



DEVELOPMENT  
AND  
INVESTMENT PLAN  
2018 – 2022

Skopje, March 2018

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# DEVELOPMENT PLAN

2018 – 2022

## **Aims and strategic determinations**

Development and investment plan of AD ESM for the period 2018-2022 defines the medium-term development of the company in order for the company to appropriately respond to the market conditions and to place acceptable market product where AD ESM can be competitive on the electricity market taking into consideration the upcoming liberalization of the electricity market.

The aims of AD ESM for the period 2018-2022 are as follows:

self-maintenance in market conditions ,  
increased profitability,  
participation on the regional electricity markets and  
increasing the installed power from renewable sources .

In order to achieve the main aim, AD ESM is planning to realize the following priority investment activities:

increased production from renewable energy sources,  
maintenance, rehabilitation and modernization of existing facilities as well as construction of new for heat and Electricity production,  
utilization of the domestic resources (lignite reserves) for electricity production,  
energy efficiency achieved by taking few measures for optimization of costs due to increasing of the generation ,  
increasing the use of natural gas .

Due to providing energy safety, acceptable market product is necessary and in order to decrease the risks, there is need of variety of energy resources in accordance to types and sources which will provide proposed development plan.

Regarding the obligations for environmental protection, special attention is paid to the requirements from the Environmental Law and which refer to environmental impact assessment of the projects and the system for managing integrated plans. At the same time, it is planned coordination with the directives of EU (IED Directive 2010/75/EU) and providing highest standards regarding environmental protection where the emissions of CO<sub>2</sub>, SO<sub>x</sub>, NO<sub>x</sub> and dust are decreased in accordance with the permitted emission in EU after 2016.

For the concrete realization of the projects, predicted with the development plan of AD ESM, it is necessary to be determined in advance the use of different financial sources: own funds, providing loans from financial institutions and commercial banks, state grants, public-private partnerships and other innovative approaches.

The planned projects are in accordance with the national strategies stated as follows:

- Development strategy of the energy power system in Republic of North Macedonia 2010 – 2030 - *(Ministry of economy, prepared by MANU, 2010)*;
- Revised development strategy of the energy power system in Republic of North Macedonia 2015 - 2035 година - *(Ministry of economy, prepared by MANU, ongoing)*;
- Strategy for use of renewable energy sources in republic of North Macedonia 2010 - 2020 - *(Ministry of economy, prepared by MANU, 2010)*;
- Energy efficiency strategy 2010 - 2020 - *(Ministry of economy, prepared by MANU, 2010)*;
- National plan for decreasing of emissions - *(Ministry of environment and physical planning, 2016)*;
- Unique list of projects which is prepared from department lists of projects based on the Program by the Government of Republic of North Macedonia , *(National Investment*

*Committee H).*

AD ESM in the following period, aiming to provide stable market product, will be focused on supplying base energy, decreasing of operation costs through supplying of mining equipment and opening of the new mine Underlying coal series (UCS) "Suvodol", providing continuity in supply with fuel of REK Bitola as well as activities connected to modernization and rehabilitation of REK Oslomej.

At the same time, following the necessities of the electricity markets, AD ESM is focused on initializing of the construction of HPP Cebren and HPP Galiste as well as reactivating of the idea for utilization of hydro potential of Vardar river.

Taking into consideration the positive experiences from the construction of wind park Bogdanci – first phase, AD ESM is planning to finalize the project entirely in the following period and to initialize the construction of new wind park Miravci.

Regarding the environmental impacts which is result of exploited mine in REK Oslomej, the land of this mine should be returned in the initial condition. AD ESM is planning to execute the recultivation of the land with construction of photovoltaic power plant (PVPP) which will be used as renewable source of electricity. The construction of PVPP in TPP Oslomej will enable larger participation of renewable energy sources for 10 MW.

AD ESC is planning to realized the following projects in the medium-term period 2018-2022

## **1. MINING EQUIPMENT FOR THE MINES IN REK BITOLA**

**Project type:** Coal mine

**Geological reserves:** 163.000.000 t

Deposit	PJS Suvodol	Brod Gneotino	<b>Total</b>
Quantity [t]	55.000.000	108. 000.000	<b>163.000.000</b>

**Exploitation reserves:** 72.000.000 t

Deposit	PJS Suvodol	Brod Gneotino	<b>Total</b>
Quantity [t]	50.000.000	22. 000.000	<b>72.000.000</b>

**Project status:** Preparation of request based on which there will be financing of the project

### **Project description**

The procurement of the mining equipment for the mines in REK "Bitola" refers to the following mines: •

- Underlying coal series(new mine) "Suvodol" •
- Existing mine "Brod – Gneotino" •
- Support mechanization for the mines' necessities

The area of the Underlying coal series deposit (UCS) "Suvodol" is located within the exploitation field of the "Suvodol" mine and has surface of around 3km<sup>2</sup>, in other words 1/3 of the total area spread over with the main coal seam (around 10km<sup>2</sup>). The Underlying coal series complex lays under the main productive seam of the Suvodol deposit and in it 1÷18 coal seams are separated. The average depth of the coal seam in the UCS amounts 14,97 m.

Through analysis and interpretation of the so far performed reserach works for exploration of UCS, as economically interesting two underlying coal seams are separated: the first underlying coal seam and the second underlying coal seam, in other words the main seam of the UCS.

During the year 2004 detailed geological and geotechnical additional explorations were performed and technical documentation was prepared, during which, the necessary parameters regarding geology, engineering – geological and geo-technical characteristics were taken.

Geological reserves of 55.000.000 tons of coal were established with this reserach works, out of which the exploitation reserves are around 50.000.000 tones, with stripping ratio of 1: 4,7 cubic meters per ton.

The technology for exploitation of the Underlying coal series "Suvodol" is performed with continuous ECS(Excavator-Conveyor belt-Spreader) systems with use of the part of the equipment of open pit Suvodol. And after finishing of the coal excavation from the main productive seam a procurement of new ECS system is planned. The coal conveyance that is excavated from the UCS will be done through the present conveyance system that is used in the "Suvodol" mine.

As an integral part of the Pelagonian tertiary basin, the "Brod – Gneotino" deposit, from geological point of view, bears all characteristics specific for the sedimentation environment of the basin, in other words is similar with the deposits "Suvodol" and "Zivojno".

The thickness of the individual coal seams, stated in certain drill holes, is characterized with great variability, which ranges from 0,2 to 7,5 m, and it should be noted that this characteristic is typical also for the thickness of each individual coal seam, because it is very variable as in horizontal also in vertical direction of its extension. The cumulative thickness (formed by the sum of the individual coal seams, as calculated from the drill holes data), ranges from 0,40 m. to the maximal 17,20 m., in other words calculated as average about the whole deposit (according to the cumulative thicknesses of the coal seams in the individual holes) amounts 8,57 m., while the relative depth at which the seam of the productive formation is found, is from 7,8 m. to 222,80 m.

The surface coal pit mine "Brod – Gneotino" is opened and in phase of exploitation. With the main mining project, since 2006, as exploitation reserves are anticipated around 34.000.000 tons of coal, with previously determined capacity of 2.000.000 tons per year. The excavation of overburden is done in accordance with the main mining project for opening and exploitation of SPM "Brod – Gneotino" with engagement of continuous technology (ETS systems), while excavation of the coal and intermediate seams overburden is done in accordance with the simplified mining project with application of discontinuous technology in other words cyclical mechanization.

For excavation of overburden two bucket wheel excavator type SRs 2000 and three dragline excavators (ES-10/70 and two ES-6/45) are engaged, while, again, the excavation of the coal and intermediate seams overburden is done with discontinuous equipment i.e. with dump trucks and with hydraulic excavators.

