Utilization of Tidal Power in Russia in Overcoming the Global Energy and Ecological Crisis

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Thanks to practical utilization of the Gybra theory cycles and proving the technical reality of capsular turbines, which transformed the lunar energy into the sun energy, there became possible the building of Rance TPP in France and the Kislaya Guba TPP in Russia. It marked a new era in utilizing of the tidal energy.

The 30 years of the exploitation the Rance and Kislaya Guba TPP had proved effectiveness of utilizing its tidal energy and the ecological safety for the environment.

I ■ THE RUSSIAN MODEL OF TPP

The Russian model and construction of a floatable power house for tidal power station prove the efficiency of utilization of the tidal power.

It is proposed to utilize the power of sea tides by cutting off large sea bays, which ensures the stability of monthly average energy irrespective of the season and time of the year.

In contrast to multibasin plants designed in the past years, the new model of tidal power utilization involves a common single-basin plant which is believed to produce maximum amount of energy at minimum cost. The energy can be conveyed to integrated power systems which can encompass a number of countries or continents. In this case the intermittent but always guaranteed supply of tidal energy can be combined with power from other stations and mutual benefit can be ensured.

For example, river hydroelectric stations with long-period storage basins can reduce power production during sizing periods if they operate jointly with tidal power stations. The water saved in the basins of hydroelectric stations (GES) can be used subsequently during quadrature periods to make up for reduced output of the tidal stations. The diurnal fluctuations of tidal stations caused by lunar tides can be smoothed by using reversible turbines that function to generate electrical energy during peak power demand and to pump up water so as to absorb excess power from nuclear and thermal power stations.

Utilisation de l'énergie marémotrice en Russie dans un contexte de globalisation de la production d'électricité et de crise écologique

Les 30 ans d'exploitation de l'usine de la Rance en France et de celle de Kislogubskaya en Russie on montré l'intérêt économique et écologique, ainsi que les bonnes performances de l'énergie marémotrice.

L'expérience de Kislaya Guba a aidé à résoudre l'essentiel des problèmes de construction maritime et d'exploitation à la fois performante et respectueuse de l'environnement.

Les usines marémotrices en projet de Mezen et Tugur pourraient représenter respectivement des puissances de 17 millions de kW et 8 millions de kW et des productions de 50 TWh par an et 20 TWh par an. La première est située côté européen, la deuxième, côté Japon. Quant à l'usine de Pensinskaya, d'une capacité de 87 millions de kW, elle pourrait s'insérer dans le contexte d'une liaison ferroviaire et énergétique entre Russie et Etats-Unis sous le détroit de Bering.

The implementation of this mode can ensure safe and cost-effective operation of thermal and nuclear stations (TES, AES) with constant output in some countries which benefit from high tides at their coastlines provided ; they are included in developed power systems incorporating many thermal and nuclear power stations of various types and hydroelectric plants with large water basins.

II ■ THE FLOAT CONSTRUCTION METHOD

There was also a cost barrier to be cleared for reasonable economic backing of tidal station projects, because the tidal station at Rance came out to be 2.5 times as costly as a comparable river hydroelectric station.

A possible approach could be the well known floatable construction methods, though they had never been tried out for the erection of hydroelectric stations. This method was used for erecting the experimental Kislogubskaya Tidal Station, which has made it possible to dispense with building expensive coffer-dams in the sea. Floatable construction methods permitted a cost reduction of one third of the estimated and were subsequently referred to as the Russian construction method in a series of tidal station projects in Canada, the United Kingdom, Australia.

This method was used in 1977-1984 for 330 and 750 kV power transmission lines to cross the Kakhovskoye water basin. 126 m high towers were secured on floatable foundations, 40 to 45 m in diameter, up to 8000 t in displacement that were erected in a dock pit ashore near the power transmission line site.

In the subsequent construction of a hydraulic complex at the Gulf of Finland between 1983 and 1988, the floatable structure method was used for erecting two water passages comprised of large blocks. Each block measuring 130 × 51 × 12 m at 30 000 t displacement consists of five 24 m span water outlets. It is constructed in a special dock and tugged jointly with the gates to the erection site under any weather conditions, including ice cover.

As concerns the size and structure design, these blocks represent prototypes of the floatable power houses for the large tidal power stations designed for the Sea of Okhotsk and the White Sea.

