RESEARCH REPORTS AND NOTES

ENERGY PRODUCTION, IMPORTS, AND CONSUMPTION IN REVOLUTIONARY CUBA*

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The extensive post-1973 literature analyzing and comparing national energy policies across countries has generally excluded Cuba, purportedly because of the unavailability of appropriate data. As a result, very little serious work has been carried out assessing Cuba's current energy balances and the efficacy of its policies in adjusting to the new global energy situation.[1] While it is incontrovertible that available official Cuban energy data are weak, it can be argued that, when supplemented with data from other sources and with reasonable estimates, they can serve as the basis for tentative analysis of energy policies. This note attempts to lay the groundwork for such future analyses by bringing together and evaluating energy supply and consumption data covering the first two decades of revolutionary government. While the emphasis is on the period 1959–78, pre-1959 data are introduced when appropriate in an effort to put recent trends in historical perspective. The first section focuses on primary energy production and considers the contribution of commercial and noncommercial sources to domestic energy supply. In the second section, imports of primary energy products are considered and their role in total energy supply evaluated. The last section examines tentatively some aspects of Cuban energy consumption and at-

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tempts to relate consumption patterns to policies that were in effect during the period.

ENERGY PRODUCTION

Important domestic sources of primary energy in Cuba during 1959–78, for which production data are available or can be estimated, include petroleum, natural gas, hydroelectricity, ethyl alcohol, bagasse, fuelwood, and charcoal. For commercial fuels (petroleum, natural gas, hydroelectricity, and ethyl alcohol), published annual production data appear to be good indicators of domestic availability. This is not the case for noncommercial fuels (bagasse, fuelwood, and charcoal), which are often consumed directly by producers and not picked up by the statistical system. For bagasse, production data are not available but can be estimated under some limiting assumptions; for fuelwood and charcoal, published data underestimate actual production by a substantial margin. The contribution of each of these energy sources to domestic supply is discussed briefly below.

Petroleum. Commercial petroleum production in Cuba began in 1915 with the discovery of the Bacuranao field; another commercial field was discovered at Jarahueca in 1943. Petroleum output from these two fields was small, averaging about 4,000 MT per year during 1950–54 (table 1). The discovery of the important Jatibonico field in 1954 shot up production to an average of about 30,000 MT per year during 1955–58 and gave rise to a flurry of concession applications and exploratory drilling activities by domestic and foreign companies. Small fields were discovered subsequently at Catalina, Cristales, and Guanabo. However, as most of the exploratory wells either turned up dry or found petroleum in quantities too small or of too low quality to justify commercial exploitation, the exploration boom subsided.[2]

At the end of October 1959, the revolutionary leadership, convinced that Cuba had vast petroleum reserves that had not been exploited by the foreign oil companies operating in Cuba, since the companies could reap higher profits from refining and marketing imported crude, seized the exploration records of the oil companies.[3] Using financial and technical assistance from the Soviet Union and Romania, Cuba undertook an ambitious program aimed at boosting petroleum production.[4] The program has been successful in increasing output, although it appears that it has been less so in finding new petroleum in significant quantities. Production for 1960–67 averaged 50,000 MT per year, rose to over 200,000 MT per year in 1968–69 when output peaked at the Guanabo field, and steadied at almost 140,000 MT per year in 1970–74 as production declined at mature fields (such as Jatibonico and Cristales). Produc-

tion gains from new fields east of Havana (Boca Jaruco and Varadero) pushed output above 250,000 MT per year in 1975–78.[5]

Natural Gas. Prior to 1968, small quantities of natural gas co-produced with petroleum were generally flared. In that year, commercialization of natural gas began with the completion of two small gas pipelines connecting the Cristales petroleum field with a thermoelectric plant in Ciego de Avila.[6] Natural gas production statistics only began to be reported in 1971 (table 1).

Hydroelectricity. Cuba's hydroelectric resources are limited: its rivers have low heads, carry relatively small volumes of water, and are subject to uneven rates of flow during the year.[7] Installed hydroelectric generating capacity during the 1950s was approximately 3–4 Mw in six small plants.[8] In the mid-1950s, construction began on a 42.6 Mw hydroelectric plant at the Hanabanilla River: the plant came on-line in 1962–63 and reached its full generating capacity in 1967–68.[9] In the 1950s, before the Hanabanilla plant was completed, electricity generated by hydroelectric plants averaged about 14,500 Mwh per year (table 1); in the 1960s and 1970s, hydroelectric plants generated on average about 69,000 Mwh per year.

Ethyl Alcohol. One of the sugar byproducts produced in Cuba in significant quantities was ethyl alcohol, with distilleries commonly integrated with sugar mills. A portion of the ethyl alcohol produced was natural alcohol used by the liquor industry; the remainder was denatured alcohol, used primarily as a domestic cooking fuel and as a feedstock in the chemical industry. During World War II, when imported petroleum supplies were limited, domestically produced anhydrous alcohol was mixed with gasoline to produce a gasohol mix called *carburante nacional*; this practice was discontinued after the war. Denatured alcohol production during the 1950s averaged slightly over 100,000 Kl per year and rose to over 150,000 Kl per year in the 1960s (table 1). Production declined sharply in 1970–78, to about 73,000 Kl per year, as a result of government policies diverting molasses from alcohol into cattle feed production.[10]

Bagasse. Bagasse, the moist mass of stalks and leaves left behind after sugar cane is ground to extract its juice, is the leading domestic source of energy. Bagasse is used as a fuel exclusively in sugar mills, because its bulkiness and low caloric value make it uneconomical to transport.

Official data on bagasse production, and on bagasse used as fuel, are not available. However, estimates of bagasse available as fuel for 1952–78 have been made using official data on sugar can milled[11] and assuming (1) a fixed bagasse-to-milled-cane ratio of .250[12] and (2) full use of the available bagasse as fuel. These estimates show (in million MT) an average of 10.8 for 1952–59, 10.7 for 1960–69 and 13.8 for 1970–78.

TABLE 1 *Production of Commercial Energy, 1950–1978*

Year	Petroleum (1000 MT)	Natural Gas (million M^3)	Hydroelectricity (1000 Mwh)	Ethyl Alcohol (1000 Kl)
1950	6	—	13	59
1951	4	—	13	61
1952	3	—	10	93
1953	2	—	12	140
1954	4	—	14	131
1955	24	—	13	143
1956	44	—	10	154
1957	26	—	20	107
1958	25	—	20	23
1959	28	—	20	124
1960	25	—	20	187
1961	28	—	7	177
1962	43	—	25	89
1963	31	—	50	116
1964	37	—	100	145
1965	57	—	57	143
1966	69	—	131	149
1967	113	—	109	170
1968	198	—	81	180
1969	206	—	75	185
1970	159	—	75	91
1971	120	5.8	88	66
1972	112	6.9	74	70
1973	138	14.5	62	70
1974	168	19.5	89	71
1975	226	17.2	62	67
1976	235	21.3	53	69
1977	256	17.0	73	77
1978	288	10.6	80	77

Sources: Petroleum: 1950–58—U.S. Bureau of Mines, *Minerals Yearbook*, various years; 1959–67—*Cuba Economic News* 4, no. 34 (1968), p. 4; 1968–78—Cuba, Comité Estatal de Estadísticas, *Anuario Estadístico de Cuba 1978* and earlier volumes. Natural Gas: Cuba, Comité Estatal de Estadísticas, *Anuario Estadístico de Cuba 1978*, and earlier volumes. Hydroelectricity: United Nations, Statistical Office, *World Energy Supplies 1950–1974* and more recent volumes. Alcohol: 1950–59—Cuba Económica y Financiera, *Anuario Azucarero de Cuba 1959* and earlier volumes; 1960–61—Cuba, Ministerio del Comercio Exterior, *Anuario Azucarero de Cuba 1961*; 1962—Cuba, Junta Central de Planificación, *Principales Indicadores de la Actividad Económica 1962*; 1963–78—Cuba, Comité Estatal de Estadísticas, *Anuario Estadístico de Cuba 1978* and earlier volumes.

