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SEPTEMBER 1962

GENERAL ELECTRIC

PRELIMINARY REPORT OF FIELD SURVEY TEAMS
on the
GENERATION AND UTILIZATION OF POWER IN RURAL AREAS OF DEVELOPING COUNTRIES

Submitted to

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I.

INTRODUCTION

This preliminary report presents the principal impressions and tentative conclusions of the field investigations on the Generation and Utilization of Power in Rural Areas in Developing Countries, carried out under General Electric Contract, AID-REPAS 1. Field surveys of approximately two months duration were conducted in India and in Chile, Colombia and Peru. The purpose of the surveys was to assess the need for and the impact of electrification on rural development, particularly at the village level.

To conduct the field investigations, two four-man survey teams were organized. The Indian Team included Dale J. Hekhuis, Economist, General Engineering Laboratory, General Electric Company; Paul Rosenstein-Rodan, Economist, Center for International Studies, Massachusetts Institute of Technology; Kailash K. Singh, Social Psychologist, Lucknow University, India; and Stanton R. Smith, Engineer-Economist, Stanford Research Institute. The Latin American Team consisted of Thomas O. Paine, Physicist, General Engineering Laboratory, General Electric Company; George Street, Jr., Engineer, General Engineering Laboratory, General Electric Company; Frank L. Turner, Economist, Stanford Research Institute; and E. Gordon Alderfer, Program Development Officer, CARE, Inc.

The report has been organized to present at the outset a general review of existing rural electrification programs in India and Colombia.

These sections of the report are concerned with such basic considerations as power costs, subsidies, tariffs, and load factors. A separate section contains the observations of the field survey teams on the significance of small scale power units from the standpoint of village development programs. One of the primary findings of both survey teams was the need for a more effective focusing of rural electrification projects on viable rural development opportunities, so a section is included on possible systems approaches to the rural development problem. Appendices setting forth detailed site descriptions and evaluations of specific rural areas visited are also provided.

Finally, a qualification should be made with respect to the purpose and findings of this report. As indicated in the title, the report is preliminary. It should be considered a working progress report summarizing the results of the field survey investigations. Considerable analytical work remains to be completed on energy cost and utilization problems before valid specific conclusions can be drawn.

II.

RURAL ELECTRIFICATION IN INDIA

National Power Capacity and Trends

In the past decade India has carried out a fairly rapid electrification program increasing installed capacity from 2.3 million Kw in 1950 to 5.7 million in 1961 (see Table 1).

While the rate of growth in the past decade has been high, 8.6 percent per annum, it has been inadequate to meet the nation's rising requirements. As a result, in the next five years under the third five year plan, India plans to double the annual rate of expansion to 17.4 percent and more than double generating capacity to 12.7 million Kw. This expansion in generating capacity in the next five year period will take place almost entirely in the public sector costing rupees 1039 crores or approximately two billion U.S. dollars. The expansion of power in private industrial plants totals only five percent of this, or rupees 50 crores. The total expansion in generating capacity for the third five year plan will be about equally divided between increased capacity of large scale coal-fired thermal plants and hydroelectric plants, 3.6 and 3.2 million kw respectively. The expansion of diesel generating plants is negligible and these stations which totaled only five percent of the nation's public utility capacity in 1961 will decline to three percent in 1966.

India's generating capacity is becoming increasingly oriented toward large scale hydroelectric and coal-fired thermal stations serving major transmission grids because of the low cost of electricity generation in

Table 1

Electric Generating Capacity in India
1950, 1961 and 1966 Projection

	1950	1961	1966 (plan target)
Public Utilities			
Hydro Plant			
Installed Capacity Mw	559	1932	5100
Electric production (million kwh)	2520	7850	-----
Steam Plant			
Installed Capacity Mw	1004	2439	5660
Electric production (million kwh)	2387	8790	-----
Oil Plant			
Installed Capacity Mw	149	311	360
Electric Production (million kwh)	200	360	-----
Nuclear Plant	-----	-----	150
Subtotal Capacity MW	1712	4682	11,270
Private Industrial Installations			
Installed Capacity MW	588	1015	1420
Electric production (million kwh)	1468	2850	-----
Total Installed Capacity MW	2300	5696	12,690
Total Electric Production (million kwh)	6575	19,850	-----

Source: The Third Five Year Plan, op. cit., p. XXIII-55, and p. 402.

these stations. The average cost of generating electricity during the third plan period in hydroelectric stations is estimated at three mills, in thermal stations at six mills, whereas diesel power costs are estimated to total 52 mills (see Table 2). The low cost of hydroelectric power generation in India is to be expected in a nation which has only utilized a small fraction of its hydroelectric potential. India has an estimated hydroelectric potential of 40 million Kw and even the planned expansion by 1966 will utilize only an eighth of this potential. There are, therefore, many favorable sites for hydroelectric development ahead in India. The earlier versions of the third five year plan had anticipated constructing 9.1 million Kw of hydroelectric capacity by 1966 but this was revised downward to 5.1 Kw because of the difficulties of international financing and high overall capital requirements. Even so, the relative importance of hydroelectric power will increase in India to account for about 40 percent of total capacity and more than half of all power production by 1966. The Kw cost of recent large scale thermal and hydroelectric capacity in India is indicated in Table 3 and it may be seen that some hydroelectric plants have been erected at smaller capital costs than thermal plants.

India generated 20 billion Kw hours of electricity in 1961 and industry utilized more than 60 percent of this total (see Table 4). The domestic and commercial consumption for lighting totaled only about 12 percent of the total power generated, a relatively small proportion, nearly all of which was consumed in urban areas. Irrigation consumption totaled only 4.2 percent of the power generated. The low level of consumption

Table 2

Average Third Year Plan Cost of Electricity in India by Generation Type

Type	Cost per Kw Hour nP	Cost per Kw Hour U.S. Cents
Hydroelectric	1.2	0.3
Coal thermal	3.0	0.6
Nuclear	4.0	0.8
Diesel	25.0	5.2

Note: 100 nP = 1 rupee = 21 U.S. cents

Source: The Third Five Year Plan, Planning Commission, New Delhi, 1961, p. 399.

Table 3

Capital Costs of Selected Indian Thermal and Hydroelectric Power Stations Constructed in Second Five Year Plan

Station	Installed Capacity (kw)	Cost per Kw (dollars)
Coal-fired thermal		
Addition to Bokara, Bihar	50,000	147
Korba, Madya Pradesh	90,000	200
Katni, Madya Pradesh	20,000	285
Addition to Kheparkheda, Pradesh	60,000	280
Hydroelectric		
Kurdah, Madras	129,000	390
Barapole, Coorg	139,000	310
Laxmi, Kerala	51,000	190
Sholayar, Kerala	54,000	155
Panniar, Kerala	25,000	250

Source:
Regional Economic Development and Nuclear Power in India, National Planning Association, Washington, 1957, p. 31.

of electricity by the domestic rural consumer is indicated in Table 5 which provides an estimate of demand for electricity by sector. Only one-fourth of one percent of all the electricity consumed in 1960 was utilized for domestic purposes in the rural areas. In spite of a fairly rapid rural electrification program, this consumption of electricity for domestic purposes in the rural areas is expected to remain only one-third of one percent of all the electricity consumed by the end of the third five year plan, and less than one percent in 1975. This low level of rural electricity consumption reflects not only the relatively small number of the rural population living in electrified villages and towns, 9.6 million in 1960 expected to increase to 19.7 million in 1965; but also the very low level of per capita consumption of electricity in these rural areas estimated at 4 Kw hours per year in 1960 to increase to only 5.5 Kw hours per year in 1965.[1]

India's policy of electrifying the country by the construction and extension of state-wide grid systems has allowed the various State Electricity Boards to construct their most economical large scale generating plants serving state-wide urban connecting grids, and to realize the additional generating cost economies achieved by higher load factors. Under the national planning guidance of the Central Water and Power Commission these state grids are becoming integrated into a national grid so as to utilize optimally the nation's hydroelectric facilities and efficient mine-

[1] See estimates by the National Council of Applied Economic Research in Demand for Energy in India, 1960, New Delhi, p. 46.

Table 4

India: Pattern of Electric Consumption
1961 Estimated

	Million Kwhr	Percent of Total
Domestic and residential light and small power	1,492.0	7.5%
Commercial light and small power	870.0	4.4
Industrial power	12,313.5	62.0
Traction	449.0	2.3
Public Lighting	192.0	1.0
Irrigation	836.0	4.2
Public water works and sewage pumping	455.0	2.3
Losses in electric system	3,242.5	16.3
TOTAL GENERATION	19,850.0	100.0%

Source: The Third Five Year Plan, op. cit., p. XXIII-65.

Table 5

Estimate of Demand for Electricity by Sector
1960-1975
(million Kwh)

	1960	1965	1975
Agriculture (irrigation)	510	970	3,000
Industry	12,400	24,500	82,500
Domestic urban	1,384	2,332	6,512
Domestic rural[1]	38	108	929
Services	1,450	2,450	6,850
Transport	920	1,520	3,170
TOTAL	16,702	31,880	102,961

[1] Based on the following assumptions: electrified rural population in millions -1960: 9.6; 1965: 19.7; 1975: 84.5; and per capita consumption in rural areas in kwhr/year 1960: 4.0; 1965; 5.5; 1975: 11.0.

Source: Demand for Energy in India, NCAER, 1960, p. 46.

site coal-fired steam plants as base load plants and the less efficient and older facilities as part-time peaking units. As these transmission grids have expanded a larger proportion of the countryside has become accessible to extensions off these grids which have provided the basis for India's present rural electrification program.

Scope of Rural Electrification

Table 6 provides data on the number of towns and villages electrified in India by size, in 1956 and 1961 and the Third Five Year Plan targets for 1966. As may be seen in this table, by 1961 India had succeeded in electrifying all towns above a population of 20,000 almost nine tenths of the 856 towns in the 10,000 and 20,000 population range, more than one-half of the 3101 communities in the 5000 to 10,000 population range, but only a small fraction of the more than one-half million villages under 5000 population. It is anticipated that the electrical grids in India will reach all communities above 5000 population by 1966, about one-half of the 10,000 villages with populations between 2000 and 5000, and about seven percent of the 545,000 villages in India with populations under 2000. These smaller villages will be electrified dependent upon their proximity to larger towns or their being within a reasonable distance of transmission lines established between load centers and generating facilities. As a consequence, those villages electrified will typically be those most directly benefiting from the rising incomes in the urban and industrializing sector of the economy and thus most able to pay the cost of electrification and able to utilize electricity productively.

Table 6

Number of Towns and Villages Electrified in India, by Size
1956, 1961 and Projection for 1966

Population Range	Total Number[a]	No. Elect. by March 1956	No. Elect. by March 1961	No. Elect. by March 1966 (est)	Percent Electrified by 1966
Over 100,000	73	73	73	73	100%
50,000-100,000	111	111	111	111	100
20,000-50,000	401	366	399	401	100
10,000-20,000	856	350	756	856	100
5,100-10,000	3,101	1200	1,800	3,101	100
2,000-5,000	10,000			5,000	50
500-2,000	180,000	5300	19,861	33,458	6
Less than 500	365,000				
TOTAL	560,000	7400	23,000	43,000	8%

[a]According to 1951 census.

Source: The Third Five Year Plan, Draft Report, Government of India, Planning Commission, Delhi, May 1961, p. XXIII-40.

Table 7
INDIAN VILLAGES AND TOWNS WITH PUBLIC ELECTRIC SUPPLY IN MARCH 1961

Sl. No.	Name of State	Population as per 1961 Census in millions	No. of villages and towns with population as per 1951 Census between over 0 to 500	500	Total No. of Villages & Towns as per 1951 Census	Percent of places with population up to 500 to total villages & towns Col.4x100 / Col.6	No. of villages and towns electrified as on 31.3.61 (Estimated)	No. of villages and towns per 100 square miles of area	Average population per village Col.3 / Col.6	Density of population per sq. mile as per 1961 census	Per Cent of villages and towns electrified to total Col.8x100 / Col.6	Overhead lines 2.2 KV to 37.5 KV as on 31.3.60 in Kilometres. Total in State	Average per Village Col.13 / Col.6
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1.	Andhra Pradesh	35.98	11,308	15,435	26,743(vii)	42.3(iii)	2125(iii)	25(xiii)	1345(iii)	339(vii)	7.9(iv)	10,483	0.392(v)
2.	Assam	11.86	20,060	5,295	25,355(v)	79.1(xii)	55(xiv)	30(x)	468(xii)	139(xiv)	0.2(xiv)	146	0.006(xii)
3.	Bihar	46.46	45,909	22,169	68,078(xii)	67.5(ix)	1850(v)	102(ii)	682(ix)	69(iii)	2.7(viii)	8,444	0.124(vii)
4.	Gujarat	20.62	10,332	8,131	18,463(ii)	56.0(iv)	735(viii)	26(xii)	1117(iv)	286(xi)	3.9(vii)	N.A.	N.A.
5.	Kerala	16.88	580	4,105	4,685(i)	12.4(i)	1670(vi)	31(ix)	3602(i)	1125(i)	35.5(i)	5,478	1.169(i)
6.	Madhya Pradesh	32.39	57,286	12,950	70,236(xiii)	81.5(xiii)	420(xi)	41(vi)	461(xiii)	189(xii)	0.6(xi)	2,144	0.031(x)
7.	Madras	33.65	6,511	12,135	18,646(iii)	32.9(ii)	6000(i)	37(vii)	1804(ii)	671(iv)	32.3(ii)	12,745	0.684(ix)
8.	Maharashtra	39.50	20,439	16,002	36,441(ix)	56.1(v)	690(ix)	30(xi)	1084(v)	333(viii)	1.9(ix)	N.A.	N.A.
9.	Mysore	23.55	16,320	9,847	26,167(vi)	62.2(vii)	1650(vii)	35(viii)	899(viii)	317(ix)	6.3(v)	16,362	0.625(iii)
10.	Orissa	17.57	40.654	7,783	48,437(xi)	83.9(xiv)	140(xiii)	80(iv)	363(xiv)	292(x)	0.3(xiii)	950	0.0196(xi)
11.	Punjab	20.30	12,235	8,814	21,049(iv)	58.0(vi)	2030(iv)	45(v)	964(vi)	431(vi)	9.6(iii)	9,413	0.447(iv)
12.	Rajasthan	20.15	23,830	8,101	31,931(viii)	74.7(xi)	140(xii)	24(xiv)	631(xi)	152(xiii)	0.4(xii)	1,067	0.033(ix)
13.	Uttar Pradesh	73.75	75,458	36,750	112,208(xiv)	67.3(viii)	4500(ii)	99(iii)	658(x)	650(v)	4.0(vi)	16,835	0.15(vi)
14.	West Bengal	34.97	26,105	12,486	38,591(x)	67.6(x)	480(x)	114(i)	906(vii)	1030(ii)	1.2(x)	2,286	0.0592(viii)
	Total for States excluding Jammu and Kashmir	427.63	367,027	180,003	547,030	67.1	22485	48	782	372	4.1	-	-

Note: 1) Details for Jammu and Kashmir are not given as no precise data is available.

2) The total No. of villages and towns electrified as on 3.3.61 is as given by Rural Electrification Directorate of Central Water and Power Commission. These are different from the figures furnished for Madras by the State Electricity Board, as hamlets are also included in the latter's count.

Table 8

Electricity Consumption in Madras--Fiscal 1961 Sales Total and Average Revenue by Type of Consumer

Type of Consumer	Sales: Millions of Kwh	Sales: Percent of Total	Revenue: Millions of Rupees	Revenue: Percent of Total	Average Revenue: nP	Average Revenue: U.S. Cents
Domestic	100	7.8%	24.5	22.8%	24.4	5.1¢
Industrial	756	59.5%	48.6	45.3	6.3	1.3
Traction	28	2.2	2.6	2.4	9.1	1.9
Street Lighting	21	1.7	4.2	4.0	20.4	4.3
Agriculture	366	28.8	27.4	25.5	7.5	1.6
TOTAL	1271	100.0%	107.3	100.0%	8.4	1.8¢

Source: Report of the Study Team on Rural Electrification in Madras, Planning Commission, New Delhi, 1961.

Table 9

Rural Electricity Grid Extension Costs in Madras

Cost Item	Annual Revenue Required before connection is authorized (as percent of Capital Costs of Extension	Actual Annual Revenue Required to Cover Costs in 1961 (as percent of Capital Costs of Extension)
Cost of Power	1.7%	3.3%
Operation & Maintenance	3.0	7.2
Depreciation	2.5	3.5
Interest	3.5	4.2
TOTAL	10.0%	18.2%

Source: Report of the Study Team on Rural Electrification in Madras, Planning Commission, Delhi, 1961.

The progress of the various Indian states in rural electrification differs sharply. Four states have made considerable progress: Madras, Kerala, Andhra Pradesh, and the Punjab. These states had electrified the following proportions of their total villages and towns: 36, 32, 10 and 8 percent respectively (see Table 7). Various factors tended to make rural electrification easier in these states. In Kerala there is a relatively low proportion of smaller villages, only 12 percent of the villages have a population of less than 500 as compared to the all-India average where two-thirds of all villages have populations under 500 (see Table 7, Column 7). In Madras and Andhra Pradesh, the typical village also tends to be somewhat larger in size, increasing the minimum load of the village electrical installation. Significant pumping loads supplement the lighting loads, and in addition, Madras, Kerala and the Punjab have each developed electric transmission and grid systems served by a large proportion of low cost hydroelectric power.

Subsidies for Rural Electrification

However, though these states are serving the optimum villages first, their rural electrification programs are being heavily subsidized by the urban industrial and domestic consumers. In Madras, for example, a state which has succeeded in electrifying the largest proportion of villages, the State Electricity Board estimated that the total annual subsidy to rural users in 1958, when only 4000 villages were electrified, was 1-1/2 crores of rupees, or three million U.S. dollars. The subsidy is estimated to total almost half the cost of supplying rural

electricity and is high in relation to the planned annual investment of six crores of rupees to extend rural electricity to the remaining 8000 less economic villages in Madras under the Third Five Year Plan.

The State Electricity Board of Madras is now expanding its rural electrification program by connecting approximately 1300 villages per year. In this connection, the state electrical engineers conduct load surveys in prospective villages in order to determine the priority of order to connect those villages first where the losses would be minimized. This formula is presented in Table 12 where the estimated annual revenue required from a village before connection is authorized is 10 percent of the capital cost of the extension of power to the village including transmission and distribution line and transformer costs. It is estimated that of this 10 percent, 1.7 percent goes to pay the cost of power, 3.0 percent to power operation and maintenance costs, 2.5 percent to depreciation, and 3.5 percent to interest. However, cost experience in 1961 indicated that annual revenue would have to equal 18.2 percent of the capital cost of a rural extension before the system would pay its way. This was because the basic cost of power and the operation and maintenance expenses had both more than doubled (see Table 9).

Cost of Diesel Generated Power

Given rural electricity rates as low as 1.5 and 2.1 cents per kw hour the state electricity boards in India have not undertaken to serve rural communities isolated from transmission grids by small scale diesel generation except on an interim load building basis awaiting grid connection. As has been noted in Table 2, the electricity cost of large diesel

generators in India is 10 to 15 times that of coal or hydroelectric costs. In small scale diesel generation given diesel fuel at 50 U.S. cents per imperial gallon, about one half of which is taxes levied to lessen the foreign exchange drain, the cost of power from small diesel generators is prohibitive for rural use. At a load factor of 30 percent, using 50¢ fuel, the total cost per kw/hour ranges from about 12 U.S. cents for a 25 kw unit down to about 7 U.S. cents for a 100 kw unit.

Table 10
Capacity of Diesel Power Stations in India
1956

Plant Capacity (kw)	Number of Stations
Up to 100	124
101-250	126
251-500	110
501-750	54
751-1000	25
1001-2500	52
2501-5000	9
TOTAL	500

Source: Demand for Energy in India, NCAER, 1960, p. 155.

Reflecting the high cost of small scale diesel electric power generation, there are only a relatively small number of public utility diesel power stations in India. Table 10 provides the capacity of 500 existing diesel power stations in India in 1956.[1] The state electricity board officials have declared that apart from a relatively small number of isolated urban stations and interim load building activity awaiting grid connections, diesel power installations are not considered, and

[1]Since 1956 approximately 250 diesel sets of 100 Kw capacity and less have been installed under the Colombo Plan.

these interim stations usually range upwards of 250 kw capacity. This aversion to oil generation in India was indicated in Table 1 where the total installed oil-fired capacity of the public utilities is only about 5 percent of the total capacity, a proportion which is destined to continue to decline in the next Five Year Plan to 3 percent in 1966. Electricity produced in these generating stations was even a smaller fraction, about 2 percent of the total electricity produced in India in 1961.

Utilization of Power

In spite of the higher cost of serving the rural consumer the rural electricity rates today are often as low and at times lower than those of the urban consumer. In Madras state, for example, low tension power is supplied at a rate of 10 nP (2.1 U.S. cents) per kw hour for such agricultural processing industries as rice hulling, flour grinding, oil pressing, sugarcane crushing and cotton ginning. For cottage industries and for agricultural water pumping, the rate is 7 nP per unit (1.5 U.S. cents). As a result of these low rates, there is considerable incentive to shift irrigation pumping from the bullock or diesel engine pump to electric pumps, and by 1960, it was estimated that 28 percent of all the power generated in Madras State was consumed in irrigation pump sets (see Table 8). Therefore the losses in rural electricity in Madras were incurred even though the rural load contains a relatively high proportion of pumping and industry demand; pumping takes up about 50 percent of the rural load, rural industries 25 percent, and domestic use only 25 percent.

In Table 12, the cost of lift irrigation in Madras by bullocks, diesel engine pump, and electric pump have been compared. It may be noted that the principal reduction in cost is achieved by the shift from the bullock to the diesel engine pump which reduces the cost per acre per crop of paddy from 300 rupees down to 83 rupees. At the subsidized rural electricity rate of 7 nP per kw hour, the cost of electric pumping is still lower at 56 rupees. Without the subsidy, however, electric pumping would not be cheaper than diesel.

Furthermore despite low rates, load factors for rural communities in Madras are still low. Table 12 presents power consumption data for domestic, agricultural and industrial consumers for 14 typical villages in Madras.

Table 11
Electricity in Irrigation Pumping in Madras

Number of agricultural pumping sets connected as of March 31, 1961	117,695
Average unit capacity of a pump	5 to 6 Hp
Pump lift range	10 to 110 ft.
Consumption of power for irrigation per acre of land	800 units
Cost at 7 nP per unit	Rs. 56

Cost of lifting water from wells for irrigation per acre per crop of paddy by alternative methods:

By bullocks	Rs. 500/-
By diesel engine pump	Rs. 83/-
By electric pump	Rs. 56/-

Source:
Report of the Study Team on Rural Electrification in Madras. Planning Commission, New Delhi, November 1961.

Table 12
CONSUMPTION OF POWER IN A SAMPLE OF 14 VILLAGES IN MADRAS STATE, INDIA
AUGUST 1960-JULY 1961

Village	Domestic			Agricultural			Industrial			Street Lights			Total		
	KW Connected	Kwh Year	Use Factor	KW# Connec.	Kwh Year	Use Factor	KW# Connec.	Kwh Year	Use Factor	KW Connec.	Kwh Year		KW Connec.	Kwh Year	Use Factor
Palapur	6.45	1,027	1.82	141.2	171,096	13.82	-	-	-	.85	2,376	32.0	148.50	174,499	13.4
Pukkathurai	7.52	4,728	7.2	47.6	61,667	14.80	-	-	-	.40	2,336	66.7	55.52	68,731	14.1
Tiruvandavoor	7.52	-	-	59.7	34,050	6.50	-	-	-	-	-	-	67.22	34,050	5.78
Moosivakkam	3.09	699*	6.24	38.25	12,273	8.79	-	-	-	2.08	1,808*	23.8	43.42	14,780*	9.32
Mudaloor	109.0	15,784	1.65	68.2	47,777	8.00	13.20	10,576	9.15	1.42	2,785	22.4	191.82	76,922	4.58
Perungulam	73.06	15,521	2.42	7.65	5,950	8.87	33.40	23,248	7.96	-	4.632	-	114.11	49,351	4.93
Sivanthipatti	14.99	2,462	1.88	179.2	153,668	9.78	-	-	-	.56	1.164	23.7	194.75	157,294	9.24
Moolkarapatti	129.06	26,273	2.32	123.6	63,208	5.84	18.80	27,808	16.90	4.30	8.892	23.6	275.76	126,181	5.24
Mannimangalam	9.0	2,921	3.71	51.3	8,123	1.81	9.32	4,484	5.44	-	-	-	69.62	15,528	2.23
Padappai	30.2	16,625	6.3	132.5	54,984	4.73	59.20	58,392	11.25	-	-	-	221.9	130,001	6.70
Ninnakarai	20.5	8,433	4.69	60.7	17,728	3.34	27.50	11,014	4.57	-	-	-	108.7	37,175	3.90
Guduvancheri	34.5	19,703	6.52	12.12	6,180	5.81	84.00	N.R. in det.	-	-	-	-	130.62	-	-
Mambakkam	2.7	683	2.89	59.7	16,829	3.22	18.64	N.R.	-	-	-	-	81.04	-	-
Vandalur	21.6	7,814	4.13	25.2	5,552	2.52	44.50	27,688	7.11	-	-	-	91.3	41,054	5.14
														910,786	

Obtained from connected HP by assuming motor efficiency of 0.80.
* Data for five months only.

$$\text{Use Factor} = \frac{\text{Kwh used}}{\text{Connected load} \times 24.365}$$

III.

RURAL ELECTRIFICATION IN COLOMBIA

National Power Capacity and Trends

A study of the national capacity was completed in August 1961 by the Colombian Government's power planning and regulatory authority, Instituto de Aprovechamiento de Aguas y Fomento Electrico, hereafter referred to by its abbreviated title "Electroaguas." This study and related annexes provide the latest nationwide data available on capacity and generation for the calendar year 1960.

According to the Electroaguas study, Colombia's total installed capacity in 1960 operated by firms serving the public was 669,910 Kw consisting of 31 percent thermal and 69 percent hydro capacity. Broken down regionally, the installed capacity is greatest in three Departments: (1) Antioquia, based on the power load of Medellin, (2) Cundinamarca based on Bogota requirements, and (3) in Valle where a major load is needed for the Cauca Valley's urban and industrial complex. Other major load centers are in Atlantico (Barranquilla) and Caldas (Manizales-Pereira).

The bulk of the capacity, 88 percent, lies in seven Departments inhabited by about 66 percent of the total population. Not included in the Electroaguas statistics is an additional 241,000 Kw of capacity owned by manufacturing or mining concerns and some unreported small scale public service plants in rural areas consisting of generators below 100 Kw capacity.

Table 1

PUBLIC POWER CAPACITY IN COLOMBIA, BY DEPARTMENTS
DECEMBER 31, 1960

Department	Major Load Centers	Total Capacity	Percent of Total Capacity	Percent of Total Population (1960)
Antioquia	Medellin	154,310	23%	14%
Cundinamarca	Bogota	154,136	23	16
Valle	Cali	123,646	19	12
Atlantico	Barranquilla	52,871	8	4
Caldas	Manizales-Pereria	51,482	8	9
Bolivar	Cartagena	28,723	4	5
Santander	Bucaramanga	21,793	3	6
Subtotal		586,961	88%	66%
All others		82,949	12	34
Total		669,910	100%	100%

The number of power plants in Colombia registered with Electroaguas at the end of 1960 was 824, of which 408 or 49.5 percent were hydro plants and 416 or 50.5 percent were thermal. The average capacity of the hydro plants was 1126 Kw and the average capacity of the non-hydro plants was 505 Kw. Plants in the latter group were predominantly diesel.

Generating plants in Colombia are grouped by classes according to capacity. Plants of 25,000 Kw or above are in Class A, while the smallest category of plants, 100 Kw or less, are in Class G. The total capacity by class is shown in Table 2 and illustrates the fact that more than half of Colombia's capacity, 52 percent, consists of large Class A plants. These plants are concentrated in the first three major load centers shown in Table 1 and have industrial loads which exceed the residential lighting load. Industrial loads vary slightly by month but were, for example, 39 percent in Cali and 31 percent in Bogota in July 1960. Plants below 1000 Kw, in Classes E, F, and G are scattered in smaller communities, and the load is primarily residential. Although Electroaguas is attempting to standardize rates and centralize controls, these small, unconnected plants and the companies which control them present a widely differing pattern of rates, capacities, and means of financial support.

The bulk of Colombia's installed capacity is owned and operated by municipal or private companies. The first category of companies (see Table 2) includes firms with a 1960 total capacity of 452,189 Kw or 68 percent of the national total. The firms in this group are (a)

Table 2

GENERATING PLANTS IN COLOMBIA, BY CAPACITY
DECEMBER 31, 1960

Class	Capacity (kw)	Percent of Total Capacity	No. of Plants	Average Capacity (kw)
Class A (25,000 kw or above)	349,815	52%	6	58,303
Class B (10,001 to 25,000 kw)	76,600	11	5	15,320
Class C (5,001 to 10,000 kw)	66,457	10	9	7,384
Class D (1,001 to 5,000 kw)	89,430	14	39	2,293
Class E (501 to 1,000 kw)	32,094	5	43	746
Class F (101 to 500 kw)	35,233	5	152	232
Class G (1 to 100 kw)	20,281	3	570	36
Total	669,910	100%	824	813

Empresas Publicas de Medellin, (b) Empresa de Energia de Bogota, (c) Central de Anchicaya, in the industrial center of Cali in Valle Department and (d) Compania Colombiana de Electricidad with its principal capacity in Barranquilla in Atlantico Department. The latter company is a privately owned subsidiary of the American and Foreign Power Company.

A second category, consisting of two power companies with a combined total of 37,590 Kw capacity in 1960 are located in urban centers with smaller populations than cities served by the first category: (a) Central Hidroelectrica de Caldas centered in Manizales in Caldas Department and (b) the Empresas Publicas de Cartegena located in Bolivar Department.

A third category of companies is composed of affiliate companies of the government-owned Electroaguas. The 19 affiliate companies, seven of which are called "Electrificadora," operated capacity totaling 107,708 Kw or 16 percent of the total in 1960. The fourth category consists of small town-owned companies which account for the remaining 72,423 Kw or 11 percent of the total national capacity in 1960.

In summary, the national capacity in 1960 was operated as follows:

Company Category	Company Description	Capacity (kw)	Percent of Total
I	Major urban areas municipal or private firms (Medellin, Bogota, Cali, Barranquilla)	452,189	67.5%
II	Secondary urban area, largely private firms (Manizales, Cartagena)	37,590	5.6

Table 3

NATIONAL ANNUAL LOAD FACTORS IN SELECTED COUNTRIES

	Year	Installed Public Service Capacity (kw)	Potential Annual Generation (millions kwh)	Actual Generation (millions kwh)	National Annual Load Factor (percent)
Colombia[a]	1960	670,000	5,869	2,795	47.6%
Chile[b]	1959	596,000	5,221	2,838	54.4
Peru[c]	1959	320,000	2,790	971	34.8
India[d]	1959	3,496,000	30,625	12,810	41.8
Pakistan[e]	1957	439,000	3,846	950	24.7

a. Electroaguas, Bogota (does not include self-generation by industry, 241,000 kw).
b. UN Statistical Yearbook.
c. UN Statistical Yearbook.
d. For fiscal year ending April 1, 1959, UN Statistical Yearbook.
e. For fiscal year ending April 1, 1959, UN Statistical Yearbook.

Table 4

GROWTH OF INSTALLED CAPACITY IN COLOMBIA
1960-1970

Calendar Year	New Installed Capacity (mw)	Total Installed Capacity by End of Year Indicated (mw)
1960	10	670
1961	63	733
1962	434 (Guadalupe River)	1,167
1963	61	1,228
1964	25	1,253
1965	149 (Prado, Mayo Rivers plus thermal plants)	1,402
1966	420 (Bogota and Cauca Rivers)	1,822
1967	--	1,822
1968	650 (Mare River)	2,472
1969-70	728 (location not known)	3,200

Note: Names of major rivers for hydro projects are shown in parentheses; source is Electroaguas.

Table 5

COLOMBIA'S POPULATION GROWTH AND WATTS OF INSTALLED CAPACITY PER INHABITANT
1960-1970

Calendar Year	Total Population	Rural Inhabitants	Installed Capacity (mw)	Watts of Installed Capacity per Inhabitant
1960	14,987	8,436	670	45
1965 (est.)	17,207[a]	8,431[b]	1,822[c]	106
1970 (est.)	20,169[d]	8,596[c]	3,200[b]	159

a. 2.8% average annual growth.
b. Assumes that rural population as a percentage of total population will decline from 56% in 1960 to 49% in 1965, and 43% in 1970.
c. Electroaguas forecast.
d. 3.2% average annual growth, Electroaguas forecast.

III	Affiliated Government companies of Electroaguas (in smaller cities than Categories I and II)	107,708	16.1
IV	Tertiary Urban Area Town-owned firms	72,423	10.8
	TOTAL	669,910	100.0%

Measured in terms of its national load factor, Colombia compares favorably with other less developed countries. In 1960, Colombia's 670,000 Kw of installed capacity generated 2.8 billion Kw/hours, representing a national annual load factor of 47.6 percent as shown in Table 3. This is higher than Peru's 1959 load factor of 34.8 percent and India's 1959 load factor of 41.8 percent. Colombia's load factor in 1960 was below the comparable 1959 figure for Chile of 54.4 percent.

Colombia's plans for the future, according to Electroaguas, call for an annual average increase in installed capacity of about 13.5 percent. Also planned is a reduction in the percentage of thermal and diesel capacity from 31 percent in 1960 to about 25 percent by 1965. This additional capacity, including transmission and sub-stations, is estimated to cost some 600 million U.S. dollars. The planned growth of installed public service capacity is shown in Table 4.

On the basis of the planned additions to capacity and anticipated population growth, Colombia's installed capacity per inhabitant is likely to rise from 45 watts in 1960 to 159 watts in 1970, as shown in Table 5.

The Rural Population and Its Access to Power

Now growing at an annual rate of about 2.8 percent, Colombia's total population in 1962 is roughly 15.6 million. Assuming a slightly rising

future growth rate, the nation's population may reach 20 million by 1970. The percentage of persons classified as rural inhabitants has declined slightly in recent years both proportionally and in absolute terms, falling from 8.4 million in 1960 to an estimated 8.1 million in 1962. The decline is caused by the migration from rural to urban areas and to the geographic expansion of urban areas. By 1970 the percentage of rural population to total population should decline even further to possibly 43 percent as compared with 56 percent in 1960.

In 1960, 8 percent of the rural population or 715,000 persons had access to power from Class A capacity plants, i.e., plants of 25,000 Kw capacity or greater. Rural population is defined as persons residing in communities of less than 1600 inhabitants. This group can be described as the portion of the rural population with access to grid power from four major urban area systems: Medellin, Cali, Bogota, and Barranquilla. Another 36 percent of the rural population or 3.0 million persons in 1960 had access to power from smaller generators in Classes B through F, that is, power supplied by plants of 25,000 Kw capacity down to 100 Kw capacity.

A further segment of the rural population, an estimated 2.7 million persons, or 33 percent, had access to G class (supplied by generators of less than 100 Kw capacity)power while the remainder of the rural population, 23 percent or 2.0 million persons, had no access to power. Therefore a total of 92 percent (36, 33, 23 percent) of the rural population, or some 7.7 million persons, were in 1960 residing in communities

Table 6

RURAL POPULATION WITH ACCESS TO ELECTRIC POWER IN 1960
AND ESTIMATES FOR 1970
(Unit: 10^3 Persons)

	1960	Percent	1970	Percent
Total population (rural plus urban)	14,987[a]		20,169[b]	
Rural population	8,436[a]	(100)%	8,596[c]	(100)%
Rural population with grid power	715[d]	(8)	1,719[e]	(20)
Rural population served by B, C, D, E, F Class plants (100 kw to 25,000 kw plants)	3,014[f]	(36)	6,877 (all rural inhabitants outside grid areas)	(80)
Est. rural population served by G Class plants only (less than 100 kw plants)	2,734[g]	(33)		
Est. rural population without access to power	1,973	(23)		

a. Electroaguas estimate.
b. Electroaguas estimate assuming 3% annual average growth.
c. Electroaguas estimate assuming a decline in the percentage of rural population from 56% in 1960 to 43% in 1970.
d. Based on Electroaguas publication, Informe, August 1961, pp. 20 and 21. The "A" Class plants serve the rural population in the vicinity of Medillin, Cali, Bogota, and Baranquilla.
e. Electroaguas estimate.
f. Class B plants range from 10,001 to 25,000 kw; Class C from 5,001 to 10,000 kw; Class D from 1,001 to 5,000; Class E from 501 to 1,000 kw; Class F from 101 to 500 kw.
g. Class G power is produced by generators of less than 100 kw capacity. The figure of 2,734,000 persons served by Class G plants was derived as follows, on the basis of watts of capacity per inhabitant in the next higher generator class. The watts of capacity per inhabitant for Class F generators is 17, according to the Electroaguas Informe cited above, page 29. The total capacity of the Class G generator group is 46,475 kw (Ibid., page 30, pp. 30 and 31). The Class G total capacity divided by 17 watts is 2,734,000 persons.

where grid power was not available.

