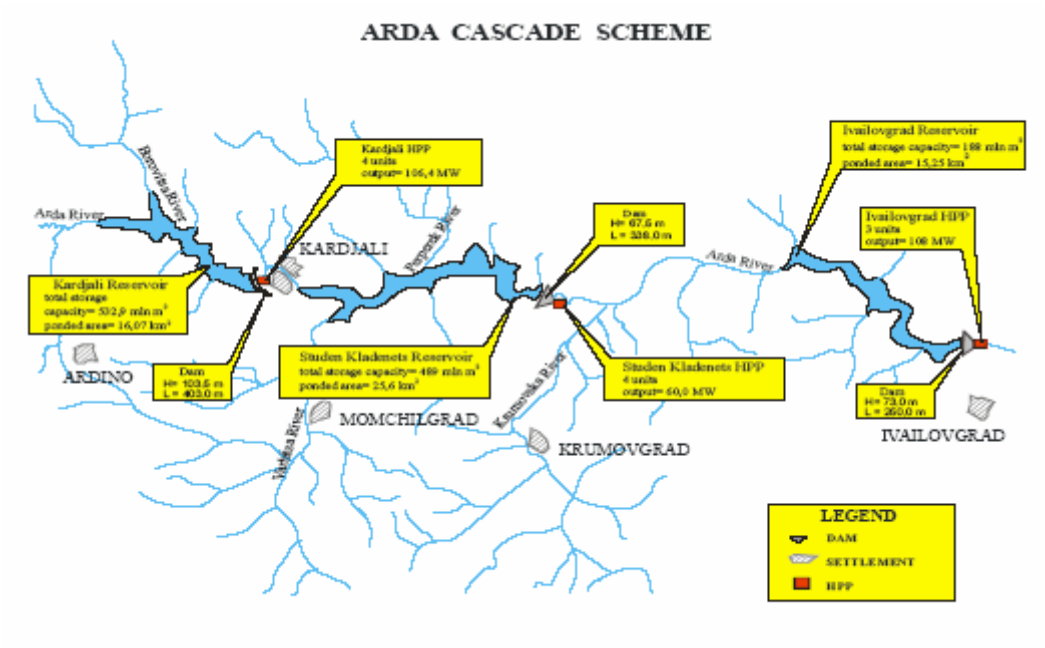
Annex 5

BULGARIA MAP DOLNA ARDA CASCADE

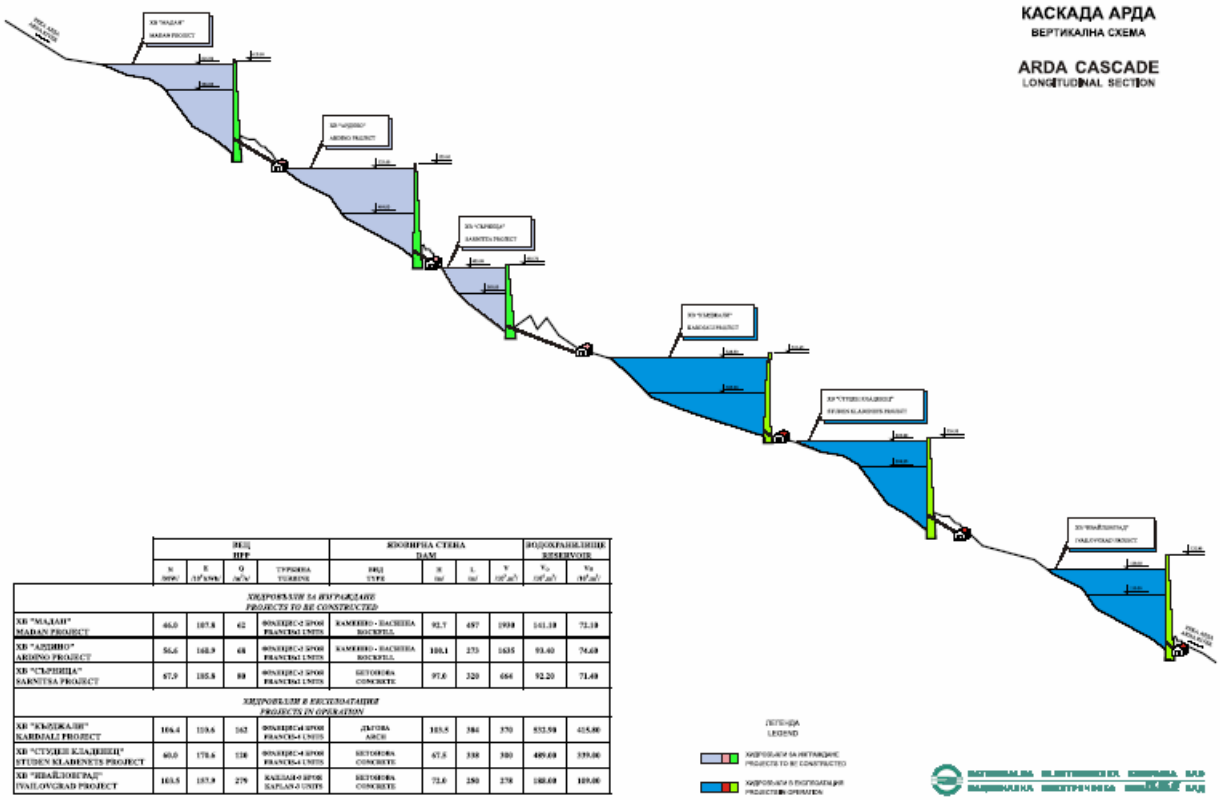
Annex 6

SCHEME DOLNA ARDA CASCADE



Annex 7

LONGITUDINAL SECTION DOLNA ARDA CASCADE



	ВЕЦ HPP				ЯЗОВИРНА СТЕНА DAM				ВОДОХРАНИЛИЩЕ RESERVOIR	
	N (MW)	E (10⁶ kWh)	Q (m³/s)	ТУРБИНА TURBINE	ВИД TYPE	H (m)	L (m)	V (10⁶ m³)	V_{tr} (10⁶ m³)	V_R (10⁶ m³)
ХИДРОУЗЛИ ЗА ИЗГРАЖДАНЕ / PROJECTS TO BE CONSTRUCTED										
ХЕ "МАДАН" MADAN PROJECT	46.0	107.8	62	ФРЕНСИС-1 БРОЯ FRANCIS-1 UNITS	КАМЕННО - НАСИПНА ROCKFILL	92.7	497	1930	141.10	72.10
ХЕ "АДЪНО" ARDINO PROJECT	56.6	160.9	68	ФРЕНСИС-1 БРОЯ FRANCIS-1 UNITS	КАМЕННО - НАСИПНА ROCKFILL	100.1	273	1635	93.40	74.60
ХЕ "СЪРНИЦА" SARNITSA PROJECT	67.9	185.8	80	ФРЕНСИС-1 БРОЯ FRANCIS-1 UNITS	БЕТОНОВА CONCRETE	97.0	320	684	92.20	71.40
ХИДРОУЗЛИ В ЕКСПЛОАТАЦИЯ / PROJECTS IN OPERATION										
ХЕ "КЪЗЪКЛИЙ" KARDJALI PROJECT	106.4	110.6	162	ФРЕНСИС-4 БРОЯ FRANCIS-4 UNITS	ДЪГОВА ARCH	103.5	384	570	532.50	415.00
ХЕ "СТУДЕН КЛАДЕНЕЦ" STUDEN KLADENETS PROJECT	60.0	170.6	138	ФРЕНСИС-4 БРОЯ FRANCIS-4 UNITS	БЕТОНОВА CONCRETE	67.5	388	380	409.60	339.00
ХЕ "ПЕЙЛОВГРАД" PYALOVGRAD PROJECT	103.5	187.9	279	КАПЛАН-3 БРОЯ KAPLAN-3 UNITS	БЕТОНОВА CONCRETE	72.0	250	270	188.60	109.00

Annex 8

LETTER OF APPROVAL

DRAFT

Republic of Bulgaria

MINISTRY OF ENVIRONMENT AND WATER

Letter of Approval

Undersigned, as a legal and authorized representative of the Republic of Bulgaria;

Acknowledging that the Republic of Bulgaria has ratified the United Nations Framework Convention on Climate Change in 1995;

Taking into consideration that the Republic of Bulgaria has ratified the Kyoto Protocol in 2002;

Recalling that the Republic of Bulgaria and the Republic of Austria have signed a Memorandum of Understanding regarding bilateral co-operation under Article 6 of the Kyoto Protocol to the United Nations Framework Convention on Climate Change in 2002;

Bearing in mind that the Government of the Republic of Bulgaria has authorized the Ministry of Environment and Water of the Republic of Bulgaria, and that the Government of the Republic of Austria has authorized the "Kommunalkredit Austria AG", to act as Parties to the Memorandum of understanding regarding bilateral co-operation for the realization of Joint Implementation projects, signed between both countries;

Taking into account that the designated authorities, as the Parties to the Memorandum, have endorsed the development of the below mentioned project, for the purposes of Joint Implementation (JI) under Article 6 of the Kyoto Protocol;

Referring to:

Proposal number/date	26-00-0610/30.03.2006
Title	"Rehabilitation of Dolna Arda hydropower cascade, Bulgaria"
Location	Along the "Arda" river, Bulgaria
Project Company (Supplier of the ERUs)	"National Electric Company", Bulgaria

hereinafter referred to as "the JI project";

Taking into consideration that the JI project is expected to provide a reduction in greenhouse gas emissions by sources that are additional to any that would otherwise occur;

DRAFT

Declares that:

1. The Republic of Bulgaria will comply with its obligations under the Kyoto Protocol, including the eligibility requirements, as stated under paragraph 21 of the Annex to Decision 16/CP.7 (Guidelines for the implementation of Article 6 of the Kyoto Protocol) and paragraph 2 of the Annex to Decision 18/CP.7 (Modalities, rules and guidelines for emissions trading under Article 17 of the Kyoto Protocol), in order to participate in JI mechanism according to Article 6 of the Kyoto Protocol;
2. The Republic of Bulgaria commits itself to take all steps required under the Kyoto Protocol and/or the relevant rules, decisions, modalities, guidelines and procedures thereunder, concerning the transfer of emission reductions from the JI project, including avoidance of double counting according to the Directive 2004/101/EC and the relevant decisions of the European Commission.
3. The Republic of Bulgaria approves the Project as a Joint Implementation project in accordance with Article 6 of the Kyoto Protocol and the subsequent decisions, adopted by the Conference of the Parties, serving as the Meeting of the Parties (COP/MOP) and the decisions, approved by the Joint Implementation Supervisory Committee.
4. The Republic of Bulgaria authorizes the "Supplier" and any future owner of the JI project to make a claim for Emission Reduction Units (ERUs), by the operation of the JI project, in accordance with Article 6 of the Kyoto Protocol.
5. The Republic of Bulgaria accepts to transfer the verified ERUs up to 267 465 t CO_2 equivalent, generated through the JI project during the period 2008 – 2012 and contracted between the "Supplier" and the "Kommunalkredit Austria AG".
6. The transfer of ERUs from the Republic of Bulgaria to the Republic of Austria will be free of any taxes or levies.
7. The transfer of ERUs from the Republic of Bulgaria to the Republic of Austria is irrespective of any legal or other transfer of the JI project to third Parties.
8. In case that the Republic of Bulgaria and the Republic of Austria fully comply with the eligibility requirements of paragraph 21 of the Annex to Decision 16/CP.7 (Guidelines for the implementation of Article 6 of the Kyoto Protocol), the verification of emission reductions generated through the JI project and the transfer of ERUs will be based on paragraph 23 of this Annex ('JI Track one').

Signature:

/...../

Mr. Dzhevdet Chakarov
Minister of Environment and Water of the Republic of Bulgaria

Date: 10 October 2006
Sofia, Bulgaria

Annex 9

DECISION MOEW REGIONAL INSPECTORATE HASKOVO

MINISTRY OF ENVIRONMENT AND WATERS

REGIONAL INSPECTORATE ON ENVIRONMENT AND WATERS- HASKOVO

DECISION No: ХА-57-ПР/ 2005

on
Determining the Necessity of Environmental Impact Assessment Report

On the grounds of art. 93, par. 5 of the Law on Environmental Protection and the written documentation submitted by the Investor in Appendix No:2 to art. 6 of the Regulation on the Conditions and the Order of Preparing an Environmental Impact Assessment Report regarding investment proposals for construction, activities and technologies,

I DECIDED

that an Environmental Impact Assessment Report **will not be made** in connection with **the investment proposal** for Construction of new capacities to the existing Studen Kladenets HPP.
Location: The power plant extension will be done on the right side of the powerhouse to the direction of Arda River flow and about 500 m^2 of the territory of Studen Kaldenets HPP will be engaged, and on the right side of the power plant towards the road going to the dam, a two-storey administrative building will be constructed.
Investor: Natsinalna Elektricheska Kompania EAD- 5, Veslets Str, Sofia 1040.

Characterisitcs of the Investment Proposal:

Extension is envisaged for Studen Kladenets HPP- new construction, which includes the installation of 1 Fransis turbine with a vertical axis, with a capacity of 19,75/ 16 MW (maximal/rated) with mechanical equipment- cooling water system, drainage system, compressed air system, modification of the bridge crane, turbine governor, main inlet valve, hydro-mechanical equipment and one complete functional generator with a rated power of 23 MVA. For the processing of ecological waters, defined as 2,0 m^3 /sec for preserving the river ecosystem below Studen Kaldenets HPP, one Fransis turbine with s horizontal axis, with max power P= 1330 kW and rated power P= 1000 kW in a set with a system for the governor, hydraulic oil pressure system and butterfly valve are envisaged. Besides, one electrical generator will be provided, which will be brushless, synchronous type with built-in excitation system and regulation system. With respect to the power plant extension, the following civil works are envisaged: increase of the power plant site area to the direction of Arda River flow for installation of the two new turbine groups; construction of an underground penstock from the bottom of the surge tank to the HPP, construction of an administrative building for the

power plant operation. All the activities related with the new construction in Studen Kladenets HPP will be on the site to the power plant, belonging to NEK EAD.

MOTIVES:

1. The implementaton of the investment proposal and the normal operation will not result in any considerable negative impact on the environment.
2. In order to decrease the air pollution by dust in hot and dry weather, the civil works site will be sprinkled with water during the extension construction.
3. The waters from the civil works site will pass through a mechanical precipitator before going into Arda River.
4. There will be no necessity of changing the existing road infrastructure or building of a new one. There will be some improvement in part of the road to Studen Kladenets HPP on the side of the village of Studen Kladenets.
5. The small turbine will process 2 m^3/sec of ecological waters, which are intended for providing of water to the river bed (for improving the river ecosystem) in the periods when the power plant is not in operation.
6. The additionally installed turbine will limit the spillages going through the dam spillway and will reduce the damages related with such spillages.
8. Electricity will be generated from a renewable energy source.
9. The investment proposal does not affect any territories or habitats protected by law, mountainous and forest areas, wet zones, existing monuments of culture and territories with a specific sanitary statute.
10. There will be daily inspections of the technical condition of the machines needed for the civil works, so that there will no pollution of fuel and lubrication oils.
11. The fuel and lubrication oil charging will be done outside the water site.
12. The Investor has notified the Municipality by letter No:53-00-400/18.05.2005 and the affected population by an announcement in the newspaper “Now Zhivot”- 19.05.2005.
13. Neither written, nor oral objections against the investment proposal have been submitted to the Regional Inspectorate on Environment and Waters – Haskovo.

This decision does not cancel the Investor’s obligations under the Law on Environment Protection and other special laws and secondary legislation acts and cannot be used as grounds for canceling the responsibility under the active Regulation on Environment.

In case of some changes in the investment proposal, or changing the investor or changes in some of the circumstances under which this decision has been issued, the investor/the new investor shall notify RIEW- Haskovo within one month after such changes come into force.

This decision can be appealed within a 7-day period to the Minister of Environment and Waters or to the Director of RIEW- Haskovo, pursuant to the Law of Administrative Proceedings.

MSc Eng. D. Iliev
Director of RIEW- Haskovo
(signature and stamp)

Date: 19.09.2005

Annex 10

DOLNA ARDA ENVIRONMENTAL AUDIT

NATSIONALNA ELEKTRICHESKA KOMPANIA EAD

5, Vesletz Str., Sofia 1040, Bulgaria, Tel. (359 2) 9263 636, Fax: (359 2) 987 25 50, www.nek.bg

Environmental Audit

Rehabilitation Project of Dolna Arda Hydro Power Cascade, Bulgaria

Sofia, October 2005

CONTENTS

Environmental Audit Report
Dolna Arda Cascade Rehabilitation Project

I. INFORMATION FOR CONTACT WITH THE INVESTOR

1. Investor's name, Unified Civil ID Number, place of residence, citizenship – natural person; head office and unified identification number of a legal entity.

   NEK - EAD
   Dipl. Eng. Vassil Anastasov – Chief Executive Officer

2. Mailing address:

   1040 Sofia, 5 Veslets str.

3. Telephone, fax, e-mail

   Phone: 926 3445
   Fax: 926 3504

4. Contact person

   Dipl. Eng. Christo Schwabski
   Phone: 926 3445
   Fax: 926 3504; 9263437
   e-mail: hshvabski@nek.bg
   GSM: 0889 63 52 62

II. PROJECT CHARACTERISTICS

1. PROJECT SUMMARY

The Project for rehabilitation of Dolna Arda Cascade covers the required works for rehabilitation of Kardjali Hydro Power Plant (HPP), HPP Studen Kladenets and HPP Ivailovgrad.

The three hydro power plants are situated in the lower course of the river Arda and have been built within the integrated waterpower systems Kardjali, Studen Kladenets and Ivailovgrad for the purpose of power-generating processing of the water accumulated in them.

