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A COMMERCIAL APPROACH TO RURAL ELECTRIFICATION

by Kenneth W. Finch

NOTE: This text is subject to editorial revision.

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## Introduction

This paper analyses some of the financial and commercial aspects of selling electricity to the inhabited rural areas of the Island of Trinidad, an island of 1 864 square miles, situated off the Venezuelan coast in latitude 10° North. Its economy is based on agriculture and petroleum, although for the last ten years the establishment of secondary industries has been successfully encouraged by Government at an ever increasing tempo. The paper attempts to establish the extent to which extension of electricity services into the rural areas can be carried out on a sound commercial basis without subsidization. It is hoped that some of the analyses might apply to rural areas in other tropical and semi-tropical countries.

## 2. Market research

As a preliminary it is necessary to know the present and potential demand for electricity in the area, that is to say, the demand which is supported by both a capacity and a willingness to pay a fair price for the services required. This is analysed in three paragraphs below under the headings Residential, Agricultural, and Industrial including Petroleum.

### (a) Residential

A firm of market research consultants, D. M. Searl Associates, Port-of-Spain, Trinidad, was commissioned to undertake a study to determine the amount of money spent by householders in non-electrified very rural areas on functions that could be performed with electricity, such as lighting, ironing, cooking, radio. The survey was undertaken in two sample areas, both in sugar-farming districts. Because of the high rate of illiteracy in the sample areas, the investigators spent a considerable time with each family discussing their habits of purchasing to establish accurate ideas of their expenditure, which is analysed below under four sub-divisions.

The use of pitch oil lighting was found to be universal. Flambeaux, although homemade from scrap material and therefore cheap, do not burn  
/fuel economically.

fuel economically. The lamp most commonly used is consequently the type of fuel-oil lamp manufactured overseas and marketed in Trinidad at a cost of about \$2<sup>1/2</sup> including a glass shade. The average yearly expenditure on pitch oil for lighting was \$13. However, the replacement of parts, especially the fragile glass shades which are often broken, results in a further average expenditure of \$9 a year, making a total of \$22.

In connection with ironing, it emerged that in homes where the budget permits clothes are regularly sent out to laundries for both washing and ironing. On the other hand many householders were counted where ironing was not a routine task because it was considered too much bother to press clothes. In view of the difficulty of ironing without electricity and the comparative ease and economy with which this task can be performed with an electric iron, there is good reason to expect that the amount of ironing done in non-electrified homes would increase rapidly after connection to the mains. In only a small number of households is the heating of irons for pressing clothes achieved through burning wood. The disadvantage of a wood fire, the heat it throws off in the surrounding air, the smoke and the soot do not appear to be of such consequence where cooking is involved. These disadvantages are probably largely responsible for the general rejection of wood as a fuel for ironing. Therefore in households where ironing is a regular part of the routine, it is usual to use coal (charcoal). The average expenditure in houses where this is done is \$15 a year.

The most commonly used fuel for cooking was wood. With few exceptions this wood is gathered at no cost, other than the labour, from areas reasonably close to the home. It is burned in a fireside which is home-made from mud or clay tapia and lasts a long time with a minimum of upkeep. The average yearly expenditure for cooking with brushwood is therefore nil and the average expenditure in those cases where wood was purchased is \$21 a year. A small minority of households was found to use pitch

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1/2 \$1 = one West Indies dollar = 4 shillings and 2 pence sterling.

/oil stoves

oil stoves for cooking, often of homemade or local made type. In many instances the pitch oil stoves were supplementary to wood-burning firesides. The average yearly expenditure on pitch oil in such households was \$19. Only a few homes were found to use charcoal for cooking, the number being too small to permit of the use of the word "average".

Radios were found in many of the homes sampled, the majority being operated on dry cell batteries with wet cell batteries being used in fewer cases. The average yearly expenditure on radio batteries was \$26.

The expenditure under the different heads mentioned for different income groups in the sample areas are summarised in table 1 below. From this it is seen that there is an average of \$46 a year now being spent by such householders for cooking, lighting, ironing and radio batteries in the lowest income group area and \$55 in a slightly less poor area. In the advent of an electricity supply, the money allocated to ironing would probably be increased. The gradual increase in living standards would also add year by year to the resources available.

