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PROGRESS IN THE IMPLEMENTATION OF THE PROGRAMME OF ACTION FOR THE SUSTAINABLE DEVELOPMENT OF SMALL ISLAND DEVELOPING STATES

Report of the Secretary-General

Addendum

Sustainable development of energy resources in small island developing States

SUMMARY

In small island developing States, imported petroleum is the chief source of primary commercial energy. Their total daily petroleum consumption, however, is only about 1.3 per cent of total world consumption. Per capita energy consumption in small island developing States varies widely, from levels exceeding that in industrialized nations to as low as that in least developed countries, making it difficult to make many meaningful generalizations in consumption patterns and trends in small island developing States as a whole. Considering the dependence on imported energy supplies, small island developing States need to remain focused on improving the management and regulation of conventional power supply and petroleum imports.

Most small island developing States remain heavily dependent on traditional forms of energy such as fuelwood and bagasse, particularly in rural and remote areas. Attempts to develop renewable energy technologies, mostly small-scale, stand-alone units in dispersed settings, have had limited success. Solar energy has found use with solar photovoltaic systems for electrification of remote areas, and solar water heating is used in homes, hotels and commercial establishments. In further developing renewable energy sources, emphasis should be on the options that have shown some promise: solar photovoltaic systems in remote islands, solar water heating in urban areas and hydropower.

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EXPLANATORY NOTES

The following abbreviations and symbols have been used:

b/d	barrels per day
EEZ	exclusive economic zone
ESCAP	Economic and Social Commission for Asia and the Pacific
GEF	Global Environment Facility
GNP	gross national product
ha	hectare
kgoe	kilogram of oil equivalent
km	kilometre
km^2	square kilometre
kW	kilowatt
kWh	kilowatt-hour
kWp	kilowatt-peak
m	metre
m^3	cubic metre
MW	megawatt
OECD	Organisation for Economic Cooperation and Development
t	metric ton
toe	metric ton of oil equivalent
UNDP	United Nations Development Programme
US$	United States dollars
%	per cent
--	not available
...	nil

INTRODUCTION

1. Limited or scarce indigenous commercial energy resources and difficulties in securing energy supplies exacerbate the many constraints in economic and social development of small island developing States.

2. Imported petroleum is the chief source of primary commercial energy; indeed with the exception of hydropower in less than a third of the small island developing States, it is the only source of primary commercial energy in these States and territories. However, at the global level, small island developing States and territories are not significant consumers of petroleum. Their total consumption of petroleum is estimated at about 880,000 b/d out of a daily world consumption of more than 66 million b/d.

3. The cost, source and usage of energy have become major concerns for small island States, prompting a great need for careful energy planning. Energy management in small island developing States will essentially include increasing efficiency of energy use as well as an examination of indigenous energy resources. Environmental impacts are also of great importance and must be taken into careful consideration if the integrity of the food and fuel resource base are to be maintained and the natural endowments of the islands are to be preserved.

I. PRIMARY ENERGY RESOURCES

4. Petroleum is the chief source of primary commercial energy. It is produced in Bahrain, Barbados, Cuba, Papua New Guinea and Trinidad and Tobago. Petroleum export is an important source of revenue for Papua New Guinea, having exported about 120,000 b/d and Trinidad and Tobago, with an export of more than 150,000 b/d, in 1994. Bahrain is a major producer of natural gas, with an output of about 4.8 million tons of oil equivalent in 1992. 1/

5. Island arc basins in the Caribbean Sea and the south-western Pacific have been investigated for their hydrocarbon potential. However, since 1985, virtually all licensed acreage in the Caribbean Sea has been surrendered, in Aruba, the Bahamas, Barbados and the Netherlands Antilles. Elsewhere, in Seychelles, about 22,000 km^2 is still under licence for exploration, where marine seismic surveys of about 4,700 line-km were last conducted in 1987/88, and in Maldives, where licensed acreage was relinquished in 1991. In most of the island States and territories in the south-western Pacific, only preliminary reconnaissance exploration activities have been carried out. All licences in Fiji, Tonga and Vanuatu have been relinquished since the mid-1980s. In Fiji, four exploratory wells were drilled in 1982, but all tested dry with minor gas shows. 2/

6. As for coal resources, there are virtually no delineated coal deposits in any of the small island developing States and territories.

