

ASSURANCE OF GOOD ENVIRONMENTAL CONDITIONS DURING OPERATION AND MAINTENANCE OF LARGE HYDRO POWER PLANTS (HPPs)

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Abstract: Commitment to standard ISO 14001 (Environmental Management Systems) means a wide range of activities related with assurance of good environmental conditions during processes of operation and maintenance of large HPPs. The basic point is to comply with and fulfill all environmental conditions related to legislation and also all voluntarily commitments mutually agreed with local communities, societies etc. Environmental activities include first of all monitoring of environmental parameters, due consideration of flora and fauna problems arising in artificial water retention reservoirs for energy production, effective use of renewable energy source and civil structures, waste management and fulfillment of signed concession contracts covering water exploitation for electricity generation taking into consideration the aspect of due environmental protection.

Keywords: environmental activities, operation and maintenance of large hydro power plants, waste management

ZAGOTAVLJANJE DOBREGA STANJA OKOLJA PRI OBRATOVANJU IN VZDRŽEVANJU VELIKIH HIDROELEKTRARN (HE)

Povzetek: Zavezanost standardu ISO 14001 (Sistemi ravnanja z okoljem) pomeni širok nabor aktivnosti povezanih z zagotavljanjem dobrega stanja okolja pri procesih obratovanja in vzdrževanja velikih HE. Osnovno izhodišče je upoštevanje in izpolnjevanje vseh pogojev, povezanih z okoljem, iz zakonodaje, dodatno pa aktivnosti obsegajo ukrepe, ki izhajajo iz prostovoljnih sprejetih obveznosti ali obveznosti, dogovorjenih s posameznimi lokalnimi skupnostmi, društvi itd. Okoljske aktivnosti tako obsegajo predvsem spremljanje okoljskih parametrov, upoštevanje problematike vodne flore in favne v umetnih energetske vodnih zadrževalnikih, smotno izrabo obnovljivega energetskega vira ter gradbenih objektov, skrbno ravnanje z odpadki in izpolnjevanje zahtev podpisanih koncesijskih pogodb za rabo vode za proizvodnjo električne energije glede vidika varstva okolja.

Ključne besede: okoljske aktivnosti, obratovanje in vzdrževanje velikih hidroelektrarn, ravnanje z odpadki

1. Hydro power plants impact on the environment

Construction of water retention reservoirs represents a wide-ranging invasion upon the water course with different consequences on chemical, hydrological, climatic, landscape, economic and last but not least biological properties and characteristics of a changed river or stream section while different impacts can be noticed also far away in the downstream river course. Thus, within regular maintenance, operation and especially during development and investment processes the environmental aspects have to be constantly considered. Consequently, regulatory framework as well as professional practice in the field of hydro power plants and environmental protection shall be followed. In order to provide due consideration of environmental aspects, the environmental problems relating to the hydro power plants shall be firstly identified. Performing its basic economic activity, i.e. electricity generation in hydro power plants, the company of Savske elektrarne Ljubljana in the role of Operator and Concessionaire of four large dams according to ICOLD (International Committee on Large Dams) – dams of Moste, Mavčiče, Medvode and Vrhovo have always ensued from its corporate social responsibility. So, through many years' practice the environmental problems occurring as a result of operation and maintenance of large HPPs have been divided into:

Aspects in connection with natural space:

1. flood waters
2. water and watercourse quality
3. groundwater
4. use of space
5. living environment

6. settling of bed load sediments
7. erosion
8. sediments deposit

and aspects in connection with electricity generation in the hydro power plants:

1. production process
2. basic and auxiliary products used within production process
3. transport and waste
4. use of surfaces
5. waste, waste heat from production process
6. use of potable water, waste waters from different structures
7. immissions, emissions resulting from production process

Up to 2002, the given aspects and their impacts on the environment were managed within the existing legislation. Beside regulatory framework (laws, decrees, regulations, acts, conventions, etc.) this includes also issued legal provisions regulating operation and maintenance and encompassing different administrative authorizations and provisions (applications permits, water permits, etc.). In 2002, legislative changes (Water Act) brought along a requirement for resumed energy exploitation of water sources by concession. As a result, concession contracts mainly integrating or upgrading the former permits were gradually signed for the mentioned hydro power plants. At the same time and in spite of relatively satisfactory situation in the field of environmental impacts control (regular in-house and inspection control), in 2002 the company voluntarily decided to introduce the environmental management system according to the international standard ISO 14001.

