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THE TECHNICAL AND ECONOMIC CRITERIA TO BE APPLIED IN PREPARING AN ELECTRICITY PRODUCTION PROGRAMME

submitted by the

Committee of Tariff Studies of the International Union of Producers and Distributors of Electric Power (UNIPEDE)*

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1. The problem of planning

In view of the growth of electricity consumption, the fact that a delay of several years necessarily elapses between the decision to build a power plant and its commissioning means that plans must be drawn up for the development of the production system. From the long-term point of view, such plans cannot aspire to great accuracy and they must be prepared for limited periods only, due regard being paid, in the study of long-term effects, to the decisions that must be taken given the probable life span of the equipment.

The characteristics of the various types of generation (hydroelectric and thermal plants) are not similar so far as performance is concerned. Hence their ability to cover consumption adequately at different points of the demand curve, with due regard to the conditions required, varies rather widely. Moreover, the economic characteristics of the various types of power plant vary considerably: hydroelectric production requires large-scale investment but has low operating costs, whereas thermal production, which has high operating costs, may need a relatively smaller investment.

Accordingly, the preparation of an equipment programme, being of a technical and economic nature, may be expressed in very general terms as the definition of a series of operations which, on being integrated into the existing system, will make it possible to satisfy a given demand as efficiently as possible. This procedure consists of four steps: (a) determination of the demand to be satisfied; (b) maintenance of a file on the equipment projects; (c) choice of the series of operations which will satisfy the demand; and (d) selection of the most advantageous of such series.

Once the demand has been defined and a file of projects opened (due regard being paid to capacity with a view to integrating the projects into the system and to investment cost), the planning problem is reduced to a choice of the economically most advantageous project, subject to the technical necessity of satisfying the demand.

Apart from consumptions that may be influenced by the very structure of the production system (e.g., self-producers such as electrochemistry and electrometallurgy), there are other types of consumption which can be forecast with sufficient accuracy for them to be used as the basis for an

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equipment programme. In practice, there are two possibilities. Firstly, if it is possible to evaluate the probable trend of consumption, a programme may be drawn up providing for the supply necessary to satisfy consumption and taking into account the statistical laws governing the operation of the system and the laws bearing on consumption trends. Secondly, the programme may be given a certain flexibility so that it can be adapted to actual consumption developments within a certain margin of reliability without jeopardizing the security of supply. In any case, it is always desirable for the plan to be flexible and adaptable to new circumstances. The plan is indispensable as an element of co-ordination and, once established, it must be carried out. But this does not exclude periodic revision in the light of any new prospects that may appear on the horizon.

When choosing from among the possible series of operations, those which will satisfy demand, an initial difficulty arises from the fact that the capacity of the production system must be adapted constantly to the demand of the network. In order to ensure that a given production system will satisfy demand over a given period, complex calculations are generally required, even if certain simplifying assumptions (e.g. constant output, "average" heads) are adopted. This practical difficulty must be overcome by methods involving the tentative application of a large number of assumptions. These methods are based on the definition, in respect of each power unit, of its contribution to demand depending on the role the particular plant or unit has to play in the production system as a whole. Experience shows that, whatever the system considered, demand is satisfied when certain characteristics, limited in number, are present in the production system. In other words, when a very small number of certain critical requirements essential for covering consumption are met by the system, the possibility of satisfying all the others is assured.

These critical requirements consist of a combination of the characteristics of the consumption diagram and of the critical characteristics of the production system. For instance, it may be said that, leaving aside a few restrictive factors, the critical requirement in a "purely" thermal production system is to cover maximum peak demand while, in a "purely" or predominantly hydroelectric system, in addition to the need to meet peak

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demand, there is also the problem of periods when water resources are inadequate.

These characteristics, although defined separately for each power plant or unit, should be considered from the aspect of their contribution to the overall system. They are, therefore, marginal characteristics, valid only for certain types of network.

2. Programmes and uncertainty

If it transpires, on the completion of a programme, that the problems which arose in practice were anticipated, the decisions taken will ensure the success of the desired objectives. On the contrary, circumstances may occur which differ from those that were expected when the programme was drawn up. In other words, a programme, however detailed, logical and coherent, cannot by its very nature foresee every eventuality. This is an important observation, because a programme is often regarded as an end in itself, as a solution to all present and future problems, particularly those related to choosing the means of production.

When the notions of "optimum solution" and "minimum cost" are under discussion, it is essential to project them and to consider the cost in terms of the final balance-sheet. Obviously, the choice that can be made at a given moment of the installations to be constructed does not depend on the relationships of the various production costs as they appear initally but rather on their future relationships. The relationships between future production costs are necessarily uncertain. A range of possibilities exists, each corresponding to an anticipated production cost which involves uncertainties. This range depends, partly, on the attitude adopted by those responsible for making the choice, and this attitude, in its turn, constitutes a subjective element which is the responsibility of the power-producing enterprise.

Each choice entails certain hazards and a decision may be based on any of the following sets of conditions: , conditions of certainty; conditions of uncertainty; and a combination of both. There is certainty when it is known that a given act leads to specific results; there is uncertainty when an act entails several possible specific results, each of which have a given

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likelihood of occurring. There is uncertainty also when an act may produce a series of specific results, the probabilities of which are either entirely unknown or meaningless. There is a combination of certainty and uncertainty when it is possible to lessen the uncertainty in the light of subsequent events. As regards programmes for production installations, uncertainty or mixed conditions are the rule.

However, there may be particular cases where secondary decisions (e.g., the partial rebuilding of a low-production unit), which are not likely to involve any radical modification in the enterprise's equipment, have to be considered as if they were based on conditions of certainty. In such cases, it is possible to follow the procedure of discounting and mathematical programming (in particular, linear programmes), in order to define specifically and in great detail the decisions that must be taken.

These scientific methods for preparing programmes also have other uses. They provide an instrument for the rational selection of plants on the basis of the initial data available which, as mentioned earlier, are subject to uncertainty. The results, however, are just as useful, since they help to clarify part of the problem and may be used as working hypotheses.

The uncertain factors are identified progressively on the basis of the information accumulated on the results of previous selections and on the new factors that occur in the general situation. The more numerous and complex the uncertain factors considered important by the enterprise, the more ample this information will be. The purpose of the information is to lessen the uncertainty of the future without, however, totally eliminating it, as the uncertain factors are, by their very nature, limitless.

In short, a production programme is more than a mere list of the projects to be carried out established on the basis of one final decision. The programme should be conceived as an instrument for reaching specific decisions based on given criteria and for achieving equally specific objectives. The criteria are numerous and several of them are subjective. Together they form a "function of decision", whose many and complex parameters are those generally used under conditions of certainty. The programme is therefore the outcome of "strategy" and should be so interpreted and applied. This strategy implies that the successive choices to be made in the

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should conform to the information that becomes available and that this information should be carefully compiled.

The programmes drawn up in accordance with certain "strategies" are necessarily flexible to the extent that they allow the choices to be adjusted to the information available at any moment. This flexibility derives from the fact that the programme does not impose any decision which would prevent the subsequent adoption either of other types of installations, under new circumstances, or of different criteria on which to base the choice, if it should prove impossible to take all the uncertain factors into account.