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2 April 1979

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EUROPE

TRANSLATIONS ON EASTERN EUROPE

Economic and Industrial Affairs

(FOUO 6/79)

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TRANSLATIONS ON EASTERN EUROPE

ECONOMIC AND INDUSTRIAL AFFAIRS

(FOUO 6/79)

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CZECHOSLOVAKIA

ENERGY INDUSTRY DEVELOPMENT TRENDS REVIEWED

Thermal Plant Development, Siting

Prague INVESTICNI VYSTAVBA in Czech No 11, 1978 pp 353-357

[Article by Eng Karel Curin: "Prospects for the Development and the Siting of Thermal Power Plant Stations"]

[Text] Long-range Plans for Power Plant Development

In recent years extensive and detailed analytical studies have been drawn up in the power industry to serve as the basis for the formulation of basic development plans covering specific time periods. These studies have characterized the power industry development plan and have specified output demand levels from the standpoint of the short-term, medium-term, and long-term future. According to the prevailing view, the short-term future represents a period of about five years, i.e., the time frame of our five-year plans, while the medium-term future covers a period of about 15 years and the long-term future a period of 25 years, i.e., from now until the year 2000 or 2005. However, it may be assumed that the length of these time periods are subject to re-evaluation, since the projected time it takes to build large-capacity nuclear power plants varies within a range of from 11 to 12 years. An awareness of this fact should be reflected both in the preliminary stages of capital spending, during the phase when preliminary plans and designs are being drawn up, and also in the long-range plans of productive plants engaged in the manufacture of technological-equipment and construction-equipment installation enterprises.

The drafting of long-range resources development plans is a wide-ranging and responsible task. Work on the drafting of such plans must be based on an awareness of the prerequisites and of the factual interrelationships which represent the sum total of the findings of the many analyses and plans drawn up by other ministries or branches of industry. Specifically, these are the primary data that describe the required increase in the output capacity of the entire system of electric power generation and distribution, the prospects for the acquisition of primary energy resources, the output and installation capacities of construction enterprises, government-to-government agreements on cooperation, siting possibilities, the assimilation of new capacities into the generation and distribution system, and, finally, the environmental impact of capital investments, including the manner in which the problems created by the demographic and sociological consequences of capital construction projects are to be resolved. In light of the draft plans that have been drawn up with regard to the future development of the Czechoslovak power industry it is apparent that there are substantive and quantitative differences of opinion as to the real prospects for this development. This is due to the increases in unit performance ratings and, in particular, due to the modification of the primary energy resources infrastructure.

A transition is taking place, and this is in line with the worldwide trend that is taking place in the developed industrial countries, that favors the increased utilization of nuclear power. For this reason, the construction of nuclear power plants is turning out to be the cornerstone of plans for the development of our power industry. At the same time, however, it must be realized that no fundamental change in the structure of power generation resources will occur before the end of the 20th century. It therefore follows that during this transitional period we must continue to build conventional, solid-fuel-fired thermal power plants, and we must do so to whatever extent is permitted by the production capacities of solid-fuel-producing industries. As far as power plants fired by refined fuels are concerned, it is not possible at this time to foresee what will actually happen with regard to prospects for the procurement of these refined fuels.

Estimates of demand levels for increased power plant output and current knowledge about primary energy resources were set forth in the working papers submitted for discussion at the highest level of party and state organs. The total output capacities specified in these recommendations consist of the projected output capacities of thermal power plants that were built and started up during the course of the Sixth Five-Year Plan and the output capacities of power plants slated to go into service by 1990.

The electric demand forecast plan projects a basic electric power consumption level of 135 TWh by 1990. This projected consumption level and time frame proved to be the most important factor that was taken into consideration in determining the volume of new power plant generating capacities that should be brought on line by 1990. The appropriate volume is set at about 14,000 MW, i.e., the sum total of increase in power plant generating capacity that will be brought on line during the Sixth, Seventh, and Eighth Five-Year Plans. In accordance with resolution No 21/1978 of the government of the CSSR the projected increment in nuclear power plant generating capacity will amount to 3,520 MW during the Seventh Five-Year Plan and 5,760 MW during the Eighth Five-Year Plan. At the same time, more accurate versions of these forecasts are being drawn up in light of the ongoing verification of demand levels, and based on these results certain revisions, which will not be too radical however, may be made in the plan.

In absolute terms this major increase in generating capacity will be clearly reflected throughout the Czechoslovak power generating system. And it is at this point that the problem of the siting of power plants comes to the forefront as a very important factor in mapping out the growth strategy of our power industry.

Plant Siting Prerequisites and Criteria

In terms of the number of feasible locations for the siting of large industrial plants, a cagetory in which power plants most certainly belong, the physical geography of the CSSR is not very suitable due to high urban population densities and the intensive cultivation of the soil by agriculture, in addition to being due to the high density of existing industrial plants and, above all, the relative unsuitability of the terrain. This situation gives rise to some problems that are very difficult to resolve when it comes to the siting of thermal power plants. The task of selecting locations that are generally feasible for the siting of power plants has been addressed in the past and is being addressed now by TERPLAN--the state institute for land-use planning, which is supposed to fulfill this task in response to the goals set for the power industry at the ministerial level. Locations have been recommended for the siting of power plants on the basis of the numerous reports prepared by TERPLAN in which the suitability of various areas was tested and verified in a systematic manner.

The power industry has selected some of the recommended locations as subjects for the preparation of long-range land-use engineering studies, which will serve as the basis for the drafting and publication of a capital construction plan. These studies are prepared by the design and engineering organization ENERGOPROJEKT, which even during the preliminary planning stage will make a major contribution to the formulation of future capital construction plans. [illegible]e scope and level of this documentation is determined at the concern l[illegible]y directive No 7/1976 issued by the general directorate of the Bohemian Power Plants Concern in Prague.

The selection of plant sites and the confirmation of investment project feasibility during the preliminary planning phase requires that from the very outset all work should be performed in a manner that consistently abides by the principle of comprehensiveness and that general public interests should be taken into account both by the power industry and also by all other concerned decision-making organs and organizations. These priorities were clearly acknowledged in the effort that was made to draw up universally valid criteria to govern the siting of power plants. In the case of conventional power plants such site selection criteria have not yet been published, nor is it likely that they will be published at any time in the near future. In the past, and at the present time as well, a basic methodical approach is in use which for all practical purposes is tantamount to a set of basic site selection criteria. Historically, the most important criteria used to govern the siting of nuclear power plants has been the determination that such plants should be located a specified distance away from residential areas so as to provide for the protection of the local population. Since this approach failed in principle to resolve the problem of how to provide for the complete protection of the living environment, not to mention the fact that it could not be applied in a country with a land area as small as that of the CSSR, it proved to be necessary to take a new approach. A system of criteria was developed for the siting of nuclear power plants that addressed this issue not just strictly from the standpoint of safety, but also in the broad sense from the standpoint of land-use planning criteria. This system was based on the experience that was gained in connection with work on site planning for large-scale industrial plants, especially conventional power plants, and also in connection with the selection of sites for the construction of the first VVER-440-type nuclear power plants. The first official document of this type was issued by the Federal Ministry of Fuels and Power in cooperation with the Czechoslovak Atomic Energy Commission in December 1972. This document was superseded in August 1976 by universally valid safety regulations issued by the Czechoslovak Atomic Energy Commission under the heading "Criteria for the Siting of Nuclear Power Installations." However, the criteria spelled out in this document and, where applicable, the fulfillment of these criteria do not supersede the site selection statements made by competent official bodies that are required pursuant to the provisions of existing Czechoslovak law (e.g., the decree of the Federal Ministry, of Technological and Investment Development published in SBIRKA ZAKONU No 163-1973 concerning construction project documentation).

These criteria are used to evaluate the suitability of plant sites from the following basic viewpoints:

--the technical feasibility of the construction and operation of nuclear power installations,

--protection of the natural and living environment,

--the relative social benefits to be derived from using proposed construction sites for other purposes,

--the economic efficiency of the construction and operation of such installations.

In principle, these criteria consist of two basic groups which are:

--exclusionary (classes I and II)

--and relative (for economic and other reasons).

It is assumed that these criteria will be supplemented and updated as required by the prevailing level of scientific and technical knowledge and the passage of new laws.

The most important criteria are the class-I exclusionary criteria which preclude the construction of nuclear power plants in zones which are:

--subject to intensive landslides,

--presently undermined or slated to be undermined in the future,

--classified as nature preserves,

--classified as having a seismicity rating of VIII° MCS [expansion unknown] or higher,

--designated as protected areas for the cultivation of natural medicines,

--in which as a result of the normal operation of nuclear power plants it would not be possible to prevent excessive radiation dosages for individuals in accordance the relevant decrees of the ministries of health of the CSR and SSR and where, in the event of a plant accident, radiation dosages may not exceed specified levels for the most exposed individuals living in the vicinity of a nuclear power plant (25 rems for the whole body, 150 rems for adult thyroid glands, and 75 rems for the thyroid glands of children),

--which are known to contain deposits of economically important raw materials,

--which are in the vicinity of superhighways and main railroad lines and waterways that are under construction.

Class-II exclusionary criteria cover zones:

--with unfavorable geological characteristics,

--with soil load limits less than 0.03 N/mm^2 at a depth of 7 meters,

--with seismicity ratings ranging between VI° and VII° MCS,

--with underwater tables higher than 2 meters below the surface,

--which are prone to flooding and which might be flooded in the event of dam breaks,

--with ground relief elevations higher than 15 meters,

--where it is impossible to lay railroad track sidings on the construction site,

--where the permeability of substrata rocks would permit the contamination of groundwater,

--which are designated as protected drinking water supply areas,

--which are designated as national natural preserves,

--with important cultural monuments,

--where under normal operating conditions it is impossible to insure that the target cumulative dosage level per unit of power plant output will not exceed 4 rems/MW per annum and where, in the event of a plant accident, it is not possible to insure that radiation levels will not exceed the level determined by the product of target cumulative dosage level prescribed for normal operations and for the service life of the nuclear power plant,

--where the heating of watercourses by plant waste heat would exceed permissible biological limits,

--where exploratory work is under way for mineral natural resources,

--where there is agricultural land that must be protected from annexation,

--which are designated as recreational and tourist areas,

--which are designated as buffer zones around airports and radio beacons,

--which are designated as superhighway rights-of-way or as buffer zones for superhighways, railroad lines, and transit gas pipelines, oil pipelines, and other important commodity transport systems,

--which are considered to be suitable for investment projects with even higher levels of land-use and technical exigencies,

--in which vehicular traffic collosions might occur,

--which are considered to be unsuitable due to special national interests.