2. Environmental management system control by ISO 14001

The company of Savske elektrarne Ljubljana was aware of the consequences resulting from construction and operation of the hydro power plants and effecting the environment already before its decision to regulate its environmental management system according to ISO 14001 and for that reason acted in accordance with legislation and regulations in the relevant sphere. With its operation open to the social environment, by organization of Open Doors Days and by welcoming various schools of different degrees organizing numerous excursions the Company even surpassed the legislative practice. Innovations brought along by the standard arised mainly in the field of organization. In this way the environmental care got a formal framework and shape and indirectly improved. Even though the introduction of the standard did not cause additional measures to be taken in the field of operation and maintenance, except the organizational ones, the latter represented quite an achievement. The organizational measures provided transparency in performance of environmental activities related to operation and maintenance. The Company management got relevant instruments by which monitoring of due environmental care quality has been made possible. Certain environmental activities were introduced in the area of organization (keeping of different registers, assessment of environmental aspects and impacts importance, survey and establishment of environmental aims and programs, review of current affairs and performance of environmental policy, performance of environmental reports). Basic purpose and innovation of the ISO 14001 standard is namely to assure permanent environmental care improvement.

In accordance with requirements of the ISO 14001 standard which is being used by our Company as a model of the environmental management system we perform the following essential tasks:

1. set up, perform and monitor the environmental policy,
2. identify those environmental aspects of our late, existing and planned activities, products and services which can be controlled and for which we expect us to be able to exert some influence upon,
3. identify relevant statutory requirements and other requirements to which the Company has given consent,
4. identify preferential tasks and set relevant environmental objectives and targets (we recognize those environmental aspects which have an important influence or could have an important influence on the environment),
5. set up, perform and monitor environmental programs required for performance of the policy and achievement of environmental objectives and targets,
6. in framework of our operation we plan, control, supervise, monitor, perform preventive and corrective measures, perform audits and inspections by which we assure due policy implementation and sustainable accomplishment of environmental management system able to adapt to changeable conditions.

So, a new identification of environmental aspects was performed according to the provisions of the ISO 14001 standard and the following items were recognized in the register:

1. water damming,
2. water intake for HPPs,
3. water flow regulation downstream of the damming structure,

4. removal of bed load sediments, gravel and silt,
5. removal of bed load sediments and floating debris,
6. maintenance of banks,
7. operation and maintenance of HPPs (turbine-generator unit, transformer, HV switchyard, other mechanical and electrical equipment),
8. emergency events,
9. general (heating, waste, energy use, radio stations), and
10. general, use of transport vehicles.

A novelty that has arisen after introduction of the ISO 14001 standard is that beside operation in conformance with the legislation, introduction of voluntary environmental improvements has been revitalized, too. We proceeded from the principle of understanding the hydro power plants' social role. This role is extremely important. It extends from their basic energy role, i.e. electricity generation, to their significance in providing ancillary services within the electric power system where they are, technically and economically, the most favourable power plants in comparison with power plants burning other fuels (e.g. fossil-fuel power plants and nuclear power plants). The social role includes multipurpose use of water retention basins by the hydro power plants encompassing arrangements relating to water management, water supply, irrigation, protection against floods and tourism with recreation. It is wise to mention general social roles of hydro power plants since their maintenance, operation and especially construction represent a huge contribution to preservation and dissemination of Slovenian science and industry in numerous branches connected with this sphere (civil engineering, machine manufacture, electrical industry). Last but not least, electricity generation is also a strategic industry providing support to political independence of the country.

