ENERGY:
MORE THAN JUST TERAJOULES
FOR THE SOUTH PACIFIC

By

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ABSTRACT

The oil shocks of the 1970's have revealed two important features of this commodity: 1) that all countries use energy to achieve economic and social goals and 2) national stability and autonomy are closely linked to the security of its supplies. The South Pacific region has greatly experienced these effects in its pursuit of development, due to its increasing and nearly complete dependence on imported petroleum products. This is compounded by the situation of high expectations for a quality of life similar to the more developed nations of the Pacific Rim. Therefore the role of energy in these economies must be addressed before it is too late.

ACKNOWLEDGEMENT

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1. INTRODUCTION

1.1 Energy and National Development

The role of energy in economic growth is increasingly being recognized. Conventional thinking now holds that energy exploitation is a vital prerequisite for economic and social development. With this in mind, an essential feature of any development program must include a significant increase in the level of per-capita energy use. (Goldenberg et.al. 1985) However, the oil price shocks of 1973/1974 and 1979/1980 have focussed attention upon a new characteristic of this commodity; that is, the feature of dwindling supplies along with the long term trend of increasing energy costs, these being characteristic of both formal and informal energy economy. Thus, they have raised the question whether it is possible to improve living standards through the coupling of energy exploitation with the achievement of specific development goals. While energy consumption may merely be a measure of quality of life, it is particularily important for the countries with the lowest income levels. This is because energy is almost exclusively used to satisfy the most basic of human needs, for example, food processing. Therefore any constraint on energy consumption, caused by such factors as rising prices, lower income levels, or deforestation, would lead to a decline in nutritional standards and, in turn, a

decline in health and productive capacities. (Wilkinson 1984)

An important feature of energy is that it is an input or output in almost all productive activity and therefore the "linkages between energy and the rest of the economy are strong and intimate". (World Bank,1983,p.61) Also energy investments compete with those in other sectors for what are inevitably scarce investible resources, but decisions on them cannot be taken without consideration of their interrelationship with policies and trends in the rest of the economy. Therefore, this is a derived demand, in that "the value lies basically in the contribution that energy makes to the achievement of some level of satisfaction" (Siddayoo, 1982, p.66) or, in other words, is an achievement of an increase in attainment of economic and social desires.

We can see energy's importance in the fact that we substitute mechanical and electrical energy for human labour in fields, factories, service establishments, and even in homes and offices, with the motivation being the desire to increase efficiency both in the use of time and manpower. (Siddayoo 1982) With the present situation of questionable supplies, along with highly volatile cost characteristics, the role of energy in the attainment of some level of aggregate and individual satisfaction is of major concern.

Energy is also important in that it can both create employment and allow for the possibility for increased income

generated through its exploitation. These are quite often two of the main principles of regional development. This energy development can also make possible productive activities previously impossible through lack of, or inadequate supply. (Hughes 1981) This potential economic growth is intended to both raise the standard of living and to equitably distribute resources. This can be achieved by raising the productivity in the major sectors through the infusion of energy intensive technology. (Tsusaka 1984) Therefore, the better a country can exploit its energy supply, the better it will be able to dictate the cost of production. This will be a benefit for exports and also in import substitution.

The importance of energy is not limited to its role in development, it is also essential to a country's national viability and security. This came to bear after the 1979 Iranian Revolution, with the subsequent selective supply constraints. (Fesharaki 1982) If a country finds itself supporting the losing side in any future disputes, it may face the unenviable task of securing its energy supply from some other domestic or international source. Energy plays an important role in a country's economic status; thereby, being at the discretion of some foreign countries' desires may severely limit a country's autonomy.

The risk to secure energy supply increases with a country's dependence on commercial imported energy. If a

significant proportion of a country's economic development is threatened through lack of energy resources, the stability of that country may be severely jeopardized. Therefore this may cause countries to choose a less desirable course of development so that political independence is not restricted in the future. This decision is made with the knowledge that the wrong choice may severely limit future stability.

1.2. Countries

The global effect of energy on development has had spatially distinct results. These are seen by the differential structural effects within a country, either regionally or on a rural/urban basis, to the effects on a national scale, either at different stages of development, or locational and geographical. My research objective will include examining these different scales and, through this, a presentation of the different forms of energy used in the pursuit of development will be made. An area which exhibits all these characteristics is the islands of the South Pacific.

This region consists of 22 Island states and territories with a population of 5,200,000 spread over 29,000,000 square kilometres. (see Table 1.) (Mackensen & Hinrichsen 1984) Another interesting feature of this area which complicates the role of energy, is that many of these countries or territories are spatially divided; French

Polynesia covers an area of 2500 kilometres. This is expanded upon in chapter 2.(see Table 2.) The lack of size of many of these countries can be seen in the fact that the common Mercator world map has to be exaggerated in order for some of the islands to even be visible, and some even appear twice. (Mackensen & Hinrichsen 1984)

Table 1. Countries: Population and Land Area (mid-1982)

Country	Population	Area	Country	Population	Area
American Samoa	32,900	197	Northern Mariana Islands	18,400	471
Cook Islands	17,000*	240	Palua	12,400	460
Federated States of Micronesia	74,400	710	Papua New Guinea	3,197,000*	462,243
Fiji	672,000*	18,372	Pitcairn Island	60	5
French Polynesia	158,800	3,265	Solomon Islands	260,000*	27,556
Guam	108,400	541	Tokelau	1,580	10
Kiribati	61,900*	690	Tonga	98,100*	699
Marshall Islands	31,800	180	Tuvalua	7,700	26
			Vanuatu	125,600	11,800
Nauru	8,400	21	Wallis & Fatuna	11,900	255
New Caledonia	145,000	19,103	Western Samoa	161,000*	2,935
Nieu	3,150	259			

