

REHABILITATION, OPERATION AND TRANSFER OF THE SMALL HYDRO POWER PLANTS IN THE REPUBLIC OF MACEDONIA

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Abstract

The paper presents an overview of the foreseen project ROT (Rehabilitation, Operation, and Transfer) in the Republic of Macedonia. The ROT project include small hydro power plants (SHPP's) with ratings up to 5 MW: Dosnica, Sapuncica, Kalimanci, Pesocani, Pena, Matka, and Zrnovci. The authors emphasized and discussed the main tasks and features of the ROT project for each plant and outlined the expected improvement of the functional and operational usage of the units in local distribution.

The authors listed and comment the main objectives of the rehabilitation process such as availability, improvement of operating and maintenance conditions, improvement of entire plant performances and extending lifetime of equipment. The technological changes in control and communications of small hydro power plants and their implications in Macedonian power system are also presented and discussed. The complete scope of rehabilitation works is presented and the main and most interesting issues concerning operation and transfer of the plants.

1. INTRODUCTION

These small hydro power plants with ratings up to 5 MW per unit, are in operation for decades (40-50 years) and the rehabilitation process become an inevitable task. Risk of failure, for these plants, as a function of time is located in a "high risk zone". The performances and quality of service for such equipment is under the initial design characteristics and close to the unacceptable limit, needed more frequent repairs and maintenance services. Furthermore, this task becomes a very important issue for operation of the plants in a new technological and market environment since the new control philosophy and economic rules should be applied.

Electric Power Company of Macedonia (ESM) has initiated ROT project with the following main ideas and tasks:

- to perform rehabilitation of the small hydro power plants,
- to find parties who would be interested to invest in rehabilitation,
- the investor will operate with the plants for a defined period and sell the produced electricity to ESM,
- after that period the small hydro power plants will be given back to the ESM with certain warranty period and obligations.

The ROT project includes the following small hydro power plants: Dosnica, Sapuncica, Kalimanci, Pesocani, Pena, Matka, and Zrnovci. A number of technical issues have to be acknowledged by the ROT team. The first step was to perform a screening of the plants facilities on-site, and define the scope of works which would be subject of rehabilitation [1]. Concerning the civil works and mechanical/electrical equipment, the rehabilitation works were defined and listed. Legal and environmental constraints have been also considered. That way, the framework of the project include all relevant technical and legal aspects for performing rehabilitation activities and functioning of the SHPPs in the period of Operation. After the Operation, a complete Transfer is foreseen with strictly defined obligations to the Contractor.

After rehabilitation, Ships shall be in possibility to operate on grid or in islanded operation. That way, their availability shall be very important issue and shall be treated according to the implications to independent local consumers. The operating and maintenance conditions shall be well improved, such as: reduction in operating costs, reduction in maintenance costs for some equipment, availability of the spare parts for electrical and mechanical equipment in a long period, avoiding hazards and human risks, etc. With the rehabilitation of the generator and auxiliaries, in conjunction with the turbine's rehabilitation, the entire unit and plant performances should be increased. Dynamic characteristics of the scheme, such as, frequency regulation, voltage control etc., are expected to be well improved.

Nevertheless, depending of his experience, the Contractor is encouraged to consider and to meet other objectives such as environmental constraints, operating conditions etc.

However, for the ESM management one of the most important questions was: What are economical and technical parameters of the project? To answer on this question a complete cash-flow of the project has been prepared and analyzed [2].

2. REHABILITATION

2.1. THE OBJECTIVES OF THE REHABILITATION

Since the plants are being used for a long time, there is a lack of complete documentation and the available specifications present only main and most important data. The intention of the ESM was present documentation and available data to be used as a basis for creation an exhaustive and complete documentation for all foreseen rehabilitation works. The rehabilitation of the Small Hydro Power Plants (SHPPs) is foreseen upon the previously undertaken activities and available data:

- the analysis of their economical and financial outcomes,
- exploitation parameters,
- expert analysis of the existing condition of the plant site and structures,
- consideration of the possibility of the entire plant rehabilitation,
- rehabilitation of the hydro mechanical equipment and its influence on other
 - equipment,
- overall operation of the SHPPs in foreseen distribution network and
- estimation of the benefits from the complete rehabilitation.