### **Significance of the project**

The following benefits would be enabled with the procurement of the mining equipment:

Extension of the life expectancy of the thermal power plants in REK "Bitola" in the following 15 years, with opening of the coal underlying coal series i.e. the mine "Suvodol";

Reduction of the operating costs during coal excavation from "Brod – Gneotino" through procurement of mechanization for discontinuous coal excavation;

Reduction of the operating costs for engagement of support mechanization by external firms – contractors.

### **Investments**

For realization of this project 19.000.000 Euros are needed for auxiliary mechanization and 22.000.000 Euros for procurement of cyclical mechanization or in total 41.000.000 Euros.

The delivery of the mining equipment would begin successively after signing of the contract.



## **2. COAL MINE ZIVOJNO**

<b>Project type:</b>	Coal deposit
<b>Geological reserves:</b>	101.684.407 t
<b>Exploitation reserves:</b>	20.500.000 t (underground exploitation) and 32.700.000 t (surface exploitation)
<b>Project status:</b>	Revised main mining design for underground exploitation and analysis for surface exploitation are prepared up to concession level respectively cost benefits study.

### **Project description**

Deposit "Zivojno" is the third main coal deposit in Pelagonia region and it is located approximately 35km southeast of town Bitola to the border between Republic of North Macedonia and Greece or 20 km from mine Suvodol and it is extension of mine Brod-Gneotino. It is expanded to the border line with Republic of Greece on south, village Zivojno on east, village Germian on west, to the river Crna on north and spreads over an area of cca 20 m<sup>2</sup>.

The investigations in deposit Zivojno are executed in few phases starting from 1966, 1973, 1982 and 1984. According to these investigations, Elaborates for mine coal reserves with condition are obtained and the same are considered for the last additional researches in 2012 and during their elaboration.

The coal in the deposit is in more layers. Regarding the tectonics, there is considerable number of faults, and coal seam is divided in numerous blocks which according to the height are mutually displaced up to 30 m which complicates the conditions and coal excavation when exploitation is considered. This is especially important if it is considered the proposed underground technology in the techno-economic elaborate for Zivojno with preliminary perception of possibilities for exploitation and use of coal from Zivojno as energy fuel. The fact that so far in Republic of North Macedonia there are no experiences with underground coal exploitation, it gives additional weight to the entire project realization as first of that kind in our country.

Preparation of main mining design started in July 2015 and it was finished with obtaining of positive revision clause in December 2017. According to preliminary conception, there is possibility of exploitation of open pit mining including reserves with quantity of 32.700.000 t, with underground exploitation (20.500.000 t) there are totally 53.200.000 t of coal. In accordance with these primary perceptions, manners of coal exploitation in Zivojno are complemented with the possibilities for applying of open pit mining exploitation technologies.

### **Significance of the project:**

Annual capacity of 2.000.000 t coal are planned with open pit mining exploitation while with underground exploitation of the Zivojno mine there is planned capacity of 1.000.000

t coal annually.

The planned annual capacity of 2.000.000 t coal from open pit mining exploitation from the Zivojno mine combined with coal from open pit coal mines (Underlying coal series – Suvodol and Brod-Gneotino) enables quantities of 6.500.000 t coal annually for period of fifteen years. These quantities would enable continuous operation of TPP Bitola in the following period.

### **Technical parameters**

<b><i>Technical parameter for coal deposit Zivojno</i></b>	
Geological reserves	101.684.407 t
Lower heating value	7.452(kJ/kg)
Lower heating value	1.782 (kcal/kg)
Humidity	46,57(%)
Ash	19,14(%)
Sulfur	0,83 (%)

### **Investments**

According to the existing main mining project for underground exploitation from 2017 for opening of the mine for underground exploitation Zivojno, there is necessity of investment of 122.500.000 Euros.

After preparation of main mining design for open pit mining exploitation, there will be more precise defining project value for investment for opening of mine. According to the existing conception (Study) for open pit mining exploitation, there is need for investment of approximately 180.000.000 Euros with designed exploitation reserves of approximately 32.700.000 t coal.

The assets necessary for opening of the mine is planned to be provided from own financial sources in amount of 15% while remaining part of the investment in amount of 85% will be provided through loan.

### **3. DETAILED GEOLOGICAL ADDITIONAL RESEARCHES IN BROD-GNEOTINO**

<b>Project type:</b>	Coal deposit
<b>Geological reserves:</b>	68.000.000 t
<b>Exploitation reserves:</b>	There is necessity of mining –technical analyses respectively study for assessment of these reserves
<b>Project status:</b>	Prepared and revised elaborates for additional detailed geological researches (Phase 1)

#### **Project description**

The coal deposit Brod-Gneotino is situated south from the area of deposit Suvodol i.e. at distance of 10 km. It is situated between villages Ribarci to the north, Tepavci and Brod to the east, Egri to the west and Crna River to the south. It is spreads over 10 km<sup>2</sup>, and it is elevated on 510÷650 m. The deposit is connected to the surrounding villages with access village roads and it is connected through those roads with the city of Bitola and Suvodol mine with asphalt road of second degree. The villages Brod and Gneotino, which are included in the deposit as well as the surrounding villages Tepavci and Egri are less populated, while the population in Novaci village and city of Bitola and the remaining older population which lives in this area are working in agriculture and stockbreeding.

In its development policy for prompt providing of exploitation coal reserves and extending of the lifetime of the thermal power plant in REK Bitola, AD ESM is performing appropriate activities in the region where there are discovered and researched emergences of coal. This area is the coal deposit Brod-Gneotino, situated between active surface mine Suvodol and potential coal deposit Zivojno at the end south-east part of Pelagonija Valley.

The deposit is subject to researches for a longer time period and thus these additional researches should be considered as continuity of activities which with certain interruptions are followed since 1974. In 1992, multipurpose researches and more inclusive examination were performed and appropriate pre-categorization of mine reserves from B to A was made. Project by the Faculty of Civil Engineering – Skopje was prepared in 1998 and it defined necessary works respectively documentation as base for preparation of investment program, where investment cost necessary for realization of these complex researches will be considered. These examinations and researches are realized in the period 2000-2001. Based on this examinations as well as on the above mentioned project concept, there are prepared elaborates which are result of analysis and reinterpretation of all researches and examinations including summarized with specification form the project from 1998 respectively obtained results from the research phase. The result from the activities in the stated period until now are the appropriate mining- geological and geo technical researches and examinations and the same are presented in various elaborates and reports.

The removing of coal waste and excavation of main coal seam in Brod-Gneotino started in

November 2007 and it is continuously ongoing until today. The first coal quantities from the mine Beod – Gneotino are excavated in April 2010 and the main belt conveyor system for coal transport is commissioned in July 2012 from Brod-Gneotino to the thermal power plant in REK Bitola with length of approximately 10 km.

As a last phase in the research during 2013, project for geological and geotechnical additional researches and examination is prepared for the coal deposit Brod-Gneotino – REK Bitola by the Faculty of Civil Engineering, Skopje. The project defines research and other works based on type, quantity, location, manner of realization, etc. mainly from geological and geotechnical aspect. It is very important precondition for obtaining substantial and concrete respectively continuous data connected to geological structure, tectonics, engineering-geological, hydrogeological and geo-mechanical characteristics of the terrain. It means entirely relevant parameters for designing and elaborating of the technology for excavation of waste and coal.

