branch of the Academy of Sciences, recently told the West German business paper *Handelsblatt* that the promise of Western investment in Siberia had not been realized. American participation had all but evaporated, while the West German and Japanese roles had shrunk to one or two large projects. Therefore, said Koptyug, Siberian scientists were projecting alternate development plans for implementation without Western technology.

The effect of the American trade embargo and overall contraction of East-West trade has been to spur the Soviet quest for efficiency-creating innovations.

The American grain embargo, although the Russians made up most of the margin with purchases elsewhere, helped inspire a Soviet decision to loosen private farming regulations early this year. As a result, the Soviets avoided a repeat of the mass slaughter of livestock that occurred after the 1975 crop disaster. The prospect of reduced grain imports also prompted Moscow to stress the "agro-industrial complex" model even more than intended at first, meaning that the embargo has accelerated the mechanization of Soviet agriculture.

Brezhnev called for corresponding efforts in other areas of technology, demanding study of "why we at times . . . spend a great deal of money buying from abroad the kind of equipment and technology which we are quite capable of producing ourselves, and often with higher quality." This inspired Electronics Industry Minister A. I. Shokin to read to the party congress from the American *Electronics* magazine: "Its technological base and the qualifications of its technicians enable the Soviet Union to produce integrated circuits of almost the same quality as the United States. . . . The circuits we were given probably do not reflect the Soviet Union's top technical standard. . . . The integrated circuits in use in the U.S.S.R. for its own needs may be technically more sophisticated." Shokin commented that he had "no grounds for denying these conclusions."

The Soviets' girding to proceed without East-West trade reflects their dim evaluation of the international situation as well as their concern for their own economy. They are responding not only to political signals but to Western economic collapse.

A significant policy tendency in the U.S.S.R. still welcomes Western decline and seeks further international destabilization on the principle that what's bad for the United States is good for Russia.

Others, including some leading lights of the 26th Party Congress, think otherwise. Not long after the incident at Three Mile Island, Academician Aleksandrov said he hoped the United States would pursue a vigorous nuclear power program because the absence of such an American strength would increase the danger of world war.

Documentation

Dr. Aleksandrov outlines the Soviet growth program

In an article called "Energy Prospects," carried in the daily Izvestia *on Feb. 21, physicist A. P. Aleksandrov outlined the shifting Soviet energy structure for the rest of the century. Aleksandrov is president of the U.S.S.R. Academy of Sciences and a member of the party Central Committee. The following excerpts from his article were translated by the Foreign Broadcast Information Service.*

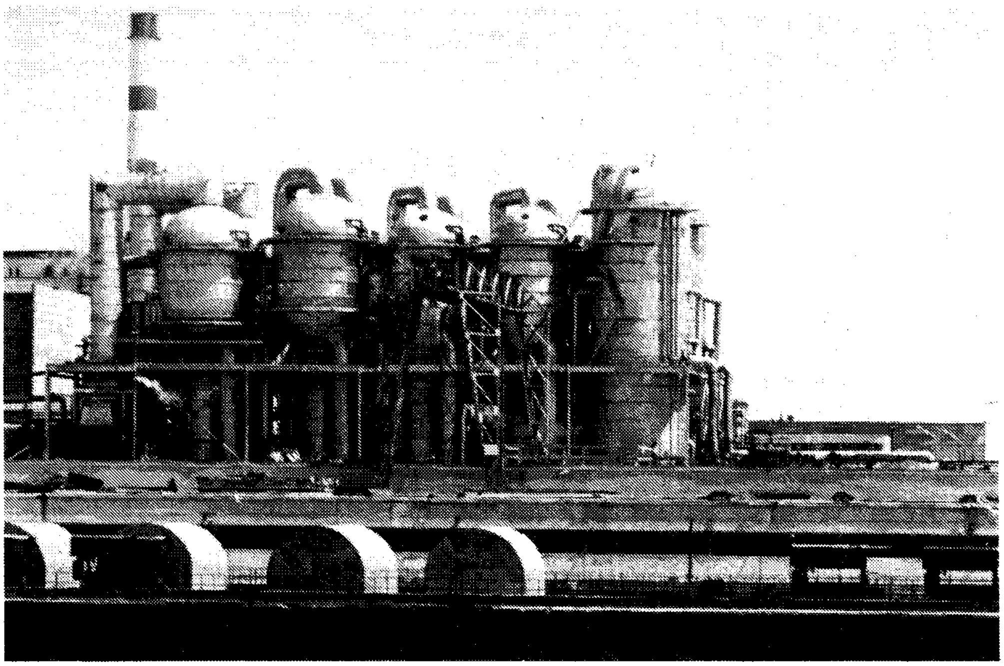
The very complex task of supplying our huge, rapidly developing national economy with energy must be resolved reliably and with a long-term view. It is not possible to resolve this task by traditional methods—that is, by increasing the extraction of oil, gas, and coal. It is necessary to substantially change the structure of their consumption and to make wide use of nontraditional energy resources.

