Energy efficiency and energy intensity
Fiji 1981–1990

Caroline Currie
The University of the South Pacific

[In many developing countries commercial energy consumption has increased relative to GDP growth and development has required major increases in energy use per capita. This has costly implications for the developing countries—particularly those who are heavily dependent on imported petroleum products. For most countries, there is a growing awareness of the need to reduce per capita energy consumption. This paper examines the particular case of energy consumption in Fiji. It measures the relationship between the consumption of energy and GDP growth in Fiji for the period 1981–1990.]

Introduction

SINCE the Industrial Revolution and until recently, economic growth has required the progressively increasing use of energy. By the early twentieth century, the rapidly industrialising nations of the world were fuelling their development via year on year increases in per capita energy use, and energy intensities (measured as the ratio of primary energy requirement to GDP) were rising—evidenced by a strong statistical relationship between the use of energy and the level of GDP. By the mid-1980s energy consumption per capita in the developed countries was six times higher than in the developing nations.[1] However, in more recent times this gap has closed, with energy consumption per capita falling in the developed countries and the use of energy in the developing countries increasing.[2]

In the 1970s the developed countries' growing appetite for commercial energy, particularly oil, and the subsequent oil price shocks—which reflected in part the increasing pressure on oil resources—shifted the focus of those countries to more rigorous energy planning for development.

To determine the success (or otherwise) of the energy planning strategies implemented, a United Nations (UN) study of energy economy in the Economic Commission for Europe (ECE) region examined measures the ECE countries were taking to achieve increased economy and efficiency in their use of energy.[3] This study measured the energy–GDP elasticities for a number of developed and developing countries. The findings were that for the developed countries the elasticities were lower than one, indicating that the rate of energy growth was lower than the rate of GDP growth for those countries, i.e. the energy intensities were falling.

One theory advanced in this study for the decline in the energy intensities in the developed countries was that it occurred as a result of a shift in the structure of energy sources from lower end use efficiency fuels (e.g. coal and petroleum products) to greater end use efficiency fuels (gas and electricity).

On a similar theme, a World Resources Institute (WRI) study of energy use highlighted the fact that in the OECD countries, energy use per capita declined by almost six per cent between 1973 and 1985, reflecting to a large extent improvements in energy efficiency as well as structural shifts in their economies.[4] And, more recently, the United Nations Environmental Data Report states that 'many countries are becoming aware of the need to reduce per capita energy consumption, particularly through increasing energy efficiency'.[5] This report shows differences in regional per capita energy consumption in toe (tonnes of oil equivalent) for a number of countries, with energy consumption per capita falling sharply in Western Europe and the USA between 1979 and 1989.

Unfortunately, the same decline in energy use per capita cannot be observed for the developing countries. Their commercial use of energy (i.e. energy sources that are purchased in the market place as opposed to, for example, bagasse and other crop residue that are by-products of the production process) has been increasing steadily. The WRI estimates that energy use per capita for the developing countries increased by 22% between 1973 and 1985, compared with the fall of 6% for the OECD countries.[6]

This has obvious economic implications for the developing countries, especially for the oil-importing countries. Development in the emerging nations is constrained in part by their ability to purchase increasing volumes of energy to meet growing demand, but energy prices are ultimately affected by the scarcity of the resource, placing a further constraint on development. The increasing reliance of the developing countries on commercial energy may, in fact, stall their economic growth unless policy makers define their energy planning strategies to promote the use of energy efficient technologies and the greater use of indigenous, renewable energy sources.

These circumstances provide the background to the present paper, which examines the energy efficiency and energy intensity of the Fiji economy for the period 1981–1990. The analysis will consider government policy in Fiji towards promoting the use of indigenous renewable energy sources, the supply of and demand for energy inputs from imports and indigenous resources, and finally, the patterns of intensity of energy use in the commercial and industrial sectors of the economy.

In this report the major sources used for statistical information on the energy sector in Fiji are the Fiji Department of Energy, *Energy Statistics Yearbook*[7] and the Bureau of Statistics *Economic Statistics* publications.

The Fiji situation

THE RHETORIC of the Fiji Government's energy policy promotes the use of indigenous renewable energy resources and the efficient use of energy.[8] Its primary objectives are to reduce the level of dependency of Fiji on imported petroleum products and to reduce the country's energy costs. A secondary factor driving the pursuit of more efficient fuels is the need to reduce the negative environmental effects of a continued increase in consumption of energy. If the policy objectives are met they could result in an improvement in Fiji's balance of payments position, a reduction in imported inflation—Fiji would be less exposed to the price volatility of the international oil marketplace—and enhancement of the security of Fiji's energy supply. Given these objectives, the Fiji Department of Energy (DOE) is extensively pursuing the research and development of indigenous energy resources.

