"International Labour Review", July 1955, while the training aspects and the impact of atomic energy on the employment market were reviewed by the Director-General, Mr. Morse, in his report on Automation and Technological Developments, presented to the International Labour Conference in 1957.

It can be seen from this brief outline that the dangers to the worker which arise from the appearance of this new source of energy for mankind and the large-scale uses of ionizing radiations in general have found an immediate new response in the ILO. As the untold wealth of this revolutionary discovery is tapped in a thousand new ways and used in smaller and less easily inspected plants, the attendant risks and dangers to the worker will multiply. The requirements of training and the organization of production are changing. All these factors afford great scope for ILO action in the years to come.

NUCLEAR POWER PROSPECTS IN FINLAND

Following a joint study by the Finnish Atomic Energy Commission and IAEA, a report on "Prospects of Nuclear Power In Finland" has been published. The report envisages in a preliminary way certain conditions under which it might be technically and economically feasible to introduce a large nuclear power station in Finland as early as 1970.

While the study is limited to the specific conditions in Finland, the hope is expressed that it will be useful to other countries as well because "the method followed, the factors discussed and some of the data supplied are sufficiently general to be useful to a number of countries, especially those where hydro power is predominant".

The study falls within the scope of a program which IAEA has initiated to further the development of nuclear power. Mr. Sterling Cole, the Director General of the Agency, writes in a Foreword to the report: "It became apparent to us through our early studies in this field that too often the economics of nuclear power were discussed in general terms and without reference to the multitude of conditions which govern each specific power situation... We have felt therefore that the realistic assessment of the prospects of nuclear power throughout the world could be based only upon a series of studies carried out against backgrounds of actual conditions and covering as wide a range of different situations as possible. The General Conference of the Agency at its fourth regular session has adopted a resolution calling for the continuation of nuclear power surveys in Member States at their request". A second national nuclear power survey was initiated last October with the dispatch of an IAEA mission to the Philippines.

Background

The Government of Finland, on 3 December 1959, informed the Agency of its intention to carry out a nuclear power study and of its desire both to benefit from the Agency's specialized experience and to contribute to the Agency's program for furthering the development of nuclear power. Approval of the Agency's participation was voted by its Board of Governors on 12 January 1960.

Work on the study began in March 1960. A joint study group was set up by the Finnish Atomic Energy Commission and the Agency's Secretariat, with cooperation by the State power company, Imatran Voima Osakeyhtio. The group was headed by the Chairman of the Finnish AEC, Professor Erkki Laurila. The Agency designated a member of its technical staff to serve as the Agency's representative and as special assistant to the head of the study group. An Agency consultant and other members of the technical divisions concerned took part in the work of the group once the preparatory stage was completed. The Agency has also consulted the Energy Division of the United Nations Economic Commission for Europe.

The basic circumstances which stimulated Finland's interest in nuclear power are summarized in the report as follows:

"In Finland the main power resource has been, and still is, water power. It is clear, however, that the hydro potential is insufficient to cover the increasing consumption over a long period of time. Already about one half of this potential has been exploited. Thus the country will necessarily have to consider the utilization of thermal power to an increasingly large extent. There is no indigenous coal or oil. For this reason it has become necessary to investigate realistically the possibilities offered by nuclear power."

Scope of the Report

Because it was not considered possible at the present stage in the rapid development of nuclear power

The Pyhäkoski hydroelectric plant on the Oulu River in central Finland. Most of Finland's electricity is supplied by water power at present, but a larger role for thermal plants is foreseen for the future

technology to make a long range prediction concerning the possibilities for establishing a substantial nuclear power program in Finland, the study addressed itself to a more limited objective. This was "to investigate the criteria and conditions under which nuclear power could feasibly be introduced, from the technical and economic standpoints, into the country's power program within the decade from 1960 to 1970".

A further limitation was the decision to study only the possibilities for production of electricity in large central station power projects. Thus the related questions of small industrial power reactors capable of producing heat as well as electricity and of installing small power plants in remote areas in the north of the country were not investigated.

The report contains 14 chapters. The first is an introduction and summary of conclusions. The next five chapters survey the general energy situation, the existing fuel resources and imports and present power production. Estimates of future power consumption through 1970 and of the power program designed to meet the anticipated needs are discussed in the next two chapters. An important chapter is devoted to the changing role of thermal power in the next decade. Possible locations for a base-load nuclear power plant in the system are then discussed from the viewpoint of the transmission of power. The next three chapters consider the costs of conventional and nuclear power over the next ten years. Conclusions and recommendations for further study are presented in the last chapter.

From a Hydro to a Hydro-Thermal System

It is clear from the results of the study that the power supply situation in Finland has up to the present not been favorable to the economic introduction of nuclear power. Hydro power, in years of normal stream flow, provides about 85 per cent of all electricity requirements, and no less than 70 per cent in years of adverse stream flow. The role of thermal stations has been to supplement hydro production during the winter months when load demand is high and water is low. Thermal stations used for these purposes have been small, 50 MW(e) or below, and have been utilized for periods varying from 300 to 1 500 hours in a year. These conditions are highly unfavorable for nuclear power plants, which, as the report states, "because of their higher capital costs require large sizes and high utilization factors for economic operation".

During the next ten years changes towards conditions more favorable to the introduction of nuclear power can be foreseen. Hydro power appears to be approaching the limits of its development in Finland. About one half of the total hydro potential has already been exploited. Development of what remains will clearly be unable to keep pace with electricity requirements, which, since 1948, have increased at the average rate of 10 per cent per year. Moreover, the remaining sites either require smaller plants or much more difficult construction efforts, so that the capital costs of future hydro plants in Finland can be expected to increase substantially.

