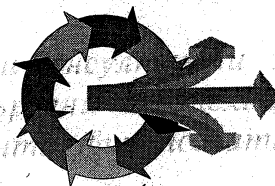


**НАУЧНО-ТЕХНИЧЕСКИ СЪЮЗ НА ЕНЕРГЕТИЦИТЕ  
ГЕРМАНСКИ СЪЮЗ НА ИНЖЕНЕРИТЕ - ДРУЖЕСТВО  
ФОРУМ ПО ЕНЕРГИЙНА ТЕХНИКА  
МИНИСТЕРСТВО НА ЕНЕРГЕТИКАТА И ЕНЕРГИЙНИТЕ  
РЕСУРСИ**

**НАЦИОНАЛНА ЕЛЕКТРИЧЕСКА КОМПАНИЯ  
ФЕДЕРАЦИЯ НА НАУЧНО-ТЕХНИЧЕСКИТЕ СЪЮЗИ  
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ПРЕХОДА**



**ЮНИ 14-17, 2002**  
**СПИСЪК НА ДОКЛАДИТЕ**  
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**Международен дом на учените "Ф.Ж. Кюри"  
Курорт "Св. Св. Константин и Елена"  
ВАРНА - БЪЛГАРИЯ**

## DEVELOPMENT OF THE FIRST GAS-FIRED COMBINED CYCLE HEAT AND POWER PLANT IN THE REPUBLIC OF MACEDONIA

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**ABSTRACT** – The ESM's Development and Investments Department recently developed strategy for the electricity power sector, in which the main attention was the development of the gas-fired combined cycle heat and power plant in the country. This should become a pilot project in the usage of natural gas as a source for electric power generation in the country and could paved a way for transfer of know-how for this sophisticated power technology which presently becomes one of the most attractive production of base load electric power energy.

This paper deals with the background and the rationale for the development of the project. The feasibility of the project is also discussed followed by the most important benefits that bring to the electric power industry in the country and the electricity and heat end-consumers. The present status of this project is also briefly addressed and some discussions about the closure of project also presented.

### 1. Background of the Project

Electric power supply in Macedonia is controlled and managed by a sole state-owned stock company of Electric Power Company of Macedonia (ESM) [1]. At present, ESM has the following power stations:

• <b>Hydro:</b>	6 Large Plants,	Generating Capacity	400 MW
• <b>Small Hydro:</b>	22 Units,	Generating Capacity	36 MW
• <b>Thermal:</b>	3 Plants,	Generating Capacity	1,010 MW
• <b>Total Generating Capacity:</b>			1,446 MW

The total production of electric power of 2000 using these power plants was 6,619 GWh, the total imported electric power of 2000 was 290.6GWh and the total exported electric power the same year was 178.6 GWh. Thus, the Macedonian electric power system was almost totally sufficient, with thermal power as main and hydropower as subordinate electric power source.

However, it is also important to notice that the maximum peak of electric power demand of 1,233 MW in 2000 occurred on December 24<sup>th</sup>. The total generating capacity of 1,446 MW is 14.5 % margin to the maximum peak demand of 1,233MW.

The total high voltage transmission power loss of the Macedonian whole system in 2000 reached almost 3.8 %, which is in good correlation with the similar power grids. The electric power consumption of Macedonia has been rising at the annual rate of 4 % to 5% for last several years and it is expected that this trend will continue, however with somehow smaller rates between 3 and 4 % yearly. Skopje, the biggest city of Macedonia, having one third (1/3) population, consumes about 40% of the total electric power generation in Macedonia. Near Skopje, however, there is no power plant.

It is also assumed that the power consumption difference of about 330MW between the average winter peak demand of 1,130MW and the average summer peak demand of 800MW

by house heating consumption, which shares relatively high ratio. Whereas, in the country of Skopje the heat distribution system by hot water is adopted for heating during winter, usually starting from the middle of October and ending at the middle of April. The average usage of crude oil in Macedonia has to be imported and this causes very high cost. The hot water supply has not always been enough these years. In addition, it is said that the oil deposit which should go to the major thermal power plant, Bitola having three billion m<sup>3</sup> remains for only another thirteen to fifteen years. This drives the country to adopt the introduction of natural gas and the gas pipe line of 500mm diameter with a capacity of about 800 – 1,000 million m<sup>3</sup> annually has been installed up to the Bulgarian boundary. Macedonian Government has a plan to expand the natural gas pipeline to the whole country after gas consumption in Skopje will be increased. The main advantage of converting the fuel energy from coal and oil to natural gas.