Some global of orientations sea buildings were decided on the period of the investigations on Kislogubskaya TPP as following : creating of construction cover materials and concretes with particularly high exploitation suitability, the creating effective ecological safety against ecological overgrown and elaboration of thew orthogonal unit which lead to cardinal lowering the cost of TPP.

III ■ THE CONSTRUCTIVE MATERIALS

For thin wall constructions of the float building of TPP, intended for work on the Arctic coast were created the covering warmhydroisolations for zones of tide and concretes special high suitability.

During 28 years of service in the tide range zone no damages occurred to the concrete ; the concrete strength is considerably higher then the design one. During the period of the plant operation the concrete was subject to more than 10 000 cycles of freezing in the air and thawing in the sea water. The impermeability of concrete is confirmed by the fact that the interior surface of the walls 15 cm thick and subject to the sea water head up to 12 m is at present dry. The protective layer over the reinforcement steel is 2 cm thick ; the reinforcement steel is not corroded.

The concrete mixtures devised and tested at the Kislogubskaya Tidal Power Plant were also used in construction of the S. Petersbourg protection barrage in the Gulf of Finland, of floating structures in the Kakhovsk water storage reservoir and also provided for in the designs of tidal power plants in the White Sea and the Sea of Okhotsk and in designs of many other marine structures erected under severe climate conditions.

IV ■ ECOLOGICALLY PURE ANTIFOULING PROTECTION

Operation of the Rance, Kislogubskaya, Annapolis and Tzjansun tidal barrage projects showed that fouling results in decreasing the discharge through water conveying structures, electric energy output and damage of structures.

28-Years period of operation of the Kislogubskaya tidal barrage project demonstrated that a conventional protection with antifouling paints was usually effective for 1-2 years. After this period the fouling biomass may attain very substantial amount (200 kg/m^2 in the bottom outlet in 1996).

Cleaning of fouling communities from water passages was an extremely labour-consuming and expensive operation which required shut-down of the power house. One of effective antifouling measures consisted in installation of an electrolyzer in the penstock which produces active chlorine having strong bactericidal properties ensuring fouling protection.

The electrolizing system is designed as that applied in ship construction. Its operation consists in pumping sea water (raw material) through an electrolizer and supply of active chlorine solution into the penstock. Such system operating at the Kislogubskaya power house since 1979 ensured 100 % fouling protection of the penstocks.

Long-term studied conducted at this tidal barrage project proved that this antifouling system is ecologically benign. Chlorine impact was detected only within the penstock, 6-10 m from the source. At the exit from the penstock and on the tidal barrage water surface no chlorine traces have been found.

Chlorine was found to affect just 0.1 % water passed through the tidal barrage power house structures. Survival of zooplankton in this amount of water is 86 %.

Since 1972 studies of concrete compositions with biocidal additives called non-fouling have been carried out at the Kislogubskaya tidal barrage project. There is no fouling at some such concrete substances for more than 10 years. Application of non-fouling concrete is 10-20 times more effective and economic as compared with antifouling paints.

V ■ ORTHOGONAL HYDROPOWER SET FOR TPP

A new double-effect cross-jet turbine, termed provisionally « orthogonal turbine », has been developed. This turbine may be considered as an analogue of the Darieux rotor with rectilinear blades (arranged in parallel to the axis of rotation) employed in wind power utilization.

Studies of this rotor type aimed at its employment in hydraulic turbines were conducted in Canada and Japan in the 70s and 80s.

However since the studies have revealed a low efficiency of the rotor (0.36) and a number of limitations concerning the head, further studies were stopped.

In Russia the studies of orthogonal turbines with the purpose of employing these turbines at TPP were started in 1988 and are under way at present [4]

The advantages of orthogonal turbines in tidal power utilization reside in the possibility of the double-effect operation without changing the rotor rotation sense, the possibility of arranging the generator in the machine room but not in the bulb. The series production of the turbine blades can be organized in most machine building plants and not at specialized turbine manufactures since the rotor blades are rectilinear in shape and the blade cross-section is constant through the blade length. In addition, the orthogonal turbines are more beneficial for the zooplankton due to the low linear velocity of blades motion.

Model studies of large turbines with a modernized turbine chamber resulted in the maximum efficiency equalling 0.67 (and may be up to 0.7-0.8) for high-speed turbines, up to 10 m in dia, at heads up to 6-8 m.