The point is that in this century the growth of the power industry in all industrially developed countries and here in the U.S.S.R. has taken place on the basis of a sharp relative increase in the extraction and consumption of oil and, in part, of natural gas and a relative fall in the proportion of coal. Oil now accounts for about 50 percent of the country's fuel and energy balance, while coal accounts for only about 25 percent. . . .

The limited nature of reserves of oil in large-scale deposits now being exploited and the tendency for the cost of this oil to increase make it necessary, in examining long-term prospects for the power industry, to change its structure in such a way as to substantially increase the relative proportion of coal in the fuel and energy balance, to approximately maintain the proportion of natural gas, to substantially reduce the proportion of oil for fuel and in the late 20th century to go over to using oil mainly as a feedstock material for the chemical and microbiological industries.

The entire shortfall in the fuel and energy balance must be covered . . . by substantially extending the proportion of nuclear power, using thermal neutron and fast breeder reactors and, in the future, thermonuclear power. . . .

Naturally, it will also be necessary to expand the utilization of other types of energy resources—solar, geothermal, water and wind power—but it is probable



B. Prikhodko/United Nations-APN

An atomic desalination plant in Kazakhistan: applying nuclear power's development potential.

that even in the long term all of them will account for not more than 5 percent of the country's fuel and energy balance. They will not be considered in this article, although their local significance—particularly in southern regions of the U.S.S.R.—will be relatively great.

At present oil is the most universal energy source. Petroleum and petroleum products are used in all the main spheres of consumption. Therefore it will be necessary in the future to oust oil and petroleum products from all the main spheres of consumption of energy resources, using coal and nuclear power instead.

NUCLEAR HEATING

In many cases, however, the direct utilization of coal or nuclear power is impossible or unsuitable, as in aviation, for instance. In these cases it is necessary to obtain suitable secondary energy sources. Let us take a look at how this can be done.

It is easiest of all to resolve the task of obtaining low potential heat for heat supply in cities. In today's reactors at nuclear power stations, the primary energy released by the chain-reaction of splitting atomic nuclei is converted into heat for heating the fuel elements containing the fissionable uranium. This heat is transferred by the water in the primary system, which is pumped through the reactor and either yields steam directly—the steam then goes to the turbogenerator—or, in a steam generator, heats the water in the secondary system, which provides the steam sent to the turbogenerator.

It is possible to separate off some of the steam with suitable parameters from the turbine and channel it into heat exchange units in the heat supply network. This is the principle of the nuclear thermal power station (ATETs), which generates both heat and electricity.

It is possible in general to channel hot water from the primary system not into the turbogenerator, but into a heat exchanger in an intermediate system. The hot water in the intermediate system is pumped through the heat exchangers of the heat supply network. This is the principle of nuclear heat supply station (AST). It should be noted that our specialists carried out this development on A. N. Kosygin's initiative. Both the first and the second solutions are economical and technically feasible and will be implemented during the next five-year plan.

In view of the fact that approximately 50 percent more primary energy sources are utilized in producing low potential heat than in producing electricity, this sphere of application of nuclear power will be of very great significance as regards savings in the next 10 years. Thus the utilization of ASTs and ATETs fully solves the problem of ousting petroleum products from the sphere of production of low potential heat.

