Energy consumption and economic activity in Fiji

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Abstract

The high reliance on imported energy inputs by Pacific island nations has led to a search for an appropriate energy policy framework that could be utilised to reduce this dependency. Development of such a policy framework requires a thorough understanding of the interaction of energy and energy based products in the production processes of the economy. This study examines the pattern of energy consumption and growth in Fiji. The analysis is extended to examine how efforts to increase energy conservation and efficiency have performed in the commercial and household sectors of Fiji's economy. Results from the analysis are further utilised to develop policies to enhance government's energy consumption strategy.

Introduction

The extensive use of energy and energy based inputs in the production processes of Pacific island countries has strong implications for their growth and development. The Pacific island region is heavily dependent on imported petroleum products to meet their local energy demands (Yu & Taplin 1997). With such high reliance on imported energy products, a significant proportion of the export earnings, which otherwise could be channelled into productive domestic investments, will now be used to meet

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expenditure on these imported products. Furthermore, heavy dependence on imported oil products in relation to total exports makes the island economies vulnerable to external economic shocks (Tzeng 1989; Yu & Taplin 1997; and Reddy & Yanagida 1998).

Apart from concern about the loss of foreign exchange earnings and vulnerability to external shocks, increased consumption of energy products has also raised concerns with regard to its impact on the environment. This is problematic because of the sharp rise in anthropogenic emissions such as carbon monoxide (C0), hydrocarbons (HCs), nitrogen oxides (NO_x), sulphur dioxide (SO_2) and TSP_s (Shrestha & Malla 1996).

Given these concerns, the search for an appropriate framework for energy policy making in the Pacific islands has intensified. To date, the only work that has addressed this issue for the Pacific islands has been that of Yu, Taplin and Akura (1997). The lack of such a policy framework may at least in part be explained by a lack of basic understanding of the energy use profile with respect to individual sectors of the economy.

To begin to narrow this knowledge gap, this article applies a methodology to disaggregate the interaction of energy with other factors in the commercial and household sectors of the Fijian economy. In particular, the decomposition of energy use into structural change effects, energy intensity effects and aggregate output growth effects is used to examine the effect of economic growth in Fiji on energy consumption. The paper is divided into four sections. The first section briefly reviews literature on the analysis of the energy–Gross Domestic Product (GDP) relationship and the second provides an overview of Fiji's energy demand, consumption and dependency since 1970. The third section utilises a comparative statics approach to decompose the energy use by commercial and household sectors. The fourth section provides a summary and policy implications drawn from the paper.

The energy–GDP relationship

The importance of energy as an input in the growth and development process gained more prominence following the oil price increases in 1973/74 and 1978/79 than at any other time. Subsequently, a significant volume of research—most of it in developed countries, primarily because of the large role energy and energy based inputs play in their production processes—has investigated the relationship between energy and economic growth.

Studies by Kraft and Kraft (1978) and Abosedra and Baghestani (1989) report a strong causality running unidirectionally from Gross National Product (GNP) to energy consumption. Ebohon (1996) investigated the causality between energy consumption and economic growth for Tanzania and Nigeria, finding a simultaneous causal relationship between energy consumption and economic growth for both countries. In exploring the possible adverse effects of high energy prices on economic growth, Rasche and Tatom (1977) specified a new type of production function for the United States, in which they included energy as an explanatory variable along with the conventional variables (land, labour and capital). They showed that energy price increases induced declining trends on potential GNP over the study period.

However, other studies have found no causality between energy consumption and economic growth (see Akarca & Long 1980; Yu & Hwang 1984; Yu & Choi 1985; and Erol & Yu 1987). Proops (1984) concluded that energy intensities[1] increased as the economies moved from agriculture to industries and Cheng (1995), Berndt (1978) and Proops (1984) suggest that energy intensity falls when the economy moves from industry to service.

Given the developmental stage at which the Fijian economy is now, it is quite reasonable to assume a strong relationship between energy and economic growth. This assertion is confirmed by a general equilibrium analysis by Sturton (1992), which revealed that Fiji experienced one of the highest real exchange rates during the years following the energy price shocks. His analysis reported a 7 to 8 per cent deterioration in the terms of trade for selected Pacific island countries including Fiji and the report concluded that the energy price shocks have resulted in considerable reduction in the real standard of living of the people.

