

The Capacity Expansion Process
in the Electricity Supply Industry

by

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Abstract

The aim of this paper is to make a brief description of a model of the policies for achieving an adequate level of capacity in the Electricity Supply Industry. The purpose of the model at this stage is to reproduce the effect of those policies and of exogenous events on the performance of the industry.

This problem is an important one because the industry has found itself with a considerable excess of installed capacity for meeting a slackening demand.

Introduction

The critical feature of the process of achieving an adequate level of generating capacity for meeting peak demand in this industry is the long time it takes (7-8 years) to construct a new power station. This determines the minimum time horizon of the forecasts on which are based the investment programmes and ordering decisions for generating plant.

In the 1960's these demand forecasts were based mainly on the past demand trend and on future growth estimates derived from the government's National Plan of 1964 which proved to be overoptimistic, Fig. 1 shows the actual orders placed by the industry since 1953. This ordering pattern has left the industry with a financially painful 42% excess of capacity (Fig. 2) and another 34% under construction to be commissioned between 1976 and 1981.

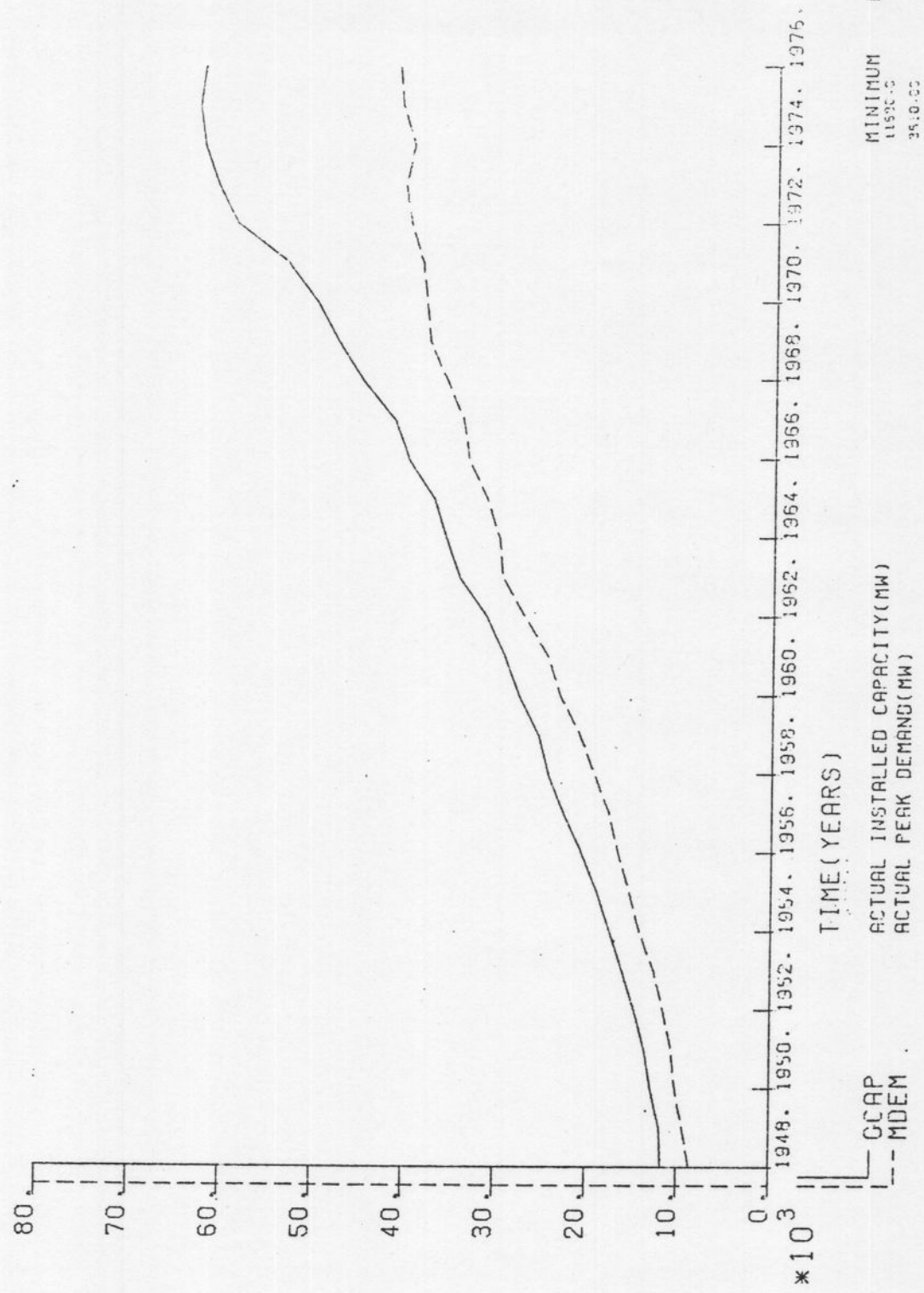


FIG.2 ACTUAL INSTALLED CAPACITY AND PEAK DEMAND
UK ELECTRICITY SUPPLY INDUSTRY

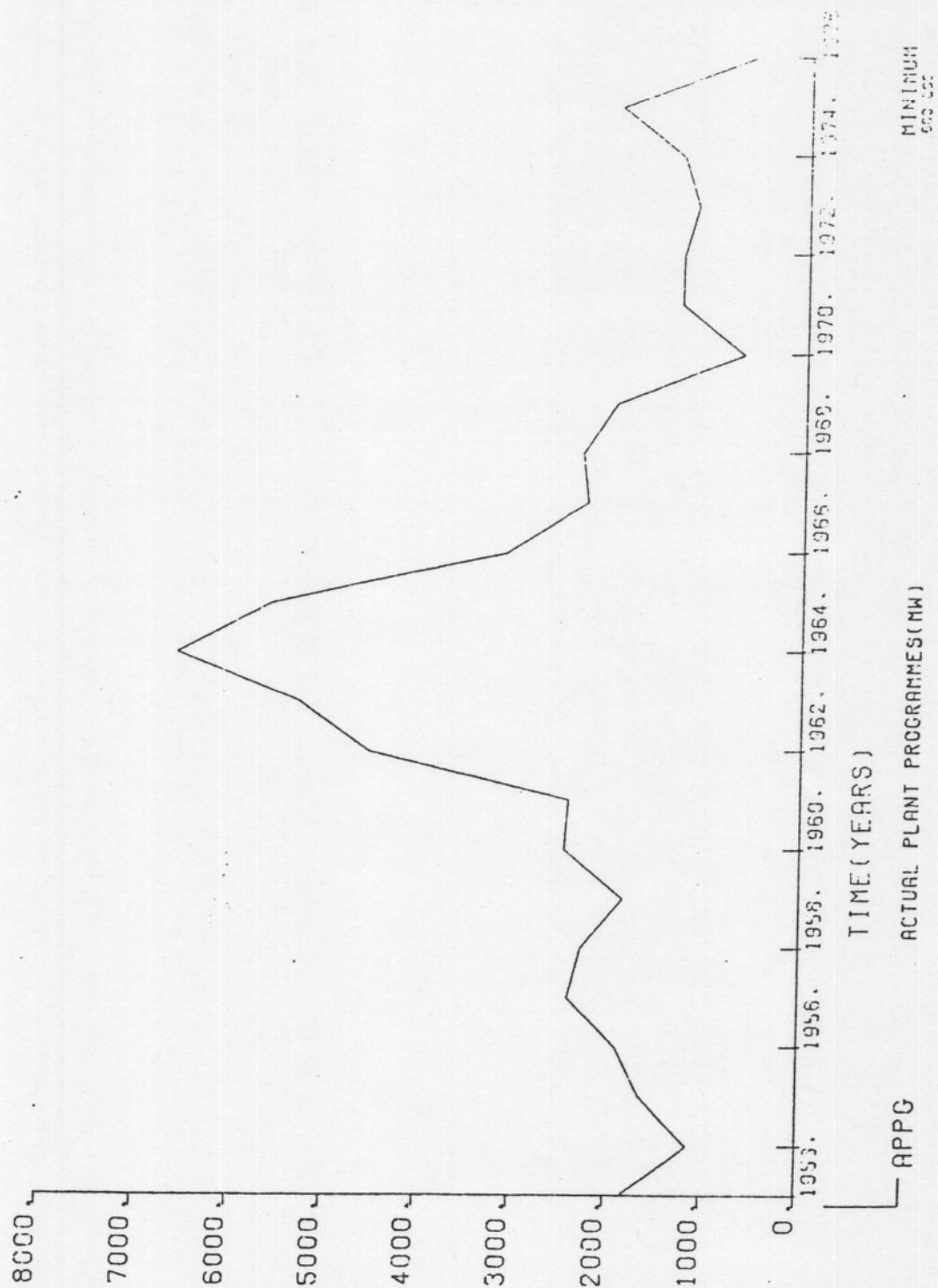


FIG.1 ACTUAL PLANT PROGRAMMES ADOPTED BY THE IND
UK ELECTRICITY SUPPLY INDUSTRY

Apart from these problems arising from its internal structure, the industry is subject to the effect of external influences coming from its environment, of which the more important are:

