

Identified Regional Power Projects

1. General

The West European power grid is a highly meshed power system with high load density, short distances between consumers and power stations and the highest transmission voltage of 400 kV. Contrarily, in the Central Asian Countries and in almost the whole of the former Soviet Union, the power grid is characterised by a low load density and long distances between the generation plants and the load centres. This brought into existence a power grid with long transmission lines, transmission voltages of 500 kV and above and numerous single lines instead of looped circuits. Due to the long distances, often the investments were too high for loop connections. They would offer an increased security of supply, since in case of failure of one transmission line the second branch maintains the supply. Finally, as mentioned in chapter 3, Need for Improvement of the Power System, the Central Asian power grid suffers from under-investments in maintenance, rehabilitation and use of modern technology during the past years.

The high voltages, the long distances, the single line connections and the under-investments formed the basis of different proposals for regional power projects described in the following chapter. The geographic location of the different projects can be seen from the drawing of the Unified Power Grid of the Central Asian countries, presented in Annex 3, Map of the Central Asia Power Grid:

2. Identified Projects in Kazakhstan

KEGOC's representatives indicated the following power projects for possible financing within the Regional Economic Co-operation Project:

2.1 Reinforcement of the 500 kV Axis Ekibastuz – Jambul

The existing transmission line from Ekibastuz to Jambul allows interconnection of the combined North Kazakh - Russian grid of Siberia and the Ural with the Central Asian grid, consisting of the power systems of Southern Kaz, the Kyrgyz Republic, Uzbekistan, Turkmenistan and Tajikistan. This north-south interconnection was planned in the Soviet times with a voltage level of 1150 kV but finally implemented with one 500 kV circuit that has, due to stability reasons, a transport capacity of about 500 MW.

The reason for this north-south link was the chronic deficit of power in the southern Kazakh grid, resulting in the necessity to transport electric energy from the coal power plants of northern Kazakhstan to the consumers in the south. However, due to the decline of heavy industries in the South (even in 1998 the peak demand of the south reaches only 42 % of the peak load of the year 1990), at the moment the Southern grid is almost self sufficient in power supply. Deficit is mainly recorded in winter in the time of the annual peak, when the rivers carry less water. In addition Kazakhstan has to absorb in summer electricity from the Kyrgyz Republic when water is supplied for irrigation purposes to Kazakhstan and the additional release of water generates more electricity than the Kyrgyz Republic can consume. This energy is generally paid back in the form of coal supplies.

Until recently the 500 kV north-south link was not effectively used, mainly due to stability reasons. When the line was commissioned in 1986 two heavily loaded grids namely that of North Kazakhstan, Siberia and Ural and that of Central Asia worked in parallel. With the weak loads in the existing grids the north-south link is no longer supported by the connected

grids, the reactive loading was unfavourably increased and the north–south link no longer works satisfactorily. Operation will be more effective after installation of additional reactors in the 500 kV substations or, if necessary, static Var compensation equipment is implemented. Further improvement is obtained when the transport capacity of the north south link is increased through the construction of a second circuit. The planned construction of a nuclear power station in Akgres would provide as well required reactive power that is needed for stable operation of the link.

As mentioned above, the north–south link is presently not operating satisfactorily but it plays as well a less important role than during the Soviet times. This is due to the fact that, as mentioned above, the southern Kazakhstan grid is almost self-sufficient in power supply since demand decreased. As soon as the free power market in Kazakhstan is operational and industries start working again demand will rise and energy flows from the Ekibastuz area to the Southern grid will again be necessary.

The parallel operation of the northern and southern grids with the connection to the Central Asian grid will be necessary to maintain the traditional power flows between the Northern grid of Kazakhstan and all other Central Asian countries. The interconnected systems will benefit from additional generation and power/frequency capacity and possibilities for power exchange. Furthermore it keeps open the opportunity for power trade to the benefit of the participating partners. This means that the importance of construction of the second north–south circuit has been delayed due to the disintegration of the Soviet system but it is still of importance as soon as economics will recover.

Ekibastuz - Agadyr

The area around Karagand needed more energy so that the first section of the North–South axis was overloaded and reduced the overall transport capacity of the link to Agadyr substation. Due to that reason, already during the Soviet times, the construction of the second circuit of the 550 km transmission line between Ekibastuz and Agadyr was started. However, after disintegration of the Soviet Union works were stopped in 1994 with foundations of the transmission line towers totally completed, 40 % of towers erected and 20 % of conductors strung. The remaining works for erection of the transmission line still have to be executed as well as the construction of the feeder bays in the 500 kV substations of Ekibastuz and Agadyr.

