectricity system) and 32% (FEA thermal systems taken as a whole).

There is abundant biomass resource, in the form of forest as well as agricultural and industrial waste, to warrant serious consideration of biomass-fuelled power systems. The two major options are direct combustion systems using a steam engine or turbine connected to an alternator and power gasification systems. The sugar mills, for instance, use bagasse to generate all their electrical energy requirements; a few sawmills generate electricity and steam on-site and a 25 kW wood-fired steam power cogeneration system supplies electricity and heat for drying copra at a plantation in Taveuni.

Electricity from the 80 MW Monasavu hydroelectricity scheme in the interior of Viti Levu, the largest island in Fiji, is distributed to over 90% of the electricity consumers supplied by the FEA. Apart from this large hydropower scheme, two mini hydro-schemes (with a total capacity of 250 kW) supplies electricity to two remote communities. There is very significant potential for greater use of hydroelectricity, generated from small-scale micro-units or medium mini systems.

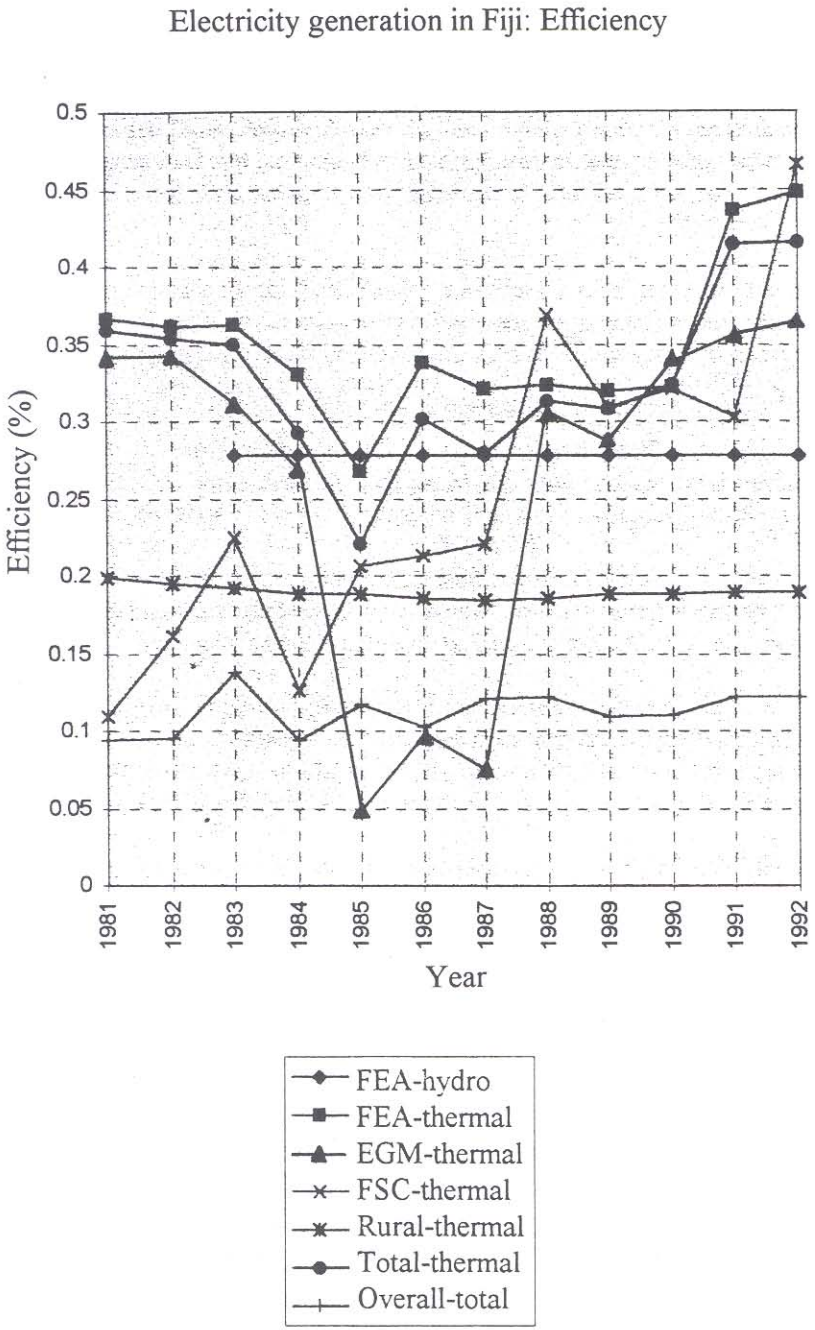

Fig. 6. Overall efficiencies of electricity generation in Fiji.

5. CONCLUSION

In Fiji, energy comes from a number of sources of which the three dominant sources are petroleum products (for transportation, household and industrial use and for electricity generation), hydropower (for electricity generation) and biomass (for cooking, process heat and electricity generation). Other sources include coal (for industrial use), solar energy (for hot water and lighting), geothermal (mainly for cooking).

Electricity is generated using hydropower, diesel fuel and bagasse (for the sugar mills). Biomass, in the form of firewood, sawdust, bark and agricultural waste (mainly coconut husk and shell), is used to provide process heat for industries and commercial enterprises as well as to generate electricity.

The efficiency of energy conversion varies considerably, depending on the source of energy and the scale of conversion. Rural electrification diesel generator sets are fairly inefficient, with conversion efficiencies of 15%, while the Monasavu hydroelectric power station has an overall efficiency of 30%.

The sugar mills use bagasse to generate all their electrical demand and the overall efficiency of conversion (bagasse to electricity) is only around 1% (an energy content of 20 MJ/kg is assumed for the bagasse). If the use of steam is considered, then the overall efficiency increases considerably.

While there is good scope for greater use of renewable (such as hydropower and biomass) for electricity generation, it appears unlikely that these will make significant inroads. However, there are industries such as the sugar mills, sawmills, copra mills and other industries that are looking increasingly at the feasibility of generating their own power through the use of the waste products they generate.

Thus, Fiji's electricity generation will continue to be dominated by the hydroelectricity facility at Monasavu (for most of Viti Levu) while the rest of Fiji will continue to rely upon diesel generation, through large central power stations or small diesel generator sets for the rural and remote communities.

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