The number of rural inhabitants covered by grid power, 8 percent in 1960, is of course changing. The Electroaguas forecasts a moderate expansion of rural electrification by means of grid extensions to 1970. The number of rural inhabitants served by grid power is expected to rise from 8 percent or about 715,000 persons in 1960 to 20 percent of 1.7 million persons in 1970. This would leave 6.9 million persons with access to power from local generators or with no power access whatsoever. Even these modest expansion plans can be questioned because of the year-to-year problems of securing budget support and of the rising claims for power in the industrialized urban areas.

It is difficult to say what proportion of the inhabitants having access to power are actual users, but the percentage of users is probably small. This is largely because of the high cost of distribution outside the town limits. Some indication of the low proportion of users can be seen from the fact that in a typical rural area pueblo, a household of five persons often has 120 watts of connected load, suggesting an average of 20 watts per person. However, in Departments where the proportion of rural inhabitants is highest, the installed capacity per person is often lower than 20 watts, as shown in Table 7 and 8. Considering the fact that most of the capacity is for urban area consumption, the national average of watts of installed capacity per rural inhabitant is probably a small fraction of the overall national average of 45 watts per rural and urban inhabitant.

Table 7

WATTS OF INSTALLED CAPACITY IN TEN DEPARTMENTS HAVING THE HIGHEST PROPORTION OF RURAL INHABITANTS

Department (Or Other Geographical Sub-Division)	Percentage of Rural Inhabitants	Watts of Installed Capacity per Inhabitant
Choco	85%	6
Boyaca	83	11
Cauca	81	17
Intendencias	79	12
Narino	74	16
Tolima	70	17
Magdalena	63	22
Meta	63	16
Santander	62	24
Norte de Santander	59	25
National Average	57	45

Table 8

RELATION BETWEEN INSTALLED CAPACITY OF PUBLIC SERVICE COMPANIES AND POPULATION
1960

Department	Installed Capacity		Population					
	Kw	% of National Capacity	Total	% of Total Population	Urban	Rural	% Urban	Watts per Inhabitant
Antioquia	154,310	23.0%	2,033,790	13.6%	940,960	1,092,830	46.3%	76
Atlantico	52,871	7.9	611,740	4.1	548,741	62,999	89.7	86
Bolivar	28,723	4.3	786,200	5.2	379,211	406,989	48.2	37
Boyaca	9,174	1.4	866,390	5.8	150,326	716,064	17.4	11
Caldas	51,482	7.7	1,377,540	9.2	552,344	825,196	40.1	37
Cauca	8,733	1.3	524,510	3.5	99,949	424,561	19.1	17
Cordoba	5,448	0.8	421,950	2.8	102,297	319,653	24.2	13
Cundinamarca	154,136	23.0	2,330,280	15.6	1,433,611	896,669	61.5	66
Choco	939	0.1	148,970	1.0	22,819	126,151	15.3	6
Huila	6,728	1.0	375,580	2.5	121,798	253,782	32.4	18
Magdalena	11,316	1.7	523,170	3.5	192,762	330,408	36.8	22
Meta	1,279	0.2	80,540	0.5	29,685	50,855	36.9	16
Narino	9,886	1.5	621,070	4.1	159,881	461,189	25.7	16
Norte de Santander	10,968	1.6	439,610	2.9	179,147	260,463	40.8	25
Santander	21,793	3.2	921,530	6.2	352,878	568,652	38.3	24
Tolima	15,171	2.3	871,110	5.8	264,588	606,522	30.4	17
Valle	123,646	18.5	1,776,750	11.9	961,220	815,530	54.1	70
Intendencias and Comisarias	3,307	0.5	276,290	1.8	58,684	217,606	21.2	12
Total	669,910	100.0%	14,987,020	100.0%	6,550,901	8,436,119	43.7	45

Aside from any statistical measures, there is an obvious indicator of low wattage availability in many of Colombia's smaller towns. Power systems are grossly overloaded during the evening period of peak use and the Survey Team typically found it impossible for the inhabitants to read by electric lights until 9 or 10 PM. Thus even the limited watts of capacity per inhabitant is often not available when it is needed the most.

Financing Rural Electrification

To permit the expansion of Colombia's power system to rural areas and to offset some of the uneconomic characteristics of the system, substantial financing assistance is obtained from overseas sources of capital, and from the National, Departmental and local community governments. Much of this financial help comes from the central government's agency for the promotion and regulation of power--the Instituto de Aprovechamiento de Aguas y Fomento Electrico. This agency, known by the abbreviated title, Electroaguas, was established in 1957 and is now engaged in a wide variety of functions related to power, especially for non-urban areas. Some of Electroaguas' functions include: load building through irrigation projects, financing of small power plants, financing grid extensions, purchasing of power from the large urban area power companies for distribution to rural areas, rate investigation and control, raising of domestic and foreign capital for expanded services, and planning the national power system.

Through Electroaguas, funds are channelled to supplement the earnings of local power firms. Funds are provided to Electroaguas

in several ways and are in turn allocated to the affiliated companies (sociedades filiales) in the Departments. The affiliated companies, numbering 19 in all, are usually called "Electrificadoras." These regional companies assist in the establishment of power plants in smaller towns, arrange for grid extensions, and the purchase of power for distribution.

The Electroaguas in 1961 received funds with which to finance its own operations and those of the 19 affiliated companies from the following sources, according to the recent Electroaguas progress report, Informe de Una Administracion, June 1957 to June 1962. Known income in 1961 is noted in parentheses.

1. A portion of the Government revenue from beverage taxes (11.2 million pesos).
2. Direct appropriations from the Government (35.2 million pesos).
3. A portion of the budget for improving municipal services (about 1.4 million pesos).
4. Sale of power facilities to private parties.

Although the report does not specify all items of income, those portions which can be identified for 1961 total 47.8 million pesos, or about U.S. $5.5 million.

The bulk of the budget in 1961, at least 29.0 million pesos or about the equivalent of U.S. $3.3 million, was provided by Electroaguas to the regional affiliated firms. This amount helped to offset the losses of rural area power companies and to finance expanded services.

Funds for future expansion of power systems are obtained through domestic and foreign loans. Since 1959, credits have been received from the National Federation of Coffee Growers (Federacion Nacional de Cafeteros de Colombia), the Banco de Colombia and the Banco de Bogota. These loans totaled $1.9 million U.S., as of June 1962.

Coffee barter arrangements with Finland, Spain, Hungary and Czechoslovakia provide or have provided Electroaguas with drawing rights from 1959 through 1961, equivalent to U.S. $5.2 million. The largest capital drawings from abroad may be yet to come through the International Bank for Reconstruction and Development (World Bank) judging by formal applications by Electroaguas for financing during the period February 1961 to June 1962. These applications seek a total of U.S. $35.5 million. Such funds, if approved, will finance the expansion of generating, and transmitting facilities chiefly in outlying Departments including Bolivar, Norte de Santander, Narino, Cauca, Tolima, Caldas, Santander, Cordoba and Magdalena.

Rural area power firms are helped in less direct ways as well. The municipio often provides personnel to manage or to collect fees, and furnishes buildings to house power plants. Depreciation and fixed costs for invested capital are often a municipio rather than a power company problem. At least no accounting of these items was made by the power companies visited in Venecia, Andes Jardin, and Ebejico in Antioquia Department. Presumably some reserves for depreciation are maintained in the municipio budgets.

The Survey Team sought to determine the level of load factors in two ways: by field interviews and an examination of Electroaguas records. During field visits, interviews were held with officials concerned with power generation in towns visited. Time did not permit a detailed examination of records for power companies and often officials were uninformed of kwh generated because power was not metered. In small communities customers are charged by the number of bulbs connected.

In the municipio of Jardin, Antioquia, visited by the Survey Team, the annual load appeared to be about 800,000 kwh, taking into account the unusually extensive lighting of the church and plaza. As against this load, the local hydro capacity of 350 Kw was capable of generating some 3,066,000 kwh annually, thus suggesting a factor of 26 percent. In Ebejico, also visited by the Survey Team, a diesel plant was used in combination with a hydro generator, and an annual load factor of 15 percent was indicated.

A review of records from Electroaguas revealed more detailed information on load factors. The Survey Team endeavored to obtain the widest possible sample of power company experience from these records in the following way: From a listing of 151 companies, three types of companies were screened (a) those providing power from diesel or steam generating plants only, (b) those operating hydro capacity only, and (c) those operating hydro plants in combination with diesel or steam plants for peaking. The 1960 output data for only certain companies was available from a 1961 Electroaguas survey of fuel costs.

Unfortunately, the output data was not available for most of the 151 companies, but was sufficient for the calculation of load factors for 12 companies operating diesel or steam plants only (Table 9), 6 companies operating hydro facilities only (Table 10) and 3 companies operating mixed hydro-diesel generating plants (Table 11).

In reviewing load factor data, a rough correlation was found between the load factor and the percent of rural population in the area served by various power companies. Judging from the sample of power company data, comments of power company officials and the Survey Team's own observations, the higher the rural population in the area served, the worse the load factor is likely to be. For example in Giradot, 143 kilometers southwest of Bogota, the percentage of rural population in the area served by the local power company is only 8 percent and the load factor was a reasonably high 41 percent. In Sahagun in Cordoba Department, the rural population was 85 percent and the load factor 20 percent. The apparent correlation is illustrated in Table 9 and in the diagram that follows.

There are exceptions, such as the community of Rionegro near Medellin mentioned below where the population is predominantly rural but the load factor is a high 67 percent.

A small sample of power companies producing power from hydroelectric generators only was obtainable from Electroaguas data and is shown in Table 10. As in the case of the companies with diesel power only, the companies in Table 10 are those for which data were

Table 9

ANNUAL LOAD FACTORS AND RURAL POPULATION SERVED FOR COLOMBIAN POWER COMPANIES
USING DIESEL OR STEAM PLANTS ONLY--1960

Name of Company	Location (municipio)	Department	Generating Capacity (kw)	Type of Power (diesel or steam)	Annual Potential Kwh Generation	Actual Generation (kwh)	Population in Zone Served (rural population)	Percent of Rural Population in Zone Served	Annual Load Factor (percent)
Electrificadora de Cordoba	Cerete	Cordoba	842	Diesel	7,375,920	601,453	16,740 (10,496)	62.7%	8.2%
Electrificadora de Cordoba	Lorica	Cordoba	494	Diesel	4,327,440	1,027,590	47,470 (36,979)	77.9	23.7
Electrificadora de Cordoba	Sahagun	Cordoba	300	Diesel	2,628,000	518,624	47,930 (40,788)	85.1	19.7
Electrificadora del Choco	Quibido	Choco	700	Diesel	6,132,000	1,878,983	47,140[a] (36,013)	76.4	30.6
Central Termoelectrico de Calamar	Calamar	Bolivar	380	Diesel	3,328,800	892,960	15,190 (9,858)	64.9	26.8
Electrificadora de Cundinamarca	Billeta	Cundinamarca	209	Diesel	1,830,840	456,427	12,250 (8,893)	72.6	24.9
Empresa de En. Elec. de Magangue	Magangue	Bolivar	1,568	Diesel	13,735,680	2,824,138	48,060 (26,433)	55.0	20.6
Empresas Municipales de Monteria	Monteria	Cordoba	2,520	Diesel	22,075,200	8,513,180	98,800 (68,468)	69.3	38.6
Cia. Colombiana de Electricidad	Giradot	Cundinamarca	5,512	Diesel	48,285,120	19,633,990	52,670 (4,266)	8.1	40.7
Empresas Publicas de Barrancabermeja	Barrancabermeja	Santander	3,940	Diesel	34,514,400	12,093,840	64,390 (18,931)	29.4	35.0
Empresa de Energia Electrica de Sincelejo	Sincelejo	Bolivar	1,500	Diesel	13,140,000	3,759,810	48,100 (16,643)	34.6	28.6
Central Termoelectrica de Cospique Cartagena	Cospique	Bolivar	10,000	Steam	58,800,000[b]	19,097,366[b]	18,740 (3,405)	18.2	32.5
Total			27,965		216,173,400[b]	71,298,361	517,480 (281,173)	54.3	33.0

a. Includes municipios of Quibido and Bagado.
b. The Cospique plant in 1960 operated only 245 days, starting operations May 1 (58.8 million kwh = 245 days x 24 hours x 10,000 kw).

LOAD FACTORS OF COMPANIES OPERATING DIESEL AND STEAM PLANTS
IN RELATION TO THE PERCENTAGE OF RURAL POPULATION
COLOMBIA, 1960

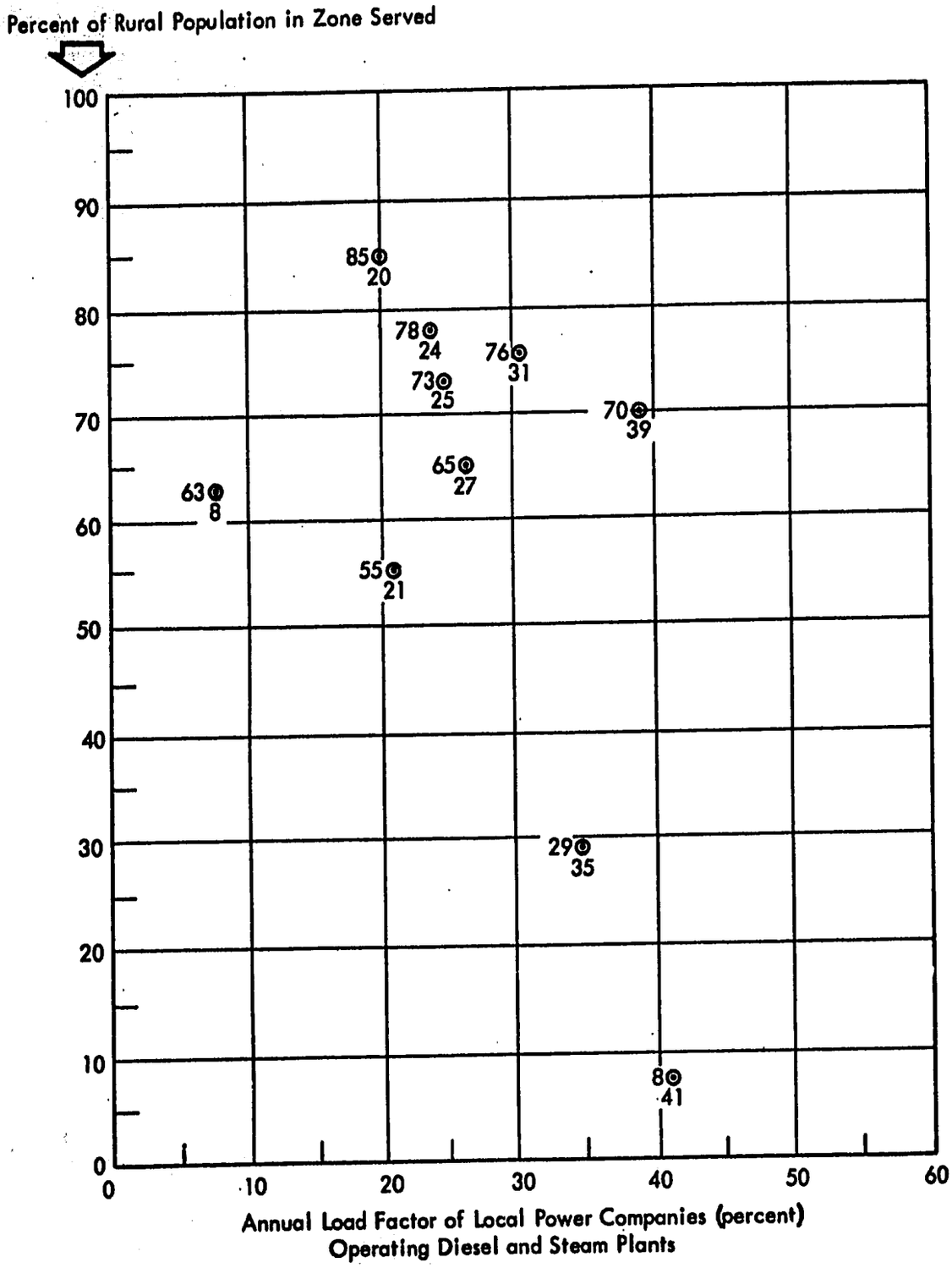


Table 10

ANNUAL LOAD FACTORS AND RURAL POPULATION SERVED FOR COLOMBIAN POWER COMPANIES
SUPPLYING POWER FROM HYDROGENERATORS ONLY
1960

Name of Company	Location	Department	Generating Capacity (kw)	Annual Potential Generation (kwh)	Actual Generation (kwh)	Population in Zone Served (Rural Population)	Percent of Rural Population in Zone Served	Annual Load Factor (percent)
Empresa de Energia El de Puerto Berrio	Puerto Berrio	Antioquia	1,760	15,417,600	8,516,450	14,830 (6,585)	44.4%	55.2%
Empresa de Energia Electrica de Tamesis	Tamesis	Antioquia	1,004	8,795,040	2,995,865	17,580 (14,064)	80.0	34.0
Energia Electrica de Riosucio y Supia	Riosucia	Caldas	650	5,694,000	2,310,738	63,390 (50,823)	80.2	40.6
Central Hidroelectrica de la Florida	La Florida[a]	Valle	2,100	18,396,000	10,789,018	n.a.[b]	n.a.[b]	58.6
Central Electrica "La Cascada" San Gil	San Gil	Santander	2,141	18,755,160	7,690,488	54,910 (36,839)	67.1	41.0
Empresa de Energia Electrica de Chiquinquira	Chiquinquira	Boyaca	960	8,409,600	1,373,360	55,070 (41,871)	76.0	16.3
Total			8,615	75,467,400	33,675,919	205,780[b] (150,182)	73.0%	44.6%

a. The town of La Florida is located in Valle, but for power administration, the 2,100 kw plant at La Florida is included in the grouping of power companies called Centrales Electricas del Cauca S.A. located in the neighboring Department of Cauca.
b. Excludes population of La Florida of about 20,550 persons according to different source.

Table 11

ANNUAL LOAD FACTORS AND RURAL POPULATION SERVED FOR POWER COMPANIES IN COLOMBIA GENERATING POWER FROM BOTH DIESEL AND HYDRO PLANTS
1960

Name of Company	Location	Department	Total Capacity (kw)	Hydro Capacity (kw)	Diesel Capacity (kw)	Total Potential Annual Generation (kwh)	Actual Generation (kwh)	Population in Zone Served (Rural Population)	Percent of Rural Population in Zone Served	Annual Load Factor (percent)
Empresa de Energia Electrica de Riobajo	Rionegro	Antioquia	1,290	1,090	200	11,300,400	7,512,315	25,160 (17,009)	67.6%	66.5%[a]
Empresa de Energia Electrica de Ocana	Ocana	Norte de Santander	747	180	567	6,543,720	2,022,494	28,790 (11,689)	40.6	30.9
Energia Electrica del Socorro	Socorro[b]	Santander	780	280	500	6,832,800	325,709 (sic)	34,550 (18,322)	53.0	4.8
Total			2,817	1,550	1,267	24,676,920	9,860,518	88,500 (47,020)	53.1%	40.0%

a. The unusually high load factor for Rionegro may be explained by the existence of farms established by Medellin interests where irrigation is needed for pasture land. A further reason could be small industry, such as a shoe manufacturing plant, visited by an SRI staff member. The vicinity of Rionegro is also a resort area, about 38 km southeast of Medellin on a paved road.

b. The 280 kw hydroplant at Socorro produced 181,460 kwh during 1960; the 500 kw diesel plant produced 164,249 kwh. The combined total was 325,709 kwh.

available on (a) capacity in 1960 and (b) output in the same year.

The load factors for companies providing power from hydro facilities are much better than for the diesel generating group. For the limited sample available the average factor was 45 percent. The higher factor is attributable to lower rates, which are about one third of the rates charged by diesel-based companies (see Table 12). In only three cases were 1960 data available on companies with mixed capacity, that is both hydro and diesel. Of the three companies, two had 1960 load factors below 30 percent. One company, however, that located in the town of Rionegro, 38 kilometers from Medellin, recorded an unusually high load factor of 67 percent in 1960. This may be explained by the fact that the vicinity of Rionegro contains pasture land where Medellin interests have begun to irrigate alfalfa crops for cattle. The three cases where both capacity and generation data are available are shown in Table 11.

Power Rates

Characterized by scattered, independent local generating companies, Colombia's power system has widely differing power rates and various methods for computing charges to customers. In the small towns, such as Jardin (urban population 5000), in Antioquia, a 350 Kw hydro generator serves the community, and rates for residential users are 2 centavos per month per installed watt of lighting. Assuming that a typical household has 120 watts with a daily use of 300 watt hours, the monthly charge would be 2.40 pesos equal to 27.6¢ U.S. currency. The monthly use might be 9 kw/hours indicating that the charge

Table 12

AVERAGE SALES PRICE PER KWH FOR COMPANIES
ACCORDING TO TYPE OF GENERATING CAPACITY, COLOMBIA
1960
(Sales Prices Expressed in U.S. Cents)

Type of Company	Average Sales Price for Companies Sampled	Index Number (For Comparison)
Companies with hydro capacity only	0.860¢/kwh	100
Companies with both hydro and diesel capacity	1.501¢/kwh	175
Companies with diesel capacity only	2.648¢/kwh	308

would be equivalent to 27 centavos per kw/hour or 3.1¢ per kw/hour in U.S. currency.

Contrasting with the rate in Jardin, is the residential rate in the city of Cerete (population 16,740) in Cordoba Department. Power in Cerete is provided by a 2520 Kw diesel generator and the rate charged to residential consumers is 44.8 centavos, the equivalent of 5.2 U.S. cents per kw/hour and the highest rate reported to the Survey Team in Colombia. (The average rate for power charged to all consumers in Cerete is somewhat lower as shown in Table 13).

In the town of Andes (urban population about 7000) in Antioquia Department, the rate per kw/hour was the equivalent of 0.5¢ for residential, 0.7¢ for industrial, and 0.9¢ for commercial consumers, irrespective of the amount consumed.

One of the principal functions of Electroaguas is to study rates and rate structures and to gradually raise rates to economic levels throughout Colombia. Each upward revision presents formidable problems, according to Electroaguas and its affiliated companies. Once a rate is established, an upward adjustment can be achieved only after prolonged studies, hearings and negotiations. Except for urban areas where commercial and industrial consumption is high, the adjustment of Colombia's rates will be a protracted process.

In order to analyze the level of rates in Colombia for this report, Electroaguas rate data covering 47 companies was reviewed. From this data, the average sales price per kw/hour sold was identified for three classes of companies: (a) companies producing power from

diesel generators only, (b) from hydro-electric generators only and (c) from companies with mixed, hydro and diesel capacity.

The rates charged by 20 companies or groups of companies were obtained for the sample. The results showed that rates for companies with hydroelectric power were lowest, for mixed-generating capacity companies were the next lowest, while the rates for companies operating diesel plants only were the highest as shown in Table 12. The rates for diesel companies were three times as high as the rates charged by the companies using hydro generating capacity.

The following three tables show actual sales prices for companies in the three groups, diesel, hydro and mixed generating capacity companies (see Tables 13, 14, and 15.)

Power Costs in Rural Communities and Relationship to Rates

During field visits to power companies in rural areas, company officials informed the Survey Team that they kept records on fuel and lubricant costs, personnel costs, spare parts and maintenance. However, fixed costs derived from capital charges and depreciation were not taken into account because the municipio (probably Electroaguas through the Electrificadora) provided the initial capital and no interest or amortization was payable by the Company. When the generator was fully depreciated, the plant manager in Venecia, Antioquia said, the municipio would purchase a new one.

Table 13

AVERAGE SALES PRICE PER KWH OF COLOMBIAN POWER COMPANIES
WITH DIESEL GENERATING CAPACITY ONLY
1960

Locality	Department	Capacity (kw)	Average Sales Price Converted to U.S. Cents (11.5¢ = 1 peso)
Sincelejo	Bolivar	1,500	2.667¢
Cerete	Cordoba	842	3.521
Lorica	Cordoba	494	2.360
Sahagun	Cordoba	300	2.734
Quibido	Choco	700	1.157
Cauca Valley	Valle	1,500	3.450[a]
Average sales price			2.648

a. The Cauca Valley Corporation has sold power from diesel plants at 30 centavos per kwh but will reportedly discontinue the practice in the future.

Source: Electroaguas, Bogota except for Cauca Valley.

Table 14

AVERAGE SALES PRICE PER KWH OF COLOMBIAN POWER COMPANIES
WITH HYDROELECTRIC CAPACITY ONLY
1960

Locality	Department	Capacity (kw)	Average Sales Price Converted to U.S. Cents (11.5¢ = 1 peso)
Puerto Berrio	Antioquia	1,760	0.874¢
Tamesis	Antioquia	1,004	0.762
Chiquinquira	Boyaca	960	0.941
5 localities in Caldas	Caldas	26,440	0.828
Riosucio y Supia	Caldas	650	0.869
La Florida	Cauca	2,100	0.576
Lebrija	Santander	9,000	1.142
San Gil	Santander	2,141	0.889
Average sales price			0.860

Source: Electroaguas, Bogota.

Table 15

AVERAGE SALES PRICE PER KWH OF COLOMBIAN POWER COMPANIES
WITH MIXED HYDRO AND THERMAL CAPACITY
1960

Case No.	Locality	Department	Combined Capacity (kw)	% Hydro	Average Sales Price Converted to U.S. Cents (11.5¢ = 1 peso)
1	6 towns	Huila	6,065	68%	1.281¢
2	5 towns	Narino	6,041	92	0.930
3	3 towns	N. de Santander	8,229	13	1.673
4	Pamplona	N. de Santander	816	10	1.909
5	Ocana	N. de Santander	747	24	2.283
6	Socorro	Santander	780	36	1.389
Average sales price					1.501

Source: Electroaguas, Bogota.

In response to a written inquiry, Electroaguas said, "it is impossible to determine the operating costs of diesel plants in the 200 to 500 Kw capacity range, except for the cost of fuel per kwh which is known."

One element in the cost picture is known, however, namely fuel costs per Kw/hour and these are shown in Table 16, Column 1. Additional data on fuel costs per gallon are presented in Table 18. The capital costs are not known but can be assumed on the basis of a rule of thumb cited by the Electrificadora, namely that the equivalent of $230 dollars per installed kw of diesel capacity covers capital costs for generation, transmission and distribution equipment. Other estimates used by the UN suggest a lower figure of $193 per installed Kw. For estimate purposes, the $230 figure is used below.

The generating capacity, kw/hours generated and hence load factors are known for certain companies shown in Table 9. Line losses are not known but since transmission is local, they would presumably be small.

Various interest rates and amortization schedules were reported to the Survey Team in Colombia, but 15 years amortization and depreciation (assuming low use factors) plus 6 percent interest in unpaid balances seems reasonable.

Operating costs consisting of personnel, maintenance and spare parts actually checked in Colombia varied from the equivalent of 1.35¢ per kw/hour in a small 90 kw plant to 0.624¢ per kw/hour in a 1760 kw plant.

Using the known data plus the foregoing assumptions, estimates of actual costs have been constructed as shown in Table 16. The critical element is fixed charges for capital and depreciation shown in columns G and J of Table 16. These costs are critical because they are typically disregarded by the smaller companies in rural areas. If they were taken into account, the costs at current load factors would usually exceed the rates charged.

Using the same data, the charges in costs per kw/hour have been calculated on the assumption that the load factors were raised from actual 1960 levels to 30 percent. The results of this calculation are shown in Table 17.

Summarizing the conclusions in Table 16 and Table 17, the 842 kw diesel plant at Cerete, in Cordoba Department, operating with an 8.2 percent load factor in 1960 produced power at a cost of 6.9¢ per kw/hour, as compared to its selling rate of 3.5¢. If the load factor had been raised from the 1960 level of 8.2 percent to 30 percent, the costs would have fallen from about 6.9¢ to 3.7¢ and the selling rates would have nearly covered costs.

The 300 kw diesel plant at Sahagun in Cordoba, operating with a load factor of 19.7 percent in 1960 produced power at a cost of about 4.5¢ per kw/hour and sold power at 2.7¢. If this same plant had raised its load factor to 30 percent from the 1960 figure of 19.7, its cost would have fallen from 4.5¢ to about 3.9¢.

Table 16

ESTIMATED 1960 COSTS PER KWH COMPARED WITH 1960 RATES FOR EIGHT COMPANIES
OPERATING DIESEL GENERATORS ONLY
(Cost Units: U.S. Cents)

(A) Company	(B) Location by Municipio and Department	(C) Generating Capacity[a] (kw)	(D) Estimated Capital Cost[b] (U.S. $)	(E) Actual 1960 Output[a] (kwh)	(F) Annual Load Factor[a] 1960 (%)	(G) Estimated Fixed Costs per Kwh Based on (D) and (E)[c]	(H) Estimated Operating Costs per Kwh[d]	(I) Actual Fuel Cost[a] 1960 per Kwh (in centavos)	(J) Depreciation Cost Based on 15-Year Life per Kwh and (D) and (E)	(K) Total Estimated Costs per Kwh 1960	(L) Actual 1960 Rates, Averages for All Power Sold
Electrificadora de Cordoba	Cerete, Cordoba	842	$ 194,000	601,453	8.2%	2.2¢	1.0¢	1.5¢ (13.05)	2.2¢	6.9¢	3.5¢
Electrificadora de Cordoba	Sahagun, Cordoba	300	69,000	518,624	19.7	0.9	1.1	1.6 (13.5)	0.9	4.5	2.7
Electrificadora de Bolivar	Magangue, Bolivar	1,568	360,640	2,824,138	20.6	0.9	0.6	1.2 (10.21)	0.9	3.6	n.a.
Electrificadora de Cundinamarca	Villeta, Cundinamarca	209	48,070	456,427	24.9	0.7	1.3	1.3 (11.59)	0.7	4.0	1.2
Electrificadora de Cordoba	Lorica, Cordoba	494	114,000	1,027,590	23.7	0.8	1.1	0.9 (8.1)	0.7	3.5	2.4
Central Termoelectrico de Calamar	Calamar, Bolivar	380	87,400	892,960	26.8	0.7	1.1	1.0 (8.42)	0.7	3.5	1.8
Electrificadora del Choco	Quibido, Choco	700	161,000	1,873,983	30.6	0.6	1.0	1.6 (14.07)	0.6	3.2	1.2
Cia. Colombiana de Electricidad	Giradot, Cundinamarca	5,512	1,267,760	19,633,990	40.7	0.4	0.5	0.8 (6.81)	0.4	2.1	1.5

Note: The actual data shown in this table are for companies operating diesel generators only. Data for 12 companies was found showing 1960 capacity and output. Although computations could have been made for all 12 companies, this table selects 8 companies, ranging from the lowest capacity and load factor companies to the highest to illustrate the costs in relation to rates.

a. Electroaguas, Bogota, 1962 cost study.
b. Estimated by Electrificadora de Antioquia at $230 per kw of installed capacity including transmission and distribution. Compares with UN estimates of $193 for small diesels. Assumes 15-year, 6% interest amortization.
c. Because power company costs for collection, meter reading, and operating are borne by local government budgets, costs are difficult to estimate. Actual cases measured by the survey group range from 1.35¢ per kwh to 0.624.
d. All conversions made at U.S. 11.5¢ = 1 peso.

Table 17

PROBABLE CHANGES IN COSTS PER KWH RESULTING FROM AN INCREASE IN 1960 LOAD FACTORS TO 30 PERCENT

(A) Company	(B) Location by Municipio and Department	(C) Generating Capacity (kw)	(D) Estimated Capital Cost	(E) Output at 30% Load Factor (actual 1960 output and load factor in kwh)	(F) Estimated Fixed Costs per Kwh (1960 est.)	(G) Estimated Operating Costs per Kwh (1960 est.)	(H) 1960 Fuel Costs per Kwh (1960 est.)	(I) Depreciation Cost per Kwh (1960 est.)	(J) Total Estimated Cost at 30% Load Factor per Kwh (1960 est.)	(K) Difference between 1960 Cost and Costs at 30% Load Factor
Electrificadora de Cordoba	Cerete, Cordoba	842	$194,000	2,212,776 (601,453 8.2%)	0.6¢ (2.2)	1.0¢ (1.0)	1.5¢ (1.5)	0.6¢ (2.2)	3.7¢ (6.9)	-3.2¢
Electrificadora de Cordoba	Sahagun, Cordoba	300	69,000	788,400 (518,624 19.7%)	0.6 (0.9)	1.1 (1.1)	1.6 (1.6)	0.6 (0.9)	3.9 (4.5)	-0.6
Electrificadora de Bolivar	Magangue, Bolivar	1,568	360,640	4,120,704 (2,824,138 20.6%)	0.6 (0.9)	0.6 (0.6)	1.2 (1.2)	0.6 (0.9)	3.0 (3.6)	-0.6

Note: The three diesel generating companies shown were those with the lowest load factors shown in Table 16.

Table 18

CONSUMPTION OF DIESEL OIL, PRICE PAID FOR DIESEL OIL, COST PER KW-HOUR OF DIESEL OIL AND OTHER MATERIALS CONSUMED BY SELECTED DIESEL POWER PLANTS IN COLOMBIA - 1960

(A) Name of Company	(B) Location (municipio)	(C) Department	(D) Gen. Capacity (kw)	(E) Act. Generation (kwh)	(F) Diesel Oil Consumed in 1960 (US gallons)	(G) Price Paid in 1960 per US gal. of diesel oil (US ¢)	(H) Total cost of matls consumed in 1960 (diesel, oil grease, etc. in US ¢)	(I) Cost of diesel oil and grease etc. in 1960 per Kw/hour (Column J/G)
Electrificadora de Cordoba	Cerete	Cordoba	842	601,453	63,715	10.12¢	9029	1.5¢
Electrificadora de Cordoba	Lorica	Cordoba	494	1,027,590	80,339	9.43	9576	0.9
Electrificadora de Cordoba	Sahagun	Cordoba	300	518,624	60,207	10.57	8032	1.6
Electrificadora del Choco	Quibido	Choco	700	1,878,933	181,091	12.31	30, 408	1.6
Central Termo-electrico de Calamar	Calamar	Bolivar	380	892,960	77,813	8.86	8647	1.0
Elect. de Cundinamarca	Villeta	Cundinamarca	209	456,427	45,098	9.55	6086	1.3
Empresa de En.. Elec.de Magangue	Magangue	Bolivar	1 568	2,824,138	328,032	8.74	33, 172	1.2
Empresas Munic. de Monteria	Monteria	Cordoba	2 520	8,513,180	691,787	10.00	110,401	1.3
Cia. Colombiana de Electricidad	Giradot	Cundinamarca	5 512	19,633,990	1,554,756	8.74	153,787	0.8
Empresas Publicas de Barrancabermeja	Barrancabermeja	Santander	3 940	12,093,840	801,287	7.13	65,644	0.5
Empresa de Energia Elec. de Sincelejo	Sincelejo	Bolivar	1 500	3,759,810	366,666	8.63	61,864	1.6

a. Includes municipios of Quibido and Bagado.

Source: Electroaguas, Bogota, 1961, Section for Tariffs and Statistics)

NOTE: Companies selected for the above table are those which operated diesel plants only in 1960. The average cost of diesel oil for the above plants was 9.45 U.S. ¢ per U.S. gallon. A study by Electroaguas covering 34 companies (including the above 11) shows an average price of 9.1¢ US gallon paid by all 34 companies. The highest price paid by any one of the 34 companies was 1.10 pesos equal to 12.65 US¢ and the lowest price was 0.62 pesos equal to 7.3 US¢.