According to information received from KEGOC, in this second line circuit an additional 500/220 kV substation is planned to be constructed at Karagand for power supply for this industrial area.

The termination of the line would complete the works already started, provide a redundant circuit for power supplies between the coal mining centre of Ekibastuz and Agadyr and establish the first section of the second north – south circuit.

Agadyr – Ukgres

Second line section for reinforcement of the north – south axis is the transmission line between Agadyr and Ukgres. For this purpose about 400 km of 500 kV transmission line need to be constructed, as well as the respective feeder bays in the terminal substations.

Ukgres - Jambul

Power flow from the northern power grid of Kazakhstan to its south-western part passes through the single circuit 500 kV line from Ukgres, via Bishkek S/S in the Kyrgyz Republic and continues from there to Uzbekistan, Turkmenistan and Tajikistan. The length of the existing single circuit 500 kV line from Ukgres to Jambul amounts to almost 800 km and

passes through the Kyrgyz Republic. With the construction of a direct 500 kV line from Ukgres to Jambul the line length would be reduced to about 260 km and remain entirely on the territory of Kazakhstan.

The big regional importance of this transmission line lies in the fact that Ukgres, Jambul and Almaty substations will be connected in a loop that has a higher reliability than a single circuit connection. In this way from Ukgres in Kazakhstan, via the power grid in Kyrgyz Republic to Syradarian in Uzbekistan all 500 kV substations will be connected in a loop. In addition, stability will be increased since a larger transport capacity is available for the tie line from north to south.

KEGOC designed the line section between Ukgres and Jambul with an intermediate 500/220 kV substation in Tshu for the local power distribution with 220 kV. This allows disentangling the 220 kV grid that is partly fed from the Kyrgyz Republic and partly from Kazakhstan. In addition a double circuit line shall be constructed from Tshu to the transmission line from Almaty to Bishkek which will be opened to connect it to the new substation. However, the construction of the second connection from Tshu to the Bishkek – Almaty line cannot be recommended from its economic feasibility.

2.2 Installation of Reactors for the 500 kV and 220 kV Transmission Lines

The demand in Southern Kazakhstan declined to the level of the year 1974, due to decrease of demand caused by the shut down of large chemical plants. Therefore the 500 kV line between Almaty, Kazakhstan, via Bishkek, Kyrgyz Republic to Tashkent, Uzbekistan is lightly loaded, so that excessive voltage increases are recorded in the 220 kV network that reach up to 260 kV. This even obliges the operators to completely switch off this 500 kV line leaving only weak 220 kV lines to maintain power transfer on this important international east–west connection. Network calculations proved that in Jambul S/S (Ka) it is necessary to install 3 x 67.5 MVA reactors together with the related 500 kV switching devices.

In the 220 kV system of Kzyl-Orda about 40 MVA of shunt reactors for 220 kV need to be installed. During the Consultant's country visit it was mentioned that some reactors might be financed through the Worldbank/EBRD project. The final needs still must be clarified.

2.3 Installation of Emergency Control Equipment for International Parallel Operation

Within the KEGOC rehabilitation program, financed by EBRD and the Worldbank the transmission system will be refurbished. This includes among others, the replacement of protective relaying based on state-of-the-art microprocessor technology to improve the safety and reliability of the entire transmission system and the installation of further shunt reactors to improve voltage quality and reliability of power delivery in the transmission system.

In addition, the dispatch control within Kazakhstan will be upgraded by the installation of SCADA (Supervisory Control and Data Acquisition) at 9 Regional Dispatch Centres (RDC) and SCADA/EMS (Emergency Management System) at the National Dispatch Centre (NDC). Furthermore, the telecommunication system between substations, RDCs and the NDC will be reinforced.

However, protection system and especially SCADA/EMS must be improved for operation with the Russian and the Central Asian Grid in the same way as the system is reinforced within Kazakhstan, financed by the EBRD and Worldbank. Driven by privatisation and the free market system for electric power, KEGOC is the first utility that rehabilitates and upgrades its national dispatch centre. But the refurbishment and improvement must be established also for international trade.