Based on this project, there was beginning of activities at the end of 2014 for realization of the contract concluded between JSC North Macedonian Power Plants, Skopje and group of bidders: Institute of Civil Engineering Macedonia (GIM) AD Skopje and GEING Krebs und Kifer International, etc. DOO Skopje with the following subject: “Performing of geological and geotechnical additional researches and examinations of coal deposit Brod-Gneotino” (phase 1).

In the period while additional researches were being performed, at the same time, there was constant expert supervision by the supervisory body Geohidroinzenering DOOEL Skopje as well as occasional project supervision by the Faculty of Civil Engineering Skopje. The activities with all planned drilling, mapping, testing, analysis and appropriate elaborates (with positive revising clause) of executed works was done in May 2017.

After finishing all works planned with the project and contract, the obtained results are systemized in few elaborates with synthesis character where all results from all phases of the researches are presented. This means that all separate profiles of research drills from the previous phases should be presented in the elaborates respectively all recent knowledge is integrated together with the latest results through the following technical documentation:

- Elaborate for classification, categorization and calculation of coal reserves,
- Elaborate from engineering – geological and hydrogeological researches and examinations,
- Elaborate from geo-mechanical researches and examinations
- Elaborate for examination of self-inflammability and content of gas of the deposit.

***Project significance:***

The recent knowledge based on the research works and the fact that there is active mine for surface coal mining (first quantities of waste excavated in 2007 and first coal quantities - 2010), justifies the reasons for additional research of coal seams, north and northwest of SM Brod-Gneotino where seams infiltrate in larger depth. The coal reserves situated in these layers are seriously large potential quantity of energy raw material which would contribute for extending the lifetime of REK Bitola with exploitation.

### **Technical parameters**

<b>Technical parameters for the coal deposit Brod-Gneotino (2014÷2016)</b>	
Geological reserves	68.000.000 t
Lower heating value	8.879(kJ/kg)
Lower heating value	2.121 (kcal/kg)
Humidity	46,95(%)
Ash	14,37(%)
Sulfur (total)	0,79 (%)

### **Investment costs**

The total amount for execution and supervision of the detailed geological additional researches (phase 1) of 3.471.214,80 Euros is provided of own financial sources of AD ESM. For execution and supervision of research-exploitation well fields from phase 2, there are planned assets of approximately 520.000 Euros which will be provided also from own financial sources of AD ESM.

#### **4. MODERNIZATION AND REVITALIZATION OF TPP OSLOMEJ**

<b><i>Project type:</i></b>	Electricity production
<b><i>Installed power:</i></b>	125 MWeI
<b><i>Electricity production:</i></b>	700 GWh
<b><i>Project status:</i></b>	There is prepared feasibility study

##### **Project description**

TPP Oslomej, is the second thermal power plant (by install capacity) in Republic of North Macedonia , which produces around 10% of domestic electricity production. TPP Oslomej has a total installed power of 125 MW and it was commissioned in 1980.

This thermal power plant currently uses the last reserves of local lignite mine Oslomej - West (Basin Kicevo) as primary fuel with an average calorific value of 7,600 kJ / kg, the specific consumption of 1,5 kg / kWh, additional specific consumption of fuel oil from 2,16 gr / Wh.

Due to depletion of the available coal reserves and the serious obstacles that stem from socio - cultural environment in relation to the exploration of the site Popovjani (Kicevo basin) with exploitation reserves of 9,000,000 tons, this power plant is facing significantly with uncertainties regarding supply fuel.

In order to extend the operational life of TPP Oslomej, in 2015 year a Feasibility Study was prepared by renowned consultants for modernization of the plant by using imported coal with higher calorific value.

The study contains an analysis of the potential suppliers of coal with higher calorific value with quantitative and qualitative confirmation (certificate) and safety analyzes for the period that follows.

Modernization of TPP Oslomej according to the feasibility study predicts:

- replacing the steam boiler with new one,
- modernization of turbine equipment,
- automation of the unit, generator,
- auxiliary equipment for coal management,
- waste waters treatment, and
- equipment for decreasing of exhaust gases emissions in accordance with the new European regulations.

AD ESM in 2014 prepared qualitative and quantitative analysis of different options for supplying of TPP Oslomej with fuel. In accordance with the decision by the Government of Republic of North Macedonia , AD ESM published Public Procurement in 2015 for selection of consultant for preparation of analysis for the possibilities of supplying of TPP Oslomej with natural gas. The final version of the analysis was prepared by the Consultant in February 2016.

In order to determine more precisely and to additionally check the data contained in the analyses for supply with fuel of TPP Oslomej (coal and natural gas), AD ESM engaged reviser for analysis revision. The final revision report regarding supply of TPP Oslomej with fuel is submitted to AD ESM in September 2016. At the end of 2017, there were established

contacts with companies (contractors with numerous references regarding TPP with coal) which offered few indicative variants for options with supply of coal and revitalization of TPP Oslomej.

Based on the directions of reputable companies for revitalization of TPP Oslomej, it is necessary AD ESM to invest priority equipment (steam boiler) in amount of approximately 45 million Euros.

***Significance of the project:***

The strategic goal is to diagnostic of the current condition of TPP Oslomej in order to expand the lifespan of the power plant in accordance with national requirements and the environmental requirements of EU and providing long-term and sustainable supply of coal.

***Technical parameters for modernized TPP Oslomej***

The technical parameters of the modernized TPP Oslomej are defined in the Feasibility Study and they will be defined after selection of the most appropriate model for rehabilitation of boiler and other equipment. It is planned to increase the current installed power, while the steam parameters remain unchanged (steam flow 380 t/h and pressure 130 bar) in order to use the existing turbine equipment which will be subject to a process of revitalization in future and at the same time the capital investments for the equipment will be decreased.

***Investment Costs***

The total investment for the first phase of revitalization of TPP Oslomej is estimated at 45 million Euros.

## **5. REVITALIZATION AND MODERNIZATION OF TPP BITOLA**

**The Project revitalization and modernization of TPP Bitola** includes three realization phases as follows:

1. Revitalization and modernization of the turbines, generators and automation in TPP Bitola
2. Revitalization and modernization of TPP Bitola with decreasing of the NO<sub>x</sub>
3. Revitalization and modernization of TPP Bitola with decreasing of SO<sub>x</sub> and dust
4. Modernization of the cooling towers

The Power Plant has been in operation more than 30 years. The 3 units in TPP Bitola started with operation in 1982, 1984 and 1988 respectively. Each unit separately after finalized revitalization and modernization of TPP Bitola – phase I, has a capacity of 233,2 MW<sub>el</sub> and consumes annually about 2 million tons of coal.

The contract for revitalization and modernization of turbines, generators and automation was signed in December 2009 with the Russian company Silovie Masini. The project was realized in the period 2010-2012, each year one unit and it was finalized in November 2012. The total value of the project is 56,83 million Euros. This modernization extends the lifetime for 120.000 hours and increases the power of each unit for additional 8,2 MW.

### **Revitalization and Modernization of the boilers and decreasing of NO<sub>x</sub> in TPP Bitola – phase II**

**Project type:** Electricity production

**Increasing boilers efficiency:** It is planned increasing of the efficiency to 86,5% and decreasing of NO<sub>x</sub> gases and extension of the operation lifetime for 120.000 hours

**Project status:** Boilers 2 and 3 are modernized while the contract for boiler 1 is not extended. There is a process of legal procedure for payment of guarantees and compensation of damages.