### Development of a New Combined Cycle Heat and Power Plant in Macedonia

The development of the present energy situation in the country was done in order to establish a long-term development of the electric power sector in the country. Few studies were also conducted for the investigation of the structure of the consumers and availabilities of new energy sources in the country [2]-[3]. As a result, a new short, middle and long term development strategy for the electric power company was developed showing that one of the major steps forward will be the expansion of the infrastructure of gas pipeline and more intensive usage of the available gas for the production of electric and thermal heat energy. These investigations gave the following conclusions [4]:

To solve the big impact on the Macedonian economy and the anxiety of citizens about the highly possible power shortage, it is said that *the installation of a new power plant is a key and urgent issue for Macedonia*. The project, in responding to the balance between the power demand gap in 2004 after four years from 2000, at the time of winter peak demand of 1,233 MW, a power shortage of 192 MW (= 1200MW x 4%/year x 4yrs) should be equal to the capacity of a new power plant. The capacity is equal to 12% of the total electric power generation in Macedonia.

The oil deposit in Macedonia for the main fuel to Bitola Thermal Power plant is almost exhausted. Crude oil remains for only fifteen years and high cost oil has to be imported because of no oil production in Macedonia. Then, the expansion of natural gas consumption now becomes a key issue in Macedonia as a total energy policy. Up to the capital Skopje the pipeline of 500mm diameter has been already installed from the Bulgarian boundary. *It is necessary to build a new thermal power plant consuming big amount of natural gas.*

The new thermal power plant of firing natural gas should be a combined cycle heat and power plant of most efficient and energy saving, consisting of a gas turbine and a steam turbine with heat supply. The plant will meet with the Governmental policy and contribute to the efficient use of fuel and environmental improvement.

The capital Skopje having one-third of population and consuming about 40% electric power in the same time has no power station in the near area. *The installation of a new power plant in the area of the most power consumption, that is, Skopje, is welcomed the most.* The total technical transmission loss in ESM's system reaches about 8% compared to the total distribution power. *A new power plant installed in the existing "ENERGETIKA" area in Skopje power plant located in the city Skopje will contribute to the reduction of the transmission loss in Macedonia.*

The demand of heat in Skopje is also high. "ENERGETIKA" Skopje heat and power plant, which ESM now owns used to supply hot water for heating to the surrounding area by the process steam to a steel company next to the plant. At this moment ESM is supplying the amount of only 36 MWth heat to the lifelong users by firing high cost oil and 40t/h process steam. Many people living in the area of ESM's hot water supply system are now

waiting for heat supply equivalent to the amount of further 36MWth. The completion of plant as quick as possible is expected in terms of heat supply.

- The site candidate for the plant, "ENERGETIKA" Skopje power plant, has a large amount of usable equipment such as hot water supply system, substation, make-up water treatment, waste water treatment, boiler feed-water supply system, steam piping, steam turbine building and cranes, control room, etc. *By re-using this equipment to the maximum extent, the project cost of the new plant can be reduced and the project is positioned as a renovation plant as well.*
- *The new plant, a gas fired combined cycle heat and power plant with dry low NOx combustors will contribute to the reduction of SOx and NOx emissions due to clean firing.* Depending on gas conversion and the effect of energy saving efficient plant, CO<sub>2</sub> reduction is also possible to contribute to the reduction of the global green house effect.