In the energy supply area, the DOE is currently undertaking programmes to assess the potential of renewable energy sources such as geothermal, hydro, wave and wind power. Over the last decade, small-scale solar-based-energy trial and pilot projects have been successfully carried out and hydro and mini-hydro stations have been developed. A national fuelwood strategy has been formulated to address the long-term availability of fuelwood in rural areas. An institutional stove building programme involving the installation of wood stoves in schools has been underway for over ten years. A project to develop a smaller version of the institutional stove that would make efficient use of local wood resources for cooking fuel is nearing completion and the Department is currently promoting the potential for producing energy from waste.

On the energy demand side, the measures, mainly involving energy management and conservation, are ones that consumers themselves may adopt to improve the efficiency of the energy they use. The measures that the DOE have pursued in their promotion of best practice are: the use of efficient technology, employing energy management practices, cogeneration, heat recovery, fuel switching and adoption of good energy housekeeping practices.

How successful have these measures been in accelerating energy efficiency and economy in Fiji and in promoting the use of indigenous renewable energy over imported energy sources?

Fiji's energy supply is derived from imported fuel and from local renewable energy resources. In 1981, the domestic requirement for imported petroleum product inputs was approximately 306,473 kl, with large volumes of diesel fuel being used in the production of electricity.[9] With the coming on stream of the Monasavu hydro scheme in 1983, domestic requirements for petroleum products fell sharply (to 201,957 kl in 1984, a reduction of approximately 34% over 1981). Much of the reduction can be explained by the fall in the Fiji Electricity Authority's (FEA's) demand for industrial distillate oil (IDO). Between 1983 and 1984 the domestic requirement for IDO fell by 71% (from 72,707 kl to 21,225 kl).

Over the period 1981–1990 the use of petroleum products in electricity generation declined by approximately 86%. Notwithstanding this, petroleum products remain a major source of primary energy supply for Fiji. By 1990, domestic requirements for petroleum products, at 231,677 kl, were approximately 24% below their 1981 levels.

In terms of the indigenous resources, bagasse supply in overall energy supply has grown from 839,660 tonnes in 1980 to 1,049,965 tonnes in 1990, an increase of 25%, as the country's output of sugar has grown. Over the same period fuelwood in energy supply has increased by 14%.

On the basis of the data presented in the *Energy Statistics Yearbook*, it appears that the indigenous energy resources increased in importance relative to the imported energy resources over the 1980s. By 1990, Fiji's primary energy supply from indigenous renewable resources 'hydro, fuelwood and bagasse' accounted for a higher proportion of the overall primary energy supply (65% compared with 53.5% in 1981). This changing pattern of energy supply in Fiji is illustrated in Figure 1.1.[10]

Figure 1.1 **Primary energy supply, 1981 and 1990**

More importantly for this analysis, the pattern of energy demand or consumption also changed towards a greater demand for energy derived from indigenous energy sources. Between 1981 and 1990, the share of final energy consumption derived from coal and petroleum products (not including consumption of electricity derived from petroleum products) declined by 4.7% to 56.7 % of final consumption. The share of energy consumption from fuelwood increased slightly (1.8%) to 32.4% of final consumption, while the share of electricity consumption derived from diesel, hydro and bagasse consumption increased by 2.8% to 10.8% of final consumption.

In Fiji, a substantial proportion of the energy consumed is now derived from indigenous resources. Between 1981 and 1990, the share of renewable energy resources (hydro, bagasse and wood) in final energy consumption increased from 32% to 43%, the increase being primarily due to the effect of Monasavu. Figure 1.2 shows energy consumption by source in 1981 and 1990.

Figure 1.2 **Energy Consumption by Source 1981 and 1990**

Data Considerations

IT SHOULD be clarified at this point that while the figures in the DOE *Energy Statistics Yearbook* on final consumption of energy include the consumption of primary fuels and consumption of electricity from the conversion of primary fuels, they omit the consumption of process heat from bagasse.[11] Energy from bagasse is consumed in the form of process heat, mainly by the Fiji Sugar Corporation. As the DOE Yearbook tables presently stand bagasse has a significant role in primary energy supply but an insignificant final energy consumption role. The result of this omission is that the Yearbook underestimates the final energy consumption in Fiji and also underestimates the extent of final energy consumption derived from indigenous fuels.