Introduction of the ISO 14001 standard encouraged also an open support to multi-purpose use of water retention basins by the hydro power plants (Pišek, 2000). Commitment to standard ISO 14001 (Environmental Management Systems) namely means a wide range of activities related with assurance of good environmental conditions during processes of operation and maintenance of large HPPs and defined by the legislation. Additionally, these activities include measures resulting from voluntarily commitments or obligations agreed with individual local communities, societies, etc.

The multipurpose use of water retention basins adjacent to the hydro power plants will generally increase in future. Such contemplations have been confirmed by data obtained from abroad. For example, irrigation represents an enormous water consuming process since it is assigned three quarters of total yearly consumption in the world. In order to meet the requirements of an increasing number of people, cultivable surfaces that need to be irrigated shall be enlarged each year for 3%. Due to such an increased consumption additional water sources shall be provided. Mainly, the aquifers have already been exploited (50% of all supply is provided by groundwater and underground accumulation) so that practically the only option which would provide compliance with such increased requirements is to construct new water retention basins. The principal task of such basins will be to enhance the groundwater quantity and the underground accumulations and to provide enough water supplies required for irrigation of agricultural surfaces. One of basic purposes or often even the only purpose of dams construction was protection against floods. In future as well, decreasing of flood risk will represent a priority task since floods represent 40% of all natural disasters. Dams with retention capacities of storage reservoirs proved to be an efficient measure decreasing the risk of flood waters of catastrophic extensiveness.

3. Concession contracts covering water exploitation for electricity generation from the environmental protection aspect

Within the years 2002 and 2007 and in accordance with the Water Act and special Act Governing the Conditions of the Concession for the Exploitation of Energy Potential of the Lower Sava River we gradually signed concession contracts for all large HPPs we have been operating (July 8, 2002 Concession contract for the exploitation of energy potential of the lower Sava River - for the Vrhovo HPP, November 20, 2003 Concession Contract covering the Sava River water use for electricity generation in hydro power plants of Moste, Mavčiče and Medvode, and January 25, 2007 Concession contract covering the water power use for electricity generation in the Završnica HPP).

The mentioned contracts (Republic of Slovenia, *Concession Contract 2002, 2003 and 2007*) define different obligations of the Concessionaire and regarding specifics of an individual HPP they can differ from each other even though they pursue the same aims. The obligations are mostly connected with the following:

- Concessionaire obligations relating to enforcement of water rights, and
- Concessionaire obligations regarding protection of the environment.

By fulfillment of these obligations we assure protection against floods, prevention of harmful bed load sediments and floating debris deposit, protection of biological diversity, protection of water quality, protection of

high nature values and cultural heritage, implementation of tourist and recreational activities and prevention of damage caused by ecological accidents.

4. Environmental activities

Within its business procedures, the Company of Savske elektrarne Ljubljana duly considers all the identified environmental aspects. Such consideration of environmental aspects fits into the quality of operation itself which is not possible at all without an overall respect of legislation, including the environmental one, and without being conscious of living environment quality preservation. Practical illustrations of the given aspects within processes of regular maintenance and operation turn out to be as follows:

1. cleaning of floating debris in front of the turbine racks
2. monitoring of water quality in the storage reservoirs
3. monitoring of groundwater activities within the influential area of storage reservoirs
4. use of environmental friendly and naturally degradable substances in operation and maintenance of equipment (oils, lubricants)
5. cooperation with inspection agencies and state authorities, with general organizations and those from the environmental protection area
6. performance of larger maintenance works preventing excessive depositing of sediments (rehabilitation of the Zbilje Lake, reconstruction of the Moste dam root, and of the Završnica storage reservoir)
7. remediation of storage reservoir water impacts on the surrounding waters by sealing of the reservoirs (Mavčiče, Vrhovo)

As we have shown by the example, the environmental activities are extremely extensive. In order to illustrate the problem we will give a description of some of the most typical ones in the continuation of this text. The following environmental activities will be described: monitoring of environmental parameters, handling with bed load sediments and floating debris in water retention basins, waste management, consideration of water flora and fauna problems in artificial water retention reservoirs for energy production and effective use of renewable energy source and civil structures.