Source:ADB 1985; Connell 1984. * denotes 1983 populations

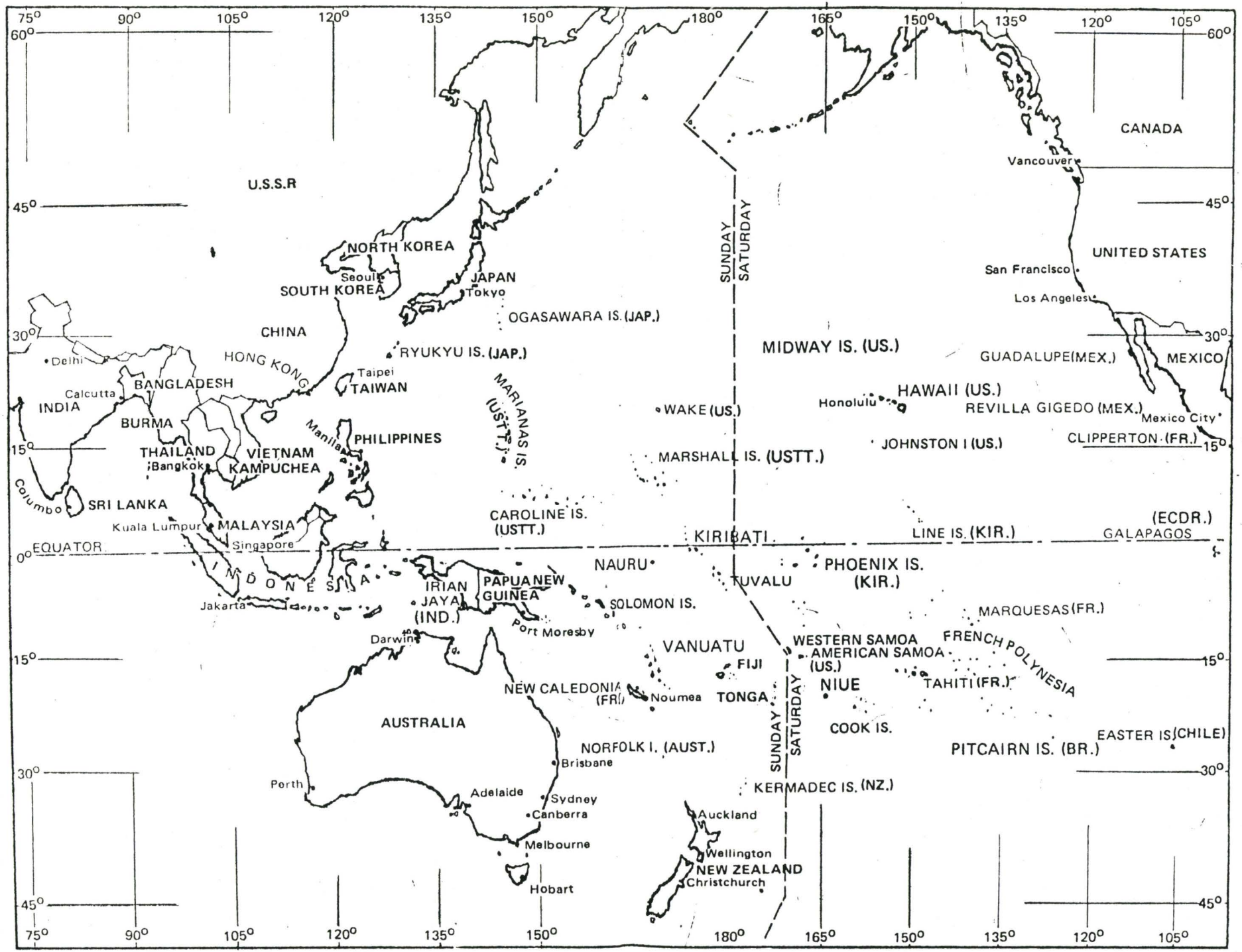
In this whole area, there is only 87,757 square kilometres of land, and only 2,200,000 people, not including Papua New Guinea. As seen in Map 1, this region is located in the Southern Pacific and is bordered by the Phillipines to the north, Australia to the west, New Zealand to the south, and Hawaii to the east.

2. Background

2.1. History of Energy in the Region

In the past century and a half, the Pacific area has changed from being a net exporter of energy, in the form of whale and coconut oil, to an area almost entirely dependent on imports. The shift began in the late nineteenth century with merchants demonstrating the attractive qualities of kerosene for lighting and cooking. This, in turn, saw the eventual change to imported energy.

Solid fuel imports were of early significance in Fiji, where New South Wales coal was being imported by 1880 for early sugar mills and steam cane railways; much larger volumes of coal were imported a little later for nickel-smelting in New Caledonia. (Bloomfield & Bloomfield 1976) In 1950, the total commercial energy in developing Oceania was still modest at only 250,000 metric tons of coal equivalent, with New Caledonia and Fiji consuming 55% and 20% of the total respectively. The significance of industry can be seen since approximately 50% of commercial energy was solid, with liquid less than 40%. Non-commercial energy was estimated to supply in excess of 90% of all energy consumed in Papua New Guinea and the Solomon Islands, while in Fiji, probably a better representative of other islands, was roughly 75% non commercial. (Asian Development Bank 1982) Total commercial energy use increased 12 fold between 1950 and 1975 and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especially from 1964 to 1974. (Bloomfield & Bloomfield 1976) During the 1960's, in the process of developing their economies, most of the countries in the area rapidly increased their consumption of commercial energy, especially oil products. This made oil the dominant fuel in the power, transport and industrial sectors. This dependency arose as oil compared with coal, the major fuel it displaced, is cleaner, easier to handle, and until recently, less expensive. (Brown 1982) From early stages of the large scale consumption of crude oil, it appeared quite abundant on a global scale, although it was clearly inequitably distributed. This left the area in a situation whereby in 1974, 98% of total commercial energy was imported, while in 1950 only 85% was imported. This dependence is also seen in that local production of commercial energy (entirely hydro-electric), declined as a proportion of total energy consumed from 12.2% in 1950 to less than 2% in 1974. (Bloomfield & Bloomfield 1976) While absolute volumes obviously have increased substantially there has also been a substantial, change in composition. Solid fuel imports decreased absolutely after a peak in mid 1950's, and fell proportionally from 53% of total energy imports in 1950 to 26% in 1960, 1.5% in 1970 and .2% in 1974. Consequently liquid fuel imports have dominated the pattern of energy imports in developing Oceania. The total volume of liquid imports rose from 111,000 metric ton coal

equivalent in 1950, 778,000 in 1960, 2,267,000 in 1970 and approximately 5,460,000 in 1974. (ADB 1982)

While the composition and quantity has changed, the supplier has as well. Originally all fuel imports were refined petroleum products from the Persian Gulf and the U.S.. In the late 1950's and early 1960's, Australia and Singapore became suppliers, with the U.S. becoming much less important. Since 1971, the supply has also included liquid crude petroleum from Guam, but the most important supplier is the politically unstable Middle East region.

2.2. Energy/Debt Crisis in the Pacific

The most significant external events which have influenced the economic growth of the region during the past 15 years have been the two oil shocks coupled with the prolonged recession in the industrialized countries. This energy problem is three dimensional. The immediate effect of the oil price increases was a drastic deterioration in the balance of payments. This is due to the change from traditional, low energy using activities to modern, high production technology, since they have required large inputs of energy. Stability tests have shown that the accelerated rise in energy prices between 1973 and 1980 did not seem to affect the basic energy-gross domestic product (GDP) relationship in both industrialized and developing countries. (Zilberfarb & Adams 1981) That is, the ratio of per capita

change between energy consumption to a change in GDP. For example, a typical scenario for the South Pacific can be seen, as between 1970 and 1978, the Cook Islands had an elasticity of 1.67. This is in comparison to the developed countries being around 1. This means that much more energy had to be injected into the economy to get a marginal increase in GDP. Other South Pacific examples can be seen in Appendix A. Thus the economic growth of developing countries requires a more than proportionate increase in energy consumption and, as such, puts a relatively heavier burden on these countries' energy bills. The economic dependence and vulnerability of Pacific island nations is largely the result of the high cost of energy coupled with the region's almost complete dependence on imported fuels. (Harnnett et. al. 1984) Any increase in energy costs can be critical as demand in many states is relatively inelastic, at least in the short term, without affecting development plans. As oil prices increase, more of a country's scarce foreign exchange must go for fuel, which, in turn, leaves less funds available for other equally important imports such as food and medical supplies. (see Figure 2.) Since inflation and a country's debt are affected by increased fuel costs, the economies which are more dependent on petroleum are more vulnerable. (South Pacific Economic Bureau 1980) Moreover, exports like crops or minerals require processing and shipping. Any increase in

fuel costs can have a significant impact on the ability of many Pacific nations to continue their export drive.