The electric power pattern in Finland is accordingly expected to change gradually in the next decade from "pure hydro" to "mixed hydro-thermal", with thermal plants beginning to be built in large sizes and for base load operation.

Thus, two of the main threshold conditions for introduction of nuclear power into Finland, namely, the achievement of sufficient plant sizes and utilization factors, seem likely to be met towards the end of the next decade. It is estimated, for example, that a thermal plant with a capacity of 250 MW(e) might be operated in 1970 with a utilization factor of over 75 per cent.

Leading members of the joint Finnish-IAEA study group meeting in Helsinki. Left to right: Mr. L. Nevanlinna, System Engineer, Imatran Voima; Mr. M. Laurila, Director, Electrical Department, Imatran Voima; Professor E. Laurila, Chairman, Finnish Atomic Energy Commission; Dr. C. Erginsoy, Project Officer for IAEA; and Mr. R. Tuuli, Nuclear Engineer, Imatran Voima

Cost Comparison - Coal Versus Nuclear Plants

A second question remains, however. This is "whether this base load capacity could be more economically obtained in a nuclear power plant than a coal-fired plant".

Under current conditions it is clear that nuclear power is not able to compete. A key factor is the cost of coal, which is now available in Finland at an average cost for delivered heat of about 500 Finnish marks (FM) per giga calorie (G cal.)*, "a remarkably low price". The low price is due mainly to the availability of crushed coal from Poland, which, since 1950, has supplied from 70 to 90 per cent of Finland's coal each year. The price, however, has in the past fluctuated widely and the quoted figure reflects a sharp decline which took place in 1958. At present, total generation costs from coal-fired plants range from about 2 to 2.5 FM (6.5 to 7.8 mills) per kilowatt hour, which is considerably less than can be postulated for any nuclear power plant under current technology.

Many uncertainties govern any attempt to compare generation costs in Finland from nuclear and coal-fired plants ten years from now. Nevertheless, certain trends favorable to nuclear power may be discerned.

One concerns the importation of coal. Assuming, conservatively, that for the next ten years electricity production increases at 8 per cent per year, instead of the recent 10 per cent per year, only about 60 per cent, under current plans for hydro development, would be generated by water power in a mean water year. To supply the remainder would require importation of 2.5 million tons of coal or its equivalent, about ten times the present amount. The report comments that "a disproportionate increase in the importation of energy requirements is certainly not desirable in a country where foreign trade plays such a vital part in the economy. Thus the present lively interest in the prospects of nuclear power in Finland is entirely justified on national economic grounds". This is the more true since the limited amount of prospecting for nuclear fuels thus far done "gives the promise that nuclear fuel needs may eventually be met by national production".

A further factor favorable to nuclear power is the likelihood that its technology will improve faster during the next ten years than the technology of conventional power stations.

The various factors are equated by the report in a series of comparisons of the cost of power from nuclear and coal-fired generating stations for the years 1960, 1965 and 1970. The nuclear power costs used refer to gas-cooled natural uranium and boiling water systems, selected as examples because of their "proven" status, although the report does not exclude the possibility that a technological breakthrough "may bring another type to the forefront".

Cost estimates are made based on alternative assumptions regarding several important variables. Thus conventional power costs are calculated on the basis of two coal prices, one corresponding to the present very low delivered heat cost (at the coast) of about 500 FM/G cal, the other to a heat cost of 750 FM/G cal. For both coal-fired and nuclear stations, alternative estimates are made assuming a 6 per cent and an 8 per cent interest rate, and assuming plant utilization factors of 50, 60, 70 and 80 per cent. It is assumed that the maximum size of generating unit feasible in 1965 will be 150 MW(e) but that by 1970 this will increase to 250 MW(e), so that for the latter year estimates are made for both sizes.

Conclusion

The comparison for 1965 is acknowledged to be hypothetical, "since the power situation is not likely to allow the construction of a base-load thermal plant other than those already undertaken". It is noted, however, that a comparison on the basis of a 150 MW(e) plant shows nuclear costs to be "far from competitive" within the range of the assumed utilization factors, interest rates and coal costs.

For 1970, however, one basis of comparison shows that a nuclear plant may become competitive, this basis being the assumption of a 250 MW(e) plant size, a 6 per cent interest rate, a heat cost for coal of 750 FM/G cal and a utilization factor of 80 per cent.

A change in the heat costs for coal from 500 to 750 FM/G cal would not be surprising since over the last ten years coal prices have varied from "rather less than 500 FM/G cal to twice this figure". Similarly the interest rate in Finland has recently varied between 6.5 and 8 per cent for domestic financing and down to 5.5 per cent for foreign financing. The analysis showing achievement of a 250 MW(e) size and an 80 per cent utilization factor to be feasible was referred to earlier.

The report concludes by recommending the further work which would be desirable for studying nuclear power prospects in Finland. Regarding large central station power plants, recommended studies would concern domestic and foreign exchange requirements, fuel cycle costs, optimum plant sizes, and power costs for many different reactor systems. Also recommended for study are the possible use of reactors to supply heat and for small power plants in the remote north. For a later time the report recommends studies on a "substantial nuclear power program", should the results of further studies on the threshold conditions for the introduction of nuclear power prove positive.

* *US $1 = 320 FM. 1 G cal = 3.97 million British Thermal Units (BTU). The quoted cost is thus about 40 cents per BTU.*