4.1 Monitoring of environmental parameters

The legislation covering the sphere of the environment stipulates numerous monitorings. Due to maintenance and operation processes also some other environmental parameters are being additionally monitored. Altogether, 43 parameters are being monitored (Table 1). They can be roughly divided into the following groups:

- parameters in the water retention basin (condition of banks, sedimentation of reservoirs, sedimentation of sediment traps, condition of damming profiles, sediments analyses, water quality)
- parameters on civil structures (seismicity in the large dam area),
- parameters connected with work processes (environmental noise indicators, waste waters, emission of substances from combustion plants, waste), and
- parameters connected with operation (flow measurements, measurements of water level and water temperature change)

Table 1: Parameter origin (1 to 34 – register of relevant environmental legislation and 35 to 43 – register of other environmental requirements)

No.	Activity (environmental parameter)	Structure	Period
1.	Monitoring of banks condition	HPP Moste	yearly
2.	Sedimentation of reservoir	HPP Moste	10 years
3.	Sedimentation of sediment trap	HPP Moste	yearly
4.	Condition of damming profiles	HPP Moste	yearly
5.	Sediments analysis	HPP Moste	half-yearly
6.	Water quality	HPP Moste	half-yearly

7.	Seismicity in the area of large dam	HPP Moste	yearly (special report each time an earthquake achieves above 5% of ground acceleration)
8.	Environmental noise indicators	HPP Moste	3 years
9.	Emission of substances from combustion plants (small combustion plant)	HPP Moste	yearly
10.	Fuel oil tank tightness	HPP Moste	5 years
11.	Monitoring of banks condition	HPP Mavčiče	yearly
12.	Condition of damming profiles	HPP Mavčiče	yearly
13.	Sedimentation of reservoir	HPP Mavčiče	10 years
14.	Sedimentation of sediment trap	HPP Mavčiče	yearly
15.	Water quality	HPP Mavčiče	half-yearly
16.	Seismicity in the area of large dam	HPP Mavčiče	yearly (special report each time an earthquake achieves above 5% of ground acceleration)
17.	Environmental noise indicators	HPP Mavčiče	3 years
18.	Waste waters (small water treatment plant)	HPP Medvode	3 years
19.	Emission of substances from combustion plants (small combustion plant)	HPP Medvode	yearly
20.	Monitoring of banks condition	HPP Medvode	yearly
21.	Sedimentation of reservoir	HPP Medvode	10 years
22.	Condition of damming profiles	HPP Medvode	yearly
23.	Water quality	HPP Medvode	half-yearly
24.	Seismicity in the area of large dam	HPP Medvode	yearly (special report each time an earthquake achieves above 5% of ground acceleration)
25.	Environmental noise indicators	HPP Medvode	3 years
26.	Water quality	HPP Vrhovo	Permanent monitoring
27.	Monitoring of banks condition	HPP Vrhovo	yearly
28.	Sedimentation of reservoir	HPP Vrhovo	2 years
29.	Condition of damming profiles	HPP Vrhovo	yearly
30.	Water temperature change	HPP Vrhovo	Permanent monitoring
31.	Seismicity in the area of large dam	HPP Vrhovo	yearly (special report each time an earthquake achieves above 5% of ground acceleration)
32.	Environmental noise indicators	HPP Vrhovo	3 years

33.	Waste waters (small water treatment plant)	HPP Vrhovo	3 years
34.	Waste	all HPPs	yearly
35.	Flow measurements	HPP Moste	Permanent monitoring
36.	Water level measurements	HPP Moste	Permanent monitoring
37.	Water temperature change (tailwater)	HPP Moste	Permanent monitoring
38.	Flow measurements	HPP Mavčiče	Permanent monitoring
39.	Water level measurements	HPP Mavčiče	Permanent monitoring
40.	Flow measurements	HPP Medvode	Permanent monitoring
41.	Water level measurements	HPP Medvode	Permanent monitoring
42.	Flow measurements	HPP Vrhovo	Permanent monitoring
43.	Water level measurements	HPP Vrhovo	Permanent monitoring

