ECONOMIC OPERATION OF LARGE POWER STATIONS

AS AFFECTING DESIGN AND SCHEDULING

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[1] GENERAL

With the advent of need to enormous energies for use in the everywhere activities of civilized man, there has been a rapid increase in the production and usage of electrical energy.

The installations of an electric power system, thus; serve for:

1- Generation of electric energy at the suitable sites.

2- Transmission of the generated energy to locations of load centers.

3- Distribution of energy among the individual consumers.

All is being done for the aim of contineous supply of the consumer with low cost electric energy at the required standard voltage and frequency,with the admittance of only small specified variations.

1.1. Generating Plants:

Generators operating at the power stations are the power sources. The following types of power generation plants are used:

1.1.1. Thermal or Steam Power Stations:

In a steam power station, fuel (coal or petrol products) gives up its heat of combustion to boilers which deliver steam at high tempratures and presures to steam turbines. The steam loses heat energy in driving the turbines, which are coupled directly or through gearings to electrical generators. Figure (1) shows a schematic illustration of a thermal power station arrangement.

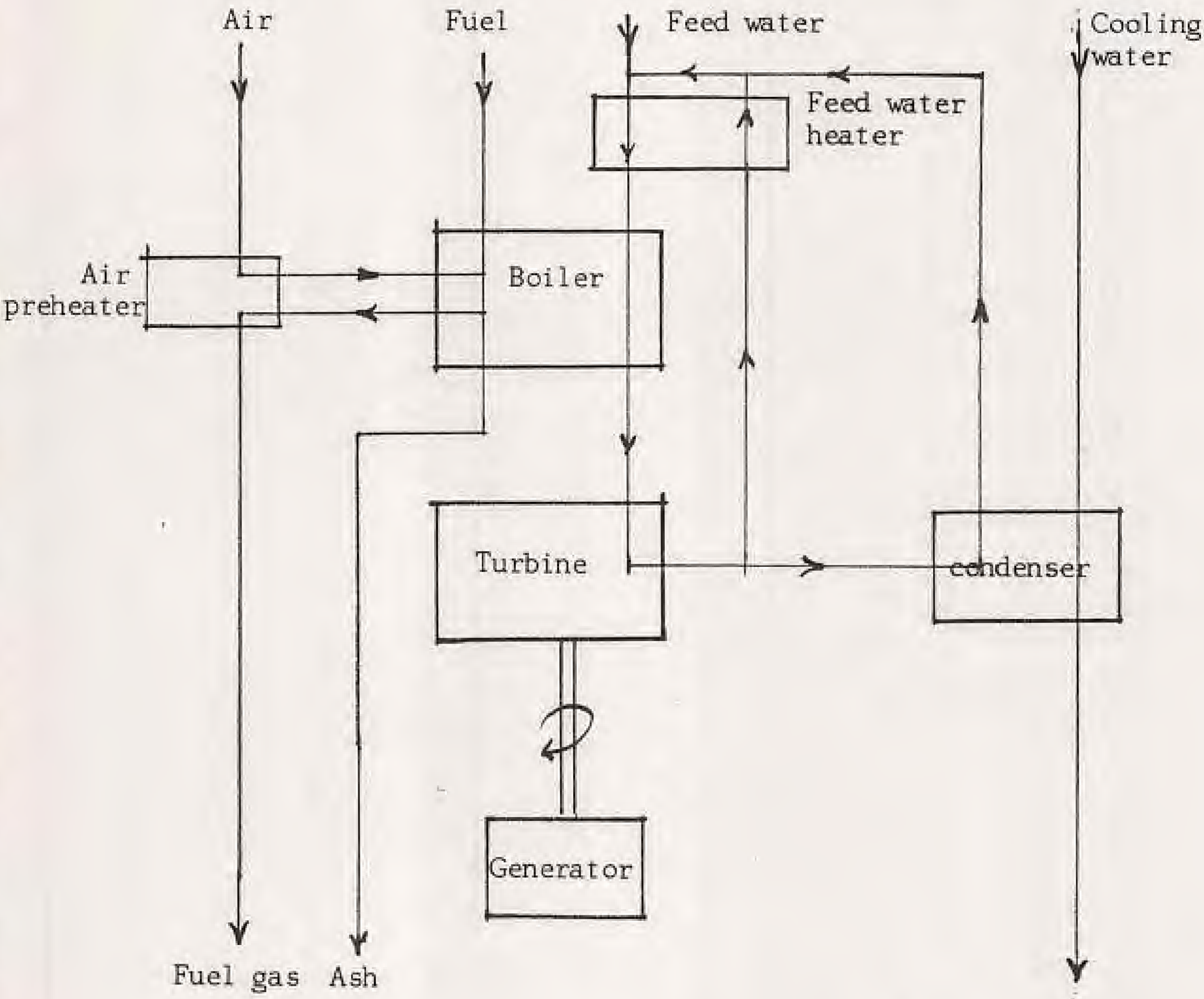

Figure [1]

Thermal Power Station Arrangment

1.1.2. Hydraulic Power Stations:

These make use of the costless enormous energy of water falls heads operate hydraulic turbines that are coupled to electric generators.

1.1.3. Nuclear Power Stations :

While fuel is the source of heat energy in thermal power stations, it is made use of the physical principles of nuclear fission to produce heat energy used in nuclear power stations.

(2) ENERGY ECONOMICS AND THE CHOICE OF THE POWER STATIONS SITE

2.1. For Thermal Power Stations:

In order to keep the costs of distribution as low as possible it is best to have the station near the centre of its district of supply. This is espacially the case when the transmission is by direct current and voltage transformations are not possible. If the transmission is by alternating current it is not so necessary for the site to be in the midst of the district served, as the energy can be led easily at high voltage into the district and then transformed down for use at a number of convenient points.