The alternative design of the Tugur TPP has demonstrated that the employment of orthogonal turbines *(fig. 1)* will result in cutting down the construction costs in excess of 1.5 times as compared with the alternative with axial-flow turbines.

VI ■ LARGE ENVIRONMENTAL SAFE TPP IN RUSSIA OF GLOBAL IMPORTANCE

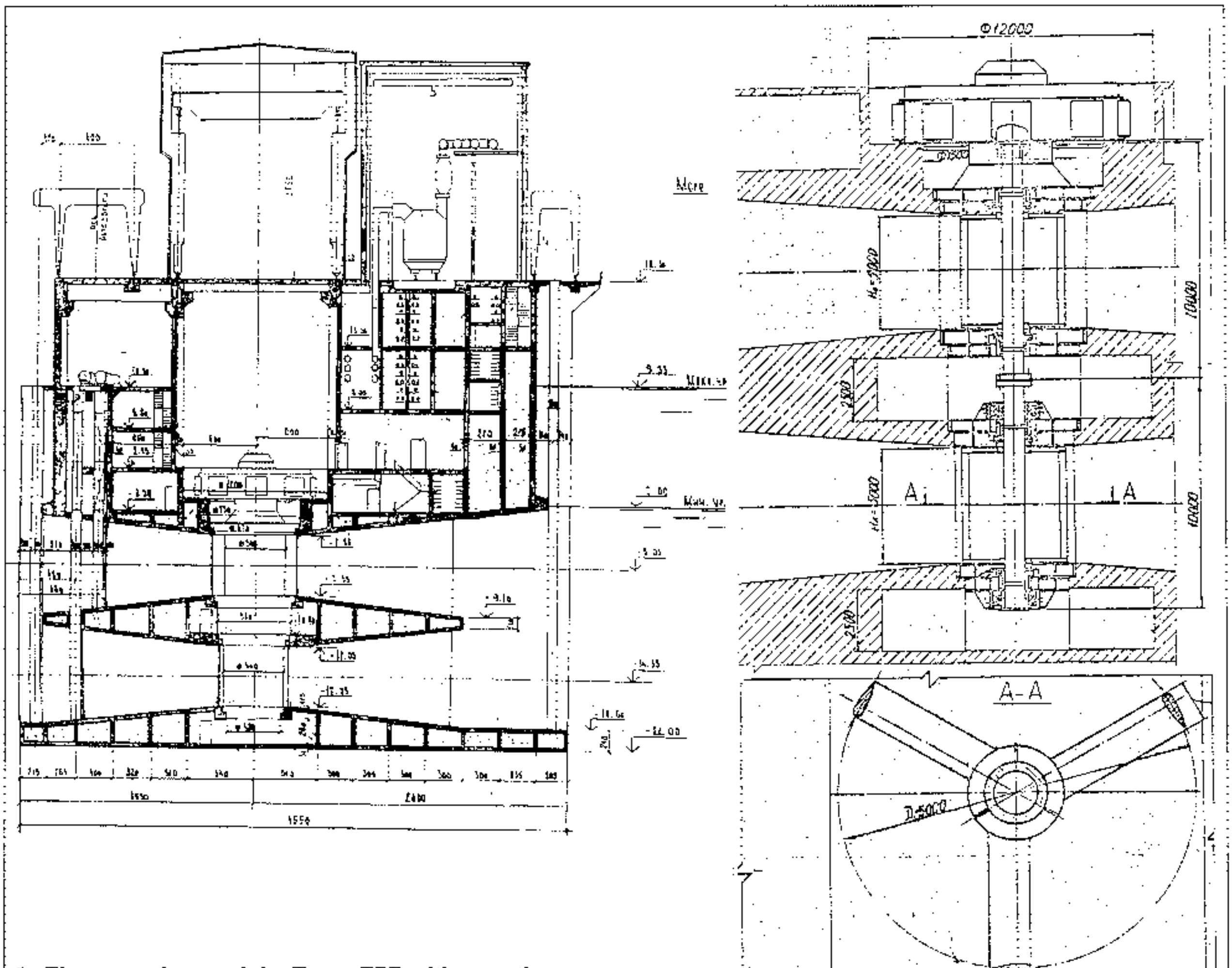
Single-basin tidal power plants do not pollute the atmosphere, do not disturb the natural tide rhytm, do not inundate arable lands and require no additional funds for land reclamation and purification of harmful effluents, while the purification of gas effluents of thermal power plants requires considerable expenses amounting in USA up to 30 billion dollars annually. Consideration of this effect in the design of the Mercey TPP (UK) has demonstrated that the TPP enables saving of 627 mill., this amounting to about a half of capital investments rendering thus the TPP construction justifiable economically.

