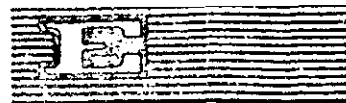


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TRINIDAD'S POWER SYSTEM

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NOTE: This text is subject to editorial revision.

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/1.Introduction

1. Introduction

The Island of Trinidad, 1,864 square miles in area, lies 10° North of the Equator and just 9.4 miles off the Venezuelan coast. The principal town, Port-of-Spain, has a population of 121,150 and the second town, San Fernando, 25 miles away, has a population of 39,800. The total population of the island was 788,600 in 1959.

Electricity was introduced to Port-of-Spain at the turn of the century by group of local business men. In 1901, the concern was bought over by a Canadian who later handed over the undertaking to the Trinidad Electric Company Limited. The Company's franchise expired in 1937 by which time electricity was available only in the city of Port-of-Spain and its immediate environs. Responsibility for electricity was then vested in the Trinidad Electricity Board, representing the City Council and Government. In 1946 the City Council was given the responsibility of distributing electricity within the city limits and the Trinidad and Tobago Electricity Commission was made solely responsible for the generation of the public supply of electrical energy together with all distribution except that in the city of Port-of-Spain and in the Borough of San Fernando. The Borough of San Fernando operated a diesel station from 1923 until 1954. In this year it was sold to the Commission and used as a peak load station until 1957 when it was deactivated. San Fernando now buys its supply of electrical energy in bulk from the Commission.

The present paper traces the history of the growth of Trinidad's power industry from 1936 to 1960.

2. Rate of growth of public electricity supplies

In the period 1937 to 1943 the number of units generated per year increased from 4.4 million to 24 million, at a reasonably consistent yearly growth rate of 32.7 per cent. The shortage of plant, resulting from the war years, made it necessary to ration electricity from May 1942 to May 1944. As is usual with rationing, the effect on sales of energy in the first year was not great but for many years subsequent to the rationing period the growth rate fell from 32.7 per cent to 10.9 per cent.

/Shortage of

Shortage of appliances following the war contributed to this slower growth. Rationing coupled with appliance shortages had created a state of mind among the public in which electricity had no place. To counteract this Commission started advertising in 1952, at the same time introducing promotional rates. Government's Aid to Pioneer Industries Ordinance enacted in April 1952 started a programme of light industrialization. The combined effect of these efforts was that the generation of electricity increased at a yearly rate of 18.2 per cent. This percentage increase has been maintained ever since, thereby reflecting the general and continuous upsurge in economic activity. These changes are illustrated in figure I. The yearly load factor has been improved from 54.4 per cent in 1950 to 60.5 per cent in 1959.