While the crisis in energy has many roots, the most important is the extent to which the nations permitted themselves to become dependent upon crude oil for their heat, light, and power. This crisis has been perpetuated by the rising demand for a higher standard of material living among islanders. These aspirations are higher and rising faster than in other less developed countries, because of the close relationship between island states and their developed metropolitan neighbours. (Shand 1980)

Energy problems in the Pacific are particularly large, as the region relies heavily on Middle East imports. The political problems of Iran/Iraq reflect probable constraints on economic well being for the region in years to come. This has grave implications since long term planning can only be based on tentative situations.

The purpose of this report will be to discuss the perelous condition created by the energy dilemma. If the region does not take major steps to decrease its dependence upon imported oil, it will be extremely vulnerable to any disruption in supplies. By examining the differential role of energy on rural, urban and domestic development, a platform will be put in place for examining other possible energy futures. This platform can then be used for analyzing various

The Value of Energy as a % of Exports in Western Samoa

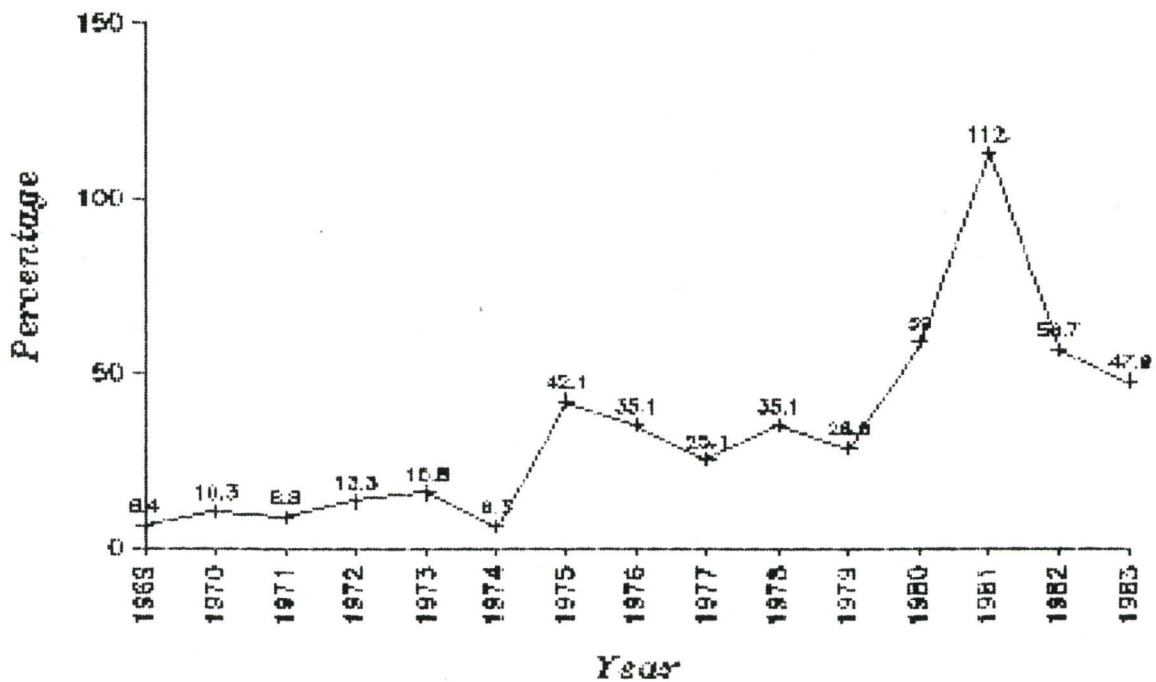

FIGURE 1.

options for solving this precarious energy position.

For example, should a major military or political upheaval in the Mid East halt crude oil exports, the economic, social and political effects upon the region could be disastrous. Even without a cutoff, a continual dependence would increasingly be harmful as the cost of importing oil probably will continue to rise in the long term more rapidly than their ability to pay. Countries need to look at ways to diversify supplies, in type and/or supply for the long term. In the long term, because 20 years is too short to allow the development of many alternative options, strenuous efforts will be needed to replace oil as a primary energy source. This should include the use of natural gas, coal, and renewable energy resources such as hydro power. Also biomass and the direct utility of solar energy in various ways.

In the initial stages, assuming no excess demand exists, a rise the in price of oil has two main short run effects on oil imports: 1) substitution effects against oil and 2) an income effect. (Siddayoo 1982) The substitution effects take the form of 1) shifts to other energy sources, domestically produced or imported at lower prices; 2) shifts to other factors of production, such as capital; 3) reductions in the consumption of energy intensive products as price increases relative to those of less energy intensive products. In the short run, substitution effects will likely be

restricted by a time lag due to the inability of rapid capital adjustments to the infrastructure in place.

The income effects felt will include a drop in real income as a result of the increases in the cost of oil. Assuming that no substitution is possible (a quite realistic assumption for the short term), the same amount of funds will buy less oil and the same total allocation of funds will buy less of all goods. The income effect will be felt both in the foreign sector and in the domestic sector: 1) in the balance of payments, because effective purchasing power of foreign exchange earnings changes, and 2) in the domestic sector, because of the impact on the cost of inputs, directly through oil import costs and indirectly through the repercussions of higher oil import costs.

Therefore the dilemma facing the South Pacific islands is the need to increase the amount of imported commercial energy such that they can pursue their economic development strategies, without further increasing their government's debt. In the short term, significant domestic substitutes are not expected to be available, and technology limits their choice of other fuels. To reduce the burden, alternative indigenous energy resources must be developed at high capital costs. Coupled with this move is a tendency to underestimate the impact of energy price increases and the effect on overall costs. This is due to the lack of recognition for the mutual

dependency between the cost of basic inputs of production with indirect energy costs. This means that price increases have extensive repercussions throughout the system.

A third energy problem results from the already greatly diminished non-commercial energy resources of rural being further reduced due to increasingly high costs of substitute fuel. While this problem may not affect all countries to the same extent, each feels some of the effects of increased uncontrolled exploitation of these resources. This may take the form of animal resource use, diversion of water routes or through the use of woodfuels. All of these problems create indirect impacts on the environments of the given countries, which may in turn create worse problems than the energy dilemma. For example, many South Pacific nations depend heavily on traditional sources of energy, most of which are renewable, including firewood, charcoal, crop residues, and animal dung. This source of energy is particularly important for the urban poor, especially for cooking and in the rural areas. The problem though, is that the demand in some cases is much larger than supply. This over-exploitation creates problems such as deforestation, which in turn causes erosion, siltation and desertification as fuelwood supplies are exhausted. Animal and crop residues are then burned, depriving soils of valuable nutrients and organic conditioning material. (World Bank 1980)

3. The Uniqueness of the South Pacific Region

This area of the world is distinct from all others in many ways, and therefore its energy problems are unique. Because of this fact, the South Pacific should not blindly adopt any other country's solution , as it will quite likely not be entirely adequate to solve the region's problems. In proposing options for this area, one must take into account the delineating factors: a) geography and b) economy, which in turn dictate the specific energy requirements needed by these islands in their pursuit of development.