Moreover, the experience of many years in operation of the La Rance TPP (France) and Jiang-xia (China) TPP is evidencing the beneficial effect of TPP upon the environment (recreation zones, transportation routes, fishing, exotic cultures plantations).

At present the Mezen, the Tugur and the Penzhinsk TPP are the projects construction of which is technically feasible in the XXIst century and which are needed in Russia and neighbouring countries of Europe, Asia and America.

The Tugur TPP is located at the Sea of Okhotsk coast. The design studies were carried out during 1991-1996. The installed capacity is 8 mill.kW, the annual energy output 20 bill.kWh.

The TPP comprises 106 floating caissons with hydropower sets and a barrage with sluices. The construction period was estimated as 11 years, the first power sets being put in operation during the 7th year of construction, at the non-completed water-retaining structures front. The capital investments amount to 11 bill. roubles (in 1984 prices). The TPP operation would save 7 mill.t of fuel equivalent or 13



1. The power house of the Tugur TPP with an orthogonal turbines (project).

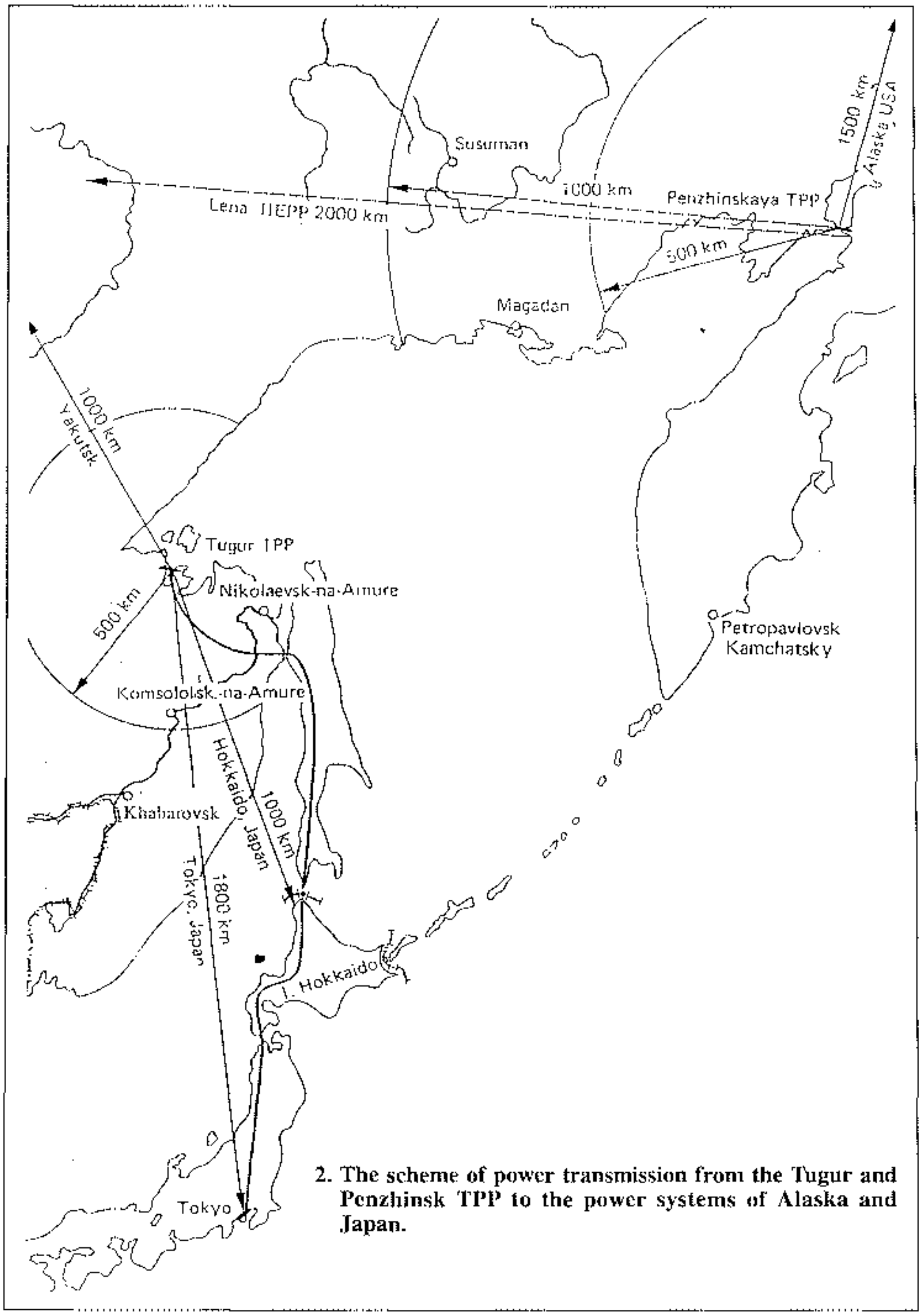
mill.t of replaced Kansk-Achinsk coal. The prime cost of energy in the integrated power grid of the East will be 6.6 kopecks/kWh, this being half the cost of energy of a coal-fired thermal power plant (12.3 kopecks/kWh) and by 30 per cent lower than the cost of energy generated at a nuclear power plant. The term of repayment of additional investments (as compared with the thermal power plant) is 7.5 years, the 5 per cent interests being considered ; taking into account the prevention of atmosphere pollution, the pay out period is only 4 years. The effluents amount cutting down makes 20 mill.t for CO_2, 96 thou.t for SO_2, 104 thou.t for No_x, 48 thou.t for flying ash. 16.4 mill.t of oxygene will be saved.