However, in order to improve rehabilitation process additional expert analysis such as inspection, measurements, investigation and data collecting, are encouraged to be performed by the Contractor. It is expected that with such analysis all the requirements in the specifications prepared by the Electric Power Company of Macedonia (ESM) shall be fully met.

Availability. With the rehabilitation the availability of the SHPPs should be well improved in term of generated electrical output (power and energy). The Ships shall be in possibility to operate on grid or in islanded operation. That way, their availability shall be very important task and shall be treated according to the implications to independent local consumers.

Improvement of operating and maintenance conditions. The operating and maintenance conditions should be also well improved after the rehabilitation, such as reduction in operating costs, reduction in maintenance costs for some equipment, availability of the spare parts for all equipment in a long period, avoiding hazards and human risks. The technological changes in control and communications of power plants and power system shall be respected and applied. The new control system shall provide: stable operation of the units, lower exploitation costs, faster starting and synchronizing to the network, reliable and precise process control of all plant components and improvement of the unit and plant efficiency.

Improvement of entire plant performances. With the rehabilitation of the generator and auxiliaries, in conjunction with the turbine's rehabilitation, the entire unit and plant performances should be increased. Dynamic benefits of the scheme, such as, frequency regulation, voltage control etc., should be well improved. In the SHPP Matka the additional unit shall be installed and that way the plant capacity shall be well improved.

Extending life-time of electrical and mechanical equipment. In the present situation the most of the electromechanical equipment is in use for a long time and its technological lifetime is ended or rapidly decreased. Risk of failure as a function of time is located in a "high risk zone". Furthermore, the performances and quality of service for such equipment is under the initial design characteristics and close to the un-acceptable limit. Therefore, the equipment need more frequent repairs and maintenance services. The rehabilitation shall extend lifetime of all considered equipment.

2.2. THE SCOPE OF THE REHABILITATION WORKS

For each particular Small Hydro Power Plant, the scope of works to be performed by the Contractor [3], shall include: detailed project planning, engineering, co-ordination and management of the complete equipment which is subject of rehabilitation. A special attention is given to new equipment such as Control system, Protection system, Communication facilities, etc. The Contractor shall provide all necessary assistance, expert advice and reports in project implementation from the design stage, up to the end of obligation under the ROT project scheme.

On the other side the ESM shall assist/perform the following works: data base completion, parameterization, testing and commissioning, and providing all additional

information concerning operation of the SHHPs in a Distribution network. During the rehabilitation period the ESM shall provide all necessary assistance in: power supply, water supply, telecommunications, food and medical help. The Contractor shall cover all expenses for the ESM works.

The limits of works between Contractor and ESM shall be defined as follow:

- external communication with Distribution Control Center in each SHPP;
- external connection to the 35 kV lines at the exit of the plant area.

The limits of works with other rehabilitated equipment shall be:

- all electrical wiring and connections to the terminals of all new and existing
- technological equipment,
- connections to all new and existing instrumentation.

In order to meet all requirements during exploitation the Contractor and ESM shall cooperate and coordinate their activities with ESM according to contract. In front of ESM, ESM managers, engineers and other staff concerning particular equipment in all period of operation shall provide coordination. However, the Contractor or his representative shall co-operate with other legal representatives such as local authorities, government (Ministry of Economy), etc.

2.3. ENDING OF THE REHABILITATION PERIOD

At the end of the rehabilitation period the Contractor shall complete whole documentation concerning plant equipment. Documentation shall be stored in an appropriate place in SHPP and shall be available for possible use by ESM during whole period covered under the ROT scheme.