- a) the restrictions imposed by the government on a wide range of decisions
- b) the competition presented by the Gas Industry
- c) the sharp and sudden changes in price and availability of fossil fuels

An illustrating example of these external influences is the pressure being exerted by the government for the early ordering of Drax B (a coal fired plant) by the CEGB that will benefit the Power Engineering Industry, which badly needs orders, and the NCB.

The Model

The model has been constructed with the necessary detail to reproduce the current state of affairs in the industry in order to form a basis for an overall analysis of the system's structure and its behaviour with the aim of finding policies that would avoid present overcapacity and that would work well for various future scenarios.

This paper concentrates on the description of the sectors of the model dealing with the ordering, construction, commissioning, running and scrapping of generating capacity. A model to show the financial implications of these decisions is currently being tested.

A simplified influence diagram of the model is presented in Fig. 3 showing the most important feedback loops in the system. The main sectors of the model are: Capacity Expansion, Capacity Depletion and Demand Forecasting.

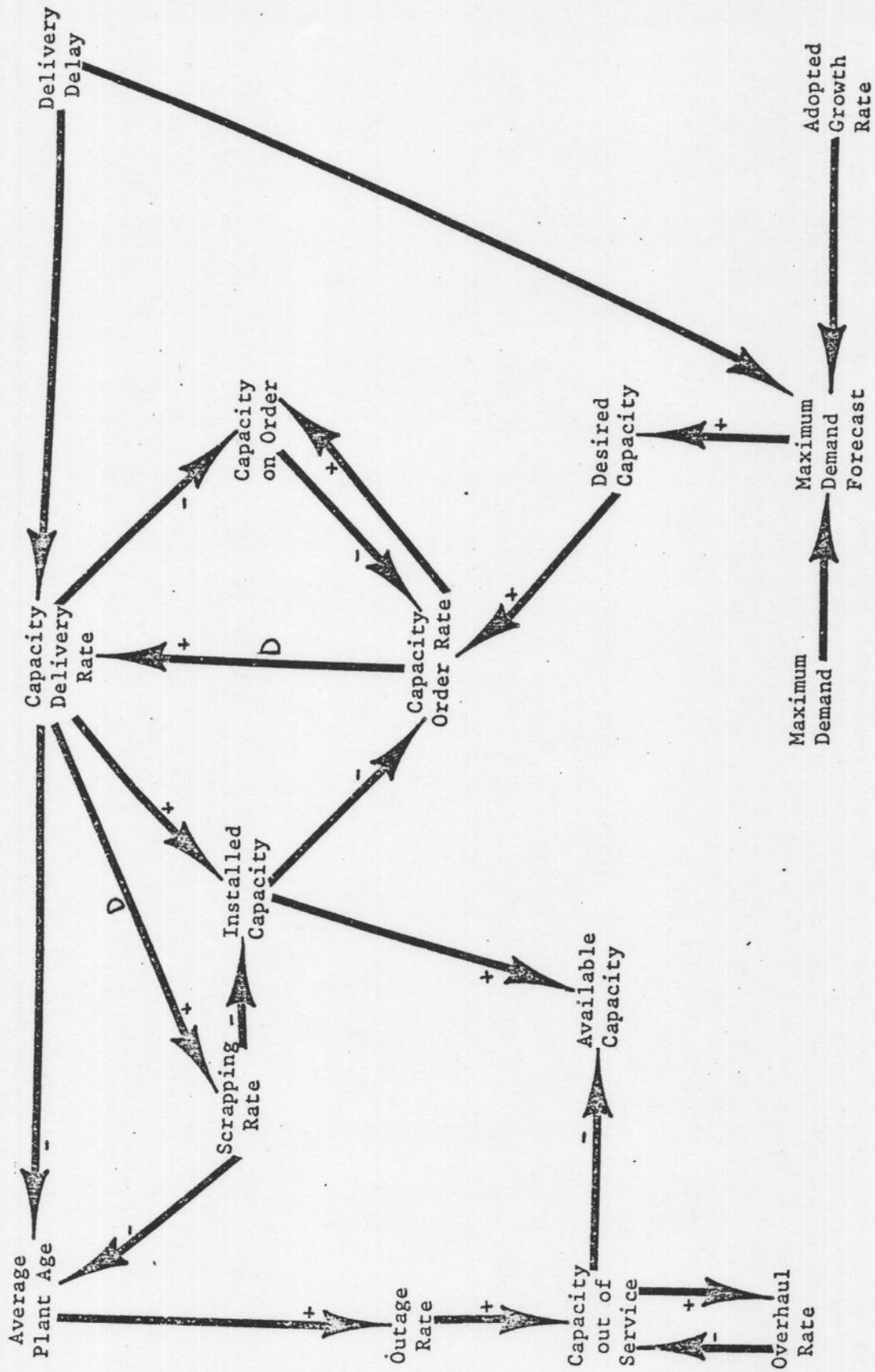


Fig.3. Simplified Influence Diagram of Capacity Expansion Process

Capacity Expansion Sector

This sector models the mechanism by means of which the system seeks to achieve an adequate level of capacity for meeting maximum demand. This is the most important sector of the model as it contains the most critical feedback loop which determines the main features of the system's behaviour. It simulates how the system reacts to changes in peak demand by ordering, commissioning and withdrawing or scrapping generating plant, and how this response is highly affected by the long time needed to construct that plant. This delay is the main source of problems as it impairs the speed of response of the system and increases the vulnerability to error in the demand forecasts.

The installed capacity, which is all the generating capacity owned by the industry, is increased by the capacity delivery rate and decreased by the scrapping and withdrawal rate. The capacity delivery rate represents the generating plant brought into service every year and is modelled as a delay function of the rate at which that plant is ordered seven years earlier.

The capacity order rate, which is the plant programme adopted each year by the industry, is simulated in a discrete pattern by means of a PULSE function. The amount ordered each year is either an integer multiple of the minimum plant size available that year when the required new plant is greater than the minimum plant size or nothing when it is less than that minimum size, this is achieved using a CLIP function.

