THE TRANSACTIONS OF THE

CANADIAN SECTIONAL MEETING

of the

WORLD POWER CONFERENCE

MONTREAL

7-11 SEPTEMBER, 1958

VOLUME 2

PRODUCTION OF HYDRAULIC ENERGY

Canadian National Committee of the World Power Conference

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Production d'énergie hydro-électrique (Conception des aménagements)

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Production of Hydraulic Energy
(System Planning)

By

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in cooperation with

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Introduction

There is little doubt that the obtaining of additional power resources is a primary concern of every industrial country in the world to-day. The use of power per capita has risen steadily over the past few decades and in most countries power demand is doubling approximately every seven to ten years. It is beyond dispute that the future industrial well-being of any nation will be closely bound up with its power resources.

The power resources of the world are not evenly distributed amongst the countries. Some sections of the globe are endowed with abundant water power potentials while other countries lacking large water resources have available steam generating fuels. The whole picture of power generation has been further expanded by the advent of nuclear fuels.

The wise planning of power systems within a country, a state or an area, calls for the utilization of wide technical experience and judgment. System planning has become a specialized field and the papers in this section portray some of the latest techniques in different countries. The papers deal with modern hydro-electric potential evaluation and the role of water-power

in the development of large power systems. Since the availability of water is dependent on natural hydrologic phenomena, the availability of hydro-electric generating capacity is also studied with this in mind. The papers also discuss the economic use and development of water power in conjunction with thermal and nuclear power plants. A growing development in the use of thermal plants is the adaptation of the gas turbine as a prime mover. One paper (31 A_1/2) gives an interesting description of an unattended 100,000 KW gas turbine plant under construction at Port Mann, B.C., Canada. Two outstanding features of the gas turbine plant are that it can be brought on the line in 20 minutes and it can be readily operated by remote control.

The matter of nuclear power was briefly discussed in some of the papers, but apparently the advent of nuclear plants into the field has been so recent that their true function in the overall system planning cannot yet be evaluated.

In the matter of system planning, it seems to this reporter, that a very broad and far-sighted policy should be considered by the officials entrusted with this work. Let me illustrate what is meant by referring to gold mining in Canada. A short-sighted operator, bent only upon maximum returns on investment would mine out all of the high-grade ore as quickly as possible and abandon the mine in a few years. Such 'high-grade' mining would leave lower grade ores underground and perhaps make them technically and economically unobtainable for all time. On the other hand, a wiser operator would mine some lower grade ore and mix it with the high-grade production. In this way, a reasonable profit would be realized over a much longer period of years. In applying this idea to system planning, could it be possible, that a judicious development of higher cost sites along with very low cost sites might benefit a country in the long run? In the long range view, hydraulic resources are renewable, while thermal fuels, once used, are gone forever. It would be interesting to read in, say, one thousand years what writers will be saying about the tremendous expenditure of chemicals (coal, oil and minerals) in combustive processes during our centuries.

In a more specific review of the papers in this section, they will be classified under the following headings.

A. Economic System Planning in Various Countries.
B. Hydro-Electric System Planning.
C. Thermal Plants in the Power System.
D. The Economics of Pumped Storage Plants.

A. Economic System Planning in Various Countries

Since most power systems include water power plants, and since hydraulic developments are entirely dependent upon topography and hydrology, it is not surprising that the economics of system planning will vary considerably from country to country. In Austria (paper 136 A/1) hydro developments supply most of the power. Austria is fortunate in its possession of water power sites and it is stated that 61% of its power is obtained from run-of-river plants, 20% from storage plants and 19% from thermal plants.

In Scotland (paper 33 $A_1/4$) the two Scottish Boards, North and South, develop power from water, thermal and nuclear sources. Water power predominates in the north and coal-fired plants in the south. It is estimated that nuclear plants will assume an increasingly important place in the Scottish power picture and two such plants will be in operation by 1966-67.