Rehabilitation of the individual HPP will include:

- HPP Kardjali – rehabilitation of the mechanical and electrical part of the equipment and of the control system. All works are carried out inside the power house.
- HPP Studen Kladenets – rehabilitation of the mechanical and electrical part of the equipment (without that of the stator windings of the four generators), the control system and the switchyard. These works are carried out inside the

powerhouse and on the switchyard site. The plans for HPP Studen Kladenets envisage extension – new construction that includes erection of one vertical-shaft Francis turbine with output 19,75/16 MW (maximum/rated) and one horizontal-shaft Francis turbine of maximum output P = 1330 kW and rated output P = 1000 kW. The smaller turbine is designed to process the ecological water releases needed for preservation of the river ecosystem downstream of the hydro power plant.

- HPP Ivailovgrad – rehabilitation of the mechanical and electrical part of the equipment and of the control system. All works are carried out inside the powerhouse.

2. SUBSTANTIATION OF THE NEED FOR THE PROJECT

The need for implementation of the Project is dictated by:

- Ensuring the normal and effective operation of the hydro-power plants which involves rehabilitation of the equipment and the electrical part taking into account the conditions and the long operation period;
- Possible enhancement of the economic effect of the cascade through utilization of a part of the overflow from Studen Kladenets dam with construction of an additional 16 MW capacity at HPP Studen Kladenets;
- Ensuring the required minimum permissible flow downstream of HPP Studen Kladenets through the erection of a turbine with output P = 1 MW and $Q_{dev.}$ = 2 m^3/s for protection of the river ecosystem in the sector between the dams Studen Kladenets and Ivailovgrad.

Studen Kladenets Dam has been in operation since 1958. About 40,4% of the total capacity of the cascade is concentrated in it. Before 1971 the inflow into the water reservoir consisted of the natural afflux from the river Arda, and after 1971 (start of the operation of Kardjali dam) the processed water from Kardjali dam was added to the proper afflux. Before 1970 the dam was unable to balance and utilize the whole afflux, and overflowed almost every year. After coming of Kardjali dam into operation the overflow events decreased; however, irrespective of that, overflows were observed during one third of the years of joint operation of the two dams,. The volume of unutilized water masses was 1,5% of the afflux.

As a result of an assessment of the water-economy operation of Studen Kladenets dam performed by the Dams and Cascades Enterprise of NEK-EAD in 2001 (assessment reports are drawn up in conformity with an Intra-Ministerial Regulation on the Operation of Water-Power Facilities within the system of NEK) the annual average overflow losses were 14572 thousand kWh, or 8,6% of the plant output.

That determines the necessity for reassessment of its design capacity for the purpose of extension of the capacities and reduction of power losses.

Studies for implementation of that opportunity were performed by Energoproject EAD and presented within the Project.

Other arguments in favor of the Project are:

- Increased power generation by renewable energy source – water;
- Efficient utilization of the available water-power potential of the country in conditions of limited financial resources, growing prices of the imported energy sources, the restrictions ensuing from our covenants with the European Union about the nuclear and thermal power plants related to the environmental protection and risk problems;
- High availability and load-following capacity of hydro-power plants that result in increased energy efficiency of the generating capacities in the power system and during parallel operation within UCTE. After their rehabilitation, HPP Kardjali, Studen Kladenets, and Ivailovgrad will participate in:
  - covering of peak and off-peak loads;
  - frequency control;
  - fast activation of the reserve upon loss of capacity.
- Erection of the sixth small unit with 1000 kW rated output for processing of the expected ecological water releases will enable a gradual improvement of the condition of the Arda river ecosystem in the sector between HPP Studen Kladenets and the tailrace of Ivailovgrad dam.

Taking into account the importance of Dolna Arda Cascade in the power system of the country, the investment proposal for rehabilitation of the cascade is of national significance.

3. RELATION TO OTHER EXISTING WORKS APPROVED BY THE TERRITORY STRUCTURE PLAN OR OTHER PLANS

Rehabilitation of HPP Kardjali and HPP Ivailovgrad is done just on the equipment of hydro-power plants and for that reason it is carried out in the power house of each plant. During the rehabilitation works, only the machine to be rehabilitated is put out of operation.

The rehabilitation of HPP Studen Kladenets includes part of the equipment of the plant and extension. The rehabilitation of the equipment, similar to that in other HPP's, is carried out inside the power house with successive putting out of operation of the turbo-generator sets. The plant extension is outside the building to the left and right of its attendance area.

HPP Kardjali is a surface type, located at the dam downstream toe. The power house is situated immediately adjacent to the dam wall upstream of the r. Arda regulation. The power plant can be reached by an asphalted road, with dimensions large enough for the rehabilitation works. From the the discharge channel of HPP Kardjali to the tailrace of Studen Kladenets dam (downstream of the Lead and Zinc Works), a distance about 2,5-3,0 km, the Kardjali Municipality is planning construction of hydro-engineering facilities in order to achieve a constant waterplane in the Arda that would be part of development of a public park zone for recreation and sport.

HPP Studen Kladenets is a diversion-type plant. It is situated 600 m away in a direct line, and 1,5 km along the road below the dam wall, 500-800 m away from the village of Studen Kladenets. About 150-200 m to the southeast of the building are the residential buildings of the operator staff, and 250-300 to the southwest are the buildings of Dams and Cascades (residential and administrative). Down the slope are the deserted buildings of a boarding school that has been closed down. A 3rd-class asphalt road Haskovo-Krumovgrad of the national road system runs along the crest of Studen Kladenets dam. From the dam crest to the power house there is an asphalt road reaching the village of Studen Kladenets.

HPP Ivailovgrad is build-in the dam, which top structure is the dam spillway. The dam can be reached by the 3rd class asphalt road Harmanly (Liubimets) – Ivailovgrad. An asphalt road runs to the plantfrom the dam crest. There are no settlements in the vicinity. The dam is 8-9 km away from the Bulgaria-Greece border.

The rehabilitation of all three hydro-power plants takes place on sites belonging to NEK-EAD and is not in conflict with either existing or potentially newly developed infrastructure facilities.

4. DETAILED INFORMATION ON REVIEWED ALTERNATIVES

The rehabilitation of HPP Kardjali and HPP Ivailovgrad was decided on the basis of an assessment of the condition of the mechanical and electrical equipment and the opportunities for improving operation efficiency. For that reason, no alternatives have been considered with respect to the two hydro-power plants, but rehabilitation is proposed for the purpose of achieving certain economic parameters and operating reliability through their control.

Rehabilitation of the mechanical and electrical equipment of HPP Studen Kladenets was decided on the same conditions as that of the other two hydro-power plants.

Two alternatives of extension of HPP Studen Kladenets were considered with respect to:

- Location
  - Option AI – the power plant site is about 250 m down the course of the Arda (downstream of the existing HPP).
  - Option AII – the power plant site is about 1500 m down the course of the Arda (downstream of the existing HPP).
  - Option B – the extension is on the site of the existing plant.
- Manner of water intake for the Studen Kladenets dam
  - Option B I – water intake from the penstock downstream of the caisson well of the existing HPP Studen Kladenets.
  - Option B II – water intake from Studen Kladenets dam at the elevation of the existing water intake.
  - Option B III – water intake from Studen Kladenets dam at an elevation higher than that of the existing water intake.

- Option B IV – water intake from the water tower of the existing HPP Studen Kladenets.

  Appendix: Options

- Size of the installed capacity
  - Repowering of the installed capacity by 16 MW with developed discharge $Q_{dev.}$ = 30 m^3/s.
  - Repowering of the installed capacity by 30 MW with developed discharge $Q_{dev.}$ = 60 m^3/s.

All options include erection of a small turbine for processing of the ecological water releases with output 1 MW and developed discharge $Q_{dev.}$ = 2 m^3/s.

Upon extension of the capacity of HPP Studen Kladenets the turbine will be delivered together with the required equipment (mechanical equipment of the turbine – cooling system, draining and dewatering system, compressed-air system) and a generator with the required supplementary electrical systems and equipment (exciter, protection system, main transformer control system 110 kV, switchgear, etc.).

The machine for ecological releases processing will also be delivered complete with generator and a set of LV electrical equipment (control system, alarms, measurement and data collection).

The alternatives were assessed on the basis of the following main requirements:

- Minimum capital investments;
- Minimum in-operation energy losses;
- Minimum restrictions during construction;
- Minimum restrictions during operation.

Considering these conditions, the Project proposes Option B IV which meets all four requirements.

5. SITE LOCATION, INCLUSIVE OF THE AREA REQUIRED FOR TEMPORARY WORKS DURING CONSTRUCTION

Rehabilitation of HPP Kardjali is carried out inside the power house only. The power plant attendance area is used for delivery of the equipment (see Photo 1). The area occupied in the process of rehabilitation in and around the powerhouse belongs to NEK-EAD. After completion of the rehabilitation the present condition will be preserved.

Rehabilitation of HPP Ivailovgrad is carried out inside the power house. The plantplatform is used for delivery of the equipment (see Photo 9). The area occupied in the process of rehabilitation in and around the powerhouse belongs to NEK-EAD. After completion of the rehabilitation the present condition will be preserved.

Rehabilitation of HPP Studen Kladenets is carried out inside the power house. The plantplatform is used for delivery of equipment (see Photo 5). The area occupied in the process of rehabilitation in and around the power house belongs to NEK-EAD.

After completion of the rehabilitation the present condition of the existing plant(old part) will be preserved.

The extension of HPP Studen Kladenets is built on the right-hand side of the building in the direction of the course of r. Arda (Drawing No. 205-35023; Photo 7). The total area needed for the new construction work (including the gate stage to the underground penstock, the area needed for deployment of the construction equipment, temporary sites for storage of building materials, etc.) is about 800 m^2. The required area belongs to the power house of HPP Studen Kladenets and is property of NEK-EAD. To the left of the plant, near the road to the dam wall, a two-storey building for the administration offices of HPP Studen Kladenets (Photo 6). The building will be situated on the concrete platform of the plantbelonging to NEK EAD and occupies about 100 m^2.

The extension is connected to the water tower by means of a penstock.

During operation, as a result of the extension, 500 m^2 of the territory of HPP Studen Kladenets will be occupied as compared to the present consition.

6. DESCRIPTION OF THE MAIN PROCESSES (ACCORDING TO PUBLISHED DATA); CAPACITY

Dolna Arda Cascade is built on the Arda. It includes the three integrated water-power systems Kardjali, Studen Kladenets and Ivailovgrad; its total storage reservoir is 1209 mln m^3 (plan of the Arda Cascade).

Kardjali dam is the top stage of the Dolna Arda Cascade. It is on the middle course of the Arda about 2-2,5 km upstream of the town of Kardjali. It was commissioned in 1971. Its main function is power generation. The water reservoir supplies water for the industry of the town of Kardjali. A regular water balance has been kept since 1971 when the plantwas commissioned. The main technical characteristics of the dam and HPP Kardjali are:

• Total storage reservoir	$10^6 m^3/s$	532,9
• Available capacity	$10^6 m^3/s$	415,9
• Unavailable capacity	$10^6 m^3/s$	117,0
• Highest operating water level (HOWL)	m	324,30
• Dam type		Arch-gravity
• Dam height	m	103,5
• Ponded area (HOWL)	km^2	16,07
• Total installed capacity	MW	106,4
• Turbine type		Francis vertical-shaft
• Number of turbines		4
• Developed discharge (1 turbine)	m^3/s	40,5
• Annual average output of electricity	GWh	165

The second stage of Dolna Arda Cascade is Studen Kladenets dam. It is situated downstream of the confluence of the river Verbitsa into the Arda about 2-2,5 km away by the road from the village of Studen Kladenets. HPP Studen Kladenets is a diversion-type plant. The Integrated water-power system has been in operation since 1958 . It is designed mainly for power generation. The main technical characteristics of the dam and HPP Studen Kladenets are:

• Total storage reservoir	$10^6 m^3/s$	489,0
• Available capacity	$10^6 m^3/s$	339,0
• Unavailable capacity	$10^6 m^3/s$	115,0
• Highest operating water level (HOWL)	m	225,0
• Dam type		Concrete-gravity
• Dam height	m	67,5
• Ponded area (HOWL)	km^2	25,6
• Total installed capacity	MW	60
• Turbine type		Francis vertical-shaft
• Number of turbines		4
• Developed discharge (1 turbine)	m^3/s	30,0
• Annual average output of electricity	GWh	217,0

The last stage of Dolna Arda Cascade is Ivailovgrad dam. The integrated water-power system is 10 km northwest of the town of Ivailovgrad and about 8-9 km from the border with Greece. HPP Ivailovgrad is a storage-type plant. The integrated water-power system is in operation since 1965 . It is designed mainly for power generation. Its water may be used, to a smaller extent, for irrigation in the country and every year, during the period May to September, according to the 1964 Agreement, 186 mln m^3 is supplied to Greece,. The technical characteristics of the dam and HPP Ivailovgrad are:

• Total storage reservoir	$10^6 m^3/s$	188,0
• Available capacity	$10^6 m^3/s$	109,0
• Unavailable capacity	$10^6 m^3/s$	79,0
• Highest operating water level (HOWL)	m	130,75
• Dam type		Concrete-gravity
• Dam height	m	72,0
• Ponded area (HOWL)	km^2	19,6
• Total installed capacity	MW	108,0
• Turbine type		Kaplan

			vertical-shaft
•	Number of turbines		3
•	Developed discharge (1 turbine)	m^3/s	93,0
•	Annual average output of electricity	GWh	210,0

The rehabilitation works on the equipment at each one of the three HPP include:

HPP KARDJALI

New mechanical components and equipment will be supplied for each unit for rehabilitation of the mechanical part of the generating equipment.

Francis Type Turbine Runner

The runner is Francis type, the runner rim, boss and blades will be cast of steel G-X4CrNi13-4 by DIN EN 10283, welded together, heat treated, machine-finished and statically balanced.

Electro-hydraulic Governor

The design of the hydraulic governor is based on the following technical data: rated output 32 MW, runner diameter 2260 mm and rotating speed 250 rpm.

Throttle Valves

The throttle valves have been designed as emergency closing valves with counter-weight.

Generators

The existing rotor poles of the four generators will be dismantled and rewound.

Type	Vertical-shaft hydro-alternator, Russian Model BGC 525/110-24
Number of machines	4
Rated referred power	31,25 MVA
Rated power factor	cos φ = 0,85
Rated voltage	10,5 kV

Characteristics of rewound generators (calculated levels)

Rated referred power	36,00 MVA
Rated power factor	cos φ = 0,9
Rated voltage	10,5 kV

Excitation System

The existing excitation system with the machine exciter will be replaced by a static thyristor excitation system for slip-ring synchronous generators. The excitation

system THYNE 5 has a digital (microprocessor) regulator type GMR3 for automatic mode (voltage regulation) and manual mode (rotor current regulation) with a standby rectifier.

Protections

Digital protection of machines 1-4 is provided.

Digital protection of transformers 1-2 is provided.

Control System

The hydro-power plants will be equipped with VA TECH SAT systems. The control system provides 4 control levels:

- Supervisory control level (Joint Control)
- Plantlevel control.
- Unit level control (set regulators).
- Equipment level control.

The control levels on the dispatch center, plant and set regulator side are an integral part of the computerized control and monitoring system. Each individual control level uses the control and monitoring devices of different plants in the plant, such as governor, exciter, alternating current distribution boards, etc.

General control is performed by AK 1703ACP automated components. Their general control functions include: electrical measurement of the three-phase system levels (backup measurement); Switchgear HV and MV control and monitoring; auxiliaries control and monitoring; interface to the vibration monitoring system; interlocks, alarm signals.

AC/DC Board

Common part control panel – main distribution board; control panel of 1st machine, 2nd machine, 3rd machine, 4th machine; turbine-level control panel, AC distribution boards, DC distribution boards.

HPP STUDEN KLADENETS

New mechanical components and equipment will be supplied for each unit for rehabilitation of the mechanical part of the generating sets.

Francis Type Turbine Runner

The runner is Francis type, the runner rim, boss and blades will be cast of steel G-X4CrNi13-4 by DIN EN 10283, welded together, heat treated, machine-finished and statically balanced.

Electrohydraulic Governor

The design of the hydraulic governor is based on the following technical data: rated output 16 MW, runner diameter 2105 mm and rotating speed 214,28 rpm.

Throttle Valves

The throttle valves have been designed as emergency closing valves with counter-weight.

Generators

The stator windings of the four generators have already been rehabilitated, therefore no works are planned on the generator stators.

The existing rotor poles of the four generators will be dismantled and rewound.

Type	Vertical-shaft hydro-alternator, Russian Model BGC 525/99-28
Number of machines	4
Rated referred power	18,75 MVA
Rated power factor	cos φ = 0,8
Rated voltage	10,5 kV

Excitation System

The existing excitation system with the machine exciter will be replaced by a static thyristor excitation system for slip-ring synchronous generators. The excitation system THYNE 5 has a digital (microprocessor) regulator type GMR3 for automatic mode (voltage regulation) and manual mode (rotor current regulation) with a standby rectifier.

Protections

Digital protection of machines 1-4 is provided.

Digital protection of transformers 1-2 is provided.

Control system

The hydro-power plants will be equipped with VA TECH SAT systems. The control system provides for 4 control levels:

- Supervisory control level (Joint Control)
- Plantlevel control.
- Unit level control (set regulators).
- Equipment level control.

The control levels on the dispatch center, plant and set regulator side are an integral part of the computerized control and monitoring system. Each individual control level uses the control and monitoring devices of different plants in the plant, such as governor, exciter, alternating current distribution boards, etc.