3.1. Geography

The first distinguishing feature is the unique geography of the area. The limited land mass imposes obvious constraints upon any possible expansion of biomass fuel supplies. This is compounded by the problem of continued population growth and by the fact that the majority of the inhabitants live in rural areas. Therefore, in supplying energy to a country's consumers, large power grids must be constructed which minimize efficiency of supply.

Archipelagos pose another problem, if governments try to equitably supply all of one's constituents, it may mean repetitions of small inefficient energy resources. This drastically reduces any possible economies of scale. Another problem is that underwater electrical transmission lines have had little success over any great distance. Therefore, Papua

New Guinea's blessing of hydropower on various islands, does not mean that those not blessed will have a supply, even though the quantity is sufficient. Large scale problems are also created by the fact that internal transport severely limits many development hopes in that it fragments the clients of any prospective investments and also greatly increases supply costs. This is further complicated by the fact that these islands are isolated even without the fragmentation of demand. This is compounded due to the area's special difficulties regarding external communications. (United Nations 1974) Isolation becomes restrictive with removal from main air and shipping routes and world markets.

Table 2. Isolation: Percentage Urban and Archipelago Size

Country	%Urban	Archipelago	Country	%Urban	Archipelago
American Samoa	34	50	Northern Marshall Islands	79	--
Cook Islands	22	--	Palua	62	--
Federated States of Micronesia	23	--	Papua New Guinea	13	1500
Fiji	38	520	Pitcairn Island	--	--
French Polynesia	51	2460	Solomon Islands	8	800
Guam	100	6	Tokelau	--	--
Kiribati	29	1590	Tonga	26	55
Mariana Islands	--	--	Tuaulu	28	400
Nauru	47	--	Vanuatu	12	680
New Caledonia	53	--	Wallis & Fatuna	--	--
Nieu	--	--	Western Samoa	20	180

Source: Connell 1984.

Shand (1980) identifies four facts that are compounded by the islands' small land area. Generally, we will find that 1) a narrower range of production conditions exists and thus the range of primary commodities produced has a greater vulnerability to natural hazards; 2) the competitive disadvantage of low export volume is further complicated by isolation and fragmentation; 3) there tends to be a greater concentration of exports in particular overseas markets, since there are few exchange categories and the output of each is low; 4) there is greater market vulnerability, since the individual countries are price takers and as such, become the subject to the fluctuations of prices in world markets.

3.2. Economy

Kristoferson et. al. identify a set of factors which, in combination, creates the economic context that limits the energy resources and dictates the needs. (1985) 1) Limited demand retards the potential for indigenous production and, as a result, limits the possible multiplier effects associated with most economic activities; 2) exports are characteristically dominated by one or two primary commodities that, in combination with the sometimes present tourism, dominate export earnings. This is in direct contrast to the fact that the restricted domestic production means that small islands must import a wide range of goods, including most of

their commercial fuels. This is compounded by the small size of demand and the geographic remoteness of many islands, which means that these imports are expensive and subject to extreme fluctuations in availability. Because these economies are extremely open, they make any form of integrated long term development planning almost impossible to implement, since so much of the economy is beyond the direct control of the local planners. Another less acknowledged problem is that many forms of infrastructure and administrative costs are of a fixed minimum size. This means that a greater share of the Gross Domestic Product (GDP) must go to such activities, which, in turn, requires a reduction of funds from other sectors of the economy. (Kristoferson et. al. 1985)

Shand (1980) believes, through the combination of the above situation, that the diseconomies of small-scale and the per-capita cost of various social and general administrative services greatly limit the scope for raising internal resources to meet these needs. The gap which is then created can only be narrowed by external development with budgetary aid. This smallness eliminates any possibility of transplanting macro state economic policy to this micro level. Their great dependence on imports and exports in the formal economy means that they have very special features which cannot be ignored. The close integration of these small countries with the world economy, in comparison to larger

countries with their own viable markets and production sites, leaves the South Pacific countries vulnerable to foreign economic instability.

The economic disadvantages of these countries is not simply the result of their small scale, but is also caused by their reduced scope for specialization and their limited capacity for shifting resources. (Hope 1980) These two factors are major constraints on any planned economic development in the future. This makes the role of energy even more important in the economies of these nations. In consideration of all the presented limiting factors, energy in these economies tends not to be a benefit, but rather a hindrance. If these countries are to improve their economic stability, they must decrease their energy disadvantage.

The economic characteristic that must still be addressed is the fact, that although there is a high rate of growth in most of these countries, the high average income conceals many of the inequalities in the distribution of wealth. There is also the problem that these countries are not seeing a structural transformation, that is, the development of these economies still depends heavily upon external stimuli. This means that the lowest income group, if not the country as a whole, will be extremely vulnerable to any disruptions in the world economy.

4. Sectoral Effects of Energy in the Region.

The importance of energy with respect to development can best be seen through a sectoral analysis. Energy's role has many facets, from its use in the informal economy, particularly in rural areas and domestic uses, to the introduction of commercial energy, generally in urban uses. As expected, the end use of energy varies, as does the source of supply. The range of choices includes the commercially imported oil products to the locally produced fuelwood supplies or dung cakes. Therefore, to address energy's role in development, an analysis of the sectoral end uses and their altering role through time must be assessed.

4.1. Urban Energy Use

Goldenberg et. al. (1985) identifies the evolutionary role of energy in the built enviroment and urban sector from the infrastructural building period through to the post-industrial phase. The initial period of growth was the creation of infrastructure for development. This was delineated by the rapid increase seen in the production and consumption of basic materials such as steel and cement. These provided the building blocks for construction of factories, commercial buildings, roads, railways and bridges. During this period, the production and use of these materials tended to grow much faster than the economy as a whole. Since the basic material processing industries are so energy

intensive, industrial energy use would typically grow much more rapidly than GDP during this period. This is the stage at which many of these countries found themselves during the energy crisis of the 1970's. In all countries, industrial strategies were closely linked to energy demand. Thus increasing energy costs have had a strong bearing on the profitability of different industrial options. (World Bank 1983) Therefore, the oil price shocks created a context in which these nations, along with the rest of the world, had to recognize and accept the vital role which energy played.

Nations such as Tonga appear best suited to weather any increased cost of energy, because of their lack of industrial and infrastructural development. The more heavily industrialized nations and territories, that is, Papua New Guinea, New Caledonia, etc. consume much larger amounts of energy and thus are more vulnerable to any price increase. (Harnett et. al. 1984) This, in turn, can weaken the development prospects for these nations.