In addition to this, the DOE energy statistics data do not take into account the consumption of energy from fuelwood in the industrial and agro-processing sectors, although they do record domestic sector consumption. The supply of fuelwood to industry for the generation of electricity or more commonly process heat, may be between 100,000 and 200,000 tonnes per annum.[12] Assuming that the lower figure is correct, then about 1,800 terajoules (Tj) of energy is being missed.[13] A figure of 1,800 Tj would make the 1990 primary energy supply from fuelwood approximately 40% higher and total energy supply higher by 7%.

These omissions mean that in the following analysis the overall electricity and energy intensities will be understated. However, in terms of the commercial energy intensities, (that is, the use of energy purchased in the marketplace, e.g. petroleum products, coal, gas and electricity excluding energy generated as a by-product or from a waste product of the industrial process), the understatement will be considerably less and there is no reason to believe, a priori, that the pattern of the movements of the commercial energy intensities of the economy will be altered significantly. The intensity of use of commercial energy is of particular interest in terms of the implications for the Fiji economy. Commercial energy intensities reflect the need for higher fuel imports or available indigenous energy sources as an economy expands.

Measuring energy intensities

FINAL energy consumption in Fiji increased by 6.4% between 1981 and 1990 (from 13,272 Tj to 14,126 Tj), an annual average growth rate of 0.6%, while the gross domestic product (GDP) of the country increased by almost 17% over the same period, an annual average increase of 1.7% (although growth has typically been uneven over the period). This is a surprising result, particularly since an earlier study of Fiji's energy consumption indicated a close correlation between the rate of growth of output and energy consumption, with the growth in annual energy consumption being greater than the average annual increases in GDP.[14] One possible explanation for this apparent deviation from past trends is that Fiji became more energy efficient over the period of the 1980s.

We can test this hypothesis by examining the energy intensity ratio of the economy over that period. The energy intensity ratio is measured as total energy consumption (total energy demand measured in terajoules) divided by GDP in constant F$ million terms. This is an important ratio because it can be used to gauge energy economy and efficiency of energy.

The following paragraphs briefly describe the measurement of energy intensity in Fiji. A preliminary investigation to identify the major contributing factors underlying the change in the energy intensity ratio that has occurred in the last decade is also undertaken.

Table 1.1 shows that Fiji's energy intensity declined by 1.9 Tj per F$m of GDP between 1981 and 1990. The petroleum and electricity intensities indicate that the economy became less dependent on imported petroleum products for its energy requirements and more dependent on electricity for energy consumption during the 1980s. Specifically, the share of total petroleum products, measured as the ratio of total petroleum consumption to GDP, fell from 10.3 terajoules (Tj) per F$m of GDP in 1981 to 8.7 Tj per F$m of GDP in 1990, while the share of electricity increased steadily.

Table 1.1 **Energy intensity 1981–1990**

	Total Energy Intensity[1]	Total Petroleum Intensity[2]	Total Electricity Intensity[3]
1981	18.1	10.3	1.5
1982	17.3	9.3	1.5
1983	18.4	10.1	1.5
1984	17.3	9.3	1.6
1985	18.1	9.7	1.7
1986	18.0	9.8	1.7
1987	17.9	9.4	1.8
1988	17.0	8.7	1.8
1989	16.3	8.6	1.8
1990	16.2	8.6	1.8

Source: Currie C. Urban Energy Survey, Department of Energy, Fiji.
1. Total energy consumption/GDP$m. Excludes non-energy consumption
2. Total petroleum consumption/GDP$m
3. Total electricity consumption/GDP$m

This is significant. The data suggest that there was a discernible change in the ratio of economic growth to energy use occurring after 1980. Two questions now require to be answered. What are the likely reasons for such a turnaround? And, what is the scope for achieving or sustaining economic growth while minimising the rate of growth of overall and particular fuel energy demands in Fiji (in other words, reducing or holding down the growth in energy intensities)? To provide answers to these questions it is necessary to undertake a brief overview of the industrial structure of the Fiji economy and the structure of energy use. The following analysis provides a preliminary investigation of the possible causes of the improved energy intensity ratios of the Fiji economy.

GDP and energy consumption

TABLE 1.2 compares final energy consumption between 1981 and 1990 for the various consumer categories contributing to Fiji's GDP. The transport sector's importance as the major consumer of petroleum products—accounting for approximately 74% of petroleum

consumption—is highlighted. Other major points to note are the decline in the consumption of petroleum products by the transport sector, a small increase in the industrial/commercial sector's consumption of petroleum products, and a substantial increase in consumption of electricity by the industrial/ commercial sector.