### **Project description:**

This project is planned to include:

- Increasing of boilers efficiency to 86,5%
- Providing production of 700 t/h superheated steam (545°C, 140bar), with work of 5 mills and coal with decreased and variable calorific value in range of 6179 to 8101kJ/kg
- Examination and determining of existing condition of heating areas, replacing the same in accordance with examination results, and at the same time, extending their lifetime for 120.000 hours
- Examination and modification of the system for preparation of coal dust, aero mixture, as well as combustion system in order to be provided reduction of NOx during work with coal with variable and worsen quality. After accomplished modernization NOx emission must not be higher than 200mg/Nm<sup>3</sup> (in accordance with Directive 2001/80/EC)

### **Project significance:**

Project for revitalization and modernization of TPP Bitola – phase two includes:

- Extending the lifetime of boilers for at least 120.000 hours;
- Increasing of boilers efficiency;
- Decreasing of NOx emission.

### **Investment costs**

The total amount of investment for all three units is 88.500.000 million Euros for all three units without participation of Hermes insurance which amounts 8.500.000 million Euros for all three units.

For financing of the project for revitalization and modernization of TPP Bitola with reduction of NOx, for units 2 and 3, AD ESM concluded Agreement for loan with state guarantee on 24.82012 with Deutsche Bank in amount of 49.232.018,00 million Euros with included Hermes insurance.

The total value of the investment for the project revitalization and modernization of TPP Bitola with decreasing of NOx for unit 1 is 29.416.000 Euros, out of which the amount according to the Loan Agreement with state guarantee with Deutsche Bank is 24.328.674,21 Euros with included insurance for loan in amount of 2.450.000 Euros. The remaining necessary assets for part of the investment for realization of this project would be provided from the budget of AD ESM.

## **Current activities**

There is ongoing arbitration procedure in front of the Court of Arbitration in Switzerland.

## **Revitalization of TPP Bitola for decreasing of SO<sub>x</sub> and dust – phase III**

**Project type:** Improving of the ecological performances

**Project status:** Feasibility Study is prepared for decreasing of SO<sub>x</sub> and dust, extended with the influence of all dangerous matters from REK Bitola

### **Project description:**

Considering the seriously outdated criteria for restriction of gas emissions from the large combustion plants and which are not fulfilled by TPP Bitola, it is necessary to decrease SO<sub>x</sub> and dust in order to be achieved the prescribed norms. AD ESM tends to improve the ecological characteristics in TPP Bitola and therefore, submitted request to *Yokogawa Electric Corp* for preparation of feasibility study for construction of desulfurization plant, where there is obtained positive opinion i.e. the project is selected to be implemented within the program "Study of Economic Partnership in Development Countries in FY2011)". The program is financed by the Japanese Government and the feasibility study for desulfurization of the exhaust gases in TPP Bitola was prepared in February 2012.

Taking into the consideration, the high investment value obtained from the mentioned study, there is necessity of construction of desulfurization plant as well as the fact that on the desulfurization market, there are other technologies, the preparation of the feasibility study for reduction of SO<sub>x</sub> and dust is in final phase extended with impact assessment of all other dangerous matters from REK Bitola as well as comparative analysis for wet and dry procedure.

The study concerning the selected optimal technology for desulfurization and reducing emissions of particles during operating of units in REK Bitola. In this way, the following ESMents have been defined: principles of selected technology, selected technical solutions including technical description and elaboration of options for implementation, subsystems, devices and system equipment for desulphurization and reducing emissions of particular matters, total costs for implementation, as well as the allocation of costs for construction and exploitation of desulphurization system and for reduction of emissions of particular matters.

In accordance with the recommendations by the elaborator of the feasibility study, it is planned this project will be implemented in two phases:

Phase I –Reduction of dust, which contains:

Reconstruction of the electrostatic filter

Replacement of induced draft fans and flue gas ducts.

II phase -Reduction of SOx-desulphurization, which contains:

- *Preparatory work*
- *Civil Engineering works:*
  - Construction part
  - Gypsum storage
  
- *Mechanical equipment installation:*
  - Desulfurization 1
  - Desulfurization 2
  - Steel construction
  - Limestone crusher
  - Additional equipment
  
- *Electrical Equipment and Instalton:*
  - High Voltage Supply
  - Low voltage distribution
  - Control system
  - Owner's costs

**Project significance**

- Reduce emissions and immission of SOx and dust within limits proscribed by European directives and European national legislation;
- Improve the ambiental air in the vicinity of REK Bitola and the city of Bitola;
- Positive influence over climate change;
- Reducing the noise of the plant;
- Ability to produce gypsum and its placing on the market;
- Socio-economic aspects and improved conditions for workers and the population living around REK Bitola;
- Reducing the various respiratory diseases and external costs (reduced absence from work, costs for medicines, etc.).

### **Investment costs**

The total value for construction of the project in accordance with the feasibility study is 140 million Euros, where 20.000.000 Euros are planned for decreasing of dust and 120.000.000 Euros for desulfurization. For financing of this project AD ESM will address the Ministry of finance due to providing state guarantee and procedure for selection of most favorable financier of the project will follow.

### **Revitalization and modernization of TPP Bitola phase IV – modernization of cooling towers**

**Project type:** Improving of the efficiency of ecological performances

**Project status:** Initial phase of implementation

#### **Project description:**

This project includes:

- Rehabilitation of the reinforced – concrete shell structure of cooling towers
- Reconstruction and replacement of the asbestos cement ESMents from filling of the cooling towers with new ecological friendly materials
- Increasing the efficiency of the cooling towers

#### **Project significance:**

The following benefits are expected from the project revitalization and modernization of TPP Bitola – phase four:

- Extending the lifetime of the cooling towers;
- Increasing the efficiency of the cooling towers (decreasing the temperature of the cooling water for approximately 2 °C compared to the current values), and that includes increasing of boiler efficiency;
- Improving of the ecological performances with removing of asbestos materials.

## **6. DISTRICT HEATING IN BITOLA, NOVACI, AND MOGILA – PHASE I**

**Project type:** Production and distribution of heat energy for heating

**Installed power:** 100 MW

**Planned annual production of heat energy:** approximately 125.000MWh

**Project status:** Selected consultant for the project

### **Project description**

The district heating system foresees generation of heating energy by recovering the steam from turbines 2 and 3 in TPP Bitola. By means of a 12,83 km long hot water transmission line going through arable agricultural land along the settlements of Novaci and Logovardi would supply city of Bitola with heating energy.

Going through the steam-water transformers, the steam recovered from the turbines generates heating energy transported via the hot water transmission line to the primary pump station in the city of Bitola.

The heating energy will be distributed to Bitola by a primary and secondary hot water transmission line to the ultimate users. The hot water distribution line (DL) from REK Bitola to the municipality of Bitola will be constructed from two previously isolated pipes with a leakage detection system. The temperature regime of the transmission line is defined at 115/700C (incoming temperature of 1150C, return temperature of 700C).

The project district heating of Bitola, Novaci, and Mogila will include the construction of:

- 1) heating energy generation system (HS – REK)
- 2) hot water transmission line (HTL),
- 3) primary pump and heating station in Bitola (PPHS),
- 4) hot water distribution grid (HDG) in Bitola
- 5) heating substations (HS) in buildings.

### **Significance of the project**

The realization of this project will enable considerable substitution of the electricity used as a heating mean, which will increase reliability and consistency of distribution electricity grid.

It can be emphasized that this project will impact:

- Reduction of emissions from combustion of wood, household and coal fuel in small domestic stoves as well as in furnaces of public and commercial buildings, SO<sub>x</sub>, NO<sub>x</sub>, CO, etc. ;
- Reduction of CO<sub>2</sub> emissions at the level of R. North Macedonia ;
- Improving the quality of ambient air;
- Reducing the likelihood of possible inadequate treatment of waste oil in the preparation, which is used for heating;
- Reduction of respiratory diseases;
- Increasing the quality and service of living;
- Reducing the consumption of electricity used for heating the premises;
- Reduction of losses in distribution of electricity to low voltage and high voltage networks;
- Optimization of the energy resources used for heating the premises in individual objects.