These criteria exclude tracts of land as construction sites for nuclear power plants for reasons that are essentially explicit or conditional. The class-I criteria are explicit, while the class-II criteria are conditional. If a chosen construction site does not meet one or more of the class-II exclusionary criteria, it will be necessary in subsequent project planning phases either to make required adjustments in the project plan, to exempt the project from statutory regulations, or to modify the priorities of the project sponsor. It is probable that some statutory regulations will have to be waived in all plant siting cases.

Within the context of government-to-government cooperation among the CEMA countries discussions have already taken place in appropriate commissions concerning issues related to the feasibility of issuing regulations governing the selection of nuclear power plant construction sites that would be enforced in all the CEMA countries. Such discussions were held during bilateral negotiations between delegations representing the CSSR and the USSR in March 1977, and so it is to be expected that within the foreseeable future regulations will be agreed upon and spelled out that will be mandatory for both sides and that will supplement or supersede the abovementioned criteria. In essence, though, these criteria will not be subjected to any radical revision, rather they will be defined in greater detail and enlarged upon in pace with the acquisition of new knowledge and experience.

Basic Interrelationships Between Plant Site Selection and Land-use Planning Registers

Pursuant to Law No 50/1976 SBIRKA ZAKONU on Land-use Planning and the Building Regulations (the building code) builders are required when selecting sites for plant construction to refer to land-use planning registers during the land-use forecasting and land-use planning phases. In this connection their work is to be based on long-range power industry development forecasts, and for the purposes of the drafters of land-use planning registers (hereafter abbreviated UPD) this data base consists of or should consist of the findings arrived at in studies prepared by TERPLAN and ENERGOPROJEKT. If a given construction site is written up in a UPD and if this site selection is approved, the conditions will have been met for the trouble-free wrapping up of preliminary building project paperwork, including land-use permits.

However, the fact of the matter is that during the phase when UPD's are being drawn up no data are available on selected construction sites, and so power industry capital projects, for the construction of conventional power plants and especially for the construction of nuclear plants, are not mentioned in the UPD's. The principal reasons for this are attributable to the effects of the growth of the power industry, especially the nuclear power industry, where the standards of and modifications in nuclear plant engineering plans, having to do with such things as power ratings, performance parameters, land-use and technical exigencies, nuclear power plant equipment safety systems, the environmental impact of plant construction and operation, and so on, have an effect on the feasibility of selecting a given site and writing it up in a UPD. It turns out that one way to get around this problem consists in the gradual and regular amendment of UPD's for given land zones which over the long run are slated to provide sites for the construction of nuclear power plants while at the same time incorporating into these UPD's a statement of the demands and capital investment projects which will be generated by or are necessarily related to this kind of construction activity. However, such amendments usually conflict with the schedules for the planning, design, and construction of nuclear power plants. This means that preliminary and final project planning documents--and the resultant land-use planning decisions--must do a proper job of reconciling these conflicts, with reference to the appropriate UPD, in the case of a given land zone.

This procedure is exemplified by the site selection process for the construction of the North Moravia nuclear power plant. Lipnik nad Becovou, one of the alternative sites for the construction of this power plant which was written into the land-use plan for the Hana region (the presentday urban agglomeration of Olomouc, Prerov, and Prostejov), does not meet some of the exclusionary criteria, and so at the present time two other alternative sites are being closely studied:

--the Majetin site (10 kilometers south of Olomouc),

--the Blahutovice site (north of Hranice).

These sites were not written into the Hana UPD or into the UPD's for the Beskid and Valassko regions, which were drawn up between 1971 and 1972 and approved by the North Moravia Kraj National Committee between 1972 and 1973. Some aspects of the site selection process for this nuclear power plant are similar for all of the alternative sites, e.g., the tie-in with the reservoir dam slated for construction at Teplice nad Becovou, but there are other factors--and these are in the majority--that are clearly at variance with and necessitate amendments to the UPD and revisions in the regional plan for the development of this urban agglomeration. It turns out, therefore, that on the basis of the new information that is coming in concerning the development of the nuclear power industry nuclear power plant or nuclear center site selection work should be viewed as the starting point for zone development and administration during the phase when land-use registers are being compiled for large territorial units. This would be a question of drawing up land-use forecasts as the starting point for the transition to the formulation of land-use plans. Based on the links between individual types of UPD's, large-scale capital investment projects would eventually be transferred from the purely informational to the project-realization sections of UPD's with regard to such areas as housing construction for plant construction and operational personnel, the provision of industrial water sources and supply systems, and so on. With regard to the impact of nuclear power plants on the living environment UPD's will be a reflection of the knowledge and depth of current information in this area which in turn should be clearly reflected in the drafting of land-use forecasts for large territorial units. In spite of the wide-ranging nature of the total volume of information that will be needed it will be advisable to make sure that all this information is taken into account during the appropriate UPD drafting phases so that it will be possible for the subsequent zoning of capital construction activity to proceed in an optimal manner.

The Plan for the Construction of Power Plants at Selected Sites and Their Primary Characteristics

The plan for the construction of thermal power plants during the Sixth, Seventh, and Eighth Five-Year plans, that is, through 1990, covers the following installations listed in tables I and II.

Table I.

(1) Klasické elektrárny		
(2) Lokalita	(3) Instalovaný elektrický výkon [MW]	(4) Rok uvedení do provozu
Chvaletice I	4 × 200	1977 ÷ 79
Počerady II	2 × 200	1977 ÷ 78
Mělník III	1 × 500	1981
Prunéřov II	5 × 210	1981 ÷ 82
Opatovice II	2 × 500	1985 ÷ 86

Key:

1. Conventional power plants
2. Construction site/plant designation/
3. Projected on-line power rating (MW)
4. Projected target date for plant startup

Table II.

(1) Jaderné elektrárny		
(2) Lokalita	(3) Instalovaný výkon [MW]	(4) Rok uvedení do provozu
V1 Jaslovské Bohunice	2 × 440	1978 ÷ 1979
V2 Jaslovské Bohunice	2 × 440	1981 ÷ 1982
E Dukovany	4 × 440	1982 ÷ 1985
JE Mochovce I	4 × 440	1985 ÷ 1986
JE Jižní Čechy (Malovice)	2 × 1000	1987 ÷ 1989
JE Severní Morava	1 × 1000	1. blok 1989
	1 × 1000	2. blok 1991
JE Mochovce II	1 × 1000	1990

Key:

1. Nuclear power plants
2. Construction site/plant designation/
3. Projected on-line power rating (MW)
4. Projected target date for plant startup

In addition to these power plants, work was completed at the start of the Sixth Five-Year Plan on the construction of the Tusimice II power plant (4 power generating units with power ratings of 200 MW each) and the Detmarovice power plant (4 x 200 MW).

Some of the other possibilities under consideration with respect to the construction of conventional power plants include the proposed installation of a 200 MW power generating unit so as to expand the generating capacity of the existing power plant at Porici near Trutnov. Another source for the combined generation of electricity and heat will be provided by the installation of the Ervenice regional heating plant at the Ervenice site on the grounds of the existing Ervenice II power plant. The output capacity of this new heating plant should fall within a range of 2 - 3 x 250 - 300 MW.

It is a basic characteristic of sites chosen for the construction of conventional power plants that they are limited to areas where construction activity has not yet gotten under way. A prime example of this is the power plant slated for construction in the vicinity of Opatovice. The Opatovice power plant, with a projected power rating of 2 x 500 MW, will be fired by brown coal from the North Bohemia Brown Coal Mining District and will operate strictly by means of steam condensation; cooling will be circulatory based on the use of cooling towers (one per power generating unit). The plant will be built on the grounds of the existing Opatovice I power plant; the most unusual feature of this plant will be the delivery of its fuel by water, as in the case of the Chvaletice I power plant. The construction of the Opatovice II power plant will make it possible to proceed with the conversion of the condensation steam-turbine systems in the Opatovice I power plant so as to accommodate the installation of heating plant equipment for the supply of heat to the cities of Hradec Kralove and Pardubice. This construction project will necessitate auxillary capital investment work, including making the Labe navigable along the section between Chvaletice and Opatovice and, most likely, the construction of a water treatment storage reservoir at Pecin. However, the latter project will produce major benefits in terms of water resources management.

The installation of a 200 MW power generating unit at Porici actually amounts to an expansion of the existing power plants at this site. It will be necessary to modify and recontour the grounds of this construction site to some extent so that the new power generating unit can be built in the designated area. The most conspicuous auxillary capital investment project involves the construction of a smaller reservoir dam that will secure a supply of industrial water from the Upa River. The design of the 200 MW turbine systems will probably be identical to the design of the turbine generators used in existing plants equipped with 200 MW generating units that are sometimes required to provide semi-peak-load service.

The Ervenice regional heating plant is to be built on the grounds of the existing Ervenice II power plant, but in order to make room for the construction of this project it will be necessary to demolish the existing Ervenice II plant. In addition to the demolition of the existing plant, it will be necessary to make allowances for the troublesome building foundation conditions of this site in view of the fact that the terrain has been undermined. Ash storage and disposal will also pose difficult engineering and operational problems. The technique that is now being recommended calls for the ash waste to be deposited in a dry or semi-dry state on the outer overburden piles of nearby opencast mines. However, there are questions about this system that have not yet been fully answered. In view of the need to insure deliveries of an adequate volume of coal fuel the construction of the Ervenice heating plant will very likely depend on the opening of a new coal mine. According to the long-range plans of the North Bohemia brown coal mining concern, the opening of a new mine at Bylany should make it possible to increase coal production. From the standpoint of the long-range goals for the development of this region's power industry the combined generation of heat and electric power appears in the long runto be a very viable option. The construction of this plant is also intended as a possible replacement for the existing Komorany power plant (whose service life will come to an end in the 1990's) and as a possible new heat supply source for all of those areas that are still being served by this power plant. However, it will be important to determine how the operation of industrial plants, including power plants, will affect the total living environment in the North Bohemia Kraj. But it is also necessary to take into account the decided benefits that will accure from the siting of the Ervenice heating plant directly in a coal mining basin, the availability of an industrial water supply, the possibility of depositing waste ash on land that has been torn up by strip mining activities, the capabilities of an experienced team of operational personnel, and so on.