It is considerably more difficult to find a way of replacing the light petroleum products which are burned in engines. Back in the time of World War I, however, Germany used products similar to gasoline which were obtained by distilling volatile lignite products. This process has been known for a long time—at the end of the last century that is how "lighting gas" for illuminating cities was obtained. Today in a number of countries, including our own, a substantial further improvement in the process is under way: new catalysts and techniques make it possible to process coal at substantially lower temperatures and pressures and increase the yield of useful liquid products. Obviously the continuing increase in prices for petroleum products will make synthetic gasoline and motor fuels competitive in comparison with light petroleum products in the next five years. The commercial production of synthetic motor fuels will, it seems, be organized in our country in the regions of major coalfields during the 11th and 12th Five Year Plans [1981-1990—ed.] Naturally, the power for these processes will be supplied by burning some of the coal or by nuclear power.

Thus here too petroleum products can be phased out by chemical and technological processing of coal and by its interaction with water and vapor or hydrogen. Various types of organic waste, instead of coal, could be converted into gaseous or liquid fuel in a similar way.

Let us move on to the utilization of energy sources in metallurgy and the chemicals industry. It is difficult and disadvantageous to use atomic power stations (AES) as flexible capacities. The larger capital expenditures on them compared with conventional power stations and the small fuel component in the cost of electricity mean that it is economically expedient to use them on a permanent, "base" load system. Moreover, intermittent load systems inevitably reduce the reliable life of AES because of metal fatigue phenomena under an intermittent load.

This applies to a still greater degree to AES using fast breeder reactors, since in addition to the points noted above, operation at reduced capacities will lead to underproduction of secondary nuclear fuel; that is, it will destroy the main purpose of the reactor as a breeder of nuclear fuel.

These circumstances could restrict the relative "weight" of nuclear plants in energy systems, which is extremely undesirable.

There is only one way to avoid such restrictions—the use of some kind of low-inertia energy storage system, for instance, the use of hydraulic accumulators or the production of some kind of energy source or end product. For instance, the production of hydrogen on the downward curve of the graph of the load of an energy system, by channeling surplus energy from an AES into the production of hydrogen from water, constitutes a possible form of storage. This hydrogen, burned in a gas turbine, can be used to cover peak loads. It can be used in metallurgy for heating and as a reducing agent for oxide ores. It can also be used in obtaining ammonia or in other chemical production techniques, or finally, in the power-engineering processing of coal in order to obtain synthetic hydrocarbons. Processes of this kind are being developed, and it is already clear in principle that they could be very useful, since, in addition to yielding necessary products, they eliminate an important shortcoming of nuclear power engineering—the disadvantages of using it in flexible systems.

The reasoning can be applied to the use of nuclear power to phase petroleum products and natural gas out from metallurgy and the chemical industry. By using electrochemical and plasma technologies and by utilizing selective methods of excitation of the necessary energy levels in molecules and atoms, it is possible to combine several chemical processes with the use of nuclear power. This potential will be extended when high-temperature reactors, which are now at the development stage, come into use.

30-YEAR OIL PHASEOUT

Thus, we can see that the use of coal and nuclear power, taking into account the possibility of producing secondary energy sources, can cover all spheres of consumption of primary energy sources. Of course, this requires large-scale research and development of economically feasible techniques. That is why the assimilation of this process will probably be gradually extended, even after the end of our century. However, it is extremely important that no "power impasse' threatens us. It is, of course, clear that such a restructuring will take a long time—approximately 30 years. Will traditional energy resources be enough over that time for the rate of growth in the power industry which our country needs? And, moreover, is it possible to create a structure for the nuclear power industry which will enable it to be used virtually indefinitely from the viewpoint of resources and environmental pollution?

We should first of all dwell on oil. Does our country have sufficient oil resources to supply all our needs and a suitable volume of oil exports to the socialist community countries and certain other countries over the period of change in the structure of energy consumption—that is, for approximately 30 years? Will these resources supply oil for long-term utilization—for many decades—in those spheres of consumption where it proves irreplaceable? "Predictions" are often made in the foreign press to the effect that in 10 years' time the Soviet Union will be forced to purchase oil abroad. These reports have only one aim—the desire to cast doubt on the stability of our country's economy. In reality our country has sufficient oil and gas resources not only to satisfy domestic needs, but also to continue energy exports on a useful scale.

At the same time, it must be said that we are not exploiting our oil resources economically enough at present; in a number of areas of use, we use up considerably more oil than necessary. And we are not yet extracting oil fully enough from the deposits being worked. We must make considerably wider use of methods which increase the level of recovery of oil. Here it is necessary to create a pricing system that makes additional oil recovery using intensive extraction methods profitable.