The advent of the Grid has an important effect on the site and size of plant . Attnetion is focused on the facilities for generation rather than on distribution, although the later cannot be disregarded. The site is chosen so that an abundant supply of cooling water for the condenser is available, and there is a low cost for the transport of fuel. The basic idea is that energy should be collected at places where it is cheap, fed into the high voltage network or grid and then drawn off at various tapping points.

The price of land, the precautions necessary to keep the atmosphere in populated districts unppolluted by firmes and by the residue from pulverized fuel,and the reservation of land for future developments all tend to shift the site away from towns. After having paid consideration to these points, that site which is nearest the centre of the load is chosen. It is clear that the site must be suitable for supporting a large building with heavy machinery, frequently the cost of foundations is a main item and must be carfully considered.

A 25 MW, station occupies about 10 000 square yards and a 100 MW, Station occupies about 36 000 square yards , with natural cooling 20 000 and 80 000 gal. per min. of cooling water are required respectively, whereas with towers the figures are 4 500 and 15 000; at 40 per cent load factor the coal per day is 160 tons and 530 tons. These figures allow a preliminary estimate to be made of the size of the site, the quantity of cooling water needed, and the required transport facilities, but a very liberal allowance must be made for future extensions.

2.2. For a Hydraulic Power Station:

The site of a hydro-electric plant is determined by natural conditions. The water must be available at a usable head and in sufficient quantity. If the flow is not regular enough for continuous supply, there must be convenient accommodation for a reseroir or dam at a reasonable cost, the lower the head the larger must be the reservoir. Other considerations may help in the fixing of the site , for instance, the erratic flow of the Colorado River has created dangerous conditions resulting in damage to life and property, so that the building of the Boulder Dam was welcome for flood control as well as for the construction of the hydro-electric station. If water is stored by a dam and reservoir. it must be carfully arranged that the heavy flows during peak loads do not cause floods downstream.