4.2 Handling with floating debris and bed load sediments in water retention basins

Handling with floating debris and bed load sediments in water retention basins is determined and defined in the environment related legislation and in concession contracts signed in accordance with it for energy potential exploitation. With performance of such activities protection against floods, prevention of damage caused by ecological accident and protection of water quality are assured. Handling with floating debris and bed load sediments in water retention basins is also connected with processes of operation and maintenance of large HPPs since accumulation of sediments in the retention basin and assembling of floating debris in front of the dam can impact the power generation process.

Handling with floating debris and bed load sediments as well as their outflows always occur in parallel. For example, sediments outflow occurs especially during increase of watercourse levels, or at flood water levels. This serves to prevent excessive deepening of the Sava River bed in the downstream direction and all the relating impacts. In such circumstances greater outflows of floating debris can't be prevented eventhough floating debris removal is prescribed. In case of medium and low discharges trash booms are used (barrages) for floating debris removal. The barrage of Lipce is operating at the Moste HPP, the barrage of Prebačevu at the Mavčiče HPP and the barrage of Hotemež at the Vrhovo HPP. At such discharges most of the floating debris, which is then removed in accordance with relevant legislation, is stopped by these barrages. The floating debris is segregated (plastics, organic waste) in order to be used for composting.

Yearly removed quantities of floating debris depend on natural circumstances (precipitations amount in the Sava River basin and relating river flows). The floating debris quantities increase in case of bad maintenance of river banks in the catchment area which is however not in our responsibility. Pursuant to the concession contract we are namely responsible only for maintainance of banks in the concession area while all the other falls under the responsibility of the local community or state (Savske elektrarne Ljubljana: *Poročila o okoljskem pregledu 2007 do 2009*). Moreover, we are not responsible for waste dumping on the banks upstream of the structure which causes formation of disturbing floating debris (plastic bottles, refrigerators, car tyres, etc.). Both issues fall under the responsibility of the State and municipal offices while we can only draw the attention to these problems. For example, in 2008 we removed the following quantities of floating debris (in accordance with the Decree on Waste Management):

Vrhovo HPP (trash boom Hotemež and Vrhovo dam):

20 02 01 »biodegradable waste«	350.700 kg
20 01 38 »wood not stated under 20 01 37*«	12.120 kg and
20 01 39 »plastic«	5.120 kg

Moste HPP (trash boom Lipce):

20 02 01 »biodegradable waste «	110.300 kg
20 01 38 » wood not stated under 20 01 37*«	3.400 kg and
20 01 39 » plastic «	6.980 kg

Mavčiče HPP (dam and trash boom Prebačevu):

20 02 01 » biodegradable waste «	149.930 kg
20 01 38 » wood not stated under 20 01 37*«	17.870 kg and
20 01 39 » plastic «	11.000 kg
Medvode HPP (dam):	
20 02 01 » biodegradable waste «	34.700 kg
20 01 38 » wood not stated under 20 01 37*«	1.500 kg and
20 01 39 » plastic «	560 kg

In the company of Savske elektrarne Ljubljana d.o.o. the bed load management is settled according to special concession contracts. Temporarily, and depending upon special sediment traps filling up, the debris is being removed. Sediment transport on the existing large dams can not be duly provided since the river dynamics has changed. A compromise between the natural state of sediment transport and the state occurring after construction of a large dam lies in removal of debris in special sediment traps. This results in an increase of flood safety effects. A larger part of gravel is being removed from the river and so the river sediment transport is essentially lower as in natural circumstances. Data on removed debris quantities for 2009 are as follows:

- Slovenski Javornik (Jesenice) 45.265 m³ and
- Majdičev log (Kranj) 26.133 m³.