Table 1.2 **Consumption of energy by consumer group 1990 (Unit = Terajoules)**

	Indust/comm	Transport
Petro Prods	914	5514
% change 1981-1990	+3.6%	-1.2%
Coal	431	-
% change 1981-1990	-11%	-
Electricity	1266	-
% change 1981-1990	+45%	-
Total	2611	5514
% change 1981-1990	+16.6%	-1.2%

Source: Currie C. Urban Energy Survey, Department of Energy, Fiji.

Table 1.3 indicates that the industrial sector's contribution to GDP has remained fairly static between 1986 and 1991 (at approximately 13.5% of GDP) while the contribution of the commercial sector has grown by more than 3%.[15] Over the period, commercial sector output (GDP $m at constant 1977 prices) increased by 20% compared with industrial sector output, which increased by 10% (the agricultural sector is not considered here).

Table 1.3 **GDP by sector 1986–1991**

Year	GDP($m)	Industry Total	Industry Output as %GDP	Commercial Total ($m)	Commercial Output as %GDP
1986	760.5	104.8	13.8	469.7	61.8
1987	711.5	94.0	13.2	443.6	62.3
1988	728.4	94.6	13.0	463.7	63.7
1989	815.6	104.7	12.8	521.2	63.9
1990	854.9	111.5	13.0	560.4	65.6
1991	860.6	115.8	13.5	563.1	65.4

Source: Bureau of Statistics *Current Economic Statistics*, October 1993.

The transport sector

THE TRANSPORT sector is considered separately from the commercial sector, for the reason that the measurement of energy under the heading of 'Transport' in the *Energy Statistics Yearbook* covers energy purchases from all sources for transport purposes (including domestic sector consumption), as opposed to energy purchases solely for commercial transport purposes. The distinction is important, but does not change the general direction of the energy intensities for the transport sector.

Within the transport and communications sector there has been a 36% increase in output since 1985. Almost all of the growth in output in this sector occurred after 1987, when there is a radical change in the relationship between growth of output and energy usage, with petroleum product consumption increasing by significantly less. From the available data, it appears that there has been an improvement in the intensity of use of petroleum inputs in transportation, measured as the ratio of final transport energy consumption to total GDP. The reason for the improvement is not clear. Amongst other things, it may be the result of improved fuel efficiency, or a reduction in the number of journeys made, i.e. better distribution systems and more fuel efficient vehicle use.

However, given the importance of the transport sector to overall energy consumption, it is likely that the reduction in petroleum intensity in transportation has been a contributing factor to the fall in the energy intensity of the economy.

The commercial sector

WITHIN the commercial sector the major areas of growth of output (not including transport) have occurred in the wholesale and retail trade sectors (27%), the hotel, restaurant and cafe sector (7.4%) and finance, insurance and business services (18%). These are all sectors where electricity has traditionally been the major source of energy.

Could the commercial sector be contributing to the increase in the **electricity intensity** of the economy and the fall overall in the **petroleum intensity**?

The commercial sector is historically more electricity intensive than the industrial sector and has grown in size relative to the industrial sector in recent years. Unfortunately, the available data are not sufficiently

detailed to assess if there has been any change in the intensity of use of electricity or petroleum by this sector.

However, leaving aside the transport component of the sector, it is unlikely that the commercial sector has contributed to the fall in the overall petroleum intensity, because of the sector's low petroleum usage. On electricity intensities, the *Energy Statistics Yearbook* indicates a fall in the consumption of electricity by the commercial sector occurred between 1985 and 1991.

This is a surprising result, given the growth in the commercial sector over the last five years. Two likely explanations for this fall are that:

(a) rather than indicating an overall reduction in electricity purchases, it reflects some reclassification of commercial companies as manufacturing/industrial companies to take advantage of the Government's tax free incentives; and

(b) (according to strong indications) the commercial sector has substituted other fuels, in particular Liquid Propane Gas (LPG), for electricity for a large part of its energy requirements. Given these factors, it is unlikely that the commercial sector is contributing to any great extent to the increasing electricity intensity of the economy.

The industrial sector

THE INDUSTRIAL sector has not expanded as rapidly as the commercial sector although it experienced growth of approximately 10.5% over the period 1986–1991. Growth in this sector has been largely concentrated in light manufacturing activities (garments, food processing, furniture and leatherware, etc.) which are relatively electricity intensive industries. Industry sectors that have been in decline in recent years (measured by the annual indices of industrial production) include heavy energy use industries such as cement production, roofing iron, structural metals, plastics, etc. These industries were inevitably affected by the events of 1987; nevertheless, with the exception of structural metals, all of these industries were already in decline prior to 1987.