At least two factors suggest that the estimates overstate actual amounts of bagasse used as fuel in the sugar mills. First, to the extent that sugar cane is burned prior to milling, the bagasse-to-milled-cane fraction will be lower than the .250 used to derive the estimates. Traditionally, sugar cane was harvested and milled in Cuba while still green; an alternative labor-saving harvesting system, in which sugar cane fields are burned prior to harvesting, known in Cuba as the Australian system, has been the subject of experimentation since 1960. By burning the sugar cane leaves, the top, and part of the bark, as well as the underbrush, the Australian method raises labor productivity in manual harvesting and permits the wider use of harvesting machines. Sugar cane harvested following this method has been found to have industrial yields similar to those corresponding to sugar cane harvested following the traditional method, but bagasse production is lower.[13] The Australian system was used extensively in 1971–72 but less thereafter; there are no data to allow adjustment of the bagasse availability estimates to account for the use of the Australian system. Second, a small portion of the bagasse has been used as raw material in the experimental or commercial production of newsprint, pulp, paper, and particle board.[14] Since there are no systematic data regarding the percentage of bagasse used for nonfuel purposes, no adjustment has been made in the estimates to account for this factor.

Fuelwood. Traditionally, fuelwood has been used in rural homes for cooking and as fuel in some local industries, such as bakeries. In addition, fuelwood plays an important role in the sugar industry, where it is used to start up sugar mills (before bagasse is available) and to make up for bagasse shortages during the milling process. According to Cuban official sources,[15] average fuelwood production (in thousand cubic meters) was 207.6 for 1958–59, 1143.3 for 1960–69, and 1652.7 for 1970–76 (official production data are not available for 1977–78). These figures probably understate actual production, as they appear to include only fuelwood that was marketed.

Charcoal. Charcoal, made from mangrove and other coastal shrubs, was an important home cooking fuel in urban areas until the mid-1940s, when it began to be replaced in this use by kerosene, propane, and electricity. Production of charcoal peaked in 1940 at about 222,206 short tons[16] and declined thereafter to 55,000 short tons in 1953 and 37,700 in 1958. Production rose again to 55,300 in 1959, reached a peak average between 1960 and 1965 of 168,200 short tons, and then declined for the rest of the decade to an average of 99,800 for 1966–69. Figures for 1970–76 show an average production of 72,500 short tons; data for 1977–78 are not available.[17]

Table 2 estimates the supply of domestic energy during 1959–78 by combining production data above converted to a standard unit, thou-

sand metric tons of petroleum or equivalent.[18] Examination of the estimates suggests the importance of bagasse in domestic energy supply; for the entire period, bagasse provided approximately 80 percent of domestically produced energy, with its contribution rising as high as 92 percent in 1959 and 88 percent in 1970. Also readily noticeable are the increased importance of petroleum and the decline in the contribution of alcohol and charcoal to domestic energy supply. Because of the disproportionate importance of bagasse and wide year-to-year fluctuations in bagasse production, no clear trends in the expansion of domestic energy supply can be discerned. During 1959–69, domestic energy supply was basically stagnant, hovering around 2.4 million MT of petroleum equivalent; excluding 1970, when bagasse output shot up as a result of a record-high sugar crop, domestic supply in the 1970s expanded modestly, at a rate of about 4 percent per annum in 1971–78.

ENERGY IMPORTS

As will be shown below, Cuba depends heavily on imports to meet its energy requirements. Imported petroleum products fuel thermoelectric plants, power factories and vehicles, and are used as cooking fuel. Coal is imported on a smaller scale and used primarily by the sugar and steel industries, in foundries, for gas manufacturing, and as fuel for steam locomotives.

Between 1950 and 1958, imports of petroleum and petroleum products more than doubled, from 1.8 to 4.1 million metric tons. During most of this period, the United States was Cuba's main supplier of crude and gasoline, while Aruba and Curaçao provided the bulk of fuel oil. Coal imports averaged about 87,000 MT annually during the 1950s, almost all originating from the United States, with Belgium, the Netherlands, West Germany, and the United Kingdom providing small amounts of coke.[19]

These import patterns were upset in 1960. On 13 February 1960, Cuba and the Soviet Union concluded a commercial and payments agreement that provided for the barter of Soviet goods, including petroleum and petroleum products, for Cuban sugar and other goods. As petroleum shipments from the Soviet Union began to arrive in April 1960, at the same time that the international oil companies operating refineries in Cuba (Esso, Texaco, and Royal-Dutch Shell) continued their normal purchases of crude from their affiliates, it became increasingly clear that a petroleum glut was in the making. On 17 May 1960, the Cuban National Bank informed the foreign oil companies that each would have to purchase and process 300,000 MT of Soviet crude during 1960. This move was ostensibly taken to help Cuba's dwindling dollar reserves, since the Soviet crude was obtained through barter and did

TABLE 2 Domestic energy supply, 1959–1978 (in thousand metric tons of petroleum or equivalent)

	1959	*1960*	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Petroleum	28	25	28	43	31	37	57	69	113	198
Natural Gas	—	—	—	—	—	—	—	—	—	—
Hydro-electricity	17	17	6	21	42	84	48	110	91	68
Alcohol	65	97	92	46	61	76	74	78	89	94
Bagasse	2000	2124	2428	1642	1410	1660	2267	1642	2267	1892
Fuelwood	32	71	239	180*	115	143	131	129	133	194
Charcoal	35	119	84	109	116	103	105	78	71	62
TOTAL	2177	2453	2877	2041	1775	2103	2682	2106	2764	2508

	1969	*1970*	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*	*1977*	*1978*
Petroleum	206	159	120	112	138	168	226	235	256	288
Natural Gas	—	—	5	6	12	16	14	18	14	9
Hydro-electricity	63	63	74	62	52	74	52	44	61	67
Alcohol	96	47	35	36	36	37	35	36	40	40
Bagasse	1821	3570	2303	1946	2124	2213	2250	2321	2500	3000
Fuelwood	245	198	219	231	249	231	230	216	216*	216*
Charcoal	41	30	41	48	48	50	55	48	48*	48*
TOTAL	2472	4067	2797	2441	2659	2789	2862	2918	3135	3668

Sources: Petroleum, natural gas, hydroelectricity, alcohol: see table 1. Bagasse: Estimated based on data on sugar cane milled from Cuba, Junta Central de Planificación, *Anuario Estadístico de Cuba*, various years, and Comité Estatal de Estadísticas, *Anuario Estadístico de Cuba 1978*. Fuelwood and charcoal: Cuba, Junta Central de Planificación, *Anuario Estadístico de Cuba 1974* and more recent volumes.

*Estimated.

not require payment in convertible currency. The oil companies balked and the government promptly retaliated on 29 June 1960, by seizing the refineries. From then on, Cuba-U.S. economic and political relations deteriorated rapidly, with the Soviet Union and its allies taking over in supplying Cuba with petroleum, petroleum products, and coal.

Official Cuban data on imports of petroleum and petroleum products are given in table 3. Data for 1960–61 are not available, as Cuban foreign trade statistics for these two years have not been published. Considering that since mid-1960 the Soviet Union has been, for all practical purposes, Cuba's exclusive supplier of petroleum and petroleum products,[20] rough estimates of Cuban imports in 1960 and 1961 have been based on data on Soviet exports to Cuba in table 4. Cuba has not yet published foreign trade data for 1977 and 1978;[21] petroleum and

petroleum imports in these two years cannot be approximated using the same procedure used for 1960–61 since, beginning with the 1977 edition, the Soviet trade yearbook discontinued publication of data on the *quantity* of exports of energy products, including petroleum and petroleum products.[22]

Cuban imports of petroleum and petroleum products rose by 78 percent between 1959 and 1969 (from 3.2 to 5.7 million MT), averaging about 4.5 MT per year. However, during late 1967 and early 1968, the Soviet Union allegedly withheld fuel supplies from Cuba because of political differences. The data support a slowdown in the supply of imported petroleum and petroleum products in these two years: 1967 and 1968 showed increases over the previous year of only .9 and 2.3 percent, respectively. Imports in 1969 rose by 8.6 percent, signaling that

TABLE 3 Supply of Petroleum and Petroleum Products, 1959–1976 (in thousand metric tons)

		Imports				
	Domestic Production	*Crude*	*Petroleum Products*	*Total*	*Apparent Supply*	*Domestic Production as a % of Supply*
1959	28	1710	1442	3152	3180	0.9
1960	25			4000*	4025	0.6
1961	28			4000*	4028	0.7
1962	43	3720	763	4483	4526	1.0
1963	31	3709	379	4088	4119	0.8
1964	37	3496	1102	4598	4635	0.8
1965	57	3483	1114	4597	4654	1.2
1966	69	3826	1232	5058	5127	1.3
1967	113	3713	1394	5107	5220	2.2
1968	198	3851	1375	5226	5454	3.6
1969	206	4156	1519	5675	5881	3.5
1970	159	4261	1769	6030	6189	2.6
1971	120	4757	2077	6834	6954	1.7
1972	112	4749	1942	6691	6803	1.6
1973	138	5243	1918	7161	7299	1.9
1974	168	5875	1911	7786	7954	2.1
1975	226	5797	1971	7768	7994	2.8
1976	235	5783	2457	8240	8475	2.8

Sources: Domestic production—see table 1. Imports: 1959—calculated from Cuba, Junta Central de Planificación, Dirección de Estadística, *Comercio Exterior de Cuba* 1; 1962–64—calculated from Cuba, Junta Central de Planificación, Dirección General de Estadística, *Comercio Exterior de Cuba: Importación 1962*, and volumes for 1963, 1964; 1965–76—Cuba, Junta Central de Planificación, *Anuario Estadístico de Cuba* (various volumes) and Comité Estatal de Estadísticas, *Anuario Estadístico de Cuba 1978*.