4.3 Waste management

Different waste is produced within large HPPs operation and maintenance processes. Rules covering management of waste that generates during in-house work processes are stipulated by special internal regulations. The regulations define in detail relevant conditions of sorting, collection and temporary storage, removal and registration of waste. The waste management area is quite extensively determined also by the legislation which shall be duly considered by the regulations as well. Thus, waste is divided into hazardous and municipal waste, sump sludge, waste package material, and waste electric and electronic equipment.

As regards possible risks, the group of hazardous waste is the most standing out. Typical examples of hazardous waste are:

- Waste oils (hydraulic, motor, engine oils and lubricants),
- Waste oils and other liquids serving for isolation or heat transfer,
- Waste paints, varnishes and coats,
- Diluters, waste solvents and degreasing substances,
- Gas, oil, fuel oil,
- Certain fractions of waste electrical equipment,
- Waste greasy rags and used absorber, and
- Waste package material containing hazardous substances.

Hazardous waste is collected into special ecological equipment (containers, vessels, hazardous liquid waste tanks, metal tanks with lids, metal drums, collecting trays and similar) which shall be labeled so as to provide due identification of the hazardous waste type (tags according to the classification list set by the legislation). Removal of hazardous waste involves its transfer to collectors, traders or waste treatment contractors with duly acquired (and valid) permit issued by the Ministry of the Environment and Spatial Planning – Environmental Agency of the Republic of Slovenia. Records on delivered waste are kept on the basis of record sheets on waste treatment which represent a basis of yearly reports on waste generation.

As regards quantities of generated waste, municipal waste represents the largest group. Municipal waste and similar industrial waste generating within the Company of Savske elektrarne d.o.o. are as follows:

- Mixed municipal waste (20 03 01)
- Paper and cardboard (20 01 01),
- Metals (20 01 40),
- Glass (20 01 02),
- Plastic (20 01 39),
- Wood not specified under 20 01 37 (20 01 38),
- Biodegradable waste (20 02 01),
- Sump sludge (20 03 04),
- Used printer toners not specified under 08 03 17 (08 03 18),
- Discarded electric and electronic equipment containing hazardous substances and not specified under 20 01 21 and 20 01 23 (20 01 35*),
- Discarded electric and electronic equipment not specified under 20 01 21, 20 01 23 and 20 01 35 (20 01 36),

- Fluorescent tubes and other waste containing mercury (20 01 21*),
- Batteries and accumulators specified under 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing such batteries and accumulators (20 01 33*).

Collecting points are arranged for municipal waste collection. A municipal waste collecting point is a duly arranged place for placement of waste vessels and containers. It shall comply with relevant provisions valid in the area of an individual HPP municipality, if waste is being collected on the municipal level, or other regulations, if waste is being collected in another way (e.g. on a national level).

Temporarily, other types of waste generate as well. For such waste, its management is provided on a day-by-day basis and in accordance with the legislation in force. A special case includes for example removed radioactive fire detectors, equipment containing polychlorobifenil (PCB) and construction waste generating at larger maintenance interventions (restoration and reconstruction of complete structures).

4.4 Water flora and fauna problems

Water retention basins have a double impact on habitat types and typical local flora and fauna (Savske elektrarne Ljubljana, *web page*). The first impact is a direct one and occurs already at the structure siting and construction. Due to civil works carried out during construction of a dam and solidification of river banks along the whole storage reservoir, at the water inflow into the reservoir and at its outflow under the dam or from the powerhouse of the hydropower plant, and of course due to flooding of the area the original river bed with all its habitat and biotic characteristics is irreversibly destroyed. Downstream of the dam the water regime is changed to such an extent that it causes partial changes of fauna and flora. In spite of fish passes construction, a river dam or a stream dam represents an invincible barrier for many water organisms so that any migration is interrupted.