The emergency control system for international operation must be co-ordinated with the national equipment that will be ordered and the existing and planned equipment in other countries. Since the other countries are not yet advanced in their planning for the international power market and the necessary equipment, the situation for design and procurement still must be solved.

2.4 Increase of Capacity of Transmission Lines

The stability of operation of transmission lines is guaranteed through various automatic systems for:

- Avoidance of a disturbance to stable parallel operation (AS);
- Elimination of asynchronous operation (AA);
- Limitation of voltage drop (AU);
- Reduction of loading (or avoidance of inadmissible overload) of equipment (AE).

The first fundamental subsystem is the most important and guarantees the stability of the power system. Each subsystem consists of several automatic system which are sometimes interlinked. The AS system alone includes:

- Automatic system for reducing the load of the grid after disconnection of lines or transformers,
- Automatic load reduction system in the event of overload on the lines due to active power,
- Automatic load reduction systems if generators are shut down,
- Automatic systems for load reduction in the case of nearby or long duration short circuits.

The remaining systems have further sub-systems and, due to its complexity, the whole stabilisation system is not further explained here.

The automatic emergency system can be made more effective through introduction of digital telecommunication systems and modern computers. This allows an increase in the transport capacity of transmission lines which would otherwise be reduced due to spurious or late tripping of relays in the existing antiquated system. Furthermore a modern automatic system could re-establish stable conditions much more quickly in the event of a system disturbance.

2.5 Introduction of a Trans-Asian Synchronised United System (TASUS)

During Soviet times power generation and transmission was ruled and controlled by the Unified Power System (UPS) with the Central Dispatching Office in Moscow and the Regional Dispatch Centre for Central Asia in Tashkent. The dispatching system was hierarchically arranged and based on standards and rules of GOSP.

Now the UPS has fallen apart into independent national networks and the dispatching system still functions due to the good relations between the personnel of the different load dispatch centres who rely on each other and trust that energy is returned immediately that has been supplied on an involuntary basis . In addition, Kazakhstan has separated even more and entered the way for private power companies and market prices for electric energy and is implementing the free energy market. The remaining countries will probably more or

less head towards the same direction, especially since market prices for electric energy are applied more and more. For gas and oil international market are widely used already.

Due to that reason a new body will be created that organises the power trade among the Central Asian countries and their neighbours including the technical conditions for proper operation of the new body. It is thought that it will be based on an organisation such as the UCPTTE (Union pour la Coordination de la Production et du Transport de l'Electricite) as existing in Western Europe, however, adapted to the regional conditions.

For the implementation of such Trans-Asian Synchronised United System (TASUS) the following main tasks have to be implemented between the future member states:

- Definition of organisational rules between the member states and for power trade;
- Definition of technical rules each member state has to respect;
- Time table to implement the organisational and technical rules;
- Implementation of governmental, legal, and institutional frame works necessary for the TASUS;
- Implementation of technical changes.

The creation of a TASUS will require long multi-governmental discussions and will require a long time. Since the energy market is in constant change, the institutional and legal framework will also constantly change.

In addition, it must be taken into consideration that the electricity market is strongly interlinked with the gas and oil market and to the prices of coal. This trade can always take reference to international market conditions, but the electricity market is also connected to water rights and these can only be solved on the basis of common understanding.

2.6 Reduction of Emissions Through Environmentally Friendly Power Generation

In view of the emissions of the gas and oil industry and those of thermal power plant several projects were proposed that will reduced the regional balance of emissions from burning oil and gas products:

In Xelorda gas is flared that is obtained as waste during exploitation of the oil fields. The califoric value of the burnt gas corresponds to about 600 GWh of electric energy and in a power plant about 400 – 500 GWh of electric energy could be replaced that is presently supplied from KEGOC from existing thermal power plants.

The Chimgent refinery burns excess gas that developed during the refinery process of crude oil. This gas could be used for production of electric power

In Uralsh, Karajaganak a large refinery burns the residues of the petrol distillery. At the same time electric energy for this north-western region is imported from Russia. Power generation with the fuel from the refinery would use the oil products that are flared only.