*Estimated.

TABLE 4 *Soviet Exports of Energy Products to Cuba, 1960–1976 (in thousand metric tons)*

	*Crude Petroleum and Petroleum Products**			*Coal and Coke*		
	Total	*Crude Petroleum*	*Petroleum Products*	*Total*	*Anthracite and Coal*	*Coke*
1960	2164.8	1648.5	516.3	12	7	5
1961	4028.6	2979.8	1048.8	144	134	10
1962	4384.4	3629.3	755.1	24	—	24
1963	4219.9	3765.6	454.3	39	11	28
1964	4559.3	3426.6	1132.7	31	—	31
1965	4726.6	3512.6	1214.0	31	—	31
1966	5090.4	3840.2	1250.2	56	30	26
1967	5286.2	3837.7	1448.5	127	88	39
1968	5303	na	na	111	79	32
1969	5760	na	na	119	86	33
1970	5987	na	na	89	51	38
1971	6400	na	na	112	78	54
1972	7000	na	na	113	56	57
1973	7435	na	na	116	62	54
1974	7643	na	na	127	76	51
1975	8060	na	na	95	63	32
1976	8809	na	na	na	na	na

Source: *Vneshniaia Torgovlia SSSR v 1960 g.* (Moscow, 1961) and volumes for 1959–63, 1965, 1967, 1969, 1970, 1972, 1975, 1976.

*Petroleum products include gasoline, gas oil, fuel oil and lubricants (lubricating oils, solid lubricants, grease additives and paraffin).

a political accommodation had been reached. Between 1970 and 1976, imports rose by 37 percent, from 6.0 to 8.2 million MT, and averaged about 7.2 million MT per year. The overwhelming importance of imported crude petroleum and petroleum products compared to domestic production in the apparent supply of liquid fuels during 1959–76 is shown in table 3.

According to official statistics, Cuban imports of coal and coke in 1959 reached almost 118,000 MT.[23] In 1962–64, imports averaged about 98,000 MT per year; during this period, import statistics record bituminous coal, anthracite, and coke imports from the Soviet Union, anthracite imports from Albania and North Vietnam, and bituminous coal and coke imports from Poland so that during this period the Soviet Union provided less than 40 percent, by weight, of coal and coke imports.[24] Imports rose to an average 119,000 MT per year in 1965–69 and 123,000 MT in 1970–73 and declined to 91,000 MT in 1974–76.[25] Though Cuban trade data do not indicate origin of coal and coke imports after 1964,

comparison of Cuban coal import data with Soviet data (table 4) suggests that since the late 1960s, the Soviet Union has been the source of virtually all Cuban coal and coke imports. Official Polish trade data last record bituminous coal shipments to Cuba in 1965 and coke shipments in 1967.[26]

Table 5 combines domestic energy production data with energy import data converted to a standard unit to estimate Cuban energy supply for 1959–76. During the period, energy supply grew at an average annual rate of 4.4 percent, reaching a level of approximately 11.2 million MT of petroleum equivalent in 1976. The expansion pattern was not steady, showing both rapid growth spurts and periods of supply stagnation or even decline. Examination of the data also suggests that during the entire period 1959–76 the contribution of imports to total energy supply rose considerably. This is not surprising since, as discussed earlier, domestic energy supply expanded more slowly than imports. During 1959–61, domestic energy production accounted for an average of almost 40 percent of total supply. For 1962–69, the domestic share fell to an average of less than 32 percent and further deteriorated to an average of less than 27 percent in 1971–76. (In these calculations, 1970 has been excluded since it was an abnormal year in terms of sugar output and, therefore, of bagasse production.) This pattern has an ominous implication for Cuba as it indicates clearly that the dependence on imported energy has deepened in the last two decades.

ENERGY CONSUMPTION

In comparison with production and import statistics, Cuba's energy consumption statistics are scarcer and weaker. Official data on total energy consumption, on consumption by sectors, or on consumption by industry are not available. The only official published data refer to the contribution of different energy sources to energy consumption. Some annual estimates of consumption of commercial energy, liquid fuels, electricity, etc., are available from the United Nations Statistical Office and are useful in filling the vacuum. This section reviews the available data on energy consumption and presents a tentative picture of Cuban energy consumption patterns based on a combination of these data.

Global Energy Consumption

The United Nations Statistical Office, in its publication *World Energy Supplies*,[27] presents several time series of annual observations relating to apparent Cuban total and per capita commercial energy consumption: overall energy consumption, consumption of solid fuels, consumption of energy petroleum products and natural gas, and consumption of

TABLE 5 Energy Supply, 1959–1976 (in thousand metric tons of petroleum or equivalent)

	Domestic Production	*Imports*	*Apparent Supply*	*Domestic Production as a % of Supply*
1959	2177	3232	5409	40.2
1960	2453	4070*	6523	37.6
1961	2877	4070*	6947	41.4
1962	2041	4535	6576	31.0
1963	1775	4156	5931	29.9
1964	2103	4684	6787	31.0
1965	2682	4687	7369	36.4
1966	2106	5129	7235	29.1
1967	2764	5203	7968	34.7
1968	2508	5340	7848	32.0
1969	2472	5759	8231	30.0
1970	4067	6116	10183	39.9
1971	2797	6922	9719	28.8
1972	2441	6789	9231	26.4
1973	2659	7234	9893	26.9
1974	2789	7848	10637	26.2
1975	2862	7837	10699	26.8
1976	2918	8301	11219	26.0

Sources: Domestic production: see table 2. Imports: Petroleum and petroleum products, see table 3. Coal and coke, 1959—Cuba, Junta Central de Planificación, Dirección de Estadística, *Comercio Exterior de Cuba*; 1962–64—Cuba, Junta Central de Planificación, Dirección General de Estadística, *Comercio Exterior de Cuba: Importación 1962* and later volumes; 1965–76—Cuba, Junta Central de Planificación, *Anuario Estadístico de Cuba*, various years and Comité Estatal de Estadísticas, *Anuario Estadístico de Cuba 1978*.

*Estimated.

electricity. Using these data, it can be calculated that during 1959–78, Cuban overall energy consumption and consumption of energy petroleum products rose at an average annual rate of 3.4 percent; electricity consumption rose at a brisker pace, averaging 5.5 percent per annum. On a per capita basis, the growth of overall energy consumption and of consumption of energy petroleum products averaged about 1.2 percent per annum, while electricity consumption grew at a rate of 3.3 percent per annum. Energy consumption growth during this period, measured either in absolute or in per capita terms, was considerably slower than during the decade of the 1950s: overall energy consumption during 1950–59 grew at an average annual rate of 9.8 percent (7.6 percent per capita) and consumption of petroleum products and of electricity at 9.9 percent (7.6 percent per capita).

In 1950, Cuban per capita energy consumption of 480 Kg of coal or equivalent ranked sixth among Latin American countries (table 6). Between 1950 and 1959, per capita energy consumption grew by a vigorous 92 percent to 924 Kg, and fifth place in Latin America. During 1959–78, per capita energy consumption grew by only 26 percent to 1168 Kg, a rate of growth sharply below that of every country except Chile and in marked contrast to growth rates exceeding 100 percent reached by more than half of the countries. Still, despite this poor performance, in 1978 Cuba still ranked seventh among Latin American nations in per capita energy consumption, by virtue of its relatively high consumption level in 1959.