The second impact is an indirect one. In a standstill storage reservoir behind a dam the structure of water fauna species changes almost in a whole or at least to some extent (a share of individual of them). These changes are caused by gradual eutrofication of water and almost as a rule - pollution. Moreover, on the reservoir banks which are often solidified by ripraps or arranged in some other way, flora and vegetation characteristic for stagnant waters or marshy sites expands. With construction of only one larger dam the sediments transport downstream of the dam decreases and in case of construction of a HPPs chain, such decrease intensifies till complete interruption of the carrying agency of the watercourse. With retention of water, its erosion power is decreased and the river starts losing its natural life rhythm wherein changing of shape, width and course of the river bed or creation of sand banks represents a normal phenomenon.

As regards flora and fauna changes compensatory measures were taken in practice, i.e. during construction and also later on during large HPPs operation and maintenance processes. They consisted of different structures and activities implementation.

Spawning grounds have been existing downstream of the Mavčiče HPP (from 1986) and the Vrhovo HPP (from 1993) dams and they fulfill their task quite well. The two spawning grounds were built in accordance with the requirements of the fishing clubs during construction of both HPPs. As regards maintenance of both spawning grounds we cooperate with the two fishing clubs acting in the area of the HPPs. We have already performed some repair works required after certain damage caused by flood waters.

In 1995, we largely improved the conditions as regards silting of the Medvode HPP storage reservoir (Somrak, 1994). After construction of the Mavčiče HPP, mainly small fractions of sediments began to accumulate in the reservoir. However, as the years went by, their quantity raised to such a level that during operation of the HPP, at some places, the sediments began to peer out of the water. Being in contact with air they began to rot and smell. Our motive for the area rehabilitation was not a business one, yet it represented a sort of support to local tourism, providing also better conditions for water organisms. Following the environmental protection requirements a new technology of silt pumping was used, i.e. the pumps installed on a floating dredger pumped the silt directly via pipelines to the river bank. In the preliminary phase, four lagoons of an approximate surface of 3 ha and with a capacity of 150.000 to 200.000 m³ were created in an already silted river branch whereto the silt was pumped during the rehabilitation works. A relatively noiseless dredger using biological oils was used. The lagoons were separated from the river bed by an embankment which represented at the same time a transport road serving for rehabilitation purposes and a future promenade along the Sava River bank. After rehabilitation, when water has leaked out of the lagoons behind the embankment, and in accordance with due rehabilitation requirements the resulting surfaces served for construction of different facilities of social and tourist infrastructure and for nature preservation purposes. The surface of the first upstream lagoon was intended for natural overgrowing of the landscape which provided better conditions for birds living in the area. The other lagoons were intended for walkways, recreation grounds and children's playgrounds and other activities – Figure 1 (multipurpose area). The area was leased by the Medvode Municipality while its operator is a local tourist society of Zbilje.

Figure 1: Zbilje – lake rehabilitation



In 2007 and 2008, the problem of an excessive expansion of water flora in the Medvode HPP storage reservoir was solved by purchasing a water flora harvesting machine (Figure 2), by construction of pontoon moorings and construction of a disposal facility (Figure 3), by installation of a container and signature of a contract covering organic waste composting (company of Kostak Krško). The water flora harvesting machine (or boat) was supplied by a German manufacturer Berky, who has already had some experiences with construction of such boats. It is namely a vessel which is capable of harvesting water flora down to the depth of around 1.50 m and loading it on the deck. When its storage capacities are fulfilled, the ship unloads the harvested vegetation ashore where it becomes useful for composting. Such excessive expansion of water flora occurs mainly in warmer years which are now, from statistics point of view, more often (especially in August). After a certain period of time, when external temperatures are high enough and no essential precipitations occur which would provide larger water inflow into the lake, the lake water temperatures as well reach the value causing an excessive growth of the water flora. Moreover, water flora is constantly being cut off the base ground and decomposing on the surface which is quite annoying for tourism and also for water fauna.