3 Identified Projects in the Kyrgyz Republic

Kyrgyzenergo's representatives indicated the following power projects for possible financing within the Regional Economic Co-operation Project:

3.1 Improvement of Emergency Control System

In the Central Asian power grid numerous 500 kV lines exist that lead to parts of the network which are otherwise not interconnected, so that in case of failure of this line this section is cut and isolated. In other sections of the grid, one 500 kV line runs in parallel with one or two 220 kV lines. In such cases the weaker branch, in this case the 220 kV lines determine the transfer capacity of the parallel system. Only a smaller part of the 500 kV transmission system is designed according to the $n - 1$ criterion, so that if one transmission line fails the power flow can be taken over by the redundant parallel or looped system.

In case of fault in one of the 500 kV transmission lines that are not designed according to the $n - 1$ principle and since power frequency regulation cannot substitute the loss of generation capacity, it is necessary to shed load and emergency schedules have been worked out for this load shedding. For that purpose 8 control points exist that control the emergency system within the Central Asian grid.

If a fault on one of the crucial lines occurs, the line trips and, on the one side, the excess power generation must be reduced and, on the other side, load must be shed. Similarly, if a large generator drops, appropriate load must be shed. If the disturbance is too large, frequency deviations become too severe and in many cases this results in a collapse of the complete power system. After such blackout the power plants must be gradually restarted, load is taken up and the grid is synchronised again.

In 1998 10 major blackouts of the complete Central Asian grid occurred, especially when the big hydro plant of Nurek in Tajikistan fell off the grid. To demonstrate the importance of the blackout, although it was possible to rebuild the power system within 30 minutes, 1.6 GWh could not be produced and sold in the Central Asian grid. With production cost of 5 US cents/kWh, this sums up to 80,000 \$ for one incident that was even quickly restored. In this year already two major faults had occurred by July 1999.

The existing emergency control is based on old relay technology, without the use of modern on-line recording and processing of data with computers.

The construction of a modern emergency control would include all 5 Central Asian countries and the installation of increased and improved power/frequency control could be part of this. In addition, data collection at the various power stations and switching stations, telecommunication equipment, and the computer equipment would result in the establishment of a modern dispatch of the international transmission lines and generation plants with SCADA (Supervisory Control and Data Acquisition) equipment.

The proposed improvement of the emergency control equipment foresees the upgrading of this same equipment, as identified in the Kazakh proposal to increase the capacity of the transmission lines. The projects only differ in the point of view of the operator: the Kyrgyz proposal focuses on the stability of operation, whereas the Kazakh proposal highlights the increase of transport capacity of the transmission line. Both functions are obtained with the same equipment.

3.2 Establishment of Central Asian Electro Pool

During the Soviet times the Central Asian power market was a centrally organised power pool based on a strict hierarchically structure that used the ingenious energy resources in huge power plants utilising the decreasing unit costs with size and taking no account to national borders. In addition the command economy provided large subsidies for its power system operation and extension and consumers paid little for any kind of energy.

The separation into national power utilities, introduction of national energy policy and laws, application of market prices for oil, gas and electricity, and national energy borders makes it necessary to create a new Central Asian Electro Pool. This Electro Pool will replace the old Soviet power pool and redefine the power trade between the participating partners of the power pool in Central Asia.

The new Central Asian Electro Pool must leave place for the ongoing restructuring of the power sector with private generation and distribution companies, companies in charge of the transmission system and the possibility of an eventually competitive market, where all market participants will enjoy open and non-discriminatory access to the regional power system. For establishment of a Central Asian Electro Pool the conceptual model must be developed and many of the present problems of power trade must be solved, such as lack of political solution, barter trade between electricity, gas, oil and water rights and non-payments of these trades, high commercial and technical losses, and reduction of accounts receivable. Parallel to the establishment of the market, the necessary technical infrastructure must be created (metering, telemetering, information system), either significantly enhanced or built from scratch.

It is evident that the Power Pool must be developed as a regional pool since the regional grid was designed during the Soviet times as a multi-country system which will continue to operate, but re-organised due to the past developments and expected changes. It is thought that the Central Asian Electro Pool might be similarly organised as the UCPTE or the South African power pool, adapted to the Central Asian conditions.

3.3 Improvement of Power Frequency Control

Control of frequency in power systems is generally managed by a three level system whose goals are security of the interconnected system and security and economy of the different subsystems. These three levels are primary, secondary and tertiary controls.

Primary control is used to restore rapidly the balance between generation and load. The choice of the most suitable action is directly related to the system state, namely, normal operation, operation after disturbances and operation in defence conditions.