7. Hydropower resources for primary electricity production in the small island developing countries range from zero in the low countries (e.g., Maldives, Niue

and Tuvalu) to moderate (many island countries have mini-hydro power capacity of a few megawatts), to extensive (e.g., Fiji, Solomon Islands and Vanuatu, with capacity of a few hundred megawatts). As shown in table 1, hydropower has been developed in 11 small island developing States and territories, where it accounts for 4 to 13 per cent of total commercial energy supply; Comoros, Mauritius and Sao Tome and Principe in the Atlantic and Indian Oceans and adjacent areas; Fiji, Palau and Samoa in the Pacific; and Dominica and Saint Vincent and the Grenadines in the Caribbean Sea. Total annual hydroelectricity generation varies widely in these countries, from a high of about 460 million kWh in Papua New Guinea to about 2 million kWh in Comoros. The relative scarcity of hydropower development in the island countries, while technically successful, was in large part attributable to many financial and institutional problems associated with their development and, not least, environmental considerations.

Table 1. Small island developing States - resources, primary energy consumption and production

State or territory	Total population 1992 (thousands)	Land area (km^2)	GNP per capita 1992 (US$)	EEZ (km^2)	Forest area 1989/90 (as % of land area)	Consumption of primary energy 1992 (thousand toe)	Oil (thousand t)	Hydro-electricity (million kWh)	Fuelwood (thousand m^3)	Bagasse (thousand t)
Atlantic Ocean										
Cape Verde	384	4 033	840	789 000	--	36	...	...	--	--
Sao Tome and Principe	124	964	370	128 000	--	25	...	8	--	--
Indian Ocean and adjacent areas										
Comoros	585	2 171	530	249 000	15.7	22	...	2	--	--
Maldives	227	298	700	959 000	3.3		...	...	--	--
Mauritius	1 098	2 045	2 800	1 113 000	30.8	448	...	113	40	2 221
Seychelles	72	280	5 750	1 349 000	18.5	50	...	...	--	--
Pacific Ocean										
Cook Islands	17	236	--	1 830 000	--	7	...	...	--	--
Fiji	739	18 274	2 050	1 135 000	64.9	253	...	390	37	1 471
Kiribati	74	728	--	2 641 000	--	7	...	...	--	--
Marshall Islands	49	181	--	2 131 000	--	--	...	...	--	--
Micronesia, Federated States of	110	701	--	2 978 000	--	--	...	...	--	--
Nauru	10	21	--	431 000	--	44	...	...	--	--
Niue	2	259	--	390 000	--	1	...	...	--	--
Palau	16	416	--	629 000	--	82	...	30	--	--
Papua New Guinea	4 056	461 691	990	2 367 000	84.4	784	...	460	5 533	98
Samoa	158	2 842	960	9 600	47.3	45	...	20	70	7
Solomon Islands	342	28 446	720	1 340 000	91.5	53	...	...	138	--
Tokelau	2	10	--	290 000	--	--	...	...	--	--
Tonga	97	699	--	597 000	--	30	...	...	--	--
Tuvalu	12	24	--	328 000	--	--	...	...	--	--
Vanuatu	157	14 763	1 230	680 000	75.0	20	...	...	24	--
Caribbean Sea										
Antigua and Barbuda	66	442	6 100	--	--	96	...	...	--	--

State or territory	Total population 1992 (thousands)	Land area (km^2)	GNP per capita 1992 (US$)	EEZ (km^2)	Forest area 1989/90 (as % of land area)	Consumption of primary energy 1992 (thousand toe)	Oil (thousand t)	Hydro-electricity (million kWh)	Fuelwood (thousand m^3)	Bagasse (thousand t)
Aruba	62		--	--	--	213	...	...	--	--
Bahamas	264	13 935	11 670	759 000	32.4	602	...	...	--	--
Barbados	259	431	6 210	167 000	--	328	62	...	--	179
Cuba	10 811	114 524	--	363 000	25.1	8 717	936	82	2 529	22 820
Dominica	72	751	2 670	20 000	41.3	21	...	16	--	--
Dominican Republic	7 471	49 000	1 070	--	12.6	3 040	...	...	--	--
Grenada	91	344	2 350	268 000	8.8	40	...	...	--	--
Haiti	6 755	28 000	--	--	1.3	223	...	...	--	--
Jamaica	2 469	10 991	1 390	298 000	17.2	2 604	...	130	13	743
Netherlands Antilles	175	961	--	--	--	923	...	...	--	--
Saint Kitts and Nevis	42	268	4 120	68 000	16.7	25	...	...	--	64
Saint Lucia	137	616	2 900	68 000	13.1	331	...	...	--	--
Saint Vincent and the Grenadines	109	383	2 040	68 000	35.9	31	...	39	--	--
United States Virgin Islands	107	342	--	a/	--	2 266	...	...	--	--
Mediterranean Sea										
Cyprus	716	9 251	10 300	99 000	13.3	1 446	...	...	--	--
Others										
Bahrain	533	622	7 940	5 000	5.9	5 514	2 002 b/	...	--	--
Papua New Guinea	4 056	461 691	990	2 367 000	84.4	784	...	460	5 533	98
Singapore	2 769	581	16 970	300	4.9	16 482	...	...	--	--
Trinidad and Tobago	1 265	5 130	3 990	77 000	43.1	7 458	7 009	...	22	371