Energy and economic growth in Fiji

Pattern of energy consumption

The primary energy consumption in Fiji is derived from three sources: coal, crude oil and electricity. Table 1 shows the quantities of each of these energy products consumed in Fiji for the period from 1977 to 1992. While crude oil continues to be the dominant source for total energy consumption, its consumption in Fiji has declined since 1977. Part of this decline in crude oil consumption may stem from the substitution of diesel electric generators with hydropower electricity (World Conservation Union 1993). Prior to 1982—when a major (80 MW) hydropower station was established at Monasavu in Viti Levu—Fiji's electricity demand was met by diesel based generators. This station alone supplies approximately 97% of all electricity consumed in Fiji (Government of Fiji 1993) and there are also a number of mini/micro hydro-schemes in Fiji (see appendix 1). Despite this substitution effect, the increase in crude oil use in the 1991/92 period may well reflect increased economic activity in the economy during this period.

Table 1 Primary energy consumption by fuel type, 1977–92 (annual averages)

Year	Crude oil ('000 barrels)	Coal ('000 tons)	Electricity (gigawatt/hour)
1977–80	1836.5	22.5	189.8
1981–85	1650.4	16.2	239.6
1986–90	1387.4	9.8	332.2
1991–92	1591.5	42.5	425.0

Source ADB 1994.

To gain an insight into how the rate of growth of energy consumption may be associated with the growth rate of individual sectors of the economy, table 2 offers a preliminary glance at the rate of growth of various economic sectors and the overall Fijian economy, with concurrent energy use figures.

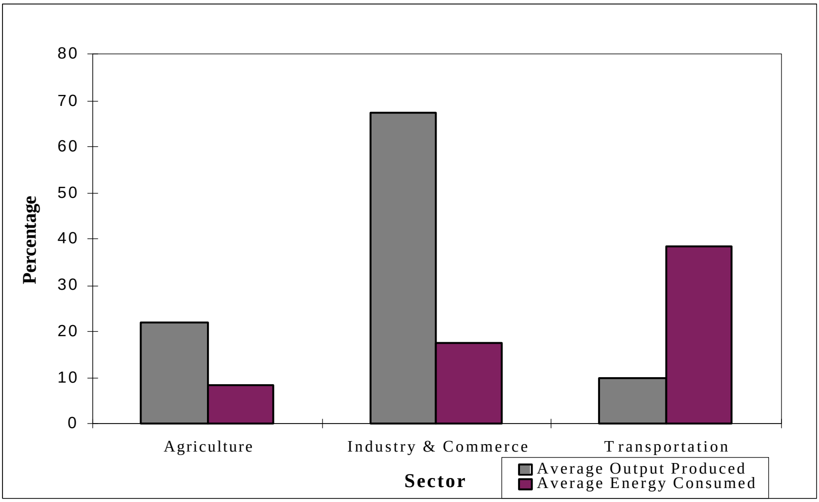
The trend in growth from the late seventies to the late eighties, as displayed in table 2, shows a positive correlation with the pattern of energy use. A better picture of the energy consumption pattern can be obtained by examining the energy intensity of each of these sectors. The total energy consumption can be divided into four sectors: Agriculture, Industry, Transport and Household. Since the contribution of the household sector to total GDP is not measured, it is not included in this part of the analysis. Figure 1 shows the average proportion of energy consumed by agriculture, industry and commerce, and the transport sector. The contributions of each of these sectors towards the GDP are also provided in figure 1.

Table 2 Average annual percentage change in real output and energy, 1976–80

Year	Sectoral Contribution to GDP			GDP	Energy Use
	Agriculture	Industrial	Services		
1970–72	-2.4	5.7	11.7	6.9	na
1973–75	1.1	0.8	8.0	5.1	na
1976–80	5.0	3.8	6.7	4.0	1.9
1981–85	1.7	-2.8	2.5	0.8	0.4
1986–90	6.9	9.1	1.7	3.9	2.3

Source Author's calculation using data from DOE, *Energy Statistics Yearbook* (various years) and BOS, *Current Economic Statistics* (various years).
na = Data not available.

Figure 1 Average sectoral output produced and energy consumption, 1979–92



Source Data obtained from BOS, *Current Economic Statistics* (various years) and DOE, *Energy Statistics Yearbook* (various years).