(3) Operating Costs of a Steam Power Station

There are three kinds of costs, a fixed cost which is independent of the maximum output or the energy output,a semi-fixed cost which depends upon the maximum demand but is independent of the total energy output,and a cost which is proportional to the output. If we call these costs £A per annum, £B per KW, maximum demand per annum, and £C per kWh., respectively, the annual cost of the station is:

£ (A + B x kW. + C x kWh.).

A station of 10 000 kW.,maximum may possess the formula, for example:

£ (10 0000 + 8 x kW. + 0.015 kWh.).

Whilst a 100 000 kW. station may have the formula

£ (70 0000 + 5 x kW. + 0.006 kWh.).

The fixed cost represented by A is due to the cost of the central organization , salaries of the higher officials, capital cost of land (espacially if some land is held for future developments and is not being used for present kilowatt demand) etc..... The semi-fixed charge represented by B is due to the salaries of the charge engineers and spares, and normal running losses and costs. The charge C is mainly on account of fuel, water, etc..

It is difficult to seperate the charges A and B , and for a given station they may be lumped together to form a charge D x kW.

The cost of installation of a large steam power station can be divided approximately as follows:

-	Buildings	35%
-	Fuel handling,boilers,etc..	20%
-	Turbines, generators	25%
-	Switchgear	10%
-	Transformers,cables ,sundries	10%

Interest has to be allowed at about 10% , and a sinking fund provided to replace the installation at the end of its useful life,which is estimated at about twenty years.

The advantage of a high load factor can be easily seen by cosidering the case of the larger stem power station as shown by the above equations.

Also from the above formulae, it is clearly indicated that the larger the power plant, the lower will be the cost of the produced energy.

[4] ECONOMICS OF POWER STATION ENTERCONNECTIONS WITH A UNIFIED GRID AS AFFECTING THE ENERGY COST:

The interconnection of a power station with a unified grid can be achieved by several alternatives. In each case, the regime of power flow will differ. Consequently, the loadings of the network lines and associated energy losses will differ from one scheme to another. The cost of the power loss over the years is also on economically determining factor influencingthe energy price and has to be taken into consideration in the design stage.

Further, the interconnection alternatives will affect S.C. level in the whole network. Increasing the S.C. level encounters the increase of the S.C. capacity of the installed switchgear and equipment, comprising additional cost influencing the energy price.

Furthermore, the interconnection alternatives will affect the system stability. The equivalent cost for the outage of the system while in or in part rpresents a complicated economy problem that has to be taken into consideration as influencing the energy production economics.

Therefore, in the design stage, the interconnection alternatives of a new power station have to be studied in the light of the resulting power losses of the system,the short circuit level and the stability, Fig.(2). The lower the resulting losses, the lower the resulting short circuit with a resulting stable system under single and double contingencies,the more economical will be the generating plant. This is clear as the higher losses cost money, the higher short circuit level requires more expensive switchgear and the less stable system,the higer the probability supply interuption which in turn is equivalent to loss in the national economy.

[5] Operating Regime of Power Stations in a Mixed System as Affecting the Energy Price:

Figures (3-5) show three various load curves of a unified power system to which various types of power stations are connected,e.g. hydro-electric,thermal steam and gas. The construction of new units of a given type to meet the load requirments will clearly affect the energy pricing in any system of pricing either, average cost pricing or marginal cost pricing.

In the same manner , the way to meet the load requirments by operating on type of power station or other in a given time of the day with hour the same affects on the energy pricing and electricity terrif. The details of these will be the subjects of succeeding lectures.