Source: Department for Policy Coordination and Sustainable Development of the United Nations Secretariat, based on Energy Statistics Yearbook, 1992 (United Nations publication, Sales No. 94.XVII.9); and International Monetary Fund, International Financial Statistics, various issues.

a/ Included in United States EEZ.

b/ Bahrain's natural gas production in 1992 = 4,791,000 toe.

II. NEW AND RENEWABLE SOURCES OF ENERGY

8. Of the new and renewable sources of energy, biomass accounts by far for the major share in small island countries. Fuelwood is most commonly used for cooking, especially in rural households. Almost all fuelwood for cooking is obtained at no financial cost from natural forests. Few island countries have any sizeable commercial production of fuelwood and whatever is available in the market appears to be purchased by relatively affluent households, for supply conveniences or for special occasions; very few island countries have forest areas covering a substantial part of their land area (see table 1). Also widely used are coconut residues (shells, husks and stemwood) and residues from coffee, cocoa and such other crops as maize, cassava, peanuts and rice. Biofuel is also used in small-scale agro-industry for process heat for drying copra, coffee, tea, fish and other foodstuffs.

9. In those island countries where sugar cane is grown in large quantities, bagasse is used as fuel for sugar mills. Notably, in Fiji, about 30 per cent of the peak electricity demand is produced from bagasse, including electricity used in the sugar mills themselves. 3/

10. The principal uses of direct solar energy in the island countries are for heating and drying, for solar water heating in urban houses as well as commercial establishments and drying of crops for consumption or processing, as well as for solar water purification and distillation on a limited scale. Solar energy is also used for photovoltaic systems as electric power sources in some rural areas and remote islands. Solar photovoltaic systems have been used on many islands, mainly in dispersed settings, for telecommunication transmission and reception, lighting, small medical refrigerators and water pumping. The largest concentration of photovoltaic modules (more than 8,000) is in the French Polynesian islands, with a combined generating capacity of more than 280 kW (on average about 50 watts per unit, sufficient for an incandescent light-bulb). Also, in Tuvalu, photovoltaic-based electricity is used for lighting needs in a number of households in the outer islands and customer growth is limited only by the availability of new photovoltaic units, constrained by lack of capital and reliant on donors. Photovoltaic use is growing, owing in large part to declining installation and operating costs.

11. Prospects have been improving for electricity generation by wind turbines, but much depends on site availability. In the tropics, locations with favourable wind regimes are scarce. However, several small island developing States have favourable sites for wind energy, perhaps prone to severe storm conditions; Cape Verde has a number of grid-connected wind turbines in operation.

III. ENERGY DEMAND

12. Total energy consumption in the small island developing countries under consideration has been gradually increasing during the period 1982-1992, from about 7 million to about 8.4 million tons of oil equivalent, an average annual increase of less than 2 per cent. However, not all of these small island developing States experienced increases; total energy consumption in a number of

them declined; in fact, there were more declines registered in per capita energy consumption as increasing demand from expanding populations outpaced energy supply (see table 2).

13. In 1992, per capita energy consumption in these small island developing States ranged widely from a low of less than 100 kilograms of oil equivalent (kgoe) to more than 5,000 kgoe, averaging about 1,200 kgoe. In comparison, worldwide, an average of about 600 kgoe was registered for all developing countries and about 60 kgoe in the least developed countries. Per capita energy consumption in more than 20 small island developing States exceeds the average of developing countries as a whole, but in a number of them consumption levels fall in the range of least developed countries. In four of the island developing countries and territories - Bahrain, Nauru, Netherlands Antilles and United States Virgin Islands - per capita energy consumption exceeds the average of OECD countries. Owing to the wide range in energy consumption among small island developing States, it is difficult to make any generalizations in consumption patterns and trends in these countries. However, as elsewhere, increasing use of modern fuels and per capita GNP are closely linked.