### **Investment costs**

The total value of the project in accordance with the study is 87,73 million Euros where the first phase of the value would be 66,65 million Euros. Considering the revising of the factor for connection and larger concentration of the consumers for the first phase for the city of Bitola, costs for this stage will be lower than firstly predicted value. New terms of reference is prepared in cooperation between the implementation team of AD ESM and Faculty of Mechanical Engineering – Skopje including new heat consumers in the first phase of 100 MW and decreased cross section of heat pipeline from 700mm to 500 mm. Based on this offered solution, the elaborator of the basic design continued preparation in this direction. The investment for the mentioned offered solution will be approximately 46 million Euros. Regarding the realization of the project, loan agreement is signed with KfW on 29.12.2015 in amount of 39 million Euros.

## **7. CLINICAL CENTER**

**Project type:** Production of electricity, heat energy and technical steam

**Installed power:** 3 MWe<sub>el</sub> +3 MW<sub>th</sub>

**Production of heat and electricity:**  
28.400 MW<sub>hth</sub> +22.000 MW<sub>hel</sub>

**Project status:** Prepared information for construction and managing with cogeneration plant for production of electricity, heat energy and technical steam for Clinical center Mother Teresa – Skopje

### **Project Description:**

Cogeneration Plant for production of electricity, heat and technical steam –“Klinichki Centar” (Clinical Center) is required to meet the needs of energy during the year and for this purpose is planned installation of cogeneration modules combined with steam and hot water boilers.

The installed power of this facility should be sized according to the needs of each clinic during the year, taking into account the reliability and the redundancy in the supply of the object of particular public interest.

The Feasibility Study prepared by the MACEF / RI, for supply of electrical and thermal energy for Clinical Center was updated last year in order to select and optimizes the new cogeneration production capacity.

Using the feasibility study as a basis for further activities, an assessment was conducted on the possibility for replacing existing old equipment for production of hot water for heating and technological steam with natural gas plant for combined production of electricity, heat and technological steam.

Current energy needs and plans for future consumption in the boundary of Clinical Center are in line and with comply with the Ministry of Health. In the economic analysis for this project, current prices on the regulated and free market for electricity, thermal energy and natural gas for the calculation of cost of energy are used.

In addition, an analysis is prepared of the circumstances of the distribution network in the part of Skopje, as well as the proposal of four possible solutions for connection to the future cogeneration plant to the distribution system.

### **Significance of the project**

With implementation of this project, the costs for Clinical Center for providing electrical energy and thermal energy (hot water and steam) will be reduced significantly compared

with the actual condition.

The existing equipment which is in operation for more than 40 years, is overused, maintenance costs are increased and high losses in the existing internal distribution network occurs.

Investing in new energy-efficient equipment will result in high reliability and safety of operations, reduced costs of operation and maintenance, which would satisfy the environmental standards by using natural gas as fuel.

### **Investment costs**

In the analysis for the possible solutions for selection of cogeneration plant, three variants are prepared for the planned investment in the Clinical center including 3 MW, 6 MW and 9 MW plant. For each of the variants, there is determined production price of electricity and heat energy.

Within each variant are analyzed more scenarios regarding electricity price and heat energy.

Each scenario is analyzed through techno-economic analysis where there is appropriately examined profitability and as criteria are used the following parameters: current net value, internal rate of return and the period for investment return.

Additionally, there is prepared sensitivity analysis for the price of electricity and heat energy compared to the gas price.

Based on the analysis, there are results which are acceptable and justified for realization of techno-economic aspect.

Based on the results from techno-economic analysis, sensitivity analysis as well as the possibility for placing electricity surpluses to the distribution grid, the following the solution is proposed:

- To prepare basic design and revision for plant with installed power of 9 MW,
- To begin the realization of variant 1 i.e. planned with installed power of 3 MW.
- Depending on the development plans of Clinical Center – for increasing of the energy consumption, improving of the conditions of distribution grid as well as favorable conditions on the electricity market, to approach gradually to realization of entire investment i.e. planned with installed power of 9MW.

The investment for the first phase of cogeneration plant with installed capacity of 3MW, is estimated at 2.887.500 Euros, and it is planned to be financed from own financial sources of AD ESM The exact value of the investment will be known after the drafting of the basic design and its revision.



## **8. WIND PARK BOGDANCI – PHASE TWO**

<b><i>Project type:</i></b>	Electricity production
<b><i>Installed power:</i></b>	13,8 W
<b><i>Planned annual electricity production:</i></b>	50 GWh
<b><i>Project status:</i></b>	Submitted request to the Ministry of finance for debit with state guarantee

### **Project description**

The Wind Park is located in southeast part of Republic of North Macedonia at the territory of municipality Bogdanci. The location is situated on the hills Ranavec and Glavite at elevation of 300 – 500 m and it is characterized with low vegetation and relatively uneven terrain.

Considering the size and complexity of the project, the implementation will be in two phases and it will not disrupt the technical functionality of the facility.

The first phase, realized in 2014, included construction of access road, substation, and transmission line, assembly of 16 wind turbines with total installed power of 36,8 MW and connection to energy power system (EPS) of Republic of North Macedonia . After finalizing of this phase, the facility is operating with more than half of the total predicted capacity.

Along with the second phase, infrastructure of WP Bogdanci would be finished with additional construction of access road and 20kV cable grid to the new turbines.

The Wind Park Bogdanci – phase two includes installation of 4 wind turbines, each with nominal power between 3 and 4 MW, which results in total installed power of 13,8 MW and additional production of approximately 50 GWh. Therefore, the total production of WP Bogdanci would be 150 GWh.

### **Project significance:**

This project achieves the following effects:

- The installed power of the production capacities of AD ESM is increased for additional 13,8 MW and annual production of additional 50GWh.
- New technology for electricity production in the production mix of AD ESM is introduced.
- The project Wind park Bogdanci will be finalized entirely.
- The construction of the park will increase the share of renewable sources in the production of AD ESM. Republic of North Macedonia has an obligation to the European Union for reaching the set goal- 20% production of renewable sources in the energy balance and that goal is set and supported by all relevant institutions in RM.

### **Technical parameters of WP Bogdanci – phase two**

<b>Basic characteristics of WP Bogdanci – phase two</b>	
Average wind speed	7,1 m/sec
Number of turbines	4
Installed power	13.8 MW
Rotor diameter	108 m
Average annual production	50 GWh
Voltage level	110 kV

### **Investment costs**

The total investment which amounts 21,000,000 Euros is planned to be financed by own assets of AD ESM or more precisely total amount of 3.150.000 Euros, while the remaining part of investment in amount of 17.850.000 will be provided with loan with state guarantee.

The assets for which the repayment of the debt is planned will be provided from the current operation of JSC North Macedonian Power Plants.

## **9. WIND PARK MIRAVCI – PHASE ONE**

**Project type:** Electricity production

**Installed power:** 14 W

**Planned annual electricity production:** 45 GWh

**Project status:** Preparation of preliminary design

### **Project description**

The Wind Park Miravci would consist of 12 – 15 wind turbines, each with nominal power of 3-4 MW which would result in total installed power of approximately 50 MW and nominal annual electricity production of approximately 127 GWh. Furthermore, the park includes construction of access roads, platforms, 20kV cable grid, substation, transmission line and grid connection (transmission or distribution).