Table 1  
(West Indies dollars)

	<u>Mount Pleasant</u> (Sample of 64 houses visited out of a total of 256)		<u>Carytal</u> (All 62 houses visited)	
	No.	Mean yearly expenditure	No.	Mean yearly expenditure
Use only wood for cooking	45	44	51	41
Use pitch oil for cooking	19	81	11	71
<u>Income group</u>				
A	0	-	0	-
B	4	84	0	-
C	26	64	19	54
D	34	43	43	42
Total	64	55	62	46

A statistical analysis of domestic customers, who were connected to the Commission's supply for the first time in 1953, showed that, over a four-year period to 1957, the average yearly increase of consumption of electricity was ten per cent in the Northern Area. The percentage increase was greatest in the groups of customers using less than 100 units yearly and least in the group consuming over 500 units yearly. Customers using less than 100 units yearly showed the greatest increase in the second year tapering off in the third and fourth years, whereas customers consuming 100 to 300 units yearly attained their maximum increases in the third or fourth year. The trend of customers using more than 300 units yearly was indeterminate. This could be explained by the comparatively small number of customers in these groups. These increases are shown in figure I.

The Commission will in 1960 be operating an assisted wiring scheme under which low income group houses can repay the cost of wiring with their electricity bills. Over five years the yearly cost of an average house will be about \$18. An electric "coal pot" can be paid for over three years at about \$10 a year. The overall average bill for customers on the flat rate of 13¢ a unit is about \$30 a year. The Commission is considering changing the domestic rate by reducing the minimum floor area charge from \$3 a month for 500 sq.ft. to \$2 for 400 sq.ft. to bring it into line with rural houses and make it more worthwhile for rural householders to use irons, hot plates, etc., by buying all units at 3¢. Thus it is seen that most householders, even in the poorest areas, without increasing their present expenditure can afford to wire their houses and use electricity for many purposes and as a result considerably raise their standard of comfort and convenience.

The overall average revenue from residential premises in Trinidad has risen from about \$40 a year in 1952 to \$43 a year in 1959. Duly considering the potential revenue shown in the survey, it is considered conservative to use an overall average of \$40 a year for new areas five years after connection.

Table 2 shows the use made in 1956 of domestic apparatus in two fairly prosperous sample areas that had been on supply for some time.

/Table 2

Table 2

Surveyed Sept/Oct. 1956 by D.M. Searl Associates.	RURAL				
	Curepe Sangre Grande		Couva California		Overall
	A	B	A	B	
	Monthly Income	\$10-\$100	over \$100	\$10-\$100	over \$100
<u>Method of Cooking</u>	%	%	%	%	%
Electric	-	7.5	3.7	9.5	3.7
Progas	-	32.5	-	4.8	7.4
Pitch oil	60.0	45.0	31.5	66.7	49.3
Wood	21.4	7.5	38.9	-	21.2
Coals	18.6	7.5	25.9	19.0	18.4
<u>Apparatus used</u>					
Refrigerator	10.0	75.0	1.8	38.0	24.8
Radio	51.4	82.5	35.1	80.9	56.6
Iron	44.2	72.5	55.5	90.4	53.5
None	28.5	2.5	27.1	-	19.2

(b) Agricultural

The geographical intermingling of industry in general and the petroleum industry in particular with the agricultural section of the community makes wide disparities between industrial wages and agricultural wages in a small country untenable on a long-term basis. As, however, the prices for Trinidad's primary agricultural products are fixed by world supply and demand and similar crops are produced in larger quantities in countries with lower living standards and lower wage rates than Trinidad, it is essential that Trinidad's agricultural productivity should be raised to support higher wages for agricultural workers. Increased mechanization, including electrification, can play a very significant part in this. The present and potential needs for energy in agriculture are first dealt with on a "crop" basis.

Sugar manufacture in Trinidad has tended to concentrate on a decreasing number of highly mechanized factories. There are at present two large /factories dealing

factories dealing with the bulk of the country's crops and three smaller factories dealing with the remainder. All the factories use bagasse as fuel for their energy requirements during the crop period, but the two larger and two of the smaller factories have found it more economical to use public electricity supplies during the off-crop period. If an economic use for bagasse as a raw material for paper is finally established - and it has often been suggested - then other sources of energy would have to be sought. The transfer of the cane in the field from carts to lorries or trains for onward transport to the factories needs energy to operate cranes or winches. This is largely done by self propelling mobile cranes. Fixed stations are used for canes grown by small scale cane farmers. Some of these have been electrified but unfortunately they are often in areas remote from main supply. Research is being undertaken in the possible prevention of damage by froghoppers by the use of sodium lighting. One sugar company operates a swamp reclamation scheme at present using 80 horsepower of electrically operated pumps.