14. Most small island developing States depend heavily on traditional forms of energy such as fuelwood, charcoal and bagasse, particularly in rural areas. Traditional fuels are estimated to account for more than 50 per cent of total energy in many small island developing States compared to an average of about 25 per cent for all developing countries. As mentioned earlier, of the indigenous energy sources, biomass accounts for the largest share of the energy requirement, as it is used extensively for cooking and as a fuel in a variety of small-scale agro-industries.

15. Imported oil, mainly end-use products, is the main source of commercial energy, especially in small remote islands at great distances away from mainland areas. In fact it is the only source of primary commercial energy in about 28 small island developing States. However, to put the daily petroleum consumption of small island developing States in proper perspective, current daily demand is about 0.88 million b/d out of a total world consumption of more than 66 million b/d, an amount of about 1.3 per cent of world petroleum demand. Most of the imported petroleum, mainly products, are used for transportation and electricity generation. The share of imported petroleum used for electricity generation varies widely among small island developing States as seen in table 3, from about 70 to 100 per cent in the high range to less than 25 per cent in the low end; on average, in small island developing States, more than a third of the petroleum is converted to electricity.

16. Table 3 also shows that, in small island developing States, the share of petroleum imports in total imports ranges from a low of about 3 per cent to more than 20 per cent. The ratio of petroleum imports to total exports on average is comparatively higher than in other developing countries: in a number of small island developing States, the value of petroleum imports exceeds the value of total merchandise exports.

Table 2. Total and per capita primary energy consumption, 1982-1992

State or territory	Total energy consumption (thousand toe)			Per capita consumption (kgoe)		
	1982	1992	Annual change (percentage)	1982	1992	Annual change (percentage)
Atlantic Ocean						
Cape Verde	34	36	0.5	110	94	-1.4
Sao Tome and Principe	12	25	6.7	135	202	3.7
Indian Ocean and adjacent areas						
Comoros	12	22	5.5	29	38	2.5
Maldives	6	33	15.6	37	145	12.5
Mauritius	170	448	8.8	171	408	7.9
Seychelles	28	50	5.3	406	694	4.9
Pacific Ocean						
Cook Islands	12	7	-4.9	632	412	-3.9
Fiji	256	253	-0.1	393	342	-1.3
Kiribati	9	7	-2.3	150	95	-4.1
Marshall Islands	--	--	--	--	--	
Micronesia, Federated States of	--	--				
Nauru	40	44	0.9	5 714	4 400	-2.4
Niue	1	1	0.0	250	500	6.3
Northern Marianas	--	--	--	--		
Palau	50	82	4.5	352	369	0.4
Papua New Guinea	667	784	1.5	195	193	-0.1
Samoa	39	45	1.3	244	285	1.4
Solomon Islands	41	53	2.3	165	155	-0.6
Tokelau	--	--	--	--		
Tonga	14	30	6.9	139	309	7.3
Tuvalu	--	--		--	--	
Vanuatu	17	20	1.5	134	127	-0.5
Caribbean Sea						
Antigua and Barbuda	83	96	1.3	1 078	1 455	2.7
Aruba	--	213		--	3 435	
Bahamas	828	602	-2.9	3 851	2 280	-4.8
Barbados	210	328	4.1	814	1 266	4.0

State or territory	Total energy consumption (thousand toe) 1982	1992	Annual change (percentage)	Per capita consumption (kgoe) 1982	1992	Annual change (percentage)
Cuba	10 303	8 717	-1.5	1 046	806	-2.4
Dominica	13	21	4.4	173	292	4.8
Dominican Republic	1 775	3 203	5.4	305	429	3.1
Grenada	20	40	6.3	183	440	8.0
Haiti	223	244	0.8	37	36	-0.2
Jamaica	1 917	2 604	2.8	861	1 055	1.8
Netherlands Antilles	2 444	923	-8.8	9 660	5 274	-5.5
Saint Kitts and Nevis	21	25	1.6	467	595	2.2
Saint Lucia	36	331	20.3	293	2 416	19.3
Saint Vincent and the Grenadines	15	31	6.6	149	284	5.9
United States Virgin Islands	2 812	2 266	-2.0	28 120	21 178	-2.6
Mediterranean Sea						
Cyprus	831	1 446	5.0	1 292	2 020	4.1
Others						
Bahrain	3 360	5 514	4.5	8 842	10 345	1.4
Singapore	10 496	16 482	4.1	4 239	5 952	3.1
Trinidad and Tobago	4 549	7 458	4.5	4 208	5 896	3.1

Source: Department for Policy Coordination and Sustainable Development of the United Nations Secretariat, based on Energy Statistics Yearbook, 1984 and 1992 (United Nations publications, Sales Nos. 86.XVII.2 and 94.XVII.9).