It has been found that as the output of an economy increases over

TABLE 6 Latin America Per Capita Energy Consumption, 1950, 1959, and 1978

	Consumption in Kg of Coal or Equivalent			*Percent Change*	
Country	*1950*	*1959*	*1978*	*1959–1950*	*1978–1959*
Argentina	787	1104	1873	40	70
Bolivia	86	144	368	67	156
Brazil	198	295	794	49	169
Chile	609	801	997	32	24
Colombia	295	468	700	59	50
Costa Rica	193	193	564	0	192
Cuba	480	924	1168	92	26
Dominican Republic	69	172	464	149	170
Ecuador	111	174	505	57	190
El Salvador	72	129	265	79	105
Guatemala	106	164	260	55	59
Guyana	305	498	1070	63	115
Haiti	17	34	57	100	68
Honduras	104	155	284	49	83
Jamaica	94	546	1823	481	234
Mexico	567	742	1384	31	87
Nicaragua	83	163	517	96	210
Panama	314	464	991	48	114
Paraguay	24	90	200	275	122
Peru	305	407	649	33	59
Puerto Rico	507	1210	4664	139	286
Trinidad	1436	1615	4965	12	207
Uruguay	476	824	1054	73	28
Venezuela	901	1892	2989	120	58

Source: United Nations, Statistical Office, *World Energy Supplies 1950–1974*, Series J, no. 19 (New York: United Nations, 1976) and more recent volumes.

time, so does its level of energy consumption, although not necessarily at the same pace; likewise, the higher a nation's output in comparison with other nations, the higher generally its level of energy consumption. Darmstadter and associates have shown, for a large number of countries, that a statistical relationship between economic activity and energy consumption holds both when time series or cross section data are analyzed.[28] Although Polach has estimated well-behaved energy consumption-economic activity relationships for centrally planned economies for 1950–67,[29] a recent comparative study of responses to the energy crisis by Halvorsen and Thornton found no statistical relation between energy consumption and economic activity for these countries. They deduce that this result may come about because of the stability that the planning process imposes on consumption growth rates, though it is also possible that it may reflect the fact that industrial fuel consumption is relatively unaffected by changes in the size of agricultural harvests that account for much of the variability in the growth of national income in these countries.[30]

In order to determine whether the Cuban case would support the results obtained by Polach or by Halvorsen-Thornton, the energy consumption–economic activity relation for Cuba was estimated using various indicators. The same estimating equation used by Halvorsen and Thornton, which postulates that per capita energy consumption is a function of the per capita level of economic activity and a time trend, has been used.[31] The equation, in logarithmic form, is

$$\ln (\text{CENER}/\text{POP})_t = a + b \ln (\text{GNP}/\text{POP})_t + cT + u,$$

where CENER is total commercial energy consumption (or some other energy consumption measure) in thousand metric tons of coal or equivalent; POP is population in thousands; GNP is a measure of economic activity in constant prices; T is a time trend; t is the year; and u is a disturbance term. It follows that b is the elasticity of demand for energy with respect to economic activity, c is the trend rate of growth, and a is a constant.

Three different energy consumption series, all originating from *World Energy Supplies*, were used as dependent variables: overall energy consumption (CENER), consumption of energy petroleum products (CPETR), and electricity consumption (CELEC). The consumption series were converted to a per capita basis using official Cuban population figures (POP). Because of insuperable difficulties in obtaining a consistent economic activity series for the entire period 1950–78, the equation was estimated independently for three shorter time spans. For 1950–59, a period during which Cuban national accounts data were computed following familiar Western methodology, a series on gross national prod-

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uct at constant prices has been used.[32] However, beginning in 1960, the Soviet national accounting methodology was adopted and gross material product (GMP) and global social product (GSP) became the only overall economic activity indicators computed. Use of these series raises serious problems: figures for 1960–61 have never been published and the calculation methodology was modified at least three times during 1962–78 so that four unconnected subseries exist. Moreover, the published series have been calculated using a combination of current and constant prices: the output of the foreign trade, domestic trade, and transportation sectors is valued at current prices while, for the remaining sectors, output is valued at current and, at the same time, at constant 1965 prices since official prices in these sectors have purportedly not changed since 1965.[33] The result is that official GMP and GSP series used in estimating the equation for 1962–78 should be considered as given in current prices.[34] An estimated gross national product (GNP) series in constant 1976 dollars (GNP$) for 1960–77 prepared by the World Bank was also used in the estimation.[35]

Regression results are summarized in table 7; t-ratios are shown in parenthesis underneath each of the estimated coefficients. As the regression results for the three time periods paralleled each other across dependent variables, only the results obtained when total energy consumption was used as the dependent variable are discussed here.

For the period 1950–59, the estimated elasticity of energy consumption with respect to economic activity is 1.22 and the annual rate of growth of energy consumption is 6.96 percent. The elasticity coefficient is statistically significant only at the 75 percent confidence level, while the time trend is so at the 95 percent level. Overall, the independent variables explained about two-thirds (R^2 = .6628) of the year-to-year variation in energy consumption. These results can be interpreted as suggesting that changes in per capita energy consumption were affected by changes in activity per capita and by a simple time trend as well as by some unexplained variable. The magnitude and sign of the elasticity coefficient suggest that, given a change in economic activity, a greater change in energy consumption occurred. The time trend, which accounts for changes in factors that influence energy consumption unrelated to current economic activity (such as changes in the efficiency of energy use by industry, changes in consumer taste, changes in capital stocks and in the stocks of household appliances and automobiles, etc.) was also found to be very important.

For the periods 1962–78 and 1960–77, the results painted a different picture. Estimated elasticities were close to zero and not statistically significant while the time trend coefficients were highly significant. (For 1960–77, the elasticity of electricity consumption was about .6 and highly significant. It is not clear why this anomalous result comes about.) The

TABLE 7 Regression Results

Time period	Independent Variables	Dependent Variables CENER/POP	CPETR/POP	CELEC/POP
1950–1959	Constant	0.2190	−0.2919	−1.2322
		(0.2272)	(−0.2974)	(−8.0042)
	GNP/POP	1.2211	1.1628	0.4425
		(1.2379)	(1.1576)	(2.8087)
	T	0.0696	0.0712	0.0704
		(3.0361)	(3.0504)	(19.2228)
	R^2	.6628	.6588	.9843
1962–1978 (I)	Constant	−0.1642	−0.6083	−0.9444
		(−4.9866)	(−17.4591)	(−16.1930)
	GSP/POP	0.0255	0.0210	0.0256
		(0.3680)	(0.2867)	(0.2089)
	T	0.0218	0.0227	0.0412
		(5.1151)	(5.0278)	(5.4466)
	R^2	.9492	.9461	.9522
(II)	Constant	−0.1809	−0.6279	−0.9547
		(−3.4299)	(−11.2860)	(−10.2505)
	GMP/POP	−0.0064	−0.0117	0.0007
		(−0.1152)	(−0.1996)	(0.0074)
	T	0.0237	0.0245	0.0426
		(7.4622)	(7.3369)	(7.6194)
	R^2	.9487	.9460	.9521
1960–1977	Constant	−0.2285	−0.6757	−0.8992
		(−6.9518)	(−18.3774)	(−22.4730)
	GNP$/POP	−0.0148	−0.0275	0.5932
		(−0.0888)	(−0.1480)	(2.9293)
	T	0.0240	0.0247	0.0412
		(12.7454)	(11.7407)	(17.9767)
	R^2	.9229	.9107	.9565

All numbers in parentheses are t statistics.
CENER—Total energy consumption
CPETR—Consumption of energy petroleum products
CELEC—Consumption of electricity
GNP—Gross national product in pesos
GSP—Gross social product in pesos
GMP—Gross material product in pesos
GNP$—Estimate of gross national product in U.S. dollars
POP—Population
T—Time trend

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results imply that during these periods, current levels of economic activity, as measured either by GMP or GSP at current prices or by the estimated GNP in dollars at constant prices, had no detectable influence on current levels of energy consumption and that all the variability in energy consumption explained by the equations (about .95) was accounted for by the trend variable.[36] The results for Cuba during the revolutionary period support Halvorsen-Thornton's findings that for centrally planned economies there is little or no statistical relationship between energy consumption and economic activity and changes in energy consumption are adequately explained by a time trend alone. It should be stressed that these results are tentative, since the economic activity measures used in the estimation are far from being the desired ones.

Consumption According to Energy Source

The 1972 Cuban statistical yearbook included for the first time a table on the structure of net energy consumption by energy source. Subsequent yearbooks have expanded and updated the data so that time series for the period 1966–77 are available (table 8). Definitions and methodological notes have not been published with the table, so there are difficulties in interpreting the data. For instance, biomass (*combustibles vegetales*) is not defined; it can be presumed that bagasse and fuelwood are considered in this category, but there may be others as well. There is ambiguity as to whether or not the data refer exclusively to primary energy since manufactured gas (made from coke) is included. A similar problem arises with regard to electricity: hydroelectricity is a primary source, but electricity produced by oil-fired thermoelectric plants is not. As the table gives the contribution of fuels to energy consumption in percentage terms only, actual energy consumption during the period cannot be determined.