Both cacao and coffee need drying before the beans can be marketed. The traditional method of doing this was using energy from the sun, but the trend is now towards artificial drying. Approximately three driers using oil for heating but requiring 15 horsepower of electricity for fan driving have been installed in Trinidad in recent years. During the same period four all-electric driers, making a total demand of 355 kilowatts for heating and fans, have also been installed. Trinidad's total cacao production is about 21 million pounds a year. To dry the whole crop electrically would require about 3 million units a year.

Rice growing needs energy in two ways, firstly on the irrigation level and secondly on the hulling of the final product. It has been estimated that the potential demand for hulling is in the neighbourhood of 2 500 horsepower, as there are known to be 250 internal combustion engines at present driving hullers of an average capacity of 10 horsepower.

There are at present 3 600 horsepower of prime movers in the timber industry in Trinidad fairly widely divided over the forestry areas. Of these 2 100 horsepower are electrically driven and 1 500 horsepower are still driven by internal combustion engines.

/As regards



As regards horticulture, experiments recently undertaken have shown that it is possible to grow mushrooms and temperate region flowers by use of air-conditioned growing areas. While such enterprises are likely to be kept near to the urban areas where they would find their natural markets, they would themselves be in the rural part of the country. The advent of more hotels will increase the demand for horticultural products.

With regard to the dairy industry, the advent of a cannery, the construction of which has already started, together with research into suitable grasses for dairy herds in the tropics should lead to demands for electricity for milking, sterilising, cheese-making, etc.

It is estimated that to provide 1" of irrigation water at the roots of plants needs 0.9 horsepower of pumps an acre. In a paper called "The Irrigation needs of Trinidad" by George Smith of the Imperial College of Tropical Agriculture in January, 1959, it has been shown that some irrigation is needed for optimum crop production over the whole of Trinidad for some time between January and May. Some areas require as much as 3" in an average dry season.

(c) Industrial (including petroleum)

The petroleum industry is a big help to rural electrification in southern Trinidad, as the industry's field requirements are increasingly being taken from the public supply. In the early stages of the industry the companies had no alternative but to provide their own power stations in the centre of their fields and run their own distribution lines to their various well locations. Such supplies were, of course, used for their own residential camps but were not generally available for non-employees working on the agricultural enterprises which are geographically interwoven with the oil industry in southern Trinidad. As a public supply of electricity has been available in southern Trinidad since 1954, the companies have made an increasing use of it but there are still over 7 500 horsepower internal combustion engines operating to generate electricity for oilfields in southern Trinidad. These are fairly widely scattered and provide a potential public demand that will one day help the commercial extension of supplies to these rural areas.

/The efforts

The efforts of the Industrial Development Corporation to encourage the establishment of secondary industries on industrial estates in the country areas are helping rural electrification.

As regards the tourist industry, the establishment of hotels contemplated along the North Coast will provide a potential demand that should ultimately justify the necessary transmission lines which will also serve the agricultural and rural portions of this part of Trinidad. The consumption pattern of typical hotels is set out in table 3.

Table 3

No. of rooms	Yearly consumption	Maximum demand
100	382 800	82
70	720 000	100
130	804 000	104
63	780 000	128

3. Commercial justification for extensions

(a) General

It is necessary to have some method of assessing whether the additional income that would result from any extension would be sufficient to justify incurring the capital costs required to make the extension. To do this accurately, it would be necessary to know the amount of electricity that would be sold, together with the load factor at which the sales would occur and how the time of maximum demand of the extension would fit into the system maximum demand curve. To do this would involve a great deal of detailed forecasting. To make use of the figures when obtained, it would be necessary not only to know many average costs leading up to the various tariff charges, but a second set of averages showing the proportional effect of units of variance. To estimate the effect of an extension on this basis would involve a great deal of engineering and accountancy work which, in the ultimate, would depend upon the accuracy with which the initial forecasts were made. It is, therefore, thought necessary to find some other method of reasonable accuracy and of sufficient /simplicity that