Up to 4 mill.kW of electric power can be transmitted into the Japan power grid *(fig. 2)*.

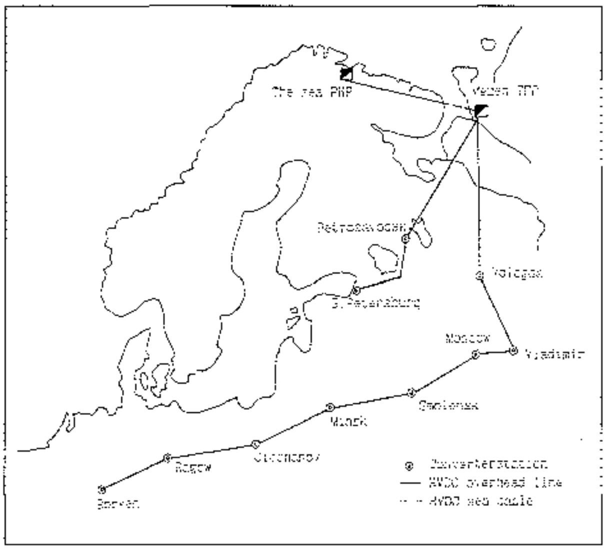
The Mezen TPP will be of real importance in the case the suggested at present power pool West-East [5] will be implemented. The full power potential of the Mezen TPP could be utilized in this pool providing the growing electric power demand of West Europe and the European part of Russia with ecologically pure energy. The design studies of 1996 estimated the installed capacity of the TPP as 17 mill.kW, the annual power output being 50 bill.kWh.

The electric energy of the Mezen TPP can be transmitted via Smolensk to the Central Europe *(fig. 3)*.

The Penzhinsk TPP. The preliminary investigations carried out in 1972- 1985 demonstrated that the installed capacity of the Penzhinsk TPP will reach the unheard — of value — 87 mill.kW. However the economical justification of the plant under the present-day conditions seems to be impossible as the plant capacity is far in excess of the possible power demand of the region. The suggestions made recently in USA about the construction of the Bering Strait Tunnel allow to consider the Penzhinsk TPP as the source of ecologically pure energy for the North America even in the foreseeable future.



2. The scheme of power transmission from the Tugur and Penzhinsk TPP to the power systems of Alaska and Japan.



3. Utilization of the Mezen TPP power in the integrated power system of Europe (« East-West »).

The international cooperation in designing and investigations of tidal power installations is gaining special importance as the tidal power plants are at present designed all over the world.

Such problems as employment of the floating caissons, development of new types of equipment, economic justification of TPP construction considering the ecological effects, improvement of the patterns of TPP operation in the integrated power systems of global scale, participation of governments in the financing of tidal power utilization should be the object of international discussion of all the specialists engaged in tidal power utilization.

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