### 3. Basic Plan of the Gas Fired Combined Cycle Heat and Power Plant

The new plant should be installed in the site of the existing "ENERGETIKA" Skopje power plant and as much equipment and systems as possible from the existing plant should be exploited for a new plant. The existing power plant used to be operated having five oil fired steam boilers, two steam turbines of 15MW each, 100MWth equivalent heat supply system, and 40t/h steam supply system. However, two steam turbines have been in the dead situation due to decrepitude, and these days together with the condition of high oil price, two boiler has adjusted to work on natural gas and operated to supply 30MWth equivalent heat to the surrounding area in winter season and 40t/h process steam to the next steel company without generating electricity power. As such, the operating equipment out of the existing plant such as heat supply system and water piping, steam turbine house and maintenance cranes in the house, control room, etc. can be re-used for the new plant. Also, the existing plant used to be operated as an industrial plant owned by a steel company and have spare substations and transformers for future addition. This electrical equipment can be also re-used for the new plant. Thus, re-usable equipments can be exploited to the maximum extent for the new plant so that the existing plant is positioned as a renovation plant as well. The rehabilitation of steam turbines should not be done because this will increase the cost of the project unnecessarily. The existing boilers should remain as spare generators in case the gas turbine is not working.

After the site investigation, the following equipment was found able for the exploitation of the new plant [4]:

- Water treatment plant, Water supply system, Steam piping, Deaerators
- 100 MWth hot water supply system
- Five boiler feed-water pumps (*Two pumps out of five should be retrieved.*)
- Make-up water treatment plant and tank (*Already renewed recently.*)
- Spare feeders of substations (*Re-usable*)
- Start-up transformer and 6.3 kV/400V transformer
- Three steam boilers of 32 t/h each as spares (*These boilers are to be fired when the gas turbine stops.*)
- Steam turbine/house and maintenance cranes (*A 60 MW new turbine to be installed in the currently non-existing steam turbine No.3 space. The steam turbine house should be expanded.*)

A new 190MW class gas-fired gas turbine combined cycle power plant shall be installed in Macedonia. The new plant consists of a 130 MW class gas turbine and generator, a heat recovery steam generator (HRSG) utilizing gas turbine exhaust gas heat, and a 60 MW class condensing steam turbine and generator. Mechanical cooling towers are applied for cooling the condenser water to the condenser. The new equipment together with the re-used existing plant will comprise a combined heat and power plant, which can usually supply the process steam of 40t/h

supplying steel company and the maximum hot water heat of 100 MWth in winter season. The equipment/system consisting of the new:

- 130 MW class gas turbine and generator
- Ditto-auxiliary equipment & control system (*oil cooling system, electrical system, etc.*)
- Gas pressure control system (*control valve, flow meter, piping, etc.*)
- Back-up fuel system (*Distillate oil or equivalent*)
- Heat recovery steam generator (HRSG)
- Ditto auxiliary (*Stack, duct, etc.*), control system and instruments
- 60-MW class steam turbine and generator
- Ditto-auxiliary equipment (*oil cooling system, electrical system, etc.*), and control system
- Steam turbine bypass system (*Valves, piping, etc.*)
- Dry low NOx combustors for gas firing, water injection type oil fired combustors (*NOx emission level to be less than 40 ppm.*)
- Mechanical type cooling towers with auxiliary equipment (*water piping, valves, etc.*)
- Others (*air compressors, maintenance tools, spares*)

Portions of this project charged to the Macedonian side are the followings:

- Civil works (*To include the modification/expansion of the existing turbine house. Also to include the relocation of the existing maintenance shop next to the turbine house.*)
- Erection works
- Modification and/or relocation of the existing steam and water piping
- Installation of high-pressure gas piping (*about 1 km*) and gas receiving station (*Up to the gas pressure control system.*)
- Clean-up and modification of the existing 5000 kl oil tank for the back-up fuel system and related pumps & piping (*about 500 m*)
- Rehabilitation of two existing boiler feed-water pumps
- Others (*lighting, fencing, necessary security, etc.*)

### Implementation plan

As there is no domestic supplier in Macedonia of a combined cycle power plant adopting a gas turbine. All equipment consisting of the combined cycle power plant including a HRSG and a steam turbine shall be imported from an overseas supplier. There are no experienced construction workers and civil workers of thermal power plants in Macedonia. Under the supervision by an overseas supplier of the equipment, the Macedonian side can manage the construction work of even a combined cycle power plant. It is desired to adopt such construction and/or civil workers for the plant, taking technology transfer, cost advantage, and other considerations. The total management capability of Macedonian domestic technology concerning the procurement and construction of a combined cycle power plant is not well developed. Therefore, technology transfer from an overseas supplier is necessary in this field. In order to get the full performance of a combined cycle power plant, the major equipment supplier such as gas turbine shall take the role of a main contractor in charge of engineering, construction and supervision of construction under a single responsibility. Also, standardized technology shall be adopted to maximum extent in terms of shortening of design and procurement of equipment. Thus, almost all equipment of the plant will be imported from an overseas supplier. The Macedonian side shall share the works such as civil works, construction works, and maintenance works of some existing equipment, procurement of some equipment or materials and supervision of the contractor.