General control is performed by AK 1703ACP automated components. Their general control functions include: electrical measurement of the three-phase system levels (backup measurement); HV and MV switchgear control and monitoring; auxiliaries

control and monitoring; interface to the vibration monitoring system; interlocks, alarm signals.

HPP IVAILOVGRAD

New mechanical components and equipment will be supplied for each unit for rehabilitation of the mechanical part of the generating equipment.

Kaplan TypeTurbine Runner

The runner is Kaplan type, the runner rim, boss and blades will be cast of steel, G-X4CrNi13-4 by DIN EN 10283, welded together, heat treated, machine-finished and statically balanced.

Electrohydraulic Governor

The design of the hydraulic governor is based on the following technical data: rated output 37,7 MW, runner diameter 3700 mm and rotating speed 187,5 rpm.

Throttle Valves

The throttle valves have been designed as emergency closing valves with counter-weight.

Generators

The stator and rotor windings will be rehabilitated.

Type	Vertical-shaft hydro-alternator, Russian Model BGC 650/130-32
Number of machines	4
Rated referred power	43,3 MVA
Rated power factor	cos φ = 0,85
Rated voltage	10,5 kV

Characteristics of rewound generators (calculated levels)

Rated referred power	47,00 MVA
Rated power factor	cos φ = 0,9
Rated voltage	10,5 kV

Excitation System

The existing excitation system with the machine exciter will be replaced by a static thyristor excitation system for slip-ring synchronous generators. The excitation system THYNE 5 has a digital (microprocessor) regulator type GMR3 for automatic mode (voltage regulation) and manual mode (rotor current regulation) with a standby rectifier.

Protections

Digital protection of machines 1-4 is provided.

Since the protection functions of the digital relay protection systems (DRS) are implemented in a software configuration, it is possible to determine the functions of DRS-COMPACT in such a manner that they mutually backup each other. The configuration can be modified to a certain extent in the design phase.

Digital protection of transformers 1-2 is provided.

Control system

The hydro-power plants will be equipped with VA TECH SATsystems. The control system provides for 4 control levels:

- Supervisory control level (Joint Control)
- Plant level control.
- Unit level control (set regulators).
- Equipment level control.

The control levels on the dispatch center, plant and set regulator side are an integral part of the computerized control and monitoring system. Each individual control level uses the control and monitoring devices of different plants in the plant, such as governor, exciter, alternating current distribution boards, etc.

General control is performed by AK 1703ACP automated components. Their general control functions include: electrical measurement of the three-phase system levels (backup measurement); HV and MV switchgear control and monitoring; auxiliaries control and monitoring; interface to the vibration monitoring system; interlocks, alarm signals.

ADDITIONAL MACHINES FOR HPP STUDEN KLADENETS

Machine No. 5

The power house will be extended to the right along the course of the Arda. The new additional machine will be erected at HPP Studen Kladenets with the following main characteristics:

Vertical-shaft Francis turbine

Maximum/rated output	19,75/16 MW
Synchronous speed	300 rpm
Rated net fall	57,50 m
Flow rate at rated net fall	30,04 m^3/s
Guaranteed average weighted efficiency	92,728%

The machine will be delivered with the following extra mechanical equipment:

- Water cooling system;
- Draining and dewatering system;
- Compressed-air system;

- Bridge crane modification;
- Governor;
- Master throttle valve;
- Hydro-mechanical equipment – penstock and suction pipe gate.

One (1) completely functional generator with rated power 23 MVA; cos φ = 0,85 and rated rotation speed 300 rpm. will be supplied

The computed characteristic values of the new generator are as follows:

- Rated referred power 23 MVA
- Rated voltage 10,5 kV
- Rated current 1265 A

The machine will be delivered together with the following additional electrical systems and equipment: exciter; protection system; control system; vibration monitoring; 10,5 kV switchgear; AC/DC board; main transformer 110 kV switchgear.

Additional Small Machine and Aquxiliary Facilities

The additional small machine with net output 1000 kW will process the ecological releases determined as 2,0 m^3/s for protection of the river ecosystem downstream of HPP Studen Kladenets. The machine will have the following technical characteristics:

Turbine type Francis, horizontal-shaft with maximum output 1330 kW complete with governor system, hydraulic oil-pressure system and throttle valve. The Francis turbine has the following hydraulic characteristics:

- Design gross fall 61,00 m
- Rated net fall 60,00 m
- Rated delivery 2,00 m^3/s
- Rated power of turbine 1076 kW
- Turbine rotation speed 1000 rpm

One electricity generator, brushless, synchronous type with built-in exciter and regulator system. The generator has the following technical data:

- Shaft horizontal
- Maximum output of turbine Pmech = 1330 kW
- Normal power 1450 kVA
- Rated current 2064 A
- Power factor cos φ = 0,9
- Rated voltage 0,4 kV +/-5%
- Rotation speed 1000 rpm

The machine will be supplied complete with LV electrical equipment. The set of accessories includes a complete control system, protections, indicators, alarms, data measurement and collection devices.

The envisaged extension of HPP Studen Kladenets involves construction works including:

- The area of the plant will be increased in the direction along the course of the Arda for erection of the two new turbosets No. 5 and No. 6 (Drg.No. 205-35023 and Drg. No. 205-35022).
- Construction of an underground penstock from the bottom of the water tower to the HPP. The penstock length is L = 166,61 m and its diameter - D = 4000 mm. The lining is steel-reinforced concrete (Drg. No. 205-35021; 205-35028). Before the two turbines the pipeline branches out and feeds the large turbine with $Q_{dev.}$ = 30 m^3/s and the small one with $Q_{dev.}$ = 2 m^3/s.
- Construction of an administrative building for plantoperation (on the left side of the plant– Photo 6).

All equipment rehabilitation works and the new construction of HPP Studen Kladenets take place inside the hydro-power plants and on the sites owned by NEK EAD.

7. PLAN OF THE NEW OR MODIFICATION OF THE EXISTING ROAD INFRASTRUCTURE

Properly maintained asphalt roads – branching off from the national road network – lead to the buildings of all HPP (subject of the rehabilitation envisaged by the Project).

Construction of a new or modification of the existing road infrastructure is not necessary. Part of the road to HPP Studen Kladenets on the side of the village of Studen Kladenets will be upgraded.

8. PROGRAM OF CONSTRUCTION WORKS, OPERATION AND CLOSING DOWN, RECULTIVATION AND SUBSEQUENT UTILIZATION PHASES

The for rehabilitation program for the three hydro-power plants was developed for the period 01.09.2005 - 24.09.2010. The time schedules for the individual hydro-power plants are:

- for HPP Kardjali - 01.09.2005 - 20.08.2010
- for HPP Studen Kladenets - 01.09.2005 - 17.09.2010
- for HPP Ivailovgrad - 01.09.2005 - 27.10.2009
- for HPP Studen Kladenets (extension) - 01.09.2005 - 24.09.2007.

The Program envisages rehabilitation of the machines consecutively: while one machine in each plant is rehabilitated, the remaining machines shall operate and generate electricity throughout the Project performance period. The rehabilitation starts from Unit 1 of HPP Kardjali and end with completion of the rehabilitation of the four units of HPP Studen Kladenets.

The envisaged time limits include performance of all construction and erection works with testing and recultivation of the site of new construction of HPP Studen Kladenets.

The three hydro-power plants subject to rehabilitation have been in operation: HPP Studen Kladenets – since 1958 ; HPP Ivailovgrad – since 1967 and HPP Kardjali – since 1971.

Hydro-power plants have two extremely important properties – “maintainability” and “durability”. These properties permit their rehabilitation (subject of the Project) for the purpose of improving their efficiency and extension of their operation time. Real-time “closing down” cannot be considered with respect to a hydro-power plant. In Bulgaria there are hydro-power plants that have been operating for over 70 years, and the large cascades such as Iskar, Batak Hydro-Power System have been in operation for 45 years with very good performance and reliability.

9. PROPOSED CONSTRUCTION METHODS

The main rehabilitation works at HPP Kardjali, Studen Kladenets and Ivailovgrad are dismantling and erection works performed inside the power house of each plant, on one turboset at a time.

Construction works include the extension of HPP Studen Kladenets.

The management and technology of construction and erection works will take into account the specific conditions at each hydro-power plant.

The construction of Units No. 5 and No. 6 of HPP Studen Kladenets will consist of surface (turbine building and administrative building) and underground (penstock and turbine level of HPP) works.

The extension works at HPP Studen Kladenets will include excavation, blasting (on some conditions and after a specially developed design), filling, shuttering, reinforcing, concrete and erection works.

Up-to-date materials, structures and equipment will be used for performance of the rehabilitation Project which will assure qigh quality of the construction and erection works and reliability of the hydro-power plants during commercial operation.

10. NATURAL RESOURCES TO BE USED DURING CONSTRUCTION AND OPERATION

Natural resources, used during construction

The resources that will be used during the construction and erection works for implementation of the rehabilitation and extension Project will include excavated materials (mainly rock from the underground workings for backfilling, rehabilitation of roads in the region, stone concrete), concrete (rubble, sand, cement), metal formwork, reinforcement, metal for the manufacture of equipment, mechanical and electrical components and the control systems. The volume of each resource type will be finalized during the engineering and detailed design phases.

Natural resources, used during operation

During operation of the rehabilitated hydro-power plants HPP Kardjali, HPP Studen Kladenets – old part and HPP Ivailovgrad, the energy/cost efficiency of the hydro-power plants and their operating reliability are improved. Upon extension of HPP Studen Kladenets the large machine will process an additional discharge 30 m^3/s of water and the total processed discharge at HPP Studen Kladenets will increase from 120 m^3/s to 150 m^3/s. In addition, the small turbine will process 2 m^3/s of ecological releases required for flooding of the river bed during the periods when the plantis not operating.

The natural resource used by the hydro-power plants of the Dolna Arda Cascade is water. The flow of the Arda regulated inside the water reservoirs of the three integrated water-power systems guarantees 592 GWh annual average electricity output (according to reports of Dams and Cascades Enterprise) from a renewable energy source with definite environmental advantages over the other energy sources.

11. EXPECTED WASTE GENERATION – WASTE TYPES, QUANTITIES AND MANNER OF DISPOSAL

The works envisaged within the Project for rehabilitation of Dolna Arda Cascade consist mainly of erection works inside the powerhouses of the hydropower plants. The new construction at HPP Studen Kladenets is of a comparatively smaller scope.

During implementation of the Project, the following types of waste according to the waste classification (Annex No. 1 to Regulation No. 3/01.04.2004 of the Ministry of Environment and Waters and Ministry of Health, State Gazette No.44/25.05.2004) will be generated:

- 17.09 – metals – generated during erection works in the power houses of hydro-power plants.
- 17.01 – concrete, bricks, roof tiles – during works at the extension of HPP Studen Kladenets and the administrative building.
- 17.02 – wood, glass and plastics during construction of the extension and administrative building of HPP Studen Kladenets.
- 15.01 – paper, cardboard and plastic packings (of products used by the construction and erection workers), wooden and metal cases (for equipment).
- 17.05 – earth from excavation of the underground penstock to HPP Studen Kladenets and of the pits for the turbine level of the hydro-power plant.
- 08.01 – waste from delivered and removed paints and varnishes for the extension of HPP Studen Kladenets.

The quantity of all types of waste is quite limited because it is generated mainly in construction process where all materials are utilized in the best way possible. There

is no temporary construction on any of the three sites that usually causes generation of significant quantities of wastes because the existing bases and infrastructure at each of the hydro-power plants are used. The volumes of all waste types will be assessed during the engineering and detailed design phase.

Temporary waste storage, haulage and disposal (during repair works) will be done in conformity with the Waste Management Plan at each plant. The Investor meets the requirements of the Waste Management Act (State Gazette No.86/2003).

The material excavated for the extension of HPP Studen Kladenets is used for upgrading of the road network, backfilling and stone concrete, metals are delivered for recycling and the rest of wastes are disposed at the closest disposal site with consideration of their type and properties. In the event that any hazardous waste is generated (paints, varnishes, oil products) it shall be deposited in a hazardous waste cell at legitimate landfills.

The existing base for oils and lubricants of each plant is utilized.

Disposal sites that can be used are those of the towns of Kardjali, Haskovo and Ivailovgrad.

12. INFORMATION ON CONSIDERED ENVIRONMENTAL IMPACT MITIGATION MEASURES

The following for mitigation of the environmental impacts are considered in the Project:

- Erection of the additional turbine No. 5 at HPP Studen Kladenets for $Q_{dev.}$ = 30 m^3/s, whereby overflows through the dam spillway and the related possible damages will be reduced.
- Erection of a small turbine $Q_{dev.}$ = 2 m^3/s at HPP Studen Kladenets to process the ecological releases for the purpose of improving the river ecosystem in the sector HPP Studen Kladenets – the tailrace of Ivailovgrad dam (in particular upstream of the confluence of the rivers Krumovitsa and Arda).
- Optimization of the size of the new construction at HPP Studen Kladenets by selecting the option whereby the rehabilitation objectives are achieved.
- Improvement of the energy efficiency of the three hydro-power plants for power generation by a renewable energy source.
- Selection of equipment with the control systems required for improving the operating reliability of the cascade and reduction of the in- operation environmental risk.

13. OTHER ACTIVITIES RELATED TO THE PROJECT

For implementation of the design underlying the Project for rehabilitation of the three hydro-power plants of the Dolna Arda Cascade opportunities shall be created for:

- Utilization of the capacities for manufacture of turbine and generator equipment for hydro-power plants and the related mechanical and electrical components;
- The capacity of the enterprises for production of construction materials will be utilized;
- Railway and road vehicles will be used for delivery of equipment and materials to the hydro-power plants;
- The hydro-power plants of the Cascade will increase their electricity output.

14. OTHER PERMITS REQUIRED IN CONNECTION WITH THE INVESTMENT PROPOSAL

Pursuant to the Bulgarian legislation, the following permits shall be obtained for the Project for rehabilitation of hydro-power plants of the Dolna Arda Cascade: permit for use of water by Studen Kladenets dam for the extension of the hydro-power plantand the documents related to design, construction works and site commissioning.

III. PROJECT LOCATION

1. PLAN, MAPS AND PHOTOS SHOWING THE PROJECT BOUNDARIES

The following documentation shall be attached to the designs for rehabilitation of HPP Kardjali, HPP Studen Kladenets and HPP Ivailovgrad:

For HPP Kardjali

- Photograph 1 – the power house of HPP Kardjali, where the envisaged works will be performed and the surrounding area that will be used for delivery of the equipment.

For HPP Ivailovgrad

- Photograph 9 – the power house of HPP Ivailovgrad, where the envisaged works will be performed and the surrounding area that will be used for delivery of the equipment.

For HPP Studen Kladenets

- Site plan – options AI, AII, БI, БII and БIII;
- Site plan – option BIV (an option developed in the design);
- Cadastral map – the power house of HPP Studen Kladenets with transformers and the 110 kV switchyard, sites on the right and left of the

plant, where construction of the plantextension and of administrative building will take place, road communications to the hydro-power plant;

- Drawing No. 205-35023 – situation of the new construction referred to the old part of the plant;
- Drawing No. 205-35021 – general longitudinal profile;
- Drawing No. 205-35022 – vertical section of the power house of the hydro-power plant;
- Drawing No. 205-35028 – standard lining of the underground penstock;
- Photographs No. 2 - No. 9 – views of the dam and HPP Studen Kladenets, the Arda downstream of the dam in 1956 and in 2005 (at a time of low water), the extension sites of the hydro-power plantand for construction of an administrative building, overflow through the spillway of Studen Kladenets dam.

2. EXISTING LAND USERS AND THER ADAPTATION TO THE PROJECT SITE

Rehabilitation of the equipment of the three hydro-power plants will be performed inside the plantbuildings. The extension of HPP Studen Kladenets will be built on an area adjacent to the plant. The areas are property of NEK-EAD.

3. ZONING OR LAND USE IN CONFORMITY WITH APPROVED PLANS

The lands are property of NEK-EAD and electricity generating capacities have been built on them - HPP Kardjali, HPP Studen Kladenets and HPP Ivailovgrad.

4. SENSITIVE TERRITORIES, INCLUDING SENSITIVE AREAS, VULNERABLE AREAS, AREAS OF PREFERENTIAL PROTECTION, SANITARY RESTRICTED AREAS, ETC. NATIONAL ENVIRONMENTAL NETWORK

The hydro-engineering facilities of Dolna Arda Cascade are located in the East Rhodopi mountains. The National Strategy on the Protection of Biological Diversity in this part of the country including the valley of the Arda from its springs to the border, according to available data on the flora and fauna as of 1994, is indicated as a region of medium and high significance considering the summarized data on the rich variety of species, endemic and rare taxa (Appendix: Chart No. 7 of the National Strategy).

To the south of the right-hand bank of Studen Kladenets dam is the Valtchi Dol Reserve declared by Order No. 877/1980 for preservation of Griffon vultures, habitats of rare and endangered bird species, locations of endemic plants, and ecosystems typical of the East Rhodopi. To the west of Studen Kladenets dam is an ornitologically significant area, Studen Kladenets, and in the direction of r. Krumovitsa is the ornitologically significant area Krumovitsa. Above the village of Studen

Kladenets there is a cooling cave. The gorge Shaytan Cupru is between the dam and the plant. There is a number of archaeological and historical monuments in the region around the dams. The antique Villa Armira, the sepulchre mound near the village of Svirachi of the Thracian-Roman period are unique monuments of culture.

There are no sensitive areas or sites of the National Ecological Network within the range of the rehabilitation works and the extension of HPP Studen Kladenets.

5. DETAILS ABOUT ALL CONSIDERED LOCATION ALTERNATIVES

There is no alternative to rehabilitation of the equipment of the three hydro-power plants because it concerns upgrading of the equipment in them and achievement of higher production efficiency. The rehabilitation objective rules out a zero alternative.