A second major reserve is to increase the recovery of condensate when exploiting the gasfields. Thus, for instance, in Urengoy, on Yamal Island, and in the Caspian Depression, it is possible to extract a significant quantity of condensate from great depths, and this must be done. A major reserve for saving oil is the possibility of refining it more thoroughly into light petroleum products; this modernization must be carried out in the 11th and 12th Five-Year Plan periods in general. The implementation of these measures and the substitution of coal, gas, and nuclear power for oil used for fixed energy supply are the next stages in restructuring the fuel and energy complex.

It should be added that our country still has considerable areas which are promising for oil and gas. . . . In this connection, it must be mentioned that scientific studies by physicists, geologists, and instrument-makers have led in recent years to a significant increase in the efficiency of geophysical prospecting methods. It is evidently expedient to carry out a geophysical survey of likely oil- and gas-bearing regions in the European part of the country and in western and eastern Siberia, as well as at a number of places on the ocean shelves. This will result in a great saving on exploratory drilling operations.

Of course, we must direct considerable attention to stepping up the use of other types of fuel—bituminous shales, for instance—in the power industry (and power and chemical industry).

Although their caloric value is low, an Estonian collective of power engineers has developed methods for the steady, full combustion of these shales. This experience should be extended to other major shale regions—in Kazakhstan, the Volga area and the Ukraine. It is particularly important that the highly stable combustion of shale powder gives rise to hopes for the possible creation of power stations with increased flexibility.

A substantial contribution can also be made to the power industry by using waste heat as well as organic waste from cities, industry, and agriculture. For instance, urban organic waste could supply more than 10 percent of the city's heat requirements and waste from livestock raising, when converted into methane gas by microbiological processes, could fully supply heat requirements in the sector.

With oil-saving measures and more efficient utilization of oil, and taking other resources into account, it will be possible to extend the time taken to restructure the fuel and energy complex to 40 to 50 years, which will appreciably lessen the strain in the transition period.

However, even this longer period of change in the structure of the power industry cannot allow a postponement of the commencement of work on creating a nuclear power industry suitable for the long term and on developing the means of using such energy in all spheres of consumption of traditional energy sources.

POWER WITHOUT LIMITS

The point is that the power industry has a high degree of inertia—its highly capital-intensive and materials-intensive nature as well as the length of time taken to develop new, economically acceptable techniques make it necessary to begin the development of all aspects of the new energy structure now. The main task is to create a nuclear power industry structure such that the industry will be supplied with fuel indefinitely. The thermal neutron reactors now being used can utilize about 1 percent of the raw uranium. And they cannot provide for the nuclear power industry in the long term. Science has found a radical method—it is possible to create fast breeder reactors which make it possible to utilize uranium reserves more fully.

Commercial reactors of this type have been created in our country. One of them, the BN-350, has been in operation for a long time, and the BN-600 was started up in 1980. There is still complex work ahead, however, on increasing the speed of production of plutonium and its return to the fuel cycle, since only then will it be possible to move toward a nuclear power industry providing itself with fuel for an unlimited time and developing at the pace the country needs.

The possibility is not excluded that it will be difficult to ensure the necessary rate of growth in the power industry in the distant future by producing plutonium in fast breeder reactors and through the extraction of natural uranium. In this event science is also preparing a solution: the merging of the nuclei of light elements—thermonuclear fusion—is accompanied by the release of neutrons. Some of them could be captured by uranium-238 to yield plutonium.

The possible speed of production of plutonium in these hybrid fission-fusion reactors is very great and will ensure any necessary rate of development of the nuclear power industry. As yet there are no such reactors, but they will be created by the end of the century. They will most likely be created sooner than pure fusion reactors. Therefore, in a couple of centuries' time, when the coal shortage begins to make itself felt, nuclear power of all kinds will be able to supply all spheres of energy consumption for an indefinite period. Thus the structure of the infinitely developing nuclear power industry will be as follows: thermal neutron reactors will be joined by fast breeder reactors, and they may be joined by hybrid reactors. In parallel, large capacity fusion reactors will be created.

Thus the future development of the power industry will not be restricted by a shortage of energy resources if the appropriate reorganization of its structure is carried out in good time. This is entirely realistic in our country.