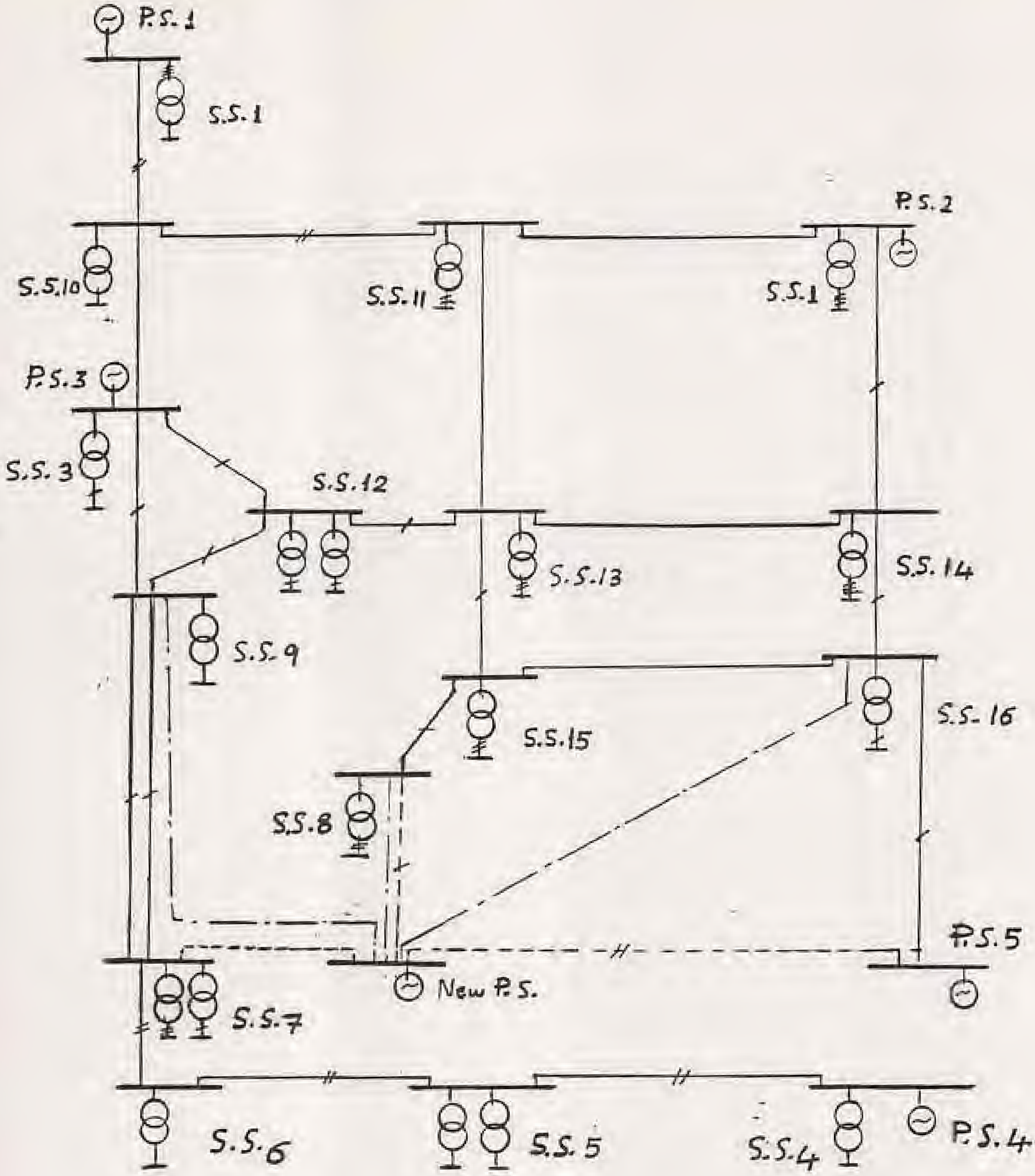

Fig. [2]

Examples of new P.S. Interconnection schemes.

--------- First suggested scheme.

-.-.-.-. Second suggested scheme.