The 1568 kw diesel plant at Magangue operated with a factor of 20.6 percent in 1960 and produced power at about 3.6¢ per kw/hour. By raising the load factor to 30 percent, the costs would have declined from 3.6¢ to about 3.0¢ per kw/hour.

Table 16 brings out the point that of the eight cases listed, the rates in all cases were below what would have been actual costs if fixed charges had been taken into account.

A further indication of the cost situation was brought to the attention of the Survey Team by the Cauca Valley Corporation. This Corporation operating in cooperation with the Central de Anchicaya, Ltd. is one of the four class "A" power companies in Colombia operating generators with a capacity in excess of 25,000 kw. A part of the system consists of a 1500 kw diesel generator of recent model, and judging by the system's reputation is probably as efficiently run as any in Colom bia. Cost experience with the diesel generator taking into account capital charges and depreciation is as follows:

Costs per kw/hour delivered to residential consumers in rural communities near Cali:	4.0¢ (35 centavos)
Sales price per kw/hour to same consumer:	3.5¢ (30 centavos)
Financial loss sustained per kw/hour:	about 0.5¢

The Cauca Valley Corporation stated that this experience was so unsatisfactory that they had recently adopted a policy of denying diesel generated power to rural communities in the vicinity of Cali because

the financial losses were considered excessive. Judging by the Cauca Valley Corporation experience,none of the rates shown in Table 16 for diesel generation companies would appear to cover actual costs.

The Significance of Power Costs in Rural Areas

Despite the anticipated annual growth in installed capacity of 13.5 percent to 1970, major elements of the rural population, some 7.0 million persons will still be without grid power in that year. This means that pressures will mount for local, unconnected generating capacity with its attendant load factors problems and costs. While hydro power in Colombia is generally economical, diesel power, given the present rate structure and load factors, is uneconomical.

Where hydro potential does not exist, the diesel plant, despite its higher costs, offers a solution for bringing electricity to rural areas, and Electroaguas plans to raise small diesel capacity, although at a much slower pace than in the past. The outlook for and some of the effects of diesel electrification appears as follows: In 1960, installed capacity of diesel generators in classes D, E, F, and G (those with 5000 Kw capacity or below) was 63,109 Kw or about one tenth of the total national capacity. (This figure may include some actual plans of Electroaguas for an increase in this kind of capacity by another 8000 kw by 1965, to a total of 71,000 kw). With its load factor typically in a range of 20 percent, these small generators could cost the Colombian economy some 1.9¢ per Kw/hour produced, or nearly $3.0 million annually in the form of a subsidy for rural electrification.

Summary Observations on Power Utilization in Colombia

The most striking observation with respect to the use of power in rural areas in Colombia is that it is almost wholly confined to illumination -street lighting and households. This is particularly true of Class G plants (less than 100 kw capacity), where 80-90 percent of the total power consumed goes for illumination. In the case of plants in Classes D, E, and F (101-5000 kw capacity) at least two thirds of the total power consumption is for lighting.

Furthermore, it was not at all unusual to discover in the course of the field investigations, that in several instances where power had been available for as long as 30-40 years, there was a singular lack of application of power for purposes other than illumination (see Appendix B).

This indicates that the mere availability of power is insufficient for purposes of bringing about productive applications. It also suggests, and this was brought out in on-site discussions with local representatives, that there has been very little comprehension of alternative uses for power.

IV.

OBSERVATIONS ON SMALL SCALE POWER UNITS FOR VILLAGES

Utilization of Energy

Generally speaking the on-site investigations of village communities revealed only a limited opportunity for the productive application of electric energy supplied by small scale generating units.

With respect to irrigation pumping, direct diesel pumping is invariably more economical than electric pump sets supplied with electric energy from small scale generating units. Further, given the pattern of land tenure in India, in many cases three to four acre holdings, it is difficult to justify either a .esel or an electric pump. The Indian Government is making attempts to consolidate holdings, but in many parts of the country the size of the holdings is so small that even consolidated holdings will require common sharing of pumped water supply, an arrangement which has so far been extremely difficult to arrange to the satisfaction of the parties concerned.

There also appears to be very little potential for the consumption of electricity by small industry at the village level because the traditional industries--weaving, tanning, oil expelling, shoe-making etc.-- simply cannot compete with the larger and more efficient units in the market towns and cities. Currently these industries are economically marginal or sub-marginal, the daily income per artisan ranging between Rs. 50 to Rs. 1.25 or $.10-$.25. It appears that the only reason that these industries have not been completely wiped out is that the local product

is viewed as having special properties -Ghani oil, for example, is said to be purer, healthier, more tasty and resistant to deterioration than the mill product- or the artisan is willing, in the absence of suitable alternatives, to pay a heavy price in terms of hard work, undernourishment and poverty for being able to continue with the trade.

Again, if it is appropriate under certain circumstances, e.g, lack of access to market towns or the existence of a local market, to perform certain processing operations at the village level such as grain grinding or oil expelling, then it would appear to be more economical to utilize the shaft power of an internal combustion engine directly rather than convert shaft power to electric energy to power an electric motor.

From the standpoint of domestic usage, particularly for illumination, it is less costly to utilize kerosene or gasoline-mantle lanterns than it is to use this same fuel to power a small scale engine-generator which supplied electricity to an electric light bulb.

Given this limited opportunity for the application of electric energy, on the one hand, which works against the possibility of achieving an appreciable load factor, and the favorable economics of shaft power as against electric energy for satisfying principal existing requirements for power, it appears doubtful that the introduction of electric energy by means of a small scale generating unit can be justified at the village level.

This is not to say, of course, that power may not be worthwhile social and political investment for purposes of improving rural amenities and avoiding dissidence. For example, one business executive stated to the survey team that a "power plant was worth 100 policemen" since power provides the basis for entertainment, education and vocational opportunities for an otherwise restive rural populace. However, it is important to be clear with respect to the costs of providing such services and whether in the absence of significant productive applications of electric energy in agriculture and small industry, such services would prove to be transitory.

Generation of Energy

At the outset of the field surveys, it was hypothesized that a small scale engine-generator (10-15 Kw) capable of utilizing alternative indigenous fuels would be an effective and economical means for supplying electric energy to individual villages. This hypothesis was not borne out in either Latin America or India.

From the standpoint of the scale of generation, in the limited number of instances where it was judged that electric energy might make a productive contribution at the village level (population 2000-3000), it is estimated that a 50 Kw unit would be the minimum size required. In addition, it would be advisable to install excess capacity at the outset to provide for future load growth. Further, some reserve or standby capacity should be allowed for in order to assure a dependable supply.

Table 1

DAILY FUEL REQUIREMENTS OF 15 KW GENERATORS OPERATING AT A 30 PERCENT LOAD FACTOR

Plant	Fuel	HHV (btu/lb)	SFC lbs kw/hr	Plant eff. (%)	Fuel rate lbs/ day
Diesel-electric	Diesel oil	19,750	.745	23.1	80
Gas-electric	Gasoline	20,750	1.11	14.8	120
Closed cycle, compound steam engine-electric	Diesel oil	19,750	1.153	15.0	125
"	Bunker C	18,000	1.266	15.0	140
"	Coal	11,800	1.93	15.0	210
"	Wood	8,500	2.68	15.0	290
"	Agri. Waste	7,500	3.04	15.0	330

NOTE:
In calculating fuel requirements, the best generation efficiencies at rated output are assumed. Actual fuel rates will exceed these values as a power plant installation will rarely operate at peak load and performance.

Table 2

FUEL PRICES AT SELECTED SITES IN INDIA

Location	Type of Fuel	Price	
		Rupees	Dollars
Rajasthan			
Jhuntha	Crude oil	1.62/gal	.28/gal
Berat	Crude oil	1.62/gal	.28/gal
	Fuel Wood	30-37 ton	6.35-7.85/ton
Malpura	Crude oil	1.62/gal	.28/gal
Peepalia	High speed oil	2.81 gal	.50/gal
Maharashstrah			
Jammer	Crude oil	1.44/gal	.25/gal
	Fuel Wood	40-50/ton	8.47-12.71/ton
Paldhi	Crude oil	1.44/gal	.25/gal
	Fuel Wood	40-60/ton	8.47-12.71/ton
Uttar Pradesh			
Srinagar	High speed oil	3.30/gal	.58/gal
Bridgmanganj	Crude oil	1.94/gal	.34/gal
	High speed oil	2.75/gal	.48/gal
	Fuel wood	24-43/ton	5.08-9.17/ton
Chandrawal	Crude oil	1.12/gal	.20/gal
Nautanwa	Crude oil	2.00/gal	.35/gal
	High speed oil	3.25/gal	.58/gal
	Fuel wood	50-60/ton	10.59-12.71/ton
Orissa			
Tikabali	Fuel wood	24/ton	5.08/ton

NOTE:
Rupee prices are for imperial gallons.
Dollar prices are for U.S. gallons.

Table 3

FUEL PRICES AT SELECTED SITES IN SOUTH AMERICA

PERU

Fuel	Local Price (sole)	U.S. Price ($)
Collejon de Huaylas Area		
Gasoline, regular	4.90/gal	.18/gal
Gasoline, high test	5.90/gal	.22/gal
High speed oil	4.30/gal	.16/gal
Kerosene	2.80/gal	.105/gal

Delivery charges for most liquid fuels to communities 5 and 10 kms from fuel station may add 1.00 sole/gal ($.037/gal) to the above prices.

Junin Area		
Gasoline, regular	4.10-4.80/gal	.15-.18/gal
Gasoline, high test	5.60/gal	.21/gal
High speed oil	4.10/gal	.15/gal
Kerosene	2.20-2.50/gal	.08-.10/gal

CHILE

Cautin Area	(pesos)	($)
Gasoline, regular	87/ltr	.22/gal
High speed oil	85/ltr	.215/gal
Kerosene	70/ltr	.177/gal
Wood	35/kg	21.10/ton

COLOMBIA

North Coast Areas		
Gasoline, regular	1.00-1.05/gal	.11-.12/gal
High speed oil	.90-1.00/gal	.10-.11/gal
Kerosene	.90-1.10/gal	.10-.13/gal

From the standpoint of fuel supply, it was discovered that the supply of fuels such as wood, rice hulls, dung, straw, leaves, etc. is, in most cases insufficient to meet the daily requirements of an engine-generator of adequate size on a dependable basis (see Table 1 for estimates of daily fuel requirements for a 15 Kw generator with a 30% load factor). Some of these fuels are seasonal in supply; e.g., rice hulls and straw, and would be bulky to stockpile. Some have uses other than for combustion such as agricultural waste for animal feed. Some are concentrated geographically as is coal in India. In this case the transport costs of getting the coal into the villages is an effective deterrent to its use. Wood is available in certain instances as in selected areas in the State of Orissa and in southern Chile which has extensive forest resources. However in most cases wood is simply not available in the quantity required or is too costly (see Table 2). What little fuel wood is available is utilized for cooking and heating. It should also be pointed out that India has imposed extremely severe limitations on the use of wood for fuel in view of her already severely depleted forest reserves.

With respect to hydro power, the upland area of Peru and Colombia in the Andes are notable for glacier fed streams with a year round flow of a capacity ranging from 50 to 500 Kw. Because of their high gradient, 150 to 300 feet per mile, are a prime source of power for generation of electricity. Very little has been accomplished to date in exploiting this stream power for rural use in both Peru and Colombia.

Wind power appears to offer only a limited applicability in both India and Latin America. In upland Peru (Alta Plano) there are sustained daytime winds. The north coast of Colombia also experiences low velocity (5-10 mph) winds throughout the year. However, these regions also have readily available gasoline and diesel fuels at prices that would make generation of electricity by wind power non-competitive, making its use problematical except for isolated instances in these areas.

Furthermore, the most efficient use of wind power, where available, would appear to be for pumping rather than generation of electricity. Finally, it appears that wind power generating units, because of technical and economic considerations, are largely restricted in capacity to the 5-25 Kw range.

Solar power is not a practical possibility for near future application. Substantial research and development work remains to be done to increase conversion efficiencies and to reduce equipment costs in order to compete with conventional equipment.

In the case of dung as a fuel input, the bio-gas generator which has been developed in India offers a limited potential as an energy supply and has the added advantage of producing a fertilizer residue. Family size units with 100 $ft.^3$ daily capacity have been built and tested by the Indian Agricultural Research Institute. From the standpoint of the family size unit, gas production would be sufficient for lighting (4-5 $ft.^3$ of gas per hour for a gas lamp) and cooking (10 $ft.^3$ of gas per hour per burner) needs.

At its current stage of development, however, the bio-gas unit is too expensive for the average villager. The total cost of a family size unit has been estimated at 500 rupees or $100. However, the total installed cost of units in villages near Bombay has approximated 2000 rupees or $400, clearly not within the reach of the Indian villagers.

In the case of fuels for diesel or gasoline engines, widespread distribution systems have been established in both Latin America and India. Under these circumstances, internal combustion engines would appear to be the most appropriate equipment for the local generation of energy other than local hydro. However, diesel generation provides expensive power in comparison to both the ability to pay in rural areas and to the existing rural electric rate structures. This is particularly true in India where the price of high speed diesel fuel in rural areas is extremely high (see Table 2) reflecting a high tax designed to discourage consumption of imported petroleum fuels. It is less true in Colombia and Peru where domestically produced fuels are considerably cheaper in price (see Table 3).

V.

APPROACHES TO RURAL DEVELOPMENT

A major conclusion of the field survey teams is that the planning and implementation of rural electrification projects needs to be more effectively focused on viable rural development opportunities. This section, therefore, sets forth some suggestions for clarifying the relationship between rural electrification, on the one hand, and rural development on the other. In this connection, a brief review is made of India's rural small industry development experience, the need for a systems development approach is outlined and the relative merits of the village vs. the market town as a nodal growth center are discussed.

Village Industry Program

India's village industry program dates back to the teaching of Mahatma Ghandi and his followers which brought about a new consciousness of the importance of traditional village industries as a means of upgrading village life. Partly as a challenge to the British, but mostly out of personal conviction, Ghandi and his followers had created the All India Spinners Association and the All India Village Industries Association for the revival and encouragement of traditional rural industries including the Charkha (hand spinning) and weaving industries. There was an important social context to these efforts and village self-

sufficiency was one of the prime objectives.[1]

In 1956, as part of a national small industry program which was having considerable impact in urban areas, 26 pilot projects were sanctioned with the special aim of accelerating rural industrialization.

One of the objectives of this scheme was to develop a pattern of industrial extension services that would be necessary in undertaking rural industrial programs in community development blocks. The effort was to concentrate in part on new industries, and in part on the traditional village industries. The most successful industries in these schemes were expected to be builders hardware, soap-making, fruit and vegetable preservation, electrical goods and accessories, general engineering workshops, agricultural implements, saw mills, foundry and blacksmithery, and bucket and steel trunk making units.

Of the 26 pilot projects, only 15 were really started, and of these only 9 were considered successful. The most successful in the final analysis were those involving traditional industries; namely, Khadi, Ambar charkha, or handlooms. Even here the "successes" were sub-

[1] "My idea of a village swaraj is that it is a complete republic--independent of its neighbors for its own vital wants, and yet interdependent for many others in which dependence is a necessity. Thus every village's first concern will be to grow its own food crops and cotton for its cloth. It should then have a reserve for its cattle, recreation and playgrounds for adults and children. Then, if there is more land available, it will grow useful money crops, thus excluding ganja, tobacco, opium and the like. The village itself will maintain a village theater, school, and public hall. It will have its own waterworks ensuring clean water supply. This can be done through controlled wells or tanks. Education will be compulsory up to the final basic course. As far as possible every activity will be conducted on the co-operative basis. There will be no castes such as we have today with their graded untouchability." Gandhi, as quoted in Kurukshetra monthly organization of the community development project administration, October 2, 1954, p. 34.

sidized heavily. The evaluation of this effort made in 1959 stated:

> "The experience of these projects shows that where there is no electricity and other facilities for the growth of small industries are lacking or are inadequate, and where the area is generally backward, a program of assistance to traditional and village industries can still be undertaken..."[1]

It is generally recognized, however, that this effort was not particularly successful.[2] Industry has gravitated to those centers where it can operate effectively, namely where raw materials, labor, power, capital, and markets were present (i.e., the congested supercities). During 1951-57, 47.2 percent of the new manufacturing enterprises were located in Class 1 cities (over 100,000 population) where 41.8 percent of the urban population resides. On the other hand, Class II and III cities (20-100,000 population) with 26.9 percent of the population received only 19.3 percent of the new manufacturing enterprises. Finally, towns of less than 20,000 population, with 31.4 percent of the population, received 33.1 percent of the new enterprises.[3] This preliminary assessment of industrialization does not reflect the size of the new manufacturing enterprises. It can be expected that the distortion in favor of the large cities (particularly Calcutta and Bombay) is

[1] Report of the Study Team on Community Development Industrial Pilot Projects, Ministry of Community Development and Cooperation, Government of India, December 1959, p. 50.

[2] See Appendix A for evidence in support of this statement.

[3] "Industrial Development and Urban Growth with Particular Reference to Industrial Location" William Bredo, Paper 9, Seminar on Urbanization in India, University of California, Berkeley, California, June 1960.

even more pronounced than shown since the average size of new manufacturing establishments in the large cities is bound to be substantially larger in terms of number of employees, capital, etc. than the average for small towns.

The Third Five Year Plan calls for substantial expenditures for village industry. Most importantly, it calls for a new government guarantee to cover bank loans to such industries. Proposed expenditures under the plan are shown in Table 1. (These figures include expenditures in both village and urban sectors.)

A more ambitious plan to accelerate village industrialization has been suggested recently by Shri Manubhai Shah, the Union Minister of Industry. In a memorandum he has called for the creation of an autonomous National Board for Rural Industrialization, with a substantial budget of Rs. 200-250 crores for 5 to 7 years, which would have the task of selecting about 10,000 villages (2000 without electricity) setting up village work sheds on rural industrial estates, and promoting not only traditional industries, but also manufacture of radio parts, cycles, diesel engines, pumps, agricultural implements, sewing machines, instruments, plastics, etc. The main aim will be to "Carry Industry to Village."[1]

[1] "Notes on Rural Industrialization", Shri Manubhai Shah, Union Minister of Industry, New Delhi, August 1961.

Table 1

INDIA: PROPOSED ALLOCATIONS UNDER THIRD PLAN FOR VILLAGE AND SMALL INDUSTRIES

	Second Plan	Third Plan
	(Rs. crores)	
Handloom	29.7	34.0
Powerloom in the handloom sector	2.0	4.0
Khadi and village industries	82.4	92.4
Sericulture	3.1	7.0
Coir industry	2.0	3.2
Handicrafts	4.8	8.6
Small scale industries	44.4	84.6
Industrial Estates	11.6	30.2
TOTAL	180.0	264.0

Source: The Third Five Year Plan.

Need for a Systems Development Approach

The preceding discussion suggests that there is a need for an approach to rural development that would view the interrelationship between energy and development not in the context of a village industry program, but rather from the standpoint of a systems analyst. The systems analyst would be concerned with an energy supply system consisting of generation, transmission and distribution sub-systems and an energy utilization system consisting of the agricultural production, small industry and consumption sectors of the rural economy.[1] He would also be concerned with the interrelation of these systems inasmuch as the characteristics of one system had design and cost implications for the other and vice versa. For example, it is clear that the type of generating system and the cost of delivered energy are greatly influenced by the characteristics of the load to be supplied (the utilization system.) In addition, he would be concerned with the "scale" problem from the standpoint of determining the optimal capacity of a local generating system and identifying the scale of operation of various types of small industries which would be viable for rural areas.

The systems development approach would help overcome the parochialism in development projects that sometimes arises from a departmental focus. For example, the state electricity boards or departments in

[1] See Appendix C for discussion of the systems approach.

connection with their rural electrification programs, tend to view their task, as one limited to generating and distributing electricity. This is understandable given the tremendous demands placed on these organizations from the standpoint of the installation of new capacity and the requirements which have been levied on them from the standpoint of extending the number of electrified villages. Nevertheless, it has to be recognized that energy supply is only half the job and that there is no automatic process which insures the productive use of electric energy once it has been made available. Thus there needs to be a simultaneous analytic determination of the design and characteristics of both the supply and the utilization system lest one be out of balance with respect to the other. Furthermore having proceeded with the installation of new supply capacity, there needs to be a coupling with a concerted load building program aimed at achieving an economic load factor through the effective application of power to productive uses.

In a similar way, it needs to be recognized that in anticipating and appraising the impact of energy on a newly electrified area that one must consider not only an economic system but a social system as well. In fact, the interrelation between the directly economic and technological realm, on the one side, and the domain of the non-economic, social and psychological phenomena, on the other, is so extensive that evaluation in either area without adequate information concerning the other is likely to be highly superficial.

From the standpoint of implementing a systems analysis for purposes of this project, it is recommended that an analytic model be constructed for the purpose of accomplishing a cost analysis of the following six situations:

Off Grid Energy	Grid Energy
Village	Village
Cluster of Villages	Cluster of Villages
Market Town	Market Town

The objective of this analysis would be to determine which of these situations would constitute economic opportunities for the utilization of electric energy.

The Village vs. the Small Town as Nodal Growth Center

The contention that rural villages can be economically industrialized, even for mechanized service industries, is questionable. Past experience indicates that the likelihood of economic success of industrial decentralization would be greater in a program concentrating on small rural towns from 10,000 to 20,000 population, nearly all of which already have been electrified through grid extension in India. This program would then have its impact upon the surrounding rural economy.

The Kibboutz in Israel

It may be useful at this point to digress slightly and consider the experience of the Israel Kibboutz. The social composition of the Kibboutz has little resemblance to that of the Indian village. It is of recent origin (30-40 years), composed at first of individuals or families--many of which had recently immigrated to Israel,

and many of which were highly trained in diverse fields. It was and still is a very experimental social approach to the agricultural problems of Israel, and it is a communal approach in a non-Communist country. The Kibboutz economy is the result of many attempts and many failures. Its success finally depended on the diversity of the approaches attempted.

The Kibboutz highlights one approach to rural industrialization; namely, making the village the nucleus for providing entrepreneurship and investment capital. The Kibboutz has provided managerial and supervisory personnel from its well endowed membership. It has also been able to be an effective device for accumulating capital by enforcing minimum consumption patterns while striving for maximum production from its ideologically oriented membership.

Yet, in the Kibboutz, industrialization has not provided much employment for its members. Table 2 indicates that in 1950 about 10 percent of the Kibboutz membership was employed in small industries or as artisans. Thus it is difficult to say that the Kibboutz experience can be taken as an indication that village industry can begin to resolve agricultural unemployment problems. On the other hand, it does suggest that certain industries with modern technology can be established within the village, namely, industries which depend heavily on agricultural raw materials (such as food processing, textiles, leather, etc.) or those whose products find a ready market in agriculture (namely, service

industries, farm implements, construction materials, chemicals, etc.) Such industries provide both forward and backward linkages between the agricultural sector and the industrial sector.

Table 2
SMALL INDUSTRIES IN 212 KIBBOUTZIM-ISRAEL
1950

Industry	Number of Enterprises	Number of Workers
Food processing	27	507
Metal working	43	676
Wood and carpentry	25	450
Construction materials	13	416
Textiles	8	114
Leather	5	126
Chemicals	5	116
Paper and printing	6	88
Miscellaneous	16	24
TOTAL	148	2507

Source:
L'economie collective du Kibboutz Israelien, J. Shatil, Paris, 1960, p. 177. In 1950 there were some 70,000 members in Kibboutzim in Israel (about 5 percent of the total population. Of these slightly more than 31,000 were permanent workers. Thus about 9 percent of the total workers were devoted to small industries. In addition, another 797 were artisans. In total, 10 percent were therefore employed outside of agriculture.

Vereda vs. Municipio in Colombia

Many persons interviewed by the Survey Team recommended an

initial effort to benefit the veredas or small villages on the basis of an especially urgent need for economic and social improvement at the village level.

The vereda is typically a collection of huts, inhabited by 200 to 500 persons engaged in the non-mechanized farming of small plots. The grouping of people in a vereda is apparently based on social or security considerations more than on economic factors. For marketing and for the purchase of necessities, the inhabitants of veredas typically go to a nearby market town or pueblo.

These market towns usually are the administrative and economic center of a municipio or county. Wholesale buyers of coffee, yucca, sugarcane and livestock typically operate in the market town. The principal church, schools and the circuit judge in the municipio are located in the town. The municipio area surrounding such market towns varies widely in size and in the proportion of rural and urban inhabitants. A recently made study in Colombia indicates a rough correlation between the total population of a municipio and the number of urban inhabitants.

The number of urban residents tends to be higher in municipios with larger total populations in accordance with the following general pattern:

Total Municipio Population	Typical Percentage of Urban Inhabitants	Typical Number of Urban Inhabitants
10,000 to 20,000	5	500 to 1000
20,000 to 30,000	15	3000 to 4500
30,000 to 50,000	35	10,500 to 17,500

Municipio boundaries have undoubtedly been determined in part by arbitrary decisions, but economic factors have had an influence as well. For example, river valleys, mountain barriers, and roadways have historically influenced the clustering of people within geographic areas which have now become municipios.

The Survey Team felt that the concentration of economic activity and population in the urban area of a municipio offered an economic base midway between the more modernized, major urban areas and the village level. The urbanized center of a municipio also appeared to offer promise of greater economic returns for a development program associated with the utilization of energy than did the village. The generally ready access by the villagers to the urbanized center further suggested that economic improvements in the urban area would have an impact in terms of higher employment and income on the rural inhabitants in the municipio.

Some discussion of possible types of small industry suitable for market towns in Colombia will help make the foregoing suggestions more tangible, particularly from the standpoint of building productive electric power load. Table 3 lists typical small industries which have been found feasible in Colombia, with approximate

installed horsepower, connected load, employment and capitalization requirements. It cannot be too assured that any given industry would prove successful in any locality, of course, inasmuch as the viability of some industries is based in part on an urban market which might not be available in other localities, and requirements for raw materials, management and capital will vary.

Table 4 is included to provide a cross check on the power requirements shown in Table 3, and to provide a rule of thumb for estimating power needs for industries in Colombia. The data in Table 4 relate average power requirements to other characteristics of industries in various size categories. The size categories are based on the number of employees, ranging from the smallest establishments with 1 to 9 employees, up to larger scale plants employing 200 or more persons. On the assumption that industries in rural areas would be of smaller scale, only the first three of seven categories have been included in Table 4.

Table 4 indicates that the smallest manufacturing plants with 1 to 9 employees require about 5 Kw, larger industries employing 10 to 24 workers need about 15 Kw, and those with 25 to 49 employees require about 50 Kw.

The extent to which industries actually consume electrical energy in relation to the power of their connected load was not checked in Colombia. Experience in the United States, however, suggests

Table 3
TYPICAL SMALL SCALE INDUSTRIES IN COLOMBIA

Type of Industry	Products	Horse-power	Employ-ment	Capital-ization	Location
Foundry	Pulleys, base plates and other parts for agricultural machinery, coffee picking cases, metal plates for coffee bean depulping grinders.	10	15	$17,250	Armenia, Caldas
Apparel	Men's work uniforms, blue jeans, work shirts, boys shorts (50% sold direct to factories using uniforms, 30% mostly low price jeans sold to wholesalers, 20% mostly quality jeans sold to retail outlets.)	4	15	$41,400	Armenia, Caldas
Cement products and metal wire assembling	Cement mosaic tiles for floors and walls, reinforced concrete fence posts, metal wire chicken coops.	8	4[a]	$ 8,625	Armenia, Caldas
Brick-making	Building bricks and tiles.	15-25	23[b]	$17,250	Cali, Palmira, Valle Dept.[b]
Ceramics	Ornamental ceramics vases, dishes.	5[c]	12	$16,100	Bogota, Cundinamarca
Special-ized Bricks	Facing bricks.	5[c]	18	$23,000	Bogota, Cundinamarca
Shoe Mfg.	Leather shoes.	15[c]	25	$17,250	Rionegro, Antioquia
Apparel		18[c]	29	$36,800	Manizales, Caldas
Leather goods		12[c]	13	$ 2,300	Pereira, Caldas
Wood-working	Tables, chairs, other furniture, window and door frames	2-5[c]	3	460	Medellin, Antioquia
Plastic goods		25[c]	18	$57,500	Manizales, Caldas

a. Operates with one press only.
b. Data are typical of two plants inspected by SRI in May 1962, located at Cali and Palmira in Valle. Plants are equipped with electric powered brick machines but could operate without power.
c. Estimates.

Table 4

POWER REQUIREMENTS FOR SMALL SCALE INDUSTRIES IN COLOMBIA

1959

Category of Industrial Establishments by Number of Employees	Number of Industrial Establishments per Category in Colombia	Total Installed Horsepower per Category	Average Horsepower per Industrial Establishment	Average Kw Required per Industrial Establishment
1-9 employees	6550	40,400	6.2	5
10-24 employees	2326	47,400	20.4	15
25-49 employees	835	54,700	65.5	50

Source: Government of Colombia, Departmento Administrativo Nacional de Estadistica, via Banco Popular, Bogota, 1962.

that a typical small industry uses only one fourth to one third of its potential maximum requirements. For example, an industry with a 25 Kw connected load might utilize its full requirement only one fourth of the working day; thus the kw/hours utilized by a typical small industry in Colombia might be roughly calculated as follows:

9 working hours x 1/4 x 25 Kw = 56.25 kw/hours of power consumed daily.

This usage factor is a further inducement to the clustering of small industries in market towns, where their combined usages can help to build load factors to economically viable values.

Village vs. Town in India

In India it is difficult to conceive of the village as a self-generator of new industry, although the traditional industries (khadi, coir, handlooms, etc.) evolved over time from within the resources of the village. Modern small industries imply an urban training not available within the village. This training must be imported either by bringing entrepreneurs and skilled workers to the villager, or by selecting promising villages and training them.

The Karve committee, which helped pave the way for the small industry program in India, had this to say about the pattern of industrial decentralization.[1]

> "The pattern of industrial activity that should gradually emerge is that of a group of villages having its natural industrial and urban center. These small urban centers will be similarly related to bigger ones. Thus a pyramid of industry broad-based on a progressive rural economy will be built up. In such an organization small centers can experience a cooperative interest in the bigger ones, and these latter would develop a genuinely supporting instead of an exploitational relationship towards the smaller towns and the countryside."

This brief discussion highlights the fact that the issues of urban versus rural development, of centralized versus decentralized growth, and regional balance in development, are clouded by many complexities, which are unlikely to be resolved in the near future.

[1] Report of Villages and Small Scale Industry Committee, Planning Commission, Government of India, New Delhi, October 1955, p. 22.

Consequently economists, sociologists, and planners will have to do some "educated" guessing. Such an educated guessing effort was undertaken in India at a seminar on rural industrialization sponsored by the Ford Foundation in March 1960.[1] The main conclusion of this meeting seemed to be that industrial decentralization would be at best mean decentralization from the very large urban centers toward the smaller towns. Rural industrialization could not be conceived as a village goal, but as an area objective. Within given areas of rural India, nodal growth centers would provide a need and opportunity for clusters of small industry. It is around these clusters, probably located in market towns, that a foundation for rural industrialization might be established.

It was further proposed that the block instead of the village be considered as the center of gravity and planning unit for rural industrialization. The block administration has been superimposed on the traditional administrative machinery of India, but only for development purposes. The traditional administrative units were the village, the tehsil or taluka (with a population of 200,000), the district (with a population of about one million), and the state. Yet the block may well be the most practical unit for agro-industrial planning.

[1] "Seminar Report--Rural Industrialization in Economic Development" by Richard Morse, the Ford Foundation, New Delhi, April 16, 1960.

VI.

PRINCIPAL FINDINGS AND IMPLICATIONS FOR FUTURE ACTIVITIES

what are the problems?

Principal Findings

1. This project should place particular emphasis on problems of power utilization in the agricultural processing, small industry and consumption sectors of the rural economy, since increased load factors and more productive uses of power are essential to raising rural living standards.
2. The appropriate context for a research project on rural power supply and productive utilization should include villages, clusters of villages and market towns.
3. The planning and implementation of rural electrification projects needs to be more effectively focused on viable rural development opportunities.
4. The analysis of energy supply costs and energy utilization requires a systems development approach from the standpoint of designing and interrelating power supply and utilization systems with rural development programs.
5. It appears doubtful that local power generating units at the village level can be justified, with the possible exception of small hydro electric generators, because of high fuel costs, low load factors, lack of diversity of power use, and the lesser cost of shaft power.

These findings are general inasmuch as they relate to the field survey portion of the project study. Analytical work is in progress with respect to rural energy cost and utilization problems which will lead to more definite conclusions.

Implications of Findings for Research

In general the findings indicate that the original scope of the project with its emphasis on the provision of locally-generated power to the small village community was too narrowly defined. As indicated above, it is the judgment of both survey teams that a meaningful research project on the significance of the productive uses of power for rural development requires an analysis of supply and demand for electrical energy either from a grid, or locally-generated in three specific situations: the village, the cluster of villages, and the market town. This approach to the problem can give the development planner an analytical model for optimal power supply and utilization patterns for a given situation and their cost consequences, and provide realistic information on the integration of electrification programs with rural development.

Granting the desirability of focusing on the rural sector as a whole rather than on the individual village, there is a need for specific information on the types and scales of small scale industries which are viable in rural areas. This question is a basic one, inasmuch as the potential use of power by small industry establishments should constitute a significant portion of the total productive power usage in a rural community. Unfortunately little useful information has been compiled relative to the specific types of small industry which might be viable in a rural area, particularly at the market town level.

The findings of the field survey teams also indicate that the type and scope of the field pilot projects requires further clarification.

Questions to be resolved in this connection include:

1. The potentialities of the market town with respect to productive rural uses of electrical energy.
2. The possibilities for cooperative efforts with overseas institutions in carrying out pilot projects.
3. The type of evaluation model which will be required by such projects.
4. The need for additional information on relevant site and small industry factors.
5. The relative priority to be assigned to the village, the cluster of villages and the market town as candidates for pilot projects

During the next few months, further discussions will be held by the project team to assess these problems.

APPENDIX A

ON-SITE INVESTIGATIONS IN INDIA

RAJASTHAN

Two sites were visited in Rajasthan: a group of villages in Raipur Block of Jodhpur Division and Berat, some 50 miles from Jaipur, the capital of Rajasthan. The visits were made on the suggestion of the Chief Secretary to the Government, Sri B. Mehta. Malpura, a town near Jaipur, was visited to study the utilization of electricity generated by diesel generators supplied under the Colombo Plan.

Raipur Community Development Block

Raipur Block was visited in the third week of April and subsequently in the first week of July. The Block is named after Raipur, which is the largest village, and is its headquarters. Pali district, in which Raipur is located, has been selected for intensive agricultural work under the Package Program of the Ford Foundation. In this connection special efforts are being made in Raipur to introduce improved farm practices and to increase agricultural production. Mr. Shivlahri Sharma is the Block Development Officer.

The Raipur Block is in an arid, partly hilly, region having an average annual rainfall of between 11-13 inches. The Aravali hills touch the block in the east and proceed in a generally southweard direction leaving the rest of the territory in a fairly even plain cut across by the Luni River and its various tributaries. The river is dry except in the rainy season when the rain in the catchment area rushes forward in a southwestern direction towards Gujerat and the Rann of Cutch.

Agriculture, which is the single most important occupation in the area, is heavily dependent on irrigation. Irrigation, in turn, is accomplished principally by means of bullock-powered Persian wheels. The principal crops of the area are chillies, wheat, jowar, bajra (millets), oilseeds, cotton and gram.

A sizeable portion of the population is engaged in sheep and goat farming, and in most of the villages there are a limited number of families engaged in traditional rural industries such as weaving, tanning and oil expelling.

The villages visited within a six mile radius from Raipur include Deepawas, Megarda, Bar, Jhuntha and Peepalia. Each of these villages is discussed below.

Village of Raipur

Raipur is one of the largest villages of the area with a population exceeding 6000. It has a post and telegraph office, a public telephone and is located two miles from Haripur, a railway station on the Jaipur Ahmedabad meter guage railway line.