As data tends to be quite limited or is of questionable reliability, and thus is hard to make comaparisons with, this section will concentrate more on the seemingly more reliable sources from Fiji, Solomon Islands and Papua New Guinea. As these are not a true representation of many of these islands in the region, this will have to be acknowledged when trying to extrapolate the data to any

particular country. It is hoped, though, that this may offer a general example of the problem at hand.

4.1.1. Industrial Energy Use

Analyzing the demand in Fiji, industries accounted for approximately 42% of the total energy consumed between 1979 and 1982. The sector was dominated mostly by sugar manufacturing and its energy supply (bagasse- the residue which remains after crushing sugarcane). (Gunasekera 1984) Approximately 4.7% and 4.4% of the total energy consumed was supplied by oil and petroleum generated electricity, respectively. Coal is only a minor energy source in Fiji, though rapidly increasing. Only 3% of the total energy consumed is coal generated. This is solely used for cement production. Local utilization of coal increased to 18,000 tons in 1984 from only 1,700 tons in 1972. (Gunasekera 1984) Traditional fuels accounted for less than 20% of energy supply between 1979 and 1982 as well. (see Table 3.) As the

Table 3. Energy use by industry and transportation in Fiji. (in terajoules)

Sector	Coal	Petrol		Electric		Traditional		Total	
Year	'79 & '82	'79	'82	'79	'82	'79	'82	'79	'82
Industry	674	1366	941	771	833	557	586	3368	3034
Transit		4704	5165					4704	5165
Air		132	44					132	44
Road		3019	3400					3019	3400
Water		1553	1721					1553	1721
Total Used	674	6804	6884	1103	1168	2803	2979	11385	11705

Source: United Nations 1985.

industrial sector plays a large role in any country's planned for development, Fiji may be in a difficult position if the seemingly imminent energy cost increases occur.

In 1982 for Papua New Guinea, industry only accounted for 17.5% sectoral demand energy in terajoules with only a marginal growth over the last several years. Approximately 21% of all imported petroleum products were used by the industrial sector. This means that any future increase in the cost of imported petroleum will be felt quite strongly. This may decrease the potential for exports and/or also limit the potential for import substitution.

One advantage that may hold future promise is the abundance of hydro power. If Papua New Guinea can build upon its potential electricity supply, increased export competitiveness may result. In 1982 approximately 77% of the total hydro electricity produced was consumed by the industrial sector. The reason total energy use is relatively insignificant in comparison to Fiji and most likely many other islands, is that there is a large exploitation of traditional fuels such as biomass or fuelwood. These fuels account for approximately 50% of energy demanded by industry.

As for the Solomon Islands, in the period from 1979 to 1982 roughly 34% of the petroleum products were used by the industrial sector. But these imported products accounted for approximately 97% of industrial energy consumed. This is a frightful situation, because if any increase in energy costs

does occur, the industrial sector will be devastated. If the Solomon Islands are to develop, they will certainly have to try and diversify their energy sources. Hopefully this diversification will come about through the exploitation of reliable indigenous supplies.

In a World Bank report (1980 p.65), it is revealed that an essential savings of just over 20% of commercial energy consumption could be made in 10 years in the industrial sector. This was mostly based upon "retrofitting and technical improvements". While this would not hold completely true for all countries in the region, it does present some hope for the area. If development is to be achieved, then these countries should seek not only the cheapest energy source available but also the most reliable for the foreseeable future.If not, the country may soon see itself in the same position as that created after 1980.

4.1.2. Commercial & Services

The commercial and service sector also represents a facet of social and economic development which tends to be highly energy intensive. In many of the smaller nations, the service sector may represent a disproportionately high rate of energy consumption. In Fiji, 40% of petroleum electricity production is consumed by this sector. (Gunasekera 1984)

This sector also includes the highly energy intensive,

modern tourism industry. This can be seen by the fact that energy requirements of tourist industry are high, with air conditioned hotels and sophisticated services a prerequisite; a rapid expansion of tourism will further burden electrical generation capacity. (Gunasekera 1984) While only 5% of the total energy is consumed by this sector, its dependence on petroleum based electricity makes it quite vulnerable to any future withdrawl of supply or increases in cost. Because of the large dependence on electricity - almost 100% - the source of power generation becomes the key in addressing any future strategies. Countries blessed with indigenous energy supplies which are adaptable to electricity production will have a real advantage in the future over their less fortunate neighbours.

What also must be recognized about the commercial and service sector is that if future development does take place, the absolute share of growth will be consistent, though not at the same rate as newly developing sectors. Consumers will be able to afford the pleasures of this sector and will increasingly demand more from it.

A second feature observed in this sector is the fact that in many nations, the true government cost for energy is so high, that other services have to be neglected. For example, in Kiribati, in 1982, 50% of the country's budget goes to producing electricity. (Kinnicutt 1983) Therefore the energy/development dilemma is not solely a question of inputs

in consumer goods, but is also relevant as a provision of governmental expenditures for infrastructure.

4.1.3. Transportation

Transportation offers the most complex dilemma. One obvious goal of national development is to unify a country. Unfortunately the jurisdictional structure of many of these nations dictates that this can only be accomplished by massive outlays of capital which in turn "create" an increased demand. The role of transportation in outgrowth is increased by the fact that development also requires international integration. Therefore, a cyclical process of energy use is put in place by the prospective aim for an economic, social and national development.

Some interesting facts about energy use in transportation should first be spelled out. In the Pacific region, the average per capita use of gasoline is a third of a gallon per day. This is in comparison to Hawaii where consumption is about four and a half gallons of gasoline per capita. (Kinnicutt 1983) Hawaii's military and civilian population use three times more petrol, than all the South Pacific islands together. This reveals the potential growth for energy use in the near future.

The energy question depends, not only on volume, but also on price. The cost of delivering petroleum reflects the

geographical fact of isolation and small markets. Since it is impossible to bring tankers to one convenient stop and unload large quantities in the Pacific, small vessels must travel from place to place unloading small quantities. This means an increase in the relative cost of transportation. The price per gallon also reflects the cost of storage facilities. Unfortunately, in the Pacific, size offers no economies of scale. But because petroleum is so important, a secure supply is higher on the priority list than price. In Los Angeles, in 1982, gasoline was $.70, per gallon delivered from refinery to service station, while in the Cook Islands, that same gallon was $1.75, delivered from terminal to service station. (Kinnicutt 1983) This has obvious effects on development.

With disproportionately high fuel prices, attracting the tourist or business dollar becomes increasingly difficult. If reduced service or investment occurs, then further impingement on foreign exchange results, putting the country in an even more difficult position for development. Thus the fuel costs influence the price of all imports into the country. Especially important is the maintenance of the ability of a country's exports to be competitive on the foreign markets. This means a close dependence on the relative cost of energy as an input for commodities. The larger the relative cost, the less likely the output will be competitive.

On the Solomon Islands, energy demanded by the

transport sector remained fairly constant at approximately 28% of total energy consumed, over the period between 1979 and 1982. The use of road transport is the major consumer at roughly 75% of total transport petroleum. The transport sector's dependence on oil can be seen in that 65% of all imported petroleum is used by transportation. As there are no viable alternatives to oil as a source of power for transport, and since energy conservation in transport has proven extremely difficult, transportation will continue in at least the short term to be almost solely petroleum dependent. Therefore, transportation linkages with development are precarious but have been proven necessary.