As in the case of conventional power plants, I do not intend to discuss the basic characteristics of those nuclear power plant construction sites where construction has already gotten under way. This is in reference to the V1 and V2 nuclear plants at Jaslovske Bohunice and the Dukovany nuclear plant with its VVER-440 reactor units.

The nuclear power plant at Mochovce is being considered as another power plant that will be equipped with VVER-440 reactor units. This site was chosen as one of several other construction sites selected during 1972 for nuclear power plants without shield walls. The Mochovce site is in Levice Okres; in order to make the necessary room for the construction project it will be necessary to demolish the obec of Mochovce; site preparation for the plant's foundation will necessitate increased labor and costs. The construction of this plant is also giving rise to the need for auxiliary capital investment. In addition to replacing the housing and public utilities stock for the residents of Mochovce, it will be necessary to invest capital in the construction of a dam for the storage of the required volume of industrial water. The valley-like nature of this location will also have an impact on the general costs plan of the building site, primarily in terms of ancillary construction needs and also due to site preparation needs. Four power generating units with output ratings of 440 MW each are slated for construction, and allowances are to be made for the possibility of adding on additional output capacity. It is expected that the plant will operate strictly by means of steam condensation processes and that it will supply electric power for the national power grid. For the time being it is expected that the turbine assemblies will put out a unit load of 220 MW. Given the current capabilities of the Czechoslovak power plant equipment industry and in view of the final engineering designs for the No 3 and No 4 power generating units at the Dukovany power plant, the possibility that the unit power output ratings of these turbine assemblies might go as high as 440 MW is not being ruled out.

According to the long-range plans for the development of the Czechoslovak power industry, the Malovice plant in South Bohemia is supposed to be the first nuclear power plant in this country to be equipped with VVER-1000 reactor units and shield walls. This construction site, lying on the border of the Prachatice and Ceske Budejovice okreses, was chosen as one of several sites affording the possibility of obtaining process feedwater from the Vltava River. Even though this site meets this criterion, it is still situated at a rather considerable distance from the Vltava River, and the supply of water to this plant will be relatively expensive both as a capital cost and as an operational cost. The microregion near the village of Malovice that was originally recommended as a building site lay completely outside the bounds of cultivated farmlands and was mostly forested, but geological survey studies demonstrated the total unsuitability of this building site. For this reason, considertion was given to moving the building site a certain distance to one of two alternative microregions where geological conditions were tolerable, but where the construction site would encroach on farmlands with soil quality ratings in class 4 and class 5. Otherwise, this site proved to be suitable in terms of its position and area. The most costly auxiliary investment project will be the installation of electric power transmission lines, which is not a problem unique to this construction site, but is rather a problem that must be dealt with at all power plant construction sites. Energy demand levels were also estimated recently from the standpoint of this plant's capacity for supplying heat to Ceske Budejovice and to agricultural and, possibly, food processing industries, in addition to the electric power which it will feed in to the national power grid. However, it turns out that the only way to supply heat directly to consumers is at the expense of a certain drop-off in electric power generation, that is, there is no way to harness the power plant's low-potential waste heat. It is projected that during the first 2 x 1,000 MW phase of construction the power plant will be equipped with four turbine assemblies with power output ratings of 500 MW each and with a 100 percent steam condensation process. Preliminary studies show that it is possible to equip the turbine systems with appropriate feedwater heating stages. A very interesting situation will arise in connection with plans for the construction of a cellulose and paper products combine in Olesnik which is not far from the Malovice site. Here, in relatively close proximity to Ceske Budejovice, a complex consisting of two major capital projects is going to rise up that is bound to influence the need for a comprehensive plan (primarily regional in nature) governing both of these projects and all of their auxillary and spin-off capital projects. It is likely that there will also be some demand for the heat that could be supplied by the Malovice nuclear power plant, and this in turn could also lead to the modification of the size of the plant's turbine systems. In general it is expected that the Malovice plant will have a total power output rating of around 4,000 MW.

Another nuclear power plant equipped with shielded VVER-1000 reactor units which is supposed to be built and on-line before work is completed on the construction of the Malovice plant is the nuclear power plant serving North Moravia known as the Majetin nuclear power plant. In essence this site is intended as a substitute for the Lipnik nad Becovou site that was being contemplated earlier. The Lipnik nad Becovou site is located at a point between Lipnik nad Becovou and the village of Tyn nad Becovou on the left bank of the Becva River in Prerov Okres. The land area of this site is relatively small, and the site is located on a tract of land that is prone to flooding. After the construction of the water storage reservoir at Teplice nad Becovou is completed, the flood hazard should be reduced considerably, and it should be possible to raise the construction site terrain above the disastrous floodstage level. However, the problem remains of devision means to protect the building site (both of the dam and of the power plant) from these floodwaters while construction is under way. The construction of the Teplice reservoir dam is a prerequisite capital project that must be completed first in order to make it possible to gain access to the necessary volume of process feedwater. It is expected that the Majetin plant will operate strictly by means of steam condensation and that its four turbine systems will have a power output rating of 500 MW each. At the present time the Lipnik nad Becovou nuclear power plant construction site is regarded more as a less preferable, back-up plan in contrast to the Majetin site that is now under consideration. The most important reason cited to substantiate this decision is the fact that the Lipnik nad Becovou locale does not meet site selection criteria in view of the fact that, if it were chosen, the nuclear power plant would be located downstream from the reservoir dam. And in the event of some unforeseen development at the dam site the power plant site might be flooded.

The Majetin plant construction site is located 11 kilometers south of the Olomouc city center, roughly in the center of the triangle whose points are represented by the cities of Olomouc, Prerov, and Prostejov. In comparison with the high-quality farmland soil of the area that surrounds it, this site is located on less desirable farmland between the Morava River and the Olomouc-Prerov railroad line. One disadvantage of this site is the relatively high groundwater level, the lowering of which will require the undertaking of rather difficult technical and engineering measures. On the other hand, the decision to incorporate the Majetin nuclear power plant into the thermal generating plant system supplying heat to Olomouc and Prerov and possibly other cities as well appears to be very advantageous. At the same time, it is planned that after work is completed on the erection of the power plant structures and its auxillary facilities (and after it has been furnished with the heat it needs for startup purposes), the Majetin plant will be linked up with the new heating plant now slated for construction to supply heat to Olomouc and Prerov. This would make it possible to dispense with the necessity of building a heating plant on the grounds of the Majetin power plant. By virtue of its size and power output rating the Majetin nuclear power plant is similar to the alternative nuclear power plant that could be constructed at the Lipnik site, whereby it is believed that for a power output rating of 2 x 1,000 MW the electric power transmission lines would have to be linked up with the rebuilt Prosenice distribution substation coupled with the necessity of building a new ultra-high-tension distribution substation to accommodate the additional output. Similarly, consideration is already being given to the possibility of building a new distribution substation concurrently with the construction of the power plant. The construction of the Teplice nad Becovou reservoir dam is still a prerequisite capital project that must be completed in order to provide access to the necessary volume of process feedwater.

The environmental impact of both of these nuclear power plant site alternatives were subjected to computer analysis. The results of this analysis showed that it will be possible to abide by all current health and safety regulations and norms. If stricter health and safety criteria should go into effect at some time in the future, primarily with respect to population density and growth, consideration is being given to the selection of still other alternative sites for the construction of a North Moravia nuclear plant in the area north of Hranice in the vicinity of Blahutovice Obec or if need be in the vicinity of Starojicka Lhota Obec in Novy Jicin Okres. No land-use planning documents have as yet been drawn up for these sites that would approximate the level of those drawn up for the Lipnik and Majetin sites, but it is to be expected that to do so would pose no major obstacles of a land-use planning or engineering nature.

On the basis of the experience that has been gained to date from the drafting of preliminary plans for the construction of high-performance nuclear power plants it can be demonstrated that the further growth of our country's power industry is closely related to the making of timely decisions with regard to the selection of nuclear power plant construction sites and to the ensuing comprehensive determination of their impact on general social interests.

Prague-Leningrad Design Cooperation

Prague INVESTICNI VYSTAVBA in Czech No 11, 1978 pp 357-359

[Article by Eng Josef Nekolny: "Cooperation Between ENERGOPROJEKT of Prague and TEPLOELEKTROPROJEKT of Leningrad"]

[Text] The Soviet Union's first nuclear power plant went into service in 1954. By the following year of 1955 the Soviet government was already providing other countries with scientific, technical, and industrial assistance in connection with the development and research effort dedicated to finding peaceful uses for nuclear energy. And by March 1956 an agreement had already been signed between the governments of the USSR and the CSSR concerning cooperation and assistance to be furnished by the Soviet Union on connection with the construction of Czechoslovakia's first nuclear power plant designated "A1."

A close working relationship was established between Czechoslovak designers and the Soviet design organization TEPLOENERGOPROJEKT Leningrad, where in an atmosphere of close cooperation work began on the development of design and production plans for the A1 nuclear power plant. Over a period of more than 20 years during which they have been engaged in cooperation with the Soviet Union, starting with the first beginnings in 1956, when Czechoslovak design engineers started to build on their experience in the design of conventional power plants, the design engineering staff of ENERGOPROJEKT has laid a solid foundation for the drafting of complex and wide-ranging nuclear power plant designs.

With the technical assistance of the Soviet Union ENERGOPROJEKT, in its capacity as a general design contractor, is drawing up all manner of preliminary and final design plans for nuclear power plants which are intended to supply industry and the general public with electric and thermal power.

During the initial stages of the process dedicated to finding peaceful uses for nuclear energy numerous proposals were advanced for all kinds of nuclear power plants (which is quite natural in light of the new scientific discoveries and inventions that were being made) with reactors cooled with gas, light water, liquid metals, and so on, moderated with graphite and heavy water, and so on and so forth with many subvariations and combinations of various component designs. At that time, when no one had any previous experience in the production of equipment for nuclear power plants and their operation, it was very difficult to make objective judgments as to the prospective viability of specific system designs in terms of the difficulty of manufacturing and operational problems, the demands that would have to be met by the scientific and technological infrastructure, or the demands that would have to be met relative to the marshaling of scientific-technological, material, and financial resources. For this reason, a number of different designs were drawn up for nuclear power plants that were intended to be built as prototype systems so that the feasibility of one design or another could be tested in practice.