In normal operation primary frequency control maintains a balance between generation and consumption by suitable actions on generation units (gates of hydro units, valves on thermal units, power set points on HVDC links, etc.), or by demand side management, by automatic disconnection of pre-heaters on certain power plants and/or by overload operation (i. g. gas turbines).

Maintaining the frequency near to its nominal value is important for the security of the system and all partners in the interconnected system are jointly liable. In the Central Asian grid however, only four hydro power stations are equipped and able to perform the primary power/frequency regulation, namely Togtogul (1200 MW in Kyrgyz Republic), Chervak (776 MW in Uzbekistan), Nurek (1350 MW in Tajikistan), and Kapchagay (434 MW in Kazakhstan). Generally either Kyrgyz Republic or Tajikistan perform this task. Turkmenistan has no power station for primary power/frequency control and is therefore dependent on the other states and particularly on the only 500 kV transmission line that connects the Turkmen grid to those of the other countries.

These four hydro stations are not always able to offer the full range of power regulation. In summer Togtogul and Nurek have to operate occasionally with full output due to the irrigation needs and can during that period only cover a reduced regulation range. In winter Nurek has only small inflows into the reservoir and can only contribute to a small extent the regulation requirements. Chervak is only working in the evening hours as peak power plant and runs idle during daytime. In addition Nurek power plant is connected to the grid through one single

circuit line only, if this line trips, the power station is not available for power/frequency control. Out of these reasons mainly Togtogul with its 1.5 fold annual reservoir provided power frequency regulation for the complete Central Asian power grid.

Consequently the regulation capacity of these four hydro power stations is not enough and further power stations including the large thermal power plants should be equipped with primary power/frequency control. (In the UCPT system 2.5 % of the present load is operated for primary control.) Better primary control also results in a substantial improvement to the voltage profile in the whole system and the reduction of power flows due to power/frequency regulation requirements. Only a joint understanding of all partners of the system of the need to improve the primary control and to pay for received primary control capacity will allow the improvement of the system. Else one partner might operate his system on the expense of the other partners.

In the Kyrgyz Republic the remaining power stations of the Naryn Cascade will be equipped with governors for power frequency control, namely Tashkumyr 3 x 150 MW, Kurpskay 3 x 200 MW and Shamaldyskay 3 x 80 MW. The improvement of the power/frequency regulation will provide benefit mainly for the power system of the neighbouring countries that do not have sufficient regulation capacity. They, in return, pay for the services of power regulation.

3.4 Construction of Kambarata I HPP

Most of the hydro power stations are located at the Lower Naryn river, with Toktogul HPP as biggest plant of the cascade. The primary purpose and the current practice of the Toktogul reservoir has been to provide multi-year and seasonal storage for irrigation demand in Uzbekistan and Kazakhstan. Water is stored behind the Toktogul reservoir for summer releases to meet this demand. The hydro plants downstream of Toktogul do not have a seasonal storage and are used for daily peaking and regulation. Power and energy is generated as a by-product of irrigation releases. As a result, electricity generation in the summer is in excess of the internal demand of the Kyrgyz Republic. Within the former Soviet Union, this excess was transmitted to the other republics of Central Asia through the 500 kV network. In winter, when water was conserved for the summer irrigation requirements, electric power, gas, oil and coal would flow back from the other Central Asian republics to meet the winter load and to provide for heating of Kyrgyzstan. A regional balance and optimisation of water for power and irrigation was achieved.

Kambarata I HPP, located in the middle part of the Naryn river, upstream of Toktogul, would have a live storage of about 3,43 million cubic meters and provide seasonal storage. The installed capacity of the plant would be 1,900 MW with an average energy production of 5,088 GWh/year. The total construction cost is estimated to vary between US\$ 1.67 billion for the blast dam alternative and US\$ 1.85 billion for the arch dam alternative.

With the construction of Kambarata I HPP, the energy output of all hydropower facilities of the Naryn river would be able to closely follow the monthly fluctuations of the internal demand of the Kyrgyz Republic and would meet that demand without any power shortage during the winter months. During the summer months Toktogul and the down stream run-off river plants would satisfy power demand under the irrigation scheme and in winter Kambarata would generate at maximum output since its waters are kept in the Toktogul reservoir. In this way the irrigation requirements of Uzbekistan and Kazakhstan can be satisfied without disturbing the needs of power generation of the Kyrgyz Republic.