As seen in Table 4.,in Fiji, the transport sector accounted for 44% of the total energy consumed in 1982 in comparison to 41% in 1979. Road transport dominated with 66% of the total transport energy consumed being used by this mode. An interesting feature is that 33% of transport energy is used by air travel. This reflects the importance of the linkages to the outside world for both trade and tourism. Again, as noted in the Solomon Islands example, all the fuel for the transport sector in Fiji was imported petroleum products with no domestic production now or in the foreseeable future.

Papua New Guinea is characterized by a much lower energy intensity in comparison to the two former countries.

The use of energy in the transport sector only accounted for 15% of the total energy demanded. The problem, however, still arises of complete dependence on imported petroleum. Of the total imported petroleum, the transport sector consumed roughly three quarters, with road and air using 72% and 16% respectively of the transport sector's energy. This has shown little change over the period between 1979 and 1982. Since, as earlier stated, little substitution can take place, improved efficiency and conservation is needed.

The transportation sector potentially offers large conservation opportunities. Although some Pacific countries have used fiscal means, quotas, and engine size limitations, in attempts to reduce transport fuel use, it has so far proven to be difficult to organize across all modes. (Johnston 1984) But considering that transportation requires safe, high density ,high quality fuel, it is a sector where petroleum will remain very important for many years to come.

4.2. Rural Energy Demand

The South Pacific developing countries are confronted with energy problems differing from the industrialized countries, partially because the majority of the population lives in rural areas. As seen in Table 2., out of 22 island nations and territories in the South Pacific, only 4 have an urban population greater than 55%, though growing. Differences

are also seen within the countries themselves as the rural areas are distinct from the urban areas. Also consumption per capita and composition of fuel mix differ widely.(ADB 1982) To increase agricultural production and to develop small-scale industries in these areas means an increase in the quantity of energy injected into the system in the form of fertilizers, irrigation of water, funds for heating and cooling, and modest amounts of electricity. (Brown 1984) The three primary places in which energy is felt in the rural areas are : directly in the agricultural and rural electrification sector, and indirectly and directly in the natural environment.

4.2.1. Agricultural Energy Demand

Almost without exception, national development plans have called for substantially expanded agricultural production and processing.(Johnston 1984) For these and other development goals to succeed, consumption of energy will have to continue to increase more rapidly than population growth. This is then complicated by the problem of trying to slow deforestation and maintaining soil fertility without increasing oil imports.

The development plans of most of the nations are aimed at bringing about a rapid change in rural areas by modernizing the agricultural activity and increasing the productivity of land and labour. This means increasing the industrial sector

to support the agricultural activities and meet growing consumer needs. Therefore any growth of economic activity will create a greater dependence on the formal economy with a decreased emphasis on the informal economy. This may seriously dampen the ability of the rural area consumers to acquire the energy supplies which now are only achieved through the imported sources.

Examples of the maiming effects of shifting to commercially based petroleum products, include the higher costs seen in fertilizers and pesticides. This increase in cost can upset the delicate economic balance of cultivation of various local crops. In Western Samoa the cost of misting oil, which is needed to control bunchytop and leaf spot on banana plants, increased 266% in 1975 while the cost of fertilizers rose from 115% to 150%.(Bloomfield & Bloomfield 1976) This has modified the total cost structure of these economic activities.

The only source of reliable agricultural energy data is offered by Papua New Guinea. An interesting feature as revealed in Table 4., is that agriculture is not energy intensive. It is seen that a third of the GDP is based in agriculture, but the use of direct primary energy use is insignificant.(ESCAP Secretariat 1984) The use of electricity as a percentage of total electricty used was roughly 2.5% between 1979 and 1982. Also, petrochemical products

represented approximately 1% of the total energy consumed. Unfortunately there is no data on the use of traditional fuels in the agricultural sector. Because of this, the commercial

Table 4. Agricultural energy use in Papua New Guinea

	Petrol		Electricty		Total	
(units in TJ)	1979	1982	1979	1982	1979	1982
	127	170	90	108	217	278
Total used	13400	14750	4106	4357	68838	74296

Source: United Nations 1985.

fuel breakdown was roughly 60% petrochemical and 40% electrical. While admittedly not a true picture of the true end use of energy, it does show the relative importance of imported non-renewable energy versus Papua New Guinea's renewable hydro electricity.

The Solomon Islands data shows that the use of traditional fuels by agriculture as roughly 9% of the total traditional fuels used. Again we are faced with the lack of data problem, because there is no recorded use of commercial energy. The Fiji data states there is no recorded energy used by the agricultural sector. Overall then, it must be assumed, using the World Bank data and through the small amount of information we do have, that agriculture typically uses less than 5% of the total energy demanded. (World Bank 1980) While this does not hold true for all islands, we can assume it may for the region overall.

Knowing that modernization generally leads to the increased use of commercial energy, there is a strong potential for seeing a large increase in commercial energy demanded. Because of the important role which agriculture plays in these countries,if a proportional increase of energy in food occurs, the South Pacific nations will be at an increasing disadvantage to compete at the world market. This impact will be felt throughout the economy as the foreign exchange earned by agriculture has in the past financed national development.

4.2.2. Rural Eelectrification

In the past, the developing countries have seen the rural areas almost completely dependent on renewable energy resources, with fuelwood, charcoal, crop residues and animal dung accounting for virtually all fuel used. (World Bank 1981) Considering that the majority of the population of most of these countries is not served by public electricity, the potential for increased energy use in the near future is great. Except in several of the smaller countries, public electricity connections are only available to a minority of households. This ranges from 10% in the larger mountainous countries of Melanesia (Papua New Guinea, Solomon Islands and Vanuatu), to 15-20% in the small Micronesia/Polynesia countries (Kiribati, Tuvalu , and the Federated States of

Micronesia) and 30 to 40% in the medium to larger South Pacific Islands (Samoa's, Tonga, Fiji). (Johnston 1984) The development plans of most of these countries are aimed at increasing rural electrification. Peter Johnston (1984) notes that most electric power is generated by diesel systems since only a few countries have developed hydro beyond the micro scale, except Papua New Guinea, Western Samoa, Fiji and New Caledonia. In 1981, costs typically ranged from $.20 to $.40 KwH delivered within the national capitals, while on isolated islands and remote parts of larger islands, power from these diesel systems ranged between $.60 to $2.00 KwH.

Rural electrification, however, is not specifically cost limited but tends to be device limited also. For example, in Fiji, a programme of rural electrification saw the islanders being given diesel generators for a cooperative village grid network. This was on the condition that they maintained the supply themselves. Their difficulty, however, came when they had to service the systems themselves. (Twidell 1981) Obviously proves there is no easy answer to this complex problem. The rural areas are faced with the double dilemma of high rates of population growth which in turn threaten long term availibility of traditional fuel supplies. However, it still has proven difficult to supply these rural areas with the commercial fuels needed to increase agricultural productivity and encourage rural industries at a

cost that these consumers can afford.