In Italy (paper 77 $A_1/5$) since such a large portion of Italian hydro potential has been developed, that remaining is by the nature of things the more costly, since the most economic have been developed first, as in other countries. Consequently, in a number of cases, the cost of output becomes greater than that from the conventional thermal station, even though these mostly burn imported fuel. Estimates of the proportion of hydro to steam generated power in Italy (1955-1975) indicate that from power largely hydro generated (1955 – 80%:20%) the country is laying increasing emphasis on steam-generated power (1975 – 39%:61%).

The problems of a small island (Majorca) whose sources of fuel supply are sparse, are discussed in paper 34 $A_1/7$. Here, boilers of steam plants were modified to make best use of scarce local fuels. By a careful study of reservoir arrangements, the available hydraulic resources are being developed to supply peak load requirements and, at the same time, provide for irrigation and water supply.

B. Hydro-Electric System Planning

Hydro-electric system planning has always required a consideration of many factors, such as availability of water, economics of site, storage possibilities and other factors. In most countries this planning has been further complicated by the necessity to consider the use of thermal plants in the system. Paper 6 $A_1/6$ suggests the use of a method of Sequential Analysis to determine the available power capacity of a hydro-electric plant. The basic economics of storage schemes are also discussed and an example illustrating the method is given. Paper 85 $A_1/8$ discusses the comparative economy for utilizing the water power resources in the eastern regions of the Soviet Union. The paper indicates the large size of some of the Russian developments and envisages transmission over very long distances (2500 Km.).

In a paper on Modern Hydroelectric Potential Evaluation (37 $A_1/10$) the authors indicate the processes followed by the Bureau of Reclamation in evaluating hydro-electric developments when they must be considered in conjunction with irrigation, water supply and navigation. The paper points out that generation of energy and selection of plant capacity must be patterned to the power market expected during the life of the project and the power distribution system expected to be available.

A mathematical approach to system planning is made in paper 127 $A/_1 11$. Consideration is given to the position of the output of the plant on daily load diagrams, the amount of water available at any time of the year, the volume of storage available and the construction cost of the plant.

A very interesting description of the most exhaustive studies of Water Resource Development in the Hells Canyon Reach of the Snake River, a tributary of the Columbia River in the U.S.A., is given in paper 75 $A_1/13$.

C. Thermal Plants in the Power System

Most operators of power systems, even though predominately composed of water-power plants, are faced with the task of integrating thermal plants into the system. The thermal plants may be for the purpose of carrying peak load or may be required for load growth as new water-power plants become no longer available. In the thermal plant field, the advent of the gas turbine has added some new features. As pointed out in paper 31 $A_1/2$, the gas turbine has some features which make it worth consideration for certain applications. It can be operated by remote control and can be brought on the line in twenty minutes. An unknown quantity, as yet, is the noise factor which may arise in locations close to large cities.

Nuclear fired plants have not yet reached the stage where their economics of operation can be evaluated. It seems certain that they will grow in importance. Paper 33 $A_1/4$ discusses their use in Scotland, but in none of the papers is the economics of these plants discussed.

D. The Economics of Pumped Storage Plants

The economics of pumped storage plants is discussed in paper 42 $A_1/3$. The application of a pumped storage plant at Niagara Falls is an ingenious method of storing energy at a site where the flow is large and very constant. The use of such plants will undoubtedly increase as power sites decrease in availability.

Topics for Discussion

From among a number of points arising from the material in the papers assigned to this session, the following are selected and suggested as the basis for discussion:

1. What should be the basis of the planning, so that the less economic hydraulic sites are developed along with those more economic, to obtain optimum development of a country's hydraulic potential?
2. How should hydraulic, conventional thermal and nuclear developments be fitted into an overall plan for the provision of power resources to supply a growing load economically?
3. What amount of over-development of hydraulic generating resources is economically justified in a mixed hydro-thermal system, and on what does the assessment of the amount depend?
4. What factors should be considered in planning pumped storage facilities for a power system? How can the economic advantages, if any, be clearly demonstrated?