The location alternatives for the extension of HPP Studen Kladenets are determined by the point of water intake from the reservoir for the hydro-power plant.

- Option AI –the site of plant extension is situated about 250 m away along the course of the Arda downstream of the power house of HPP Studen Kladenets.
- Option AII – the site of plant extension is situated about 1500 m away along the course of the Arda downstream of the power house of HPP Studen Kladenets.
- Options BI to BIV –extension of the plant is performed on the site of the existing plant on the side of Unit 4 in the direction of the river Kurt Dere serving as outfall for the emergency channel of the plant.

Options BI, BII, BIII and BIV also differ in location of the water conduit system from the dam to the plant:

- Option BI – pressure tunnel downstream of the gate of the existing tunnel, water tower and penstock.
- Option BII – pressure tunnel with water intake from Studen Kladenets dam, water tower and penstock. The water intake is at the elevation of the existing water intake.
- Option BIII – like option BII, but the water intake is at an elevation higher that the elevation of the existing water intake.
- Option BIV – water intake from the bottom of the existing water tower of HPP Studen Kladenets.

The option proposed for implementation is BIV.

IV. POTENTIAL IMPACT CHARACTERISTICS

1. IMPACTS ON PEOPLE AND HUMAN HEALTH, ON ENVIRONMENT COMPONENTS AND FACTORS

- ## Population and Human Health

Current Status

Effect of the Plants on the Condition of Residents' Health

There are no residential buildings in the vicinity and that precludes any basic infrastructure facilities. The HV 110 kV transformers, the switchyard and the power line network that are sources of electro-magnetic emissions by no means affect the condition of the residents' health (according to Regulation No. 7/1972 the sanitary protection zone for 110 kV power lines is 10 m).

On the Personnel of Hydro-power Plants

Noise. The noise in the turbine building, on the generator level, next to the turbines, in the throttle sector, the noise exceeds the sanitary-health standard (SHS) 85 dB/A. Risk assessment at the work-places performed by a technical monitoring system shows that the exposure of the management, operator and attendant personnel is much less than 4 hours per shift that significantly reduces the risk of damage to the acoustic receptor and the central nervous system.

General vibrations. Technical inspections show that there are no general vibration levels above the standard. The exposure time is less than four hours so that the adverse health effect is precluded.

Non-ionizing radiation. Generators are sources of electrical and magnetic fields (EF and MF). The EF levels are usually very low – not exceeding 100 – 200 V/m (frequently observed in apartments and houses). The MF levels depend on the electricity consumption and may vary over a wide range. They may be near standard levels in the immediate vicinity of turbines (1 m), where the presence of workers is practically impossible. EMF are also generated by transformers, switchyards, and by the power transmission lines. The values of both fields are far below the permissible levels. It was found that EMF in hydro-power plants are of a magnitude that cannot have an adverse effect on the central nervous and cardiovascular system. Some risk exists for persons with active implantants (electric cardiac rhythm stimulators), who are not allowed to work in the turbine room.

Impact on the Population's Health during Rehabilitation of the Three Hydro-Power Plants and the Extension of HPP Studen Kladenets

Impact on the Population

The works related to rehabilitation of HPP Kardjali, HPP Studen Kladenets and HPP Ivailovgrad will be performed inside the turbine buildings and cannot have any adverse effect on the population keeping in mind their remoteness from all settlements.

With respect to the extension of HPP Studen Kladenets, the investment Project envisages digging of an additional penstock with length 166,61 m, and extension of the turbine building that will permit the installation of a new 16 MW turbine. The construction site will be in the immediate vicinity of the plant. Construction of a new administrative building is also planned. The village of Studen Kladenets is about 500-800 m away from the hydro-power plant on a direct line, and the construction works will not increase the background noise. The traffic will not increase significantly, that is why it is believed that the construction works will not result in an adverse effect on the health of the village population. The residential buildings for the personnel of the plant are about 200 m away from the construction site and those of the dam personnel - at 300 m distance from it. The construction equipment will increase the background noise. Keeping in mind that the works will stop for the night and that the work is temporary, the adverse (only irritating) effect will be minor.

Impact on the Labourers

The rehabilitation of HPP Kardjali and HPP Ivailovgrad will be performed in phases on one turbine at a time which means that during that time the remaining turbines will be operating. That will increase the exposure time to excessive noise levels for the staff performing the rehabilitation. Although hydro-power plants operate only about 3–4 in a day, it is necessary to use ear protection against the high noise intensities.

The workers building the extension of HPP Studen Kladenets will be exposed to an adverse microclimate, additional increase of the noise levels due to operation of the building equipment. The requirements of Regulation No. 04/2/26.02.2004 on the minimum requirements for healthy and safe working environment during construction and erection works shall be observed with respect to them.

Impact on the Health of the Population during Operation of the Sites

Effect on the Population

The extension and rehabilitation of HPP will not bring to changes in the situation of infrastructure components – transformers, switchyards and power transmission system. Therefore, no adverse effect on the population's health is expected.

Effect on the Personnel

With respect to the personnel of HPP Kardjali and HPP Ivailovgrad, the labour conditions remain the same and therefore no changes in the state of its health are expected.

The extension of HPP Studen Kladenets with installation of one more hydro-alternator will result in excessive noise levels during operation of all capacities. However, taking into consideration the fact that the exposure of the management, operators and the rest of the personnel will be only a few hours per shift, it is believed that the excessive noise levels cannot have an adverse effect on the central nervous system and the acoustic receptor. The same applies to the effect of electro-magnetic fields.

- **Ambient Air**

Climate

Characteristics of climate and weather factors influencing the free air condition

The catchment area of Sredna and Dolna Arda encompasses the East-Rhodopi river valleys and the surrounding mountain ridges. The ground profile is diverse:, ranging from mountainous in the west to semi-mountainous and undulating in the other part.

The water catchment area belongs to the continental-Mediterranean climatic region. The specificity of its climate consists mainly in the precipitation regime. The annual occurrence rate and territorial distribution are in close relation to air circulation and the influence of ground profile on its intensity, and respectively, on the intensity of precipitation forming processes and the quantity of precipitation. The intensification of cyclonic activity across the Mediterranean front region in the second half of the autumn and the beginning of winter determines the considerable quantity of monthly precipitation during that part of the year. All over the catchment area the precipitations reach their maximum in December when their monthly average increases from 70 mm/m^2 to 100 mm/m^2. Due to the southern situation of the region a major part of these precipitations fall in the form or rain or a mix of rain and snow. A second maximum is observed in May and June with monthly precipitation sums about 70 mm/m^2.

The distribution of precipitations by seasons exhibits close levels in winter and spring, the spring precipitations being 30-50 mm/m^2 less that in winter. The accumulation of a part of winter precipitations in the form of snow cover and the spring thaw of the latter are a prerequisite for offsetting the run-off conditions during the two seasons. Formation of the river flow in winter is considerably influenced by rainfalls during that season. The mean number of days with precipitations is 12 to 14, of which snow falls on 3 to 4 days only. The considerable quantities of winter and spring precipitations all over the catchment area as well as the frequent rainfalls in winter produce significant winter and spring flows.

The lowest sums of precipitations occur in August or September. The monthly precipitation minimum is observed in August or September - 25-45 mm/m^2. Summer precipitations are the lowest all over the catchment area varying about 120 mm/m^2. November is the month with the largest quantity of precipitations of all autumn months.

The catchment area of the Arda discussed here is among the warmest in the country. The mean temperature in January is above the freezing point in the whole region. It varies between 0.8 and 1.4 C°. The relatively high temperatures determine the time of snow cover. The average number of days with snow cover is 3 ot 4. Summer in the region is hot and dry. The average cloudiness in July is about 30%, and the average 24-hour temperatures are about 22 – 24 C°.

Climatic processes have an important share in the complex of processes (hydrological, biological, soil, etc.that take place in the environment. In many cases they are a factor determining the development of a business. On the other hand, such business may lead, to one extent or another, to changes of some climate characteristics. The construction of Dolna Arda Cascade consisting of the dams Kardjali, Studen Kladenets and Ivaylovgrad is attended by changes of one climate-forming factor only – the underlying surface. These changes are minor and include increase of the water planes with the construction of dams and change of the flora typical of that region as a result of newly built road sectors, terraces, etc. These changes may affect the thermal conditions and the humidification regime due to increase of the heat consumed in the evaporation process and the moisture content of the ground-level air stratum as a result of evaporation from the free water surface of water reservoirs.

It has been proven that dams of a size like that of the dams of the Dolna Arda Cascade do not cause any change in the air masses related to climate forming, including the formation of precipitations under the stimulating influence of local evaporation from the dam lake. In order to observe an impact of that type, the size of the changes should be equivalent to at least half of our country's territory. That was proven by the experiment carried out at Koprinka dam 4 years ago. He results of that experiment demonstrated that the influence of Stara Planina Mountain on the climate parameters in the region is stronger and more pronounced. That dam has some effect on the moisture content and temperature of the air above the dam lake and in its immediate vicinity – 15-20 m away. On the basis of the results of that experiment it can be concluded that the dams of the cascade, being situated in a mountain, will have a similar effect on the climate parameters.

The surface water regime is determined by the climate in an area. The assessment of water resources for the purpose of their efficient utilization requires good knowledge of the climate conditions. With a view to that and for more appropriate and economic operation of the hydro-engineering facilities considered, a full climate characteristic of the region is required. It should include estimated levels of the main climate indicators determining the income and loss parts of the water balance as well as a follow up of the monthly and annual variations of these indicators against the background of overall climate variations. For that purpose, the rich archive of data accumulated at meteorological plants in the region of Dolna Arda Cascade can be used.

The envisaged rehabilitation of HPP Kardjali, HPP Studen Kladenets and HPP Ivailovgrad and the extension of HPP Studen Kladenets have no influence on climate formation in the region.

Ambient Air Quality

HPP Kardjali

The works for rehabilitation of existing capacities include: dismantling part of the components of the old capacities in the plant and erection in conformity with the rehabilitation design.

The works will be performed inside the existing power houses of the plant and will not generate emissions detrimental to the free air. It should be added that the distance between the site and the town of Kardjali is over 2 km and no negative effect for the town residents can be expected. The additional traffic will be insignificant and can be ignored.

HPP Ivailovgrad

The rehabilitation again concerns existing generating capacities and will be performed inside the existing power houses of the plant and is not expected to generate emissions detrimental to the free air. Dismantling and erection works will be performed.

The abovementioned works are not a source of noxious emissions that require provision for air protection measures. The additional traffic will be incidental and of minor intensity.

The site is far from settlements and there is no hazard to the population and the environment owing to change of free air quality.

The works in closed spaces should be performed in conformity with the labor protection regulations at all three hydro-power plants.

HPP Studen Kladenets

Rehabilitation of the old units shall be performed in the same conditions as at HPP Kardjali and HPP Ivailovgrad, and creates no hazard to the population as a result of air pollution.

The construction of new energy capacities on the site will include the following works:

- construction of underground penstock for water feeding to the turbines;
- construction of an extension of the power house of HPP Studen Kladenets;
- erection works for the new capacities.

The following machines will be used during the construction works: an excavator, bulldozer, crane and heavy-duty trucks, a drilling machine. The total capacity of the equipment yard is expected to be about 400 kW. Their utilization factor is K = 0,5.

The expected noxious emissions in the above-said conditions will be the following (in g/hour):

Sulphur dioxide	100 g/hour
Nitrogen dioxide	1200 g/hour

Carbon oxide	400 g/hour
Soot	20 g/hour
Total	1720 g/hour

These emissions cannot reach levels above the permissible limits in the air due to their low intensity.

Dust (fine particulate matter) releases may exceed standard levels for a short time due to the small scale of the site.

That circumstance should be kept in mind because of the proximity to the lodgings of the operating staff. The measures undertaken in such cases are traditional – sprinkling of water over the front of excavation works in dry and hot weather and whenever the works are intensive.

During operation of the three sites, there are no noxious emissions in the air due to the specificity of hydro-power generation.

- **Water**

Surface Waters

R. Arda is a right-hand tributary of the river of Maritsa. It begins from a mountain brook that springs at elevation 1455,00. Its length is 241 km and the area of its catchment - 5201 km^2. Its larger tributaries in the reviewed sector of Dolna Arda Cascade are the rivers of Verbitsa and Krumovitsa. The water catchment area of the Arda is in the continental-Mediterranean region, the Mediterranean influence being the strongest in the water catchment of Ivailovgrad dam.

The run-off regime of the Arda is different from that of rivers in the central part of the country. It is characterized by high water during the winter season from November till March (winter and early spring). That determines high peaked waves and considerable river drift.

The Dams and Cascades enterprise manages the water economy and operation of the dams and water reservoirs. Inspections and assessments are performed every year, and full analysis and assessment of the condition of the cascade – every three years.

The most recent report, Analysis of Climatic, Hydrological and Water-economy results of Cascade Operation accepted by NEK-EAD is of 2001.

According to design data the average flow to Kardjali dam is 975.10^6 m^3, to Studen Kladenets dam 1867.10^6 m^3, and to Ivailovgrad dam – $2213,8.10^6$ m^3. As a result of the occurrence of an about 13-year period of very dry years, within the total operation period of the cascade (1971-1999) there is reduction of the flow: 11,7% for Ivailovgrad dam and 26,1% за Kardjali dam. Over the considered period the own

afflux of Studen Kladenets dam was 51% of the total afflux, and the afflux from the Verbitsa only was 31% of it.

During the winter high water in an average year 54,8: (XI-I) от the flow passes through Studen Kladenets dam, and during the spring high-water period – 32,2% (III-V).

The monthly minimum flow for the two large tributaries, the rivers of Verbitsa and Krumovitsa, is almost zero. In 2000 it reached 0,033 m^3/s for August.

High Waters

The occurrence of high waters in the valley of the Arda results from a combination of thaw and heavy rains or from prolonged rains.

Release facilities have been built on the three dams for conduction of the high waters.

For Kardjali dam

- spillway – for maximum discharge 3100 m^3/s;
- main flood gates - for 880 m^3/s.

For Studen Kladenets dam

- spillway – for maximum discharge 3600 m^3/s;
- main flood gates (2 pcs) - for 180 m^3/s.

For Ivailovgrad dam

- spillway – for maximum discharge 5250 m^3/s;
- main flood gates (2 pcs) - for 270 m^3/s.

A year of typical floods was 1996 when Q = 1500 m^3/s flowed over the Studen Kladenets dam. The flood duration was 163 hours with two peaks – the first Q = 2805 m^3/s and the second with Q = 1477 m^3/s. The maximum influx per day was 116,629.10^6 m^3.

Inwash Conditions

The inwash flow to Dolna Arda Cascade depends on the erosion characteristics of the water catchment areas and the dam banks, as well as on the operation conditions. Large-scale afforeplant carried our by the State Forestry had an extremely favourable anti-erosion effect.

Before commissioning of Kardjali dam, Studen Kladenets dam operated in very adverse conditions (the first water reservoir in the river valley, deforestated catchment area, high erosion rate).

Until 1990 (when the Rudozem tailings pond came into operation) the tailings were discharged into the dam lake and deposited there.

After construction of Borovitsa dam it started to receive part of the inwash flow to Kardjali dam.

According to data from recent measurements, the quantity of inwash deposited in the individual water reservoirs and their distribution are as below:

In Kardjali dam as of 2000

- Total volume of deposited inwash – 56,988.10^6 m^3, of which 24,6% deposited in the unavailable capacity. The unavailable capacity of the dam is 117.10^6 m^3. Due to sedimentation of the largest volume of inwash in the available capacity (between elevation 300,00 and elevation 310,00) an adjustment of the key curve of storage reservoirs was performed.

In Studen Kladenets dam as of 1999

- Total volume of deposited inwash – 79,197.10^6 m^3, of which 57% deposited in the unavailable capacity. The unavailable capacity of the dam is 115.10^6 m^3. The key curve of storage reservoirs was adjusted.

In Ivailovgrad dam as of 2000

- Total volume of deposited inwash – 21,890.10^6 m^3. 1113115 m^3, or less than 10% deposited up to the elevation of unavailable capacity.

Adjustments of the key curves were performed in 2002 after a geodetic survey of parts of the dam lakes. The difference between new and old curves was assumed rto be the inwash deposited during the period of operation.

Upon tracking the size of deposited inwash by measurement periods a gradual subsiding and stabilization of inwash deposition is observed. That is due to afforeplant of the catchment area and to all implemented measures included in the erosion control projects as well as the operating modes.

The results of the operation of the three water reservoirs do not necessitate measures for removal of the inwash from the dam lakes.

Water Balance

The total storage reservoir of the cascade is 1209,9.10^6 m^3. The river flow completely coincides in seasonal distribution with the typical load curve and power consumption which reduces the need for large seasonal volumes in the water reservoirs.

While the seasonal volumes for large water reservoirs on the other rivers in the country exceed 55% of the flow, for the Arda they are between 8 and 11%.

The integrated water-power systems of Dolna Arda Cascade come into operation in stages, the Kardjali dam functions as a compensating water reservoir. It retains the waters during the high-water period when the own afflux in the other two dams is sufficient for operation of the hydro-power plants, and supplements them during the rest of the year.

Water balance is drawn up by the water-balance method taking into account the afflux and efflux volumes in the water reservoirs. The water balance is influenced by the requirements of the power system and by the mutual influence with the water reservoir situated upstream of it.

There are significant overflows at Studen Kladenets dam (even after commissioning of Kardjali dam up to 1,5% of the afflux) and at Ivailovgrad dam (due to the small capacity of the dam in relation to some restrictions on its design imposed by the ore mines).

Water Consumption

Power Generation

Dolna Arda Cascade is designed mainly for power generation.