The Soviet side offered the Czechoslovak side a design for a natural uranium-fueled reactor cooled with carbon dioxide and moderated by heavy water (deuterium oxide). The underlying physical principles governing the operation of this type of reactor were recommended by the Soviet physicist academician Alikhanov. Soviet design organizations already had drawn up two alternative engineering designs for this kind of plant. As soon as all evaluations, recommendations, and final decisions had been made as to the plant design alternative slated for construction Czechoslovak organs and organizations (scientific research institutes, design organizations, manufacturing plants, and other institutes and management organs) went right to work, with the cooperation and technical assistance of the Soviet Union, on the drafting of blueprints, the gearing up of production capacities, and the preparation of the plant construction site located in the obec of Jaslovske Bohunice in Slovakia.

In conjunction with the drafting of engineering plans for the construction of the A1 nuclear power plant the production experience gained in this country and the knowledge acquired in other countries were also drawn upon as a basis for an evaluation of Czechoslovakia's current and long-range nuclear power program, upon which the national economy would depend for its supplies of electric and thermal energy.

Detailed studies and analyses showed that in the long run the most suitable option would be for the construction of additional nuclear power generating capacities to be based on VVER-type nuclear power plants equipped with light-water reactors, the effectiveness of which had been demonstrated not only in the Soviet Union but also elsewhere in the world.

Basic Design Concepts of Nuclear Power Plants in the CSSR as Drawn Up by ENERGOPROJEKT With the Cooperation and Technical Assistance of the USSR

The A1 Nuclear Power Plant

This power plant went into service in 1972. The total on-line power generating capacity of 150 MW is provided by a single heterogenous thermal reactor which is fueled by naturally occurring uranium metal, moderated by heavy water and a neutron reflector, and cooled by carbon dioxide gas. Three condensing system turbine systems with power ratings of 50 MW each are installed in the turbine room. The design of the main power generating plant is patterned after that of conventional power plants. This means that the turbine room with its crosswise arrangement of turbine systems lies perpendicular to the intermediate machinery room housing the steam generators, beyond which lies the separate reactor containment building housing the reactor and its auxiliary active operations, conveyance and instrumentation channels, and fuel storage bays for fresh and spent fuel. The heat-balance diagram is designed in the form of a two-stage, high-low pressure system in order to insure optimal thermal efficiency.

The V1, V2 and V3 Nuclear Power Plants

The V1 and V2 nuclear power plants are under construction at Jaslovske Bohunice. The V3 nuclear power plant is under construction at Dukovany in southern Moravia in the okres of Trebic.

On-line power ratings for the nuclear power plants:

V1-- 880 MW

V2-- 880 MW

V3--1,760 MW

The conceptual design of these power plants is based on a VVER-440 unit equipped with V-230 or V-213 type reactors with a thermal rating of 1,375 MW which are linked to two turbine systems with electrical power ratings of 220 MW each.

Nuclear power plants with VVER-440 power generating units are based on a tandem-unit design concept. The main power generating plant with its two on-line power generating units (2 x 440 MW) may be described as a functionally and systemically closed unit, which in terms of nuclear and fire safety, the handling of fresh and spent fuel, the handling or radioactive wastes, inputs and outputs of unit monitored zones and their flow through monitored zones, including the design of the control building, constitute a closed-cycle system. The design of the main power generating plant and the arrangement of auxiliary plant operations and buildings meets all of these requirements. This applies in particular to the building that houses auxiliary active operations, the plant building housing the health safety check cycle, diesel generator stations, high-pressure compressor stations, and so on. This closed-cycle relationship is patently clear when one compares various construction blueprints for power plants equipped with VVER-440 power generating units. An examination of the actual power plant design shows that in order to insure the economic efficiency of such investments it is necessary to build VVER-440 power plants in accordance with the tandem-unit design format.

The main power generating plant is operated in a series of runs with the average length of a given run amounting to 3 x 7,000 hours, that is, with one-third of the fuel load being replaced every year. The primary loop is designed to withstand a worse-case plant accident caused by the rupture of the main steam piping with discharge from both ends of the piping system.

The main power generating plant consists of the reactor building, transverse and longitudinal intermediate machinery buildings (stages), and the main turbine building. Special ventilation lines link the reactor containment structure with the tiered arrangement of wet steam condensers and the intermediate machinery room. Two reactors are housed in a common reactor containment building, and both reactors are housed in separate reactor vessels with biological shielding and with adjoining hermetically sealed boxes which contain primary loop equipment, i.e., steam generators, main circulation pumps, header fittings, circulation piping, and so on. The reactor containment building also houses auxiliary loops of the primary loop such as the boron regulation system, safety systems, primary loop back-up systems, systems for continuous coolant purification, fresh and spent fuel storage bays, conveyance and instrumentation systems, and so on.

The turbine room contains two dry-steam-driven turbine systems for each power generating unit, and each turbine has a power rating of 220 MW. The longitudinal intermediate machinery room (18 meters wide) contains water heating equipment and cooling water tanks.

Otherwise, the floor area of the intermediate machinery room is devoted to providing space for electrical equipment, i.e., internal plant power circuit switch gear with ratings of 6 and 0.4 kV, connecting cable runs, and certain ventilation and pneumatic support systems for the reactor containment building. The rest of the floor area in the intermediate machinery room is taken up by connecting piping for the secondary loop section, reduction stations generating steam for internal plant use in various operational modes, and so on. The transverse intermediate machinery rooms are reserved exclusively for electromechanical equipment and automated control systems.

The automated VVER-440 instrumentation control system comprises subsystems for data read-out, the automatic regulation of control procedures, automatic devices, and protection apparatuses. These subsystems, consisting of analogue and digital system components, constitute a uniform system of control and regulation. The plant's operational modes, whose general rules are predetermined, are designed in such a way that the control and regulation system intervenes automatically so as to make sure that the plant functions within desirable operational ranges under optimal conditions. Likewise, in the event of breakdowns, the protection of plant personnel is assured, and the control and regulation equipment is set to function automatically in such cases. In spite of the system's high level of automation, the human operator continues to be the most important component in the plant regulation process. This is why operators are still required to meet such high training qualification standards.

With regard to the safe discharge of waste heat generated by the reactor after it has been shut down, in conjunction with the engagement of back-up cooling systems and emergency sources of electric power, a general plan has been devised for the discharge of this waste heat and for supplying the plant with auxillary water.

Under the terms of this general plan provisions were also made for radiation protection, which is focused on:

--monitoring radiation levels in the plant environment (control, measurement, evaluation, logging),

--monitoring activity levels in plant system loops (levels, transportation, accumulation, leakage, integrity of system sealing),

--monitoring radiation levels in the surrounding environment,

--monitoring and keeping records of personnel exposure to radiation and contamination,

--monitoring and keeping records of the contamination of work areas, equipment, and transport vehicles,

--monitoring the effectiveness of decontamination measures,

--monitoring the level of radioactive emissions and waste,

--monitoring adherence to work safety regulations in the handling of radioactive materials.

With regard to the performance of specific radiation protection functions on plant premises it is expected that responsibility for the performance of these various functions will be distributed according to principal plant work areas:

--radiation checks of individual plant units, including the reactor containment building, the turbine room, and the building housing auxillary active operations, ventilation shafts,

--radiation checks of the surrounding environment,

--radiation checks of the plant control room building,

--radiation checks of waste water,

--geiger counter checks of individuals and laboratory areas,

--radiation checks of the radioactive waste incinerator and radioactive waste compaction facility.

Environmental radiation checks, special instrumentation checks, and plant emissions checks are performed in part by the SEJVAL centralized monitoring system, by discrete monitoring devices, and by collecting specimen from the central intake system. Portable devices are used to take ad hoc radiation readings. The centralized radiation monitoring system could be linked up with a computer. However, this possibility has not yet been taken into account in the plants where this centralized system was first put into practice.

For the sake of thoroughness it is necessary to call the reader's attention, at least briefly, to some of the other systems which safeguard the reliable functioning and operation of power generating units, starting with those systems that provide for the transportation of fresh and spent fuels, ventilation systems, decontamination systems, high-pressure and low-pressure air feed systems, radioactive materials scrubbing stations, laboratories, switchgear, a number of other electrical installations and systems, the fire protection system, the power transmission system, certain aspects of plant startup procedures, operational modes, piping systems, equipment damage prevention measures, and other systems and services which cannot be reviewed in a general survey of this nature.

For us the A1 nuclear power plant is a success story that belongs to the past, while the V1 and V2 nuclear power plants in Jaslovske Bohunice and the V3 nuclear power plant in Dukovany are all contemporary success stories, since the 440 MW unit of the V1 power plant has already entered the startup and trial-run phase.

While relying on the technical cooperation and assistance of the USSR, ENERGOPROJEKT, in its capacity as general design contractor for power engineering construction projects, drew up the preliminary engineering designs for the A1 nuclear power plant, and other Czechoslovak contractors then proceeded to draft the operational designs for this plant and to make deliveries of appropriate plant machinery and equipment.

In the case of the V1 nuclear power plant engineering designs were drawn up by the Soviet design institute TEPLOENERGOPROJEKT (Leningrad branch), including operational designs for the power plant's primary loop section. The Soviet Union supplied most of the equipment required for the construction of the primary loop section of this power plant.

With regard to the V2 and other nuclear power plants ENERGOPROJEKT has already drawn up the draft plans for this plant's instrumentation and structural sections, and other Czechoslovak contractors are providing the operational instrumentation designs and are also responsible for deliveries of most of the equipment that will be installed in the plant's primary loop section. All construction labor is being furnished by Czechoslovak partners, and the operational structural designs are being provided by ENERGOPROJEKT.

With regard to the startup of this power plant and its individual power generating units ENERGOPROJEKT has been responsible for drafting the rules that will govern startup procedures and the interface between equipment supplied by other major contractors, various provisional arrangements, and so on. During the construction phase ENERGOPROJEKT is to be responsible for furnishing reword blueprints covering various provisional arrangements, changes, modifications and additions, that prove to be necessary as a result of the advancement of construction work and the requirements that arise in connection with the completion of equipment installation work.