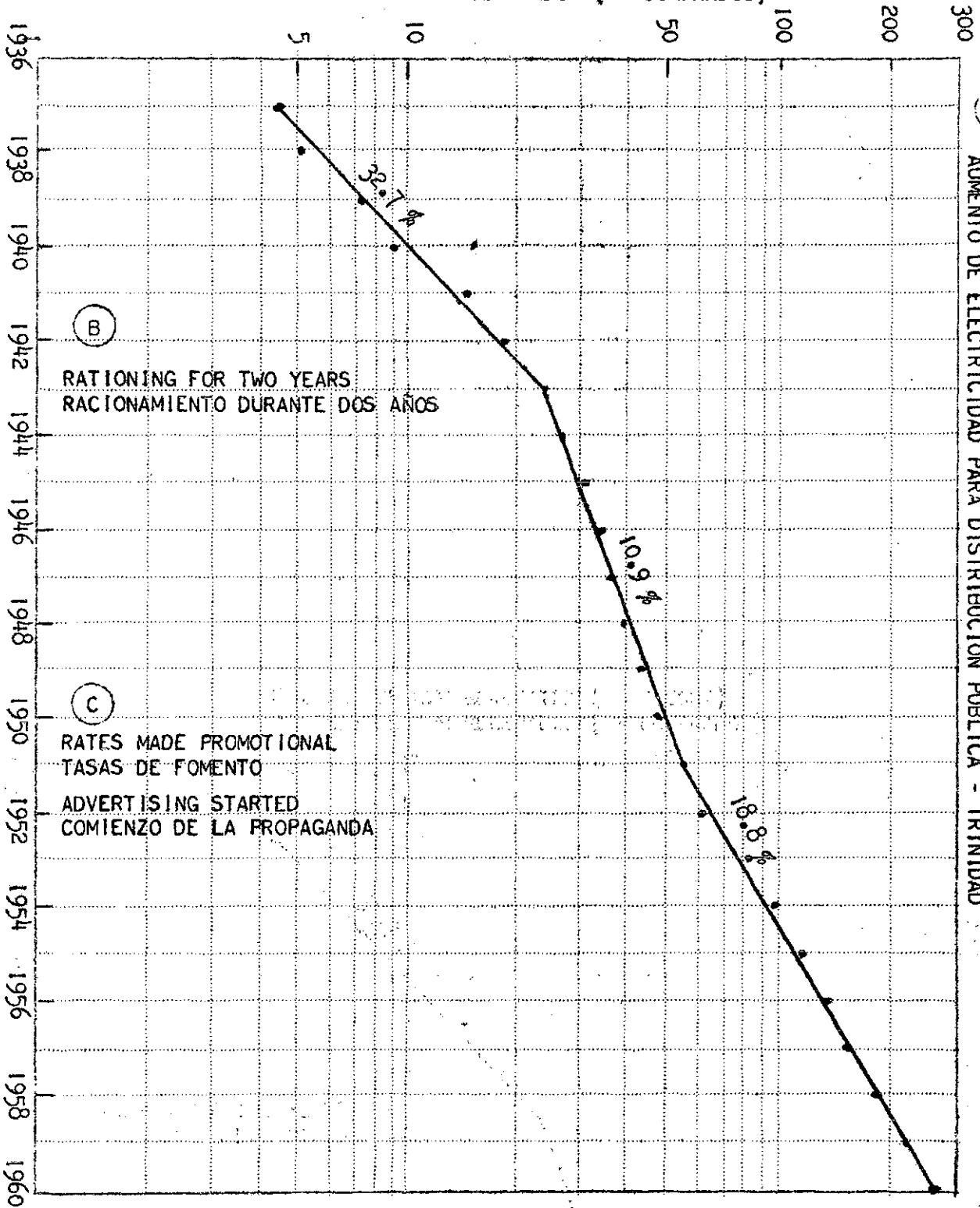
6,613 customers were supplied by the Commission when it commenced business in 1946, increasing to 15,400 by 1952 and to 54,875 by June 1960. Including the municipalities and oil companies, 80,200 Trinidad premises used electricity at the end of 1959. At 31st December, 1952, the Commission's network extended over 580,278 miles of overhead line, increasing to 1,455 miles by December, 1959.

3. Present generating plant

Figure II shows the hourly maximum demand in each year since 1948, together with the installed capacity and the firm capacity (defined as "the demand that can be supplied with the largest set not available") since 1940. It will be seen from this figure that on a number of occasions the actual maximum demand has exceeded the firm capacity. It has nevertheless been possible to meet this demand without having to interrupt supplies, by making arrangements with three owners of private standby generating stations to have their plant available during the Commission's peak periods, in co-ordination with the Commission's maintenance programme. It has occasionally been necessary to reduce the load by reducing voltage at times of peak demand. As the system grows it has become increasingly difficult to cover such short term plant deficiencies this way, because the Commission's policy is to encourage all new industries to rely

/exclusively on

MILLIONS OF KWH GENERATED (+ BOUGHT)
 MILLONES DE KWH GENERADOS (+ COMPRADOS)



(A) GROWTH OF ELECTRICITY GENERATED FOR PUBLIC SUPPLY - TRINIDAD
 AUMENTO DE ELECTRICIDAD GENERADA PARA DISTRIBUCION PUBLICA - TRINIDAD

FIGURE 1
 GRAFICO 1

(B)