The total energy capacity of the Cascade is $137,134.10^6$ kWh. It is concentrated mainly in Kardjali dam (49,5%) and Studen Kladenets dam (41,2%).

HPP Kardjali meets the peak demands (sometimes operating as base load capacity). It is operated in emergency situations.

HPP Studen Kladenets operates as a baseload, peak and standby capacity for the power system of the country.

HPP Ivailovgrad is directly dependent ton the operation of the two preceding hydro-power plants.

The major part of annual average overflow losses occur mainly at HPP Studen Kladenets – $14,572.10^6$ kWh or 8,6% of the plant output that determines the need for increasing its output and decreasing the losses from unprocessed waters.

HPP Studen Kladenets produces the largest share of the total output of the Cascade – 37,8%.

Water Supply

Water from the Kardjali dam is fed to the industries of the town of Kardjali at the rate 1,8% of its afflux. The volume supplied for the needs of the industry is relatively small and does not affect the power generation mode.

Irrigation

No water is fed for irrigation with the exception of the water supplied for irrigation in Greece and amounting to 186 mln m^3 that necessitates not only the operation of HPP Ivailovgrad, but also the operation of the two upstream hydro-power plants in a subordinate mode.

One result of the operation of Dolna Arda Cascade is the change of the regime of the river flow downstream of the water reservoirs. For Kardjali dam the sector down to the tail of Studen Kladenets dam is short. The effect is significant flow downstream of Studen Kladenets dam where the distance to the tail of Ivailovgrad dam is 25-30 km. In that sector of the river the regime of the natural flow is most severely distorted due to the peak mode operation when the minimum flow to r. Krumovitsa is formed by small gullies and declivity influx. The river of Krumovitsa has a beneficial effect on the Arda due to the natural regime variations of the flow that affect it as well. Downstream of Ivailovgrad dam the operation of the plant in an irrigation mode in summer is beneficial to the river.

Three lakes were formed during the period of operation of the three integrated water-power systems on the Arda (standing artificial water reservoirs) and water transfer sectors between them. The impact of the dams on the river flow for more than 35 years is practically over now.

The installation of turboset No. 6 at HPP Studen Kladenets for processing of the ecological releases at the rate 2 m^3/s is beneficial and indispensable to the most vulnerable sector of the Arda between Studen Kladenets dam and Ivailovgrad dam down to the confluence of r. Krumovitsa with the Arda.

Water Quality in the Arda

After completion of the extension of HPP Studen Kladenets the construction effluent should pass through a mechanical settling basin before outfalling in the Arda, in order to prevent increase of the concentration of non-soluble particles.

The operation of the three integrated water-power systems of Dolna Arda Cascade with their large capacities results in good quality of the river water flow downstream of the dam walls (See attached Information on Concentration Levels in the Basin of the Arda for the period 01.01.2004 – 01.01.2005 by *И*АОС at MoEW, Report No. 636/2004 from Regional Laboratory -Plovdiv to *И*АОС, Report No. 633/2004 from Regional Laboratory -Plovdiv to *И*АОС and Report No. 24/28.03.2005 from Regional Laboratory -Pazardzhik to UAOC).

The water intake category is determined by the extreme levels of individual indicators:

- General physical indicators - pH – III; O_2 – II; insoluble matter – II; soluble matter – I; iron – II; manganese – I; sulphates – I; nitrate nitrogen – II; PO_2 – 3rd category
- Organic pollutants - BOD – I; oxidizability – 3rd category

It should be noted that as a result of the accumulating effect of water reservoirs the water in the Arda is clean judging by the prevailing levels of the respective indicators within Categories 1 and 2 for the exception of pH, PO_2, oxidizability – 3rd Category.

According to Order No. РД-272/03.05.2001 on surface water grading in water facilities or in parts of them, the Arda from Kardjali dam to the border is 3rd category.

Ground Water

Diaclaze vein waters have formed in the cracks of the andesite. They are made up by atmospheric precipitations and drain into the Arda valley in the form of descending springs with flow rate up to 0,05 l/s, and of seasonal nature.

The extension of HPP Studen Kladenets will have no negative impact on ground waters.

Preservation of the River Ecosystems

The impact of human activity on the Arda is related to the hydro-engineering construction works in the Dolna Arda sector (Kardjali dam, Studen Kladenets dam, Ivailovgrad dam operation life 34 - 47 years) and pollution of the river course by the ore mining and ore processing industry. In the sector from Kardjali dam to Studen Kladenets dam and at Ivailovgrad dam the river ecosystems have transformed from running water ecosystems into still water ecosystems.

Disturbances of the flow flow downstream of the constructed dams are determined by the operating modes of hydro-power plants (peak, off-peak, baseload and subordinate). During the interval when hydro-power plants are not operating the river flows are formed by opening of the sluice gates at the rate of about 200 l/s. A beneficial effect on the sectors subjected to drastic flow variations is observed: downstream of Kardjali dam – the started construction of small weirs for the purpose of forming small water basins, and in the region of the v. Madzharevo, at the confluence of r. Krumovitsa the flow of which is undisturbed.

Pollution of the Arda was most active in 1967-1990 when the tailings pond Rudozem-2 was commissioned. Before 1990 the tailings were released in the river bed and in Kardjali dam. Downstream of the confluence of the rivers Cherna, Madanska and Rudozemska, shortly after 1990 the river restored its biological quality almost completely which was an evidence of its high self-purification capacity.

The flood discharge rate 2 m^3/s processed by turbine No. 6 and released into the river downstream of HPP Studen Kladenets will result in gradual recovery of the river ecosystem. That is much better than recommended in General Schedules of 2000 (10% Q_0).

Characteristics of the Dams of the Dolna Arda Cascade

General Information

Dolna Arda Cascade consists of the dams Kardjali, Studen Kladenets and Ivailovgrad, situated in a cascade along the middle and lower course of the Arda. The hydro-power plants of the Cascade were set in operation over the period 1958-1971 in the following order: HPP Studen Kladenets (1958), HPP Ivailovgrad (1967) and HPP Kardjali (1971).

Irrespective of the comparatively operation period, the dams of the Cascade are relatively poorly studied from environmental point of view. Naydenov *(1964) and* Dinitrov *(1962)* followed up the changes of hydro-chemical indicators, of the zooplankton and zoobenthos at Studen Kladenets dam in the first years after its ponding, and Naydenov *(1984)* provided information about the zooplankton of Ivailovgrad dam. At Kardjali dam, some studies were carried out on the microbiological water characteristics *(Denchev et al., 1996),* analysis of heavy metals and their accumulation in various components of the feeding chain (*Velcheva and Bachvarov, 1994; Velcheva 1996a,b; 1998; 1999; Velcheva et al.,. 2000 and Velcheva, 1997),* fish species *(Pehlivanov, 2000),* effect of water level changes on the trophic conditions in the dam *(Traykov & Boyanovsky, 2003),* the longitudinal gradients of abiotic indicators *(Traykov et al., 2003, Traykov et al., 2005a),* ecosystem condition in Kardjali dam, Studen Kladenets dam and in the Arda *(Tiufekchieva et al., 2004) and* effect of the operating mode on zooplankton in the dam *(Traykov et al., 2005b).* In connection with the studies carried out on the construction of the Gorna Arda Cascade a forecast on the development was drawn up and measures for prevention of eutrophication of Madan dam were indicated *(Boyanovsky et al., 2000).*

Abiotic Indicators

- Temperature

The large volume and depths of the dams of the Dolna Arda Cascade determine the thermal-monomictic nature of the dams. The duration of water mass stratification is 8-9 months; the circulation time encompasses the period December – beginning of March. The seasonal thermocline is situated at a depth of 7-8 m and starts “sinking” with the autumn cooling of water masses. In July/August the difference between temperatures on the surface and at the bottom of water basins reaches 19°C. The dams do not freeze, a partial ice crust has been observed only in the tail of Kardjali dam.

- Oxygen

The quantity of oxygen in the water of dams reaches its maximum in spring, in the end of the water circulation period. After the end of circulation, the vertical distribution of oxygen gradually transforms into a clinograde type in Studen Kladenets dam and in the transition and running-water zone of Kardjali dam, while in the limnic part of Kardjali dam oxygen variation with depth is described by a negative heterograde

curve. The established methalimneous oxygen concentration minimum at Kardjali dam is due to water transfer from the transitional to the running-water zone of the dam to the dam wall upon selective release of water for power generation from a definite depth. The oxygen regime of Kardjali dam is strongly influenced by the service life of the dam and the time period and quantity of water from the the Arda conducted in spring. Having in mind the similarity in the operating conditions and the depth of Studen Kladenets dam, establishment of negative heterograde curves near the dam wall can be expected.

The positive influence on oxygen regime in the bottom-level strata of water reservoirs is due to the export of water (losses) with increased oxygen consumption through the main floodgates of dams. That determines the later formation of an anoxic layer on the dam bed.

- Active Reaction (pH) and Alkalinity

The water in the dams of the Dolna Arda Cascade have a neutral-alkaline reaction. Reduction of the active reaction to pH=6.2 upon resuspension of sediments (in the case of maximum afflux) has been recorded only in the running-water zone of Kardjali dam in spring. In summer and autumn the water pH varies over the range 7.4-8.7. Water alkalinity in Kardjali dam and Studen Kladenets dam varies within the limits 1.2-1.4 meq/l, decreasing in the surface layers as a result of decalcification in summer to 0.9, and increasing to 1.5-1.7 meq/l in the hypolimnion in late summer.

- Transparency

Water transparency in Kardjali dam varies from 0.2 at the tail to 5.5 m in the limnic zone near the dam wall. A clear trend to increase of transparency from the transfer to the limnic zone can be clearly observed along the length of the dam lake as a result of decreasing quantities of suspended matter and phytoplankton.

- biogenic elements

A clear trend to reduction of biogenic elements from the transfer to the limnic zone is observed. The differences in mean concentrations of nitrous and phosphoric forms across Kardjali dam determine also the different values of their ratio. In the limnic zone, the average value of m:P is approximately 50, in the transition zone - 40, and in the running-water zone - 30. the presence of a gradient between the limnic and running-water zone in the distribution if biogenic elements and suspended matter in the dam is determined by the supply of water to the dam, mainly from the Arda (>90%), its great length and long stratification period. The established horizontal distribution is characteristic of the other dams of the cascade as well and is related to a “score-like” inflow of water in the dams and the different transformations of the inwashed solved and suspended matter - precipitation, assimilation, biodegradation, etc.

Biotic Indicators

- Phytoplankton

During the study carried out in Kardjali dam, 54 taxa distributed in groups (sections and subsections) were established as follows: *Chlorophyta* -25; *Bacillarioophyta* - 15; *Cyanoprokaryyyota* - 7; *Euglenophyta* - 3; *Pyrrhophyta* - 2; *Cryptophyta* - 1 and *Crysophyta* - 1. There is no data about the qualitative and quantitative composition of the phytoplankton in Studen Kladenets and Ivailovgrad dams.

With respect to the quantitative characteristics of phytoplankton, the three zones of Kardjali dam are clearly discernible, and a trend to increase of phytoplankton numbers and chlorophyll quantity in the dam to tail direction is observed. A well pronounced seasonal and spatial succession of plankton communities in the dam. Two peaks in the phytoplankton development were established in the limnic zone, and one in the running-water zone, in accordance with the increased trophicity. The “r-strategists” prevail in the tail of the dam, and “k-strategists” – in the limnic zone. The control prevailing in the limnic zone is *bottom-up,* in the transition zone - *top-down,* and the interrelations in the running-water zone are regulated by the flow of the Arda.

- Zooplankton

Naydenov *(1984)* comments that among Bulgarian dams, the species composition is most limited in the stages of the Arda Cascade, numbering 25 in Studen Kladenets dam and only 12 species and subspecies in Ivailovgrad dam. The zooplankton community of Kardjali dam is diverse, with 34 established taxa, distributed as follows: *Rotifera* - 12; *Cladocera* - 12; *Copepoda* - 6; *Ostracoda* - 1; *Cnidaria (Coelenterata)* - 1; *Hydracarina* - 1 and *Ciliata* - 1. The zooplankton community in Studen Kladenets dam includes 25 taxa, distributed as follows: *Rotifera* - 12; *Cladocera* - 12; *Copepoda* - 1. One of the causes of the scarce qualitative composition of the zooplankton in Studen Kladenets dam indicated by *Naydenov (1964)* is the high runout rate (RT ≈ 120 days), the small quantity of phytoplankton, large quantities of suspended matter and the predatory pressure exercised by the fish. Taking into consideration the short time of water stay in Ivailovgrad dam (RT ≈ 31 days) as compared to that in Studen Kladenets dam and Kardjali dam (RT ≈ 205 days), it can be concluded that the numbers of taxa is determined by the stay time of water in the dams of the Cascade.

- Zoobentos

According to Dimitrov *(1962)* the zoobentos of Studen Kladenets dam numbers 21 species of Chironomidae and 4 species of Oligochaeta. The zoobentos biomass in the dam is low and varies within the range 0.2 g/m - 1.5 g/m without clear predominance of one group over the other in numbers and/or biomass. In Kardjali dam, the biomass of zoobentos e 0.45 г/м , midges constituting 30% of the numbers and 75% of the zoobentos biomass. The abundance of zoobentos in the dams of Dolna Arda Cascade is several times less compared to other dams in the country.

The main cause of that is the large quantity of sediments coming from the catchment areas of the dams and their low organic content *(Dimitrov, 1962).* Considering the stabilization of water level in Studen Kladenets dam after commissioning of Kardjali dam and the development of macrophyte communities in the litoral zone, one can expect an increase not only of the biomass of the zoobentos communities but also of the number of species in the dam.

Trophic Condition

The system of trophic indice of *Carlson (1977), Carlson & Simpson (1996) (TSI)* has been used for assessment of the seasonal changes of the trophic condition. By values of these indice Kardjali dam is mesotrophic to slightly eutrophic water basin. These results coincide with the rating by boundary values of the indicators in the limnic zone *(OECD, 1982)*

The strongly pronounced gradients of main hydro-chemical and biological indicators across the dam determine the mesotrophic nature of the limnic zone and the eutrophic nature of the running-water zone. The mean values of trophic indices for Kardjali dam are as below:

Index	Mean
TSI-Хл-а	47.6
TSI-SD	48.1
TSI-TP	60.5
Mean for the dam	52.06

Irrespective of the lower situation of the two other dams in the Cascade and retaining of the larger part of the sediments in Kardjali dam, owing to the larger catchment area and afflux quantity, preservation of the meso-eutrophic character of the dams is expected.

The use of trophic indices in the classification of water basins offers a number of advantages compared to the typological system of OECD:

- Clear distinction by trophicity of water basins falling within the same typological category;
- The indices can be used separately for classification of water basins during the stratification period, TSI-Хл-а being the best suited to that purpose;
- On the basis of index differences it is possible to distinguish between the factors influencing the trophic condition and the change of their relative part with time and in space;
- It is possible to assess also short-time changes in water-basin condition.

The above-mentioned advantages of trophic indices determine their potential application in water quality monitoring and management in the lakes and dams in Bulgaria.

Conclusion

The trophic condition of dams is determined by the specific morphometric characteristics (great depth and length) of the dam lake and by their situation in the Dolna Arda Cascade. The torrentous nature of the rivers in that region and water utilization for power generation determine the strongly pronounced water level fluctuations in Kardjali dam. In that connection, the operating mode of dams (subsurface water draining, resp. changes in the stay time) is the main factor influencing the dynamics of abiotic and biotic indicators in the Cascade dams. That concerns to the highest extent oxygen content in the metha- and hypolimnion (determined by the transfer of afflux effect and the high biological production from the running-water towards the limnic zone of a dam) and the biological indicator gradients in dams. That relationship enables modification of the operating mode of the dams as a means for environment-friendly water management.

By all indicators and indices used for assessment of the trophic condition, the limnic and transition zones of Kardjali dam are mesotrophic, and the running-water zone - eutrophic. A similar trophicity reduction along the dams is expected at Studen Kladenets dam and Ivailovgrad dam as well, taking into account their supply with water mainly in the tail, and the great length of their lakes.

- ## Soils

Soils in the water catchments in the East Rhodopi are mainly maroon washed forest soils gradually turning into light brown forest soils in the higher areas. Some humus-carbonaceous (Rendzini) soils occur above the limestone rocks.

All types of soil in the region are more or less eroded (2^{nd} to 5^{th} degree). Their mechanical composition is most frequently clayey-sandy, medium to highly stony.

The catchment areas of the dams include some farm lands as well (most frequently tobacco fields) where the soil is of the antropogeneous type and agrogeneous kind.

The soil on the construction site of the extension of HPP Studen Kladenets (the exit of the tunnel) is technogeneous. It is an old embankment without any humus layer. The area occupied by it is about 400 m^2.

- ## Geological Basement

In geological terms the region of the new construction site for HPP Studen Kladenets (around the dam wall, the water tower, penstock and power house) is underlied by pyroxenic andesite – porous, prismatically cracked, interspersed with numerous calcite and quarz veins. The depth of andesite along the river bed of the Arda does not exceed 150 m. It is of the “low-crystalline” Rhodopean rock series, from the Paleogene and completely underlain by the “high-crystalline” Rhodopean series – gneiss, gneiss schists, marbles, etc. considerably metamorphosic. The color of andesite varies depending on the prevailing minerals – from dark green to pale black, bluish-green and other hues.

As base for hydro-engineering facilities, andesite has very good geomechanical indicators: bulk weight – 2,16 t/m^3; specific weight – 2,62 t/m^3; porosity – 19,62%;

plastic modulus – 110,0-140,0 t/cm^2; cube strength – 240,0-580,0 kg/cm^2; dry compression strength – 387,0 kg/cm^2 etc.