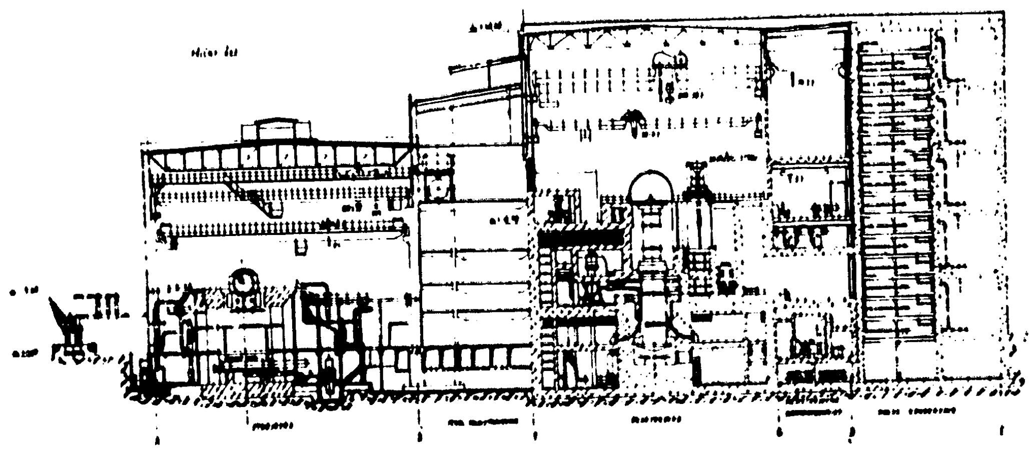
The Contribution of ENERGOPROJEKT to the Construction of Nuclear Power Plants in the CSSR

In all fields ENERGOPROJEKT exercises its right to supervise the execution of designs to which it holds patent. It does so not only by playing a co-ordinating role in connection with the drafting of operational designs, but also by means of the significant direct participation of its employees in the management of construction projects where, in collaboration with the investor and appropriate subcontractors, they help to clarify design blueprints and to guide the progress and execution of specific construction tasks. It collaborates closely with the investor in connection with the performance of the investor's technical oversight functions, by means of which the investor provides for the continuous supervision and requisite quality of all construction and installation work. Within the context of plant startup work and preparations for the full-scale testing of plant facilities ENERGOPROJEKT specialists take part in the adjustment and setting of the plant's complex control loops and protective systems from the standpoint of the overall interface and functional interrelationship between equipment and systems delivered by major contractors.

Prior to plant startup ENERGOPROJEKT also takes part in the work of project acceptance commissions, in the performance of comprehensive trial runs, and so on with a view to insuring the comprehensive fulfillment of and compliance with the design principles and goals.

Within the context of preliminary plant commissioning preparations ENERGOPROJEKT cooperates with investors and contractors in the stipulation of requirements relative to special plant operational modes, and it also contributes to and supplements data in the pre-commissioning safety report which define the operational rules of a power plant as a whole and in terms of the interrelationships that exist between its constituent components. ENERGOPROJEKT performs this function, together with the exercise of its patent oversight rights, in direct cooperation with Soviet specialists.

Diagram 1. V2 Nuclear Power Plant in Jaslovske Bohunice, Cross Section View of the Main Generating Unit



Jaderná elektrárna v Jaslovských Bohunicích V2 – příčný řez hlavním výrobním blokem

Key:

1. Turbine room
2. Longitudinal intermediate machinery room
3. Reactor containment building
4. Intermediate machinery room housing pneumatic equipment
5. Wet steam condenser module

Photo 1.

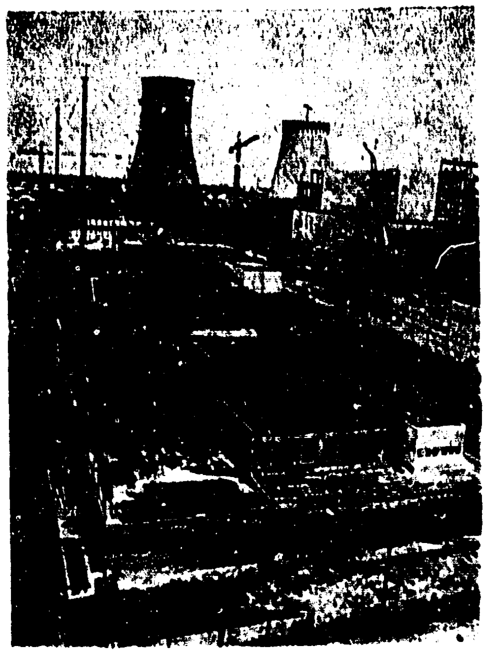


PHOTO CAPTION

A nuclear power plant in Jaslovske Bohunice; a view of feedwater treatment facilities and cooling towers.

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New Plant Designs

Prague INVESTICNI VYSTAVBA in Czech No 11, 1978 pp 360-363

[Article by Eng Jaroslav Fiala and Eng Jiri Valasek]

[Text] It is generally well known that the world's fuels and energy supply situation is unfavorable. Nor do the long-range forecasts for the production of fossil fuels, especially in their refined forms, during the remaining years of this century give us any reason to be optimistic. On a worldwide scale this state of affairs is making it necessary to look for ways to provide for the comprehensive utilization of primary energy resources and for the efficient management of all their various forms. One of the ways to accomplish this, an alternative which has been a focal point of intense interest during the past five to eight years, is the combined generation of electricity and heat--thermal engineering.

The Current State of Thermal Engineering in the CSSR

With the generation of electricity in conventional steam condensing power plants, at most only 30 percent of the primary energy source can be converted into usable energy. The remaining 70 percent is usually discharged back into the environment by the cooling water as waste heat. In the case of nuclear power plants--in view of the lower steam generation parameters that are currently being achieved in these plants--the ratio of waste heat to usable energy is even greater. This is attributable to the physical law governing the steam condensation work cycle.

The generation of heat accounts for approximately 55 percent of the CSSR's total demand for primary energy resources. Therefore, this demand for thermal energy represents a significant untapped resource that could pave the way for a reduction in the amount of energy lost in the form of waste heat and for an improvement in the thermal efficiency of power plants.

Simply put, the principle of the combined generation of electricity and heat consists in the principle which proposes that at a suitable point that portion of the steam used to drive a turbine is retrieved which has already yielded the greater part of its energy for the generation of electricity and is put back to work for heat supply purposes. The volume of steam flowing into the condenser is reduced proportionately accompanied by a corresponding reduction in the amount of heat discharged by the cooling water. A combined power plant work cycle of this nature could be employed to raise the level of primary energy utilization to from 60 to 70 percent and thus contribute to the conservation of that energy.

Thermal engineering enjoys a longstanding tradition in the CSSR; the growth of this field has been especially rapid during the past 30 years. The design concepts incorporated into the industrial heating plants used by metallurgical combines in Juncice and Kosice, the SLOVNAFT chemical enterprises in Bratislava, the Vresov combine, and other enterprises have stood the test of time with good performance records in comparison with foreign heating plants built during the same period.

By the same token, with regard to the development of sources for the supply of heat to the municipal and residential utilities sector a number of design concepts have been advanced that were quite advanced for their time. To cite just a few of the most typical examples of the great progress that has been made in this field one might mention the heating plants serving Malesice, Kosice, Ceske Budejovice, Zilina, Karlovy Vary, and so on and so forth. The conditions that had to be met before the designs for these plants could be drafted were much more complex than those that obtained in the case of industrial heating plants. The increased consumption of heat as a function of the progress that was made in the building of heating plants for residential areas made it necessary to spread out the construction of thermal plants over several long intervals. The organizational dispersion of investment in the heating supply industry proved to be a serious problem. Only rarely did it prove to be possible to mount efforts dedicated to the pooling of capital funds for the jointly financed construction of central heating plants.

It is a characteristic feature of the abovementioned heating plants that they were sited as close as possible to so-called consumption focal points, as was dictated by considerations of economic efficiency.

It was not until after the interest in clean air and living-environment engineering emerged as a prime concern of civil authorities that more sweeping and more comprehensive designs began to be advanced for centralized heating supply systems. These are exemplified by the systems serving the cities of Hradec Kralove and Pardubice with a common plant located at Opatovice, the system serving Most, Chomutov and Litvinov with a plant in Komorany, and the Ostrava system with a plant in Trebovice. These plants are based on reconstructed older steam condensing power plants in which additional equipment was installed permitting the retrieval of thermal energy. In the case of these systems, with heating plants situated away from the center of consumption focal points, ecological considerations were taken into account as a top priority. These systems represent a new development in the history of thermal engineering in Czechoslovakia, namely, the transportation of heat over greater distances.

The need to conserve imported refined fuels as much as possible and to give priority to the utilization of the domestic fuels base on the one hand and concern over the need to improve conditions affecting the health of people living in densely populated urban centers on the other hand are giving rise to the current trend that is coming into play in the Czechoslovak power industry. Namely, it is being acknowledged that essentially every power generating source must be designed in a comprehensive manner as a multipurpose facility. The feasibility of meeting consumer demand for heat is turning out to be one of the criteria that is being taken into account when searching for building sites for the erection of new power plants. Consequently, the distinction between an electric power plant and a heating plant is virtually disappearing, since an electric power plant--in addition to performing its primary mission as a source of electric power--will now always serve as a source of heat for areas lying within the technically feasible and economically acceptable range of thermal feedlines.

A study has already been drawn up examining the feasibility of supplying heat to the city of Kolin from the Chvaletice power plant, and designs are now on the drawing boards for a system that will supply heat to Trnava from the nuclear power plants in Jaslovske Bohunice.

Nuclear Power Plants as a Source of Heat

Since the construction of nuclear power plants is a key capital construction program of the Czechoslovak power industry, these plants have naturally been singled out as an area of prime interest in connection with the application of these new principles. Under the contract terms of a cooperative venture with the partner Soviet design institute VNIPIENERGOPROM of Moscow a draft study has been drawn up for a prototype multipurpose power generating plant equipped with VVER-1000 reactors. For its part, ENERGOPROJEKT of Prague is designing the plant's secondary section and equipment related to the supply of heat.

The impact of plans for this section of the nuclear power plant with its link-up with heat consumers will be most striking. Initial projections--calling for the utilization of high-performance power reactors of the type mentioned above and all of the other components of the primary section--reveal that the plant's operational modes will display certain distinctions in comparison with a specially designed heating plant. Namely, the volume of on-line heat generating capacity in the primary section is predetermined. and so the design objective must be to arrive at an effective distribution of load between both categories of energy to be supplied so that the load demand placed on this plant by the national power grid will be met and so that, at the same time, the demand load placed on the auxiliary centralized heating supply system will be accommodated in a satisfactory manner. In light of these operational conditions alone the technical challenges posed by the design requirements of this kind of power generating complex are obvious.