Table 3. Share of petroleum imports in total merchandise imports and exports, and in electricity generation, 1992

State or territory	Petroleum import (in thousand toe)	Value of petroleum import (in million US dollars) (estimated)	Total merchandise import (value in million US dollars)	Oil import as percentage of total imports	Total merchandise export (value in million US dollars)	Oil import as percentage of total exports	Petroleum import - approximate calorific equivalent (in million kWh) a/	Electricity production by thermal plants (in million kWh) b/	Share of petroleum import used in electricity generation (percentage)
Atlantic Ocean									
Cape Verde	36	5.26	180.00	2.63	5.00	105.12	144	37	25.7
St. Pierre and Miquelon	32	4.67	--	--	--	--	128	49	38.3
Sao Tome and Principe	25	3.65	--	--	--	--	100	7	7.0
Indian Ocean and adjacent areas									
Comoros	22	3.21	--	--	--	--	88	14	15.9
Maldives	33	4.82	189.00	2.29	40.00	12.05	132	30	22.7
Mauritius	448	65.41	1 623.00	3.63	1 290.00	5.07	1 792	812	45.3
Seychelles	50	7.30	192.00	3.42	44.00	16.59	200	109	54.5
Pacific Ocean									
Cook Islands	7	1.02	--	--	--	--	28	16	57.1
Fiji	253	36.94	624.00	5.33	435.00	8.49	1 012	87	8.6
Kiribati	7	1.02	37.00	2.49	5.00	20.44	28	7	25.0
Marshall Islands	--	--	--	--	--	--	--	--	--
Micronesia, Federated States of	--	--	--	--	--	--	--	--	--
Nauru	44	6.42	--	--	--	--	176	30	17.0
Niue	1	0.15	--	--	--	--	4	3	75.0
Palau	82	11.97	--	--	--	--	328	--	--
Papua New Guinea	--	--	1 523.00	--	1 790.00	--	0	1 330	--
Samoa	45	6.57	113.00	5.23	6.00	109.50	180	28	15.6
Solomon Islands	53	7.74	--	--	--	--	212	30	14.2
Tokelau	--	0.00	--	--	--	--	--	--	--
Tonga	30	4.38	63.00	6.26	12.00	36.50	120	27	22.5
Tuvalu	--	--	--	--	--	--	--	--	--
Vanuatu	20	2.92	83.00	3.17	20.00	14.60	80	29	36.3

State or territory	Petroleum import (in thousand toe)	Value of petroleum import (in million US dollars) (estimated)	Total merchandise import (value in million US dollars)	Oil import as percentage of total imports	Total merchandise export (value in million US dollars)	Oil import as percentage of total exports	Petroleum import - approximate calorific equivalent (in million kWh) a/	Electricity production by thermal plants (in million kWh) b/	Share of petroleum import used in electricity generation (percentage)
Caribbean Sea									
Antigua and Barbuda	96	14.02	--	--	--	--	384	95	24.7
Aruba	213	31.10	--	--	--	--	852	350	41.1
Bahamas	602	87.89	--	--	--	--	2 408	975	40.5
Barbados	328	47.89	471.00	9.15	190.00	25.20	1 312	537	40.9
Cuba	--	--	3 690.00	--	3 585.00	--	--	12 410	--
Dominica	21	3.07	111.00	2.49	56.00	5.48	84	15	17.9
Grenada	40	5.84	117.00	4.49	23.00	25.39	160	62	38.8
Jamaica	2 604	380.18	1 672.00	20.46	1 047.00	36.31	10 416	2 605	25.0
Netherlands Antilles	923	134.76	2 174.00	5.58	1 114.00	12.10	3 692	853	23.1
Saint Kitts and Nevis	25	3.65	--	--	--	--	100	40	40.0
Saint Lucia	331	48.33	313.00	13.90	123.00	39.29	1 324	107	8.1
Saint Vincent and the Grenadines	31	4.53	--	--	--	--	124	12	9.7
United States Virgin Islands	2 266	330.84	--	--	--	--	9 064	1 020	11.3
Mediterranean Sea									
Cyprus	1 446	211.12	3 289.00	5.78	1 002.00	21.07	5 784	2 404	41.6
Others									
Bahrain	--	--	4 125.00	--	3 368.00	--	--	3 510	--
Singapore	16 482	2 406.37	72 534.00	2.99	63 516.00	3.79	65 928	17 543	26.6
Trinidad and Tobago	--	--	1 431.00	--	1 869.00	--	0	3 945	--