The required new plant is calculated by subtracting from the amount of capacity the industry desires to have in the expected year of completion the present installed capacity (corrected by availability factors) and the capacity already under construction, and by adding the capacity planned to be scrapped and/or withdrawn from service during that period.

The desired capacity is the capacity necessary to meet the estimated peak demand in the expected year of commission plus a spare margin to cover the risks of greater plant outage than expected, more severe weather than average and serious inaccuracy in the forecast.

The capacity available for generation is the installed capacity less the capacity out of service and allowing for the stations power consumption.

Capacity Depletion Sector

The decision for retiring old plant from service is a difficult one as there is not a convincing economic case for voluntarily scrapping generating plant that is old and inefficient but still serviceable (4). The average age of power stations withdrawn from service in the period covered by this simulation has been 40 years. Hence the scrapping rate is modelled as delay function of the plant commissioned 40 years earlier.

The capacity out of service every year is increased by the outage rate which comprises both the capacity forced out of service by breakdowns and the planned outage for overhaul; and is decreased by the overhaul rate.

The outage rate is calculated as an annual fraction of the installed capacity. This fraction is the addition of the desired fraction of capacity out of service for overhaul and the fraction of capacity forced out of service whose dependence upon the average plant age has been modelled using the Wiebull distribution. The average plant age is calculated using the formulation for average age of a group of items (3).

Demand Forecast Sector

The forecast is based on the exponential growth rate of the peak demand trend, in average weather conditions, in the ten years prior to its elaboration. The adopted growth rate, which is modified mainly by considering the economic situation, is used for calculating the future estimates of peak demand.

Performance of the Model

The results of the computer simulation using the actual time series (1947/48-75/76) for maximum demand (6) as an input to the model, are compared in Figs. 4 and 5 with the actual data for the industry.

These figures illustrate that the model is achieving an acceptable fit to the actual responses of the industry by closely reproducing the shape of the orders time series and attaining a similar level of installed capacity through most of the simulation period.

The slight lag in the computed installed capacity by comparison with the actual figure shown in Fig. 4 is considered to be the effect of averaging the delivery delays of all plant (conventional, nuclear, gas turbines, etc.). Further efforts are being made to obtain more detailed data on variations in the delivery times of the different types of plant so as to improve the fit.