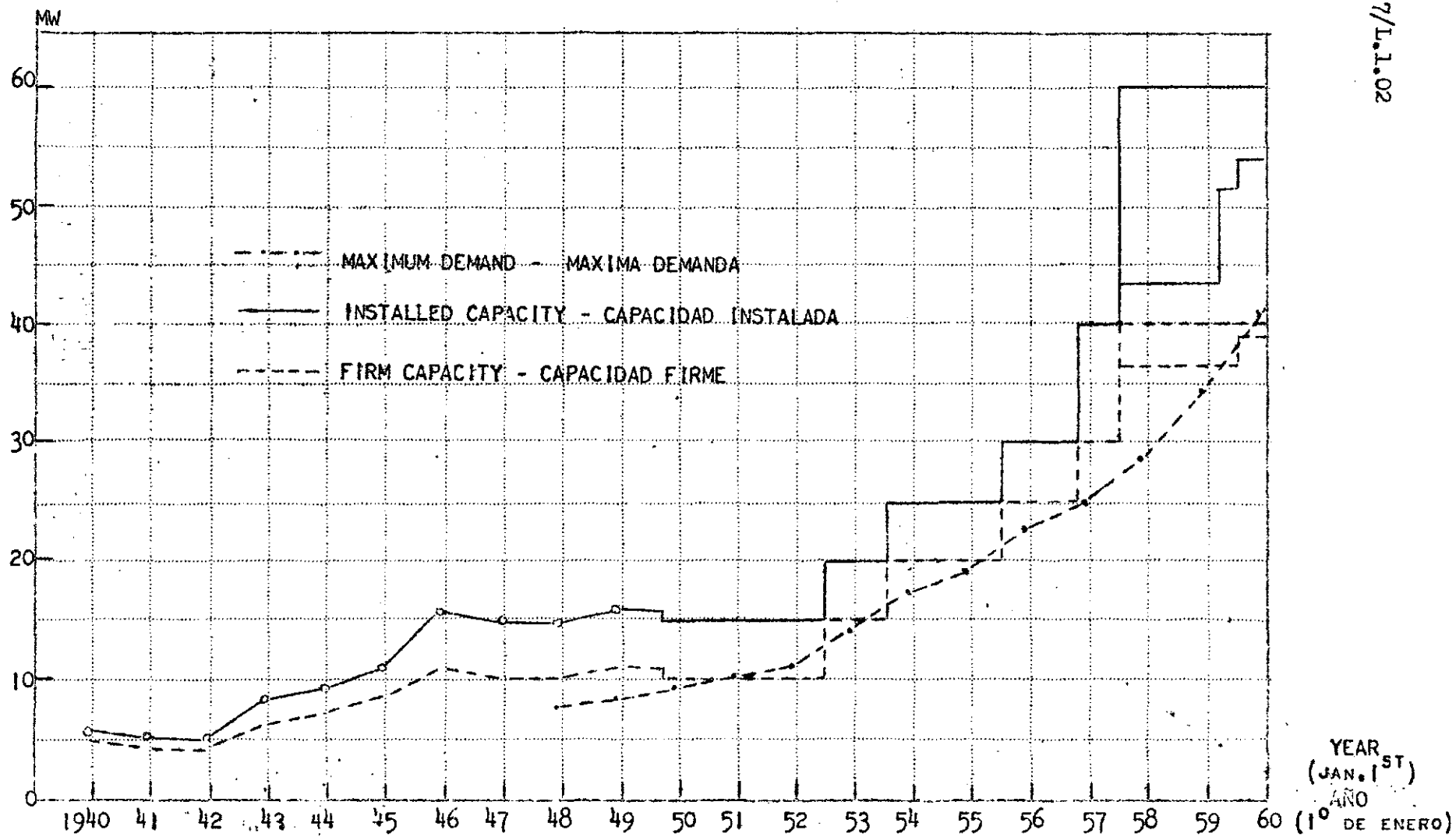
RATIONING FOR TWO YEARS
 RACIONAMIENTO DURANTE DOS AÑOS

(C)

RATES MADE PROMOTIONAL
 TASAS DE FOMENTO
 ADVERTISING STARTED
 COMIENZO DE LA PROPAGANDA

FIGURE II
 GRAFICO II

MAXIMUM DEMANDS AND GENERATING CAPACITY - TRINIDAD
 MAXIMAS DEMANDAS Y CAPACIDAD GENERADA - TRINIDAD



exclusively on it for all electrical requirements. The private plant available for such standby purposes all date back to the days before the Commission's supplies were generally available. These consist of:-

- (a) One plant of 1,000 kW diesel.
- (b) One plant of two 800 kW diesels, and
- (c) One Services plant of 2,800 kW diesel.