In addition, due to the increased installed capacity, all Kyrgyz plants could provide peak power and power/frequency regulation on a regional level.

3.5 Environmentally Effective Use of Natural Gas

At the exploration sites of the gas fields in Turkmenistan and Uzbekistan more and more gas turbines are installed for generation of electric energy for the consumers of the region. Unless combined cycle power plants are operated these power stations work with a low efficiency and discharge the exhaust gas to the environment. Simultaneously gas pipelines transport gas to the heat and power plants in the Kyrgyz Republic that have to operate throughout the year for provision of process heat for industrial needs and in particular energy for district heating in winter.

The most rational and environmental conscious energy supply for the gas fields and the Kyrgyz population would be to generate electric energy with hydro based power stations in the Kyrgyz Republic and use the existing transmission lines for power transfer to the demand centres at the gas fields. The process heat and district heating requirements in the Kyrgyz Republic shall be satisfied with heat only boilers during the summer period and with heat and power plants in the winter months which are supplied with gas by the existing gas pipeline system.

4 Identified Projects in Tajikistan

In the light of the long civil war and the resulting unlimited need for rehabilitation and upgrading works of the national power system and the missing rehabilitation master plan, Barki Tojik's representatives indicated the following power projects for possible financing within the Regional Economic Co-operation of the Central Asian States:

4.1 Construction of 500 kV Transmission Line to the Northern Network

The grid of the northern part of Tajikistan (Khojand region) that has the highest economic activity of the country is not directly connected to the southern grid, nor is it self-sufficient in power generation, with the north accounting for about 30 % of the national energy demand. Due to that reason, about 85 % of the northern demand must be imported from the southern grid by the 500 kV transmission system leading through Uzbekistan. Since the political relations between Uzbekistan and Tajikistan presently have some friction, Tajikistan has to pay US cents 5 for power supply to the northern region.

The planned 500 kV transmission line to be constructed has to cross two mountain ranges with passes of 3372 m and 3351 m, respectively. The line shall start in Regar substation, continue to a new substation Faizabad, where Rogun HPP shall be connected and terminate in a 500 kV substation at Kodjand. Barki Tojik has already chosen the line route, started with the acquisition of right-of-way and construction of access roads. The construction costs are estimated between US \$ 115 million and US \$ 200 million, according to the selected line route and encountered soil conditions.

This line is of greatest importance for Tajikistan and had been put on top of the agenda for financing, although it is not strictly a regional project. However, if at Kodjand the existing 500 kV line from Syr Daria to Lotshin is tapped the new 500 kV line can serve as additional power line from Tajikistan (Nurek) via Uzbekistan to the Kyrgyz Republic. In this way the 500 kV line from Dushanbe to Kodjand would play an essential role in the southern regional grid with benefits for Tajikistan, Uzbekistan, Turkmenistan, and the Kyrgyz Republic. The new line would present a second circuit for the present single circuit from Regar S/S via Guzar S/S to Syr-Darja S/S in Uzbekistan. This second circuit provides additional reliability of supply for power exports from the hydro power stations of Tajikistan.

Concerning the intention to become self-sufficient in power supply of the north of Tajikistan, even after the construction of this 500 kV line Tajikistan must construct additional generation capacity to cover demand during February to April when the Tajik rivers and reservoirs have

not enough water to cover demand. As an alternative Tajikistan remains dependent on power supplies from or through Uzbekistan to cover the deficit during these crucial months.

The most rational solution would be a free power market and the wheeling of power through Uzbekistan from south Tajikistan to north Tajikistan, especially since Uzbekistan also wheels power through northern Tajikistan on the 500 kV line from Syrdaria substation to Lotshin Substation.

However, a rational solution seems presently impossible, otherwise Uzbekistan would buy additional power from Tajikistan's hydro power plants in summer. This year Tajikistan offered the kWh for US cents 3, Uzbekistan was prepared to pay only US cents 1, so that finally 1,500 GWh were not produced and water was spilled; although Uzbekistan buys power from Tajikistan for US cents 5/kWh.

4.2 Construction of Rogun HPP

Rogun hydro power plant (HPP) was designed with an installed capacity of 3,600 MW and an average annual output of 13,100 GWh (plant factor 0.42). The construction was started under the former Soviet Union, but slowed down after its collapse due to lack of funds and, as a result, most of workers and experts left the site. Roads, construction infrastructure, tunnel are already completed, however parts of the started dam and some infrastructure had been destroyed by floods especially in 1996, so that the remaining construction works can only be estimated to cost about US \$ 500 million.