In view of the relatively high investment costs of a nuclear power plant its economic efficiency criterion consists in insuring the full-time utilization of the on-line generating capacity of its primary section. Likewise, the balanced application of load, devoid of rapid load variations, is more compatible with the operational characteristics of VVER-type reactors. Given the predominantly seasonal nature of heat consumption, these conditions can be met by a secondary plant section equipped with steam condensing extraction turbines. Under the terms of the request that was filed for the preparation of the abovementioned draft design for a prototype multipurpose nuclear plant equipped with VVER-1000 reactors and acting in agreement with the Soviet partner organization, it is contemplated that this plant will be equipped with a turbine system with a power rating of 500 MW electrical and adapted for the retrieval of heat at a level of 450 MW thermal coupled with the capacity for the reheating of cycle water from 60°C to 150°C. In the case of the vast majority of centralized heating supply systems that are slated for construction in this country a power plant equipped with two reactor units (that is with four turbines in the plant's secondary section) would be thoroughly capable of meeting peak-load heat demand at a thermal coefficient rating of = 1°. This means that during peak-load periods it would not be necessary to draw on the auxiliary generating capacities of fossil-fuel-fired heating plants. Since under the climatic conditions that prevail in this country the length of time during which estimated peak-load thermal-energy input is being used for heating purposes varies at a level of about 2,500 hours per annum, it must be expected that plant capacity will be committed primarily to the electric-power-generation operational mode for relatively long periods of time. Therefore, it is a basic requirement of turbine design that its operation in a strictly steam condensing cycle should be highly economical.

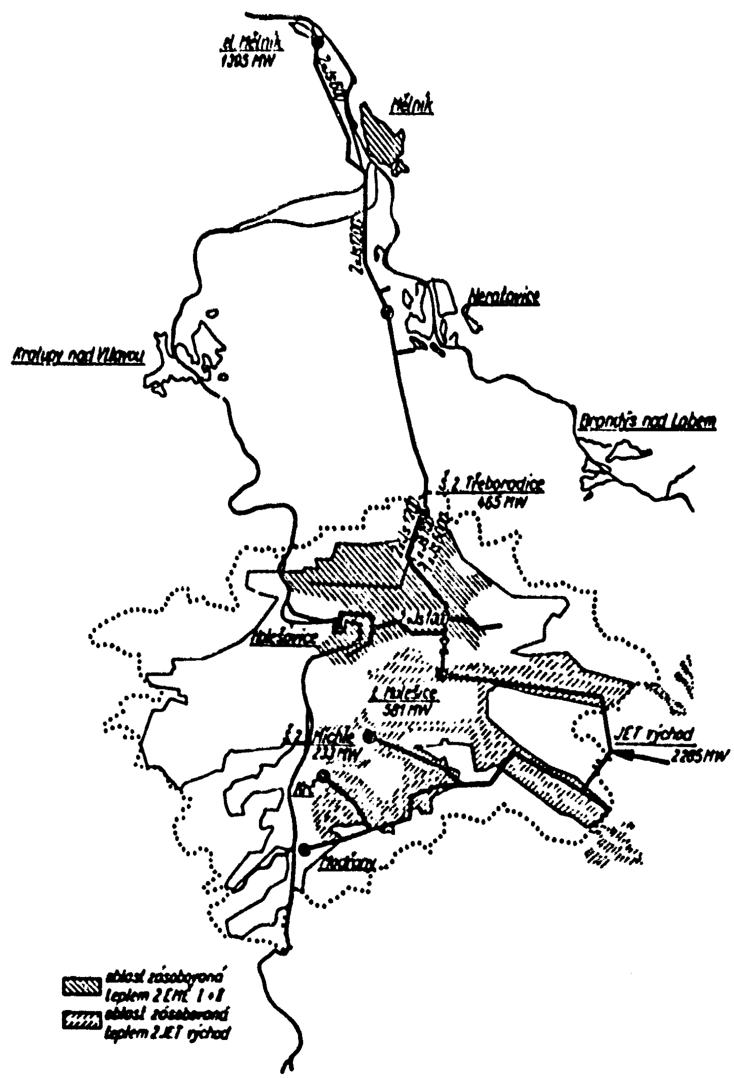
The retrieval of thermal energy generated by a nuclear power plant--at a fixed level determined by the thermal generating capacity of its reactor section--will of course result in a reduction in attainable electric power generation capacity levels. The greater this reduction, the greater will be the parameters required of the steam drawn off the turbine. In order to heat cycle water in a hotwater heating system it is sufficient for the steam in the primary heating stage to be at a pressure of approximately 0.1 MPa [Megapascal]. However, when steam is being retrieved for technological purposes pressure requirements at the point of consumption are usually much higher. If, in addition to this, one factors in the pressure losses that occur during long-distance steam transmission and system losses, which constitute a safety barrier preventing the contamination of the transmitted steam with radioactive materials, and also the requirement calling for a high degree of dependable yield when it comes to supplying heat for exposed industrial processes, the retrieval of thermal energy at higher parametric levels is always going to have a major impact on the operational mode of a nuclear power plant and on the economics of the heating supply system. This is why the advantages and disadvantages of the retrieval of process steam from a nuclear power plant must be weighed with the utmost care, namely both from the standpoint of the thermal energy source and from the standpoint of the consumer.

The impact of any reduction in the attainable level of electric power generating capacity in nuclear power plants is felt most keenly during the on-peak period of a power distribution system's daily load graph. In heating systems where hot water is the heat transfer medium the possibility arises of taking advantage of the natural storage capabilities of an extensive piping network or even using large-capacity storage plants. The postponement of increased thermal energy retrieval in conjunction with the charging of storage systems until such time as there is a dropoff in the power system's daily load graph, especially during night hours, and, conversely, the utilization of stored heat to supply consumers at times when turbine steam extraction systems are disconnected, that is, at times when turbines are operating primarily in the steam condensing cycle during peak-load hours, would make it possible for power system controllers to have access during this time to the full available electric power generating capacity of a multipurpose power plant. This kind of operation is comparable to electrical storage heating with its advantages stemming from the more balanced loading of a power plant during 24-hour periods, but this mode of operation has the added advantage of affording reduced losses of heat discharged by cooling water, that is, the advantage of increased utilization of primary energy resources.

Transitional System Designs

It is to be expected that nuclear power plants will not be used as heat supply sources until the 1990's at the earliest. In the meantime it is necessary to mount a search for those kinds of centralized heating supply system designs which, while taking into account current fuel and technological capabilities, will lay a well planned groundwork for the future transition to the ultimate configuration of these systems which will harness the thermal energy generated by nuclear plants. One example of such a transitional design is the draft plan for the supply of heat to the right-bank section of the capital city of Prague from the Melnik power plant. The conversion of the Melnik I power plant, the last plant to be built in the generation of steam condensing power plants with power ratings of 55 MW, into a heating plant, the primary section of which will be devoted to heat retrieval, is intended to bridge this time gap by supplying heat to the northern and eastern residential areas of the capital city through 1995. The completion of the first phase of this conversion program will put on-line generating capacity with a thermal power rating of 800 MW, most of which (approximately 570 MW) is earmarked for Prague with the rest going to Melnik and Neratovice. During the second phase, after 1995, when it is expected that this heat supply system will be linked up with the Melnik II power plant, where four steam condensing power generating units are on-line with power ratings of 110 MW each, the system's thermal generating capacity will be increased to 1,400 MW. By that time it will also be possible to look forward to the coming on-line of multipurpose nuclear-thermal plants. Diagram 1 shows a schematic diagram of one of the proposed design options.

Diagram 1. The Thermal Energy Transmission System Consisting of the Melnik-Prague Power Plant Working in Tandem with Nuclear Power Plants



Key:

1. Areas supplied with heat by the Melnik power plants I and II
2. Areas supplied with heat by the nuclear power plant "Vychod"

Long-distance Heat Distribution

An important component of centralized heating supply systems is the equipment used to distribute heat from its source of generation to consumption points--the thermal mains network. The importance of this component is further enhanced when heat is being distributed over long distances. For example, thermal feedlines account for approximately 60 percent of the total estimated costs of the construction of the first phase of the Melnik-Prague system.

Table 1 shows the total operating costs of a long-distance heat distribution system where the heat transfer medium is hot water heated to 150/70° C and the effects of maximum utilization.

Table 1.

(1) Js potrubí tepelného napáječe	2 × Js 800	2 × Js 1000	2 × Js 1200
(2) Přenášený tepelný výkon [MW]	353 až 715	628 až 1256	994 až 2035
(3) Celkové provozní náklady [10^3 Kčs . r^{-1} . km^{-1}]	826 až 2366	1163 až 3913	1242 až 6022
(4) Měrné celkové provozní náklady [Kčs . GJ^{-1} . km^{-1}] při využití maxima			
2500 (h . r^{-1}) (5)	0,28 až 0,36	0,20 až 0,34	0,17 až 0,32
4000 h . r^{-1}	0,16 až 0,23	0,12 až 0,21	0,10 až 0,20
6000 h . r^{-1}	0,10 až 0,15	0,08 až 0,14	0,07 až 0,13

Key:

1. Joules per second passing through thermal feedline pipework
2. Thermal energy output transmitted (MW)
3. Total operation costs (10^3 Kcs per annum per kilometer)
4. Total unit operating costs (Kcs per GJ [gigajoule] per kilometer) at peak usage levels of:
5. hours per annum

As a basic concept governing the structural design of thermal feedlines it is necessary to insist upon the so-called surface pipework option, which in general is the least capital-intensive way to construct the thermal mains network. Surface lines (the new technical term that has come into use in recent years) are pipework lines running just above the ground surface (the maximum gap between the bottom of the pipework thermal insulation and the ground surface is 30 cm) supported by low stanchions.

At the same time it is necessary to give top priority to the use of axial expansion joints not only because of considerations having to do with possible ground shifts, but primarily because of operational considerations. Axial expansion joints are built-in (at designated intervals) hydraulic resistors which, depending on the diameter of the pipe, compensate for from 2 to 7.5 percent of line pressure losses caused by friction within the pipe itself, while flexible U-type expansion bends, all other things being equal, compensate for from 19.4 to 70 percent of these losses. At the same time, the use of axial expansion joints will cut down on the length of the piping by from 10 to 13 percent.

The structural and biological aspects of surface thermal feedline design are discussed in the article by Eng Architect J. Janousek on page 366.