The close fit shown in Fig. 5 illustrates how consistent the ordering policy of the industry has been. The order pattern has been greatly influenced by political pressures which have, in the past, taken the form of recommendations to adopt future growth rates in line with Government plans. Recently these pressures are becoming more specific, as evidenced by current Government pressures for the order of a large coal fired station (Drax B) since shifting the growth rates above the demand trend no longer justifies the present political need for early large orders.

However, for assessing the effects of alternative ordering policies and forecast methods the performance of the model is satisfactory and further research work is being carried out to this purpose, running the model with various inputs of past and future demand.

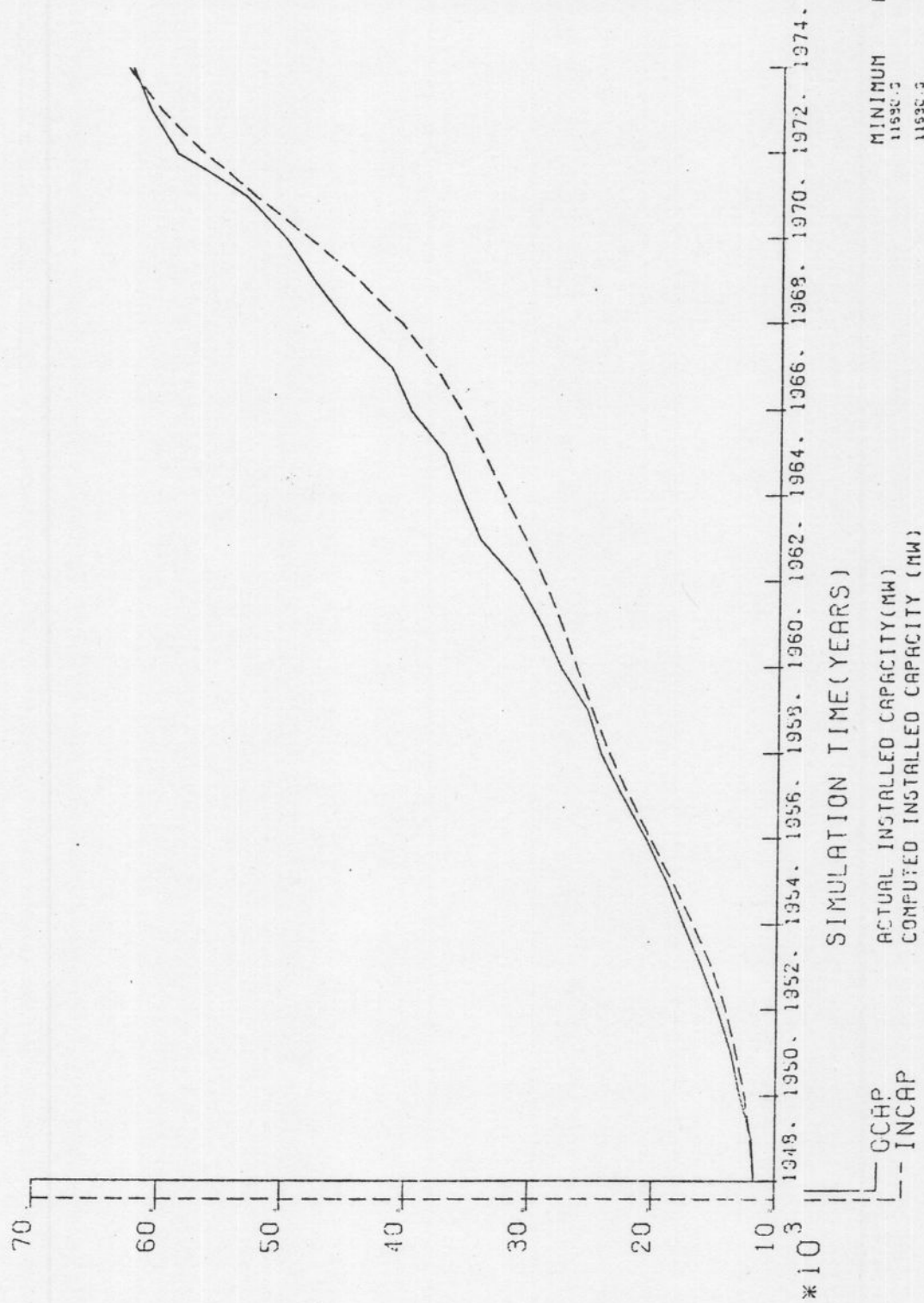


FIG.4 ACTUAL & SIMULATED ESI INSTALLED CAPACITY
UK ELECTRICITY SUPPLY INDUSTRY MODEL.