Production d'énergie hydro-électrique (Conception des aménagements)

Par

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Introduction

Il fait peu de doute que la recherche de nouvelles ressources énergétiques constitue l'un des principaux soucis de tous les pays industrialisés, de nos jours. La consommation d'énergie par habitant s'est élevée sans arrêt au cours des dernières décennies et elle a doublé dans la plupart des pays en sept à dix ans, environ. Il est incontestable que l'avenir industriel de n'importe quelle nation sera étroitement lié à l'étendue de ses ressources énergétiques.

Les ressources énergétiques du monde entier ne sont pas réparties également entre tous les pays. Certaines parties du globe sont abondamment pourvues de ressources hydrauliques, tandis que d'autres qui ne possèdent pas de grandes forces hydrauliques, ont sous la main des combustibles pouvant servir à la production de vapeur. Le tableau d'ensemble de la production d'énergie vient de subir une nouvelle expansion par l'avènement des combustibles nucléaires.

Une sage conception des réseaux d'énergie dans un pays, un état ou une région, exige une vaste expérience technique et beaucoup de jugement. L'élaboration des réseaux est devenue un champ d'action spécialisé et les mémoires soumis à cette section décrivent certaines des plus récentes techniques mises en pratique dans différents pays. Ils traitent de l'estimation moderne des ressources hydro-électriques et du rôle des forces hydrauliques dans l'aménagement de grands réseaux électriques. Vu que la quantité d'eau disponible dépend de phénomènes hydrologiques naturels, il est aussi question de la puissance hydro-électrique disponible, eu égard à ce fait. Les mémoires traitent aussi de l'utilisation et de l'aménagement économiques des forces hydrauliques, de concert avec des centrales thermiques et nucléaires. Une innovation de plus en plus répandue dans l'utilisation des centrales thermiques est l'adaptation de la turbine à gaz comme moteur primaire. L'un des mémoires (31 $A_1/2$) donne une intéressante description d'une centrale autonome de 100,000 kW et équippée de turbines à gaz, en construction à Port Mann (C.-B.), au Canada. Deux particularités frappantes de la centrale à turbines à gaz sont qu'elle peut être mise en marche normale en 20 minutes et qu'elle se commande facilement à distance.

Certains mémoires abordent brièvement la question de l'énergie nucléaire, mais selon toute apparence l'avènement des centrales nucléaires dans le domaine de la production d'électricité est si récente qu'il est encore impossible d'apprécier leur rôle réel dans la conception d'ensemble des réseaux.

Sous le rapport de la conception des réseaux, il semble au présent rapporteur que les experts auxquels ce travail est confié, devraient envisager une ligne de conduite très large et prévoyante. Pour illustrer ce qu'il faut entendre, prenons le cas de l'industrie des mines d'or au Canada. Un exploitant imprévoyant, uniquement soucieux de réaliser le maximum de bénéfices de sa mise de fonds, extrairait tout le minerai de haute teneur aussi rapidement que possible et abandonnerait la mine au bout de quelques années. Une telle extraction de minerai riche laisserait enfouis des minerais pauvres et rendrait peut-être leur extraction techniquement et économiquement impossible pour toujours. Par ailleurs, un sage exploitant extrairait une certaine quantité de minerai pauvre et le mêlerait à la production de minerai riche. De cette façon, il réaliserait un profit raisonnable durant un beaucoup plus grand nombre d'années. Si l'on appliquait cette idée à la conception des réseaux, ne serait-il pas possible que l'aménagement judicieux de ressources hydrauliques coûteuses, de pair avec celui de ressources très économiques, puisse être à l'avantage d'un pays, à la longue? Au cours d'une longue période de temps, les ressources hydrauliques se renouvellent constamment, tandis que les combustibles, une fois consommés, sont épuisés à jamais. Il serait intéressant de lire, dans mille ans par exemple, ce que les auteurs écriront au sujet de la formidable dépense de produits chimiques (houille, pétrole et minéraux) dans les procédés de combustion, à notre époque.