Surface thermal pipelines can be built to rest on articulated saddle supports (for both supply and return lines), on independent stanchions casted monolithically, in prefabricated sections, with drilled penetrations, and so on), and on embedded piles. The more widespread use of embedded piles is closely related for the most part to the degree to which it will be possible to reduce the friction coefficient between the pipe seat and the supports to a value of less than 0.1.

The justifications for surface thermal feedline runs are certainly self-evident in light of the following cost comparison example. With the same capital outlay it is possible to deliver from 1,500 to 3,000 megawatts worth of thermal energy output by laying surface lines, while with the construction of underground lines (in "unmanholed" subsurface conduits) it is only possible to deliver from 350 to 700 MW. Generally speaking, it can be said that the long-distance distribution of thermal energy is more of an economic problem rather than an engineering problem. Urban planning considerations also have a prominent role to play in this regard.

In addition to using aboveground thermal mains and the thorough industrialization of their fabrication and erection, a general reduction in the costs associated with the distribution of thermal energy might also be promoted by the selection of lower operating temperatures for cycled water, which in the long run would make it possible to utilize new non-corrosive materials for thermal main pipework and thereby contribute to the simplification of their fabrication.

Control System Arrangements for Heat Supply Systems

One of the most important tasks that must be addressed in connection with the long-distance distribution of thermal energy is the establishment of a central control system to oversee the operation of heat supply systems. In any event, full automation is a basic prerequisite for the remote control of such a system. Ideally, this means either the full automation of individual consumers (individual metering) or at least the full automation of all interchange stations (aggregate metering). However, in the case of individual heat sale metering it is still necessary to arrange for some metering that will always take place at interchange stations (for example, the metering of hydraulic ratios, the temperature regulation of heat-transfer media by means of blending, and so on).

With regard to the metered regulation of heat supply systems it is necessary to start with centralized qualitative metering supplemented by individual consumer (quantitative) metering that takes place directly at the site of individual heat consumers. This is exemplified by the successfully operated system used in Bratislava in the Petrzalka residential housing project.

In light of this brief overview of this problem it can be deduced that as far as the dispatcher in charge of an entire heat supply system or thermal mains district is concerned the relay station is still the terminus of any remote control network (with regard to the back and forth flow of information). At the present time relay stations are being built to operate in a fully automated mode, inasmuch as this is also dictated by the growing labor shortage.

The remote control system must also make provisions for the operation of pumping stations along thermal main routes, sectional shut-off points and important line junctions, and other diverse special installations.

It is in light of these basic considerations that a plan is beginning to take shape for the remote control of heat supply systems in the CSSR. The most important factor in this system is the central dispatcher in charge of the heat supply system who works together with the dispatcher in charge of the electric power system. Regional control centers and peak-load heating plants are subordinate to the central dispatcher. Provisions are to be made for the establishment of regional and central control centers in the case of large cities served by a large number of cooperating heating plants and their associated heat supply mains or in places where a large power plant supplies heat to several cities at the same time.

It is also advisable to take advantage of consolidated remote control systems for heat supply systems. Thus far, the city of Kosice has made the greatest progress along these lines in the management of its heat supply system. When it comes to the long-distance distribution of thermal energy, especially in connection with the harnessing of multipurpose nuclear power plants, water is still by far a more advantageous heat-transfer medium than those used in existing systems.

ENERGOPROJEKT Past, Future

Prague INVESTICNI VYSTAVBA in Czech No 11, 1978 pp 363-365

[Article by Eng Vaclav Kripner, CSc]

[Text] Two major, guiding trends are reflected in the development of electrical engineering in the power industry. The first trend was a product of economic influences which originally were a function of the development of the electric power system in the CSSR and later on of the integration of the electric power systems of the socialist countries into the interconnected "Mir" power grid system. The second trend was a product of the impact of the new technological vistas opened up in the field of electrical engineering. In the field of power electrical engineering these trends led to the maximalization of the parameters of and to the winding up of the mechanization phase of virtually all of the processes involved in the generation and distribution of electric power. In the electronics field they led to the miniaturization and microminiaturization of equipment and to the unparalleled growth of the information science and automation fields. More than any other design organization in the CSSR, ENERGOPROJEKT probably played the largest role in the promotion of these two trends.

In the text which follows I will present a brief survey of development trends in the individual electrical engineering fields as they unfolded within the framework of ENERGOPROJEKT, and at the same time I will also survey and forecast the developments that are expected to take place in these fields in future years.

Power Plants

The first period of ENERGOPROJEKT's involvement in the field of power plant electrical engineering can be characterized as encompassing the development of and the finding of concrete applications for units equipped with alternating-current electric generators with power ratings ranging between 50 and 55 MW. The installation of these units was spread over two generations of power plants. The first generation is represented by the power plants Trebovice I, Hodonin, and Porici II, while the second generation included the power plants Tisova I, Opatovice I, and Melnik I. The first generation of these plants was designed strictly on the basis of domestic technological expertise and it was an extension of the experience gained in this country by the plants of the Skoda and CKD [Cesko-moravska Kolben Danek] enterprises. At that time Czechoslovakia was the first country to successfully resolve questions surrounding the construction of the largest 50 MW ac-generators and 63 MW block transformers and internal plant power circuit problems. A 50 MW CKD hydrogen cooled prototype ac-generator was used for the first time in this form. In those days conventional cubicle-type 6-kV switchboards were still being used in power plants for internal power use requirements. Designers tapped the knowledge that had been gained in the field of production engineering and resolved theoretical questions surrounding the automatic starting of electric drive mechanisms so as to insure the fail-safe operation of power plants in the event of voltage drops or losses in the power plant itself or in transmission lines. The second generation of power plants equipped with 55 MW power generating units were already being designed with a view to taking advantage of cooperation with sister design organizations in the other socialist countries. Each of these power plants produced technological innovations such as high-voltage box switchboards, up-to-date circuit schematics for internal plant power use, progress toward the semi-automatic operation of electric drive mechanisms in place of interlocking mechanisms, the elimination of heavy switches in ac-generator branch lines, and so on.

The next generation of 110 MW power generating units began with the prototype 110 MW generating unit at the Tisova II power plant and continued to grow with the installation of similar units in the Tisova III, Tusimice I, Ledvice I, Vojany, Novaky, and Prunerov I power plants. Here too a number of problems were resolved affecting the design of heavy-duty electrical engineering equipment. Working together with the former Power Engineering Research Institute, 6-kA sheathed conductors were used for the first time. ENERGOPROJEKT also cooperated with CKD on the development of 4 MW turbomotors for electrically driven feed pumps, and innovations were made in the development of high-voltage and low-voltage switchgear equipment.

It was during this stage that work had already gotten under way on the construction of nuclear power plants. The design for our first nuclear power plant (the A1 with three 50 MW power generating units) already served as an indication of the qualitative changes that had taken place in both the power generation and control aspects of power plant design. First of all, it was necessary to make sure that the operational safety of nuclear power plants was placed on a higher level than that of conventional power plants. This led to the application of 5 MW synchronnous motors together with the rearrangement of internal plant power circuits, which were ranked according to their degree of relative importance to internal power use requirements. This was accompanied by the installation of more complex control mechanisms, which led to the first use of sequential automatic devices, which at that time were incorporated into the instrumentation base of the "nulte" [translation unknown, possible typographic error] generation.

The advent of 200 MW power generating units was marked by the startup of a test prototype unit at the Ledvice power plant. The Pocerady I power plant, which for test purposes was built outdoors, was one of the first plants to be equipped with 200 MW power generating units. After a fairly long interval work resumed on the construction of the well known 4 x 200 MW power plants Tusimice II, Detmarovice, and Chvaletice, which now represent state-of-the-art technology in the field of power plant electrical engineering. These plants can be described as being equipped with ac-generators with a hydrogen-cooled rotor and stator coil and a water-cooled rotor, three-phase

235 MWA block transformers, sheathed and fully shielded 10-kA generator conductors, an up-to-date circuit schematic for internal plant power circuits coupled with the use of low-lubrication high-voltage circuit breakers and low-voltage box switchboards.

At the present time a prototype 500 MW power generating unit has already been designed and is now under construction, and work is under way on the drafting of a design for the 2 x 500 MW Optovice II power plant. Once again, the ac-generators used in these units are cooled by both water and hydrogen; a single-phase 570 MWA assembly is planned for the prototype unit, while other plant projects will incorporate three-phase units with the same power rating. A qualitative change in electrical system designs was brought about by the advent of nuclear power plants, in which these designs are called upon in particular to account for the impact of nuclear safety measures on electrical equipment. The first design problem revolves around the transmission of power plant output, and in this respect it is necessary to minimize as much as possible drops in plant output being fed into the transmission line network, which in our country usually carries a load of 400 kV. Consequently, a design is being introduced for switchboards with 1-1/2 or 2 circuit breakers per branch line, and where necessary a polygon design is being used. The second design problem revolves around making provisions for internal plant power circuits that will be available under all circumstances for reactor recooling. Modern equipment is now being used, especially in the case of large-scale diesel power plants, as an emergency power source. This technique was used for the design of the new V1, V2 4 x 220 MW, and Dukovany 8 x 220 MW nuclear power plants.

A new stage in the development of power plant electrical engineering began with the application of 1,000 MW power generating units for nuclear power plants, where in most cases we can look forward to quantitative changes in the form of enhanced equipment performance parameters. In this case the most typical power plant electrical circuit schematic characterized by the interlocking connection of the ac-generator and transformer with the branch line feeding internal plant circuits, with a possible ac-generator circuit breaker installed ahead of the unit transformer and internal plant circuits, is still unchanged. In the case of conventional power plants, which are gradually being phased out in our country due to the fuel shortage, the development of power plant electrical engineering equipment came to an end with the installation of 500 MW generating units, and no future plans are being made for any increase in conventional power plant power ratings.

Heating Plants

During its 30-year history ENERGOPROJEKT has drawn up designs for a large number of heating plants with power ratings ranging between 3 MW and 55 MW, and these heating plants were designed to serve both the general public and industrial customers. The design format of public heating plants has gradually evolved into a standardized design plan with output being transmitted by one or two parallel transformers (e.g., 1 x 121/6.3 kV + 1 x 23/6.3 kV), most of which are equipped with a generator circuit breaker and a branch line for internal plant circuits. This public heating plant design format was used for practically all kraj towns and for some okres towns.