Agriculture

The agricultural produce includes chillies, wheat, jowar and bajra, oilseeds, cotton and gram. Details of acreage under different crops for the year 1951 are given in Appendix . Because of the rather sandy soil and the dry climate, crops are irrigated at least seven to eight times. Chillies are irrigated between eight to fourteen times, wheat somewhat less, and cotton about eight times. By contrast, in some parts of Uttar Pradesh, cotton is irrigated only once or twice. Of a total crop area of 14,000 acres, 8000 acres are irrigated.

Through discussions with some of the prominent villagers, it was indicated that at least 15 to 20 individuals would be willing to install electric water pumps, if power were to be made available. They argued that these pumps would be inexpensive, costing between Rs. 1200 to Rs. 1500 compared to the diesel sets which require an investment of about Rs. 2500 to Rs. 3000. Mr. Mohan Lal has installed a 5 Hp (Cooper) diesel pumping set. There is one other man who has a diesel pump. In general, Persian wheels are used for irrigation.

Industries

The existing industries include a Weavers' Cooperative Society using power looms and four flour mills run by diesel engines. Among the traditional village industries are weaving (30 families), hide tanning and shoe-making (70 families) and oil expelling done by Telis (12 families).

Weavers' Cooperative Society using Powerlooms

The name of the cooperative is 'Adarsh Vastra Utpadak Sahikari Samiti Ltd., Raipur'. Mumtaz Bakhsh has been responsible for organizing this society. He has spent a good deal of his life working in large mills at Beawar, 21 miles away, and Ahmedabad, 300 miles away. The cooperative society has 30 members. It has raised a share capital of Rs. 7250 and has been helped by the State Government with a loan of approximately Rs. 40,000. Recently, it was granted a loan of Rs. 8000 from the Reserve Bank.

A 12.5 Kw generator of German make is hooked up by a belt drive with an 18 Hp, 475 rpm, Campbell diesel engine. The cost of the diesel engine was reported to be 5000 rupees. There are 11 looms, each with a 0.75 Hp motor. The Society is paying Rs. 3 per hour to one Ghaffar Bakhsh, who owns the diesel engine, for

running it on an hourly basis. The diesel engine also operates a flour mill which is managed by Ghaffar Bakhsh. Mumtaz Bakhsh is keen on expanding operations by bringing in new machines, but he faces two limitations: one with regard to finance and the other with regard to electricity. Ghaffar Bakhsh indicated that he would dispose of his diesel engine if electricity were to be made available from a central source, and that he would like to put in a lathe machine in order to manufacture tools and implements.

Other Industries

Once electricity is available, it is reasonable to expect the flour mills to switch over to electricity. There is sufficient demand for diesel engines in the area so as to make the problem of their disposal simple. Other rural industries such as handloom, tanning and oil expelling will have no need for electricity unless technological improvements are brought in.

The Tanners' Cooperative Society

Twenty tanners have formed into a cooperative society. They have obtained Rs. 1400 as subsidy from the Khadi Commission. The Panchayat Samiti, Raipur has given them Rs. 2200 for a common workshed and Rs. 300 for purchase of tools. It was observed that the aid given has not encouraged or brought about technological improvements. When querried as to how they expected to gain in the long run from the society, in the absence of technological improvements, the tanners were at a loss to explain.

Some Prominent Individuals

1. Sri Pannalal, Sarpanch (head of the village Panchayat).

2. Sajjan Singh, son of the ex-Jagirdar of Raipur. Sajjan Singh is undoubtedly the wealthiest man of the village, owns a great number of houses in Raipur, and is reported to be looking for avenues for investment in economically productive channels.

3. Pannalal Bhandari, an agriculturist.

4. Pema Ram Sirvi, an agriculturist.

5. Mohanlal Bhandari, an agriculturist; has a 5 Hp diesel pump.

6. Gollaii Mali, an agriculturist.

the engine which is used to run a flour mill. Ram Chandra, who is a blacksmith by caste, makes razors and scissors and grinds them on a grinder attached to the engine. The manufacture of razors, scissors and other small tools, is carried on by a fairly large number of families in Sojat, about 25 miles west of Raipur. Ram Chandra worked in Sojat where he learned the trade. He is doing a fairly good business and seems to be a talented man. It is possible that with proper guidance and encouragement he might be able to expand the work and be in a position to employ others.

Oil Expeller

There are six hereditary families of oil pressers (Telis). These families are using bullock drawn Ghanis. Prem Raj, one of the Telis, has installed a 10 Hp diesel engine, an oil expeller and a flour mill. He has been thinking of starting a chillies processing (grinding) business.

Principal Impressions

In comparison with Megarda and Deepawas, the agriculturists have larger holdings and due to reasons not well known, there have been attempts to start small industries as exemplified in the cases of Ram Chandra and Prem Raj. There is a family of millionaires in this villages which owns large concerns in Madras and some other towns and cities of the south. This family is in a position to invest on local enterprises provided they are lucrative.

Village of Peepalia

This village is another three miles west of Jhuntha and six miles from Raipur. Peepalia is a large village with a total cultivated area of 2300 acres out of which 1083 acres are irrigated. Wells are the only source of irrigation water. There are about 56 wells in the village and each has approximately 17 acres under its command. Being somewhat distant from the river, only a few wells have sufficient water to stand continuous use. The Sarpanch felt that pumps could be installed at 20 to 25 wells. He mentioned the fact that in the past two years, the water table has receded and it is becoming increasingly difficult for the bullocks to pump the wells. The villagers may, therefore, be willing to deepen the wells and install electric pumps.

Cotton is one of the important crops of this village. During the present sowing season, about 50 acres are put under cotton. About 10 to 15 maunds of cotton are produced on an acre and is sold for approximately Rs. 250.

Potentials for Use of Electricity

1. Existing uses of electricity. The powerlooms, as already mentioned required 10 to 12 Kw and the flour mills can take up to 20 Kw.

2. Potential uses. (a) It may be safe to assume, provided electricity can be supplied at moderate charges, that 20 to 25 electric pumps may be installed at wells. Usually a 5 Hp diesel engine is used for pumping.

   (b) Expansion of the existing powerlooms. There is a possibility that the Adarsh Vastra Utpadak Sahikari Samiti will be expanded if electricity is available. Its power requirements might be doubled.

   (c) There is also a possibility that local entrepreneurs may invest in small scale industries once electricity is available. The possibilities include a tool manufacturing unit, a unit for processing of chillies and woodworking.

   (d) Some of the villagers would purchase electricity for domestic purposes.

Villages of Deepawas and Megarda

Deepawas is located about three miles southeast from Raipur. About a mile and a half north of Deepawas is village Megarda and about two miles north is Bar. Deepawas and Megarda were visited primarily with a view to finding out whether they are in a position to use electricity productively. In both villages, the agriculturists are relatively better off economically than the other occupational groups. Though there are castes that are hereditarily engaged in the business of oil expelling, in weaving and tanning of hides and shoe-making, they are all in a state of marginal existence. Most of the families find it necessary to seek employment as laborers during parts of the year when their business is slack.

The crops grown are the same as in Raipur, viz., chillies, wheat, jowar-bajra, cotton and oilseeds.

Megarda is a small village with a population of about 500. It has seven wells and is situated near the river, so that the wells have a good water supply. Chillies are the principal cash crop. The fields are manured heavily, weeded regularly, and irrigated 10 to 12 times during the season. Megarda has one Teli (oil expeller caste) family, 26 weaver families, and 10 tanners locally called 'Jattias'. The weavers are finding themselves in

a "tough" spot and are anxious to learn about new methods.

Village Deepawas, which is larger than Megarda, has a total cultivated area of 446 acres out of which 286 acres are irrigated. This village is predominantly agricultural and has 21 wells. There are a few families of weavers and tanners. The weavers, it was reported, are not taking much interest in weaving as they are not finding it profitable. The tanners and shoe-makers, constituting six families, are slightly better off.

Principal Impressions

Taken as a whole, it is evident that in both villages the number of wells, though well supplied with water, is small so that the potentiality for the installation of electric pumps for irrigation is limited. It should also be noted that the average holding per individual in these two villages is rather small and a number of cultivators share a well in common. As such, few find it profitable to invest in pumps unless the water is shared in common.

There are no existing industries using mechanical or electrical power. Under the conditions that exist, it does not appear that the people are in a position to take initiative for starting new enterprises.

Village of Jhuntha

Jhuntha has approximately 450 households with a population of about 2000. It is located two and a half miles northwest from Jaipur. The village is primarily agricultural and more than 50 percent of the population is engaged in agriculture. The agriculturist castes are Jats and the Sirvis. There are 70 wells in the village and most of them have a good water supply. It was stated that 20 to 25 wells might be electrified if electric power were available. Kaloo Ram Kumhar, one of the agriculturists, has a small 5 Hp diesel engine (Cooper) connected to a pump. He owns 10 acres of land but irrigates an additional 20 acres belonging to his brothers. The engine was purchased for Rs. 2300 and another Rs. 300 were spent for installing the pump and the shed. Crude oil is obtained at the rate of Rs. 1.62 per gallon, and it was reported that four gallons are sufficient to run the engine for 12 hours.

Industries

Ram Chandra Lohar works in collaboration with Pema Ram who owns a 13-14 Hp Robust diesel engine operated on crude oil. The engine was purchased second hand for Rs. 2200. Both Ram Chandra and Pema Ram contributed to the cost of

Tanning

There are about 20 families each of tanners and weavers and seven of Telis. The tanners have been encouraged to do collective tanning through a grant of the Khadi and Village Industries Commission. There did not, however, appear to be any consciousness among the tanners about the advantages of collective tanning. They had apparently taken to it because it did not cause them any special inconvenience. Furthermore the economic benefits of the changeover are not obvious.

Weaving

All of the weavers weave individually and they produce a fabric called "Reza" which has a good local demand. Its local demand enables the weavers to make a small profit. Many of them find it necessary to seek employment as laborers during some parts of the year. Recently, fly-shuttle looms have been tried with four families. These families are also continuing with the old throw-shuttle handloom. Although the fly-shuttle looms enable faster work, they do not produce the type of fabric which is locally demanded. Hari Ram, one of the weavers, felt that in due course, fly-shuttles will replace the throw-shuttles, but that before this happened the fly-shuttles should be used to produce different kinds of fabrics which, he hoped, would have a local demand.

Oil Expelling

As in other villages, oil expelling is carried on by the caste traditionally engaged in this occupation--the Telis.

Flour Mills

There is one flour mill being run by a 12 Hp diesel engine. The fuel used is high speed diesel purchased at the rate of Rs. 2.81 per gallon, including transportation charges.

Names of Prominent Villagers

1. Ratan Lal, Sarpanch (head of village Panchayat).
2. Kishan Lal, a millionnaire.
3. Bhoor Singh, an agriculturist.
4. Davaji, an agriculturist.
5. Jodhaji, an agriculturist.

Principal Impressions

Peepalia village is similar to Jhuntha with respect to the potential utilization of electricity: except for agricultural uses, the potential for commercial and industrial uses is small.

Village of Bar

Bar is located six miles east of Raipur at a point where three roads take off in three different directions, viz., to Jaipur, to Jodhpur and to Pali. Bar village has a population of 2133. The primary occupation of the population is agriculture. Out of a total area of 3300 acres which is under cultivation, 800 acres are irrigated. Irrigation is chiefly by wells of which there are 107. Being relatively far away from the river, the wells in the village do not have as good a supply of water as in some of the other villages. As such, the use of pumps is greatly restricted. A hamlet of Bar, some two miles away, near village Megarda, has a good water supply and water pumps could be installed there. The crops grown in Bar are the same as in the other villages.

Among the artisan castes are 40 families of weavers, two of carpenters and two of blacksmiths. Approximately 300 families are Malis who are traditional agriculturists. The 15 Gujar families have taken to sheep and goat rearing.

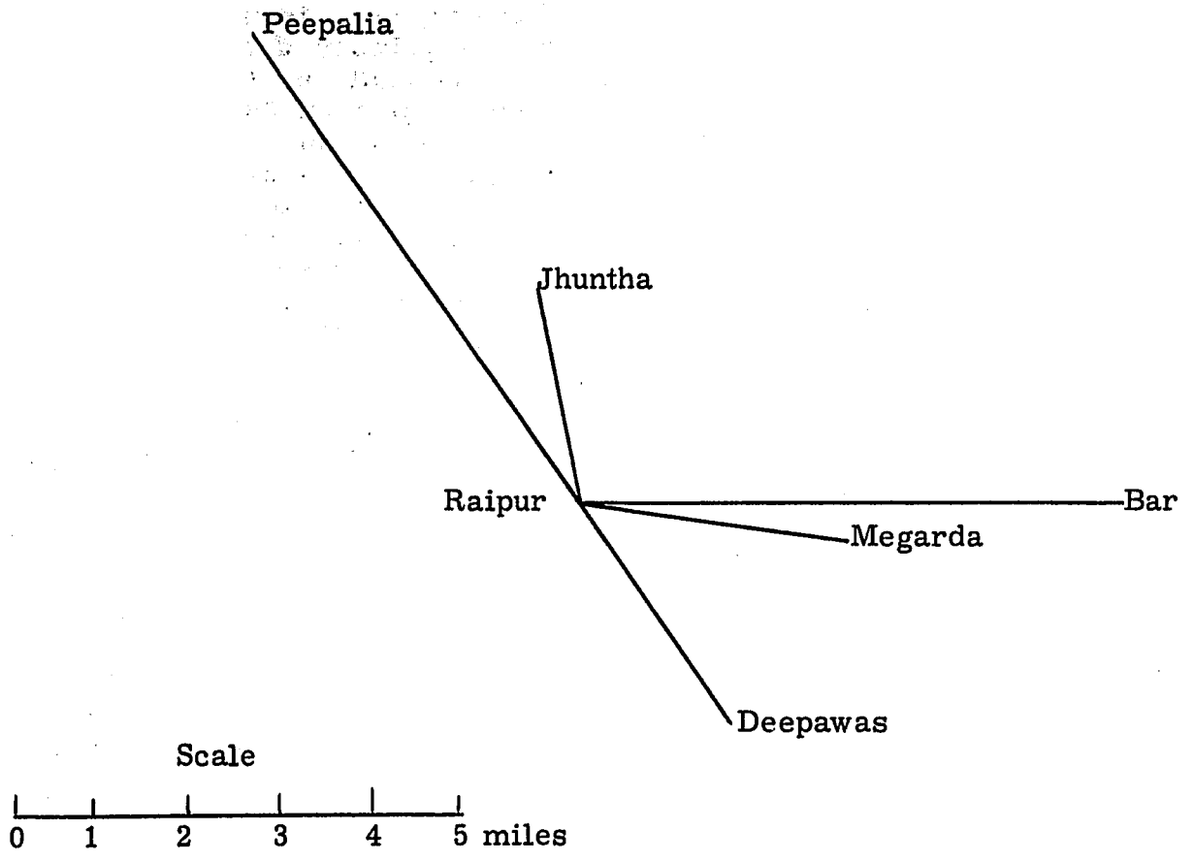
Principal Impressions

As far as could be ascertained, there is no industry in Bar which is dependent upon mechanical or electrical power. Being largely agricultural in its composition, the potentialities for the use of electricity are similar to Megarda and Deepawas. On the whole, it seems that Bar does not provide good scope for the use of electricity.

Overall Impressions - Raipur Block

Of the villages visited in Raipur Block, Raipur itself is the most promising from the viewpoint of a project in Rural Electrification and Development. There appears to be some potential for industrial use of electricity. There are a few, say six or seven, individuals who are in a position to make sizeable investments. The artisan castes, existing as they are today on a marginal or sub-marginal level, are in a frame of mind which would make them attentive to a scheme which promises higher income. Among the other villages, Jhuntha and Peepalia seem to have some potential and if the Raipur project responds well, transmission lines could be drawn to connect these villages. In Raipur it seems reasonable to assume an existing potential load requirement to the extent of 50 Kw.

A Cluster of Villages in Raipur Block



Population

Raipur	6000
Deepawas	1000
Megarda	500
Bar	2100
Jhuntha	2000
Peepalia	2500
Total	14,100

BASIC INFORMATION ABOUT SOME VILLAGES IN RAIPUR BLOCK (RAJASTHAN), 1951)

Items	Raipur	Peepalia	Bar	Megarda
Population	5873	2500	1938	421
Families	1206	500	346	78
Occupation				
Agricultural Landowners	2739	1200	1395	286
Agricultural laborers and workers on land	1152	375	208	100
Area (acres)				
Total	14,389	38,465	9336	682
Forests	3428	56	124	-----
Cultivated Land	6946	2351	3330	380
Double cropped area	657	130	392	20
Rains and Irrigation				
Rains (inches)	13-14	12-13	12-13	11-13
Irrigation Facilities: Wells	220	56	107	7
Tanks	1	----	1	-----
Total Irrigated Area (acres)	2049	1083	806	45
Crops (acreage)				
Jowar	2025	564	507	58
Bajra	983	794	852	165
Til	821	173	169	44
Chillies	193	45	166	100
Cotton	38	86	39	-----
Wheat	843	284	303	26
Gram	840	47	5675	420
Green Fodder Bajra	103	39	45	1
Cattle Wealth				
Animals	10,725	3356	7735	1887
Bullocks & Cows (adult)	3102	1000	800	143
Buffalos (adult)	387	188	166	75
Sheep	4991	1292	2788	705
Goats	2192	547	1945	709
Revenue and Taxes (Rs.)	15,435	8522	7205	746
Educational Institutions				
Junior High Schools	1	----	----	1
High Schools	1	----	----	-----
Secondary Schools	----	1	1	-----
Industries (individuals working)				
Spinning	----	130	----	-----
Weaving	63	35	140	140
Tanning	255	30	----	100
Cloth Printing & Dying	14	2	----	-----
Ghani	66	7	13	4

Village of Berat

Berat is located 50 miles east of Jaipur on the Jaipur-Delhi highway. Mythological significance, dating to the days of the Maha Bharat, is attributed to it.

Berat has a population of 6000 including the people who live in the surrounding hamlets. Wheat, barley, maize and millets are the chief crops of the area. The annual rainfall is about 24 inches. The total cultivated area is estimated to be approximately 1081 acres, out of which 800 acres are irrigated. Diesel engines located in the Berat area include the following: three diesel pumps for irrigation--two 10 Hp and one 5 Hp; a 14 Hp, 475 rpm, crude oil diesel engine which powers a saw mill; a 17-19 Hp low speed diesel engine which powers an oil pressing facility. There are also two flour mills in the area, one of which operates a cotton gin as well. There is also an oil pressing facility powered by a 17-19 Hp low speed diesel.

In selecting Berat for a visit in connection with the project, it was thought that the neighboring forests would be a possible source of fuel wood for a steam engine generator. On inquiry, it was found that the cost of wood is between Rs. 1.50 to Rs. 2.00 per maund. The price of low speed diesel fuel is Rs. 1.62 per gallon; high speed diesel oil is Rs. 3.00 per gallon.

The Chief Conservator of Forests suggested that blocks in the forests could be reserved for the purposes of the project. Since these forests are about six to ten miles away from the village, the cost of wood per maund was estimated to vary from Rs. 1.25 to Rs. 1.50 inclusive of haulage charges. While the availability of wood for fuel is assured as long as the Government is interested in the project, continued availability is not assured. Moreover, the price of wood may increase if a number of steam engine generators are installed.

There are a number of castes and occupational groups, each having their own individual interests. There does not seem to be a clear cut demand for power in any existing industry other than perhaps the saw mill and some of the wells where diesel pumps are in use.

Village of Malpura

Malpura is located at a distance of 58 miles from Jaipur on the road to Toda Raisingh. It has a population of 11,000. It is also connected by railroad with Jaipur and Toda Raisingh. There is an electric generating plant in operation, set up in 1960 under the Colombo Plan. Two 100 Kw and one 25 Kw generators are operated on diesel fuel. The diesel engines are 1000 rpm Catterpillar units and the generators were manufactured by Kato.

Utilization Pattern

The industrial connected load includes the following:

6 flour mills	60 Hp
1 ice candy unit	6 Hp
1 saw mill	10 Hp
2 well pumps	6 Hp
1 Cinema	1 Hp
1 ginning factory	10 Hp
	93 Hp

The connected load for residential lighting is about 98 Kw for 250 connections. The evening peak load is about 50 Kw. The generators are shut down during 0630-1200 and 2400-0400.

A combination flour mill-cotton ginning facility was visited. The entire facility is powered by means of a 10 Hp with belt drives for a single flour mill and 2 cotton gins. The flour mill has a capacity of 400 lbs. of flour per hour and the charge is 10 annas for grinding 80 lbs. of grain. The flour mill operates for about an hour or two per day. This reflects the existence of five other flour mills in Malpura. There are two additional cotton gins in Malpura which are powered by diesel engines.

There is a small saw mill powered by a 10 Hp motor. The saw mill also has a 26 Hp S.D. Nanda, 300 rpm diesel engine which is five years old. The purchase cost of the diesel was 5000 rupees. Mr. Bansimal, the proprietor of the mill, indicated that he was having difficulty in getting a reliable amount of electric power. As a consequence he depends heavily on his 26 Hp diesel for shaft power. He indicated that if it hadn't been for the diesel engine he would have had to go out of business.

Other Uses of Electricity

Electricity is being used for street lighting, to operate a cinema and for a tubewell. Taking all the load into account, it is clear that electricity is not being fully used and that its availability is not necessarily giving an impetus to industrial development. The following figures show the monthly generation and consumption of electricity between April 1961 and February 1962.

Month	Units Generated	Units Sold
April 1961	2896	2458
May 1961	4394	2695
June 1961	7736	7111
July 1961	5334	4684
August 1961	4492	3563
September 1961	4516	3563
October 1961	7385	4378
November 1961	5692	4467
December 1961	8868	6857
January 1962	7702	6263
February 1962	8902	7273

Fuel Supply

The diesel generators utilize high speed diesel fuel priced at Rs. 2.82 per gallon. Low speed diesel oil is available at Rs. 1.62 per gallon. Since Malpura is in a dry region, there are no forests nearby.

Electricity Tariff

Power is sold at the rate of 50 np per unit for domestic and commercial uses and at 25 np per unit for industrial uses.

List of Staff Working at Malpura Power Station

A staff of 17 persons is employed at the power station. Their position and pay is given below:

Name of Post	No.	Pay Scale	Dearness Allowance
Junior Engineer	1	150-300	40
Drivers	3	60-100	40
Helper I	2	50-70	35
Helper II	5	30-50	30
Lineman II	1	60-100	40
Fitter	1	60-100	40
Meter Reader II	1	50-70	50
Lower Division Clerk	1	60-130	40
Peon	1	25-35	30
Chowkidar (watchman)	1	25-35	30

The monthly staff salary comes to about Rs. 1200.

Plant Expenses

The total expenses on the plant including the staff come to about Rs. 40,000 per year and the income is about Rs. 25,000 per year. The plant is, therefore, running at a loss to the extent of about Rs. 15,000 annually.

Extension to Diggi

In view of the low utilization in Malpura itself, a transmission line is being extended to a nearby town-Diggi, about four miles in the direction of Jaipur. It is believed that with the electrification of Diggi, the utilization of electricity will improve.

Principal Impressions

The case of Malpura very clearly shows that the mere installation of generators and the provision of electricity does not necessarily ensure proper utilization or allround industrial and agricultural development.

MAHARASHTRA

On the advice of the officers of the Government of Maharashtra, three villages were visited. These villages -Jamner, Sonarhi and Paldhi- are located in Jalgaon district, 300 miles from Bombay, in the region known as 'Khandesh'. Geographically, Khandesh is part of the Deccan Plateau with plains and valleys; its black soil is well-known for fertility. The chief crops of this area are bananas, cotton, jowar (millets), groundnuts and chillies. Khandesh grows the bulk of the banana crop produced in India. Climatically, the country is fairly dry and agriculture prospers in areas that have the benefit of irrigation.

The three villages visited are between 20 to 25 miles from the Jalgaon railway station. The team first visited Jamner where it was met by the local government officials including the Assistant Collector of Aurangabad, Mr. Batabyal. After holding preliminary discussions with them, the team proceeded to village Sonarhi, about 8 miles away, and then to Paldhi, about a mile further to the west.

Village Jamner

Jamner is a large village and might even be called a township, having a population of 14,000. About 50 percent of the families were reported to be agricultural; that is, primarily dependent upon agriculture for a livelihood. Of the total cultivated area, which was stated to be 6709 acres, only 500 acres, or less than 10 percent, is irrigated. Wells are the chief source of water supply. Animal power and pumps operated by diesel are utilized for drawing water for irrigation. Jamner, Sonarhi and Paldhi are distinguishable from the villages visited in other parts of the country by the fact that diesel pumps are widely used for supplying irrigation and drinking water.

There are 90 irrigation and 130 drinking wells. The wells were reported to have insufficient water to permit a round-the-clock pumping. Most dried up within three to four hours but recuperated rapidly after a few hours gap.

Fuel

Diesel fuel is widely used. The price of crude oil was stated to be Rs. 1.44 per gallon. Jamner is located near a forest area which is estimated to cover 44,000 acres. However, the bulk of this area is designated as a Reserve Forest area and is not available as a source for fuel wood. The cost of wood including transport charges, at Jamner was estimated to be between Rs. 40 to Rs. 60 per ton. Normally, firewood is available at the rate of Rs. 2.50 per maund. For domestic purposes kerosene stoves are used.

Bhusawal Electric Grid

Jamner and the neighboring villages are expected to be energized in the next two years by the Bhusawal Grid. Further investigation of Jamner was not undertaken at the time due to the original orientation of the project toward smaller size, off-grid villages. Villages Sonarhi and Paldhi are not expected to have power for the next five years.

Encouragement for use of Pumps

Loans covering the total cost of pumps are provided by the Government in Jalgaon district. In Aurangabad, however, which is the adjoining district, loans up to 50 percent of the cost of the engine are provided. Roughly Rs. 560.00 per horse power are provided in loan funds for diesel engines.

Village of Sonarhi

Located at a distance of about eight miles from Jamner, Sonarhi is a small village with a population of about 1300. Agriculture is the main occupation and of the total cultivated area about 200 acres are under irrigation. Irrigation water is available from wells at a depth of about 40 feet. In many cases, there are wells of 60 feet depth. There are about 45 oil engines used primarily for irrigation pumping. The pumps cannot work eight hours at a stretch because of an insufficient water supply.

The principal crops are cotton, banana, jowar, sugarcane and chillies. It was stated that a farmer, on the average, makes a gross profit of Rs. 2100 to Rs. 2400 on each acre of land under banana.

Village Cooperative Society

Though Sonarhi is a small village, it has, like many other villages in Khandesh, a strong multi-purpose cooperative society called the "Peepal-gaon-Sonarhi Artisans' Cooperative Society". This society functions as a marketing and credit society. It deals with diesel oil, cotton, seeds and maintains a sugar shop and a cheap grain shop.

The share capital of the society is Rs. 46,000. It has been proposed that the funds of the society be used to purchase a diesel crusher for sugarcane and to provide additional irrigation facilities. In this connection, it was reported that a crusher is already in use in the village, but this could not be verified.

Village Water Supply

Sonarhi is the only village where the team found that the village people had, on their own initiative, installed a central water supply for the village. Water is pumped from a well with a 8 to 9 horsepower diesel engine which was purchased for Rs. 3000. An additional sum of Rs. 14,000 was spent for the construction of an overhead tank with a capacity of 5000 gallons. About Rs.7000 was received from the Community Development Block as a subsidy for the tank.

Village Panchayat

Sonarhi has a strong village Panchayat which is evidenced by the fact that the village has a central water supply system. The strength of the cooperative society also obtains from the leadership that the village has.

Names of Prominent Villagers

1. Eknath Ananda Patel, Sarpanch (head of the village Panchayat).

2. Rajaram Sripat, Chairman of the Cooperative Society.

3. Supada Fakera Patil, prominent agriculturist.

Principal Impressions

Sonarhi is an outstanding example of a small village full of vision and initiative. The strong Panchayat and the cooperative society show that the village can exert itself cooperatively for achieving common goals and that it is not torn by feuds and factions. However, the potential use for electricity appears to be limited to irrigation pumping.

Village Paldhi

Located about one mile from Sonarhi, Paldhi has a population of 4362. Out of the 7090 acres of cultivated land, about 800 acres are irrigated. There are 243 wells, 143 being used for irrigation. About 50 wells are being worked by diesel pumps. The agricultural produce of this village is the same as that of Sonarhi.

Cooperative Society

Paldhi has a multi-purpose cooperative society called the 'Paldhi Vividh Karya Sahikari Samiti'. The society has a share capital of Rs. 48,000 and together with the government contribution and reserve fund, its total assets exceed

Rs. 65,000. The cooperative society deals in diesel oil, seeds, gives credit to members, and maintains a fair price shop. To date it has loaned a total of Rs. 71,000 to its members with Rs. 13,000 currently outstanding. It may be noted that the Paldhi Cooperative Society is functioning more as a credit society than the one in Sonarhi. This operation is quite profitable since the cooperative bank advances loans to the member societies at an interest of 4.5 percent per annum while the society charges 7.8 percent interest on loans advanced to individuals.

Weaver Families

Paldhi has seven Koshtis (weaver families). Each family owns and operates individual handlooms. At one time, when cloth from the large textile mills was not as abundantly available as it is today, these families were doing a good business, but now they have a marginal existence. Of the seven families, only three were continuing with weaving at the time of our visit. They complained of lack of capital, and low returns in view of the time consumed in producing articles relative to the price of the finished goods.

It was learned that the weavers had approached the District Industries Board from the standpoint of the advisability of forming a cooperative but were advised that with the existing technology they would find it difficult to meet the overhead cost such as paying for the Secretary's services, meeting stationary charges, etc., which would be necessary if they formed into a cooperative society. In short, lack of capital and outdated technology have placed the weaver families in a position where they are in a virtual squeeze and how long they can continue init is problematical.

Prominent Individuals

1. Suklal Roopsingh, Sarpanch (head of the village Panchayat).

2. Dhondu Nana Patel, prominent agriculturist.

3. Gopal Ramchandra Neve, an agriculturist.

Economic Status

The average income in this area is relatively high and the people are better off than in most parts of Maharashtra.

Local Institutions and Village Leadership

Sonarhi and Paldhi both have strong cooperative societies and a cooperative tradition exists in Khandesh for sometime in the past. The Panchayat in Sonarhi seems to be active

and the one in Paldhi may also be good. In both villages, money has been spent on village works, Sonarhi being a smaller more closely-knit village, appears to have more inherent vitality.

Use of Electricity

If electricity can be made available on reasonable rates, its uses for irrigation purposes and for village lighting are quite certain. It would be difficult to say how much electricity would be consumed in this way. Other uses of electricity could be for oil expellers, for sugarcane crushers and for cotton ginning. The mere generation of electricity, however, does not assure its use in these channels. This holds for every rural area but specifically for Sonarhi and Paldhi, both of which have little industrial tradition. With respect to the use of electricity for irrigation purposes, it may be noted that a great many farmers are operating on a marginal level. They reduce the cost of agricultural operations by investing muscle power in the operations. It appeared that such farmers or those who are in similar but slightly better conditions would be reluctant to substitute electric power for muscle power.

UTTAR PRADESH

The sites visited in Uttar Pradesh are Srinagar in Tehri-Garhwal district, Bridgmanganj and Nautanwa in Gorakhpur district, Chandrawal in Lucknow district, and Chandauli and Dobhi in Varanasi and Jaunpur districts respectively.

Srinagar

Srinagar is approximately 82 miles from Rishikesh on the Hardwar-Badrinath road in the interior of the Himalayas. Situated on the banks of river Alakhnanda, one of the main tributaries of the holy Ganga, Srinagar has a population of 3500. At a time when the roads were still unmotorable, Srinagar was a flourishing commercial town and a convenient halting station for the pilgrims who made the long trek from the foot of the Himalayas at Rishikesh to Badrinath, the most holy of the Hindu shrines. The pilgrims still find it convenient to halt at Srinagar although the motorbus is now the mode of transport.

The residents of Srinagar will inform any visitor that the town is no more the flourishing commercial center it used to be. This was in the pre-bus days when traders transported goods on mule back from the plains to the interior of the Himalayas, some going all the way to Tibet, where they sold manufactured goods, especially cotton fabrics, and brought back wool and other articles on the return journey. The trade is now carried on by motor vehicles. Moreover, since buses carried more, traveled longer distances, and did not require unloading of goods in transit, many of the people who depended upon the business the traders gave them, found themselves unemployed and left Srinagar. The artisan class was also adversely hit; the goods they produced ceased to have a demand.

There has been a revival of interest in Srinagar in the recent past; due to the efforts of the Government. The necessity of strengthening the Himalayan border has led the Government to develop the border areas rapidly. The vehicular traffic that passes through Srinagar or halts there has increased manifold. The people, some of whom we met, are looking hopefully to the future. Srinagar has been declared a notified area and is being looked after by a committee consisting of 10 members. Mr. Nautiyal, our chief informant, is the Vice-Chairman of the committee. All anxiously await the day when the town will be electrified.

Government Institutions in Srinagar

The government has set up an Industrial Training Institute with Mr. M.D. Gupta as principal. This institution is expected to train 260 students every year and a half. Training

is given in carpentry, blacksmithing, lathe work, welding, surveying and civil and mechanical draftsmanship. At present 94 students are enrolled.

Industrial Estate

The Government has set up an Industrial Estate at Srinagar consisting of 12 units. Five units have been subscribed to, although the required security deposits of Rs. 2000 have not yet been made.

Government Polytechnic

The level of training at the Polytechnic is lower than the Industrial Training Institute. Students having passed high school with science are admitted for a three year diploma course in electrical, mechanical and civil engineering.

Hospitals and Schools

There is a 20-bed hospital and a T.B. ward is to be added soon. There are a number of educational institutions including primary and secondary schools, and an intermediate and degree college. Srinagar has an intermediate college for girls.

Agriculture

The area around Srinagar is poor agriculturally. The chief crops grown are wheat, paddy and madua. Srinagar itself is a town of shopkeepers, restaurant and hotel owners and of businessmen.

Cooperative Institutions

There are two cooperative societies. One is a Housing Society and the other a Consumers Society. Both these societies appeared to be inactive.

Local Crafts

In the past, Srinagar was well known for its arts and crafts products, such as brasswork, utensils, shoes, woodcraft and engravings. The utensil business has suffered a setback since the import of utensils from the plains. A few families of tanners and shoemakers had specialized in producing a type of extra soft and light shoes. Though some of these families still exist, this business has died out. Toy-making and the manufacture of small household decorative pieces is being encouraged by the Government which has initiated a Papri Wood scheme. Papri wood (Bauhinia Racemos or

Buxes Sempervirens) is particularly suitable for toy making, for walking sticks, curtain rods, and geometrical instruments. In the past Papri wood toys were exported through Tibet and China to the rest of the world.

Potential Uses for Electricity

The way the team was received and conducted in the town leaves little doubt as to the eagerness of the local leaders to have electricity. The Government of Uttar Pradesh is also desirous of electrifying Srinagar. They are considering three alternatives: first, bringing electricity from Pauri, the capital of Tehri, 21 miles away; second, constructing a hydel plant at Gantichara some miles away; and third, by installing diesel generators in Srinagar itself. The existing power requirement of the industrial training institute (which already has two 15 Kw diesel generators), the hospital, the Industrial Estate, for street lighting and for domestic purposes can very well consume 100 Kw and probably another 150 Kw in the near future.

Principal Impressions

It should be noted that the scope for industrialization in Srinagar is limited. It is difficult to visualize for the present productive uses of electricity other than for the Government institutions and the Industrial Estate. The latter has not yet found enthusiasm among the entrepreneurs. Even those who have allotted accommodation have not deposited the security of Rs. 2000 required for the purpose. The rental of the units or the conditions of hire-purchase have not yet been decided upon.

Srinagar has a tradition of business built around traders and pilgrims. It is a non-agricultural town and there seems to be little scope for agricultural processing industries. Other industries, such as utensil-making, may have a future.