The following crack systems were found in the andesite (in the region of the site): long cracks across the explored region with 330° bearing (azimuth); 3,0-4,0 m deep plaque surfaces situated among the lava streams and "prismatic" cracks (typical of andesites).

Most of the cracks in the andesite are filled up with streaks of quarz that enhance the strength of the rock.

The weathering zone depth of andesite is small, not exceeding 1,0 m.

The extension of HPP Studen Kladenets will not have a negative effect on the geological environment.

- ## Landscape

The intended extension includes a one-storey annex building to the power house – about 400 m^2 and a two-storey administrative building with 200 m^2 floor area.

The situation of the existing plant and the area around it permit construction of the planned facilities.

With a view to achieving harmony between the existing and the new construction, an overall outline shall be drawn up to show how the ensemble fits into the surrounding landscape.

Rehabilitation of the hydro-power plants at the dams Kardjali and Ivailovgrad concerns only indoor spaces and has no direct relation to the surrounding landscape.

- ## Flora and Fauna

Flora

The phyto-geographical regioning (Bondev, 1982) defines the region of the dams Kardjali, Studen Kladenets and Ivailovgrad as an European deciduous forest area, Macedonian-Thrace province, East-Rhodopean district.

According to the classification system of the types of forest vegetation habitats, the region of the dams falls within the southern forest vegetation area, Arda subarea, lower flat-hilly and and hilly-highland oak forest belt (0-900 m above sea level).

The indigenous phyto-cenoses in the region are xerophites, mainly mixed oak, Adriatic oak and oriental-hornbeam forests. They include also: Quersus cerris, Q.fraineto, Q.pubescens, Q.dalechampii, Fraxinus ornus, Acer tataricum, Tilia argentea, Carpinus orientalis.

The tree stands are of offshoot origin without exception, strongly influenced by human activity in the past.

The undergrowth consists predominantly of bushes: Cornus mas, Cotynus coggigria, Evonimus europea, Rosa canina, Paliurus spinachristi, Rhamnus cathartica, Colutea arborescens, etc.

The forest cultures created more than 50 years ago consist mainly of black pine-tree, (Pinus nigra) and less frequently, white pine-tree (Pinus silvestris) in places of higher altitude.

The East Rhodopi have been subjected to the impact of human activities for ages. As a result of illegitimate felling and uprooting, extensive agriculture and grazing, a large part of the dam catchment areas were transformed into severely eroded lands – barrens and devastated forest.

The large-scale construction of water reservoirs in a region subjected to strong erosion requires large-scale measures for restriction and stopping of erosion processes in their water catchment areas. In parallel with construction of the dams, Erosion Control Engineering Projects were implemented including complex measures – afforeplant and construction of engineering facilities.

In the first place, afforeplants encompass severely eroded barren areas and devastated forests. Improvement of the condition of the natural deciduous forest is done by means of “rejuvenation” – cutting and prohibition of grazing. Linear erosion is controlled by means of construction of weirs on all streams falling into the dam lakes wherever required.

As a result of large-scale afforeplant and erosion-protection facilities, erosion in the water catchments of dams has been seriously reduced, the landscape has changed, and all that has a beneficial effect on the climate factors.

The forest plants created in that region cover several tens of thousands decares.

Tens of thousands cubic meters have been moved to build weirs, rock lips, gabiones.

Field studies carried out by prof. Ivan Kolev in 1998 in the region of the three dams with respect to herbaceous vegetation:
:

- The grass stands in forest phytocenoses exhibit a slightly pronounced change in the species composition at the water front - some mesophites and xeromesophites have appeared side by side with the xerophites.
- The dams offer a good opportunity for irrigation of nearby farmlands. The beard-grasstand in pasture land areas is replaced by Bermuda grass the components of which are mesophytes.
- In the immediate vicinity of the shore, an extensive area is occupied by Hordeum bulbosum that is an indicator of increased air humidity. A number of rouderial species, part of them weeds, are well developed in that area.
- Backwater has no effect on the protected plant species and their habitats. The area near the cottage between the dam wall and HPP Studen Kladenets is the easternmost known field of Rhodopean Cilivriak.

The rehabilitation of HPP Kardjali and HPP Ivailovgrad has no impact on the vegetation. The works are carried out inside the power houses of the hydro-power plants.

For the extension of HPP Studen Kladenets the construction of a penstock will affect only 6 large 50-year old locust trees (Robinia pseudoaccacia) that come into the range of the gate. Since the facility is underground, and at a great depth, it will not

affect the vegetation, and will not cause drying of the surface above it (evidence to that effect is provided by studies of the tunnels of the Batak water-power system by a team of the University of Architecture, Civil Engineering and Geodesy in 1993).

Fauna

Macrozoobentos

The data about the ecological condition of the Arda in the sector downstream of Studen Kladenets dam during the past periods are scarce.

During the recent years, in connection with performance of an EIA on Gorna Arda Cascade, a team of experts from the Institute of Zoology at the Bulgarian Academy of Sciences and the Faculty of Biology at Sofia University have been performing hydrobiological monitoring of the Arda in the sector where the Cascade will operate. Individual studies were carried out during that period in the sector downstream of Studen Kladenets dam. The environmental condition was assessed on the basis of studies of the macrozoobentos river cenoses by tracing the composition and the total numbers. Special attention was paid to the numbers of individual bentos groups which was of key significance for that condition – Ephemeroptera, Plecoptera, Trichoptera, Oligochaeta , Chironomidae. Representatives of these groups were used to compute two biotic indices determining the integral environmental assessment including water quality and biological self-sufficiency of the river communities.

The results of studies in 2002 (July), 2003 (April, August, October) and 2005 (May) provide grounds for defining the overall ecological condition of the river in the sector downstream of Studen Kladenets dam as unstable and significantly less favorable compared to the river sectors in the upper course of the Arda as well as those upstream and downstream of Kardjali dam (Table1).

In certain situations (low or high waters, significant human impact, etc.) it means that the river zoocenoses undergo a negative change in their composition and structure. Generally, as a result of that, the biological diversity becomes considerably lower and the cenosis numbers – much smaller.

The main causes of that situation in the river sector downstream of Studen Kladenets dam should be sought in the complex impact of the two dams on the river ecosystem on the one hand, and the effect of the large wave of unregulated (in time and quantities) release of water from HPP – on the other side.

The rehabilitation of HPP Kardjali and HPP Ivailovgrad has no effect on the condition of macrozoobentosa in the river downstream.

The erection of the small turboset No. 6 for outlet of the ecological releases in HPP Studen Kladenets and securing of the minimum permissible flow in the Arda downstream of HPP Studen Kladenets will have a definitely beneficial effect on the river zoocenoses of macrozoobentos, however, the negative effect of the peak-mode operation of the plant will remain.

Table1. Composition (main bentos groups)
and numbers of macrozoobentos communities in the sector of Arda
(upstream and downstream of Kardjali dam – downstream of Studen Kladenets dam)
In May 2005

Bentos group	upstream of Kardjali dam	downstream of Kardjali dam	downstream of St. Kladenets dam
Nematoda		-	1
Oligochaeta		23	
Hirudinea		2	
Amphipoda		19	
Ephemeroptera	103	-	-
Baeis sp.	101		
Ecdyonurus sp.	1		
Caenis sp.	1		
Plecoptera	2		
Leuctra sp.	2		
Trichoptera	**13**		**10**
Diptera	**217**	**51**	
Chironomidae	**216**	**50**	**128**
Simuliidae			**15**
Total numbers	**350**	**95**	**154**

Ichtiofauna

Ichtiofauna Condition

The sector of the Arda downstream of Studen Kladenets dam and downstream of Ivailovgrad dam is discussed. The sector downstream of Kardjali dam is short and the sewerage of the town of Kardjali outfall into it. Besides, the rehabilitation of hydro-power plants will not change the conditions in the river compared to its current condition.

Ichtiofauna composition in that sector of the Arda is dominated by typical rheophilic (river) species. The most frequent ones are Maritsa barbel *Barbus cyclolepis,* Chub *Leuciscus cephalus* and the Maritsa vimba *Vimba melanops* represented also with relatively largest numbers. The numbers of Undermouth *Chondrostoma vardarens* are relatively less. The more shallow sectors and mouths of tributaries (for example, Krumovitsa) are inhabited by representatives of the family Cobitidae – Spiny loach. A number of carps penetrate in the river from Ivailovgrad dam (Bleak, Rudd, Black sea roach) as well as Perch – species that are, basically, inhabitants of still waters that may migrate to the rivers in spring and often remain there afterwards. The information that Wels occurs in that sector of the Arda has not been proven so far.

Identified Impacts

Since the data about the Arda ichtiofauna of the period before construction of the Dolna Arda Cascade are scarce, it is difficult to perform a thorough analysis of the changes that have occurred since that time. Obviously, after the river was developed, the Eel has disappeared from the fauna of that river, although there are verbal reports of eel catches in the later years in Ivailovgrad dam.

The results of ichtiological research during the period 1995-2000 show that the ichtiofauna in that sector is subjected to considerable negative impact by human activity. The main aspects of that impact are: pollution due to ore mining and floatation in the Madzharovo region (now terminated), intensive poaching and the run-off from Studen Kladenets dam. Currently the main factor that has the most significant negative effect on the development of ichtiofauna there remains the run-off from Studen Kladenets dam. The negative effect is due to irregular run-off conditions determined by the energy requirements in the first place and by the fact that water of permanently low temperature and with increased biogene concentration flows from the bottom strata of the dam into the river (in principle, that phenomenon is typical of bottom draining dams like most of the large dams in Bulgaria). With respect to Studen Kladenets dam, no “ecological” flooding of the river bed has been foreseen or performed due to which run-off fluctuations during operation and idle times of a hydro-power plant exert an even more drastic impact. At the same time the changes in the operation mode of HPP Studen Kladenets (with longer idle times), result in critical run-off reduction in the sector down to the mouth of the Krumovitsa.

Expected Effects of the Extension of HPP Studen Kladenets

The envisaged new construction could not have any negative effect on the river ichtiolofauna in the sector downstream of the dam, because in practice it will take place outside the river bed. The only precaution required is to plan measures against prevention of possible pollution with construction waste during construction works. At the same time, as a result of implementation of the planned works, improvement of the river environment downstream of the dam is expected thanks to the constant flooding and expected relative rise of the average temperatures during the vegetation period.

Amphibians and Reptiles

The rehabilitation of HPP Kardjali and HPP Ivailovgrad will have no impact on the herpetofauna.

The extension of HPP Studen Kladenets can be reviewed with a view to the current condition of the herpetofauna.

As a result of studies carried out in the region of Studen Kladenets dam, the rock gorge Shaytan Cupru and in the immediate vicinity of the plant (July 1965, May 1966, August 1979, March 1986, June 2005), the species composition is:

The following species have been proven in the region around the dam of Studen Kladenets and of the plant:

- Great Warty newt (Triturus karelinii)
- Agile frog (Rana dalmatina)

- Big water frog (Rana ridibunda)
- Yellow-bellied toad (Bombina variegata)
- European tree-frog (Hyla arborea)
- Macedonian lizard (Podarcis erhardii)

Other species proven near the proposed construction site are:

- Hermann's tortoise (Testudo hermanni)
- Iberian tortoise (Testudo graeca)
- European blind snake (Typhlops vermicularis)
- Light-green whip snake (Coluber najadum)
- Whip snake (Coluber caspius)

The first four species of the list above were established near the village of Studen Kladenets and the fifth – at the Studen Kladenets Game Preserve, near the village of Rabovo and between the village of Studen Kladenets and the village of Boynik.

It is highly probable to find also the following species widespread in the East Rhodopi:

- Great (common) toad (Bufo bufo)
- Green toad (Bufo viridis)
- Wall lizard (Podarcis muralis)
- Grass snake (Natrix natrix)
- Dice snake (Natrix tessellata)
- Horned viper (Vipera ammodytes)

There are no proven species entered in the "Red Book of Bulgaria" (vol. II – Animals, 1985) among those established. All species, except the Macedonian lizard, are entered in the Annexes to the Biological Diversity Act, State Gazette No. 77/09.08.2002.). All species are included in Annex Lists II and III of the Berne Convention. The annexes to Directive 92/93 of the Council of EEC contain all six species. The Warty (rested) newt and the European tree-frog, which are of higher conservation value, are also on the list of the International Union for Conservation of Nature, in the LR (low-risk) category.

Among the proven species found near the proposed construction site, only European blind snake inhabiting places with specific soil conditions is included in the Red Book of Bulgaria. It cannot be found on the rocky slope under which the pipeline will be laid. The two types of tortoises – Hermann's tortoise and the Iberian tortoise have a high conservation value and are included in the IUCN list, respectively in the LR and VU (endangered) categories as well as in the list of the CITES Convention (on international trade with endangered species). The other two species found near the plant (the Whip snake and the Light-green whip snake) are protected by the Biological Diversity Act, the Berne Convention and EEC Directive 92/93 as well as the three preceding species placed under stricter protection.

None of the species expected to be found are included in the Red Book of Bulgaria. The Annex to the BDA includes the two toads and the Horned viper; the Berne Convention includes all expected species; the lists attached to Directive 92/93 list the Green toad, the Horned viper and the Grass snake. There are no species protected by IUCN and CITES.

Only the Macedonian lizard occurs, in very limited numbers, in the region of the intended construction. It is a species frequently found in the East Rhodopi, including the valley of the Arda, and about 8 km to the west of the tail of Kardjali dam. The construction works will hardly cause anything more than to disturb some individual specimens near the construction site. All other species – proven, found in the vicinity and expected, will not be affected in any way because, even now, they do not occur in the proposed region of the construction. All amphibian species including the Great Warty newt and the Tree frog which have a higher protection status, can be found in the evorsion pits in the Shaytan Cupru gorge; both species of water snakes that have not been proven so far, can be found there. It is sure that at present the small rocky slope above the plant, where the pipeline will be driven is not inhabited by any reptiles of high conservation value (tortoises or the European blind snake). It is hardly probable to find the other species (the Whip snake, the Light-green whip snake and the Horned viper) due to the close proximity of sites where people are present all the time.

Mammals

The mammalian fauna is not affected by the rehabilitation of HPP Kardjali and HPP Ivailovgrad and the existing part of HPP Studen Kladenets. With respect to the extension of HPP Studen Kladenets, in spite of the strong impact of human activity on the sites of new construction, no impact on the mammal fauna is expected.

Ornitofauna

That region of the country as well as other parts of Kardjali District, were visited many times in 1989-2005. In connection with the extension of HPP Studen Kladenets the territory between the dam wall and the plant was explored in June 2005.

The rehabilitation of the three hydro-power plants has no impact on the ornitofauna.

List 1 presents the species of Class **Aves (Birds)** detected within that territory.

List 1

1. Gray heron (*Ardea cinerea* L.)
2. White stork (*Ciconia ciconia* (L.))
3. Black stork (*Ciconia nigra* (L.))
4. Goshhawk (*Accipiter gentilis* (L.))
5. Sparrow hawk (*Accipiter nisus* (L.))
6. Egyptian vulture (*Neophron percnopterus* (L.))
7. Common buzzard (*Buteo buteo* (L.))
8. Kestrel (*Falco tinnunculus* L.)
9. Yellow-footed gull (*Larus cachinans* Pallas)
10. Domestic pigeon (*Columba livia f. domestica* (Gmelin))

11. Wood pigeon (*Columba palumbus* L.)
12. Turtle dove (*Streotopelia turtur* (L.))
13. White dove (*Streptopellia decaocto* (Frivaldsky))
14. Swift (*Apus apus* (L.))
15. Pallid swift (*Apus palidus* (Shelley))
16. Bee eater (*Merops apiaster* L.)
17. Green woodpecker (*Picus viridis* L.)
18. Greater spotted woodpecker (*Dendrocopos major* (L.))
19. Crested lark (*Galerda cristata* (L.))
20. Swallow (*Hirundo rustica* L.)
21. Red-rumped swallow (*Hirundo dahurica* L.)
22. House martin (*Delichon urbica* (L.))
23. Crag martin (*Ptyonoprogne rupestris* (Scopoli))
24. Gray wagtail (*Motacilla cinerea* Tunstall)
25. White wagtail (*Motacilla alba alba* L.)
26. Robin (*Erithacus rubecula* (L.))
27. Nightingale (*Luscinia megarhynchos* Brehm)
28. Wheater (*Oenanthe oenanthe* (L.))
29. Blackbird (*Turdus merula* L.)
30. Mistle thrush (*Turdus viscivorus* L.)
31. Olive-tree warbler (*Hippolais olixemopym* (Strikland))
32. Blackcar (*Sylvia atricapilla* (L.))
33. Great tit (*Parus major* L.)
34. Red-backed shrike (*Lanius collurio* L.)
35. Golden oriole (*Oriolus oriolus* (L.))
36. Jay (*Garrulus glandarius* (L.))
37. Jackdaw (*Corvus monedula* L.)
38. Hooded crow (*Corvus corone cornix* L.)
39. Raven (*Corvus corax* L.)
40. Starling(*Sturnus vulgaris* L.)
41. House sparrow (*Passer domesticus* (L.))
42. Tree sparrow (*Passer montanus* (L.))
43. Chaffinch (*Fringilla coelebs* L.)
44. Green-fish (*Carduelis chloris* (L.))
45. Goldfinch (*Carduelis carduelis* (L.)
46. Linnet (*Acanthis cannabina* (L.))
47. Bunting (*Emberiza calandra* L.)
48. Cirl bunting (*Emberiza cirlus* L.)

As seen in List 1 48 bird species have been registered in the region where the extension of the hydro-power plant will be built. All species breed in that region. Within such a small territory, that species diversity can be defined as rich or, at least, relatively rich.