The site planned for construction of Wind Park Miravci is situated on the south part of the canyon Demir Kapija with altitude of 390 – 700 m and it is characterized with low vegetation and relatively steep terrain.

The reference parameters for which the calculations are done in 2010 are:

- The average wind speed on height of 50 m is 6,7 m/sec. Wind class IIC.
- 35 standard turbines with installed capacity of 1,5 MW

The wind direction on the site 2 is canalized along the Varadar river flow (Vardarec) and regarding that, the dominant directions are north- west and south - east. The strong winds are mainly coming from northwest in the winter period.

The project will be implemented in two phases including:

- the first phase with total installed power of wind turbines of 14 MW
- the second phase with total installed power of wind turbines to 50 MW

### **Project significance:**

This project achieves the following effects:

- The installed power of the production capacities of AD ESM is increased for 14 MW and annual production of additional 45 GWh.
- The construction of the park will increase the share of renewable sources in the production of AD ESM. Republic of North Macedonia has an obligation to the European Union for reaching the set goal- 20% production of renewable sources in the energy balance and that goal is set and supported by all relevant institutions in RM.
- Increasing the participation of renewable sources for electricity production including phase two of this project (total installed power of 50 MW) would compensate 116.000 t annual emissions of CO<sub>2</sub>, if this energy would be produced by the thermal power plants.

### **Technical parameters of WP Miravci – phase one**

<b>Basic characteristics of WP Miravci – phase one</b>	
Average wind speed	6,7 m/sec
Number of turbines	4-5
Installed power	14 MW
Average annual production	45 GWh
Voltage level	110 kV

### **Investment costs**

The total investment which amounts 21,000,000 Euros is planned to be financed by own assets of AD ESM or more precisely 3.000.000 Euros, while the remaining part of investment in amount of 18.000.000 will be provided with loan from financial institutions.

The assets for which the repayment of the debt is planned will be provided from the current operation of JSC North Macedonian Power Plants.

## **10. PHOTOVOLTAIC POWER PLANT AT OSLOMEJ SITE**

**Project type:** Electricity production

**Installed power:** 10 W

**Planned annual electricity production:** 14,6 GWh

**Project status:** Preparation activities

### **Project description**

TPP Oslomej, is existing thermal power plant in ownership of AD ESM having one unit with a total installed power of 125 MW respectively the second thermal power plant by installed power in the energy power system of Republic of North Macedonia . This power plant is commissioned in 1980 and participates with 10% of the domestic Electricity production and it operated until 2015. The average annual electricity production within period of 15 years (1999-2015) is 430 GWh. This power plant uses lignite as basic fuel for electricity production from the mines Oslomej- Istok and Oslomej – Zapad in the Kicevo region. Due to utilization of the exploitation coal reserves, TPP Oslomej is not operating with full capacity since 2015 respectively with planned average, annual electricity production.

In order to consider the effects of exploitation mine over the environment, the land should be returned in its primary condition. Through this measure, the land can be easily reallocated for construction of photovoltaic power plant (PVPP) and it can be used as renewable source of electricity. Construction of PVPP in TPP Oslomej will increase the part of renewable electricity sources for 10 MW. The construction costs for PVPP will be significantly decreased due to usage of the existing infrastructure of TPP Oslomej.

REK Oslomej has available land area of around 660 ha, including the open pit mines "Oslomej-Istok" (390 ha), "Oslomej - Zapad" (200 ha), the new and old ash landfill, 110 kV plant and other smaller surfaces.

Regarding the necessary area for PVPP with installed power of 10 MW, it would be around 20 ha depending on the technology and selection of PVPP. Part of the already used land areas in ownership of REK Oslomej would be reallocated for implementation of PVPP. The map below provides layout of the land in REK Oslomej.

For selection of the site for PVPP, there should be detailed insight of all potential sites where all aspects would be considered including: possibility for connection to energy power grid, terrain condition, possibility for land recultivation, geology, etc.

One of the most important parameters for implementation of PVPP is the Capacity Factor which predicts the Electricity production by PVPP. During the year, this factor is variable, it is highest in the summer months and it is around 23% - 24%. The annual average factor is also variable for different years and for the defined site is between 15% - 17%.

The electricity production from the PVPP directly depends on the capacity factor, the total

installed power, the technology of the panels and the total losses in the system. In the financial analyses prepared for this project, the following parameters are used: capacity factor 16,66% with panel efficiency of 20% installed power of 10 MW and average annual generation of 14,6 GWh.

In this part of the analysis, the investment costs for installing of PVPP will be elaborated and afterwards, the basic indicators for feasibility of the Project will be presented through the operation and maintenance costs of the power plant (production price – *LCOE*, *NPV*, *IRR*). These analyses will be reviewed for two variants:

- for regulated electricity price of 41 EUR/MWh + 15 EUR/MWh premium tariff;
- variant with analysis of market electricity price of 56 EUR/MWh + 15 EUR/MWh premium tariff

In the financial analysis, the total planned costs are within the range from 0,6 EUR/W to 0,9 EUR/W. The variant of 0,7 EUR/W is taken into consideration with additional sensitivity analysis of 15%.

Based on the obtained results from the production simulations and financial analysis, the project is feasible if appropriate panel and inverter technologies are chosen and also their grid connection or if the project is considered for implementation in market conditions for electricity sale with additional premium tariff of 15 EUR/MWh.

In the following phase, the selection of microsite, PV panels and appropriate inverters should be analyzed in details as well as connection to existing grid in Oslomej.

### **Project significance:**

This project achieves the following effects:

- The installed power of the production capacities of AD ESM is increased for 10 MW and annual production of additional 14,6 GWh.
- The construction will increase the share of renewable sources in the production of AD ESM. Republic of North Macedonia has an obligation to the European Union for reaching the set goal- 20% production of renewable sources in the energy balance and that goal is set and supported by all relevant institutions in RM.
- Increasing the participation of renewable sources for electricity production would compensate 13.000 t annual emissions of CO<sub>2</sub>, if this energy would be produced by the thermal power plants.

### **Technical parameters of PVPP Oslomej**

<b>Basic characteristics of PVPP Oslomej</b>	
Installed power	10 MW
Average annual production	14,6 GWh
Voltage level	35 / 6 kV

### **Investment costs**

The total investment which amounts 7.000.000 Euros is planned to be financed by own assets of AD ESM or more precisely 1.050.000 Euros, while the remaining part of investment in amount of 5.950.000 will be provided with loan from financial institutions.

The assets for which the repayment of the debt is planned will be provided from the current operation of JSC North Macedonian Power Plants.

## **11. HPP CEBREN**

**Project type:** Electricity production

**Installed power:** 61.30 - 464.75 MW

**Planned annual electricity production:**

183 - 1097,30 GWh

**Project status:** Prefeasibility study is prepared in 2017

### **Project description**

The hydropower potential of the Crna Reka for production of electricity can be utilized after Pelagonija valley from the entry in the canyon in the Mariovo part to the flow in the river of Vardar. The water economy solution for utilization of the water of the Crna Reka in its middle and lower flow envisages for their utilization in energy-ameliorative purposes. This section of the river flow has natural predispositions for erecting high barriers and forming reservoirs which will provide the available fall to be used for energy, and an opportunity for irrigation of vast areas in the Tikves region will be created.

The Crna Reka hydropower system (HPS) has been utilized in the lower flow before its flow in the river of Vardar with the construction of the existing HPP Tikves. The existing HPP Tikves has 4 installed generators, each of 36 m<sup>3</sup>/s and installed power of 28 MW. Total installed power of this hydropower plant with usable height gross fall of 100 meters is 112 MW and total turbine outflow of 144 m<sup>3</sup>/s. The average annual production of HPP Tikves is about 150 GWh.