Source: Department for Policy Coordination and Sustainable Development of the United Nations Secretariat, based on Energy Statistics Yearbook, 1992 (United Nations publication, Sales No. 94.XVII.9) and Statistical Yearbook, No. 39 (United Nations publication, Sales No. 94.XVII.1).

a/ One million metric tons of oil produces about 4×10^9 kWh of electricity in a modern power station.

b/ It is assumed that thermal electricity generation in small island developing States, as tabulated in Energy Statistics Yearbook, 1992, is by oil-fired or diesel-based generating plants. However, for all practical purposes, petroleum-based products provided the bulk of primary energy in almost all small island developing States.

17. In absolute terms, the use of new and renewable sources of energy is increasing, accounting for a substantial part of rural energy demand in many small island developing States, although their share of total energy supply remains at a level significantly below their potential. Most islands have abundant solar and ocean resources and considerable wind and hydropower potential, as well as geothermal resources in a number of them. Given the remote location of many small island developing States, their small energy demands and high costs of oil imports, the development of renewable energy sources seems ideal. However, in spite of efforts to develop indigenous energy resources, using a variety of pilot projects, including biogas from animal dung, biomass gasifiers, alcohol fuel, small-scale wind systems and solar photovoltaics, the overall contribution of renewable energy sources to the energy balance of most small island developing States has been disappointing. At present, only small-scale hydropower, fuelwood and charcoal contribute significantly to the overall energy needs of small island developing States, particularly in rural areas and remote islands. More recently, the use of solar energy in the Pacific islands has been increasing. Following a number of demonstration projects in the early 1980s, solar water heating is being increasingly used throughout the Pacific islands in upper-income homes, hotels and commercial establishments. 4/ Solar photovoltaic systems have also been used as an alternative to diesel generation for the electrification of remote areas.

18. As in most other developing countries, electricity in small island developing States is available mainly in cities and surrounding rural areas, and in most of these countries electricity is generated from diesel-based systems, since that is the most economical option for power generation in remote areas. However, it is very costly because most generation systems are on a small-scale to very small-scale basis. In most Pacific islands, for example, the cost of electricity generation using diesel-based utilities with capacities of 5 to 20 MW is more than US$ 0.20 per kilowatt-hour. By comparison, electricity generation costs in industrialized countries average $0.10 to $0.15 per kilowatt-hour. As can be seen in table 4, in 1992, total net installed capacity of electricity-generating plants in small island developing States and territories was about 3,500 MW, with individual country capacities ranging from more than 400 MW in the Bahamas to 5 MW and less in a number of these countries. Per capita electricity consumption has been increasing substantially in most small island developing States and territories, more than doubling during the period 1982-1992. However, in a number of these countries, negative growth rates were registered. The average per capita electricity consumption in the OECD countries of more than 8,000 kWh far exceeds that of the small island developing States.

Table 4. Net installed capacity of electric-generating plants and per capita consumption of electricity, 1982-1992

State or territory	Net installed capacity of electric-generating plants (thousand kW)			Per capita consumption of electricity (kWh)		
	1982	1992	Average annual change (percentage)	1982	1992	Average annual change (percentage)
Atlantic Ocean						
Cape Verde	3	7	7.7	58	96	4.6
Sao Tome and Principe	5	6	1.7	124	126	0.1
Indian Ocean and adjacent areas						
Comoros	4	5	2.0	24	27	1.1
Maldives	2	14	17.8	49	132	9.0
Mauritius	243	336	2.9	432	842	6.1
Seychelles	19	28	3.5	768	1 514	6.2
Pacific Ocean						
Cook Islands	6	6	0.0	526	941	5.3
Fiji	113	200	5.2	497	645	2.4
Kiribati	2	2	0.0	100	95	-0.5
Marshall Islands	--	--		--	--	
Micronesia, Federated States of	--	--		--	--	
Nauru	10	10	0.0	3 714	3 000	-1.9
Niue	1	1	0.0	750	1 500	6.3
Palau	48	62	2.3	1 021	914	-1.0
Papua New Guinea	434	490	1.1	382	441	1.3
Samoa	17	19	1.0	275	304	0.9
Solomon Islands	12	12	0.0	100	88	-1.2
Tokelau	--	--		--	--	
Tonga	6	7	1.4	119	278	7.7
Tuvalu	--	--		--	--	
Vanuatu	10	11	0.9	165	185	1.0
Caribbean Sea						
Antigua and Barbuda	26	26	0.0	857	1 439	4.7
Aruba	--	90		--	5 645	
Bahamas	312	401	2.3	3 786	3 693	-0.2
Barbados	94	140	3.6	1 341	2 073	4.0