As figure 1 indicates, the industry and commerce, and agriculture sectors, which contribute more towards gross domestic product (68 per cent and 22 per cent respectively), are less energy intensive (17 and 9 per cent respectively), while the transportation sector, which contributes less (10 per cent) is highly energy intensive (37 per cent). Assuming a certain degree of complementary relationship between the industrial and transportation sectors, the growth of the industry and commerce sector will imply increased use of transportation. This will compound the demand for energy both from increased demand for energy based inputs because of an expanded economy, and also via increased demand for transport, which is a highly energy intensive sector relative to the other sectors of the economy.

Fiji's energy dependency

Fiji continues to be largely dependent on imported energy products (table 3), most of which are oil products. As shown in table 3, the energy dependency has ranged between 66.16 and 91.58% during the 1977–1992 period, declining during the 1977–1990 period and then increasing again, though not to its former level.

Table 3 Energy dependency, 1977–92 (averages)

Year	Net energy import dependency (%)	Net oil import dependency (%)
1977–80	91.58	86.63
1981–85	86.62	83.06
1986–90	66.16	64.18
1991–92	82.35	76.70

Source ADB 1994.

The monetary value of this dependency is summarised in table 4. With respect to total imports, fuel imports alone range from approximately 10 to 26%. In terms of export earnings, the most recent available figure (for 1991–94) is approximately 21%. With a change in growth strategy (to one of export led growth), losing such an amount of export earnings will have a major negative impact on the economy.

Table 4 Average fuel import expenditure, 1970–94

Year	Fuel import as a % of total import	Fuel import as a % of total export
1970–72	10.5	18.3
1973–80	16.4	28.5
1981–85	24.5	46.0
1986–90	14.6	19.9
1991–94	13.2	21.0

Source Author's calculation using data from BOS, *Current Economic Statistics* (various years).

Decomposition of Fiji's energy use

Methodology

Following the work of Sheerin (1992), the total energy use can be decomposed into the following three constituents: output effect, structural change effect and conservation effect. The output effect measures changes in energy consumption purely on the basis that output has grown over time. Structural change effect takes into account the different rates of growth of different sectors and thus different energy intensities. Conservation effect takes into account different levels of conservation and efficiency that may be prevalent in different sectors, causing them to display different levels of energy intensity.

The decomposition of the components of the commercial[2] sector energy demand (E_i) can be illustrated as follows:

$$E_{i0} = e_{i0}Q_{i0} \qquad (1)$$
$$E_{i1} = e_{i1}Q_{i0} \qquad (2)$$

where e_{i0} and e_{i1} refer to commercial sector (i) energy intensity in the initial (0) and final (1) years respectively, and Q_{i0} and Q_{i1} refer to commercial sector output in the initial and final years.

The difference in energy demand in commercial sector i between the two years is, therefore,

$$(E_{i1} - E_{i0}) = e_{i1}Q_{i1} - e_{i0}Q_{i0} \tag{3}$$

The hypothetical consumption of energy in sector i (E^*_{i1}) in the terminal year, on the basis of its intensity of use in the base year, can be estimated. (Q^*_{i1}) the hypothetical output in the final year, is estimated utilising the structure of the economy in its initial year. Thus

$$E^*_{i1} = Q^*_{i1} e_{i1} \tag{4}$$

and the change in aggregate commercial energy use (the output effect) is calculated by summing over sectors:

$$\sum_i (E^*_{i1} - E_{i0}) = \sum_i (e_0 Q^*_1 - e_0 Q_0) = \sum_i (Q^*_1 - Q_0) e_0 \tag{5}$$

The aggregate structural change effect is calculated as the sum of the differences between actual and hypothetical output in each sector in the terminal year, assuming that sector energy intensity is unchanged:

$$\sum_i (Q^*_{i1} - Q_{i1}) e_{i0} \tag{6}$$

and the aggregate energy intensity effect is calculated by summing over sectors the differences between actual energy use in the terminal year and the hypothetical energy use assuming the energy intensity of the initial year:

$$\sum_i Q_{i1}(e_{i1} - e_{i0}) \tag{7}$$

Together, the (net) algebraic sum of these three effects is the total observed change in commercial energy consumption between base year 0 and terminal year 1 over all i industries:

$$\sum_i (E_{i1} - E_{i0}) = \sum_i (Q^*_{i1} - Q_{i0}) e_{i0} + \sum_i (Q_{i1} - Q^*_{i1}) e_{i0} + \sum_i (e_{i1} - e_{i0}) Q_{i1} \tag{8}$$

Any of the four components can carry a positive or negative sign.