simplicity that could be applied in field offices and understood by customers and potential customers. The parameters easiest to establish are the capital cost of the extension and the estimated revenue that it will bring in. It has been found that over a period of years the percentage of the revenue to the net distribution capital including work in progress, has been reasonably consistent at an average of about 27 per cent. It can therefore be deduced that if in any extension the revenue forecasted for the extension is 27 per cent or more of the costs incurred to extend the supply, then it can be completed without resulting in a deficit. This is a minimum return and it is essential that some schemes should be completed with far higher returns to cover essential capital expenditure of a non-directly revenue producing type such as primary transmission, system control equipment, protective gear improvement, etc. The ratio of revenue to distribution capital including work in progress is obviously lower than the ratio excluding work in progress, but since the profit level is the result of the lower ratio, this is the one to be maintained. However, yearly changes in the proportion of capital to work in progress will alter the actual revenue to distribution capital ratio so that the average of a number of years is most acceptable. In order to study the year to year effect of the ratio used for deciding on extensions to be undertaken, the ratio of revenue to the distribution capital excluding work in progress must be watched to eliminate the fluctuation caused by the work in progress level.

A study of the ratio for the southern area on the resulting graph appears to give an indication of the development of the load of a new customer rapidly over the first few years and then falling into a steady increase comparable to the remaining customers (see figure II). This trend has been verified by independent sampling (section 2(a), figure I). For this reason the estimated revenue in five years time is used to decide on whether a particular extension is economical.

The result is an empirical yardstick reasonably independent of profit, cost levels or interest rates that compares urban and rural extensions on an equal basis. If the ratio of distribution capital to generation capital varies, then a fresh datum ratio has to be established.

/In applying

In applying this procedure fairly units of geographical areas should be assessed. This enables the anticipated revenue from an industrial establishment or an estate making extensive use of electricity to be balanced with the lower revenue to be anticipated from the purely rural residential part of the neighbourhood. To illustrate this 23 small schemes, most of which were reasonably near each other, were examined. Taken as one scheme a capital contribution of \$17 500 would have been needed to supply 1 694 customers, that is about \$10 a customer. By taking 13 schemes separately supply was brought within reach of 1 364 customers without need of capital contribution but 10 schemes or 330 residences were left beyond the reach of mains, requiring \$32 300 or \$98 a customer. It is considered that wherever possible schemes should be worked on reasonably well-defined microgeographical areas - that is a whole valley or a complete village or group of adjacent villages.

If a potential customer or group of customers who could not be supplied within the 27 per cent basis need a supply, they can obtain it by paying a non-returnable capital contribution assessed to bring the anticipated revenue in five years to 27 per cent of the capital expenditure which the supply authority would still have to meet. Negotiations on capital contributions from agricultural estates or industrial concerns where the supply is required some distance from existing mains have never presented any great difficulty, providing the capital contribution required does not exceed the cost to such a customer to install his own generating plant. There have also been cases where groups of people have willingly got together and have jointly made the required capital contribution to obtain the convenience of the supply and to avoid the necessity of buying or repairing their own individual plants, thereby adding to their own residential convenience, saving themselves money, and facilitating the supply to lower income group residences not only on the route of the new main but also within easy reach of it, who would not otherwise have been able to be supplied. It is essential that in negotiations of this type it should manifestly be seen that all customers and groups of customers are treated equally and that there is no varying from the established figure.

/In deciding

In deciding which of a number of economic extensions are to be done first, priority must be given to those extensions that bring supplies to new industries or agricultural enterprises which will increase the country's productivity and which cannot afford to wait for a supply, in other words, which would otherwise be forced to install their own generating plant to the general detriment of the cost of public supply. On the principle of connecting as many customers as possible, as quickly as possible, with the resources available, it is necessary to carry out first those extensions where the percentage revenue from the extension gives the highest return on the capital expenditure involved. This is simply a way of saying the supply is taken first to those areas where a given length of line will bring the benefits of electricity to the greatest possible number of customers.

(b) Southern Trinidad

In the southern half of Trinidad there are about 67 000 dwellings excluding the Borough of San Fernando. So far there are 17 700 dwellings connected to the supply main and it is estimated that there are 15 500 on the route of mains not yet connected. This leaves 33 800 dwellings beyond the route of the mains, of which 2 500 are supplied by oil or sugar companies, leaving 31 300.