Figure 2: water flora harvesting machine



Figure 3: water flora disposal facility



4.5 Effective use of renewable energy source and civil structures

In the Company of Savske elektrarne Ljubljana d.o.o. we are well aware of the problem relating to increased electrical energy demand, resulting environmental pollution increase and that's why also of the importance of electricity generation from alternative renewable sources.

Within refurbishment and uprating of the HPPs we pay special attention to an increase of technical and energy efficiency. This can be achieved by permanent use of modern materials, equipment and structures. The Medvode HPP which was constructed in 1953 and refurbished during 2001 to 2003 and the Moste HPP which was constructed in 1952 while its reconstruction began in 2008 and is planned to be completed in 2010 represent two examples of such refurbishment.

Furthermore, we support also electricity generation from other alternative and renewable sources. Beside our basic activity of hydro production we aim at electricity generation from small photovoltaic power

plants (PVPP). In 2006 to 2008, construction of four such PP was completed, i.e. Mavčiče small PVPP (1st and 2nd phase) – Figure 4, Vrhovo small PVPP and Medvode small PVPP – Figure 5. For installation of such small photovoltaic power plants we used the existing structures (roofs).

The project of small PVPP Mavčiče (1st and 2nd phase) was performed by our own human resources who covered project management and coordination, supervision, construction and installation of supporting structure to the facility façade, installation of PV modules, inverters and other electrical equipment. Design and technical documentation was developed by outsourcing contractors.

Basic data of the extended Mavčiče small PVPP (1st and 2nd phase together) are so as follows:

- 420 PV modules of 170 W power (Schott Solar), out of these:
- 210 PV modules installed on the S façade of the Mavčiče HPP facility (270 m² of total surface)
- 210 PV modules installed on a flat roof of the Mavčiče HPP facility (270 m² of total surface)
- Installed power of solar generator 71,4 kWp
- Anticipated yearly production cca 72 MWh of electric energy

From the start of operation in July 2006 to January 2010 the power plant generated cca 239.970 kWh.

The project of Vrhovo small PVPP started immediately after completion of the 2nd phase of the Mavčiče small PVPP project. With the exception of design engineering the project of Vrhovo small PVPP was accomplished as well by our own staff, who covered management, supervision, construction and installation of supporting structure, manufacture and installation of electric cubicles, installation of PV modules and inverters, cable routing and commissioning.

Basic data of the Vrhovo small PVPP are as follows:

- Installed power of solar generator 77,4 kWp
- 360 PV modules of 215 W power (Sanyo HIP-215)), installed on the roof of the Vrhovo HPP structure
- Anticipated yearly production cca 74,6 MWh of electric energy

From the start of operation in December 2007 to January 2010 the power plant generated cca 168.990 kWh.

With the exception of design engineering the project of Medvode small PVPP was accomplished as well by our own personnel who covered management, supervision, construction and installation of supporting structure, manufacture and installation of electric cubicles, installation of PV modules and inverters, cable routing and commissioning.

Basic data of the Medvode small PVPP are as follows:

- Installed power of solar generator 58,8 kWp
- 280 PV modules of 210 W power (Sanyo HIP-210), installed on the roof of the Medvode maintenance centre
- Anticipated yearly production cca 60 MWh of electric energy

From the start of operation in July 2008 to January 2010 the power plant generated cca 79.300 kWh.

Figure 4: Mavčiče small PVPP



Figure 5: Medvode small PVPP



5. Conclusion

Concerning the scope of activities, assurance of good environmental conditions during operation and maintenance of large hydro power plants (HPPs) represents an extremely demanding task. Such task implies considerable material, technical, human and financial resources. As regards our comprehension of this task, it has been organized in accordance with the ISO 14001 standard and integrated within our business management system. In this way the task has been implemented also with due social responsibility and in regular cooperation with local communities wherein our HPPs are located. However, we have noticed that regulatory obligations expand and already surpass the anticipated obligations of the concession contracts, which results in an explicit influence exerted upon operation of the company.

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