In the early days the authority's sole power station was situated within the city of Port-of-Spain, near enough to the harbour to use salt water for condensing purposes and for fuel oil to be supplied by seagoing barges and pumped to the station. This Port-of-Spain station contained both diesel and steam power and continued to supply an ever expanding network. The first 5 megawatt set and boiler ordered for the new Penal Station, were installed at the Port-of-Spain station as an emergency measure since this set could be commissioned quicker than developing the new station. The set went on commercial load in July, 1952.

From 1954 to 1956 the Port-of-Spain station was modernised. New main switchgear of 250 megavolt-amperes rupturing capacity was installed in a new switch-basement, feed pumps were grouped in a feed pump bay and auxiliary switchgear centralised in a new auxiliary switchroom. Originally feed pumps and auxiliary switchgear had been scattered all over the station. Steam receivers were installed to enable any boiler to feed any turbine. An air-conditioned control room was located in the gallery that had previously housed the main switchgear. All this was done while the station was on load and without interrupting the normal supply of electrical energy. In November 1956 a 10 megawatt turbo-alternator and an additional boiler were commissioned in the station. This plant operates at 3,600 r.p.m. with steam conditions of 400 lbs/sq.in, 750°F.

It had been decided, as early as 1946, that there was a good case for building a second power station within the oil belt in Southern Trinidad, to be fuelled by natural gas piped from an oilfield. It was hoped that a station in this position would also be able to supply some of the oilfields' requirements of electricity. Work was commenced in 1950 on a station designed to have an initial capacity of 10 megawatts

/but to

but to be increased ultimately to 30 megawatts. The station was planned to generate at 6.6 kV and to operate at the same steam conditions as the Port-of-Spain Station, to facilitate interchanging of spares. The site chosen was conveniently near road and rail, situated above a water table that could provide make-up water for the cooling tower condensing system from four wells on the 50 acre station site and near a central natural gas collection station belonging to the Shell Oil Company. It was realised by 1951, even before the first set was installed, that the ultimate capacity of the station would have to be more than previously envisaged. It was decided, therefore, to change to 11 kV using an auto transformer to obviate the necessity of changing the station's main switchgear within the first two or three years of its life. The first 5 megawatt set was commissioned in 1953 and the second, generating at 11 kV, went on load in 1955. The Port-of-Spain station was linked to Penal by a 66 kV overhead line which was also used to provide supplies at five 66/12 kV substations along its length.

An analysis of the overall generating plant then undertaken showed that although the bulk of the power requirements was still in Northern Trinidad and would remain so for at least many years, it was more economical to meet these requirements by generating at Penal and transmitting energy to the North as electricity, than by transmitting natural gas to the North by pipe line and converting it into electricity in Port-of-Spain. It was, therefore, decided to install at least two 20 megawatt sets in the Penal Station. The first was commissioned in May, 1957. To meet the additional make-up water requirements for the cooling tower system, four more wells at greater distances from the station had to be bored. The cost per gallon from this project showed that it would be cheaper for the cooling water for the second 20 megawatt set and for the third which was then envisaged, to be obtained by a pumped storage scheme.

Investigations made by the consulting firm of Howard Humphreys & Sons showed that the Coora River that flowed by the station site could provide the water requirements. A site for the storage reservoir about 1 1/2 miles from the station was found. This work was put in hand and the

second 20 megawatt set, together with the water system both for this set and the third 20 megawatt machine, was brought into use in September, 1960.

This extension made it necessary to have a 33 kV switchboard linked to the original 12 kV board by a 15 MVA unit transformer. A second 66 kV line was needed to transfer energy to the North when the first 20 megawatt set was installed. This was a straight transmission circuit. To provide greater flexibility a main 66 kV substation with a ring bus was constructed in Central Trinidad near San Fernando, and behind the oil town of Pointe-à-Pierre. Three primary 66/12 kV substations that had been connected to the first 66 kV transmission line by high voltage fuses were then fed by radial feeders from the central 66 kV substation. A 132 kV link of 50 MW capacity is being constructed as part of the second and third 20 megawatt extensions.