The idea for utilization of the upper flow of the Crna Reka after the canyon in the Mariovo part is several decades old and many studies and projects have been made. Studies and designs have been prepared for many technical layers for variants for construction of HPP Cebren and HPP Galiste as upstream power plants of the existing HPP Tikves. With the construction of the cascading power plants, the hydro potential of Crna Reka would be utilized.



#### **4 (four) best ranked variant solutions:**

##### Pumped-storage hydropower plant (PSHPP) Cebren + HPP Orlov Kamen

Total volume of storage (Cebren):	915 mil. m <sup>3</sup>
Useful volume of storage (Cebren):	555 mil. m <sup>3</sup>
Useful volume of storage (Orlov Kamen):	14.9 mil. m <sup>3</sup>
Installed power of PSHPP Cebren+ HPP Orlov Kamen:	458 MW
Annual production of PSHPP Cebren+ HPP Orlov Kamen:	1044 GWh
Annual consumption:	1011 GWh
Investment costs PSHPP Cebren + HPP Orlov Kamen:	553 M€
Economic Internal Rate of Return	4.31 %
Financial Internal Rate of Return	- 0.12 %
Benefit/Cost	0.71

##### Conventional HPP Cebren (dam - upstream location, tunnel 8km)

Total volume of storage (Cebren):	250 mil. m <sup>3</sup>
Useful volume of storage (Cebren):	74 mil. m <sup>3</sup>
Installed power:	61.3 MW
Annual production:	183 GWh
Investment costs:	189 M€
Economic Internal Rate of Return	3.85 %
Financial Internal Rate of Return	- 0.48 %
Benefit/Cost	0.52

Pumped-storage hydropower plant (PSHPP) Cebren + HPP Orlov Kamen+3 SHPP

Total volume of storage (Cebren):	915 mil. m <sup>3</sup>
Useful volume of storage (Cebren):	555 mil. m <sup>3</sup>
Useful volume of storage (Orlov Kamen):	14.9 mil. m <sup>3</sup>
Installed power PSHPP Cebren + HPP Orlov Kamen+3 SHPP:	458+ 6.75MW
Annual production of PSHPP Cebren+ HPP Orlov Kamen +3 SHPP:	1044 + 53.3GWh
Annual consumption:	1011 GWh
Investment cost PSHPP Cebren+ HPP Orlov Kamen +3 SHPP:	553+9M€=562M€
Economic Internal Rate of Return	4.31 %
Financial Internal Rate of Return	1.49 %
Benefit/Cost	0.8

Conventional HPP Cebren (dam - upstream location, tunnel 8km) + dam Orlov Kamen + 3 SHPP

Total volume of storage (Cebren):	250 mil. m <sup>3</sup>
Useful volume of storage (Cebren):	74 mil. m <sup>3</sup>
Installed power:	61 + 6.75 MW
Annual production:	183 + 53.3 GWh
Investment costs:	189 + 9 + 33M€ = 231 M€
Economic Internal Rate of Return	3.85 %
Financial Internal Rate of Return	0.70%
Benefit/Cost	0.6

## **12. VARDAR VALLEY**

**Project type:** Electricity production

**Installed power:** 338 MW

**Planned annual electricity production:** 1200 GWh

**Project status:** Prefeasibility study in 2017 is prepared

### **Project description:**

The Project Vardar Valley is multipurpose project which means increasing of electricity production through utilization of water resources as well as strengthening of traffic, agricultural, touristic and industrial sector and directed to renewable development and environmental protection.

In the lower part of Vardar Valley, there is planned construction of 12 hydro-power plants, out of which the major ones would have average size of reservoir and those are: HPP Veles with estimated annual production of 270 GWh and HPP Gradec with estimated annual production 200 GWh. Other 10 hydro-power plants have been deployed in cascades down the river stream, including seven hydropower plants between reservoirs Veles and Gradec and 3 hydropower plants downstream from Gradec. They are all considered as run-of-river power plants with total production capacity of approximately 1200 GWh annually.

### **Conclusions from the prefeasibility study of 2017**

In this phase of the study, the development of the lower part of Vardar Valley may be considered as favorable regarding geological conditions, construction logistic (access, materials, etc.) as well as ecological and social influence. The average monthly and annual flows in each of the twelve hydropower plants are estimated based on the hydrological period 1961-2010. The maximum energy potential, which depends on the flow of Vardar River, may be confirmed with this study as 338 MW with average annual energy production of 197.180 MWh/annually (*scenario V01*).

More realistic *scenario – V02* is elaborating the estimation where there is obligation for irrigation and minimum ecological flow and where the total energy production is decreased with energy loss of -7.6% taking into consideration the cascade system or 1,072,080 MWh/annually.

Scenario V03 includes optimization of installed power and optimization of investment cost. The analysis includes total potential of 300 MW and annual energy production of 991390 MWh/annually or -7.5% decreasing compared to V02.

The general analysis is made for *scenario V04* with increasing of installed power of 360 MW and decreasing of investment cost with annual general energy production of 1,075,227 MWh.

The total estimated investment cost for maximum potential of 338 MW of 12 hydropower plants (V02) is 1,120 million Euros respectively 50% for construction works, 30% of electro-mechanical, hydro mechanical and electrical equipment, 2% for connection to grid and 18% for land use.

At the moment, Republic of North Macedonia has one of the lowest tariffs for electricity in Europe. Therefore, regulated tariff of 41 EUR/MWh is not applicable and none of the hydropower plants is economically justified.

The financial analysis shows that the project is economically justified only with internal rate of return (IRR) of minimum 10% with tariff which would be from 64 to 158 EUR/MWh and assumed financing conditions which is far from the existing energy tariff.

***Project significance:***

A key goal is to increase North Macedonia's own electricity production through the use of water resources, while through the construction of hydro-power plants on the river Vardar, North Macedonia seeks to regulate the water potential regime and use, spatial planning, protection of goods, the social aspects and exploitation of water resources.

By the construction of hydro-power plants on the river Vardar, the following objectives have been set:

- Change in electricity production structure by increasing the proportion of hydro-energy or energy generated from renewable sources.

- Minimize the impact on the environment through the use of water as a renewable and efficient energy source.

- Reduce energy dependence of the country through the construction of hydro-power plants as domestic energy sources.

- Improve flood protection through the regulation of watercourses.

- Prevent the lowering of underground water level in the entire area.

- Promote national development through the use of water potential as an effective source of electricity production.

### **13. OPTIMAL ENERGY UTILIZATION OF THE WATERS FROM HPP RAVEN TO ACCUMULATION KOZJAK "TUNNEL TENOVO - KOZJAK"**

**Project type:** Electricity production

**Planned annual electricity production:** solution 1 (81,78 GWh HPP Kozjak 2 + 120,26 GWh from HPP Kozjak, HPP Sveta Petka and HPP Matka 1) and solution 2 (127,76 GWh from HPP Kozjak, HPP Sveta Petka and HPP Matka 1 excluding Lukovo Pole or 146,12 from HPP Kozjak, HPP Sveta Petka and HPP Matka 1 including Lukovo Pole)

**Project status :** Prefeasibility study is prepared in 2017

#### **Project description**

The hydro power systems HPS Mavrovo and HPS Treska have been built with electricity production capacities and together contribute towards more than 50% of the total hydro production in North Macedonia . If they are hydraulically connected, parts of the waters already utilized in HPS Mavrovo could also be used in the downstream hydro plants of HPS Treska, allowing for additional electricity production.