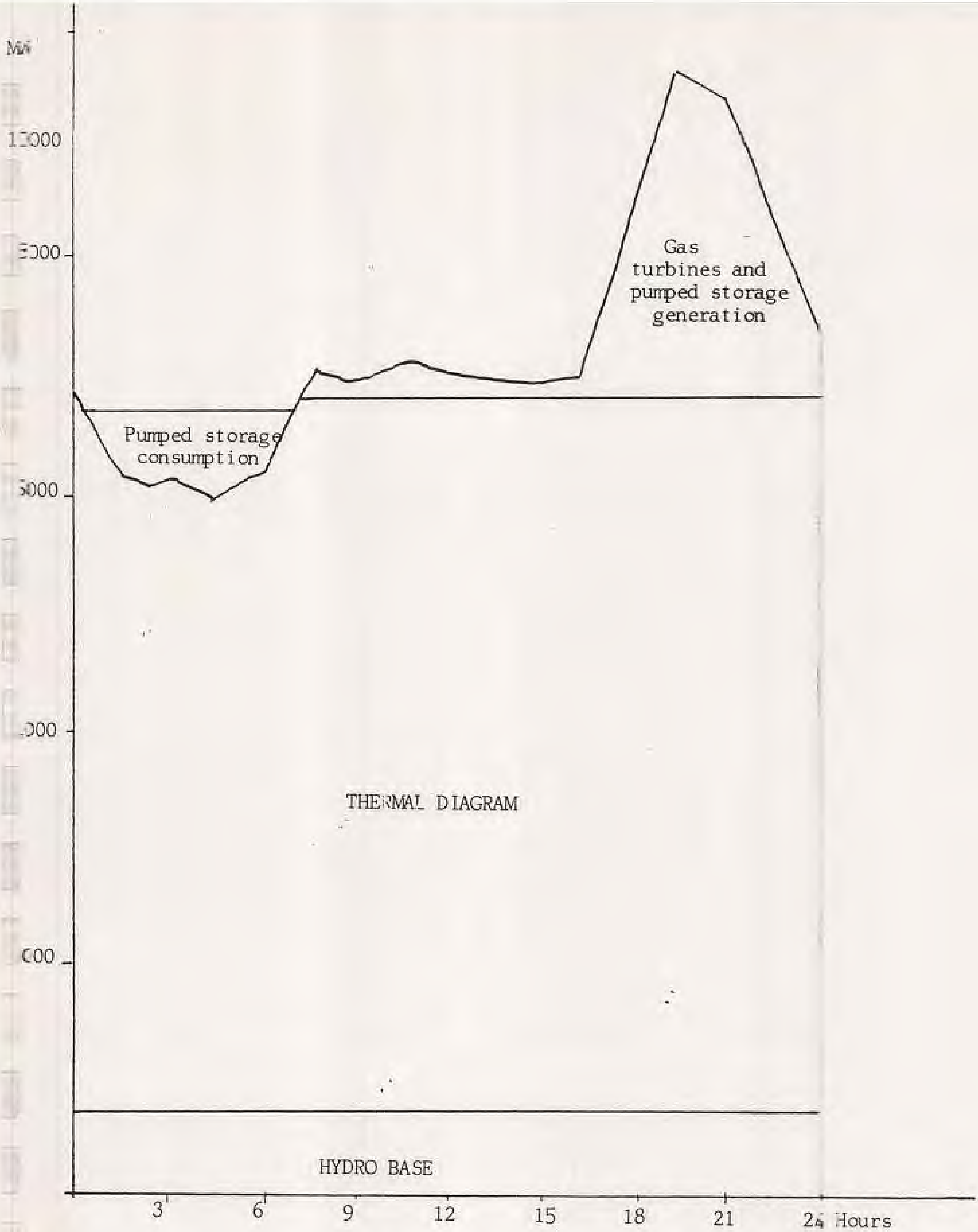

Fig. [3]

Typical daily load curve for unified power system and suggested operation schedule for economic operation.