4. Future generating plants

In 1959 a further analysis was undertaken to indicate where the next extension, required about 1963, should take place. It was found that the demands in northern Trinidad by 1965 would be such that it would then be more economical to transmit natural gas to Port-of-Spain by pipe line and generate the North's requirements of electricity at the Port-of-Spain Station. It was, therefore, decided to develop a site adjacent to the Port-of-Spain station, at present owned by the Port-of-Spain Corporation Electricity Board. This site would be able to take two 50 megawatt sets and two 60 megawatt sets. By constructing pipes or culverts across very difficult made-up ground between the Station and the harbour water front seawater would be used for cooling purposes. Steam conditions will be 900 lbs/sq.in., 900°F. The 132 kV system which had been built to transmit a maximum of 50 megawatts from South to North as part of the Penal extension scheme would then be used to enable each of the two stations to act as standby for the other, while, in general, the North's requirements would be generated in the North and the South's requirements in the South.

The pattern of plant growth after the installation of the two 50 megawatt sets in the Port-of-Spain station will be dependent on the
/relative growth

relative growth of demand for electricity in North and South Trinidad.

Preliminary plans have also been prepared for the installation of two 50 or 60 megawatt sets on the existing Penal site. These would call for a second pumped storage scheme for cooling water. An initial survey has located a suitable site for the storage reservoir about three miles from the station. This reservoir could provide more storage than the Power Station's total requirements but the pumping installations which would draw water from more than one river could be developed as the water was requires. Such a scheme might also help the agricultural development in that part of Southern Trinidad which is now subject to flooding. It might prove economical to develop the first part of this storage scheme in anticipation of the plant extensions, to obviate the necessity of continuing to maintain the eight wells, yielding 400,000 gallons a day, required for the initial 30 megawatt of plant in the station.

5. Costs of plant

The initial installation at Penal was expensive as it had to include site clearance, a road network, workshops and ancillary equipment for a larger station. Each extension, by making greater use of the original installations, has resulted in a successively lower price per kilowatt installed. By 1961 when the installed plant will be 70 MW the overall cost will be \$271 per kilowatt.

Table 1 has been completed showing the total cost and costs per kilowatt of all the plant at both stations. It also shows the authorisation, ordering and commissioning dates of the various extensions.

6. Summary

The paper traces the growth of public electricity supply in Trinidad since 1936 in three periods - from 1936 to 1943 at 32.7 per cent growth rate, from 1943 to 1951 at 10.9 per cent and from 1951 to the present at 18.2 per cent. Generation and main transmission plant is described and costs are given for the power station plant.

COSTS AND CHRONOLOGICAL TABLE OF VARIOUS EXTENSIONS

(West Indies dollars; one dollar = 4/2 d sterling)

Sets	Total cost of extension	Cost per kW of extension	Total cost of station (excluding residence)	Cost per kW for station	Date authorized	Date ordered	Date commissioned	Remarks
<u>PENAL</u>								
Nº 1 5 000 kW			3 120 738	624		Apr.1949	Jul.1953	Including dam, roads, workshop and site clearance.
Nº 2 5 000 kW	932 372	187	4 053 110	405		Nov.1949	Jun.1955	
Nº 3 20 000 kW	4 132 506	207	8 185 616	273	Jun.1953	Dec.1953	May 1957	
Nº 4 20 000 kW	10 768 000	270	18 953 616	271	Jul.1957	Dec.1957	Sep.1960	Including \$1 068 000 for pumped water scheme
Nº 5 20 000 kW					Nov.1958	Jun.1959	Oct.1961	
<u>P.O.S. "A"</u>								
14 900 kW			3 375 247	227				Cost of plant from 1939-1945. Installed capacity.
Nº 9 5 000 kW	1 430 108	286	4 805 355	241		Apr.1949	Jun.1952	Cost of extension includes a culvert of approx. \$260 000 which also serves the 10 W set
Nº 10 10 000 kW	2 711 256	271	7 516 611	251		Mar.1953	Oct.1956	Including new switch-board for whole station
<u>P.O.S. "B"</u>								
Nº 1 50 000 kW			31 445 000	314	Dec.1959		Sep.1963	Including \$7 200 000 for civil works and main providing sea-water cooling for
Nº 2 50 000 kW							Sep.1964	