State or territory	Net installed capacity of electric-generating plants (thousand kW)			Per capita consumption of electricity (kWh)		
	1982	1992	Average annual change (percentage)	1982	1992	Average annual change (percentage)
Cuba	2 975	3 988	2.7	1 124	1 155	0.2
Dominica	7	8	1.2	147	431	9.8
Dominican Republic	960	1 447	3.7	551	713	2.3
Grenada	8	9	1.1	229	681	9.9
Haiti	126	153	1.8	59	70	1.6
Jamaica	740	732	-0.1	1 011	1 108	0.8
Netherlands Antilles	390	200	-6.1	9 130	4 874	-5.7
Saint Kitts and Nevis	15	15	0.0	778	952	1.8
Saint Lucia	16	22	2.9	496	781	4.1
Saint Vincent and the Grenadines	10	14	3.1	297	468	4.1
United States Virgin Islands	341	316	-0.7	8 550	9 533	1.0
Mediterranean Sea						
Cyprus	333	546	4.5	1 779	3 358	5.8
Others						
Bahrain	588	1 050	5.3	5 287	6 585	2.0
Singapore	2 106	3 550	4.8	3 153	6 336	6.4
Trinidad and Tobago	760	1 150	3.8	2 482	3 119	2.1

Source: Department for Policy Coordination and Sustainable Development of the United Nations Secretariat, based on Energy Statistics Yearbook, 1984 and 1992 (United Nations publications, Sales Nos. 86.XVII.2 and 94.XVII.9).

IV. ENERGY RESOURCES DEVELOPMENT OPTIONS AND RECOMMENDATIONS

19. The modern economic sector of small island developing States depends almost entirely on imported petroleum products for energy, accounting for well over 90 per cent of the commercial energy used. The lack of indigenous fossil fuels in virtually all of these countries and the total reliance on a single imported energy source have caused severe balance-of-payment problems in their economies (see table 3 for the ratio of value of petroleum imports and value of total merchandise exports).

20. During the 1980s, expectations were high for the development of indigenous renewable energy resources. It was widely believed then that renewable energy technologies were becoming technically and economically viable and that the energy environment of islands was ideal for these technologies, given the remote locations, high cost of petroleum imports and abundant supplies of indigenous solar, biomass, hydropower, wind and ocean resources. In spite of concerted efforts to develop the indigenous renewable energy resources through a wide range of demonstration and investment projects using a variety of technologies, renewable energy sources have not yet made a significant contribution to the energy balance of the small island developing economies. However, the development of hydropower in a number of island countries has been relatively successful, as has been that of solar photovoltaics to a limited extent. None the less, during that time, petroleum-product demand in small island developing States increased steadily and the outlook is that the growth rate will increase well into the next century.

21. Thus, the experiences of the 1980s indicate that the energy strategies of small island developing economies may need to refocus on improving the management and regulation of conventional power plants, at least until the time when the energy supply mix in small island developing States becomes more diversified with significant contributions from renewable energy technologies. In the meantime, small island developing States will continue to require assistance in the management and supply of conventional power sources and petroleum products.

22. The development of indigenous new and renewable sources of energy should be focused on the few options that have proved to hold promise for technical, economic and financial viabilities in the setting of small island developing economies. The renewable energy technologies and resources that appear to be more promising in the near term are solar photovoltaic-based utilities, particularly for remote islands; large-scale and mini-hydropower plants, where adequate sites and institutional support are available; wind turbine generators, depending on favourable wind regimes; and the enhanced use of biomass fuel, where good sustainable biomass cover exists. In the long term, ocean thermal and seawave may prove to be substantial energy sources, although attempts at their commercial development have not yet met with success. For a comparison between technologies for production of electricity, characteristics of these technologies are summarized in table 5.