The idea for constructing a tunnel for diverting part of the waters from the river Vardar into the river Treska, i.e. from the Tenovo location to the Kozjak reservoir, has already been around for over 50 years. Based on the first Study developed for this idea, prepared by a Norwegian consultant, technical documentation has been designed only for the Tenovo – Kozjak tunnel. This Study provides power indicators and some financial analysis with current prices today and today's level of development of North Macedonia's power system. Towards the end of 2014, an analysis was made with proposed variants for implementing this idea, including the utilization of the waters from HPP Raven to Kozjak. The consultants communicated their opinion on the project variants for implementation to the Faculty of Civil Engineering Skopje.

The hydro system Mavrovo and its auxiliary structures, built in the distant 1957, is an artificial reservoir for intake of the Korab and Shara waters from the Adriatic basin into a drainage surface of 531 km<sup>2</sup>. The Mavrovo lake has a storage capacity of 270 million m<sup>3</sup>, and the waters from the Mavrovo reservoir, following their hydropower utilization through the HPP Vrben, Vrutok and Raven, flow into the Vardar river with a maximum discharge at a rate of 36 m<sup>3</sup>/s. In addition to the waters that naturally flows towards river Vardar respectively Shara waters, with the construction of HPS Mavrovo are also affected and the Korab waters that previously belonged to the Adriatic basin. With this, an artificial bifurcation was made, so part of the waters from the Adriatic basin are being transferred to the Vardar basin. From Mavrovo reservoir after HP Raven, into the river Vardar discharges approximately 250.92 million m<sup>3</sup> per year.

The construction of Lukovo Pole reservoir would enable even more additional water quantities of approximately 50 million m<sup>3</sup> in average per year, meaning 300 million m<sup>3</sup> in total. The final step to this closing this loop for construction of connection tunnel for diversion of the waters from Vardar into Treska and their power utilization is the

completion of the Treska hydro system. Through the construction of HPP Kozjak (2004) and HPP Sv. Petka (2012) and their reservoir, as well as the refurbished and upgraded HPP Matka, the diverted waters from the river Vardar would undergo additional utilization in these three hydropower plants and would be an added flow into the Vardar river at the confluence with Treska river just outside the capital Skopje. This intervention of building the tunnel would enable the waters of the Vardar River to be diverted, instead of through the Polog valley, into the Treska river, where they can be additionally utilized by HPS Treska, before they flow into Vardar near Skopje.

During preparation of prefeasibility study, there are 20 analyzed solutions out of which 7 are justified and 13 are unjustified. There 2 most favorable solutions out of 7.

### **Description of technical solution**

#### Solution 1

- Intake Structure in Raven village at the elevation of 585 m.A.S.L – bridge on r.Vardar
- Headrace tunnel to the Lakavica reservoir 8.2 km long.
- Lakavica Reservoir at a volume of approx.1.3 million m<sup>3</sup> and a natural elevation point at 570 m.A.S.L.
- Tunnel from Lakavica reservoir to the surge tank of HPP Kozjak 2 at a length of  
Lt = 18.95 km
- Surge tank for HPP Kozjak 2 at an elevation of 563 m.A.S.L or 559 m.A.S.L
- Pipeline for HPP Kozjak 2
- HPP Kozjak 2 elevation 459 m.A.S.L, with  $H_{gross} = 104$  m, or  $H_{gross} = 100$  m
- HPP Kozjak 2 with  $Q_i = 36$  m<sup>3</sup>/s and  $Q_i = 21.6$  m<sup>3</sup>/s

#### • Solution 2

- Tenovo dam at a length of 1980 m, variable head of 1 to 10 m with spillway elevation at 467 m.A.S.L and reservoir volume of approximately 2 million m<sup>3</sup>.
- Headrace tunnel from Tenovo reservoir to Kozjak reservoir, with inlet elevation at  
463 m.A.S.L and outlet elevation at 453 m.A.S.L, at a length of Lt = 14.8 km.
- Tailrace elevation in Kozjak at 563 m.A.S.L ( $Q_i = 36$  m<sup>3</sup>/s or  $Q_i = 21.6$  m<sup>3</sup>/s)

### **Project significance:**

The realization of this project would connect two hydro energy systems, Mavrovo and Treska and the energy utilization of upper flow of Vardar river will be finalized. The benefits from this project would be as follows :

### **Energy benefits**

- Additional production of power plants at Treska river of approximately

average 110 GWh annually .

- Higher engaged power of HPP Kozjak due to increased operation time at high elevation of storage.
- Operation work of hydropower plants of Treska river in periods of high tariffs as peak load power plants of liberalized electricity market which means higher income for the power plant respectively for ESM as operator.
- Possibility for additional production of newly constructed hydropower plants at the Raven-Kozjak line.

**Other benefits (protection of floods, necessity of water supply and irrigation)**

- Avoiding of spillways and floods of Vardar river in Polog Valley in periods of high flow where waters would be diverted in Treska river.
- Additional water for water supply of the settlements in the Polog Valley.
- Regulated flow of Vardar in the upper flow as well as possibility for irrigation of Polog agricultural region.

## **14. REVITALIZATION OF HPP – PHASE III**

**Project Type:** Electricity production

**Project status:** Prefeasibility Study is finished with estimation of necessary equipment and civil engineering activities

### **Project description**

In line with the construction of new capacities, AD ESM in the following period continues with the process of revitalization and modernization of existing hydro energy capacities – phase III.

These investments in the hydropower plants are aimed at using entirely the water potential of the existing hydropower plants, to undergo modernization of entire equipment with new, following the last technological achievements in this field, to increase the power of aggregates, to obtain larger production, to decrease current maintenance costs and as final aim to increase safety and stability of entire energy power system of North Macedonia .

### **Project significance:**

In the process of the third phase of modernization of existing hydropower plants as larger grips are planned the following activities:

- Replacement of energy transformers including: one in HPP Spilje, two in HPP Globocica, two in HPP Vrben and two in HPP Tikves; as well as two new regulation energy transformers in HPP Spilje.
- Modernization of two generators in HPP Globocica and one in HPP Spilje.
- Replacement of conductor rope of 35kV transmission line HPP Vrutok - HPP Vrben and replacement of protective rope with new one, integrated optic fibers; rehabilitation of 35kV transmission line HPP Spilje – HPP Globocica and construction of new 35kV transmission line HPP Kozjak – HPP Sv. Petka.
- Replacement of rotor poles of three aggregates in HPP Raven and new bearings of aggregate based on new Teflon technology.
- Replacement of rotary gates and turbine equipment of two aggregates in HPP Vrben.
- Replacement of two butterfly valves at turbine inlet including: two in HPP Spilje, two in HPP Globocica and three in HPP Spilje.
- Rehabilitation of the concrete linings of surge shafts in HPP Vrutok.

### **Investment costs**

Budget: 23.374.802 Euros



**ENDORSEMENT:**

**DEFINED ACTIVITIES AND DEADLINES FOR PROJECTS FOR WHICH AD ESM IS BEARER MAY UNDERGO CHANGES IN ACCORDANCE WITH AVAILABLE FINANCIAL ASSETS OF AD ESM AND AT THE SAME TIME PRIORITY OF PARTICULAR PROJECT MAY BE GIVEN BY MANAGEMENT BOARD OF AD ESM IN COOPERATION WITH THE SUPERVISORY BOARD AND THE GOVERNMENT OF REPUBLIC OF NORTH MACEDONIA . TAKING INTO CONSIDERATION THE ABOVEMENTIONED, ALL PROJECTS WILL BE UPDATED IN TIMELY MANNER.**