Results and discussion

Commercial energy demand. The hypothetical levels of output for the three sectors—Agriculture, Industry and Service, and Transportation—were obtained by estimating the trend line using Ordinary Least Squares estimates for the period 1970–87. Predicted and actual values of the output for the year 1992 are provided in appendix 2. Detailed results from the decomposition of net change in energy into its three components are presented in appendix 3. A summary of the results is presented in table 5. The analysis reveals that total energy use in the commercial sector of Fiji has indeed expanded. The net result, however, contains a negative structural change effect and a very substantial (negative) conservation effect. The negative structural effect is a direct result of a fall in energy intensity of the transport sector by approximately 40% (appendix 4). One of the visible changes that have occurred in the economy in the mid-1980s was, as already noted, the establishment of hydropower electricity, which has substituted a significant portion of the imported oil products.

Table 5 Output, structural change and energy intensity effects in the commercial sector, 1985 and 1992

Source	Terajoules
Aggregate output growth effect	2312.29
Structural change effect	-739.02
Conservation effect	-1157.31
Net change in energy use	415.95

Household energy demand. The household energy consumption rate in Fiji since 1980 has increased significantly (table 6). However, since the growth rate of domestic energy consumption is lower than the growth rate of population (table 7), the per capita household energy consumption has declined over this period (table 6).

Table 6 Household energy consumption, 1980–92

Year	Energy Consumption (Terajoules)	Population	Household per Capita Energy Consumption (Terajoules)
1980	4,030	634,000	0.0064
1985	4,062	697,000	0.0058
1990	4,513	732,000	0.0062
1992	4,401	749,358	0.0059

Source Data obtained from BOS, *Current Economic Statistics* (various years) and DOE, *Energy Statistics Yearbook* (various years).

Table 7 Average annual percentage change in household energy consumption and population, 1981–92

Year	Energy Consumption	Population	Consumption per Capita
1981–85	0.10	1.99	0.61
1986–92	1.85	1.19	1.59
1981–92	-1.23	1.18	0.60

Source Data obtained from BOS, *Current Economic Statistics* (various years) and DOE, *Energy Statistics Yearbook* (various years).

The net change in energy consumption is also decomposed into its three components: changes due to the population growth trend, changes due to population structure, and behavioural and technical change. Results of the decomposition using the methodology outlined earlier are presented in table 8. The growth trend in population alone has resulted in a growth in energy consumption of 382.21 terajoules. Demographic changes, and lack of conservation and inefficiency in energy use have also contributed to growth in energy consumption (96.13 and 52.92 terajoules), with a net change in energy consumption of 531.26 terajoules.

Table 8 Demographic and behavioural change effects in the household sector

Sources	Terajoules
Imputed growth in household energy consumption due to trend growth in population and energy intensity	382.21
Effect due to demographic change	96.13
Effect due to behavioural and technical change	52.92
Net change in household energy use	531.26

Summary and policy implications

The review of Fiji's energy dependency over the last two decades indicates that if efforts are not made either to increase conservation and efficiency of energy use or to move towards greater use of renewable energy sources, increased demand for imported energy products will divert an increasing proportion of export earnings towards meeting the import bill. Utilising a basic comparative statics approach, the energy use in the commercial and household sectors of Fiji's economy was decomposed into structural change effects, energy intensity effects and output growth effects.

The analysis indicates that the rate of expansion of total energy use in the commercial sector was sharply reduced as a result of (a) a structural change in the economy and (b) an increase in the efficiency of energy use. The expansion in the rate of energy use in the household sector occurred mainly as a result of population increase, although inefficient energy use practices have also contributed to this growth in household consumption of energy.

Government policy has espoused an increase in the efficiency with which energy products are used and promotion of the use of indigenous renewable energy resources (Government of Fiji 1993), but will fall short of achieving the target if the statement of these policies is not actively followed up with the necessary technical, financial and physical resources. Though this study shows that improved efficiency of energy use has reduced the rate of expansion of energy use in the commercial sector, the continued dependence on imported energy products indicates that these and other options need to be pursued vigorously if the dependency is to be reduced to any appreciable extent in the near future.