Bridgmanganj

Bridgmanganj is located in the northern part of Gorakhpur district about 22 miles south of Nautanwa. It is connected by railroad with Gonda (an adjoining district), Gorakhpur city and Nautanwa. A road links Bridgmanganj with Pharenda, the sub-divisional headquarters, which has a sugar mill and is an electrified town. Bridgmanganj has a population of about 3500 and is in the 'Terai' area, in the foothills of the Sivalik range of the Himalayas. The area receives plentiful rainfall and the soil is well suited for paddy, sugarcane and potatoes.

Bridgmanganj was first visited on May 4th, and revisited on July 15th. During the first visit, we were accompanied by the Assistant Development Commissioner, Gorakhpur, Mr. Bhagwan Din, the Assistant Engineer (Hydel), Mr. Mathur, and the District Industries Officer, Mr. Garg. Mr. K.D.N. Srivastava is the Block Development Officer. We were told that Bridgmanganj Block has a population of 64,000 with a density of 915 per square mile. Its area totals approximately 47,000 acres out of which 38,000 acres are under cultivation and little less than 5000 acres are irrigated.

Agriculture

The chief crops of the Block are:

Crops	Area (in acres)
Paddy	31,325
Wheat	3,800
Barley	3,700
Sugarcane	1,285
Potato	350
Oilseeds	425

Wheat and barley are winter crops whereas sugarcane stands in the fields almost the entire year. It was indicated that approximately 28,000 maunds of potatoes are produced about half of which transported to Gorakhpur for cold storage. Sugarcane is sent to a mill at Pharenda, some 11 miles away. Paddy, which is the main crop of the area, is processed locally or transported by dealers to markets outside Bridgmanganj.

The People

In the early part of the last century, Bridgmanganj and the adjoining area was under forests. The cultivators living on the fringe of the forest were constantly threatened by wild animals. The British Government, in order to protect them, decided to populate the forest area. John Hall Bridgman, an indigo businessman of Ghazipur, entered into a contract with the Government to settle the land. He did this work ably and, in addition to the land given to him by the Government, he acquired considerable personal property.

One gets a clear impression that there are two distinct classes in Bridgmanganj: one whom we might call the 'sons of the soil', the people who came from the neighboring area to settle in Bridgmanganj, and the other, the emigrants who came from far away places looking for a better and prosperous future. The latter group consisting of Vaishyas, the traditional

businessmen, and Muslims, are among the economically ascendent and affluent group. The others, the 'sons of the soil', have small land holdings and are engaged in petty business or are employed as laborers. A majority of them live at a subsistence level. The two are more or less distinct groups, the nature of their relationship being largely contractual and impersonal, a situation rather unusual for rural areas.

The caste composition is as follows:

Castes	Households
Vaishyas (Jaiswal, Kasaundhan, Marwari)	200
Muslims	100
Harijans	80
Brahmins	8
Others	100

Cooperatives

Bridgmanganj Block has two large sized societies called the "Bridgmanganj Cooperative Society", covering 18 villages, and the "Bhaduri Cooperative Society", covering 34 villages. There are 9 primary village societies which, together with the Bhaduri large sized society, have formed into a Cooperative Union.

The total membership in the large and small societies comes to 3500 and the share capital is Rs. 82,000. The soceities function chiefly as credit societies, but the large sized societies have also taken up some marketing functions. The Union deals with the supply of seeds.

Existing Industries

There are several multi-purpose agricultural processing units in Bridgmanganj: oil expellers, paddy processors and flour mills. There are three mills using 5-15 Hp diesel engines. Due to the imposition of excise duty, oil expelling has become less profitable relative to flour mills and paddy processing. However, the mills are kept profitably engaged in business the year round, taking up different operations according to demand the availability of raw materials.

Fuel

Firewood is available locally in price ranges Rs. 1.00 to Rs. 1.75 per maund depending upon seasonal variations. Crude oil is supplied in the village by local dealers who make

the purchase from Gorakhpur, more than 50 miles away, at Rs. 7.75 per tin of four gallons or Rs. 1.94 per gallon. High speed diesel is priced at Rs. 11 per tin or Rs. 2.75 per gallon.

Coal is available in Gorakhpur and is priced at Rs. 42 per ton.

Furniture Industry

An industrial cooperative society has been formed consisting of 30 individuals for the manufacture of furniture and related articles. Good quality wood suitable for furniture manufacture is available from the neighboring forest areas.

Hide Business

There are three large dealers in hides in Bridgmanganj. It is estimated that they deal with anywhere from 1 to 1.5 lakh hides annually. Information to the following effect was obtained from Mohammad Kalam, Nabi Jan and Abdul Kalam.

Hides are collected from the markets of Barhni, Naugarh, Nepal, Chauri Chaura and locally. The collections include buffalo hides, cowhides, and goat and sheep skins. The raw hides are treated by a process called "half tanning" so that they can be shipped to distant markets without decaying in transit. The dealers personally carry them to the markets of Kanpur, Calcutta, Bombay, Chauri Chaura and the like.

There is interest in establishing a tannery in Bridgmanganj. The dealers in hides with whom the subject was discussed are willing to make investments provided they are given the technical know-how and the assurance that a factory could be profitably run.

Oil Expelling

It has been earlier mentioned that there are three mills that are doing oil expelling besides flour milling and paddy husking. Recently, a proposal for a Tel Ghani Cooperative Society has been submitted to the Registrar, Cooperative Societies. Mr. Janardan is the President and Mr. Ram Lekha Prasad the Cashier of the Society. The latter was available for discussions. He stated that the Society, which has a membership of 25 was going to install bullock drawn Ghanis and that it will be able to compete with the mills inasmuch as a subsidy of Rs. 1.25 per maund is given by the Khadi Commission for ghanis.

Bridgmanganj itself does not produce a large quantity of oilseeds, but the neighboring area, particularly Jarwa, about 50 miles south, is surplus in oilseeds. The oil mills get most of their raw material from Jarwa and from Nepal.

Cooperative Society for Paddy Husking

A cooperative society consisting of 25 members has been formed for handpounding paddy. The society has applied for a loan of Rs. 2000 which is to be granted shortly, and has collected a share capital of Rs. 637. The President of the society is Mr. Kesho Prasad, and its vice president is Mr. Sheo Shanker Jaiswal.

The Khadi Commission gives a subsidy of six annas per maund for hand pounded paddy. The Society has already obtained seven improved Chakkis each of which is supposed to process 10 maunds paddy daily.

Potentials for Use of Electricity

Cold Storage

With the availability of electricity, there is a very good chance of a well-to-do farmer, Mr. Gauri Shanker Singh putting up a cold storage for potatoes.

Saw Mills

Bridgmanganj is located in an area which has a rich supply of fuel and timber wood. Already, there is a furniture industry and if power becomes available, the possibilities of someone setting up a saw mill are promising.

Hide Tanning

The hide dealers do not tan hides for the purposes of selling them to shoemakers. The half tanning process which they perform merely preserves the hides sufficiently to resist deterioration until they are processed in tanning factories in Kanpur, Calcutta or Bombay. The availability of electricity might be a favorable condition for the establishment of a tanning facility. Mohammad Kalam, one of the hide dealers, stated that he would be willing to invest as much as Rs. 20,000 to Rs. 30,000 for a tannery.

Tubewells

There are at present 16 tubewells in and about Bridgmanganj. With the availability of power, there will be greater incentive for some who are at present feeling the necessity of improving irrigation potential, to install electric pumps. The land holdings of many farmers are quite large and they are in a position to use a well without having to share it with others. Some, it was learned, are supplying water to neighbors on rental.

Domestic and Town Use

About 30 to 40 families would be interested in using electricity for domestic purposes. Furthermore, the railway station and the town itself may be electrified.

Weaving

At present, weaving is not being carried out in Bridgmanganj proper, but in Pulmanha, a village two miles away, three families of vegetable growers have taken to weaving. This rather unusual change of occupation was accounted for by the fact that the kinds of these families in Menhdawal, about 16 miles away, were doing good handloom business. Yarn is obtained from the textile mills of Calcutta, Bombay and Madras. In the past several years, Khalilabad, which is a railway station on the Gonda-Gorakhpur railway line, has developed into a big market for handloom goods where every Monday some Rs. 15 to Rs. 20 lakhs worth of goods are transacted.

Though Pulmanha is about 40 miles away from Khalilabad, the goods find their way to the market. In view of the localization of textile industry, there may be a possibility that powerlooms could be employed if electricity became available.

Cane Crushers

Since Bridgmanganj is located in a cane growing area, there are distinct possibilities of electric power being used for cane crushing.

Some Prominent Individuals

1. Mahabir Prasad Singhania, a businessman.

2. Jhabbu Lal, a businessman.

3. Ram Das, a businessman.

4. Gauri Shanker Prasad Jaiswal, a businessman

5. Mahabir Prasad Jaiswal, a businessman.

6. Gauri Shanker Singh, a farmer.

7. Mohammad Kalam, hide dealer.

8. Nabi Jan, hide dealer.

9. Ghanshyam Das--Jugal Kishore, proprietors of a mill doing flour milling and oil expelling.

10. Sri Ram--Pira Mal, proprietors of a mill engaged in flour milling and paddy husking.

11. Maqbul Alam, Pramukh of the Bridgmanganj Panchayat Samiti.

Principal Impressions

The potential for the use of electricity in Bridgmanganj appears to be quite good. So far electricity is not being locally generated although Mr. Gauri Shanker Singh is seriously considering generating electricity for a cold storage plant.

Assuming that electricity can be provided at a reasonable price, the existing load requirements come to about 50 Kw, half for industrial use and the remaining for domestic, street lighting and agricultural uses. In about a year or so after the installation of the plant, a load equivalent of 100 Kw or more might develop.

Due to the fact that the potential investors are traditional businessmen, have had active interests in Nepal where the business prospects are growing bleak, and are tempermentally inclined to risk on enterprises that promise good returns on investment, the prospects of Bridgmanganj responding well to a development project are promising.

Village of Chandrawal

Chandrawal village is striking example of the case where the personality of an individual has affected the Government's decision to select a village for development on considerations other than merit. Ballabh Das Ji was closely associated with the freedom movement and he commands respect not only in his villages but also in the Government.

Chandrawal is about 14 miles from Lucknow in Sarojininagar community development block, about three miles from the Lucknow-Kanpur road. The approach to Chandrawal is through a canal road which cuts the Lucknow-Kanpur road about 11 miles from Lucknow.

Chandrawal is a small village with a population of about 750. About half of the population consists of Ahirs who are traditional cattle herders and another 20 percent consists of Mohammadans. None of the families has enough capital or resources to invest on industrial enterprises.

Ballabh Das Ji donated land for the Government's training-cum-production centre and an industrial estate which is still to be constructed. In addition there is a paper mill set up with the help of the Khadi and Village Industries Commission under the sponsorship of the Motilal Memorial Society of Lucknow. The Society is running a Rural Centre at Chandrawal taking up social, educational, cultural and industrial programs. Mr. Kirti Singh Vineet is the Manager of the Rural Centre. Mr. Tandon its Secretary, and Mr. Prem Kishore Srivastava is the technical manager of the paper mill. The Khadi Commission has given a sum of Rs. 60,000 for the establishment of the paper mill.

Talks with the people reveal clearly the fact that the recent developments in Chandrawal have been and are being imposed from the top. Most of the village people do not know anything about the Industrial Estate, have no idea as to the industries that could use the facilities provided through the industrial estate, and were not certain if the paper mill or the Government's Training-cum-Production Centre were serving a useful purpose. As a matter of fact, they said that these activities were unrelated with agriculture and irrigation which were their chief problems. The area is supplied with canals so that the farmers have little difficulty in getting water. But they find it necessary to depend on wells because the canal water supply is not timely. It was reported that whenever the channels running from the wells to the farmer's fields crossed those from the canals, the canal authorities charged rentals as if the water had been supplied from canals. The cultivators were accordingly concerned about this and wanted us to help them out.

Nautanwa

Nautanwa is located on the northern extreme of district of Gorakhpur on the border of Uttar Pradesh and Nepal. It has a population of approximately 7000.

Agriculture

Nautanwa is the headquarters of a Community Development Block. The rainfall is quite good and the soil is suited for paddy. Out of the total cultivated area of 64,600 acres, about 23,000 acres is under early paddy and 33,000 acres under late paddy. Some of the other crops are sugarcane, maize, jowar and Arhar, each having about 400 acres under it.

Rice milling is being carried on in Nautanwa but it was reported that the existing regulations of the Government in regard to excise duty and the proviso that one third of the rice milled is to be supplied to the Government at prescribed rates, has made this business less profitable. There is a hand pounding paddy society and four other such cooperative societies in the Block.

Groundnuts and potatoes are produced in the area but the acreage under them is small.

Irrigation

Irrigation is required only for the Rabi crops and both tanks and wells are used. Since rainfall is good, the water level is fairly high. It is reported that the area has natural artisan wells.

Forest Areas

There is a forest area at some distance from Nautanwa, but the price of fuel wood is quite high, ranging from Rs. 2.00 to Rs. 2.50 per maund. Nautanwa is a centre for timber but there are no saw mills. Saw mills are a possibility if power becomes available.

Existing Industries and Commercial Enterprises

Nautanwa has seven flour mills, two large oil mills and one Dal (pulses) mill. This Dal mill also does oil expelling. All these mills do paddy husking as a side business. The mills are multi-purpose. They have been planned in such a way that they remain busy all the year round.

There are two cinema houses, both generating electricity by diesel engines.

Durga Oil Mills

This mill was visited with a view to getting detailed information as regards its functioning. It has two expellers, one

standard and one baby. These work 50 ghanis. The mill has a 30 Hp crude oil engine. Annually 12 to 13 thousand maunds of oilseeds are crushed. The raw materials are brought from Nepal and from Harwa, which is a surplus oil seed producing area. The oil is sold in Nepal and locally.

The proprietor stated that he is facing stiff competition. An oil mill in Nepal is under-selling him but he has not been forced out of business because he deals in credit. He also mentioned that the excise duty on oil mills has also hit the business.

A 15 Kw generator has been used by the mill for lighting and other purposes. It is operated only occasionally.

Price of Fuel

Crude oil in Nautanwa is priced at Rs. 2.00 per gallon and high speed diesel oil at Rs. 3.25 per gallon.

Potentials for Use of Electricity

If power is made available at a reasonable rate, the existing industries and the cinema houses would most likely become subscribers. A good demand for domestic lighting is anticipated. There also appear to be good possibilities for other industries or business to grow including cold storage, plastic manufacture, manufacture of hume pipes, saw mills and hide tanning.

One of the local residents, Sri Prem Chand, was stated to have applied for a loan of rupees one lakh for setting up a plastic mill. The manufacture of hume pipes is also promising because the soil and the sand are ideally suited for it. A party in nearby Nepal was reported to be already engaged in this business.

A large number of hides, estimated to be worth rupees 15 to 20 lakhs are sent to Kanpur through Nautanwa. These are reportedly brought from Nepal and some collected locally. With the availability of electricity, it is possible that a tannery could be started. Similarly, a large quantity of wool brought from Nepal passes through Nautanwa to Punjab making a wool industry a possibility.

Names of Prominent Individuals

1. Seth Chulahai Ram Murat, proprietor of the Durga Oil Mills.

2. Banarsi Lal Mahabir Prasad;

3. Adbul Rauf Lari, ex-Congress M.L.A.;

4. Ram Lagan Dubey, Secretary, Zila Congress Committee.

Principal Impressions

Overall it is clear that the existing potential for the use of electricity is promising. It also appears that once electricity is available, a number of new industries might be established. Local entrepreneurs are looking for good avenues for investment.

It should be noted, however, that Nautanwa is not a village. It has some wealthy people who have traditionally been engaged either in the marketing business or in the manufacturing business or both. Whether electrification will encourage individuals of lesser means to undertake enterprises is not certain. At least agricultural uses of electricity seem limited. The Assistant Engineer, Sri Mathur, who accompanied the team estimated the power requirement to amount to about 250 Kw.

Village of Chandauli

Chandauli, Varanasi District, was visited to study the pattern of utilization of electricity. It has a 40 Kw generator operated by a 50 horsepower high speed diesel engine.

It was difficult to get an insight into the existing utilization pattern because the officer of the State Electricity Board who was to accompany us to Chandauli could not come. Independent inquiries were, therefore, made and it was found that except for the five or six families in the canal and tubewell colonies, no use of the electricity was being made. Talks with the residents convinced us that there there was a good demand for electricity in the area but that this demand was not being met. There are two rice mills located in the neighborhood run by diesel engines. There is an oil mill, three flour mills and a few cane crushers. Why electricity was not being provided from the generator could not be ascertained to our satisfaction. One of the reasons given was that the charges were too high, amounting to ten annas per kwh.

The power generated at the Rihand Dam is likely to be supplied to Chandauli in the very near future. In this connection, the transmission lines have already been laid out.

Village of Kuti

A few years ago nothing but a small temple stood at Sadhu ki Kuti

("retreat of the holy man") in an agricultural region 22 miles north of Banaras on the road that links that north Indian city with Asamgarh. Today the place is the center of a small scale industrial and business development which has already influenced the economy and outlook of the area it serves and which, with some technical help and encouragement, could play an even more important role.

Kuti is located in the Dobhi taluka, an area of about 75 square miles, whose peoples and villages are linked by common traditions. The people of Dobhi are well known for their interest in education and their willingness to send their sons out of the villages for employment. One of these men, a member of a rural family of the Kuti region, who had attained considerable education, found employment with a Banaras newspaper. In 1958 he became impressed by the news reports of economic stirrings in various parts of India and determined to stimulate economic growth in the area from which he had come. He saw the possibility of founding a sugar mill at Kuti, since it was in a sugar-growing area and sugar cane was the chief cash crop of the cultivators of the vicinity.

This man was known to be an enthusiast rather than a realist, and because he had no record as a successful businessman, he found it difficult to persuade the cultivators to act. This only caused him to redouble his efforts. He resigned his newspaper position and threw himself into a search for backers and investors. At this point he approached Rudra Datt Singh, a member of the Action Research Planning Institute of the government of the Indian state of Uttar Pradesh, who is also from Dobhi. The Action Research Planning Institute was in the process of setting up pilot projects of small industry complexes in the rural areas at this very time. Rudra Singh knew the potentialities of the place being considered. The actual place mentioned was alkaline land, and its use for industry would take no arable land out of cultivation. Some electric power had been brought in from the town of Mau by the Irrigation Department, in connection with a tubewell program for the region. The road to Banaras had been greatly improved and was well suited to motor transport of marketable goods. There were links by road with the large market towns of Jaunpur, Azamgarh, and Chazipur, as well. Rudra Singh threw his weight behind the enterprise. Since he had been associated with the Etawah Project and other well-known government development efforts, the villagers gave the plan much more serious attention, and soon financial support and pledges of participation materialized. When a member of Parliament who had grown up in Dobhi showed interest in the effort and urged others to support it, the battle was won. Kuti is situated at the juncture of two villages, Levarua and Ailia. Cultivators from the two villages donated the land on which the sugar processing mill was to stand.

The sugar mill was set up as a pilot project of the Action Research Planning Institute of the Uttar Pradesh government, and technical help came from the Institute, an arm of the State Planning Commission. The mill was financed and organized as a cooperative. Shares worth 50,000 rupees were sold to villagers of the vicinity at 100 rupees a share. No one was allowed to purchase more than ten shares. Every shareholder was to have an equal voice in voting on matters regarding the mill. Shares were sold mostly to sugarcane cultivators who wanted an outlet for their produce. A few others have bought shares and are entitled to dividends, but bonuses (division of profits after dividends) go only to shareholders who supply cane. There is an annual meeting of shareholders to ratify decisions of the Board of Directors concerning fiscal matters and to choose nine directors. Two directors are appointed to the Board by the State Government, making a total of 11 directors. The directors meet several times a year. The main responsibility of procuring the cane, processing the sugar, and dealing with the markets is in the hands of a full time manager. The present manager is a U.P. government official, who has been lent to the mill for a three year period. In order to aid the cooperative in getting started, the state paid his salary for the first year. Not all the capital needed for the building and the equipment came from the cultivators. The state government also bought 50,000 rupees in shares and is a partner of the local people in the development. Another 50,000 rupees was borrowed from banks. The official name of the organization is "The Sugar Processors' Society, Inc. of Dobhi." The great majority of the shareholders do live in Dobhi or originated in Dobhi; but affiliation with Dobhi is not a condition of membership, and a few outsiders have bought shares also.

A sturdy building with facilities for storage was erected in 1960. The crushers installed were manufactured at Kanpur. The plant is permitted to use enough electric power to develop 75 horsepower. The crushing of cane was begun in 1961. In spite of a late start approximately 25,000 maunds of sugar cane was used. The cultivators were paid immediately upon delivery. They received about 25 percent more for their cane than previously. The waste involved in home processing was eliminated and the loss attendant upon dealing with a middleman was avoided. As a result more cultivators have come forward to deal with the mill this year, and cultivators are sowing more land to sugar cane and working it more intensively. In order to improve the quality of its raw product and its processed sugar, so as to be in a position to obtain higher prices in the market, the Co-op plans to give advice and technical help to the cultivators. The Co-op had no difficulty selling all its sugar in the Banaras market and could have sold much more. It is expected that twice as much sugar will be processed this year as last. A profit of 5000 rupees was made the

first year. Because reserves are needed, no dividend was declared. Dividends are limited by law to six percent, though a bonus may be declared in addition.

Sugarcane crushing is seasonal work, beginning in December and ending in March. During this time 80 to 100 persons are employed at the mill. All this labor is recruited from villages in the vicinity. During the rest of the year only the manager, a mechanic, the storekeeper and a watchman are needed. In order to utilize labor and the plant for a greater portion of the year, the Society has begun milling flour. The farmers can get their grain milled here at a very moderate price (8 annas, i.e., approximately 10 cents, a maund). During its initial period of operation the flour mill has ground 15 to 20 maunds of grain a day. It is expected that the use of this service will grow rapidly.

A number of private business establishments have sprung up near the Society's plant. A commission house where the farmers can leave their grain and produce for sale has been established. There is a salesroom for concrete and other building materials. Shops and stalls where wooden toys, vegetables, cloth, candies, cooked foods, pan (betel), oils, tobacco, pottery, matches, and many other products and utensils are sold now exist here. There are at least two dozen of these smaller enterprises. The land, which was considered of little value because of its alkaline condition, has become extremely valuable and is in great demand. The place has become a work, shopping, and processing center for the villages of the northern part of Dobhi. There are now at least fifty permanent residents where no one had lived before.

The growth potential of this development is considerable. But it waits upon a larger supply of electric power. Because of this shortage the government has limited the use of power to food processing enterprises. With technical help there is more of this that could be attempted. For instance, the canning of fruits and vegetables might be a feasible enterprise for the area.

Overall, the people in Kuti appear to be at a point and in a mood where some added assistance and encouragement will yield important results.

ORISSA

Village of Tikabali

The village of Tikabali, located at about 80 miles from Berhampore, district Ganjam, was the only site visited in Orissa. The visit was suggested by Mr. D.K. Purkayastha, IAS., Secretary Industries, Government of Orissa. Mr. Purkayastha is interested in Tikabali because the government is considering a proposal to set up a rural industrial estate there. Availability of power, which this project promises, was the main reason for the suggestion.

On the way to Tikabali, we talked to the Divisional Forest Officer, Bhanjnagar, to collect information about the type of fuel wood available and its price. Mr. Das, the officer concerned, stated that he was in charge of the Berhampore area. We were told that Tikabali was under the jurisdiction of the forest officer stationed at G. Udaigiri. We made an attempt to locate this officer at G. Udaigiri, but he was not available. From Mr. Das's account, it appeared that Tikabali itself does not have dense forests. One has to go 20 miles farhter west to Pasara to reach the forest area. According to Mr. Das's estimate, the cost of wood would come to a little over Rs. 1.00 per maund, including transport charges if the Forest Department were to supply it.

Tikabali has a population of about 1500. It is located in an area which produces a large quantity of oil seeds, chillies, turmeric and ginger. Agriculture is the main occupation of the people, but the area is extremely backward and inhabited by tribal people who still, by and large, have not taken to settled agriculture.

Tikabali produces two important items--raw materials for broom sticks and Pattal, a dish made out of leaves, both of which are exported to cities as far away as Madras and Bombay. There is a cooperative society which deals in forest goods called the "Agency Marketing Cooperative Society." The Society has an annual turnover of about Rs. seven to eight lakhs and has agents in Madras and Bombay. Before this Society was established the local businessmen exploited the producers by bargaining at will and paying as little as possible. The Cooperative Society has presumably minimized the exploitation and is giving the producers (suppliers) a better deal.

Industrial Estate

There is currently no industry in Tikabali. But with the establishment of the industrial estate, for which land has already been acquired, it is possible that there might be an interest in starting small industries. The possibilities for this area are (1) Tin smithy--Since utensils are brought

from Berhampore, a utensil manufacturing concern may have good scope. Similarly, the manufacture of agricultural implements may be taken up. (2) Saw mill: Being located in a forest area, saw mills and related industries have a distinct possibility; and (3) Hide Tanning: There is a tannery at Boudh in Phulbani district, north of Tikabali. The hides collected in the district are sent there. It may be possible, however, if hide collection can be properly organized, to set up a small mechanized tannery.

The electricity requirements of the industrial estate are estimated to be about 50 Kw.

Oil Mill

Since oil seeds are produced in large quantities, an oil mill is a possibility. However, the question of marketing and economics of transportation will have to be considered.

Agricultural Processing

Tikabali and the neighboring areas produce spices such as chillies, turmeric and ginger. It may be possible to set up units to process these spices. For instance, they may be crushed, packed in plastic bags and shipped to distant markets.

Agricultural Uses

Use of electricity for agricultural purposes did not appear to have any clear cut possibility.

Principal Impressions

One thing about Tikabali is very clear: the initiative for development is not local in origin but has come from the Government. Raw materials flow out from Tikabali, but those who regulate the flow do not live in Tikabali. And those who profit from this are the middlemen rather than the actual producers. It is this fact which has led the Secretary Industries to decide upon setting up an industrial estate at Tikabali. If a beginning is made and encouragement given to the people, some of them might take initiative in starting productive enterprises. However, if local enterprises are unavailable, those from Bhanjnagar, which is some 20 miles away, might take interest. This will at least have the advantage that the goods will be processed in Tikabali rather than in some far away place.

APPENDIX B

ON-SITE INVESTIGATIONS IN LATIN AMERICA

Site Investigations in Latin America

Introduction

During the late spring of 1962 the Latin American Survey Team made a six weeks trip to visit selected rural areas in Peru, Chile, and Colombia. The purpose of this survey was to obtain direct on-site information relative to the introduction of small (10 to 15 kw) electric generating plants in developing village communities, and to assess opportunities for the viable utilization of the electricity produced. A variety of regions and communities were included, ranging from tropical seacoasts to glacial mountain valleys. The major emphasis was placed on organized villages, in which some positive community activity was taking place.

Both electrified and non-electrified sites were visited, to learn from the contrasts, and to assess the existing experience of rural communities.

In each country, background information including rural development and electrification plans, demographic data and general information on fuel availability and costs were obtained from government agencies, U.S. Embassy and AID Missions, Peace Corp Units, and various local institutions. In all, some 23 rural village sites were visited.

An attempt was made to cover a representative cross section of site environments, as exemplified by the following:

- An extended Peruvian Indian high mountain valley farming community (Vicos)
- A pueblo cluster in Peru serving a market area consisting of mestizo and Indian populations in a high mountain farming community in the Andes.
- Low land farming villages in the southern Chile Indian region, and in the Magdelena delta country of Colombia.
- A tropical fishing village on the north Carribbean coast of Colombia.
- High mountain villages in the coffee growing regions of central Colombia.

Appearing at the end of this appendix are discussions of the major sites visited. Several of these are of sufficient interest for future pilot project R & D work, that an expanded discussion seems warranted. The remainder are treated in more condensed form.

Site Name and Location	Municipio of Andes, Antioquia Department, Colombia
Population	6900 Urban, 48,000 Rural
Date Investigated	June 1, 1962
Field Investigation Team	T.O. Paine, General Electric Company C. Ahrens, CARE-Peace Corps, Colombia Frank L. Turner, SRI John Lewis, Peace Corps Volunteer

1. Site Evaluation

The pueblo or market town of Andes appeared to the Survey Team to be a very promising locality for a field pilot project, involving a productive electric load building program and related community improvement programs. The considerations leading to this opinion are summarized in the following paragraphs a. through f., and described more fully in the latter part of this site report.

a. Ample Unutilized Installed Capacity for Daytime Use

Electric power for Andes is now provided by a 720 Kw hydrogenerator with a load factor of about 13.4 percent (see Table 6 near the end of this appendix). The low use of generating capacity is explained by the fact that about 82 percent of all power produced is sold to residential subscribers who consume power principally for lighting in the early evening. During the daylight hours, only a fraction of the generating capacity is used. As shown in Table 6 , the daytime load is based on the requirements of 19 commercial or service establishments, 2 corn mills, the hospital and health center, schools and the public water supply system. Even if these facilities were all to draw power simultaneously up to their maximum connected loads, they would require only 39 Kw as against the generator's rated capacity of 720 Kw.

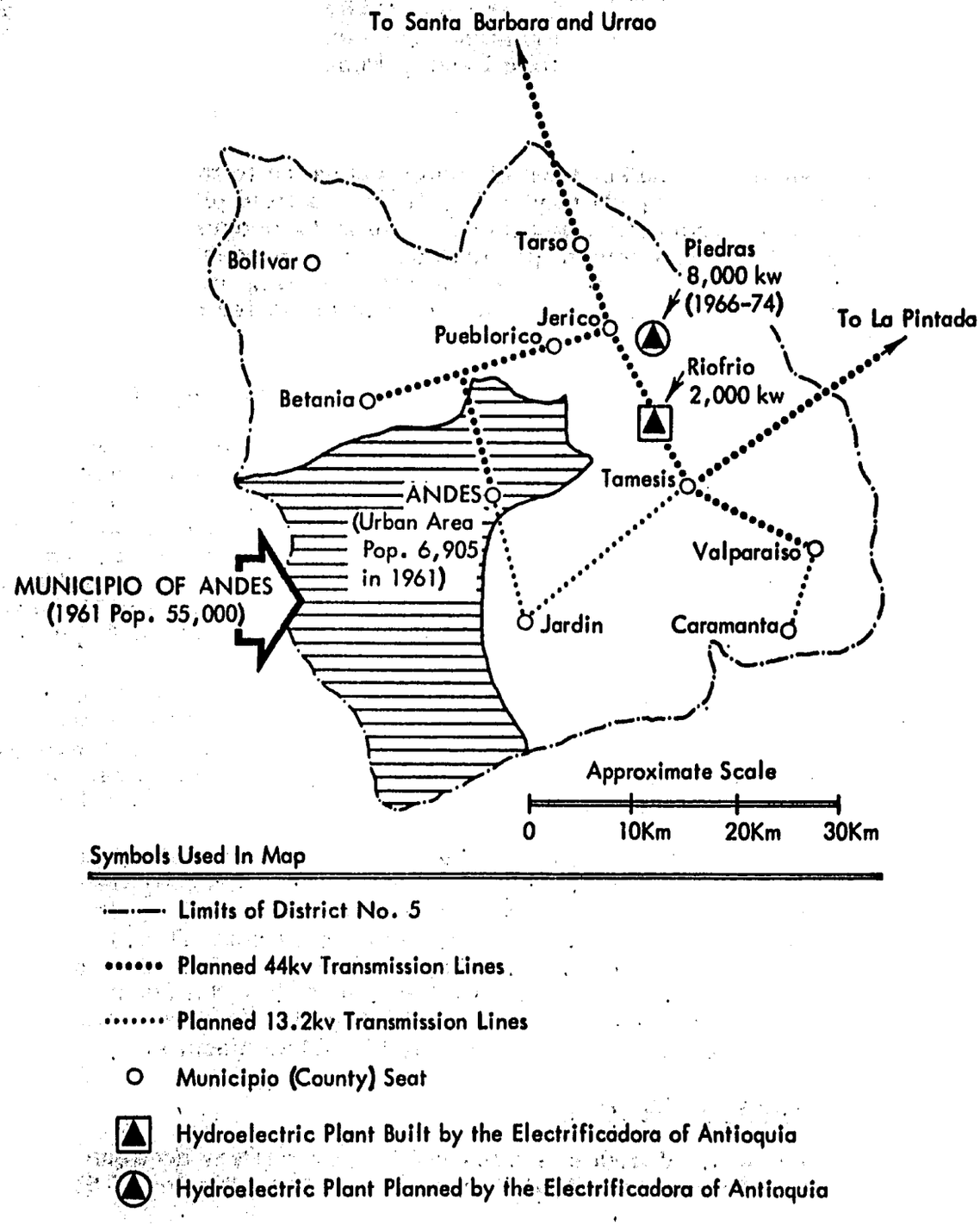
In addition to the above unused capacity, the town is expected to receive very shortly an allocation of additional power by means of a 44 Kw transmission line extending from the 2000 Kw hydro generator at the Rio Frio plant near Tamesis (see Figure 1 on the following page). The extension of a line from Tamesis is needed in Andes to double the evening power supply, according to the local authorities interviewed. This judgment has also been accepted by Electroaguas.

b. Access to Markets

The town of Andes is situated roughly midway between two market centers: Medellin, with a 1960 population of 614,000,

FIGURE 1

PLANNED ELECTRIFICATION OF DISTRICT NUMBER 5 ("JERICO DISTRICT") ANTIOQUIA DEPARTMENT, COLOMBIA, INCLUDING THE MUNICIPIO OF ANDES AS OF JUNE, 1962



located some 86 miles (139 kilometers) to the north, and Manizales about 112 miles (180 kilometers) to the south with a population of 166,000. An unpaved but well-maintained road connects Andes with Medellin and a similar road is projected for near future completion to connect Andes with roads already built and extending to Manizales. A narrow guage railway also connects Andes with the Bolombolo rail junction which in turn is connected with Medellin.

c. Industrial Possibilities

The municipio of Andes has an urban population of 6900 and a rural population of 48,000. The rural dwellers are scattered throughout 29 veredas or villages and isolated family farms in rugged mountainous country. They are economically oriented toward the market town, and look to Andes for the sale of farm products and the purchase of goods. The rural campesinos or peasants are concerned about the inflated prices they pay for manufactured consumer goods now brought in from the capital city of Medellin, and dissatisfied with the low prices they receive from the wholesale brokers who sell their farm products to Medellin. Processing industries are needed in Andes for locally produced meat, poultry, fruits, hides, tallow, corn, cabuya (sisal-like fiber), and other agricultural products. These could increase local value-added, and improve the cash return to Andes farmers by decreasing middlemen transactions. There are a number of consumer goods which might be efficiently made on a small scale locally including work clothes, tiles, metal castings, bottled drinks, sausages, cakes and bread, candy, shoes, and leather goods. Much of the rural population has comparatively ready access to Andes so benefits felt in the town such as added employment, income, or better prices would also be felt by the rural populace. With the exception of such limited facilities as a small mechanics shop, gasoline station, and two corn mills, there is now no industry in Andes. It would appear that the possibilities for developing new industry are well worth further study.

d. Receptivity of Andes to a Development Program

The town has community spirit and a desire to modernize and improve its economic position as evidenced by the presence of a Lions Club, several "4-S" (equivalent to 4-H) Clubs, a church active in seeking community improvements, women's organizations to improve home economics, marketing and buying cooperatives, and representatives of the Cafeteros (National Federation of Coffee Growers) who carry out agricultural extension work in the municipio, and

have sponsored work on schools, aqueducts, bridges, and telephone lines. The Electric Power Authority of the Department, Electrificadora de Antioquia, is planning to increase power available to Andes, as already mentioned, in the belief that power consumption here shows evidences of potential future growth. Government public health programs are active in such areas as preventive medicine, latrines, aqueducts, lectures, public health nurse, and medical services. An effective extension team is working in the town, including an agronomist, three practicos, a veterinarian, a promotor, two mejoradoras, the local Granja (Agricultural Experimental Station) Chief, two U.S. Peace Corps volunteers and a secretary. Good progress is being made and team morale is excellent. The basic difficulties confidentially described by the team in Andes are the usual ones: resistance of campesinos to change, extremely paternalistic clergy, and over 50% illiteracy rate.

e. Mechanism for Encouraging Capital Formation

Although no figures are available on savings and borrowings in the area, the presence of two branch banks in Andes already provides a mechanism for encouraging savings and loans. The presence of these banks also suggests that some capital formation may now be occurring in the community, although lack of capital is cited as a deterrent to development.

f. Need for Improvements in the Vicinity of Andes

Andes is located in the coffee growing area of Colombia's highlands. The campesino has an income which typically ranges from the equivalent of $300 to $400 annually shared by a family of four or five persons. As the price of coffee declines, as it has in recent years, the condition of the campesino worsens. Indicative of the plight of these peasants is the farsighted action being taken by the National Federation of Coffee Growers to diversify crops and to augment rural incomes by introducing better strains of livestock and poultry, the introduction of new animals, and the training of women in better home economics. Despite these efforts, living standards among the peasants are depressed, and the violencia (banditry and terror) still exists in parts of Antioquia. The nearby town of Venecia visited by the team is under military government. Many persons interviewed by the Survey Team, including Colombian Army personnel, felt that a correlation exists between depressed rural living standards and violencia outbreaks. It was stated that the violencia, although originally

political in motivation, had persisted in part because of unfavorable economic opportunities in rural areas. If a successful development program could be demonstrated in Andes, the example could be followed in similar communities elsewhere in Colombia's highlands to improve the conditions of the depressed campesino populace.