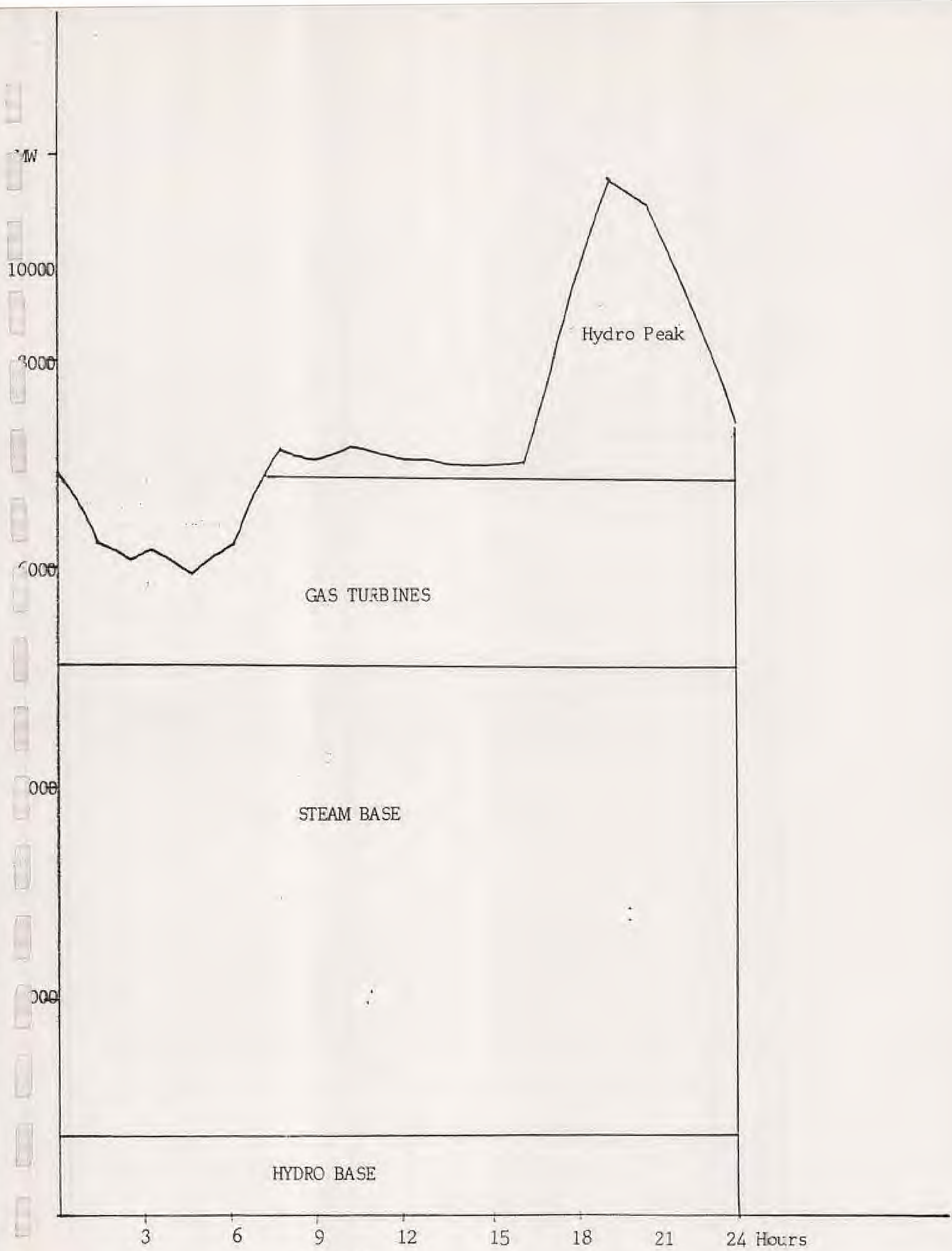

Fig. [4]

Typical daily load curve for unified power system and another suggested operation schedule for economic operation under given conditions.