Table 5. Characteristics of technologies for production of electricity

Technology	Size/description of system	Estimated cost/KwH a/ (US$)	Capacity factor range b/ (percentage)	Area required	Temporal characteristics
Wind	Few to tens of kW, not grid connected	0.50-1.00	10-30	Little	Intermittent, needs storage
Photovoltaic	Several kW range, not grid connected	1.00-2.00	15-25	$20m^2$/kWp	Intermittent, needs storage
Solar thermal energy conversion	Several kW to tens of MW, stand alone or grid connected	0.50-2.00	15-25	3-15 ha/MW	Intermittent, needs storage
Hydropower	Few MW and up, grid connected	0.50-1.00	50-70	As required	Water availability dictates limitations
Ocean thermal energy conversion-shore based	5 MW 40 MW	0.50-1.00	70-90	Little	Baseload power
Solar pond	5 MW salt gradient excavating/ diking	0.50-1.00	70-90	20 ha/MW	Baseload power with peaking possibilities
Wood	Few MW and up, boiler, gasifier	0.15-0.25 c/	70-90	800 ha/MW	Baseload power
Coal	Few MW and up	0.10-0.25 c/	70-90	1 ha/MW	Baseload power
Diesel	Fractional to several MW engine generator	0.40-0.50 c/	70-90	Little	Baseload power
Residual oil	Several tens of MW boiler	0.25-0.30 c/	70-90	Little	Baseload power

Source: Department for Policy Coordination and Sustainable Development of the United Nations Secretariat, based on various reports and studies.

a/ Very rough estimates; actual costs can be expected to be higher.

b/ Fraction of time source can produce energy, averaged over a year of operation.

c/ Environmental protection equipment will increase cost.

23. There are many and varied reasons for the disappointing results of most renewable energy technologies promoted in the small island countries, from a lack of detailed understanding of the economic and technical viability of these technologies in the setting of small island developing States, to insufficient efforts in organizing active participation of the local community at the early planning stage. It is important that adequate training in system operation and maintenance be provided on a long-term basis and support for local organizations to plan, operate, maintain, finance and expand the use of the technology be continued until a truly sustainable basis is achieved.

24. Energy conservation and efficiency measures play a key role in any energy management/planning process. Programmes designed for energy conservation on both the supply and the demand sides are the most effective ways to substantial savings in energy consumption. Energy conservation and efficiency measures are all the more imperative given that the economic development process has traditionally led to higher energy intensities per unit of economic output in its early stages.

25. Increased use of fuelwood, a renewable energy source, has led to much deforestation. To enhance the forest cover for sustainable fuelwood resources development, the Global Environment Facility (GEF) can play a role in the protection of forests and reforestation with new and additional grant and concessional financing, as these activities clearly relate to the four focal areas of GEF, are country-driven and are national priorities to support sustainable development. GEF financing could also contribute to the transition from the pilot phase of those renewable energy technologies with demonstrated viability, hydroelectricity, solar heating and photovoltaics, to the longer term operational status.

26. It is apparent that small island developing economies will continue to rely on imported petroleum products for their commercial energy requirements and on biomass for non-commercial needs. In a number of island countries, hydroelectricity has gained significantly in the commercial energy mix, although new installations of scale are not foreseen in the near term. On many of the islands, use of biomass as domestic fuel and for process heat for drying agricultural products and foodstuff appears to be sustainable; however, increased consumption and long-term environmental impacts may need closer attention. For the petroleum products import sector, the main issues are, on the economics side, the need to monitor and analyse petroleum products transportation and distribution costs, and on environment-related matters, for increased surveillance of the integrity of offshore and onshore transportation of petroleum products, storage safety standards and waste oil disposal.

27. Several factors constrain the market penetration of renewable energy technologies in small island developing States: mainly, technology, as local producers are not in a position to service a larger-scale demand, and price constraints, as in the case of solar photovoltaic units, customer growth for which is limited by lack of capital and in several cases reliance on donors.

28. The development of electric power supply and most attempts to develop renewable energy sources in small island developing States were largely funded by donor countries, on grant, concessional and, in a few cases, near-commercial terms. Small island developing States will continue to need such assistance to enable them to make the necessary investments to expand energy services beyond urban areas.

Notes

1/ All energy statistics are based on Energy Statistics Yearbook, various issues.

2/ World Petroleum Trends, various issues.

3/ Pacific Regional Energy Assessment, vol. 1, Overview, (World Bank, in cooperation with the UNDP/ESCAP Pacific Energy Development Programme, Asian Development Bank and the Forum Secretariat Energy Division, 1992).

4/ Ibid.