It is clear from the data that, taken together, biomass and alcohol and petroleum products fulfilled the bulk of Cuba's energy needs during 1966–77. Although there have been small year-to-year fluctuations in the contribution of each of the two sources, their combined share has remained remarkably constant at about 95 percent. Electricity's share increased from around 3.5 percent in the late 1960s to around 4.5 percent in the mid-1970s. partially at the expense of natural gas (decline from 1.0 to 0.6 percent), while manufactured gas' share remained constant.

Consumption by Economic Sectors

Other than passing references, there is no systematic information on energy consumption by economic sectors such as households; agricul-

TABLE 8 Structure of Net Energy Consumption (percentages)

	*1966**	*1967**	*1968*	*1969*	*1970*	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*	*1977*
Biomass & Alcohol	40	44	43.3	40.9	52.6	42.1	37.7	37.3	36.8	36.3	36.1	37.6
Coal & Coke	1	1	1.1	0.9	0.7	0.9	1.0	0.9	0.8	0.8	0.6	0.4
Petroleum Products	55	52	51.3	53.9	43.1	52.9	56.8	57.0	57.5	57.9	57.8	56.8
Electricity	4	3	3.8	3.9	3.3	3.7	4.1	4.4	4.5	4.6	5.0	4.7
Manufactured gas	—	—	0.5	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5

Source: Cuba, Junta Central de Planificación, *Anuario Estadístico de Cuba 1972* (La Habana, 1974) and issues for 1973, 1974, 1975 and 1976; and Comité Estatal de Estadísticas, *Anuario Estadístico de Cuba 1978*.

*Rounded in the original source.

tural, industrial, and commercial enterprises; and public facilities. Using scattered information, some tentative notes on energy consumption by households and by industry have been put together.

Household Energy Consumption / Households generally consumed three types of energy: cooking fuels, electricity, and gasoline for motor vehicles. Government policies to curb household energy consumption, or to change the consumption mix, have affected consumption patterns in all three areas.

Cooking fuels: Official data on the usage of different fuels for home consumption during 1966–77 are given in table 9. For the entire period, kerosene accounted for an average of over 60 percent of home fuel usage; the contributions of ethyl alcohol and charcoal declined during the period; and those of gas and electricity remained basically constant. Some of these shifts were the direct result of government policies. In January 1969, a national drive was launched to replace alcohol with imported kerosene in home cooking. The rationale for the change, mentioned earlier, was that it was more profitable to use molasses for cattle feed production than for ethyl alcohol.[37] As part of the campaign, imports of kerosene were stepped up and orders for 200,000 kerosene stoves were placed with the People's Republic and China and North Korea.[38] Between 1969 and 1970, the contribution of imported kerosene in home fuel consumption rose from 61 to 73 percent, while that of domestically produced ethyl alcohol declined from 17 to 8 percent. Another policy change that affected household cooking fuels was the decision to discourage the use of electric stoves. In April 1971, Castro declared that such heavy electricity users were economically unfeasible; in May 1971, an embargo was placed on 17,000 new electric stoves that were to be distributed to workers and it was decided that the stock of

TABLE 9 *Structure of Net Consumption of Domestic Fuels (percentages)*

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Ethyl Alcohol	16	18	18	17	8	4	4	4	4	4	6	5
Charcoal	18	15	13	9	6	6	6	6	7	6	6	6
Liquified Gas	9	8	9	9	9	8	7	7	8	8	9	8
Kerosene	52	55	56	61	73	57	59	60	65	66	71	62
Manufactured gas	5	4	4	4	4	3	3	3	4	5	5	4
Fuelwood						21	20	19	11	10	3	15
Electricity						1	1	1	1	1	—	—

Source: Cuba, Junta Central de Planificación, *Anuario Estadístico de Cuba 1972* (La Habana, 1974) and issues for 1973, 1974, 1975 and 1976; and Comité Estatal de Estadísticas, *Anuario Estadístico de Cuba 1978*.

90,000 electric stoves in use nationwide would have to be replaced with gas stoves.[39]

Electricity: One of the first actions regarding the economy taken by the revolutionary government in 1959 was the reduction of electricity rates by about one-third. Consumption was stimulated by the rate decrease and by the addition of new users resulting from a rural electrification program and from construction of new public housing. As early as 1964, electricity demand began to outstrip supply resulting in frequent brownouts and blackouts. In order to alleviate the problems, starting in 1965 daylight savings time was instituted during the summer to take advantage of the longer daylight hours and reduce peak demand.[40] In September 1970, Castro entrusted a mass organization, the Committees to Defend the Revolution (CDR), with the task of getting a residential electricity conservation program moving. According to Castro, households were responsible for 48 percent of electricity demand during peak hours.[41] The CDRs established teams of youths (called *patrullas click*) to patrol their neighborhoods during peak load hours encouraging users to turn off unnecessary lights and appliances.[42]

Two important factors that have worked against household electricity conservation are a rate structure that does not encourage it and administrative failures in billing and collecting payment from customers for electric service. According to Castro, the rate structure inherited from the capitalists, which charged a certain rate for a set number of units of electricity and a lower rate for additional units, encouraged consumption and waste.[43] Despite several statements to the effect that the rate structure should be inverted to penalize heavy users by making the marginal price of electricity higher than the base price, it appears that it has not been done. As the billing equipment broke down in the early sixties, customers who were normally billed on a monthly basis

were at times not billed for twelve months or more. A deferred billing system with three meter readings per year was introduced in the late 1960s and it appears to have been moderately successful in resolving the overt billing and collecting problems.[44]

Gasoline: According to the United Nations, the stock of passenger automobiles (including taxis) in Cuba in 1958 was approximately 159,200.[45] In addition, there were some 51,300 commercial vehicles of other types, such as trucks, buses, and tractor trailers,[46] as well as a significant number of privately owned motorcycles and scooters. Hard currency import controls established in 1960 all but dried up the importation of motor vehicles for private use.[47] Since the controls also affected the importation of spare parts, the condition of privately owned motor vehicles deteriorated and their number declined significantly. On 2 January 1968, in the midst of a serious fuel shortage, a system of gasoline rationing for privately owned motor vehicles was instituted.[48] Given the ever declining stock of private motor vehicles and the gasoline rationing system, gasoline consumption by the private sector was probably of little significance after 1970.

Industrial Energy Consumption / In 1964, the Cuban Ministry of Industries released a preliminary input-output table for forty-five industries, prepared using data for the period July 1962 to June 1963. The direct requirements coefficients were published in mid-1964,[49] and the total (direct and indirect) requirements coefficients in April 1965.[50] Since the I-O matrix was prepared by the Ministry of Industries for internal planning purposes, economic activities outside the ministry (such as agriculture and transportation) were not included. There is information that more recent input-output tables have been prepared,[51] but they were not available.

In the absence of systematic information on energy consumption by industry, input-output coefficients may be used to identify those industrial sectors that are important energy users. Needless to say, the coefficients are badly outdated by now and inferences drawn from them may be misleading; nevertheless, their use here to identify important energy users is probably justified. The section of the total requirements table referring to requirements of petroleum and electricity for each of the forty-five industries is reproduced in table 10. For each of the industries listed, the two columns show the value of petroleum and electricity purchases required to produce a peso's worth of output. For example, in order to produce 1000 pesos' worth of output, the nickel and cobalt industry (industry 9) had to purchase inputs from the petroleum industry for 137.32 pesos and from the electricity industry for 2.91 pesos. Intuitively, the larger the coefficient, the heavier the relative importance of petroleum or electricity in the production function for that industry.

Examination of the petroleum requirements coefficients suggests that the cement, ceramics, electricity, ferrous metallurgy, mining, nickel and cobalt, paper and artificial wood, basic chemicals, paint, and glass industries were important petroleum users in 1962–63. Likewise, the cement, ceramics, ferrous metallurgy, mining, and glass industries were important users of electricity. These data confirm other information about the use of petroleum products and electricity by the industrial sector.[52]

Industrial energy conservation has been a high government priority. In March 1971, a national drive was begun to improve the fuel efficiency of industrial boilers.[53] To deal with the increased volumes of gas oil and gasoline demanded by the transportation sector, an ambitious program to reconstruct the national railroad and to modernize the highway system has been started. Large industrial electricity users have adopted a system of staggered work schedules called *acomodo de carga* aimed at reducing peak load demand. The following sections discuss energy consumption and conservation efforts in three important industries: electricity, sugar, and nickel.