4.2.3. Enviroment

All energy supplies have an effect on the enviroment, even if only to change the balance of radiation reaching the earth's surface. Therefore, the important issue concerns the nature of the impact on the enviroment and the balance between the needs of the economy and the needs of the enviroment. Since the predominant shift is toward renewable energy supplies, and the problems of the dominant present-day technologies are well documented, the emphasis of this discussion will be on the possible new encountered effects.

The effects of renewable energy technology tend to be immediate, limited in scale, and non-persistent in comparison to present technologies. There are two main areas of concern: the community, and the ecological system.

The possible harmful effects on the health and safety of workers are the community's main concern. This is becoming increasingly important as awareness of potential problems including cancers and other diseases come to light. Also considered is the possibility of explosions and other accidents. The important feature of these concerns is their political significance as a result of direct potential effects on the community. For example, there are potential safety hazards connected with hydroelectric power production.

The effects on the ecological systems are often thought to be of secondary importance to health and safety. The importance of these potential effects is merely a political perception as opposed to being a functional reality. (Mowle & Williams 1981) This is because the ecological processes have no direct political voice. These concerns are derived from a fear for the continued existence of a healthy enviroment to live in. Biomass usage is often cited as an example having significant ecological effects at the local level with its potential problems with processing technologies used to convert the raw materials into a useable fuel.

4.3. Domestic Energy Consumption

The largest component of the domestic sector is energy used in households. Because households account for the bulk of energy consumption in poor countries, the impact of energy technologies will, to a large extent, depend on the developing country's ability to make them available in forms compatible with needs and lifestyles of their people. If one excludes bagasse used in the sugar industry, domestic consumption is the main source of the demand for biomass fuels. With wood, charcoal and crop residues, used for cooking. The second domestic effect is felt through the food supply.

4.3.1. Household Energy Use

In Papua New Guinea, 4.7% of total petroleum products

were consumed by households. Electricty provides just less than 1% of demanded household energy, or 10.5% of total electricity consumed. By far the most dominant fuel used by the household sector is traditional fuels. These accounted for roughly 98% of the total energy demanded by the domestic sector. This shows that the household sector in Papua New Guinea is relatively secure from any external shocks which may affect the formal energy supply, but if traditional fuels are not managed properly, long term stability could be seriously jeopardized, with both enviromental and social ramifications.

A study of the Solomon Islands shows the great dependence of traditional fuels as a household energy supply, with 96% of household energy demanded being satisfied by this source. (see Table 5.) The problems of dependency discussed as applying to Papua New Guinea also apply here. The

Table 5. Household energy consumption in the Solomon Islands.

	Petrol		Electric		Traditonal		Total	
(energy	1979	1982	1979	1982	1979	1982	1979	1982
in TJ)	43	43	11	18	1485	1622	1539	1683
	1327	1497	61	83	1631	1768	3019	3348

Source: United Nations 1985.

dependence on petroleum as an energy source is quite small at 2.6% of energy demanded. This is double that of the dependency shown by Papua New Guinea, where electricity consumption is showing a rapid increase in use relative to total electricity demanded from 18% in 1979 to 21.7% in 1982.

Also a strong dependence is seen in the fact that roughly 91% of traditional fuels were consumed by the household sector. Approximately 50% of total energy demanded was consumed by the household sector between 1979 and 1982. This is in comparison to Papua New Guinea where approximately 68% of total energy demanded was used to furnish households.

Fiji's energy demanded is quite unique in that household energy is only 28% of all energy demanded between 1979 and 1982. This reveals the more diversified energy uses compared with the other two countries. Also interesting is the fact that traditional energy sources only accounted for 69.5% of total energy demanded by the household sector. This was due to the increased dependence on petroleum products, now accounting for 23.5%. Another way to look at this is the fact that over 10% of all petroleum used, was consumed in the household sector. This shift has great significance, as the majority of the households spend much of their incomes on energy, an increase in the dependence of commercial energy could significantly cripple the domestic purchasing power for other goods. Electricity is also quite important at roughly 20% of energy consumed. This might be a viable alternative if Fiji continues to increase its exploitation of hydropower.

4.3.2. Food/Energy Crisis

Though the South Pacific on the whole has no

quantitative food problems at present, as many Asian countries do, malnutrition does occur. (Khan 1977) Each of history's revolutions in food production systems has been based on the adoption of a new fuel source. (Soedjatmako 1984) Equity is no longer merely a morally desirable objective, but has now become a fundamental necessity due to the high cost of energy and its social, economic and ecological consequences. Thus the combined effect of the energy/food crisis threatens the welfare of these countries. Due to the energy crisis and its subsequent depletion of foreign exchange earnings, the government must choose between energy or food imports.

This energy crisis has essentially four impacts on the food situation. 1) Through impacts on fertilizers and other oil based inputs which caused significant increases in their costs. 2) The requirements of poor people for the cheapest energy source, that is, fuelwood, leads to ecological effects, which are adverse to food production. 3) Cropland may be shifted to the production of biomass energy, making food more scarce. 4) In the substitution of energy crops for food crops which may start an inflationary spiral of food prices. (Soedjatmako 1984)

This proves, that the South Pacific nations will not be able to solve their food problems without rectifying their energy problems. Without a satisfactory solution to both, their economic growth will be severely constrained.

5. Conclusion

Probably there is no country that does not use the energy supply system as a tool for achieving social goals. This means that energy is not a subject for studying by itself, as it is an indispensible element of running a modern economy. We must therefore ask what it does for us, how it does it and what costs must be borne by our chosen path. Which means the real value depends not only on the pattern of consumer demand but also on the cost of meeting that demand in all ways. This complex relationship of energy with the country as a whole, be it in achieving an increased standard of living or maintaining national stability, has been questioned with recent events in the world economy.

The two oil shocks of the 1970's have created difficult circumstances with which all of the South Pacific countries have had to come to grips. This has been due partly to the typical development path, which has dictated an increased demand of imported commercial energy, but also because of the decreasing supply and ability to exploit traditional energy sources. This change has created specific economic, social and national autonomy implications unlike the past course of development.

This choice of increased dependence on imported energy has had profound effects on many of these countries' people. Not only has the source of energy been changed but the methods

of exploiting its benefits have dictated an increased integration into the world market economy. As these countries tend to be quite poor, they are faced with tremendous burdens of acquiring these tools for energy utilization. This is difficult both at the individual and national levels.

Governments and individuals alike are forced to make decisions between energy and other equally important commodities. While the individual is faced with integration into the market economy and its effects, the national government must contend with a given amount of foreign exchange which means they must optimize their imports of oil. Should the government adopt a policy of maintaining its original level of oil imports, it must either increase its earnings or resort to borrowing.

These problems are compounded by geographic isolation and population dispersion. In combination, the role of energy is proportionally increased in importance compared with other commodities. This means that the effects on both import substitution and exports are pronounced, with different sectors experiencing distinct effects. Unfortunately, the sectors which tend to increase with modernization are those which are most energy intensive. This puts the countries in an increasingly perilous situation.