6 bird (Aves) species (List 2) of those listed above for the region of the construction site come under **Annex 2** (plant and animal species endangered with extinction and preservation of which is a priority) of the **Biological Diversity Act** (State Gazette No.77/2004, Section II – Protected Areas, Art. 6, item 4 (2) and (3)).

List 2

1. **White stork (*Ciconia ciconia* (L.))**
2. **Black stork (*Ciconia nigra* (L.))**
3. **Egyptian vulture (*Neophron percnopterus* (L.))**
4. **Griffon vulture (*Gips fulvus* (Hablizl))**
5. **Kingfisher (*Alcedo atthis* L.)**
6. **Red-backed shrike (*Lanius collurio* L.)**

A very small area will be affected by construction of the power plant extension and of the administrative & public services building and by laying of the pipeline.

Digging of the penstock (about 200 m) will not disturb the ground surface above it.

The construction of the administrative & public services building will cover part of the existing concrete platform to the north of and next to the hydro-power plant itself where there are no natural elements – plants or animal specimen except the few specimens of House sparrows inhabiting the site.

Operation of the hydro-power plant will not fatally affect the animal species using the river water for drinking and bathing. Ecological release of a certain quantity of water is envisaged in order to prevent drying of the river bed. The various bird species feeding with the species inhabiting the river (fishes, crustaceans, insects, etc.) and with underwater and surface vegetation will have better living conditions than the present, including the current feeding base.

Of the species in List 2 only migrating (mainly roaming) specimens of **Egyptian and Griffon** vultures that nest in that part of the country have been observed.

The two stork species, and the **Kingfisher** in particular, are related to the river downstream of the storage reservoir and of the site where they have been observed. Only the sixth species - the **Red-backed shrike** – has been observed near the site but outside the area to be affected. Besides, that species is quite numerous in this country.

A nesting couple of **Olive-tree warbler** – a rare species in this country, occurring only in the southernmost parts of the country on sunny mountain sides, including stony slopes with scarce ligneous vegetation, mainly fruticose species, has been registered near the construction site; however, the new construction will not affect the territory inhabited by the couple which is to the west of the site.

No protected natural sites are indicated on the territory of the site or near it. The Valchi Dol Reserve inhabited, among other species, by two species rare in the country - the **Egyptian and Griffon** vultures, is far enough from the site to the south of it. Taking into account the nature of the site, any negative impact on the reserve territory should be ruled out since such impact has never been reported during the operation of the existing HPP Studen Kladenets so far. Immediatelt to the west of the site is the eastern border of the Ornitologically Significant Site (OSS) Studen Kladenets Dam, and further to the south is the northern border of OSS Krumovitsa;

however, having in mind the nature of the facility, no negative impacts on these two OSS are possible either.

In these circumstances, there are no grounds for maintaining that the construction works and operation of the HPP Studen Kladenets extension will inflict irretrievable damage on the ornitofauna in that region of the country because it will not cause destruction of its habitats and thence – extinction of rare and endangered bird species.

- **Waste**

The rehabilitation of HPP Kardjali, HPP Studen Kladenets and HPP Ivailovgrad will be performed inside the buildings of the hydro-power plants. In terms of organization and technology it is actually identical to an overhaul. All waste generated during the rehabilitation are included in the Waste Management Plan of each plant developed for the case of maintenance works. Their quantity will be estimated in a further design phase.

During the new construction for the extension of HPP Studen Kladenets the generated waste types and their six-digit code indicated in the Waste List in Annex No. 1 of Ordinance No. 3/01.04.2004 of the Ministry of Environment and Waters and the Ministry of Health (SG No.44/25.05.2004) for waste classification are as below:

15. Waste packings
    - 15.01.01 – paper and cardboard packings;
    - 15.01.02 – plastic packings;
    - 15.01.03 – wooden packings;
    - 15.01.04 – metal packings.
17. Construction waste
    - 17.01.01 – concrete;
    - 17.01.02 – bricks;
    - 17.01.03 – roof and wall tiles, etc.;
    - 17.02.01 – wood;
    - 17.02.02 – glass;
    - 17.02.03 – plastics;
    - 17.04.05 – iron and steel;
    - 17.05.04 – earth and rock different from those mentioned under 17.05.03 .
08. Waste generated by use of coatings (paint, varnish)
    - 08.01.11* – waste paint and varnish containing organic solvents or other hazardous substances;
    - 08.01.12 – waste paint and varnish different from those mentioned under 08.01.11*.

The waste indicated above should be collected separately and, under contract with an appropriate contractor, transported to an agreed waste landfill. Particular caution shall be applied to disposal of waste bearing the code for hazardous (a code containing *).

Management of the waste generated during construction works shall be performed by the Investor and the Contractor of the Site.

After completion of the extension all waste generated during the construction works shall be removed from the construction site. The quantity of various waste types will be defined in the engineering and detailed design phase.

During operation of the three hydro-power plants after their rehabilitation the waqste types and quantities are those generated during the current regular operation of the hydro-power plants.

- ## Noise and Vibrations

Current Status

Rehabilitation of hydro-power plants of the Dolna Arda Cascade

The current noise source in the Project implementation territory is the main equipment of the existing HPP Kardjali, HPP Studen Kladenets and HPP Ivailovgrad – hydro-alternators and switchyard transformers. The turbines of the hydro-power plants are installed below the turbine building elevation and are not a source of noise in the environment. The three hydro-power plants are far from any settlements.

Extension of HPP Studen Kladenets

Power generation at HPP Studen Kladenets takes place in a definite mode. The walkdown of the site was carried out during the idle time of the plant. The only source of noise in the environment at that time were the switchyard transformers. The measured noise level at 5 m distance from them was 54,3 dBA. During operation of the hydro-power plant the noise level within its site is determined mainly by the noise of hydro-alternators penetrating into the environment through the building enclosures. The building is solid with a high percentage of glazed area of the exterior walls. On the generator floor the noise levels reach 94 dBA according to data from reports of the Haskovo Regional Inspectorate for Public Control and Health Protection on noise in the working environment. The noise levels on the HPP may reach 71-72 dBA in immediate proximity to the façade walls of the generator room which is near the standard noise level for an industrial area - 70 dBA.

Near the power house of HPP Studen Kladenets is the village of Studen Kladenets, situated about 500 m away from its site. The territory of the village is sufficiently far and naturally protected from noise by the rock formations surrounding the site of the plant in that direction. The same applies to the group of residential buildings for the plant operating staff situated about 100-200 m away from it. During operation of the plant the sanitary standard noise levels for residential areas (55 dBA in the daytime and 45 dBA at night) are not exceeded.

With its present operation HPP Studen Kladenets does not have an excessive noise impact on the environment.

Expected Noise Impact during Project Implementation

No changes of the current condition will occur during rehabilitation of the equipment at the three hydro-power plants.

During the construction works the activities related to repowering of the plant, performed by means of various machines, equipment and vehicles are a source of noise. The Project envisages construction of a new 166,61 m penstock, extension of the power house of the hydro-power plant, erection of two more turbines and two hydro-alternators, construction of a new administrative building. The construction works will be performed by traditional technologies encompassing various types of works (drilling and blasting to a limited extent, excavation, filling, boxwork, reinforcing, concrete placing, erection, haulage). The main machines used for the purpose will be: excavator, bulldozer, crane lorry, concrete pump, drilling equipment, cargo trucks.

The noise levels emitted during operation of the different types of machines are: excavator - 80÷91 dBA, bulldozer - 97÷105 dBA, crane lorry - 92÷98 dBA, drilling equipment - 105÷120 dBA, cargo trucks - 85÷90 dBA.

During blasting works, instantaneous noise pulses will be emitted. Their levels depend on the blasting system used. If included in the Project, such works will be of a limited scope.

All noise sources for the exception of cargo trucks will be concentrated on the hydro-power plant site where all constriction works will be carried out and where the construction equipment will be deployed. During simultaneous operation of some machines a total noise level on the plant site about and above 95 dBA may be expected. Construction works will be performed in the daytime only.

The expected level of the noise reaching the village of Studen Kladenets, in the case of unobstructed noise propagation is 47 dBA – below the sanitary limit for the daytime 55 dBA. In addition to its remoteness, the village is naturally screened off by the rock formations around the site of the plant. That screening effect of the ground relief is also observed with respect to the residential buildings of the plant operating staff. In the case of noise penetration from the construction works in that direction, the expected noise level reaching the area is about 65 dBA. Its impact will be felt only in the daytime for limited time periods.

The transport vehicles serving the construction works do not cross the village of Studen Kladenets. The few runs made by them will not have a significant disturbing effect on the territories along their route inclusive of the residential and administrative buildings of the operating staff of Dams and Cascades Enterprise situated on the right of the road to HPP Studen Kladenets.

During operation, after implementation of the Project, a new source of noise on the site of HPP Studen Kladenets will be the additional hydro-mechanical and electrical equipment installed in the power house. Repowering of the plant will be achieved by erection of two more Francis turbines: one 16 MW vertical-shaft and one 1 MW

horizontal-shaft complete with hydro-alternators. Their start-up will contribute insignificantly to the noise levelin the generator room (not exceeding 1 dBA), so no change in the noise conditions on the HPP territory is expected.

The extension of HPP Studen Kladenets will not have an excessive noise impact on the environment.

At all three hydro-power plants the rehabilitation, including the extension of HPP Studen Kladenets, will not have an excessive noise impact on the environment. No special measures are needed for protection of the environment against noise.

- **Risk**

The ecological risk at hydro-engineering facilities is mainly related to the operation safety of the hydro-power systems and facilities.

The Dams and Cascades Enterprise performs monitoring of the technical condition of the facilities. The three dam walls (with the highest safety grade) are equipped with a large number and various types of control and measurement instrumentation that constitutes the Control and Instrumentation system (C&I) of each dam. Regular measurements are performed in conformity with a special program. Visual inspections of all facilities (including the power houses) are performed twice in a year and inspection reports on their condition are drawn up. Assessment Reports on the condition of every dam wall are developed every three years and accepted by a Board of Experts of NEK-EAD with the participation of independent experts:

- The conclusion of the most recent Technical Board of Experts appointed by the CEO of NEK-EAD for the dam wall of Kardjali on 27.03.2003 is: The wall of Kardjali dam is in very good technical condition, and may be operated without restrictions.
- The conclusion of the most recent Technical Board of Experts appointed by the CEO of NEK-EAD for the dam wall of Studen Kladenets on 27.03.2003 is: The wall of Studen Kladenets dam is in very good technical and operating condition, performs as designed and may be operated without restrictions.
- The conclusion of the most recent Technical Board of Experts appointed by the CEO of NEK-EAD for the dam wall of Ivailovgrad on 10.03.2005 is: The wall of Ivailovgrad dam with its related facilities is technically in an operable state. It performs as designed and may be operated without restrictions.
- A seismic risk assessment was performed of Kardjali dam in accordance with the new regioning of the country. The conclusion was that the dam meets the requirements and may be operated without restrictions. A seismic risk analysis of the dam walls of Studen Kladenets and Ivailovgrad is forthcoming.

Three operation units were established at the hydro-power plants:

- hydro-engineering;
- mechanical;
- electrical.

Rhodopi HPP Group is in charge of operation of the mechanical and electrical equipment.

2. IMPACT ON SOME ELEMENTS OF THE NATIONAL ECOLOGICAL NETWORK, INCLUDING THOSE SITUATED IN THE PROXIMITY OF THE PROJECT SITE

None.

3. IMPACT TYPE (DIRECT, INDIRECT, SECONDARY, CUMULATIVE, SHORT-, MEDIUM- AND LONG-TERM, PERMANENT AND TEMPORARY, POSITIVE AND NEGATIVE)

The works performed in the process of rehabilitation of HPP Kardjali, HPP Studen Kladenets and HPP Ivailovgrad are comparable to the maintenance of machines. All impacts occur within the working environment.

For the extension of HPP Studen Kladenets the impacts are as follows:

During construction works the negative impacts are:

- on the free air – direct, short-term (within the construction works phase), temporary, without any cumulative effect;
- on the geological environment, soils, flora and fauna, landscape, noise – direct, permanent, without any cumulative effect. The impacts affect an area subjected to technogeneous influence on the construction sites of hydro-power plants (extension and administrative building).

During operation of the three hydro-power plants, the current condition of the environment will be preserved. During operation of HPP Studen Kladenets the water discharge rate will increase from 120 m^3/s to 150 m^3/s; the load upon the geological base under the new part of the building will increase; part of the area around the plant will be occupied by the extension; six locust trees will be cut and new vegetation will develop after the recultivation; the landscape will be changed to some extent (by the extension of the building).

These impacts are direct, permanent, long-term, without any cumulative effect.

The positive impacts after rehabilitation of HPP Kardjali, HPP Studen Kladenets and HPP Ivailovgrad are:

- achievement of high energy efficiency of power generation by the three hydro-power plants within the national power system and in the conditions of parallel operation with UCTE;
- reduction of the losses from unprocessed (overflowing) water at Studen Kladenets Integrated Hydro-power System and the possible related damage;
- assurance of the minimum permissible flow in the Arda downstream of HPP Studen Kladenets;
- gradual improvement of the condition of the river ecosystem in the sector HPP Studen Kladenets – the tail of Ivailovgrad dam;

- opening of about 80 - 100 job positions during the works envisaged by the Project (in regions with economic and social problems) as well as loading of the production capacities of the equipment manufacturing works and of the companies producing building materials;
- larger output of electric power from an everlasting and renewable natural energy source – водата.

4. SCOPE OF THE IMPACT

HPP Kardjali is within the Kardjali Municipality; HPP Studen Kladenets is on the territory of Krumovgrad Municipality and HPP Ivailovgrad is on the territory of Ivailovgrad Municipality. No settlements are affected by the works performed under the Project.

5. IMPACT OCCURRENCE PROBABILITY

The impacts indicated are directly related to the works envisaged by the Project.

6. IMPACT DURATION, FREQUENCY AND REVERSIBILITY

The duration, frequency and reversibility of every impact on environmental components and factors are presented in items IV.1 and 3.

7. MEASURES RELATED TO PREVENTION, MITIGATION OR REMEDY OF SIGNIFICANT NEGATIVE IMPACTS ON THE ENVIRONMENT THAT SHALL BE INCLUDED IN THE PROJECT

The Measures that shall be envisaged for prevention, mitigation or remedy of significant negative impacts on the environment are:

During development of the Engineering and Detailed Design:

- To create the organization and technology for performance of excavation, lining and concrete works in the underground penstock and the extension of the hydro-power plant depending on the proximity of facilities of HPP Studen Kladenets.
- To seek the most acceptable architectural solution for the new part of HPP Studen Kladenets and the administrative building, by developing an overall profile showing how the ensemble fits into the surrounding landscape.

During Construction:

- To reduce the risk of dust pollution in hot and dry weather, the construction site of the extension of HPP Studen Kladenets shall be sprinkled with water.
- The effluent from the construction site of the extension shall outfall into the Arda after passing through a mechanical settling tank.
- Perform daily inspections of the construction equipment (for oil spills). The malfunctioning construction machines and transport vehicles shall not be used.
- After completion of the construction works, seek an opportunity to provide fertile soil for biological recultivation of the site of the extension of HPP Studen Kladenets.
- Pursuant to the requirements set by the Water Act, install flow meters on the new machines.
- Include the waste generated during the rehabilitation in the Maintenance Waste Management Plans of the three hydro-power plants.
- The construction waste from the extension and administrative building of HPP Studen Kladenets shall be collected, kept in temporary storage, transport and disposed in conformity with the Waste Management Act.
- The maintenance personnel shall work with ear muffs during rehabilitation of the hydro-power plants while the available capacities are operating.
- Provide suitable workclothes and personal protection means (helmets, safety belts, isolating gloves, etc.) to the construction workers.

During Operation:

The environmental protection problems of Dolna Arda Cascade do not arise from implementation of the Project for rehabilitation of the three hydro-power plants and the extension of HPP Studen Kladenets.

Dolna Arda Cascade has almost the longest service life (after the Batak Hydro-Power system, the Iskar Cascade). It is important for the country to perform an investigation, analysis and assessment of the impact of the Cascade on both the economic and social development of the regions as well as on the environment. On the basis of the results, to introduce certain amendments (without prejudice to their energy and cost efficiency) in the operating modes of the water reservoirs with a view to their strong impact on the trofic response of the ecosystem. That applies to release of the high waters through the bottom outlets, lake level control during the vegetation period, pollution source control in the water catchment areas, development of a complete weather characteristic of the region, etc., many of which were discussed in the process of developing the EIA Report for Gorna Arda Cascade.

After nearly 40 years of operation, performance of such a large-scale study by a multidisciplinary team (similar to that for the Batak hydro-power system performed in three years) is necessary and justified.

8. CROSS-BORDER NATURE OF THE IMPACTS

None. The border is far enough from HPP Ivailovgrad and the rehabilitation does not change the operation conditions established throughout the operation period of the system.