Electric Industry: The electric industry is Cuba's largest user of petroleum products, consuming about 20 percent of all liquid fuels in two types of plants: thermoelectric plants that use fuel oil and diesel plants that use gas oil.[54] In 1967, the electric industry used 34 percent of the fuel oil and a significant share of the gas oil used nationally.[55]

In the last two decades, Cuban electric generating capacity has increased almost five-fold, from 397 Mw in 1958 to 1,936 Mw in 1978. In addition, a national network of high-voltage transmission lines connecting power plants and consuming centers has been completed. In all, according to Castro, investments in the electric industry have exceeded 800 million pesos.[56] Despite these efforts, electricity demand has continually exceeded supply: power shortages were experienced during 203 days in 1973, 88 days in 1974, and 295 days in 1976.[57] The Ministry of the Electric Industry, which accounted for more than 80 percent of electricity generated, served virtually all residential customers, as well as most small- and medium-sized industrial enterprises and public facilities. Electricity generated by other enterprises generally went to fulfill their own needs, although in some cases they served some residential users. In 1977, the Cuban electrical system consumed, on average, 313.7 grams of petroleum products per kwh generated, compared to an average usage of 398.6 grams per kwh in 1958.[58] Between 1976 and 1977, average consumption of petroleum products per kwh generated declined by 4.7 grams. This reduction, equivalent to an annual fuel saving of 27,500 MT,[59] comes about because obsolete power plants have been scrapped and larger more fuel-efficient plants have taken their place.[60]

Sugar Industry: In addition to consuming practically all the ba-

TABLE 10 Direct and Indirect Requirements Per Peso of Delivery to Final Demand, 1962–1963

	Petroleum	*Electricity*
1. Automotive	.00295	.00497
2. Cement	.14670	.03038
3. Ceramics	.06973	.02361
4. Electricity	.16219	1.00088
5. Fertilizers	.00645	.00122
6. Ferrous metallurgy	.04253	.02310
7. Non-ferrous metallurgy	.00600	.00783
8. Mining	.08414	.06534
9. Nickel and cobalt	.13732	.00291
10. Petroleum	1.00099	.00450
11. Paper and artificial wood	.05778	.01740
12. Basic chemicals	.07726	.01507
13. Salt	.02076	.00336
14. Agricultural machinery	.01186	.00888
15. Naval construction	.00443	.00470
16. Mechanical work	.00658	.00577
17. Soft drinks	.01085	.01061
18. Beer and malt	.01424	.01233
19. Cigarettes	.00209	.00190
20. Paper manufactures	.02420	.01022
21. Apparel	.00474	.00638
22. Leather products	.00351	.00522
23. Metal containers	.00329	.00631
24. Electrical equipment	.00098	.00193
25. Matches	.00497	.00219
26. Hard fibers	.00352	.00119
27. Rubber	.01712	.01204
28. Flour	.00683	.01371
29. Textiles	.01365	.01346
30. Soap and perfumes	.01134	.00347
31. Wine and liquors	.00500	.00218
32. Wood	.00461	.00898
33. Paint	.04613	.00314
34. Plastics	.00735	.01151
35. Pharmaceuticals	.00579	.00299
36. Recovery of raw materials	.00936	.01091
37. Cigars	.00092	.00215
38. Tanneries	.00613	.00601
39. Knit fabrics	.01013	.00887
40. Glass	.11226	.02283
41. Specialty textiles	.00856	.00687
42. Graphic arts	.01708	.00671
43. Toys	.00495	.00562
44. Local industries	.00798	.00559
45. Other industries	.00778	.01091

Source: Enrique González-Romero and Zoila González-Maicas, "Algunas contribuciones al análisis de la matriz de insumo producto," *Nuestra Industria. Revista Económica* 3, no. 12 (Apr. 1965).

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gasse it produces and significant volumes of fuelwood, the sugar industry is also an important user of petroleum products. Gasoline, fuel oil, and gas oil are used widely in the agricultural, transportation, and industrial aspects of sugar production. In the late 1960s, the sugar industry was second only to the electric industry in consumption of petroleum products, a position it probably also held in the 1970s.[61]

Sugar cane harvesting machinery is typically fueled with gas oil. As mechanization of sugar cane harvesting has become more widespread, fuel consumption has risen.[62] Trucks used to carry sugar cane from the fields to the collection centers (*centros de acopio*) or directly to the mills use gasoline or gas oil. The railroad, the most common mode to transport sugar cane from collection centers to mills, is a heavy fuel oil user.

Petroleum products also play a key role in the industrial aspects of sugar production. During 1964–67, consumption of fuel oil by sugar mills ranged from 0.5 to 0.7 gallons per metric ton of sugar cane milled.[63] A national fuel conservation drive begun in 1968, targeted at the sugar mills, was largely unsuccessful as consumption of fuel oil skyrocketed during 1969–73 to a historical high of almost 3 gallons per metric ton of sugar cane milled. Fuel oil consumption declined to 1.88 and 1.67 gallons per metric ton of cane milled in 1974 and 1975, respectively, only to rise again to 2.04 gallons/MT in 1976, 2.05 gallons/MT in 1977, and 2.08 gallons/MT in 1978.[64] It can be estimated that processing of the 1978 sugar crop (when 67 million MT of sugar cane were milled) consumed over 464,000 MT of petroleum products.

Nickel Industry: Cuban nickel-bearing ores occur in the form of laterites. As Moran has pointed out, mining of laterites, which can be done by strip mining, is simple compared with that of sulfides, which must be deep-mined. However, smelting and refining ores to extract nickel is eight to ten times as energy intensive for laterites as it is for sulfides.[65] It has been estimated that energy constitutes 50 percent of the cost of processing laterite ores.[66] The Cuban nickel industry meets its substantial energy requirements by generating electricity in several thermoelectric plants; in 1967, it consumed 11 percent of total fuel oil supplies for this purpose.[67]

CONCLUSIONS

This paper has assembled and reviewed available data on energy supply and consumption during the two decades of revolutionary government in Cuba. An effort has been made to analyze, albeit tentatively, three related areas: (1) the sources of energy; (2) the patterns of energy use; and (3) government policies that affect energy supply and consumption. Limitations of data availability and reliability have prevented a satisfac-

tory, and in some cases even a preliminary, examination of important aspects of these topics. Subject to these limitations, however, several important tentative results emerging from the study merit highlighting.

First, domestic energy production expanded marginally during the period 1959–78. The data presented in this study show that bagasse is by far the most important domestic energy source, accounting on average for 80 percent of energy supply. However, bagasse production, directly correlated with sugar output, was essentially stagnant during the 1960s, with a moderate growth trend not emerging until after 1971. Production of some basic energy products of relatively little significance in the total energy balance, such as natural gas, hydroelectricity, ethyl alcohol, fuelwood, and charcoal, declined as the direct result of government policies or expanded marginally. Policies to expand petroleum production were successful, with output rising strongly with respect to pre-1959 levels. However, the share of domestically produced petroleum in apparent supply of petroleum and petroleum products continued to be hardly significant.

Second, in view of the sluggishness of domestic energy production, imports grew significantly to meet increasing energy requirements. Prerevolutionary Cuba depended on imported energy products originating primarily from the U.S. and the Caribbean; revolutionary Cuba has changed the sources of supply and deepened the external dependence on energy products. Since mid-1960, the Soviet Union has single-handedly met Cuban petroleum and petroleum products needs and an increasing share of coal and coke imports. According to estimates in the study, domestic energy production accounted for about 40 percent of energy supply in 1959–61; the domestic share declined to about 32 percent in 1962–69, and 27 percent in 1971–76.

Third, per capita energy consumption grew very slowly during the revolutionary period in comparison with the record of other Latin American countries during the same period or with the performance of the Cuban economy in the decade preceding the revolution. Between 1950 and 1959, Cuban per capita energy consumption almost doubled; between 1959 and 1978, however, it increased only by 26 percent, the slowest growth rate in Latin America for this period with the exception of Chile. For the period 1950–59, the elasticity of energy consumption with respect to economic activity was estimated to be 1.22. For 1962–78 and 1960–77, the estimated elasticity coefficient was zero, indicating that there was no detectable statistical relationship between energy consumption and economic activity during these periods; a simple time trend could explain year-to-year variability in energy consumption. Although these results are tentative because of severe data limitations, they seem to support the findings of other investigators.

Finally, energy consumption data by sectors or by industries are

so weak as to prevent any meaningful generalizations. Given the severe data limitations, very little can be said about the ways in which the Cuban economy has adjusted to the energy crisis. The fragmentary data presented here barely scratch the surface of a topic that merits further research.