It is estimated that it would cost about \$7 million to make the supply available to 27 000 of these dwellings - that is to 95 per cent of the total dwellings in the region. Using the figures from the first part of the paper it is estimated that the total revenue from 20 000 of these dwellings, five years after connection, would be about \$0.8 million a year and that industrial and agricultural revenue including street lights from these areas not yet on supply could be about \$1 million, when the oil industry can be persuaded to shut down the rest of their various internal combustion driven generators on the fields. The total revenue of \$1.8 million is 27 per cent of the total cost of \$7 million. This indicates that it should be possible to carry the supply to 95 per cent of the premises in the region without subsidy providing an intensive sales drive coupled with the assisted wiring scheme can lead to 75 per cent

/of the

of the premises on the route of mains being connected within five years; providing a supply of sufficient reliability can be given to attract the remaining oilfield load (not the refineries which will probably always generate their own supplies), and providing those schemes with the highest percentage returns are carried out first.

In about three to four years time when all the schemes above 27 per cent have been completed, it will be necessary to assess the effect of extending the supply to the few remaining microgeographical areas still without supply which show a return rate of less than 27 per cent on the profit level required to finance locally incurred capital expenditure. Until all the areas of 27 per cent and over are on supply any estate or group that will not yield 27 per cent must continue to pay a capital contribution calculated on the present basis.

It is obviously impossible in any country to provide simultaneous electricity services over its whole rural area and it is therefore necessary to have an orderly but flexible plan of sequential development. The plan must be flexible so as not to hinder industrial and agricultural development. Any plan however fairly and well drawn up will not be favourably received by the potential customers who would have to wait four or five years for their supply, but their natural impatience can be minimised by good public relations and by letting it be seen that the overall planning is done so as to spread the supply over the whole rural area as rapidly as possible. This means it is necessary for the Supply Authority not to yield to lobbying from vocal pressure groups and to seek the support of the elected representatives of the people for keeping to the orderly planned development as a method of achieving total electrification in the shortest possible time. It is also important to explain to the people in the rural community that the development of the urban and industrial sections of the supply area by increasing the scale of the Authority's operations is reducing the unit cost of production and making a material contribution to the economy and scope of rural development.

/(c) Conclusions

(c) Conclusions

It should be remembered that the object of this method of assessment is to maintain a ratio of total revenue to capital investment in transmission and distribution that will ensure sufficient yearly profit to finance at least the local expenditure of the whole of the necessary development of the generation, transmission and distribution system. It has been shown that the whole region of southern Trinidad taken as a whole would be "economic". However, availability of skilled labour and financial resources are such that even if the work is carried on at an ever increasing tempo it will take many years to complete. It is therefore necessary to continue the development in stages. The first stages must contain the "more profitable" microgeographical regions, both because at this stage of the undertakings' development uneconomic extensions would so effect the overall ratio that the required profit to finance local expenditure would not be produced and equally important, because, by carrying out first the more economic extensions available resources are so used that the supply is brought to more premises in each year than would be possible with any other system of development.

However, when all the economic extensions are completed in about four years time and the work at present executed has reached its target revenues because the overall region has been shown to be "economic", it is a reasonable deduction that the remaining microgeographical regions with returns below 27 per cent will be able to be absorbed without dropping the overall ratio below that then required, to produce the profit necessary to continue financing local expenditure on capital development. There is thus every indication that the supply can be brought on a commercial basis to 95 per cent of the dwellings in southern Trinidad without need of subsidy, providing the extensions are carried out in the planned sequence described.

4. Summary

The first part of the paper summarizes market surveys undertaken in recent years to establish the demand for electricity in the rural areas of Trinidad. The second part establishes an empirical rule for ascertaining

/whether the

FIGURE 11  
GRAFICO 11

RATIOS OF REVENUE TO TRANSMISSION & DISTRIBUTION CAPITAL EXPENDITURE  
RAZON DE GANANCIAS A GASTO DE CAPITAL POR TRASMISION Y DISTRIBUCION

- ALL TRINIDAD INCLUDING WORK IN PROGRESS  
          TODO TRINIDAD INCLUYENDO TRABAJO EN EJECUCION
- - - - - ALL TRINIDAD EXCLUDING WORK IN PROGRESS  
          TODO TRINIDAD EXCLUYENDO TRABAJO EN EJECUCION
- SOUTHERN AREAS ALONE EXCLUDING WORK IN PROGRESS  
          SOLO DISTRITOS DEL SUR EXCLUYENDO TRABAJO EN EJECUCION