Rogun HPP serves both for generation of electric energy and for water storage for irrigation. The plant, situated upstream of Nurek HPP was the key element of the Vakhsh river basin development. With its large annual regulating reservoir of 13.3 m3 billions, it could increase significantly the economic benefits of all the other seven run of the river power plants of the Vakhsh cascade by increasing their power factor. (Until now, out of the seven plants, only Nurek HPP is constructed). For example, the installed capacity of Nurek HPP amounts to 3,600 MW with an average annual energy production of 11,200 GWh, giving a plant factor of 0.43 %. Such plant is most cost effectively used to supply peak power energy at a regional level. This regional importance is documented by the size of Rogun HPP with installed capacity of 3600 MW and an estimated annual output of 13,100 GWh, compared with the present Tajik peak load of about 2,600 MW and annual production of 14,006 GWh in 1999. With an additional upstream annual reservoir the peak capacity can be better utilised according the power demand of consumers.

Generally spoken, the Tajik power generation is characterised such that Tajikistan inherited from the Soviet Union a surplus of installed capacity (peak load generation) and a shortage of energy. With the construction of Rogun HPP the Tajik energy deficit can be overcome and peak power can be exported.

In addition Rogun will provide electric energy at low cost from renewable energy sources and the plant can operate as peak power plant and allow base load operation of thermal power units abroad. Finally, additional capacity of primary frequency regulation will be provided for the regional power system. The plant has a regional importance, since it will not only produce power for the Tajik market but for the whole region.

4.3 Construction of Sangtudin 1 HPP

Located as well on the cascade of the Wakhsh river, below Rogun HPP and Nurek HPP, Sangtudin 1 HPP was started in the Soviet times too, but construction works stopped at an early stage. The plant is dimensioned for an installed capacity of 670 MW and 2,800 GWh annual production (plant factor 0.48). The construction cost of Sangtudin 1 HPP was estimated at US \$ 340 million.

Similar to Nurek HPP, Sangtudin 1 HPP will provide as run-of-river plant energy for the Tojik and regional power grid. Due to its small reservoir of 120 million m³ it cannot provide much energy in the crucial months from February to April but the high plant factor shows the valuable contribution the plant can make for the national power supply. With Rogun HPP, Sangtudin 1 HPP shares the advantages of renewable energy source, primary power frequency regulation plant and the possibility to work as peak power plant in a regional level.

4.4 Construction of a New National Load Dispatch Centre

The National Load Dispatch Centre (NDC) at Barki Tojik headquarters at Dushanbe controls the operation of power generation and HV transmission lines situated on Tajik territory, directs the nine Local Dispatch Centres (LDC), and co-ordinates with the United Dispatch Centre (UDC) in Tashkent. The NDC operator has the responsibility of monitoring the power plants, the 500 kV, 220 kV and most important 110 kV lines. The NDC is more than 20 years old, obsolete and conforms no longer to the standards of national control centres, since:

The parallel/serial interface and the pre-processing 286 PC presents a serious bottleneck with 64 bits/s only,

The system was designed for tele-measurement and tele-control only,

The central computer can hardly do more than produce some graphics and alphanumeric tables for the displays.

A reconditioning of the single-directional RTUs is not recommendable due to their age and physical condition.

The existing SCADA hardware is outdated and software cannot be upgraded.

Therefore, soft- and hardware have to be replaced together with the introduction of state-of-the-art SCADA (Supervisory Control and Data Acquisition) and Energy Management System (EMS) as well as data communication facilities and the local RTUs.

The NDC serves principally for effective power control within the country but it presents the link for the regional power exchange with the neighbouring countries that plays a fundamental role in Tajikistan, where even power flows to the national substations pass via foreign power stations.

5 Identified Projects in Uzbekistan

Minenergo explained that many projects exist in the power sector than need to be financed. However, they want to concentrate on the most important project that has at the same time the highest regional importance.

5.1 Project Recommended by Minergo, Uzbekistan

5.1.1 Construction of 500 kV Substation Sokdiana between Guzar S/S and Syrdaria TPP

A 500/220 kV switching and transformer station shall be constructed in Sokdiana and connected to the existing 500 kV transmission line from Guzar S/S to Syrdaria TPP. In the Samarkand and Buchara districts of Uzbekistan demand increased significantly during the past years due to the development of oil and gas fields and the subsequent construction of a refinery and following a boom of industrial and agricultural activities such as the construction

of a tobacco factory, etc. Due to the degradation of existing generation plants, a shortage of power exists, especially in the peak periods of demand and in case of outage of equipment.