The Contractor shall make all preparations for ending the Period of Rehabilitation and starting the Operation. From technical point of view the Period of Rehabilitation, (for all or for particular SHPP), shall be finished when all requirements for rehabilitation shall be met. After performing all tests and the results prove that the requirements are fulfil, complete Commissioning of the plant equipment shall be performed.

Each particular SHPP shall be prepared for normal operation, being connected to distribution network or operating on an isolated local network.

With successful synchronisation to middle voltage (10 kV, 35 kV) network begins the Period of Operation.

3. PERIOD OF OPERATION

3.1. DOCUMENTATION

Starting of Operation shall be documented with the following documents concerning electrical equipment for particular SHPP:

- Commissioning report,
- Detailed schedule for synchronising to network (dates, time, staff, etc.),
- Licence for connecting to network issued by ESM,

- Report of connecting to the network,
- other documents.

3.2. GENERAL REQUIREMENTS DURING OPERATION

Operation of the SHPPs may be based on available water flow or it may attempt optimum matching of energy and capacity resources of the reservoir with the corresponding requirements of local power distribution system.

In that respect, operation of SHPPs shall consider its interface with both the waterway system and the distribution system. However, operation shall neither jeopardise safety and security and not causing major disturbances to either system.

To maintain reasonable head on the turbine it should be operated to utilise the water at about the same rate as it enters the Tyrolean intake reservoir. Not meeting this objective shall cause spilling of the unused water or drawing the headwater down to an unacceptable level. During the operation period automatic control system shall be available to regulate turbine according to headwater level, but manual override capabilities shall be essential to permit lowering headwater level beyond the normal limit to meet requirements of emergency peak load.

Waterway conditions in SHPPs vary on a seasonal basis. Therefore, operation of the plant shall be result both of load demand and availability of water at a particular site at a particular time. Consequently, at times when there is abundant flow SHPPs shall operate almost continuously. At other times when flows are low, the SHPPs may only be available to handle the extreme peaks of the system load for short duration.

The operational availability of rehabilitated SHPPs shall be with the expected and designed availability level. During the operation the Contractor shall perform following coordination activities with Distribution network/ESM:

- coordination of load limits with the 35 kV lines capabilities (if there is any inconvenience),
- identification of magnitude and duration of load limits with the system equipment capabilities,
- control and monitoring,
- metering,
- electrical faults of any type,
- protection system adjustments,
- safety grounds and visible break circuit isolation at the connecting point to the distribution network,
- other activities.

3.3. QUALITY OF PRODUCED ELECTRICITY AND ENERGY METERING

The Contractor shall take all precautions that his equipment shall operate with high quality and in accordance with guaranteed characteristics. Quality of produced electricity shall be one of the most important issues and according to the following standards: **ANSI/IEEE C50.12**, **ANSI Std.368**, or other relevant IEC Standards. However, ESM shall not be restricted to check the quality of produced electricity periodically during the Period of Operation.

Metering of the produced electricity and checking of the characteristics of the energy meters shall be according to the present practice in ESM.

Measurement of energy shall be provided in the whole period and shall be checked for counting at the same time both by the Contractor and ESM. However, in addition to "on-site" verification of the kWh and kVAr produced energy, the metering may be registered and reported to remote point by control system in each SHPP.

3.4. CONTROL AND MONITORING OF SHPPs

During the operation particular SHPP shall be controlled and monitored by:

- Available staff (in first few years of operation),
- Distribution control center or other ESM control point (if such center is not established yet)

For particular SHPP the Contractor shall propose control, which shall be approved by ESM. Control shall be organized in a way that it shall meet all the requirements of both parties:

- optimal electricity generation,
- irrigation constraints,
- high quality of operational performances,
- high level of co-ordination,
- other requirements.