2. Environmental Characteristics of Andes

Andes is located in a mountain stream valley at an altitude of 4452 feet. The stream, called the Rio San Juan, is some 50 feet in width and tumbles rapidly through a gorge roughly bisecting the town. The residential area of Andes rises steeply on both sides of the stream and many houses are built on slopes, necessitating stilt-like supports in the form of wooden pillars on the downhill side. A bridge has been built, permitting ready access between the eastern and western parts of town separated by the Rio San Juan.

To the east of Andes is a hilly ridge some six miles distant, and about 20 miles to the west is a mountain range with altitudes of more than 12,000 feet (Mt. San Nicolas). The sloping terrain is farmed wherever possible, but steep inclines and the erosion of top soil due to brush cutting have reduced fertility.

The mean temperature of the town of Andes is 70 deg. F, but more than half of Andes municipio, or 140 square miles, is classified as "cold" or "frigid", while the remaining 100 square miles is classified as "temperate."

The municipio has numerous streams fed by reportedly adequate rainfall. Most of these streams drain into the Rio San Juan, which flows in a northerly direction and joins the Cauca River about 42 miles north of Andes.

The streets of the town are mostly paved. Houses are constructed with wooden frames, plastered adobe or brick walls, and tile roofs. Dominating the town near the highest point is an impressive brick church with two spires about 70 feet high, facing a large open plaza which serves as the center of town activity.

The few passenger vehicles in Andes (mostly taxis) are generally of U.S. manufacture, principally ten to fifteen year old Fords, Chevrolet and Plymouths. Trucks and buses are generally newer; and are reasonably well maintained. The campesinos living in rural areas near Andes use horses and donkeys for riding and packing purposes; motor roads do not yet penetrate to most of the veredas.

3. Per Capita Income

Data on the income of rural workers were obtained by the team from two veredas in the municipio of Andes in the form of ansers to questionnaires filled out by local U.S. Peace Corp volunteers. In one village the standard or acceptable income was considered to be the equivalent of about U.S. $420 per year, or $1.15 per day. Assuming families average 5.5 persons each, the per capita annual income would be $76. In the second village, incomes were lower, the equivalent of $288 per year or 79¢ per day; this would be about $52 per capita annually.

Incomes in the pueblo of Andes appeared to be higher, but local estimates were not obtained. Such people as the proprietors of the following establishments probably enjoy incomes two to five times the rural level: hardware and clothing stores, pharmacy, food store, cantina (restaurant-bar), trucking, bus, and taxi companies, metalworking shop, saddle and leather work store, the two branch banks, woodworking shop, and land owners residing in the town. Similarly the municipal officials, judges, and doctors probably have incomes several times those received in the rural part of the municipio.

In the rural area of Andes surveyed savings were almost unknown. In the vereda of San Pedro Abajo, 27 families out of 38 were in debt for amounts ranging from the equivalent of $58 to $92 because of farm improvement loans, deaths, or illness. In the vereda of La California, where incomes were lowest, debts typically were $23 (as compared with annual income of $288). In both villages no disposable income was reported.

4. Land Holdings

In the two veredas sampled, 60 and 75 percent of the campesinos owned their own land. In the mountainous terrain around La California, the typical land holding was 20 hectares (49.4 acres), only a portion of which was arrable. Around San Pedro Abajo, the typical holding was 3 to 4 hectares (7 to 10 acres). This pattern of land holding makes Andes a much more promising site for pilot project work aimed at benefiting the campesinos than the depressed Latifundia (large landlord holding) areas found in otherparts of Colombia.

5. Size and Location of Labor Force and Skills

Of the 1961 population of about 55,000 persons in the municipio, 6905 reside in the pueblo of Andes and the remainder in 5 corregimientos (subordinate market centers for a group of villages) and 29 veredas (villages). See Table 1.)

The population density of the municipio is about 90 per square kilometer (233 per square mile) as compared with the Departmental density for Antioquia of 32, and a national density of 13 per square kilometer, in terms of 1960 population figures. Within Power District Number Five, in which Andes is located, the municipio of Andes ranks fourth in population density out of 10 municipios.

Of the total municipio population of 55,000, the labor force is estimated to consist of 25,000 persons, or about 45 percent of the total population. This percentage is higher than the 1958 national figure of 33 percent, and includes minors in the rural areas, especially where schools are insufficient to permit instruction beyond elementary grades. In the vereda of San Pedro Abajo, the schools provide only first and second grade instruction. Typically, children over 8 or 9 years of age work on the farms, help in carrying firewood or farm products, and tend livestock.

Coffee beans are harvested and processed (grating of hulls) from about October through January. Before and after the coffee season, the campesino is partially employed, namely from February through September. During the period June through August, he is typically not productively employed. Variations in the pattern prevail from village to village, but generally the period of semi-employment begins in February and continues into September, a total of about 8 months.

6. Agriculture and Livestock

The farming population in the municipio is engaged in the production of coffee as the principal cash crop, followed by sugar cane, yucca (for starch), and platano (a small variety of banana). Other crops grown include corn, bananas, beans, and oranges. The most important animals raised are beef cattle, hogs, and chickens. Other animals raised are ducks, geese, horses, mules, a few rabbits (for fur), and guinea pigs (for food).

The population of the pueblo of Andes has declined slightly in recent years, from 7760 persons in 1958 to 6905 in 1961. The rural population has risen somewhat, from 43,138 in 1958 to about 48,000 in 1961. Certain veredas, however, have shown a decline in population due to "hunger, lack of work, lack of good pay, difficulty with the land owner," according to reports of the local Peace Corps volunteers.

The comments of town officials interviewed by the Survey Team indicate that emigration from the town of Andes is attributable to the desire for higher incomes in Medellin and to the failure of young people to return to Andes after receiving a higher education. The violencia has caused significant migration out

Table 1
Estimated Population and Labor Force in Municipio of Andes
1961

Population	Pueblo of Andes	Rural Dwellers	Total
	6905	48,000[a] (45,000 farmers and families)	54,905[b]
Total males (45%)	3107	21,600	24,707
Total females (55%)	3798	26,400	30,198
Total labor force	2244	22,560	24,804[c]
Males	1864[d]	17,280[e]	19,144
Females	380[f]	5,280[g]	5,660

a. Includes estimated 3000 not enegaged in farming, located in 5 corregimentos (subordinate market centers). According to Municipio Office, rural population in 1959 was 44,733. Above figure assumes 3.7 average annual growth based on 1958 to 1959 increase.

b. Peace Corps Volunteer reports total is 55,000, 1961.

c. Includes minors and is 45% of population.

d. 60% of males.

e. 80% of males in rural areas.

f. 10% of females.

g. 20% of females in rural areas.

Sources:
Population figures furnished by Andes Town Office; labor force figures estimated on basis of replies to questionnaires filled out by local U.S. Peace Corp volunteers.

of neighboring municipios, but this was not cited as a cause for the decline in the population of Andes.

7. Potential Industry in Andes

As mentioned at the outset of this site report, there are several characteristics of Andes which suggest a promising potential for small scale industry based on urban markets, rural markets, and services. No specific industry could be recommended without a feasibility study to assess such factors as costs of raw materials, transfer costs to markets, availability of required labor and managerial skills, and the present and potential competition. However, the following factors (a through e) suggest some industrial potential for the community:

a. Andes has adequate access by highway and rail to Medellin and in the near future will have access to Manizales. Both cities are substantial market centers, with combined 1960 populations of 779,910.

b. The successful growth of small scale industries in other towns in Colombia suggests that a similar growth could occur in Andes.

c. Andes already has excess daytime power and will soon have even more when the 44 kv line from the 2000 kw Rio Frio plant is brought in as shown in Figure 2 and tables 2, 3, 4, and 5.

Table 2

Name of Town Served	Number of Residential Subscribers	Kw-hours consumed Annually per Residential Subscriber	1960 Residential Rate
Oriente	2152	1918 kw/hours	0.68¢ (5.9 centavos)
Puerto Berrio	1962	2356 kw/hours	.82¢ (7.1 centavos)
Tamesis	1649	1536 kw/hours	.78¢ (6.8 centavos)
Andes	1390	477 kw/hours	.69¢ (6 centavos)

d. The commercial and banking communities reportedly are interested in promoting economic activity, although virtually no industry exists at present. (See items 3 and 4 of Table 6 regarding commercial and industrial establishments).

e. The labor force of some 25,000 persons in the municipio is only partially employed for about 8 months of the year, and, according to local leaders, would welcome factory employment. The National Federation of Coffee Growers told the Survey Team of their own plans to supplement peasant incomes, and stated that industry would be especially desirable for that purpose.

Table 3
Transformer Substations for District Number 5
"Jerico District," Antioquia, Colombia as
of May 1961

Substations	Transformer Capacity (kva)	Ratio	Cost[a]
Betania)	2000	44/13.2	$ 34,500
)			
Bolivar)			
Andes)			
)	2000	44/13.2	$ 34,500
Jardin)			
Pueblorico	500	44/13.2	8,625
Jerico)			
)			
Tarso)	8000	6.6/44/13.2	$138,000
TOTAL			$215,625

a. Converted at: 1 peso = 11.5 U.S. cents.
Source: Electrificadora of Antioquia.

Table 4
Transmission Plans for District Number 5
"Jerico District," Antioquia, Colombia
as of May 1961

Lines	Length (kilometers)	Tension (kv)	Cost[a]
Jerico-Pueblorico	6	44	$20,224
Pueblorico-Betania	20	44	$67,413
Partidas-Andes	12	44	$40,448
Jerico-Tamesis	20	13.2	$65,780
Tames-Jardin	20	13.2	$65,780
Valparaiso-Caramanta	10	13.2	$32,890
Betania-Bolivar	12	13.2	$39,468
Andes-Jardin	12	13.2	$36,570
Salgar-Bolivar	15	13.2	$45,712
Jerico-Tarso	10	13.2	$25,300
Tamesis-Pintada	15	13.2	$37,950
TOTAL	167		$526,870

a. Converted at: 1 peso = 11.5 U.S. cents.
Source: Electrificadora of Antioquia.

Table 5
Distribution Plans for District Number 5
"Jerico District," Antioquia, Colombia
as of May 1961

Distribution Points	Capacity in Kva 1959	Planned Expansion During 1961-74	Cost[a]
Jerico	1100	2150	$82,225
Pueblorico	250	450	$18,688
Tarso	200	350	$14,950
Tamesis	400	750	$29,900
Caramanta	350	700	$26,163
Valparaiso	300	550	$22,425
Jardin	500	950	$37,375
Andes	850	1700	$63,538
Betania	300	550	$22,425
Bolivar	900	1750	$67,275
TOTAL	5150	9900	$384,964

a. Converted at: 1 peso = 11.5 U.S. cents.
Source: Electrificadora of Antioquia.

Table 6
Estimated Annual Load Factor for 720 Kw Hydrogenerator in Andes, Antioquia Department, Colombia
1962

	Type of Load	Assumptions	Yearly Use (kwh)
1	Household illumination	a. Population in area served: 6950 (urban population of Andes, 1961). b. Persons per household: 5 c. Number of subscribers: 1390 with a connected load of 490 watts each. d. Period of use: 6 PM to 11 PM. e. Connected load: 681 kw. f. Daily use at 50 % utilization: 5 hours x 681 kw x .50 = 1703 kwh. g. Yearly use: 365 x 1703 = 621,595 (447 kwh per subscriber annually).	621,595
2	Street Lighting	a. Number of lamps and wattage: 600 lamps, 50 watts each. b. Utilization: 100%, 6 PM to 11 PM (5 hours); 33%, 11 PM to 6 AM (7 hrs.) c. Connected load: 30 kw. d. Daily use: 220 kwh. e. Yearly use: 365 x 220 = 80,300 kwh.	80,300
3	Commercial and service establishments	a. Number of establishments: 19 (hardware, clothing, food, cantina, leather goods, taxi company, trucking company, bus company, stable, gasoline pumping station, mechanics shop, metal-working shop, 2 branch banks, carpenter shop, police station, municipal office, telephone and telegraph office, pharmacy). b. Utilization: 8 AM to 6 PM (10 hrs), 75% c. Connected load: 600 watts per establishment. d. Total connected load: 19 x 600 watts = 11.4 kw. e. Daily use: 10 hours x 11.4 x .75 = 86 kwh. f. Yearly use: 365 x 86 = 31,390 kwh.	31,390
4	Industrial Load	a. Number of industries: 2 corn mills at 5 Hp each b. Connected load: 10 HP x .746 kw = 7.46 kw. c. Utilization: 25%, 90 days per year. d. Daily use: 7.46 kw x 9 hours x .25 = 16.8 kwh. e. Yearly use: 90 days x 16.8 = 1512 kwh.	1,512

Table 6
(Continued)

	Type of Load	Assumptions	Yearly Use (kwh)
5	Miscellaneous Daytime Loads	1. (a) Hospital and Public Health Center have 8 kw connected load, 50% utilization, 8 AM to 6 PM. (b) Daily use: 8 kw x 10 hours x .50 = 40 kwh. (c) Yearly use: 300 days x 40 kwh = 12,000 kwh. 2. (a) Schools have 8 kw connected, 30% utilization, 8 AM to 6 PM. (b) Daily use: 8 Kw x 10 hours x .30 = 24 kwh. (c) Yearly use: 300 days x 24 kwh = 7200 kwh. 3. (a) Public drinking water has 4 kw connected, 10% utilization. (b) Daily use: 4 kw x 10 hours x .10 = 4 kwh. (c) Yearly use: 300 x 4 = 1200 kwh. 4. Total yearly use for above three facilities: 12,000 + 7200 + 1200 = 20,400 kwh.	20,400
6	Miscellaneous Nighttime Loads	1. (a) Police station with 600 watts connected, 80% utilization, 6 PM to 8 AM. (b) Daily use: 600 watts x 14 hours x .80 = 6.7 kwh. (c) Yearly use: 365 x 6.7 = 2445 kwh. 2. (a) Church and community functions with 2000 watts connected, 6 PM to 10 PM, 30% utilization. (b) Daily use: 2000 x 4 hours x .30 = 2.4 kwh. (c) Yearly use: 365 x 2.4 = 876 kwh. 3. Total yearly use for above two facilities: 3321 kwh.	3,321
7	Total estimated annual use (1+2+3+4+5+6		758,518

Table 6
(Continued)

	Type of Load	Assumptions	Yearly Use (kwh)
8	Potential Annual Generation of Andes 720 kw Hydrogenerator	720 x 24 x 365 = 6,307,200 kwh.	6,307,200
9	Effective Capacity of Hydro-generator in Andes	Assuming 10% outage, effective capacity would be reduced by 630,720 kwh to: 5,676,480	5,676,480
10	Load factor for Andes 720 kw Hydrogenerator	758,518/5,676,480 = 13.4%	13.4%

Sources:
Peace Corps reports, interviews in Andes, observations of the Survey Group.

8. Present Utilization of Power in Andes

Power for Andes is generated by a 720 Kw hydroelectric generator installed in 1957, and the rates are comparatively cheap. Rates in Andes are as follows:

Industrial consumers 0.46¢ (4 centavos) per kw/hour.
Residential consumers 0.69¢ (6 centavos) per kw/hour.
Commercial consumers 0.92¢ (8 centavos) per kw/hour.

The above rates can be compared with the average rates for diesel plants sampled in Colombia of 2.65¢, and the average rates for small hydroelectric plants sampled of 0.86¢ per kw/hour.

Table 6 which presents an estimate of the amount of power consumed in the town of Andes, only 13.4% of the installed generating capacity is now being utilized. The amount of power consumed in Andes by residential subscribers is high when compared with the power consumed in communities served by diesel plants in rural Colombia. However, the town authorities felt that consumption was far too low, and told the Survey Team that the present generating capacity of 720 kw should be doubled to meet present needs. This need appeared justified by the experience of nearby communities in the same Department of Antioquia where residential consumers, also benefiting from cheap hydropower sources, are consuming larger amounts of electricity than residential consumers in Andes. The comparison of Andes' residential consumption with that of three other towns of Antioquia is as shown in Table 2.

Table 7 shows that during the evening peak consumption nearly equals the generating capacity. During the period of maximum demand--between 6 and 9 pm--nearly 100 percent utilization of the connected load for illumination can occur, requiring the full output of Andes' 720 kw generator.

Table 7
Connected Loads Likely to be Used During Peak Evening Demand

Type of Load	Kw
Residential illumination	681
Street lighting	30
Police	0.6
Church, etc.	2.0
TOTAL	713.6

Local power authorities in Andes stated that, in fact, the peak demand often exceeded the generator's capacity, resulting in a "brownout." This situation was found to be widespread in the rural communities surveyed by the team in Latin America. Although only a fraction of the total installed capacity is used when calculated on a 24 hour basis, the usual comment was that "the lights aren't bright enough to read by until after 9:00." Power company officials in Andes informed the Survey Team that when additional power is allocated from the Rio Frio plant, one consequence will be a small number of additional subscribers, but the principal result will be an increase in residential consumption. If consumption per subscriber were doubled from the current 447 to 894 kw hours annually, the amount would still fall below the 1649 kw hours consumed annually by residential subscribers in the neighboring town of Tamesis. (see Table 2)

This situation suggests that after the extension of the 44 kv line from the Rio Frio plant, scheduled by Electroaguas for the near future, the added power will be consumed largely by evening residential users, leaving even a greater unused capacity for productive daytime utilization than at present.

As in other rural communities in Colombia, the concept of using power during the day for industry and other productive purposes is not widely understood. The first generator in Andes, a 35 kw unit, was installed in 1915, and during the ensuing 47 years, only a small fraction of the available power has been applied to industrial and service purposes, as shown in Table 6, items 3 and 4.

Conclusion

The municipio of Andes represents a very promising potential site for a pilot project aimed at increasing the productive utilization of power to raise living standards in rural areas.

Site Name and Location	Caracoli (lowland plains farm village), Municipio of Malambo, Departmento of Atlantico, Colombia (Market is city of Barranquilla)
Population	1800 (150 + families)
Date Investigated	May 29, 1962
Field Investigation Team	E.G. Alderfer, CARE, Inc. G. Street, Jr., General Electric Co. J. Lebedef, CARE, Colombia

Type of village government:
Junta

Economic Activities:
Farming (70%)
Unskilled labor for Baranquilla (30%)
Raise own food and animals
Yucca is cash crop for starch

August annual cash income:
1800 pesos/family/year ($15/cap/year)

Services:
Church
5 grade school for 130 students (3 teachers)

Type of electric power:
None
Grid 6 km distant at 24 ctvs/kw/hour.

Availability of fuels and water:
Regular gasoline - 1.00 peso/gal
Kerosene - 1.10 peso/gal
Diesel oil - 1.00/peso/gal
Crude oil - scarce
Wood - scarce
Fresh ground water 10 ft. below surface

Major Needs:
Farm irrigation, agricultural diversity, vocational workshop, possibility of small scale starch processing from yucca.

Remarks:
Dry farming is one crop per year. Irrigation would permit several crops and diversity to supply truck garden products to Baranquilla.

Informants:
Julio del Portillo
Alfonso Donado

Peace Corps Site:
Dennis Salgado, PCV
Steve Denlinger, PCV

Site Name and Location	Corregimiento of Taganga, Santa Marta Municipio, Magdalena Dept., Colombia.
Population	1500
Date Investigated	May 31, 1962
Field Investigation Team	Martin Taylor, CARE Field Representative George Street, General Electric Co. Senor Esteban Marcos Vasquez, Secretary to the Village Police Officer

Taganga is a growing village situated 3 kilometers northeast of Santa Marta in a blind valley of approximately 10,000 square meters floor area at the head of Bahia Taganga on the Carribean coast. A steep high ridge separates Taganga from the city of Santa Marta, and they are connected by a precipitous single-lane dirt road. Other access is by sea and a few mountain trails. Otherwise Taganga communicates with no other community, being a relatively remote satellite of Santa Marta.

The climate is tropical, and it is extremely hot in the arid valley. There are no streams, and it was reported that there was no fresh ground water. The vegetation is desert-like and scrubby. The land is claimed to be sterile and what farming is done (3% of population) is some 20 kms distant.

Taganga's major enterprise is fishing, carried out by 97% of the working population, and this is their only source of income. March through July is the good fishing season, the balance of the year is bad. The people must save income from the good season to cover the total years expenses. They use dugout canoes in which it is safe to venture only a short distance offshore. If the wind is right the canoes may mount a sail, but mostly they are paddled. Ice must be imported over the mountain from Santa Marta for fish preservation, but a considerable amount of the catch inevitably spoils before delivery (Santa Marta is notorious throughout Colombia as a place where one must be cautious when eating fish.) The waters around Taganga abound in fish and lobster, but the present primitive status of the fishing enterprise is unable to exploit this resource. Fish from Taganga is sold at times as far away as Medellin and Bogota, in spite of the severe transport and spoilage problems. A few cattle (40 head vaccinated), goats, pigs and chickens are raised for family consumption, but all other food, vegetables, and fresh water must be trucked in from Santa Marta.

The village appears neat and well organized, and is definitely above the bare subsistance level. It was reported that average yearly income was 4000 pesos per family, implying a per capita income (average of 10 persons per family) of $45/year. There is a church, a 3 grade-2 room school and 2 rented houses for extra school rooms for 120 students, a health center with nurse, and a small diesel engine electric plant for village and household illumination. A number of the residents have radios (a prized possession) and would obtain electric irons if the local junta would permit their use. A significant number of houses are new and built of brick imported from Santa Marta. Streets are laid out in block fashion ending on a clean beach where the boats are drawn up. Colombian tourists occasionally visit Taganga to enjoy the swimming, particularly during the winter months. During this time Taganga celebrates its Fiesta of the Sea. Bath house facilities and a small restaurant have been built for the tourists.

Water Import

All of the fresh water must be trucked in from Santa Marta. Average consumption is 55 gallons per day per family, or 6 gallons per day per capita. The cost of a 55 gallon drum of water is 1.50 pesos, or U.S. $3.08 per 1000 gallons. On this basis a family must expend about 550 pesos per year for water, out of its 4000 peso income .

Major Needs

It was reported their major need was a means to better preserve their fish catch for unspoiled delivery to Santa Marta. They had not seriously thought of using electric refrigeration because of load requirement and capital cost.

They would also like to expand woodworking capability for boat repair and building and furniture making for Taganga.

Other opportunities were apparent to the Survey Team, these are listed as follows:

Obviously Taganga's only importance is that of fishing. Its environment and complete dependence for life necessities on Santa Marta eliminate all other possibilities. In addition, before launching into concepts to improve their fishing enterprises, a question must be considered: should the fishing activity be centered at Santa Marta or Taganga, for if Santa Marta also improves fishing operations, Taganga may no longer be competitive.

In relation to Taganga there is an obvious need to:

> Obtain a more economic community water supply (possible use of waste heat or solar energy)

Minimize spoilage of fish (possible use of available electricity).

Improve fishing canoe stability by lashing two together (similar to Polynescia catamaraus) and thereby extending fishing grounds.

Motorize fishing canoes, for direct fish delivery to Santa Marta docks.

Institute boat building industry for manufacture of larger, more worthy fishing boats (possible use of available electricity).

Expand operations into Lobster fishing (not now exploited).

These points are generally applicable to the majority of fishing villages encountered along the north coast of Colombia.

Electric Power Supply

Taganga has a diesel engine generator that was installed by the Santa Marta Municipality in June 1961. The electric company supplying Santa Marta had investigated the possibility of extending a grid into Taganga, but concluded that it would be too costly. Instead it was decided to install, free of capital charges to Taganga, an 1800 rpm, 42 HP, three cylinder, ACPM Dentz diesel engine driving a 60 cycle, 4 wire 3 phase, 230/133 volt generator. This is housed in a small brick building erected by Taganga community labor. Santa Marta Municipality performs major overhauls without labor charges, and Taganga in turn operates the equipment and charges consumers on the basis of household connection, for fuel, lubricating oil, spare parts, minor maintenance, distribution line capitalization and maintenance, and the operator's wages, if any. The Santa Marta Municipality owns the power plant, and the Taganga Community Junta owns the distribution system. The consumer installs his own wiring, outlets and bulbs; the power is not metered.

Generation is by a 33.5 KVA, 1800 rpm, 60 cycle, 4 wire, 3 phase output, 230/133 volt AC. Distribution is by a 4 wire, 3 phase, 230/133 volt AC system using #2 uninsulated wire on wooden poles. The electricity is used only for community street lighting, household illumination, radios, and ironing (illegal). The plant operates from 6 PM to 12 PM on weekdays, and from 2 PM to 12 PM on Sundays and fiesta days. In the following section the load, duty and cost factors are roughly estimated subject to later revision.

Estimated Connected Load and Duty Factors

If we assume that there are 9 fiesta days/year, 52 Sundays/year, 20 maintenance days/year, and 284 weekdays/year, then the power

plant will be operated 2315 hours/year. There are about forty 50 watt bulbs for community street lighting, giving a connected load of 2.0 Kw, with an assumed duty factor of 100%, leading to an energy use of 4630 kw/hours/year (the street lights are always on when the power plant is in operation).

There are 76 homes electrified in Taganga, each with a 60 watt bulb and a 100 watt bulb, giving a connected hom e lighting load of 12.2 kw. Although the flat statement was made that "no consumer ever turns a switch off here," we should allow for some discretion on the part of consumers for not everyone stays up until 12 PM or leaves his lights burning when he makes a trip outside the village. Assuming a duty factor of 50%, the annual home illumination energy use in Taganga should total 14,000 kw/hours/year.

The radio and illicit ironing loads probably total about 5 kw leading to an estimated energy use of 3000 kw/hours/year in this category. All of these loads are resistance loads, implying a power factor close to unity. Summing these values we arrive at an estimated total connected load for Taganga of 19.2 kw, and an estimated energy consumption of 21,730 kw/hours/year. With an allowance for maintenance outages, this leads to a power plant load factor of about 8%.

The Survey Team found that each electrified household is charged 8.00 pesos/month, yielding a total yearly revenue of 7300 pesos. Thus the estimated effective cost of the electricity is 33.6 ctvs/kw/hour, or at 8.85 pesos per U.S. dollar, 3.8¢ kw/hour. This can be compared to the cost of electrical energy from the power grid servicing Santa Marta 3 to 4 kms distant of 24 ctvs/kw/hour.

The estimated annual operating costs reported can be tabulated as follows:

Fuel consumption	4-5 tanks/month, or 2860 gallons per year.
Fuel costs	@ 106 gals for 100 pesos=2700 pesos/year.
Lubricating oil	10 pints/month at 4.50 pesos/pt = 540 pesos/year.

Costs for spare parts and minor maintenance were unavailable because the plant had been in service for only 10 months since installation, during which it had been maintenance free. No wages are paid to the operators. This leads to a lower limit of effective operating costs of 3240 pesos/year, giving a net cash balance of

4060 pesos/year. The village is now using this balance to extend the distribution system to new consumers. Very shortly they expected an additional 5 to 10 customers.

These rough engineering estimates are only intended to record the field data obtained by the Survey Team in this isolated village, and the cost estimates are preliminary, to be refined later.

Conclusions

The village of Taganga represents a promising pilot project site for a study of the impact of the productive application of power to a rural seacoast community which now engages in primitive fishing. Opportunities here would include: carpentry and blacksmithery shops for boatbuilding and outboard motor maintenance, sea water distillation for community water, refrigeration for ice-making and fish freezing, and related small industry activities, including the support of some tourist activities.

Site name and location	San Onofre, Bolivar Department, Colombia
Population	15,000 urban (including Veredas) 10,000 rural
Date Investigated	June 2, 1962
Field Investigation Team	Howard Volgenau, AID Mission/Colombia G. Street, Jr., General Electric Co.

San Onofre is a large village in a dairy and farming region (125 kilometers south of the city of Cartagena). The village is situated within large landholdings of the Latifundia type; Senor Amarruy Cavelier, the landowner, was our informant. It was interesting to obtain a landowner viewpoint relative to the problems of his underdeveloped village. The major concern of this latifundia was the raising of cattle for dairy products and meat. Very little concern or interest was expressed in improvements and in diversity of agriculture. What farming was done was done by villages on rented unirrigated land, in spite of the fact that streams abounded and ground water is readily available. The landowner admitted this region had once grown rice and exported it along the coast. He observed that he was making a reasonably comfortable living on his hacienda and that he saw no reason to go the trouble of converting from cattle to more productive farming.

Type of village government:
City council

Economic activities:
Farming (40%)
Artisan industries (20%)
Cowboys (20%)*
Land Clearing (20%)*

*These categories work for the Hacienda owner.

Estimated average annual cash income:
3000 pesos/family. (U.S. $42/year/capita)

This sum is above the bare subsistence level; it is estimated that about half this income is spent on drink.

Services:
- Churches
- Movie theatre
- 3 dentists
- 6 doctors, each with own clinic
- 12 nurses
- Maternity hospital
- 6 government schools, up to 8th grade.
- 2 private schools
- Electric power plant

Type of Electric Power:

90 Kw diesel engine generator (installed 1956 to replace older equipment)

Electric power uses: street lighting, household illumination, movie theatre, radios. Power plant operated 6 hours/day.

Each electrified household has 2 lamps, a 25 watt and a 75 watt.

Load factor approximates 14.0%.

Installed watts/capita = 6.0

Unit cost of electricity = 3.50 pesos/month for 100 watt lamp, or approximately 30 ctvs/kw/hour.

Nearest grid 40 kms distant at Maria La Baja.

Availability of fuels and water:
- Regular gasoline, 1.05 pesos/gal
- Kerosene, .90 pesos/gal
- Diesel fuel, .90 pesos/gal
- Crude oil, NA
- Coal, blacksmithing
- Wood, 90% use wood for cooking
- Charcoal, NA
- Propanes, occasional use.

Three important rivers, flooding in rainy season.
Ground water 15 to 25 feet deep.

Major Needs:
- Dry season farm irrigation.
- Electrification of pumps for cattle watering troughs (presently use 5 wind pumps).
- Agricultural diversity.
- Milk preservation and processing.
- Wood and metalworking shops.

They now deliver cattle on the hoof, but if they had meat refrigeration, it might be possible for the community to develop a leather tanning and products industry.

Site Name and Location	Lomarena (north coast fishing village), Corregimiento of Santa Catalina (Market). Departmento of Bolivar, Colombia.
Population	1500 (100 + families)
Date Investigated	May 30, 1962
Field Investigation Team	E.G. Alderfer, CARE, Inc. G. Street, Jr., General Electric Co. T.W. Bentley, Peace Corps M. Taylor, CARE, Inc., Colombia

Type of village government:
Junta

Economic activities:
fishing (100%)
Additional cash obtained through working off season at the salt mines at Galerazamba.
Average annual cash income = 1200 pesos/family/year
$12/cap.

Services:
Plans to build new 5 grade school and clinic with nurse and ittinerant doctor.

Type of electric power:
None.
Grid 15 kms distant.

Availability of fuels and water:
Regular gasoline - 1.00 pesos/gallon.
Kerosene - 1.10 peso/gal
Charcoal - very expensive
Fresh water lagoons and ground water

Major Needs:
Fish preservation
Woodworking
Boat building and repair
Garden plot irrigation

Remarks:
Fishing is in non-motorized dugout canoes. This village has been progressively washed away by the sea, so they are moving village to higher ground. This is a U.S. Peace Corps site.

Informant:
T.W. Bentley, Peace Corps.

Site Name and Location	Tarma (Complex) Junin Department, Peru
Population	(gross estimate) 16,000 urban, 30,000 rural
Date Investigated	May 16 and 17, 1962
Field Investigation Team	G. Street, Jr., General Electric Co. E.G. Alderfer, CARE, Inc. Dr. H.F. Dobyns, Cornell-Peru Project

Tarma province in the Department of Junin contains an interdependent group of Pueblos serving the market towns of La Oroya and Tarma, which in turn tranship to Lima. Of particular interest as a promising site for further evaluation is the complex of villages directly associated with the market town of Tarma. The map, Figure 1, shows the region of interest. This region contains Tarma, Acobamba, Palcamaya, Palca and Tapo. Their individual populations are:

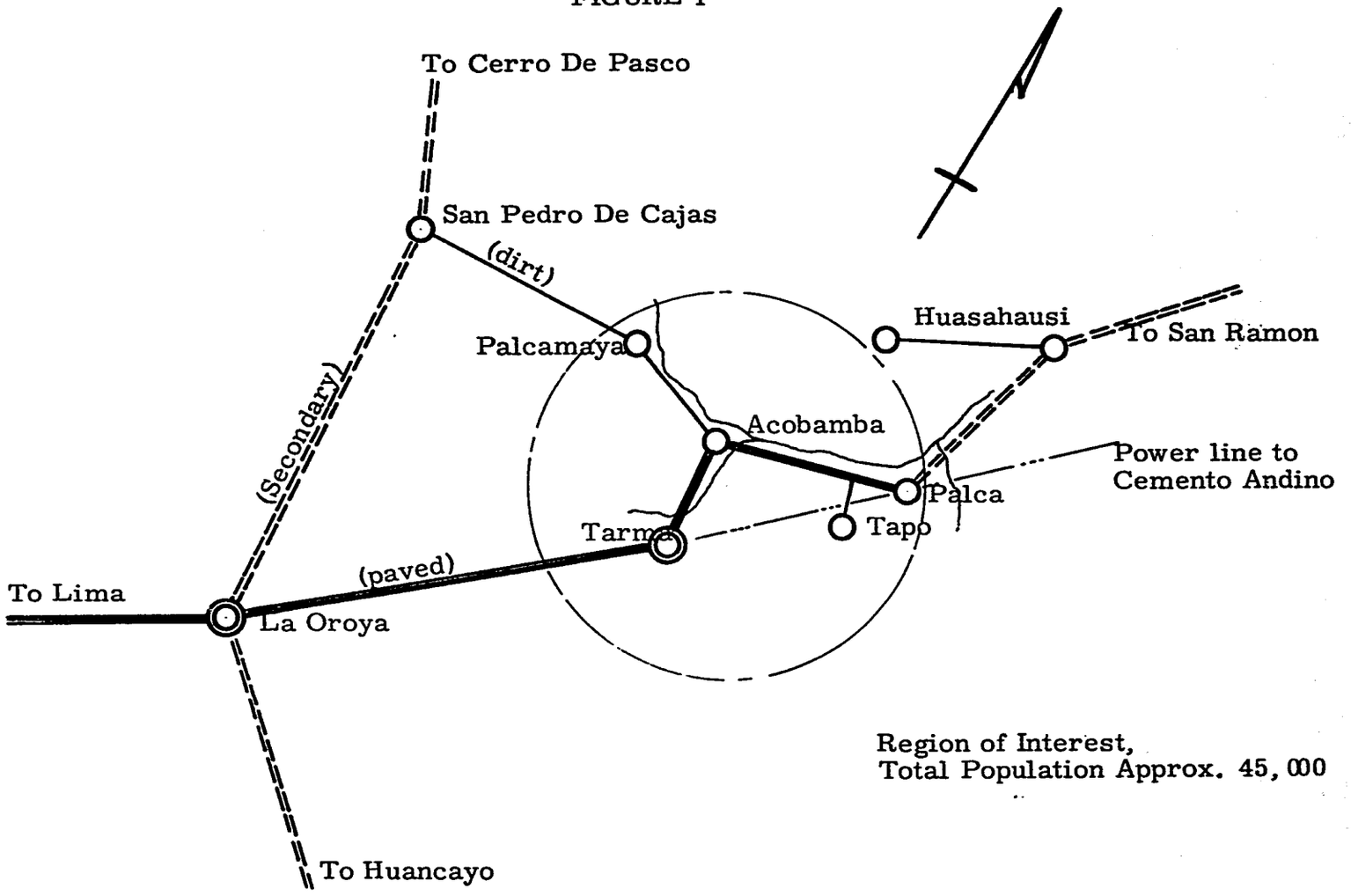
Village	Urban	Rural	Total
Tarma*	10,000	15,000	25,000
Acobamba	1,961	7,531	9,492
Palcamaya	2,300	4,200	6,500
Palca	1,200	2,600	3,800
Tapo (small)	?	?	?
Est. Totals	15,500	29,400	44,900

*These figures estimated by author only to reflect a visual impression of Tarma's size relative to adjacent villages.