Currie (1996) provides a summary of various supply and demand side measures that the Department of Energy is pursuing to reduce the dependency of energy use in Fiji. On the supply side, potential renewable energy sources are being explored, including geothermal, hydro-, wave and wind power. On the demand side, efforts are being made to increase energy efficiency and conservation through the use of efficient technology, and employing good energy management practices such as heat recovery, fuel switching and adoption of good energy housekeeping practices.

Efforts on the demand side will require educating the consumers about the ‘why’ and ‘how’ of energy conservation and efficiency practices. This could be achieved by:

- implementing a mass media campaign to educate the general public on the need to conserve energy and methods that can be adopted by households;
- introducing energy-related subjects in adult education programs;
- launching training programs on energy conservation for technical staff in institutions and factories consuming large amounts of energy; and
- setting up an advisory unit where the public can get free advice on energy related matters (Asian Energy News 1994).

On the supply side, consumers will switch consumption from imported fuel products to alternative energy resources only if the current resource price exceeds the backstop price (i.e. the price of the alternative resource). One way of achieving this might be the use of price policy. The success of price policy depends on the price elasticity of demand for these energy products. If the price elasticity is positive (high), then a price policy could be used. If the price elasticity of demand is low, then the use of price policy would lead to an increase in expenditure on these products and thus a larger import bill. Reddy and Yanagida (1998) report an inelastic demand price for energy products (-0.307) over the 1970–90 period, a result that may be due to the fact that consumers are still not aware of substitutes. Furthermore, if they are aware of such substitutes, they find that the resources are either not readily available or not an economically feasible option. This again reinforces the earlier point, that an appropriate energy use educational program needs to be launched. This should include the above components in it to be effective in reducing the overall energy import dependency of Fiji.

Notes

1 In this analysis energy intensity is measured as total energy consumption (total energy demand measured in terajoules) divided by GDP (in constant F$ million). Terajoule is a common unit of measuring energy using a multiplier of 10^{12}.

2 For the purpose of decomposition analysis, 'commercial' refers inclusively to Agriculture, Industrial and Transportation.

Appendix

Appendix 1 Mini/micro hydro schemes in Fiji

No.	Name of Scheme	Head of capacity (million)	Installed	Installation capacity (KW)	Cost (F$'000)
1	Marist Training Centre, Tutu	~165	20	1975	na
2	Nasoqo	~30	4	1984	40
3	Wairiki Catholic Mission, Taveuni	~50	8	Installed in 1930 repaired in 1986	na
4	Bukuya	~161	100	1989	900
5	Wainikeu	~122	800	1992	4000
6	Vatukarasa	~10	3	1993	150
7	Kadavu Koro	~40	20	1994	80
8	Somosomo	~na	na	na	~4500

Source Department of Energy (1994; 1995).

Appendix 2 Actual vs. predicted levels of real 1992 output by industry (F$m)

Industry Group	Predicted	Actual	Percent Difference
Agriculture	189.0	184.9	-2.2
Commerce and Service	560.5	588.2	4.8
Transportation	123.3	135.8	9.2

Appendix 3 Decomposition of output, structural change and energy intensity effects by sectors

Sector	Output Effect	Structural Effect	Conservation Effect
Agriculture	241.82	29.97	-133.85
Industry and manufacturing	392.69	-133.47	-99.17
Transportation	1677.77	-635.52	-924.29
Overall	2312.29	-739.02	-1157.31

Appendix 4 Sectoral energy intensity, 1980–92 (TJ/F$'000 output)

Year	Agriculture	Industry	Transportation
1980	6.95	4.52	78.16
1981	6.25	4.52	79.07
1982	6.25	3.40	63.75
1983	7.77	4.04	64.94
1984	6.29	4.49	56.20
1985	7.38	4.82	50.84
1986	6.30	5.87	52.09
1987	6.80	4.83	51.62
1988	7.01	4.33	44.88
1989	6.33	4.31	42.07
1990	6.66	4.28	41.54
1991	6.81	4.25	44.16
1992	6.66	4.65	44.00

Source Data obtained from BOS, *Current Economic Statistics* (various years) and DOE, *Energy Statistics Yearbook* (various years).

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Texts and Violence, Lies and Silence
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