NOTES

1. An important exception is Rafael Fermoselle, "Cuba's Energy Balances and Future Energy Picture," *Cuban Studies/Estudios Cubanos* 9, no. 2 (July 1979): 45–58. However, Fermoselle's work covers only the period 1967–76 and the sources of the data he used are not clearly spelled out.
2. See Herbert J. Sawyer, "Latin America after 1920," in Edgar Wesley Owen, ed., *Trek of the Oil Finders* (Tulsa, Okla.: American Association of Petroleum Geologists, 1975), chap. 20.
3. For an example of this view, see Ernesto Guevara, "La industrialización de Cuba," in Universidad Popular, Séptimo Ciclo, *Economía y planificación* (La Habana, June 1961), pp. 35–36.
4. It has been reported that 8.3 percent of total Soviet economic and technical assistance to Cuba during 1960–73 was devoted to geological surveys, with a significant portion allocated to petroleum exploration. Cole Blasier, "COMECON in Cuban Development," in Cole Blasier and Carmelo Mesa-Lago, eds., *Cuba in the World* (Pittsburgh, Pa.: University of Pittsburgh Press, 1979), p. 230.
5. Larry Auldridge, "Cuba's Oil Fields Now Add to Ten," *The Oil and Gas Journal* (2 May 1977), p. 305; Rafael Fermoselle, "Cuba busca petróleo en sus playas," *Petróleo Internacional* (Oct. 1979), pp. 69–72.
6. Fernando G. Dávalos, "Funciona la Termoeléctrica 'Raúl Martínez' con gas natural de Cristales," *Granma*, 12 June 1968, p. 4.
7. A comprehensive study of Latin America's hydroelectric resources by the Economic Commission for Latin America, published in 1962, estimated Cuba's hydroelectric potential at less than 100 Mw. See "Hydroelectric Resources in Latin America: Their Measurement and Utilization," *Economic Bulletin for Latin America* 7, no. 1 (Feb. 1962), p. 86.
8. U.S. Department of Commerce, *Investment in Cuba* (Washington, D.C.: U.S. Government Printing Office, 1956), p. 103.
9. "La Hidroeléctrica 'Robustiano León', un tesoro escondido en la profundidad de una montaña," *Granma*, 10 June 1977, p. 4; "En plena producción hidroeléctrica del Hanabanilla," *Granma*, 15 Feb. 1968, p. 3.
10. Joaquín Oramas, "Kerosene por el alcohol: un cambio que fortalece a nuestra ganadería," *Granma*, 3 Mar. 1969, p. 6; "El uso de kerosene por el alcohol: un cambio de hábito en pro de la economía," *Granma*, 14 Feb. 1969, p. 6.
11. Sugar cane milled data are from Cuba, Junta Central de Planificación, *Anuario Estadístico de Cuba*, various years, and Comité Estatal de Estadísticas, *Anuario Estadístico de Cuba 1978*.
12. A study of sixteen sugar mills in the Cienfuegos region in 1951 found bagasse-to-milled cane ratios by weight ranging from .244 to .324. See José Ramón Ruíz, *Una estrategia de fomento de largo alcance* (La Habana: Cia. Thomas F. Turull, S.A., 1952), p. 52. For the 1959 sugar crop, the national bagasse-to-milled cane ratio can be calculated as .254 using data from Cuba, Junta Central de Planificación, Departamento de Recursos Naturales, *Estudio de producción y consumo de energía eléctrica y uso de combustibles en los centrales azucareros* (La Habana, Feb. 1960), table 3–C; for 1968, the national average was reported as .279 in Ramón Quesada González, "Consumo de energía térmica en la producción de azúcar cruda," *CubaAzúcar* (July-Sept. 1969), p. 6. The assumption of a national bagasse-to-milled cane fraction of .250 is also made by Francisco García López and José A. Clark, "Combinaciones de evaporación de alta

eficiencia y producción de bagazo y energía eléctrica," *CubaAzúcar* (Oct.-Dec. 1969), pp. 17–31.

13. "Introducción en Cuba del sistema australiano de corte," *Economía y Desarrollo*, no. 15 (Jan.-Feb. 1973), pp. 48–71; "Comportamiento industrial de la caña quemada," *CubaAzúcar* (Apr.-June 1972), pp. 33–41; "Efectos de la quema de los campos en la producción de azúcar," *Economía y Desarrollo*, no. 10 (Mar.-Apr. 1972), pp. 92–118.
14. In 1959, 1.7 percent of the bagasse produced was used for nonfuel industrial purposes. See *Estudio de producción y consumo de energía eléctrica*, table 4. In 1975, the share was reported as 4.3 percent in United Nations Development Program, "Country Programme for Cuba," DP/GC/CUB/R.2, mimeographed (June 1976), p. 29.
15. Cuba, Junta Central de Planificación, *Anuario Estadístico de Cuba 1974* and more recent volumes.
16. *Cuba Económica y Financiera* 26, no. 301 (Apr. 1951):88.
17. Cuba, Junta Central de Planificación, *Anuario Estadístico de Cuba 1974* and more recent volumes.
18. Factors to convert production of natural gas and hydroelectricity to the standard unit were obtained from United Nations, Statistical Office, *World Energy Supplies 1950–1974*, Series J, no. 19 (New York: United Nations, 1976), p. xviii. Conversion factors for ethyl alcohol, fuelwood, and charcoal from Federal Energy Administration, National Energy Information Center, *Energy Interrelationships* (Washington, D.C.: U.S. Government Printing Office, 1977), pp. 16–17. For bagasse, the caloric content depends on the moisture level. A conversion factor of 3 MT of relatively dry bagasse (30% moisture) equivalent to 1 MT of crude petroleum is given in *Energy Interrelationships*, p. 16 and also used by Héctor Danilo, "Cuba: impacto mundial de un proyecto azucarero," *Panorama Económico Latinoamericano* 1, no. 43 (31 Oct. 1977), p. 3. However, in Cuban sugar mills, bagasse is generally burned directly, avoiding handling for air or sun drying, but resulting in higher moisture levels. Ruíz, *Una estrategia*, reports bagasse moisture content for 1951 ranging from 44.10 to 50.79% (p. 35); Quesada González, "Consumo de energía térmica," reports the national average bagasse moisture content at 49.36% for 1968. For 1974 and 1975, bagasse moisture content of 47.76 and 49.67%, respectively, are reported in Magali E. Rodríguez and Raul Gutiérrez, "Estudio sobre la calidad del bagazo," *ATAC* 37, no. 1 (Jan.-Feb. 1978):22. Thus, assuming an average bagasse moisture content of 50% for the entire period 1959–78, and following a table relating bagasse moisture content and energy value in megacalories given in Quesada González ("Consumo de energía térmica," p. 3), it has been estimated that 5.6 MT of bagasse (50% moisture) are equivalent in thermal value to 1 MT of crude petroleum of medium gravity. It should be noted that the conversion factor used here is equivalent to another factor, 6 MT of bagasse = 1 MT of distillate fuel oil, often used in the literature. See Herly Noa Silverio, "Aspectos económicos de la industrialización del bagazo," *ATAC* 37, no. 2 (May-June 1978):25.
19. Calculated from data in Cuba, Ministerio de Hacienda, Dirección General de Estadística, *Comercio Exterior 1950–1951* (La Habana, 1952) and subsequent volumes. Origin of imports obtained from the same sources.
20. For example, imports of Soviet petroleum and petroleum products in 1962 accounted for 99.97% by weight of imports in these categories. For 1963, 1964, and 1968–72, the corresponding shares of Soviet imports of petroleum and petroleum products were 99.98, 99.60, and 99.77, respectively. Calculated from data in Cuba, Junta Central de Planificación, Dirección General de Estadística, *Comercio Exterior de Cuba: Importación 1962* and volumes for 1963, 1964, and Cuba, Junta Central de Planificación, *Anuario Estadístico de Cuba*, various volumes.
21. In a departure from established practice, the official statistical yearbook for 1976, *Anuario Estadístico de Cuba 1976*, did not include trade data for 1976. See a review of this volume by Carmelo Mesa-Lago in *Cuban Studies/Estudios Cubanos* 9, no. 2 (July 1979):108–9. The latest data included in the recently published *Anuario Estadístico de Cuba 1978* refer to 1976.
22. Ministerstvo Vneshnei Torgovli SSSR, *Vneshniaia Torgovlia SSSR v 1977 g.* (Moscow, 1978). The practice of suppressing quantity of energy exports refers to trade with each country, including Cuba.