3.5. ENVIRONMENTAL CONSTRAINTS

During the operation period the Contractor shall respect common environmental constraints established by ISO/IEC, IEEE, CIGRE, EPA (Environmental Protection Agency), and the Law of Republic of Macedonia. Especially special attention shall be provided to: electromagnetic compatibility, export of voltage out of the plant, and using of oils and liquids and their elimination.

3.6. MAINTENANCE

During the Operation the Contractor is obliged to perform planned service to electrical equipment strictly according to the Operating manuals and manufacturer's recommendation. Normal service and maintenance activities on the electrical equipment shall be in respect to:

- minimal energy losses,
- irrigation activities,
- reasonable constraints issued by ESM.

For all planned service activities the Contractor shall prepare time schedule and inform ESM representative. As specified by ESM requirements in specifications, for all works concerning maintenance of electrical equipment, the Contractor shall prepare appropriate documentation. Reports for faults, outages and hazards shall be also provided to ESM.

3.7. REVISIONS AND TECHNICAL REPORTS

During the operation the Contractor shall perform scheduled inspections on equipment according to the manuals, standard procedures and the condition of the equipment.

However, ESM shall perform periodical revisions on each SHPP in order to verify condition of the equipment. Such revisions (if any) shall be in a presence of the Contractor's representative. If such revisions verify fault operation or inadequate condition of the equipment, a statement or joint report shall be prepared and signed. All such conditions shall be prevented or (if apply) recovered as soon as possible.

These revisions shall take place in the period when such control will not stop the normal operation of the units.

3.8. END OF OPERATION PERIOD

Prior to the end of the Period of Operation, the Contractor shall prepare each particular SHPP for transfer back to ESM.

The Contractor's preparation shall mainly comprise, but not be limited to:

- specification of all documentation during rehabilitation and operation,
- cleaning-up the site,
- visual inspection of all equipment,
- checking of the main characteristics of the main equipment,
- preparation of the transfer tests and schedule for performing tests,
- removing of all parts of equipment which do not belongs to SHPP,
- preparation of the tools to be left to ESM,
- other preparations.

4. TRANSFER OF THE SHPPs

4.1. PREPARATIONS FOR TRANSFER

The Contractor shall perform all activities and preparations for TRANSFER of each SHPPs under the ROT scheme. The preparations shall mainly being directed towards the following:

- complete all documentation issued and archived during rehabilitation and operation period,
- cleaning up the entire plant,
- checking of the main characteristics of the electrical equipment and
- preparation for Commissioning.

The Contractor and ESM shall prepared commissioning of all equipment and that way to contribute in overall plant transfer. The preparations shall be in accordance with the modern engineering practice in hydroelectric schemes, IEC and IEEE standards. As an example, in principle the reference is made to **IEEE Std 1248**.

The Contractor shall nominate his representative persons for commissioning of all equipment. Both the Contractor and the ESM shall prepare schedule for commissioning and transfer with:

- joint commission (LTE-Leading Test Engineers),
- date and time of commissioning,
- scheduled commissioning activities.

4.2. ENDING OF OPERATION PERIOD AND COMMISSIONING

The exact ending of operation (date, time, and conditions) shall be defined in Contract. The commissioning activities shall consist, but not be limited to the following items:

- Documentation,
- Testing of scheduled main electrical equipment,
- Tools,
- Spare parts,
- Commissioning Reports.

Commissioning Report shall verify that:

- all scheduled tasks with the scheduled Commissioning are fulfilled,
- all technical requirements in respect to the equipment are met,
- considering the equipment, process for transfer of particular SHPP may be terminated.

5. CONCLUSION

The ROT idea has become very interesting and it initiated itself a special attention, since it is original one in this region. Generally, the ROT project is a complex one, since it includes:

- rehabilitation of the small hydro power plants
- legal and environmental issues,
- functioning of the small hydro power plants in a new technological environment,
- complex economical and social aspects,
- international type of project and tendering.

6. REFERENCES

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Sliki i kusa biografija spored upatstvo od sajtot!