Of the five villages, only three were investigated due to the program emphasis at that time to survey small village situations. The three were Acobamba, Palcamaya, and Palca. Our survey conclusions, however, make it advisable to consider regional complex as a single situation within the context of utilization of electric power as a means for achieving viable economic progress.

Tarma, Acobamba and Palca and Tapo lie along the floor of a valley descending from the ridge of the Andes chain into the jungles to the east. The altitude at Tarma is about 9200 feet, falling to about 7000 feet at Palca. These villages lie on a good quality two laned asphalt highway connecting them with Lima 230 kilometers distant. Palcamaya is located in a feeder valley to the north via an erratic, deeply rutted, dirt road. The ridges on either side of the valleys are precipitous, rising to 2000 and 3000 feet above the valley floor. Small rivers flow in these valleys, fed by melting glaciers. The air is clear with ample sunshine, except

FIGURE 1


To Cerro De Pasco
San Pedro De Cajas
(dirt)
Palcamayo
Huasahausi
To San Ramon
(Secondary)
Acobamba
Power line to
Cemento Andino
Palca
Tarma
Tapo
(paved)
To Lima
La Oroya
Region of Interest,
Total Population Approx. 45,000
To Huancayo

for the rainy season during the mid year. Prevailing winds blow up the valleys, generally from the east, during daylight hours. They are mild in strength, from 5 to 10 mph.

These villages have been a source of unskilled and semi-skilled labor for the mining operations of Cerro de Pasco, although it appeared that there has been considerable layoff due to more efficient mining methods and lower copper exports. The majority of the urban population, particularly in the small villages had at one time worked in mining.

Most of the region is involved in farming, raising a variety of crops, including potatoes, maize, artichokes, barley, carrots, cabbage, spinach, lettuce, beans, alfalfa, peaches, and other cash garden crops for the Lima market. Farmlands fringe the valley floor and up the steep sides of the mountainous ridges. Irrigation is by ditch diverting a portion of the river floor. Dry farming is practiced above the ditch line.

Cattle, goats, sheep, pigs and chickens are raised for cash income. Horses and donkeys are used extensively for local transportation. Guinea pigs (CUYO) are raised by the Indian farmers for household consumption.

Each village had a number of small artisan industries to serve their respective localities; weaving of wool, tailoring, wood-working and metalworking shops (1 or 2 men) shoe making, bakeries, blacksmithing and hairdressing. Most of the villages had one or more automobiles repair shops and retail stores dealing in imported groceries, yard goods and other necessities.

Fuel costs in this region are listed below. Fuel is generally available in Tarma and Acobamba. The other villages import from them:

Regular gasoline	4.10 soles/gal	15.3¢/gal
High Test gasoline	5.60 soles/gal	20.9¢/gal
Diesel fuel	4.10 soles/gal	15.3¢/gal
Kerosene	2.20 soles/gal	8.2¢/gal
Wood	Sufficient for cooking	
Bottled gas	Scarce	

The clear impression one gets is that these villages have done a fair job of developing themselves to the extent of their available resources. Palcamaya being the most remote of this group seems lethargic and at subsistence level. They feel the pulse of Lima and are insisting on progress, which they are expressing difficulty in obtaining.

On the whole, there was a definite need for competent technical advice, particularly relating to installation of electric power, irrigation,community organization, etc. which they have been unable to obtain from their government.

The major needs of this region appear to be:

For the small villages

Introduction of adequate electric power.
Extension of irrigated farm lands with irrigation pumps.
School and clinic illumination.
Electrification of local artisan industries including:
- Sawmills
- Woodworking/metalworking shops
- Auto repair shops

For the market village

Introduction of efficient small scale industries suitable to region:
- Agricultural products
- Pottery
- Clothing
- Educational radio station
- Dairy product factory

There follows a series of descriptions for each of the villages surveyed. A brief visual impression is presented of Tarma.

Tarma (market town in Junin Province)

Tarma is known as a resort area, the mountains and valley resembling a precipitous alpine setting. There is a tourist hotel, plus other hotels, in the city proper. Tarma was the birthplace of Odria, who until seven years ago was dictator of Peru. During his regime Tarma received very favorable treatment. There are a number of schools including vocational and high schools serving the entire valley area, with school bus service. Tarma is electrified with a grid interconnection to other major towns and industrial activities. Both hydroelectric and diesel generator stations of several thousand Kw's capacity are located in Tarma. Except for the main road through the town, all the streets are either cobble or dirt. The town, however, appears cleaner and more substantial than other market towns passed through by the Survey Team.

Tarma is the center to which the region's agricultural output is delivered for transshipment to Lima and other markets. It is also the locale for goods imported into the region.

Acobamba

Acobamba is a Pueblo of 1961 inhabitants and, including the rural population, has a total of 9492. There are about 250 to 300 families in the village. This village appears to have some substance, and along with agricultural activities has a number of business and small artisan industrial efforts, including garages, saw mill, retail stores, bakeries, tailoring, etc.

Acobamba represents a common situation in Peru, that of the inability to obtain adequate electricity from the electric power grid. The grid line between Tarma and a cement plant passes directly overhead in Acobamba.

More than 40 years ago, the Servicia Electrica de Tarma connected Acobamba into their system. A capacity of 45 kw was installed; however, some 20 years ago this was reduced to 15 Kw. The village had apparently established a connected load to match the original installation, and what with rising population and new consumers the present amount of electricity is entirely inadequate. The Survey Team witnessed lamp bulbs glowing no brighter than a candle. The population has established the habit of using the faint electric glow only as a means to locate and light their gasoline mantle lanterns.

Over 176 households, including some stores, in this village, have electricity, generally one 40 watt bulb (the Mayor has several bulbs, including one of 125 watts). They are charged 30 soles per month for 24 hours, illumination, 15 soles per month for 12 hours illumination, 8 soles per month for a radio. It was estimated that the total connected load is 30 kw, includin g street lighting.

It was impossible to obtain total revenue or actual use data, but a rough estimate of unit cost of electricity is 1.50 to 2.00 soles/kw/hour or 5.6 to 7.5¢/kw/hour. In addition, the costs for the gasoline lantern was obtained which worked out to an equivalent cost of about 2.30 soles/kw/hour for a 78 watt tungsten lamp illumination.

Acobamba has been actively seeking a solution to their problems; they have been considering three possibilities in view of the fact that their present capacity will not be increased above 15 kw by the Servicia Electrica de Tarma.

Concept #1

Grid top into cemento andino power lines.
Cemento Andino will sell 200 kw, at 44,000 volts at Tarma substation for 60 ctvs./kw/hour.

Acobamba would be required to purchase a 44 Kv/2.3 Kv transformer with protective devices for installation at Tarma, install 10 kms of 2.3 Kv 3 phase transmission line, with 2.3 kv/220 volt distribution transformers. The estimated equipment cost is 1,200,000 soles. Acobamba would contribute ples from private eucalyptus tree groves) and labor.

Concept #2

Locally installed diesel or gasoline engine generator plant. Fuels are readily available and there are qualified technicians in Acobamba for plant operation.

Concept #3

Locally installed 100 Kw hydroelectric plant.

The Tarma river flows through Acobamba. Only a negligible amount of the water is diverted for irrigation purposes. An estimate of the flow rate (at end of day season) is 96 ft.^{3}/ second. The total head available at a probable plant location is 2 km downstream from the point of the possible dam site is about 35 meters, or 113 feet.

Total hydraulic head availability is 1200 water horsepower. Assuming 20% losses in ditches and penstock and 75% efficiency of the hydroelectric plant, a maximum electric output at the generator terminals of 313 Kw is indicated.

With reference to the hydro plant, the Acobamba Junta is processing for the water rights, has discussed with Cerro de Pasco the purchase of a 40 year old (scrap) 100 kw hydro electric generator, and raised locally an initial fund of 120,000 soles. They plan that whatever concept is chosen it will be operated as a private company.

Their biggest problem is to get technical advice. To date they have had no reception by the Peruvian government or national power agencies.

Palcamaya

Palcamaya is a Pueblo of 2300 with a total of 6500 plus, including the rural environs. This village is reached by a very poor and rutted dirt road about 9 kilometers out of Acobamba. This village appears somewhat run down and lethargic, and is considered at bare subsistance levels.

Aside from the typical agricultural activities, they have several small artisan industries serving the locality, including carpentry, shoemaking, repair of hats, weaving and tailoring, a garage, retail stores and several of the typical minimal restaurants of this regions.

Palcamaya is not electrified, but is interested in becoming so. Some 12 years ago, one of the citizens formed a corporation and set up a 40 Kw diesel generator, but the business failed before it got started due to incompetent management.

Running through this village is a small river that was estimated to have 200 to 300 kw terminal power in dry season. There is a dam already built by the community, and the beginning of a large diversion ditch as well as a site set aside for a hydroelectric plant with underground tail race.

Again, this village needs technical advice as to the real value of electricity and a strategy to obtain loans and equipment to set up a plant. They have not been able to obtain this type of help from the Peruvian government.

Palca

Palca is a relatively small village of 1200 people, with a total of 3800 including rural environs.

Much the same story can be written regarding agriculture and small industry activities as at Acobamba and Palcamaya. This village, however, has its own local electric plant, consisting of a hydroelectric plant (about 10 kw) installed in 1925 by a group of private individuals. All consumers are shareowners and are charged on a per bulb basis, with extra assessments for repairs as needed. It is apparent that the plant reliability is largely at an end, and the shareowners are back to gasoline lanterns. An estimate of the operating cost of electricity appears to be about 30 ctvs/kw/hour, (based on no outages), not including maintenance or equipment capitalization.

A power grid line passes over their village, but they have been unable to make any arrangement for a tap in. They do, however, have a water resource just outside the village. We estimated the flow and head (at end of dry season) and consider there is about 500 kw terminal power capability. Again this village has not been able to obtain any technical advice in this regard.

Site Name and Location	Cuyo Chico Village, Cuzco Department, Peru
Population:	1873
Date Investigated	May 17, 1962
Field Investigation Team	Oscar Aragon, Agronomist and Ing. Mauro Villavicencio, Director of Cuzco Office of Servicio de Investigaciones y Promocion Agraria (SIPA) Frank Turner, Stanford Research Institute (NOTE: Turner did not visit this site because of meetings with CRIF and SIPA during the one working day in Cuzco. Other investigators did visit the site and presented a written report and questionnaire reply.)

Characteristics of Cuyo Chico

The village of Cuyo Chico is located about 22 miles (35 kilometers) from the city of Cuzco, Department of Cuzco, in Southern Peru. The village is at an altitude of 10,500 feet and temperatures fall at night to near freezing at times and rise to about 60 degrees during the day.

The 1873 inhabitants consist of 289 households indicating an average per household of 6.5 persons. The number of births is about 75 each year and the number of deaths is about 38. The village population has grown over the last ten years from 1503 persons in 1952 to the present figure of 1873, an annual average growth of 2.2 percent. Some emigration has taken place because of poor harvests, the lack of employment opportunities, and separation from family members who have previously left the village.

Landholdings per family average about 1/2 hectare and virtually all land cultivated is owned by the cultivator himself. There is no completely level farm land. The hillside plots yield sub-standard crops (for Peru) of corn, potatoes, a kind of lima bean, wheat and barley. Livestock raised includes pigs, guinea pigs, a few vicuna and beef cattle. The average family cash incomes per year is probably not more than 1040 to 1300 soles, or U.S. $40 to $50. The village is regarded as one of the poorest in the Cuzco area.

Inhabitants of Cuyo Chico earn cash income from the sale of barley to a brewery in Cuzco and from the sale of rough timber from a community-owned stand of about 2000 pine and 9000 eucalyptus trees.

Some cash income is derived from the sale of tiles baked in Cuyo Chico, and from the sale of plaster considered to be of exceptional quality and hence in demand as a finishing layer for adobe walls.

A rough, narrow, hair-pin curve dirt road connects Cuyo Chico with the nearby town of Pisac, which in turn is connected by road with Cuzco.

The level of literacy is quite high, about 80 percent of all inhabitants being able to read. This is attributed to the presence of three schools in Cuyo Chico accommodating 300 pupils from the neighboring communities of Mask'a and Quotobamba.

Cooperatives in Cuyo Chico

The community has distinguished itself for cooperative projects which have included: (a) construction of a canal to make water more readily accessible to all parts of the village, (b) continuous construction and repair of houses under the ayuda mutual (mutual aid) procedure followed in Cuyo Chico, (c) expansion and care of 11,000 trees grown for timber purposes, (d) the organization of two buying cooperatives and one producing and marketing cooperative.

Encouraging the above type of activity has been the University of Cuzco. This national university operates programs of community improvement and conducts anthropological and economic research at Cuyo Chico. This work is carried out under an agreement, dated March 17, 1959, with the Ministry of Labor and Indian Affairs in Lima. The Cuyo Chico program is quite similar to the Cornell-Peru Project at Vicos in central Peru, also under the sponsorship of the Ministry of Labor and Indian Affairs.

Agricultural extension work at Cuyo Chico is undertaken by the Servicio de Investigaciones y Promocion Agraria (SIPA) which works closely with the US AID Mission in Lima.

Possibilities for Small Scale Industry

Site investigators from SIPA stated that the enterprising nature of the Cuyo Chico community provided a good foundation for small scale industry. The inhabitants already make tiles, plaster for adobe walls, and cut wood manually from the community-owned stand of timber.

The SIPA representatives felt that additional industries which might be established in Cuyo Chico were: a saw mill, woodworking shop, sewing machines for the fabrication of work clothes from Cuzco made textiles materials, a corn mill, a power-driven batching plant for plaster, and eventually the manufacture of leather goods. None of these industries could be justified without prior study of markets, prices, raw material availability, and competition in the

area. The inhabitants would "enthusiastically welcome" electrification to provide a base for industry according to SIPA representatives.

Means for Electrifying Cuyo Chico

The village of Cuyo Chico is located only 13 miles from a 138 kv transmission line running from the Machupicchu Hydroelectric Plant (see map at end of this Appendix). However the cost of transformers and transmission lines would be too great to use grid power from Machupicchu according to officers of the Corporacion de Reconstruccion y Fomento del Cuzco (hereafter CRIF). Also there is idle manufacturing capacity in Cuzco waiting for the increased allocation of power soon to be expected from the Machupicchu project with an eventual capacity of 120,000 kw. Any diversion of power to rural communities is out of the question, according to local authorities in Cuzco.

The power distribution map for the Machupicchu hydroelectric project shows a series of circles drawn around various load centers. These circles, about 10 miles in diameter, show the theoretical limits of areas to be served by sub-stations at the load centers. According to CRIF, it is unlikely that transmission lines will be extended even as far as the circles indicate and definitely not beyond the circles to Cuyo Chico and other communities similarly situated.

The principal hope for bringing electricity to Cuyo Chico lies in local hydroelectric generation. This appears especially promising for Cuyo Chico because of the head and volume of water flowing along the outskirts of the village. The flow volume, according to SIPA engineers, is as follows:

Stream Flow Estimates for Cuyo Chico

February through April	90 liters per second
May through November	50 liters per second
Minimum flow	45 liters per second

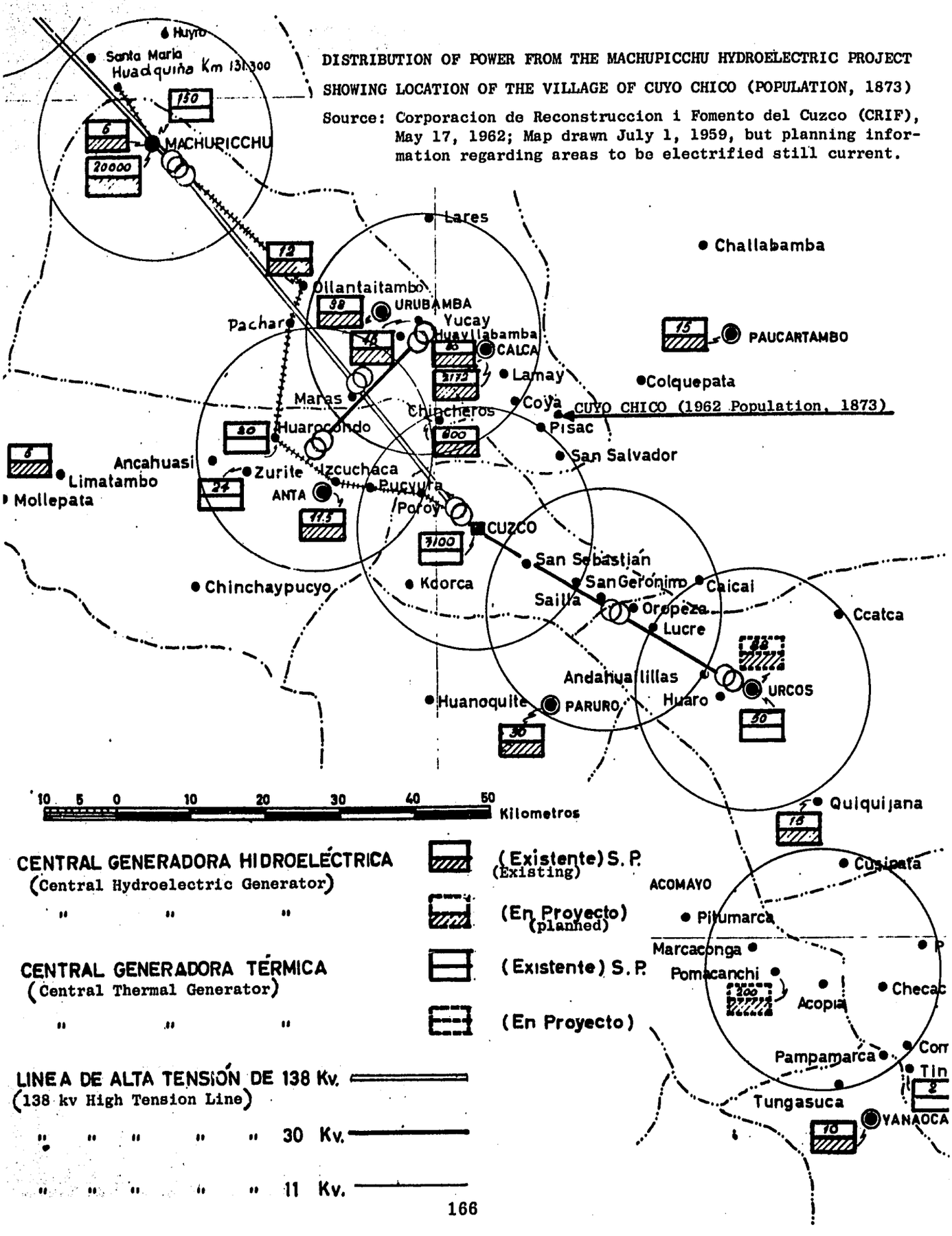
The stream at Cuyo Chico falls off sharply near the village, dropping 300 meters over a horizontal distance of only 156 meters. This suggests that a hydroelectric plant of more than 100 kw capacity might be installed.

Conclusion

The village of Cuyo Chico offers an excellent opportunity to conduct a pilot project to demonstrate the productive application of power to raise rural living standards using an integrated systems approach to the development problem.

DISTRIBUTION OF POWER FROM THE MACHUPICCHU HYDROELECTRIC PROJECT SHOWING LOCATION OF THE VILLAGE OF CUYO CHICO (POPULATION, 1873)

Source: Corporacion de Reconstruccion i Fomento del Cuzco (CRIF), May 17, 1962; Map drawn July 1, 1959, but planning information regarding areas to be electrified still current.



Site Name and Location	San Pedro de Cajas Department of Junin, Peru
Population	4800 in village
Date Investigated	May 19, 1962
Field Investigation team	Senorita Teresa Egoavil E/ Dr. H.F. Dobyns, Cornell-Peru Project

San Pedro (12,000 ft. altitude) is an agricultural community located approximately 48 kilometers (via an unimproved dirt road) north of LaOroya, to which it exports its market products. Their largest cash crop is potatoes. In 1957 a hydroelectric plant was installed by a private corporation.

Type of village government:
Incorporated Junta.

Economic activities:
Farming
Stockraising
Textiles
Ceramic roof tiles
Blacksmithery

Estimated average annual cash income:
About 3500 soles/family.

Services:
Church
Newly inaugerated medical post
2 Schools, vocational and secondary category, 680 students
Community center
Transportation co-op
Hydroelectric plant
Cattle co-op

Type of electric power:
Hydro electric.
Installed 1957 by private corporation
Installation cost 273,000 soles.

Electric power uses:
Village illumination
Household illumination
Radios

Power plant is operated 16 hours per day. Data on Kw rating and connected load were not available.

Unit charge for electricity is 60 ctvs/kw/hour (shareowners)
80 ctvs/kw/hour (non-shareowners)

Power plant operated is paid 750 soles/month.

Nearest grid is 3 km distant in Pacchapata.
San Pedro expects a grid tie-in in the future.

Availability of fuels and water:
Regular gasoline, 4.20 soles/gal
Kerosene, 2.20 soles/gal
Diesel fuel, NA
Crude oil, NA
Coal, NA
Wood, None
Straw, 3.00 soles/load
Peat, 25.00 soles/1000 blocks
Dung, collected and burned
River (300 liters/sec)

Site Name and Location	Vicos (elevated valley farming community) Province of Carhuas Department of Ancash, Peru.
Population	2080 (extended community 466 families)
Date Investigated	May 11, 1962
Field Investigation Team	E.G. Alderfer, CARE, Inc., New York F.L. Turner, SRI G. Street, Jr., General Electric Co. Dr. H.F. Dobyns, Cornell-Peru Project

Type of village government:
Junta

Economic activities:
Farming and animal raising.

Services:
Church
Five grade school
Clinic,
Gasoline-electric plant for project group.

Type of electric power:
3 1/2 KVA gasoline-electric plant (installed 1952) owned by Cornell Project.

Electric Power Uses:
Project, school, and clinic illumination. Movie Projector.

Estimated connected load:
3.8 Kw.

Load Factor:
8.74%

Unit cost of electricity:
4.33 soles/kw/hour.

Nearest grid:
35 km distance, 30 centavos/kw/hour.

Availability of fuels:
Delivered in Vicos--regular gasoline, 6.00 soles per gal.
hi-test gasoline, 7.00 soles per gal.
diesel oil - 5.30 soles per gal.
kerosene, 3.80 soles per gal.
indigenous coal and wood
water available from irrigation ditches and rivers.

Major needs:

Irrigation of farm lands above irrigation ditches
Threshing and milling
Fiber processing
Mechanized milling
Saw mill and woodworking shop

Remarks:

Vicos, through assistance from Cornell, has demonstrated significant improvement in living standards. It is an extended farm community as opposed to a pueblo type. It reflects the typical Indian situation of the Alto Plano in Peru.

Site Name and Location	Cholchol (Plains farming village, largely Indian population). Province of Temuco, Department of Cautin, Chile.
Population	1200 in Pueblo, 10,000 in total, including rural (170 + families).
Date Investigated	May 23, 1962
Field Investigation Team	T.O. Paine, General Electric Co. G. Street, Jr., General Electric Co. M. Ronan, Peace Corp

Type of village government:
Village council.

Economic activities:
Farming (100%) subsistance; Peace Corps volunteers organizing a Coop, no landowner problems.

Average annual cash income:
200 Escudos/family/year ($19/cap/year).

Services:
Churches (several)
16 bed clinic with doctor and nurse.
2-6 grade primary school
2-3 grade high school
1-4 grade primary school

Type of electric power:
15 kw diesel electric plant installed in 1921 by a private owner.

Electric power uses: village lighting, household illumination, radios.

Estimated connected load: 12 Kw.

Estimated power generated: 13,140 Kw/hours/year. (At present power plant outages average above 50% because of age).

Estimated load factor: 10.0%

Installed watts/capita = 12.5

Unit cost of electricity: 0.21 E_o/kw/hour (on basis of no outage and 100% duty factor).

Nearest grid is 23 Km distant, with no chance of grid power in future.

Availability of fuels and water:
Regular gasoline - 87 pesos/litre
Kerosene - 100 pesos/litre
Diesel fuel - 85 pesos/litre
Wood and Charcoal - very little available.
Ground water 10 to 15 feet
Adjacent river

Major needs:
Farm irrigation, pottery making, flour milling, poultry raising, dairy and cattle, and improved weaving operations, vocational workshops.

Remarks:
Village well organized, excellent community spirit, demand for electricity could replace old installation. Opportunity for irrigation to substantially improve economy.

Informants contacted:
Ltru. Nunia Rivos Nunely
Gone Ounocder Matamala Millapan
Marcclo Laudoral Mella
Yuan Alberto Reima Laudoove
Ernesto Froucoso Lauchely
Diego Narvase Lepulveda
Ramon Castillo del Pino
Nelson Trombert De La Marpe
Manuel Ouezoda Hernaudel
Escequial Nira Orriogoda
Father Ward Mundey, Maryknoll Missionary, Cholchol
Father O'Brien, Maryknoll Missionary, Temuco

U.S. Peace Corps volunteers on site:
Jim Dugan, PCV
Jim Fitzgerald, PCV

Conclusions

Cholchol would make an excellent pilot project site to investigate the provision of adequate power to support the Peace Corps volunteers with a "community services center" workshop, irrigation, and refrigeration and agricultural processing equipment for their new coop. This could be done very quickly at low cost.

Site Name and Location	Ebejico, Antioquia Department, located 68 kilometers northwest of Medellin, Colombia.
Population	About 5000 in the central pueblo (market town) and 10,000 in the surrounding rural areas.
Date Investigated	May 30, 1962
Field Investigation Team	T.O. Paine, General Electric Company C. Ahrens, CARE-Peace Corps, Bogota Frank Turner, Stanford Research Institute Richard Fiedler, U.S. Peace Corps Volunteer.

Ebejico is typical of a number of pueblos (rural market towns) in the upland coffee-growing regions. It is located within general access to major manufacturing and market centers. It is likely to undergo a number of changes in the next few years arising from its improved access to Medellin (1960 population 614,000). The principal north-south highway running from Medellin northward to Turbo is only 23 kilometers away, and the connecting road to Ebejico leading through rugged mountain terrain has recently been opened.

Plans of the central power authority (Instituto de Aprovechamiento de Aguas y Fomento de Electrico) call for the extension of a 13.2 Kv transmission line from the town of San Jeronimo, only 15 kilometers away so that Ebejico will ultimately benefit from 3 phase, 60 cycle, 120/208 volt power. The Instituto plans to carry out the above extension in 1962, but there are doubts that power will be furnished so quickly. These improvements, the local resources described below, the presence of two U.S. Peace Corps volunteers, and the cafeteros programs all suggest that Ebejico is a promising community for development.

1. Vital Statistics

The central pueblo contains 5000 persons, or 830 families averaging 6 persons per household; the rural population of the municipio is 10,000 people, or 2500 families. There are fifteen veredas or villages in addition to the central pueblo, and two corregimientos. Death rates and birth rates in the community are similar to those prevailing elsewhere in Colombia, namely 35 persons are born annually, and 15 die, per 1000 inhabitants. The birth rate for Colombia as a whole has been about 43 and the death rate 13 persons per thousand.

From 1910 until recently there was a gradual increase in population from 3000 to the current figure of 5000, but in the last few years, despite the fact that births are double the number of deaths, Ebejico's population has stayed virtually constant. The recent leveling off is attributable to the tendency

of younger persons, especially males, to migrate from the town, also families have been moving in the last ten years to escape the threat of the violencia, which is still active in neighboring areas.

2. Environmental Characteristics and Power Sources

The pueblo of Ebejico is the seat of the Municipio, and is located ten kilometers east of the Cauca River.

As one views the town from above, the pueblo looks to be about a mile in length and 200-300 yards wide extending along a valley. The valley floor slopes gently down to the Cauca River, but both sides of the valley are steep, rising sharply to 7000 feet as compared with the altitude of the town itself of 3600 feet. The floor of the valley and the foothill region extending from the town to the river is satisfactory pasture-land, and forms the basis for the local cattle industry.

Ebejico has two sources of electric power at the present time, both of which are used only for early evening illumination, with only a fractional load for other applications, which include: small household appliances, about three coolers (for carbonated drinks, drugs and butter) and a few radios. Even if both power plants are operated at their combined capacity of 77.5 kw, the lights are so dim from low voltage due to excess demand that it is impossible to read before 9:30 PM.

The first source of power is a hydro-electric generator installed in 1918 which is now characterized by chronic maintenance problems. The generator is a 37.5 kw, 3 phase, 2300 volt, 9.4 ampere, 60 cycle, 1200 rpm Westinghouse unit. A simple control panel made in Medellin includes two 15 ampere Ammeters and a 250 volt voltmeter. The turbine is supplied from 13" diameter penstocks. Water flows through a concrete raceway from a nearby stream with a roughly estimated 50 cu. ft. per second stream flow in the wet season and about 34 cu. ft. per second in the dry season.

The hydro plant is constantly in need of repairs, especially with respect to leakage in the badly rusted 13" pipes bringing water down to the turbine. Supplementing the hydro-electric generator is a more recent small diesel plant which operates from 7:30 PM to 10:30 PM. The diesel plant is a 100 Hp 40 kw unit. The principal load on the combined system consists of an estimated 3340 light bulbs averaging 25 watts each, or a total peak of 83 kw for lighting alone. The diesel unit operates only in "emergencies" but according to the local inhabitants the lighting power is insufficient even when both units are operating.

There are a number of ways in which the energy sources of Ebejico could be improved. The first is by the introduction of grid power from the Guadalupe system and other sources near Medellin. According to local authorities and to officials of the Electrificadora de Antioquia (public power authority) in Medellin (June 1 interview with Dr. Mejia), grid power for Ebejico will be delayed some years. However, according to the Instituto de Aprovechamiento de Aguas y Fomento de Electrico in Bogotá, firm plans have been made for the introduction during 1962 of grid power by means of a 15 kilometer line coming from the town of San Jerinimo carrying 13.2 kv (3 phase, 120/308 volts, 60 cycle) into Ebejico. The 15 kilometer transmission line, lightening arrestors, transformers, and other related items are estimated to cost 420,000 pesos ($48,300).

Subsequent interviews (Dr. Pisano, Director of Accion Comunal and officials of the AID Mission) led to the conclusion that the 1962 grid extension was possibly too optimistic in view of the characteristic lag in the receipt of government appropriations for rural areas. At the same time, however, it is clear that the Guadalupe grid is moving forward rapidly and the extension from San Jeronimo to Ebejico can be accomplished with a minimum of engineering difficulty and at reasonable cost.

A potential source of additional power for the community is a waterfall located 3 km from the satellite vereda (village) of La Gramala some 5 km from Ebejico. This waterfall drops a total of about 250 feet in two stages. According to rough estimates and not by actual measurement, the waterfall has a volume of some 20 to 40 cubic feet per second. Although no local stream flow records are available, village informants stated that the volume of water flow remained virtually constant throughout the year.

There are no sources of local fuel, the farmers utilize every available "piece of organic material" for compost. Almost no wood is available, except for small diameter shrubs growing above the valley. The removal of such undergrowth would aggravate erosion problems and would therefore be ill-advised.

No unusual wind or solar energy characteristics were evident. The average mean temperature is 73 deg. F. Water is brought into the village by means of an aquaducto or pipeline extending from the village upward to (polluted) mountain stream sources nearby. The local water is definitely not potable and strong local pressures have been brought to bear on AID, the government and other groups to introduce chlorination. Despite contamination, the water is freely consumed, leading to a high incidence of intestinal parasites.

3. Economic Characteristics

a. Agriculture and Livestock

The campesinos population of about 10,000 in the municipio rely on coffee beans as their principal source of income. The annual production of about 5 million pounds is sold through the Cafateros (National Federation of Coffee Growers). Secondary income is derived from other crops, including yucca (for starch), sugarcane, bananas, cacao, cabuja (for fique fiber) and platanos. Some nectarines and mangosteens are grown, but few are sold because of the problem of spoilage prior to reaching the market.

The valley floor, extending in a westerly direction for ten kilometers from Ebejico to the Cauca river, provides grazing land for cattle and horses. These animals plus hogs total some 30,000 head. In addition most of the campesinos have some poultry.

b. Industry

There is no industry in the municipio of Ebejico of a manufacturing nature, but service industries and small shops exist. Because of the local meat demand, a few cattle not sold outside Ebejico, are slaughtered, but only in sufficient quantity to meet the day-to-day demands of the urban community.

The local "Transportes ECO" line owns two 12 ton trucks and carries goods to and from Medellin. The same line operates a bus service with four daily trips to Medellin. There are some small service shops run by artisans, a shoemaker, a barber, a drugstore (quite well stocked with ethical drugs brought in from Medellin), and at least two cantinas (restaurant-bar).

c. Potential Small Industries

Although each possibility will require further study, the following small industries were identified as promising for Ebejico: manufacture of bricks and tile, rope, bag, and rug making from fique fibers, fruit processing based on local nectarines (principally juicing and canning), carbonated drinks, meat processing based on local beef cattle and poultry, manufacture of meat by-products such as sausages, hides, casein, candles and eventually tanning and shoe manufacture. Service industries, particularly metalworking, forging, casting and welding would probably be needed if economic expansion occurred. Richard

Fiedler, local U.S. Peace Corps volunteer, believed that the abundant local "Mexican Tree Fern" (cyathea arborea) could be readily developed for profitable export to florists in the United States.

The initial market for these industries would be primarily local, but as industries become more advanced, the market could extend to Medellin, especially if activities supporting Medellin firms were established in Ebejico.

d. Power Utilization

Of the foregoing potential industries, all but the tile and brick industry could use electric power, and even that industry could adopt electric equipment. Other non-industrial needs for power would include probably some five to six times as much power as is now available for domestic use. The 40 bed hospital in Ebejico needs more electricity for the equipment installed. Irrigation pumping is not practiced in the area because of the natural stream flow.

e. Size of Labor Force and Skills

Labor for industry, although predominantly unskilled at present, is relatively abundant. Of the 5000 urban population, some 1600 persons, including teenaged youths can be considered as constituting the labor force under present conditions. Of these, 200 to 300 adults and teenage males are virtually unemployed, since they are the sons or immediate relatives of landowners and feel little incentive to work at available tasks. Campesino labor, both male and female, would be available especially during the off-season of the coffee crop. According to the nearby office of the Coffee Growers Federation, small industry would be warmly welcomed to supplement the income of the campesinos.

Judging by data on the vereda of LaGramala, about 20 percent of the campesino female population are working or willing to work, and some 80 percent of the men seek or have some employment. The percentage of persons working or seeking work in the pueblo is smaller. On this basis the potential labor force in the urban and non-urban part of the municipio would be roughly as shown in Table 1. These figures include children who are typically employed in rural areas for farm chores, hauling wood, tending poultry and livestock, etc.

Table 1
Estimated Labor Force in Ebejico

	Pueblo	Rural	Total
Total Population	5000	10,000	15,000
Total Males (45%)	2250	4,500	6,750
Total Females (55%)	2750	5,500	8,250
Total Labor Force	1625	4,700	6,325
Males	1350 (60%	3,600 (80%)	4,950
Females	275 (10%)	1,100 (20%)	1,375

Of the male labor force in the pueblo of some 1600 persons, about half are land owners and half are in retail shops and in the wholesaling of farm products. A few are artisans (cobblers, carpenters) but probably only six or eight could be considered mechanically or technically skilled. There are two persons connected with the local hospital, and about 15 teachers for some 950 school children from the entire municipio who attend the newly constructed girl's high school, an elementary girl's school, and an elementary boy's school.

f. Per Capita Income

The rural worker considers an annual income of 3160 pesos as standard, which means from 7 to 9 pesos per day, or about the equivalent of U.S. $.81 to $1.03. The pueblo annual income for salaried workers is about 7 pesos per day (U.S. $0.81). Actual campesino cash incomes may be much lower than the above figures, but are supplemented in kind by the campesinos' crops and livestock.