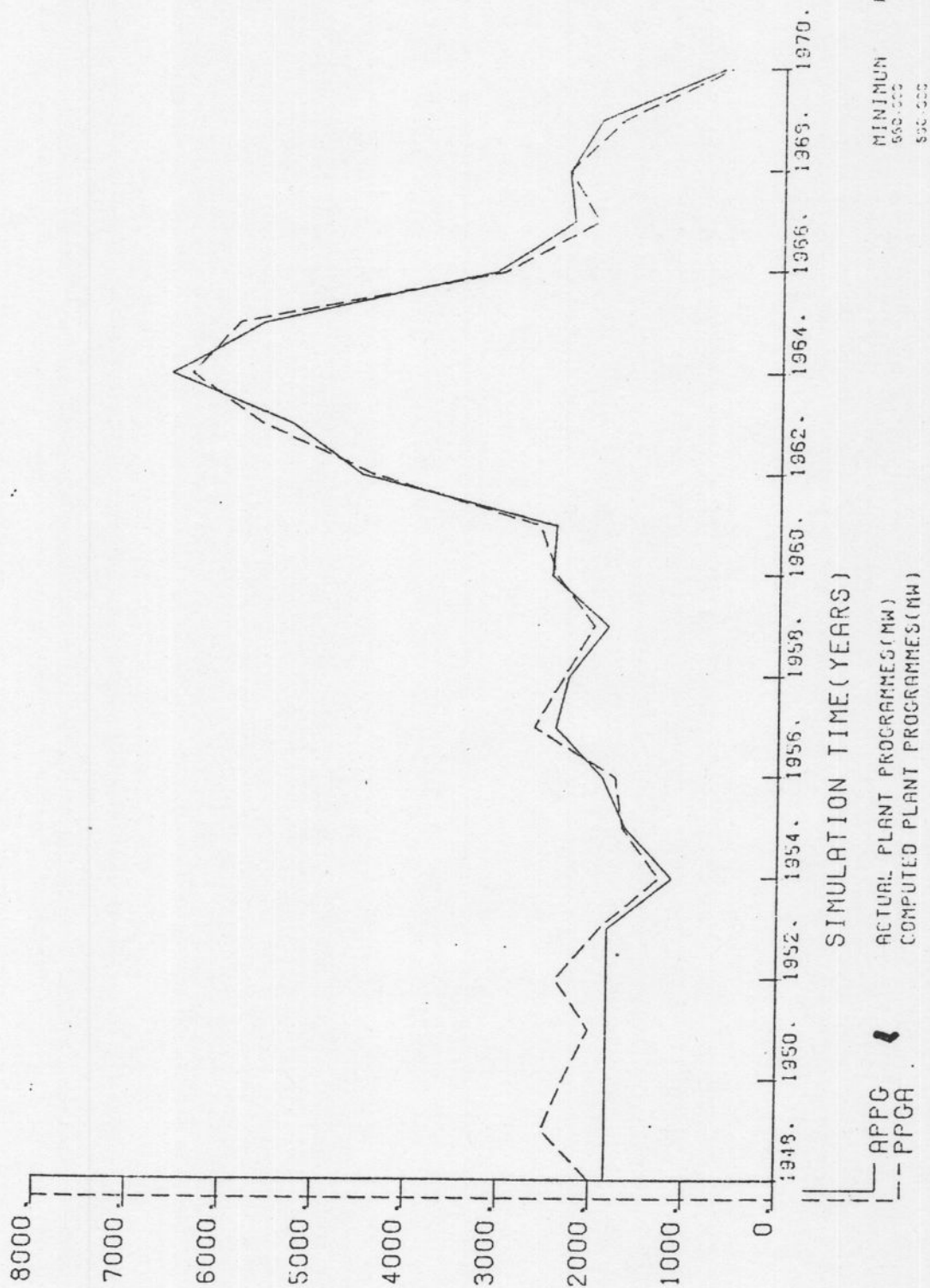


FIG. 5 ACTUAL & SIMULATED PLANT PROGRAMMES
UK ELECTRICITY SUPPLY INDUSTRY MODEL

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