APPENDICES

1. **PLAN OF DOLNA ARDA CASCADE**
2. **CADASTRAL MAP OF THE SITE OF HPP STUDEN KLADENETS**
3. **LAYOUT PLAN – OPTIONS**
4. **DRAWING NO. 205-35023**
5. **DRAWING NO. 205-35022**
6. **DRAWING NO. 205-35021**
7. **DRAWING NO. 205-35028**
8. **PHOTOGRAPHS NO. 1 TO NO. 9**
9. **REPORT NO. 636/2004**
   NO. 633/2004
   NO. 124/28.03.2005
10. **CONCENTRATION DATA FOR THE RIVER VALLEY DURING THE PERIOD 01.01.2004 – 01.01.2005**

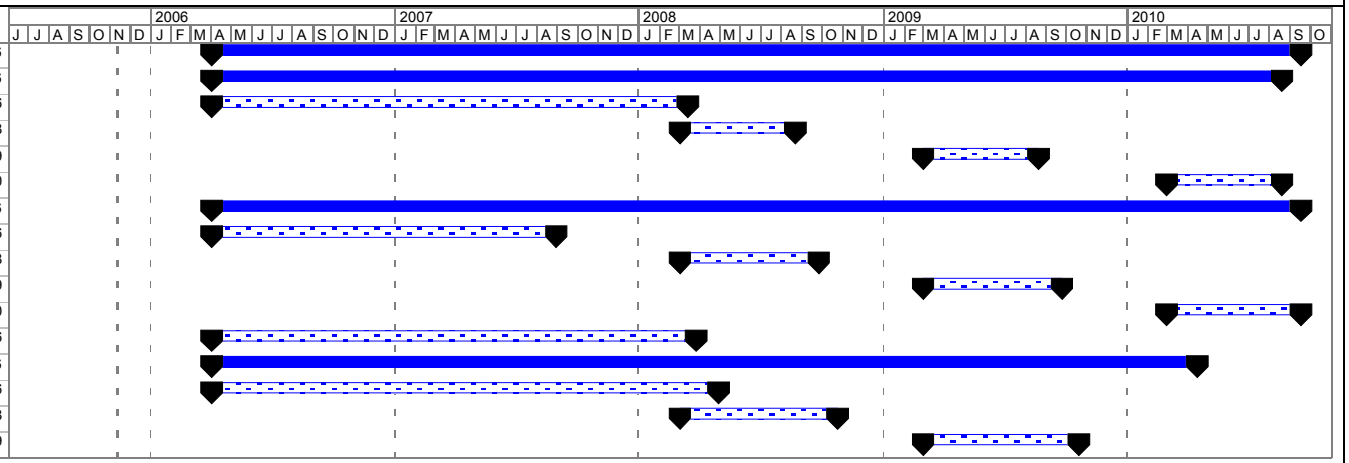
Annex 11

TIME SCHEDULE DOLNA ARDA

Dolna Arda HP Cascade

Annex 4 PDD Time Schedule Dolna Arda

Nr.	Task Name	Dauer	Anfang
1	**Dolna Arda Rehabilitation Project**	**1165 Tage**	**Mon 03.04.06**
2	**Kardjali HPP**	**1145 Tage**	**Mon 03.04.06**
3	Unit 1	510 Tage	Mon 03.04.06
4	Unit 2	125 Tage	Mon 03.03.08
5	Unit 3	125 Tage	Mon 02.03.09
6	Unit 4	125 Tage	Mon 01.03.10
7	**Studen Kladenets HPP**	**1165 Tage**	**Mon 03.04.06**
8	Unit 1	369 Tage?	Mon 03.04.06
9	Unit 2	150 Tage	Mon 03.03.08
10	Unit 3	150 Tage	Mon 02.03.09
11	Unit 4	145 Tage	Mon 01.03.10
12	Additional Turbines	518 Tage	Mon 03.04.06
13	**Ivailovgrad HPP**	**1054 Tage**	**Mon 03.04.06**
14	Unit 1	542 Tage	Mon 03.04.06
15	Unit 2	170 Tage	Mon 03.03.08
16	Unit 3	167 Tage	Mon 02.03.09



Project: TimeSchedule Dolna Arda
Date: Fre 11.11.05

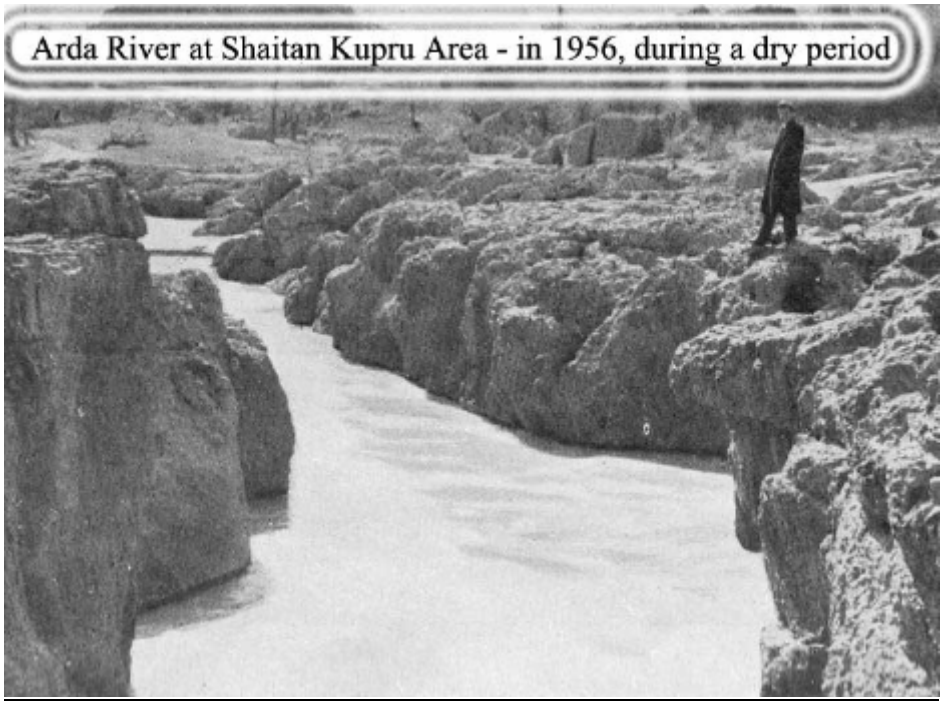
Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Annex 12

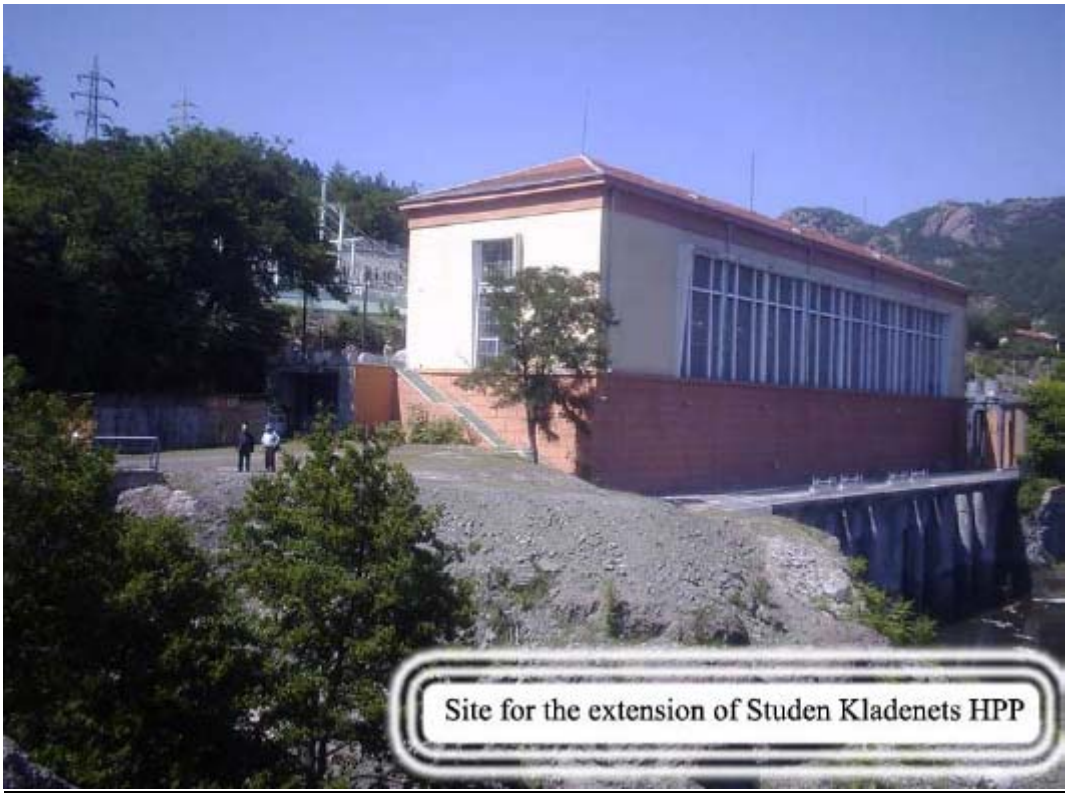
PICTURES OF THE HPP AND THE CASCADE RESERVOIRS

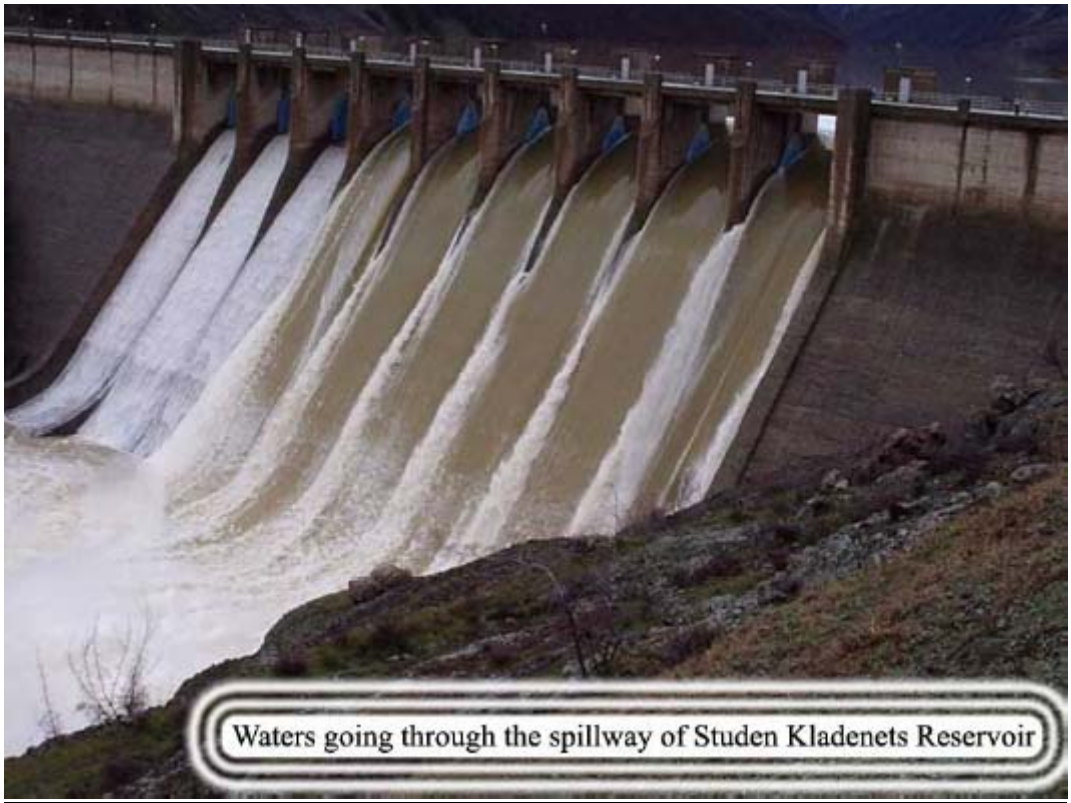
View of Studen Kaldenets Reservoir

Annexes 5-14 PDD Dolna Arda



View of Studen Kladenets HPP


Site for the extension of Studen Kladenets HPP

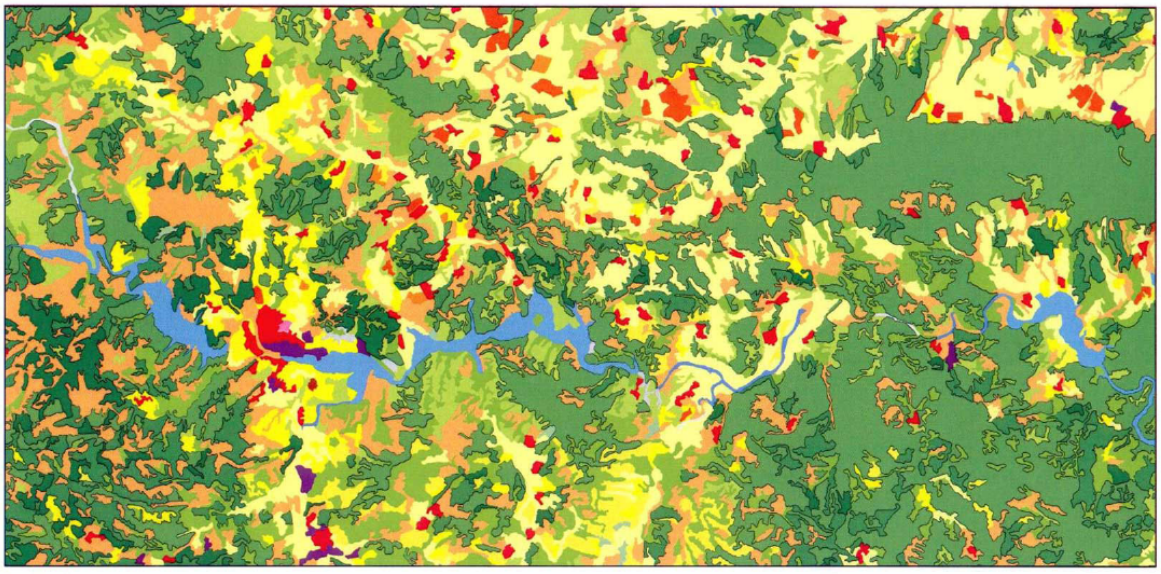

Waters going through the spillway of Studen Kladenets Reservoir

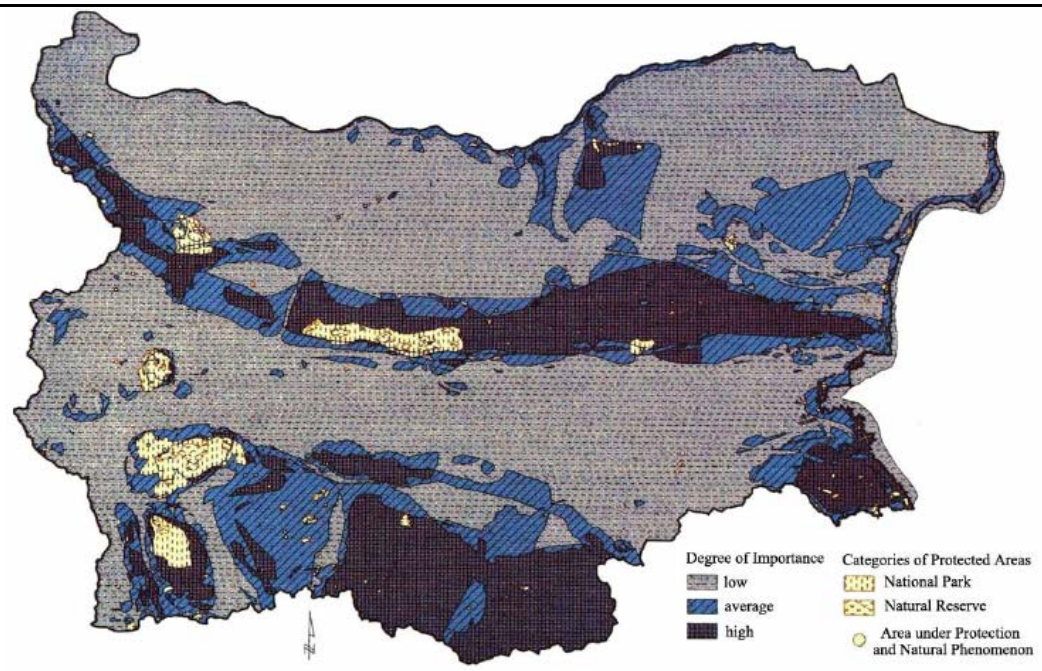
Annexes 5-14 PDD Dolna Arda

Annex 13

MAP 7 GAP ANALYSIS

CORINE LAND COVER – PART OF THE EASTERN RHODOPES





Map 7. Gap Analysis

The degree of importance of the different regions is determined on he grounds of summarised data of species diversity, endemic and rare taxons and these data accumulation on the map of protected areas of over 100 hectares.

Annexes 5-14 PDD Dolna Arda

Annex 14

OPINION KRUMOVGRAD MUNICIPALITY

MUNICIPALITY OF KRUMOVGRAD

To:
The Executive Director
NEK EAD
Sofia **15.09.2005**

Copy to:
The Executive Director
Regional Inspectorate on Environment and Waters
Haskovo

Dear Sirs,

Enclosed hereto, please find the opinion expressed by the Mayor of Krumovgrad Municipality regarding the Project for Rehabilitation of Dolna Arda Hydro Power Cascade.

Yours sincerely,

Sebihan Mehmed
Mayor
(signature and stamp)

Enclosure: Opinion

OPINION
of the Mayor of Krumovgrad Municipality
Sebihan Mehmed

Regarding: Project for Rehabilitation of Dolna Arda Hydro Power Cascade.

The Krumovgrad municipality expresses an affirmative opinion on the envisaged rehabilitation of the hydro power cascade, in particular rehabilitation of the existing hydro power units and installation of an additional hydro power unit of 1 MW capacity in Studen Kladenets HPP. Besides, the increase of the energy capacity of the hydro power plant, which is a very good solution, will result also in achieving of an environmental protection effect along the valley of Arda River towards Ivailovgrad Reservoir, as well as for restoring the river ecosystem. So far, we have not received any information related with comments, recommendations or proposals on behalf of the citizens. The only thing we are concerned about is related with the issue of high waters during pouring rains in the catchment areas of Arda River and Krumovitsa River at the same time, which might cause some floods in the villages located on the municipality territory after Krumovitsa River flows into Arda River, since there aren't any protective embankments. It should be good, if possible, to install sensors for signalization in case of water level increase in Arda River above the normal values during spring and autumn-winter periods for earlier warning.

Sebihan Mehmed
Mayor
(signature and stamp)