23. Calculated from Cuba, Junta Central de Planificación, Dirección General de Estadística, *Comercio Exterior de Cuba* 1 (La Habana, 1961).
24. Calculated from Cuba, Junta Central de Planificación, Dirección General de Estadística, *Comercio Exterior de Cuba: Importación 1962* and volumes for 1963, 1964.
25. Cuba, Junta Central de Planificación, *Anuario Estadístico de Cuba*, various years, and Cuba, Comité Estatal de Estadísticas, *Anuario Estadístico de Cuba 1978*.
26. Glowny Urzad Statystyczny, *Rocznik Statystyczny Handlu Zagranicznego 1965* (Warsaw, 1966) and volumes for 1966, 1967, 1968, 1970, 1973, 1974.
27. United Nations, Statistical Office, *World Energy Supplies 1950–1974*, and more recent volumes.
28. Joel Darmstadter et al., *Energy in the World Economy* (Baltimore, Md.: Johns Hopkins University Press, 1971), pp. 32–39, and Joel Damstadter, "Energy Consumption: Trends and Patterns," in Sam H. Schurr, ed., *Energy, Economic Growth and the Environment* (Baltimore, Md.: Johns Hopkins University Press, 1971), pp. 176–85.
29. J. G. Polach, "The Development of Energy in East Europe," in U.S. Congress, Joint Economic Committee, *Economic Developments in Countries of Eastern Europe* (Washington, D.C.: U.S. Government Printing Office, 1970), pp. 364–66.
30. Robert F. Halvorsen and Judith A. Thornton, "Comparative Responses to the Energy Crisis in Different Economic Systems: An Extensive Analysis," *Journal of Comparative Economics* 2, no. 2 (June 1978):197–98.
31. Ibid., p. 191.
32. Estimates of GNP at current prices for 1950–58 originate from the Cuban National Bank. A GNP series at constant 1953 prices was derived by deflating GNP at current prices by an index of retail prices of food items from Cuban Economic Research Project, *A Study on Cuba* (Coral Gables, Fla.: University of Miami Press, 1965), p. 474. For 1959, GNP at constant 1953 prices was estimated to have equalled level for 1957 following Felipe Pazos, "Desarrollo insuficiente y depauperación económica," *Cuadernos*, supplement to no. 47 (Mar.-Apr. 1961):49.
33. Carmelo Mesa-Lago, "Cuban Statistics Revisited," *Cuban Studies/Estudios Cubanos* 9, no. 21 (July 1979):61–62.
34. The actual GMP and GSP data used were compiled by Carmelo Mesa-Lago. See his *The Economy of Socialist Cuba: A Two-Decade Appraisal* (Albuquerque: University of New Mexico Press, 1981), table 4.
35. The series in current dollars is published, e.g., in World Bank, *1978 World Bank Atlas* (Washington, D.C.: World Bank, 1979). The series in constant dollars is available from the World Bank.
36. When the equations were estimated without the time trend, the estimated elasticities increased from zero to about .36 and were highly significant, while the explanatory power of the equations fell substantially. These statistical results suggest that multicollinearity between the economic activity variable and the time trend is present and that economic activity has no influence on energy consumption independent of a simple time trend.
37. Reportedly, in 1968, the value of the molasses needed to produce one metric ton of ethyl alcohol was about six times the world market price of a metric ton of kerosene. See *Granma*, 3 Jan. 1969, p. 4.
38. Oramas, "Kerosene por el alcohol," and "El uso de kerosene."
39. *Granma*, 26 Apr. 1971, p. 7; 3 May 1971, p. 3.
40. *Revolución*, 2 Oct. 1965, p. 1.
41. *Granma*, 29 Sept. 1970, p. 3.
42. "Mas patrullas 'click,' menos apagones," *Granma*, 27 Sept. 1971, p. 4. In late 1971, there were 31,112 patrols with 136,429 youths operating nationwide; by September 1977, membership in the patrols had swelled to several hundred thousand. See *Granma*, 26 Sept. 1977, p. 6.
43. *Granma*, 26 Apr. 1971, p. 7.
44. "Informe sobre el sistema de cobro diferido del servicio eléctrico," *Bohemia* 71, no. 1 (5 Jan. 1979):42–44.
45. United Nations, Statistical Office, *Statistical Yearbook 1959* (New York: United Nations, 1959), p. 332. Another source gives the number of taxis in Cuba on 31 Dec. 1957 at 136,574. For data, see Paul C. Roberts and Mukhtar Hamour, eds., *Cuba 1968* (Los

Angeles: Latin American Center, University of California, 1970), p. 116. Castro has estimated the stock of automobiles in 1958 at 300,000. See *Granma*, 3 Jan. 1968, p. 3.

46. United Nations, *Statistical Yearbook 1959*.
47. For an interesting discussion of the conditions leading to the imposition of the controls and their aftermath, see Edward Boorstein, *The Economic Transformation of Cuba* (New York: Monthly Review Press, 1968), chaps. 3 and 4.
48. The regulations were published in *Granma*, 3 Jan. 1968, p. 6.
49. Zoila González-Maicas, "La matriz de insumo-producto: un nuevo instrumento de planificación industrial en Cuba," *Nuestra Industria. Revista Económica* 2, no. 8 (Aug. 1964):68–75.
50. Enrique González-Romero and Zoila González-Maicas, "Algunas contribuciones al análisis y utilización de la matriz de insumo producto," *Nuestra Industria. Revista Económica* 3, no. 12 (Apr. 1965):3–25.
51. Leontief was shown an input-output table for 1965 during a visit to Cuba in early 1969. It was prepared at the level of 171 industries, aggregated to 97 industries. See Wassily Leontief, "Notes on a Visit to Cuba," *The New York Review of Books* (29 Aug. 1969), p. 15.
52. According to Castro, the principal users of fuel oil in 1967 were the electric, sugar, cement, and nickel industries; the principal users of gas oil were agriculture, transportation, the merchant marine, construction, fishing, and the sugar industry. *Granma*, 3 Jan. 1968, p. 5.
53. At that time, it was estimated that the three thousand industrial steam boilers across the nation were operating with an average thermal efficiency of 64%; raising their efficiency to 81% would mean a decline in fuel oil consumption of 160,000 MT per year. See Orlando Gómez, "A propósito del Seminario Nacional sobre Calderas," *Granma*, 19 Mar. 1971, p. 5.
54. *Granma*, 3 May 1971, p. 3.
55. *Granma*, 3 Jan. 1968, p. 5.
56. "Cinco veces mas capacidad de generación eléctrica," *Bohemia* (24 Feb. 1978), p. 52.
57. "Para 1975 la generación de electricidad crecerá en mas del ocho por ciento por encima de lo obtenido en 1974," *Granma*, 25 Jan. 1975, p. 4; "Incrementarán en 1300 Mw la capacidad de generación eléctrica," *Granma*, 27 Jan. 1977, p. 2.
58. "Cinco veces mas capacidad," p. 53.
59. "Produjo la industria eléctrica mas de 6400 milliones de kwh en 1977," *Granma*, 29 Dec. 1977, p. 2.
60. For example, a 5 Mw plant uses, on average, 420 grams of petroleum products per kwh generated; for a 30 Mw plant, consumption is 294 grams/kwh; for a 125 Mw plant, 236 grams/kwh; and for a 169 Mw plant, 217 grams/kwh. "La construcción es una tarea hermosa, creadora y transformadora," *Bohemia* 70, no. 51 (22 Dec. 1978):44.
61. "¿Cuánto petróleo puede ahorrarse en la industria azucarera?," *Granma*, 16 Feb. 1968, p. 3.
62. For the 1975 harvest, 25% of sugar cane cutting and 98% of loading were done with machines. It was projected that for the 1978–79 harvest, 50% of cutting and virtually all loading would be mechanized. See Fidel Castro, "Del Informe del Comité Central del PCC al I Congreso," *Economía y Desarrollo*, no. 36 (Jul.–Aug. 1976):18; "Hacia una zafra superior digna del XX Aniversario," *Granma*, 27 Nov. 1978, p. 1.
63. "¿Cuanto petróleo?"
64. Juan Varela-Pérez, "Consolida sus bases y se define la política energética en la industria azucarera," *Granma*, 15 Nov. 1978, p. 3.
65. Theodore H. Moran, "The International Political Economy of Cuban Nickel Development," in Cole Blasier and Carmelo Mesa-Lago, eds., *Cuba in the World* (Pittsburgh, Pa.: University of Pittsburgh Press, 1979), p. 262.
66. Ibid., p. 271, n. 31.
67. *Granma*, 3 Jan. 1968, p. 5.