The income of persons associated with the landowner group or with the brokerage of crops and livestock is estimated as being well above these figures. According to local observers, members of these two groups at harvest time show surprising amounts of cash at cock fights or other gambling events; their individual incomes are possibly 10 or more times those of the campesino.

g. Per Capita Savings

There are no banks in Ebejico. According to local estimates, five percent of the campesino's income is considered disposable, but none is aved. Possibly the urban inhabitants of Ebejico are saving money in the sense that they are lending funds to retail establishments and occasionally to rural inhabitants, or investing in the local bus and truck firm "Transportes Eco." No estimates of savings were obtained.

i. Land Holdings

Information on the municipio as a whole was not available, but in one of the villages, about 60 percent of the campesinos own their own land. The typical land plot is only one half hectare (1.2 acres). Of the farmers cultivating their own land, 70 percent own less than one hectare (2.47 acres), about 25 percent own from 1 to 2 hectares, while 5 percent own more than 2 hectares.

Conclusion

The municipio of Ebejico offers an opportunity for a pilot project using an integrated systems approach to the productive utilization of power to raise rural living standards.

APPENDIX C

ANALYTICAL APPROACHES TO PROBLEMS OF POWER SUPPLY AND UTILIZATION

ANALYTICAL APPROACHES TO PROBLEMS OF POWER SUPPLY AND UTILIZATION

Memorandum #1 - Cost Analysis of Rural Electrification

This memorandum describes the kind of information desired for a generally applicable cost analysis of rural electrification. It may not be feasible to obtain all the detail listed: this can be determined as we learn more of the availability of data and as the analysis progresses. Three sections follow:

I General Description of the Analysis
II Technical and Cost Information
III Demand Specification

I. General Description of the Analysis

We may expect that no one approach to rural electrification will be most economical under the wide range of economic conditions encountered in rural underdeveloped areas. Electricity can be supplied at several levels of centralization, and the most economical for a given rural environment is not obvious. There are also questions as to the economical voltage for high tension distribution which have not been satisfactorily analyzed: again it is probable that there is no single answer. The real need is for a sufficiently detailed analysis to define the environment where each alternative is relevant.

To illustrate some of the alternatives which should be explored: the most rudimentary stage of rural electrification would be generation at a very small scale to supply lighting requirements in a single village. Under some conditions mechanical energy could be more economically supplied directly, rather than via a double conversion from mechanical to electrical to mechanical. The next level of electrification would be to generate sufficient power in the village to supply mechanical loads as well as lighting. Electricity would be generated and distributed in the village at the standard utilization voltage - 230/400 v in India. Depending on the agricultural and industrial load, the peek demand would probably lie within the range from 25 to 200 Kw.

The third stage would be the replacement of the village generator with a distribution transformer. A number of villages would be linked with high tension distribution lines supplied from a considerably large generating plant than the preceding case--perhaps 500 to 5000 Kw--but still an isolated plant. The final step would be integration into a transmission grid. A substation

replaces the previous generating plant, and sub-transmission lines link the rural supply areas with urban loads and major generating stations.

As the system becomes more centralized, the larger investments in distribution plant are offset by savings due to larger generating plants. Also, due to diversity between peak demands on the components of the system, the aggregate generating capacity required is reduced and the load factor improved. One must know the costs of constructing distribution lines and the costs of different sizes of generating plant on the one hand, and the magnitude and diversity of loads on the other, before one can choose the most economical alternative. Further, we expect the load to grow steadily, and construction would anticipate future demands. But, to what extent should present construction provide for future loads? And what are the costs of progressively centralizing and strengthening the supply?

Considerable detailed information will be needed to complete the analysis suggested above. Two kinds of data are required. First, we should know how costs for each mode of supply vary with the peak load, the annual energy consumed, and the spatial separation of supply points. For low tension distribution the relevant supply point is the load side of the meter, for high tension distribution it is the low voltage terminals of the distribution transformer; and for a sub-transmission grid, the output of the sub-station. Costs for generation must include plants which could replace the distribution transformers and the sub-stations, and also the costs of generation in an integrated grid.

The second class of data needed is a more detailed description of the demand for electricity. Paralleling the above, one needs information on the major classes of consumers--their spatial separation, their annual consumption, their peak demand, and the extent of coincidence of their demands.

Regarding the possible sources of information, we should obtain as much of both classes of data as possible from Indian operating experience. On supply costs, equipment and construction costs from the United States, Japan and Europe, would serve as checks and would fill possible gaps in Indian data. It may also be easier to obtain. Relative costs for different equipment should be comparable between countries. But non-Indian sources seem less useful on demand data. Foreign experience on load profiles and diversity between different loads would be illustrative, but one should expect markedly different patterns of utilization.

II. Technical and Cost Information

To proceed to cost information in some detail: it is highly desirable that cost breakdowns be reported whenever possible. E.g., investment cost is much more useful than "fixed annual costs" as various rates of interest will be used in the later analysis. Similarly, different components of cost are desirable, as each may be weighted by a different shadow price. E.g., in reporting investment cost the following could be differentiated: (1) manufactured equipment, domestic and imported being separated, (2) trained technical personnel, (3) local untrained labor, (4) locally available materials, and (5) land rights. The detail listed below illustrates the information desired: quite possibly someone familiar with the particular area could supply data more pertinent to the aims of the analysis.

A. Mechanical Drive

1. Electric motors, induction, of various sizes from fractional to perhaps 50 Hp, both 1 - 3¢ in the sizes where both are available

   a. Initial cost, including transportation;
   b. Installation costs;
   c. Operating characteristics (starting current, power factor, efficiency);
   d. Expected life;
   e. Usual maintenance.

2. Small internal combustion engines suitable to replace electric motors for direct drive.

   a. Initial cost, including transportation;
   b. Installation costs, and removal costs if rendered redundant by further electrification;
   c. Expected life;
   d. Fuel and lubrication oil consumpation;
   e. Maintenance;
   f. Operators, if required.

B. Low Tension Distribution

1. Distribution line construction costs for:

   a. Various wire sizes, copper and aluminum;
   b. Different pole construction--wood, steel, concrete, including prestressed.

2. Line losses and maintenance.

3. Meters and service connections.

   a. 1- and 3-¢ for different installed capacity;
   b. Timed meters for off peak consumption.

C. High Tension Distribution

1. Distribution transformers with associated disconnect and protective gear:

   a. From about 10-250 kva, both 1- and 3-¢ for smaller, 3-¢ for larger;
   b. Installed cost and service life;
   c. Recurring costs: maintenance and losses.
   d. For both 11 and 22 kv H.T. distribution.

2. High tension distribution lines including sectionalizing and protective devices for which the requirements vary with the length of the line:

   a. Original cost and service life;
   b. Recurring costs: maintenance and losses;
   c. 11 and 22 kv;
   d. 1- and 3-¢, different wire sizes and materials (including the new composite aluminum and steel strand analogous to "Copperweld");
   e. Different kinds of poles (as under L.T. distribution) and spacing; various loading conditions,
   f. Load and length for allowable loss and voltage drop;
   g. Conversion costs to upgrade line--heavier wires, 1-¢ to 3-¢.

3. Outage rates, or service interruptions.

D. Sub-transmission

1. Sub-stations, including disconnects, protective equipment, and regulators;

   a. Initial and recurring costs as above;
   b. Capacities from about 500-5000 kva;
   c. Variations in cost for different transmission and distribution voltages.

2. Sub-transmission feeders, including the requisite protective equipment:

   a. Costs as above;

b. For relevant voltages, probably 33, 66, 132 kv;
c. Different wire sizes and pole construction;
d. Carrying capacities.

3. Outage rates.

E. Generating Stations

1. Incremental costs for extending network generating capacity in large plants, initial and recurring costs.

2. Small and medium sized plants --10-5000 kw--for isolated operation, complete plant including all auxiliaries.

   a. Small hydro units;
   b. Internal combustion engine-driven units.

3. Capital costs:

   a. Equipment, including transportation;
   b. Power plant building;
   c. Installation costs.

4. Operating costs:

   a. Lubricating oil and fuel consumption-note quality requirements, especially possibility of using bunker oil in larger units;
   b. Maintenance: materials and spare parts, facilities, and skilled personnel;
   c. Operators, noting training and skill requirements.

5. Availability, or outage rates.

6. Costs for relocating plant; value of plant for peaking purposes on the grid after grid has been extended to its location.

7. Design of standardized self-contained packages to reduce costs of equipment, installation and maintenance.

8. Possibilities of recent developments: e.g., underwater hydro "bulb"-units (French and Swiss); brushless, generators; free-piston gasifiers powering turbines.

III. Demand Specification

Let us turn to the information requirements on the demand side. The analysis as presently planned distinguishes a hierarchy of

load points as follows: individual service connections; the point of supply to the low tension lines (generally at the village level); the supply point to the high tension distribution lines (which lead to a number of villages, the number depending on such variables as the loads per village, distances between villages, and the voltage used); and finally the grid point from which a group of sub-stations would be supplied in an integrated system. Taking the lowest level of the system, the costs of direct mechanical energy supply for the individual consumer depend on: (1) his peak requirement; (2) the extent of utilization, or the load factor, and (3) the costs of the equipment appropriate for his load. On the latter point, we have specified above the information requirements. The information on peak demand and load factor is absolutely essential to evaluate costs of supply at this level of supply, and equally important for higher levels in the system.

If individual consumers in one village are to be served from common low tension lines, whether these are fed from a generating plant directly or from a high tension distribution line, two additional variables on the demand side become critical. First, as the cost of the distribution lines varies with its length, distance between individual consumers is important. Second, in general all individuals will not require their peak load at the same time. Thus the aggregate supply capacity required will be smaller than the sum of the individual peak demands. This staggering of peak demands is commonly denoted by the diversity factor; i.e., the ratio of the sum of individual peak loads to the aggregate load, or its reciprocal, the coincidence factor. The diversity factor for a group of consumers can only be determined empirically. Generally it is greater for dissimilar consumers than for similar consumers. E.g., one might expect the peak demands of agricultural and industrial users to diverge more than the demands within either class.

The above is equally true at higher levels of the electric supply system. To determine the costs of supplying a village from an isolated generator, the critical information from the demand side would be the peak demand of the village, and its load factor. However, as soon as we contemplate grouping several villages together and supplying them from a common source, we must determine the distances between villages, and the coincidence of the separate peak demands. Interconnection between villages with somewhat divergent load profiles would lower the generating capacity required from that which would be required to supply each individually. Simultaneously, the load factor would be improved. And the same considerations hold for further integration of the supply system.

To recapitulate briefly: we need four kinds of information:

1. The peak demand.

2. The extent of utilization, or the load factor.

3. The shape of the load profile, or the timing of demand at one load point relative to that at other corresponding points.

4. The spatial separation between load points...

for each of four levels of supply points...

1. Individual service connections.

2. The village level.

3. A group of perhaps 10 to 20 villages.

4. A major grid supply area comprising a number of the above village groups plus urban loads.

Not all of the above variables are independent. E.G., the sum of the individual peak loads at one level of supply, fed from a common load point at the next higher level, multiplied by the coincidence factor (or divided by the diversity factor), yields the peak demand of the latter load point. Load factors are also interrelated.

Some of the above data may not be available. But any detailed operating experience in presently electrified areas would be most helpful. Connected loads are less useful than peak demands in data for villages and service connections. Especially useful would be peak demand measurements at several levels within a supply area--at the service connections, at the distribution transformers, and at the sub-stations. This data, plus the corresponding kwh consumption, would yield diversity factors and load factors for the several levels of supply. Further comparison of detailed load profiles for industrial and agricultural use might be justified.

All of the above relates to a system having a fairly constant load over time. Our analysis must take into account regularly increasing loads with their implications for economic design of the supply system and for building ahead of demand. Thus we need realistic estimates of the rate of growth of demand in rural areas based on the experience in area which have been electrified for a period of years.

Finally, we must take account of continuity of supply. In small generating plants the provision of reserve units to ensure supply is relatively very expensive. For small isolated hydro developments it may be costly to provide for periods of low stream flow. One can estimate the cost of providing increased dependability in the supply. But is such dependability worth the price? Admitting the difficulty of estimating the value to consumers of increased dependability, the attempt seems justified. We might describe dependability in terms of the expected hours of interruption per year, the number of service interruptions per year, or the probability in a year of interruptions of various stated lengths.

Various non-conventional energy sources can be evaluated in essentially the framework suggested above. Precisely the same economic considerations apply on both the supply and demand sides. But the weighting will vary: e.g., continuity of supply isn't a major problem on a centrally supplied electric system, but is exceedingly important for a wind-powered pump.

In both the supply and demand data discussed above, the apparent maximum requirements for information are outlined. It is quite possible that some detail cannot be obtained in a reasonable period of time; other detail may not be worth the cost of collection. But we should not underestimate the value of a thorough cost analysis. Sufficiently detailed cost analyses to guide the patterns of investments in rural electrification under diverse economic conditions seem to be non-existent. Our study could be of major service in this area.

Ralph Hofmeister, M.I.T.

Memorandum #2 - Power Utilization in Minor Irrigation

This memorandum concerns the power load characteristics of minor irrigation in Indian rural communities. Irrigation in this context is defined as the controlled application of water to arable lands to supply crop requirements, not satisfied by rainfall. It is believed that power for irrigation purposes is likely to be the basic and priority requirement in rural communities and full utilization of such power will loom large in any cost-benefit calculus. The main expansion of power loads under this heading may be due to:

a. Conversion of existing methods of irrigation to mechanical or electrical pumping; and

b. Water requirements for new areas that may be brought under cultivation, contingent on the availability of irrigation (and other inputs, like fertilizers and implements.)

The power load characteristic for irrigation in a given area will depend on a variety of factors, such as the amount and distribution of rainfall, average temperature and humidity, water resources, soil properties and water utilization practices. To start with, the following data in respect to each village or cluster of villages selected will be helpful.

A. Physical Features and Climate

1. General description of the area with regard to topography and climate.

2. Maximum and minimum daily temperature range in degrees F.

3. Average rainfall and its distribution at the nearest meteorological station. This data may be gathered in the following form:

Rainfall in Inches

Month	1957	1958	1959	1960	1961
January					
February					
March					
April					
May					
June					
July					
August					
September					
October					
November					
December					
TOTAL					

B. Soil Conditions and Water Resources

1. Brief description of the organic and mineral characteristics of the top soil, its texture, depth and permeability. In general, the soil conditions that are essential for the profitable growth of irrigated crops may be checked on the following counts:

a. suitability for agricultural implements required for efficient production;

b. effective resistance to destructive soil erosion or soil depletion;

c. adequate moisture storage to meet the water requirements of the crops under normal irrigation;

d. adequate aeration to a suitable depth to permit the development of a favorable root system;

e. availability of plant nutrients sufficient for profitable yields;

f. freedom from parasitic growth.

2. Extent of the ground water resources suitable for pumping. Is the trend of water table stable, rising or declining in recent years?

3. The pumping lift range; i.e., the vertical distance through which water is lifted for irrigation purposes. Maximum lift height is to be determined by cost considerations, because for any given size of irrigation stream the power requirement is roughly proportional to the lift.

4. Specific capacity (ratio of the discharge of the well to the drawdown) of pucca wells.

C. Agricultural Data

Whatever source of power is envisaged, it is important that both the power demands at any given time and the total annual energy required for pumping water be estimated as closely as possible. It is also important that the times of day, month or of year when these loads will occur should be taken into account.

1. Total cultivated area under various crops.

2. Total uncultivated but arable area.

3. Irrigation water requirement for various crops grown in the area. The data may be collected in the following form:

Crop	Area Under Crop	Inches each month and during the season												TOTAL
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Wheat														
Paddy														
Cotton														
Millets														
Pulses														
Sorghum														
Sugarcane														
Tobacco														
Groundnuts														
Potatoes														
Gram														
Maize														
Banana														
Onions														
Others														
TOTAL														

It would be more useful to obtain data on:

a. average inches water required for one water application;

b. number of water applications during the growing season by weeks or by months.

4. Yield per acre of various crops.

   a. with irrigation,

   b. without irrigation.

5. Percentage of net area sown more than once during the year. For a fuller utilization of irrigation (and of other inputs) it is necessary to introduce more than one crop. What are the possibilities?

6. Current market prices of produced crops.

7. Requirements and availability of farm manures (cow dung) and commercial fertilizers.

D. Water Use Practices

Inadequate preparation for irrigation, improper procedures during irrigation, or both, may result in poor crop yields, even when soil conditions are favorable and ample supplies of good water are obtainable. While a detailed consideration of preparations and constructions on the farm are outside the scope of our project, it is well to bear in mind their importance for efficient agriculture. However, we propose to give more attention to irrigation procedures which include:

a. methods of delivering water to field units;
b. frequencies of irrigation;
c. depths of water applied per irrigation.

Methods of applying irrigation water to arable lands very with topography, soil conditions, feasible amounts of preparations, crops grown, available water supplies and other factors. But in general methods of irrigation may be classified as follows:

a. irrigation by surface flooding;
b. irrigation through furrows;
c. irrigation by sprinkling;
d. subirrigation.

Similarly, the proper time to irrigate and the proper depth of water to apply during an irrigation vary with local conditions. However, it would be useful to gather information on the following points:

a. depths of water per irrigation during periods of maximum growth;
b. irrigation efficiencies, i.e., the proportion of water deliveries remaining in the upper soil layers after all losses and wastes of water are deducted.

Insofar as quantitative data may be hard to get on the above mentioned points, a qualitative description of common water application procedures would be useful.

E. Equipment and Costs

The following methods of pumping water with power are feasible:

a. surface well pumps
b. canal pumps
c. tubewells
d. dewatering pumps.

While there are profitable opportunities for the use of canal and dewatering pumps in particular areas, surface well and tubewell pumps are likely to be of far wider interest in India. In the case of pumping from surface or ordinary wells, water is lifted by means of small pumps, while irrigation from tubewells is needed to tap water deep from under the ground. The choice between the two will depend on such factors as the maximum peak demand for water, pumping efficiency and costs for installation, fuel and operations.

Pumping-plant efficiency: Pumping plant efficiency may be defined as the ratio of useful water horsepower delivered by a pump to the brake horsepower. In order to use pumps most profitably it is necessary to obtain a relatively high efficiency. If the quantity of water pumped is appreciably less than the quantity for which pumps are designed, and the head is excessive, a low efficiency results. Similarly, a pump may deliver more water than it is designed for at a lower head and cause the efficiency to be low. For our purposes, it would be helpful to obtain for various types of pumps their "characteristic curves" showing the interrelationship between speed, head, discharge, and horsepower.

Types of pumps: The most commonly used pumps are:

a. centrifugal-horizontal and vertical.
b. deep well turbine
c. plunger type.

They may be operated by electrical equipment, natural gas, gasoline, diesel, or other types of fuel. It is important to gather information on the following counts.

a. various types of pumping sets available in India, either locally manufactured or imported;

b. technical data relating to their capacity, fuel requirements, operating conditions and so forth. If possible, an effort should be made to gather the manufacturer's specifications and instruction manuals.

c. purchase price of pumps and required accessories;

d. market prices of fuels of various kinds.

Irrigation pumping costs. In order to estimate the cost of orrigation water obtained through pumping, it is customary to compute all pumping costs in terms of the

volume of water delivered to the irrigated field. It is necessary to determine the irrigation pumping costs for tubewells and for smaller individual pumps of various kinds under specified operating conditions. The cost may be itemized and determined in the following form:

Description of Pump

1. Operating Conditions

   a. water pumped in acre-feet
   b. pump capacity in gallons per minute
   c. total pumping head in feet
   d. hours of operation
   e. pump efficiency in percentage
   f. horsepower rating of motor or engine

2. Investment in Plant

   a. well--drilling, casing, etc.
   b. pump--column pipe, strainer, etc.
   c. power unit with necessary appurtenances
   d. plant housing and layout
   e. installation costs

3. Fixed Charges

   a. interest on capital costs
   b. taxes and insurance
   c. depreciation on:

      i pump and power unit
      ii well and plant housing

4. Operating Charges

   a. fuel costs--ie., oil, gasoline or electricity
   b. lubricants and grease
   c. repairs anticipated annually
   d. attendance

5. Recapitulation

   Total fixed charges
   Total operating charges
   Total annual costs
   Cost of pumping per acre foot.

If there are existing pumping plants in the area, a description of their operating conditions and costs should be obtained.

Jaleel Ahmad, M.I.T.

APPENDIX D

TVA EXPERIENCE IN RURAL ELECTRIFICATION

TRIP REPORT

TVA - ELECTRICAL DEMONSTRATION BRANCH
Chattanooga, Tennessee

July 18-19, 1962

J.D. Thompson, Engineering Applications, GEL
R.L. Gessner, Thermal Engineering, GEL

TVA Trip Report

Introduction

This visit was made to the Tennessee Valley Authority offices in Chattanooga, Tennessee to obtain information and guidance from TVA pertinent to electric power usage in rural areas. Principal TVA personnel contacted were Mr. G.D. Munger, Chief-Electrical Demonstration Branch; two members of his organization, Messrs. S.S. Haffley and W.R. Walker; and Mr. W.R. New, Chief-Electrical Marketing Branch.

The report that follows covers the following topics:

1. Summary and Conclusions
2. Educational and Promotional Programs
3. Power Distribution-Rates and Load Factors
4. Predicting Loads and Extending Lines
5. Electrical Development of a Farm
6. Walk-in Refrigerators, Food Dehydrating, Crop Drying
7. Water Systems
8. Data and Publications Obtained
9. Other Sources of Information

1. SUMMARY AND CONCLUSIONS

In its early stages, TVA faced a problem that was, in many respects, similar to the one found in the newly developing nations today: the problem of promoting effective utilization of electricity as it is introduced in previously unelectrified and economically depressed rural areas. TVA's success in this endeavor is illustrated by the fact the average residential use (in electrified residences) in the TVA areas has grown from 600 kwh annually in 1933 (equal to the average for the United States as a whole) to 9600 kwh annually now (twice the national average).

The success of the TVA program of electrical development in rural areas may be attributed to the following factors:

(1) Intensive publicity and promotion, including education and training of the populace, both directly and through the local schools.

(2) Low rates for electricity. TVA distributes electricity through non-profit municipal and cooperative electric power companies, many of which receive initial financing through long term TEA loans at low interest rates. In 1961 the average charge to residential customers was 98¢ per kwh, compared to the national average of 2.46¢. The basic TVA rate for residential service is:

First 50 kwh	3.0¢/kwh
Next 150 kwh	2.0¢/kwh
Next 200 kwh	1.0¢/kwh
Next 1000 kwh	0.4¢/kwh
Additional	0.75¢/kwh

Still lower rates are in use by many of the distributors.

(3) Low prices for appliances. TVA has worked with appliance manufacturers to make available minimum cost models, stripped of non-essential features and trim, though still meeting basic NEMA and UL performance and construction requirements. In addition, the Electric Home and Farm Authority (A Federal agency) was established as an appliance financing agency, with long time periods and low interest rates that "cut financing costs in half."

(4) Recognition of the role of sanitary, pressurized water systems as a prerequisite to economic development and consequent demand for electric power.

In general, it was concluded that TVA's experience in rural electrification, while both inspiring and successful, will not parallel closely the pattern of power usage development in the emerging nations.

The rural area served by TVA is characterized by individual farm households more or less widely separated and independent, rather than by the small communities and villages typical of many of the underdeveloped countries. Also, while the rural population of the Tennessee Valley in 1930 was generally poor and uneducated in comparison with much of the rest of this country, it was far better off than its counterparts in India and South America today. Hence TVA's emphasis was on promotion of modern household appliances rather than on power utilization for basic economic development.

Nevertheless, the educational philosophies and techniques developed by TVA, and the lessons learned in their application, should be valuable when bringing electric power into any new area. The TVA wiring demonstration kits and teaching aids are especially valuable tools which could serve as models for this class of activity.

2. EDUCATIONAL AND PROMOTIONAL PROGRAMS

TVA has used every available means of personal communication to bring awareness of electricity to rural areas and create a receptive atmosphere. Personal contacts, movies, trailers, tent meetings, as well as promotional literature, have all been used.

The five primary steps in beginning the expansion of rural electrification were listed as:

(1) Establishing confidence, by working through the community leaders, local organizations, clubs, county agents, etc. rather than the independent direct approach.

(2) Through these channels, establishing educational programs, both formal and informal: group discussions, club meeting presentations, extension courses at schools.

(3) Make detailed survey of load potential with aid of questionnaire and individual volunteers calling on their neighbors. Also detailed field work in signing up customers in advance, obtaining rights of way, etc.

(4) Plan and construct the lines based on future load potential as determined in step (3).

(5) While lines are being built, conduct intensive community education programs on how to use electricity (cooking, refrigeration, lights, water heating), how to wire, explanation of costs, etc. Emphasis on doing this through the local people in community meetings.

Since the war, most of TVA's work has been through school programs, both local high schools and land grant colleges and their extension services. TVA has prepared texts and lesson plans for state education departments, and worked with both schools and equipment manufacturers to provide demonstration equipment for home economics and manual training classes. It has designed school demonstration kits for teaching both fundamentals of electricity and also maintenance and repair of all types of farm equipment (plumbing, concrete, carpentry, electrical, welding, painting, etc.) In conjunction with the state colleges, TVA regularly holds a series of two day workshops on these subjects for training of vocational teachers, bringing them up to date information on techniques and available equipment.

A number of portable demonstration kits were shown us which have been developed to explain elements of electricity, wiring devices and techniques, fuse and circuit breaker protection, and small motor operation and repair. Several trailers have also been built to demonstrate full size electrified (automated) farm equipment. All of these appeared to be well thought out, and have proved to be very effective teaching aids.

A promotional effort specifically mentioned was the traveling Home and Farm Electrical Exposition in 1950 and 1951. This was a large tent show of electrical appliances and farm equipment sponsored by the Tennessee Valley Public Power Association in conjunction with the various appliance and equipment manufacturers. 1950's grand tour included 51 stops in four states, and covered 3000 miles, with total attendance of over 370,000 people.

Until the last few years, most of the promotional effort was aimed at household appliance usage, especially ranges, water heaters, and electric heating of houses as the primary load builders. Saturation of these devices is now quite high, and promotional emphasis is being increased on automation of farm work, principally in materials handling (feed and grain, silage, produce, etc.) A program called ELECTROFARM has been established analogous to the Gold Medallion Home Program, with farms which qualify receiving a large Electrofarm display sign and appropriate publicity. Electrofarm differs basically from the Gold Medallion Home, however, in that it is intended basically as a long range planning service for the farmer in

which he can get the help of Ag. Engineers, Home Economists, equipment specialists and home planning advisors to plan the future development of his farm. The improvement projects are actually carried out only at the speed that meets the specific needs and financial abilities of the individuals and can be economically justified.

In addition to such programs, TVA maintains an extensive program of preparation of window displays and radio and newspaper advertising as a service to their power distributors, who contract for as many of the items as they wish.

3. POWER DISTRIBUTION-COSTS AND LOAD FACTORS

TVA power is distributed by 102 municipal and 51 Cooperative power companies under contracts with TVA which establish rates and require non-profit operation. The co-ops generally start as voluntary consumer organizations, obtaining loans from REA on the basis of 33 years and 2% interest.

Co-ops now serve 583,000 consumers, ranging from as low as 2500 to as high as 25,000. They average 7200 kwh/year per rural customer compared to an average of 10573 kwh/year for urban and suburban users.

The basic rate for residential service is that shown in the summary. In addition, there are three lower residential rate schedules available, the lowest being:

First 100 kwh at 2.0¢
Next 150 kwh at 1.0¢
Next 650 kwh at 0.4¢
Additional kwh at 0.675¢

In addition to the residential rates there are corresponding sets of four rate schedules each for large lighting and power loads and for outdoor lighting service. These go as low as 0.275¢/kwh.

Load factors in the 1930's averaged in the area of 40%. As the saturation of refrigerators and water heaters increased, their random operation has increased the average load factor to about 55%. This still varies widely during the year. In 1955, in an all-electric housing project including space heating, it ranged from 35% in moderate weather to over 60% in the winter.

Limited data on load factors for individual appliances is pre-

sented in Mr. New's AIEE paper (item 13 in list of data obtained).

Average figures from a community housing project were:

Lights and Refrigerator	48%
Range	25%
Water Heater	90%
Space Heating	50%*

*Based on 8 heating months, with monthly variations from 20 to 70%.

4. PREDICTING LOADS AND EXTENDING LINES

In electrifying a rural area in the early days of TVA, attempts were made to relate line extension to potential revenue. Prospective customers were asked to fill out applications, sign easements, make deposits and sign up for the purchase of appliances.

Originally, ownership of appliances was used as a measure of potential revenue. This was found to be unreliable, and later prospective customers were asked to sign up for a certain number of kwh per month.

In general, it was found that loads grew faster than predicted, and eventually the policy of relating line extension to potential revenue was abandoned, with service being extended to any applicant. In most cases, a charge is made for extending lines more than 1/2 to 3/4 mile; however, local power distributor policies differ in this matter.

For many years, TVA has not been directly involved in line extension. This function has been assumed by its power distributors, who in general are financed by the REA. Thus we were referred to REA in Washington for quantitative information on line costs and the basis for deciding on line extensions.

It was mentioned that in the 1930's the cost of a single phase #4 ACSR line was about $600/mile.

It was Mr. New's recommendation that up to date information on this subject be obtained from the Puerto Rico Water Resources Commission, which is just completing an extensive rural electrification program there. However, it was his belief that Puerto Rico is making the same mistake that TVA made many years ago in providing too little load capacity on the lines. Voltages are too low (4800 instead of 7200) and conductors too small.

5. ELECTRICAL DEVELOPMENT OF A FARM

TVA experience has shown that the electrical development of individual farms is usually a gradual step-by-step process that begins first in the home. House lighting, an iron and a radio are usually the first applications. In many cases, these items are acquired before a water system, but continued growth is virtually stymied without a water supply under pressure. The next steps in appliance acquisition are usually a water heater, refrigerator, washing machine and range in approximately that order. Next comes one or more small motors and the first are usually portable so they can be moved from job to job. Small portable motors were widely used in the early days of TVA; nearly every farmer had at least one. These small motors are used to drive fans for ventilation, saws, grinders for sharpening tools, and other miscellaneous equipment.

The next step in farm electrification is typified by such items as feed grinding and mixing machinery, milking machines and refrigeration for dairies and lighting of the farm buildings. Then the final steps in the process of electrification involve some degree of automation. The most advanced farmers may spend many thousands of dollars for automated feed handling equipment.

The largest motors on a farm are in the 5 to 7 1/2 HP range and will be found on equipment for blowing silage up into silos and for pumping water for irrigation. Feed grinding may also involve the larger motors although many machines use motors as low in capacity as 2 HP.

Luxury appliances such as a clothes dryer, dishwasher, an air conditioner, and electric heat may be acquired at any time depending on the economic status of the farmer.

6. WALK-IN REFRIGERATOR, FOOD DEHYDRATING, CROP DRYING

Before the advent of the home freezer, locker storage plants located in communities throughout the region were very important in TVA area development. One of their major impacts was improvement of diets in the area, and resulting higher level of health, due to the increased consumption of meat. Spoilage and the cost of meat to the farmer were reduced.

In the period immediately following World War II, TVA set up many privately owned locker plants. TVA's principal contributions were in planning and designing typical plants and in conducting schools for owners and patrons. Economic studies were made: the size of community required to support certain size plants was estimated. The principal emphasis in these plants was in meat storage and processing.

Here again education turned out to be an important requirement. For example, many complained about the taste of frozen meat simply because they had never experienced the taste of good unspoiled meat before, and did not know what it should taste like. Also people didn't realize that some things such as tomatoes couldn't be frozen, or that proper preparation and packaging was required for successful storage. It was emphasized that the educational programs to overcome these obstacles had to include demonstrations at the individual level before they could be successful.

Because of the lapse of time since this work was done, further information is essentially unavailable. However, we did obtain a copy of a 15 year old TVA report "Planning a Locker Plant for the Southeast." This report is a preliminary planning guide describing principal requirements and problems. Two typical plant layouts are included.

About 10-15 years ago, TVA looked into the opportunities for food dehydraters. It was stated that ways were found for drying most everything. However, the project seemed to lack general appeal and the results never amounted to very much. The more recent patented freeze-drying process (Liana process) was suggested as offering more promise. This process is now used for a wide variety of foods for consumption in hospitals, restaurants, the military, etc. Armour and United Fruit currently hold licenses in the United States. Use of this process is currently limited by the total capacity of the available processing equipment.

Little information regarding crop drying was available. However, alfalfa drying mills and sweet potato drying and curing installations were mentioned as important factors in improving both quality and yield. The Department of Agriculture is probably a better source of information in this area.

7. WATER SYSTEMS

TVA has vigorously promoted the concept that sanitary, pressurized water systems are vital to the health and resultant

economic welfare of the rural populace. Working with state health departments and the U.S. Public Health Service, they built up five trailers with different exhibition water systems, which visited every farm in the underdeveloped areas, and held educational workshops for Health Department personnel. They assisted the Health Departments in inspecting new installations, and in promoting the award of certificates of inspection.

In 1954 only 25% of the farms in the TVA area had running water and hence were potential customers for electric water heaters. Today, as a result of these efforts, over 65% of the rural homes have inside, pressurized water systems, and 68% of rural electricity customers have electric hot water heaters. TVA puts no limit on the KVA rating of water heaters.

Reference was made to the March 1956 issue of Public Health Reports (U.S. Department of Health, Education and Welfare) for a description of the water system promotional program in the Tennessee Valley. It has been a major factor in control of malaria and hepatitis in the area.

8. DATA AND PUBLICATIONS OBTAINED

(1) TVA background data - various pamphlets and brochures on history, installations, and accomplishments in power generation, flood control and navigation.

(2) Power and People in the Tennessee Valley, 1947-1949. Booklet giving detailed story of TVA accomplishments in electrical power development and rural electrification.

(3) Annual Report (1961) of the Municipal and Cooperative Distributors of TVA power, including detailed rate schedules.

(4) Planning a Locker Plant for the Southeast - A 30 page informative bulletin for those planning to build and operate a freezing locker plant (1945).

(5) 1950 TVPPA Electrical Exposition - descriptive booklet, illustrated.

(6) Electricity and Your Farm - A manual for instruction on the practical uses and application of electricity in rural areas, prepared by TVA.

(7) Materials Handling on the Farm - illustrated pamphlet.

(8) ELECTROFARM Brochure.

(9) Workshop Folder on Electric Heat in Farm Production. A TVA prepared teaching aid containing lesson plans, instructional material, and manufacturer's catalogs and bulletins.

(10) Workshop Folder on Farm Electrical Maintenance and Safety. Similar to item (9).

(11) Diagram and bill of materials for portable wiring demonstration kit.

(12) List of text books and references on electricity suited for high school vocational agriculture students (23 titles).

(13) AIEE Conf. Paper CP 56-387 - Service to the All Electric Home. This paper shows loads, load factors, etc. for various appliances and housing projects.

(14) Curves of the contribution of different appliances to load growth in the TVA area in terms of kwh. 1946-1965.

(15) Table of saturation of electric appliances in TVA area, 1950-1962.

(16) Program of 1962 displays and radio and newspaper advertising prepared by TVA for use by their power distributors.

(17) Promotional folder on residential rates and power requirements of various appliances - Mayfield distributor.

(18) Organization chart of the TVA Electrical Demonstration Branch.

9. OTHER SOURCES OF INFORMATION

Other sources of information suggested by TVA personnel are:

(1) U.S. Department of Agriculture
Rural Electrification Authority
Electric Distribution Division
Distribution Engineering Service
Electric Farming Branch

(2) National Rural Electrification Cooperatives Association, Washington, D.C. (Mr. Clyde Ellis).

(3) Armour Research Institute (Mr. Long)

(4) Puerto Rico Water Resources Commission.