The Samarkand and Buchara area is connected to the main power stations in the greater Tashkent area, where about 85 % of the generation capacity is concentrated, via one 500 kV transmission line (Gusar – Syrdaria TPP) and two parallel 220 kV lines. However, the 220 kV lines define the transport capacity of the three lines.

The 500 kV Gusar – Syrdaria line also forms an important axis from the hydropower plant of Tajikistan and from the power grid of Turkmenistan to the power plants of Uzbekistan and continuing to the power systems of Kyrgyz Republic and of Kazakhstan. Through the construction of the new 500 kV substation the 200 kV transmission lines will be less loaded and the system will have a higher transport capacity for the 500 kV system.

5.2 Projects Identified by Local Engineers

During discussions with Uzbek engineers, especially at the regional dispatch centre, numerous projects were presented that need to be implemented on a regional level.

5.2.1 Installation of Reactors for the 500 kV Transmission Line

The demand in Southern Kazakhstan declined to the level of the year 1974, due to decrease of demand caused by the shut down of big chemical plants. Therefore the 500 kV line between Almaty, Kazakhstan, via Bishkek, Kyrgyz Republic to Tashkent, Uzbekistan is lightly loaded, so that excessive voltage increases are recorded in the 220 kV network that reach up to 260 kV. This even obliges the operators to completely switch off this 500 kV line leaving only weak 220 kV lines to maintain power transfer on this important international east – west connection. Uzbekistan is most interested that the 500 kV line to Kazakhstan and northern Kyrgyzstan is not interrupted

Network calculations proved that in Jambul S/S (Kazakhstan) it is necessary to install 3 x 67.5 MVar reactors together with the related 220 kV switching devices.

5.2.2 Installation of Reactors for Seidi –Dashkovouz Transmission Line, Turkmenistan

The 378 km long transmission line from Seidi to Dashkovouz was constructed for 500 kV but is presently operated at 220 kV. This line was built without any compensation equipment in the terminal substations, so that overvoltage in Dashkovouz damaged equipment. Therefore, reactors are to be installed in Dashkovouz so that the line can be operated satisfactorily.

This line is of regional importance, since the Khorezm region consists of a Turkmen and an Uzbek part that are connected to their respective national grids with only one 220 kV line each. A thermal power plant generates additional power for the region. Since the two national parts are interconnected with several 110 kV lines, power can be exchanged in the case of fault on one of the feeding 220 kV lines. For that purpose the defective part is isolated and power is provided from the neighbouring country. The two national grids cannot operate in parallel, since the two 110 kV grids are not in phase due to mismatching vector groups of the transformers.

Overall the proposed project only concerns a small and remote region of the two countries and has only minor importance of the interconnected grid of the Central Asian countries.

5.2.3 Improvement of Power Frequency Control

Engineers from Uzbekistan also recommended the improvement of the power frequency control, as proposed by engineers from Kyrgyz Republic.

5.2.4 Improvement of Emergency Control

Engineers from Uzbekistan also recommended the improvement of the emergency control, as proposed by engineers from Kyrgyz Republic.

5.2.5 Construction of a 500 kV Line from Novo Angren to Uzbekiston Substation

The existing 500 kV transmission line from Tashkent to Novo Angren will be extended to Uzbekistan substation with a 500/220 kV transformer station in the Fergana valley. In a second stage this 500 kV substation will be looped to the existing 500 kV line from Louin to Sri Daria power station.

About 250 km of 500 kV transmission line needs to be erected. This additional line would provide reliable power supply to the fertile Fergana valley

5.2.6 Construction of 500 kV Line from Surchan to Gusar, Uzbekistan

The hydro power stations of Tajikistan are connected to the remaining grid of the Central Asian states by a single circuit 500 kV transmission line only. In the Soviet times, the construction of the line from Surchan to Gusar was already planned in order to operate two circuits and to respect the $n - 1$ criterion for this part of the network. Uzbekistan, Tajikistan, and Turkmenistan would benefit from the more reliable power system in the southern part of the Central Asian Grid.