The structural shift revealing a decline in the energy intensive industries in the period between 1985 and 1990 is likely to be a significant factor in the decline in the energy intensity of the Fiji economy. Electricity use by industry has risen by an average of 3.1 per cent a year since 1985.

The increasing demand for electricity from the industrial sector reflects the increasing tendency of industry towards light manufacturing activities (especially garment manufacturing) and the effects of the increasing use of end use appliances (such as direct heat appliances, process heat equipment and motors) that are electricity intensive. The growth of light manufacturing activities in the industrial sector has led to an increase in electricity intensive manufacturing, which on the whole tends to be less energy intensive in its requirements than heavier industry. It is therefore arguable that the increase in the electricity intensity ratio of the economy is a product of changes occurring in the industrial structure, with the low energy growth rates partially reflecting the fuel efficiency effect as the Fiji economy switches to the greater use of electricity.

Future Prospects

WHAT IS the scope for achieving sustained economic growth while minimising growth of energy intensities in Fiji? This analysis has shown that economic growth rates need not necessarily be dependent on equivalent increases in energy consumption. Fiji has demonstrated that over the period of the 1980s it was possible to achieve a level of growth that was greater than the rate of increase of energy inputs required to develop it. However, it appears from the analysis that this has largely occurred as a result of shifts in the structure of the economy, taking place in this period and for reasons other than the achievement of energy economy. It is the changing structure of industry and the ensuing change in the energy consumption patterns that have had the biggest impact on energy intensities.

It is apparent that if Fiji wishes to maintain these lower energy intensities, clear and decisive policy and public awareness measures must be put in place. The Government of Fiji must take specific and practical steps designed to minimise energy demand and further reduce industrial and commercial energy intensities. The DOE must continue its work in

the areas of energy efficiency, management and conservation. Highlighting energy efficient technology and particular aspects of energy conservation will be of much use. Of primary importance will be the formulation of appropriate energy policies specifically targeted at the sectors and industries that play a major role in the energy economy and therefore where improvements in efficiency could bring results. Generally, and in summary, the Government might consider actively encouraging research and development into the feasibility of policies that aim to:

- promote the production of energy efficient output, i.e. the specific promotion of policies aimed at maintaining the structural changes currently taking place in the Fiji economy that emphasise electricity intensive manufacturing as opposed to energy intensive industry;

- promote the use of energy efficient technology;

- encourage recycling, reducing or eliminating commercial/industrial energy waste; and

- educate consumers about measures they may take to use energy more efficiently or to conserve energy.

Notes

This paper draws on material from an urban energy survey undertaken by the author during 1993. The survey is in two parts. Part A provides an analysis of the historical data held by DOE. Part B analyses and reports on the findings of the urban energy survey. Part B is not discussed in this paper.

1. World Resources Institute, *Energy for Development*, September 1987.

2. United Nations Environment Programme, *Environmental Data Report*, 1989.

3. United Nations, *Increased Energy Economy and Efficiency*. A study on measures taken or which migh be taken to achieve increased energy efficiency, UNEP, New York, 1976.

4. World Resources Istitute, op. cit.

5. United Nations Environment Programme, *Environmental Data Report*, 1991.

6. World Resources Institute, op. cit.

7. Department of Energy, *Energy Statistics Yearbook, 1990* Suva. This is a comprehensive collectionof energy statistics relating to 1990, with historical data from throughout the 1980s. Data are provided on energy sources and supply, energy transformation, energy consumption by source, energy consumption by sector and energy costs within Fiji.

8. *Opportunities for Growth. Policies and Strategies for Fiji in the Medium Term*, Government of Fiji, February 1993, pp. 119–121.

9. Domestic requirement is defined as imports minus re-exports and minus bunkers. Figures exclude non-energy requirements.

10. Caroline Currie, Urban Energy Survey, Department of Energy, Fiji.

11. From work undertaken by Dr Graham Birse and James Goodman, Department of Energy, Fiji.

12. The figure of 100,000–200,000 tonnes is based on a number of recent surveys and estimates undertaken by the DOE.

13. Terajoule: A common unit of measurement of energy, indicating the multiplier of 10^{12}.

14. Suliana Siwatibau, Urban Energy in Fiji. A Survey of Suva's Household, Industrial and Commercial Sectors. International Development Research Centre, 1987.

15. Fiji Bureau of Statistics, *Current Economic Statistics*, October 1993. For calculations of the GDP, industry is defined as FSIC 2–4 (from the Census of Industries). Commercial sector is defined as FSIC 5–10.