In its early days ENERGOPROJEKT was engaged in the drafting of designs for industrial heating plants for large industrial complexes (the Klement Gottwald New Metallurgical Works, the East Slovakia Ironworks, Staza, the Kladno United Steelworks National Enterprise, and so on). The electrical systems of these heating plants represented one of the biggest jobs ever undertaken by heavy-duty electrical engineers involving the use of heavy-duty medium-voltage switchboards capable of handling large operational and surge current loads and, at the same time, the large recovered voltages, which are caused in particular by the widespread use of reactors to reduce power losses in the distribution of high-voltage loads. ENERGOPROJEKT tried to reduce the problems associated with the use of heavy-duty switchboards by means of an original design for industrial distribution based on junction feeding: by-pass transformer--industrial transformer--reactor, to which an ac-generator is hooked up via a circuit breaker. This design was used in the heating plant serving the Vresov combine, and its effectiveness has been fully demonstrated.

A special problem for both public and industrial heating plants is posed by internal power circuit requirements, and internal power consumption is twice as great in heating plants as it is in steam condensing power plants; this led to the development of a boiler-headers-high-voltage/low-voltage bus-bar schematic. The use of this schematic for the feeding of headers or their lengthwise interconnection in half-headers can accommodate even the most complex requirements.

At the present time work is under way on the development and planning of specific applications of heating plants equipped with heating units with power ratings as high as 135 MW. The possibility is also being studied of harnessing the waste heat that could be recovered from nuclear power plants. The electrical components of such a system would be more analogous to those used in conventional power plants.

Electric Power Substations

When ENERGOPROJEKT was just getting started on its work in the field of electric power substation design it relied on the experience gained in this area by the plants of the Skoda and CKD enterprises, but shortly after it was founded ENERGOPROJEKT started to go its own way and developed a number of original designs.

With regard to 22 kV switchgear modules ENERGOPROJEKT, already during the first years of its existence, had succeeded in consolidating switchgear design standards that had been diversified by a variety of other enterprises, and it was the principal author of the standards adopted later by the Czechoslovak State Standardization Board for the box-clad design of 22/35 kV switchgear. Later on ENERGOPROJEKT cooperated intensively with manufacturers in the development of cabinet-clad switchgear.

In the case of 110 kV switchgear too ENERGOPROJEKT drew up similar guideline standards which are now used nationwide. As time went on, other questions were resolved having to do with the gradual increase in demands for equipment performance parameters capable of handling short-circuit currents ranging between 14 kA to the present day level of 30 kA. The resolution of these problems called for the drafting of a number of theoretical studies both in the field of electrical contact resistance phenomena and in the field of electromechanical engineering. Contemporary 110 kV switchgear is fully standardized and is designed to accommodate all required operational conditions, and considerations pertaining to construction economics have also been taken into account. Depending on where they are to be installed in the electric power system, 110 kV switchgear schematics have been drawn up that range from simplified schematics (H-connections and the like), through simple bus-bars, to double and triple systems of bus-bars with an auxillary bus-bar.

One of the first tasks assigned to ENERGOPROJEKT after it was founded was the development of switchgear for the newly built 220 kV power system, which at that time served as the country's main transmission system and was interconnected with the power systems of Hungary and Poland. Some original designs were developed in this area that were used in particular in the substations located at Vyskov, Opocinek, Liskovec, Sokolnice, Bystricany, and Krizovany. At the present time, given the introduction of higher voltage loads on power transmission lines, the 220 kV system is no longer being developed.

Designers working in the power line and switchgear fields were confronted with a challenging problem in the form of the need to plan and construct a 400 kV transmission system. Here too, after resolving all of the theoretical problems that were involved, ENERGOPROJEKT developed a number of original designs that were first put to use in the manufacture of 400 kV switchgear for the electric power substations at Lemesany, Hradec, Vyskov, Prosenice, Sucany, and elsewhere. The schematic designs selected for this system consisted mainly of double busbar systems with one auxillary bus-bar. A polygon schematic was also used, and for substations which were to be linked up with high-performance power plants, especially nuclear power plants, a schematic was employed that provided for 1-1/2 and 2 circuit breakers per branch line. At the present time work is underway on the standardization of these switchgear designs taking into account all of the latest requirements pertaining to operation and construction. It is expected that the short-circuit currents will attain a maximum level of 30 kA; this equipment is required to meet strict standards with regard to performance parameters (e.g., the breaking of close shorts, and so on).

Further, ENERGOPROJEKT is making preparations for the next voltage step-up level of 750 kV, which is slated to become the transmission voltage load for our power system, this time on an international level as an integral part of the CEMA power grid "Mir." In this regard ENERGOPROJEKT has already prepared a study which surveys the switchgear capabilities of substations in the CSSR. However, in addition to the technical problems that are involved, 750 kV voltage loads also give rise to more difficult problems of an ecological and sociological nature. Moreover, it may be that 750 kV will not be the last word in voltage load step-ups, so the engineering offices of ENERGOPROJEKT are gradually gearing up to draft studies that examine the problems posed by voltage loads of 1,200 kV, which appears to be a realistic prospect as far as our country is concerned.

Encased switchgear insulated with SF-6 [expansion unknown] gas is another innovation in the field of electric power substation design. ENERGOPROJEKT responded very quickly to the challenges posed by this design problem area, and it has drawn up a number of studies whose findings can be put to use in the CSSR. At the present time work is under way on the drafting of specific designs in this area (e.g., designs for the Holesovice station, the Prazacka 110 kV station, the Vyskov 400 kV station, and a proposed 750 kV station), and technical materials are being prepared for other applications. In the area of 400 kV voltage loads and higher it is to be expected that encased switchgear insulated with SF-6, especially in view of the ecological conditions that prevail in our country, will eventually completely take the place of conventional outdoor switchgear.

Distribution transformers used in electric power substations gradually evolved from having a unit power out of 16 MVA to a unit output of 63 MVA at voltage loads of 110/22 kV and from being single-phase units with a power rating of 3 x 33 MVA (at the Opocinek substation--3 x 210 MVA) to three-phase units with a prospective power rating of 500 MVA at input voltage loads ranging between 220 and 400 kV.

Electric power substations, which constitute a system consisting of switchgear apparatuses and integrated and auxiliary equipment, are run from control rooms. The development of these facilities by ENERGOPROJEKT started with conventional high-voltage direct control at voltage loads of 220 kV and eventually tended toward the utilization of indirect controls at medium-level voltages and selective controls. At the present time larger control rooms are equipped with a small computer serving as an informational system. Substations supporting voltage loads of 110/22 kV are being designed for unattended remote control. An automated control system has been designed for the Chrast substation incorporating the use of sequential automatic devices for operational manipulation and CRT displays. Electrical protection, which was originally based on the use of relays, is now being converted to a semiconductor-based system, and plans are being made to replace this system with programmed control computers to be installed in all electric power substations.

Electric Power System Control Centers

The abovementioned integration of Czechoslovakia's electric power system necessarily led to the systems-approach management of the generation and distribution of electric power with respect to the capabilities of the power industry and consumer demand levels. This in turn led to the gradual establishment of power system control centers, which at first were in charge of the macroregions of Bohemia, Moravia, and Slovakia, but later on control centers were established for smaller regions as well. According to the conventional designs, the equipment used by these control centers consisted almost exclusively of data reporting systems, which transmitted input data to a system controller who, depending on the decisions he made, would issue orders calling for changes in generation levels and grid load configurations. ENERGOPROJEKT played a highly active role in the planning and designing of system control centers. At the present time it is also deeply involved in drawing up plans for the computerization of power system management through the introduction of an integrated, hierarchial automated dispatch control system. The designs that have been completed and the designs that are in the drafting or planning stages are setting up this system on an international and national level, and they also provide for control centers that will be in charge of regions, krajs, and districts and that will be equipped with computer systems and communication trunk lines. To start with, this equipment will serve as a data-reporting and command system. Work is also continuing on the refinement of this system in the area of machine decision-making, so that in future years we can look forward to the nearly complete automation of the electric power system.

Electric Power System Design

During the initial stages of the integration of the electric power system, that is, at a time when there were adequate supplies of primary energy resources, when industrial wastes and emissions did not have much of an effect on the environment, and when land for power plant construction sites was in plentiful supply, it was not necessary to go into a great deal of detail in substantiating decisions concerning the capital construction of power plants, electric power substations, and transmission lines. At that time economic considerations played an especially important role. Consequently, decisions concerning the development of the power system were made intuitively, oftentimes according to the personal preferences of individuals. However, it was possible for things to go on like this only for a limited period of time before the adverse effects of this situation began to make themselves flet, mainly in terms of the pollution and destruction of the environment. For this reason, it was not very long before ENERGOPROJEKT started to draw up systems-approach studies in which regions and power systems were viewed as an integral whole not just from a technical standpoint, but also in terms of the growth of energy consumption and the supply of energy resources and the impact on the environment. The technical side of the problem was also subjected to a comprehensive analysis in terms of the computation of transmission loads, load faults, system stability, and minimal and maximal loads.

Intuitive conclusions are gradually being replaced by operational analysis, which is substantially enhancing the quality of engineering, economic, and sociological decision-making.

Design Methodology

As early as the start of the 1960's traditional design techniques in the field of electrical engineering were supplemented and refined by the use of computers for the making of scientific and technical calculations. A number of high-quality programs were developed for making electrical engineering and electromechanical calculations with respect to conductors, drive mechanisms, and electric power substation functions. At the present time work is in progress on the development of a highly meticulous program for the calculation of internal power plant power consumption requirements that entails the application of Park's equations, and this program is being written up in cooperation with the Czech Institute of Technology in Prague.

The most advanced level that has been achieved to date in the modernization of the design process is represented by the SAPRO automated design support system. In this area ENERGOPROJEKT is working on a development task which will encompass the automation of key decision-making processes relative to selection of schematics and substation construction sites, engineering calculations, the drafting of technical drawings, and the writing up of materials specifications, including materials budget costs. Some aspects of this program, e.g., the computerized drafting of design drawings, have already been put into practice.

In future years ENERGOPROJEKT will be working on the fulfillment of numerous tasks which are qualitatively unprecedented and highly complex. These tasks will entail finding new ways to generate electric power, the study of the magnetohydrodynamic principle, solar energy, and finding new ways to conserve electrical engineering fabricating materials that are becoming increasingly scarce throughout the world, including the harnessing of cryogenic technological processes, It will be necessary to finish work on the development of control systems based on the utilization of new generations of computers. ENERGOPROJEKT's past performance record certainly bears witness to the fact that it will fulfill these new tasks without fail.

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