Today's energy context, with the present reduction of pricing, must not overshadow the importance of the commodity

with respect to development, be it increasing the quality of life or in nation building. The inevitable prospect of energy cost increases must be remembered. The South Pacific countries should not make short term decisions based on cheap energy, as this may hinder long term gains. This is not a time for lessened research and development into alternative energy technologies, but for increased emphasis on these methods because 1) the energy/debt relationship is not critical and 2) financial means are presently available.

APPENDIX A

Cook Islands

Year	Popn.	GDP/capita	Energy Consumption in '000 ton coal equivalent: Imports Per Capita		Tota
1968	20,000				
1969	20,000		6	300	6
1970	20,000	371.80	4	200	4
1971	21,323		5	234	5
1972	21,300	318.61	6	382	6
1973	20,500		4	195	4
1974	19,200		6	313	6
1975	18,100	741.28	7	387	7
1976	18,200	794.13	8	440	8
1977	18,400	872.61	14	761	14
1978	18,400	907.89	15	815	15
1979	18,500		15	811	15
1980	17,900		18	1006	18
1981	17,400		18	1034	18
1982	16,900				
1983	17,000				

Tonga

Energy Consumption in '000 ton coal equivalent

Year	Popn.	GDP/capita	Imports Per Capita		Total
1968	77,000				
1969	79,000				
1970	81,000	146.35	12	148	12
1971	85,400	141.33			
1972	86,800	157.12			
1973	87,600	167.03	12	137	12
1974	87,600	217.84	11	126	11
1975	88,000	183.98	16	182	16
1976	90,100	199.14	14	155	14
1977	91,800	307.53	14	153	14
1978	94,100	345.42	18	191	18
1979	92,400	478.75	18	195	18
1980	93,700	663.09	19	203	19
1981	95,100	788.14	22	231	22
1982	96,600	809.11	21	217	21
1983	98,100	799.78	22	214	22
1984	99,600				

* GDP/Capita =GDP(of country)*U.S. exchange rate (avg. of year)

elasticities = ratio of quantity demanded/ ratio of GDP Change

Fiji

Year		Energy Consumption in '000 ton coal equivalent				
		Popn.	GDP/capita	Imports Per Capita		Tota
1968	:	505,000	251.41	337	333	168
1969	:	519,000	267.28	392	393	204
1970	:	528,000	316.32	446	443	234
1971	:	533,000	340.91	522	477	254
1972	:	544,000	396.03	555	493	268
1973	:	556,000	482.93	520	405	225
1974	:	565,000	640.03	566	550	311
1975	:	576,000	803.66	507	476	274
1976	:	585,000	956.14	460	400	234
1977	:	596,000	1015.73	603	507	302
1978	:	607,000	979.38	530	501	304
1979	:	621,000	1146.71	594	541	336
1980	:	634,000	1268.26	578	543	344

Papua New Guinea

Energy Consumption in '000 ton coal equivalent

YEAR	Popn.	GDP/capita	Imports	Per Capita	Total
1968	2,310,000	177.23	273	119	275
1969	2,363,000	201.53	323	124	292
1970	2,421,000	230.32	351	145	145
1971	2,520,000	215.02	448	167	421
1972	2,540,000	243.63	686	197	500
1973	2,600,000	268.96	661	250	651
1974	2,650,000	285.51	813	300	796
1975	2,700,000	314.78	726	268	724
1976	2,760,000	359.25	828	298	822
1977	2,820,000	364.27	847	302	852
1978	2,880,000	347.63	821	290	834
1979	2,940,000	395.13	861	298	875
1980	3,000,000	381.71	892	301	902
1981	3,060,000	372.87	933	306	936
1982	3,128,000	416.07	899	290	908
1983	3,197,000	513.25	906	288	920

Kiribati

Energy Consumption in '000 ton coal equivalent

Year	Popn.	GDP/capita	Imports	Per Capita	Total
1970	54,100		10	185	10
1971	54,100		15	277	15
1972	51,000	273.36	12	235	12
1973	52,200	270.52	17	326	17
1974	52,800	480.11	23	436	23
1975	53,600	599.13	16	299	16
1976	54,500	503.81	23	422	23
1977	55,300	569.77	23	416	23
1978	56,200	614.01	10	178	10
1979	56,900	601.85	12	211	12
1980	57,500	317.68	12	209	12
1981	58,700	340.81	13	221	13
1982	60,300	413.68	13	216	13
1983	61,900		13	210	13

The Value of Energy as a Percentage of Total Exports

ear	Papua New Guinea	Cook Islands	Tonga	Kiribati	Fiji	Solomon Islands	Wester Samo
1969		14	8.9	3.8	15.8	8.8	6.4
1970	9.7	10.2	12.3	4	16.1	7.9	10.3
1971	8.9		14.8	3.7	10.5	7.8	8.8
1972	10.3		19.6	6.3	19.2	9.2	13.3
1973	4.8	9.1	14.3	4.9	21	9.8	15.8
1974	4.1	17	13.9	2.2	27.9	8.8	6.3
1975	9	23.2	16.3	3.4	27.1	18.3	42.1
1976	12.9	40.8	40	7.5	31.2	13.5	35.1
1977		35.1	28.3	11.6	32.9	12	25.1
1978		55.1	45.5	6.9	28.4	15	35.1
1979		46.9	37.6	10.6	33.7	10.9	28.6
1980	17.1	57.9	59.9	75	34.6	16.2	59
1981	28	106.6	77.9	67.8	51.5	26.4	112.8
1982	25.6	45.1	133.3		51.2	25.5	56.7
1983	24.5		102.6		46.7	25.1	47.9

Appendix B

INDUSTRY: Energy use in terajoules between 1979-1982

Country	Petrol		Electric		Traditional		Industry Energy	
	'79	'82	'79	'82	'79	'82	'79	'82
Papua New Guinea	2469	3064	3226	3352	5138	6550	10833	12966
Total Of Energy Type	13400	14750	4106	4351	51332	55196	68838	74296
Solomon Islands	425	510	44	14	-	-	439	524
Total Of Energy Type	1327	1497	61	83	1631	1768	3019	3348

Source: United Nations 1985.

Appendix C

Energy used by Transportation between 1979 and 1982 in TJ.

Country	Mode	Petrol		Total Tranportation Energy	
		1979	1982	1979	1982
Papua New Guinea	Total	9981	10778	68838	74296
	Air	1777	1777		
	Land	7128	7800		
	Water	1076	1202		
Total Of Energy Type		13400	14750		
Solomon Islands	Total	859	944	3019	3348
	Air	44	44		
	Land	643	686		
	Water	172	214		
Total Of Energy Type		1327	1497		

Source: United Nations 1985.

Appendix D

Household Energy Demand Between 1979 and 1982.

Country	Petrol		Electric		Traditional		Ttl Hhld		Ttl Ctry	
	'79	'82	'79	'82	'79	'82	'79	'82	'79	'82
Fiji	734	778	220	238	2170	2315	3313	3331	11385	11705
Total of Energy Type	6804	6884	1103	1168	2803	2979				
Papua New Guinea	778	691	397	458	46194	48646	47368	49795	68838	74296
Total of Energy Type	13400	14750	4106	4351	51332	55196				

Source: United Nations 1985.

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