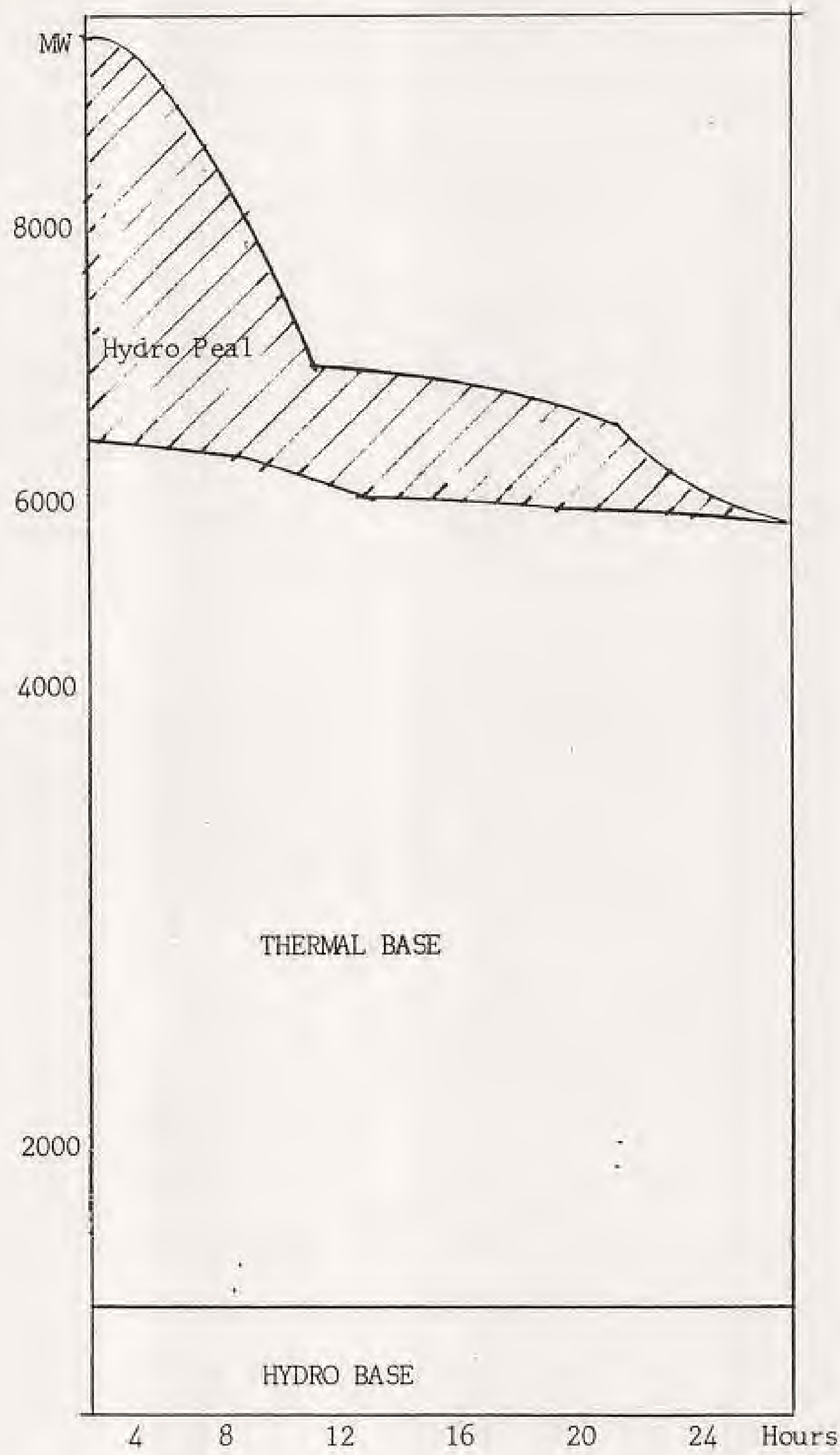

Fig.[5]

Typical daily load curve for unified power system and suggested construction scheme for economical power generation and tarrif.