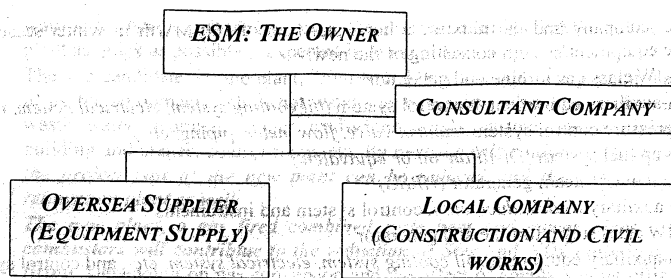


Fig. 1: Proposed structure of the project during the development and implementation phases

## 5. Required Funds and Financing

- (1) All equipment of the combined cycle power generating facilities and necessary materials shall be imported from abroad as the loan portion.
- (2) The related construction and civil works and the rehabilitation works of some existing facilities shall be born by Macedonia side as the local portion.
- (3) The followings are excluded from the construction cost:
  - Land, land adjustment, dismantling and removal of overlaid equipment.
  - Power station operation/management office
  - Staff accommodations and welfare facilities
  - Utilities for construction work

(Unit: US\$ mil.)

Item	Amount
<b>Plant Cost</b>	<b>125</b>
(Equipment component)-(1)	(93.7)
(Local portion = Equity component)-(2)	(31.3)
<b>Preparations for operation*</b>	<b>12.5</b>
(Loan component)	(106.2)
<b>Total</b>	<b>137.5</b>

\*Preparations for operation consist of the Consultant fee and the Contingency fee.

## 6. Environmental Contributions

The major benefit of this project is its environmental contribution. Here, briefly we address the so-called concept of baseline in order to compare the benefits of this project. The existing "ENERGETIKA"-Skopje power plant used to be operated with the capability of 30 MW electrical power generation, maximum 100 MWth hot water heat supply and 40 t/h process steam supply for oil firing. After the new power plant of 190 MW combined heat and power is completed, the conversion becomes completed from oil to gas, and energy saving also becomes possible by energy efficient combined cycle co-generation plant. The table below shows the environmental improvements that can be achieved by development of a gas-fired plant in comparison with the same size plant that could be coal-fired.

Pollutant	Present	Additional (coal fired)	Total (Baseline)	New gas-fired plant	Improvements
CO <sub>2</sub>	294,000	1,088,440	1,382,440	619,035	753,405 (-55%)
SO <sub>2</sub>	2,060	4,681	6,741	67	6,674 (-99%)
NO <sub>2</sub>	429	2,641	3,070	157	2,913 (-95%)

## Improvements in the Losses of the Transmission System

As we already mentioned before, the 130 MW equivalent electrical outputs by the gas and 60 MW equivalent electrical outputs by the steam turbine shall be interconnected into the Skopje substation through the spare feeders of the existing "ENERGETIKA"-Skopje power plant. About 75 MW out of 180 MW generated by the new plant could be directly transmitted to the steel smelting company. Another 105 MW shall be transmitted and distributed through the Skopje substation and 110kV transmission lines to the city Skopje. This will result in the reduction of 400kV power transmission volume to Skopje, the improvement of the worried issue of the transmission lines, and the total stabilization of the ESM's transmission system. Approximately 11.6 GWh could reduce the evaluated transmission losses. This means that the transmission losses rate could be improved by 0.7 % from 3.8 % to 3.1 %.

## Recommendations and Conclusions

The proposed project, a 190 MW Gas Fired Combined Cycle Heat and Power plant, will contribute to the Macedonian power and heat supply infrastructure construction to great extent by the following features after completion. Macedonian Government and the ESM should make their efforts in securing favorable and secured financing sources, either by appropriate loan agreements or through joint ventures or with independent power producers to execute the implementation of this project on the fast track priority basis. In respect to that the following features of this project should be emphasized:

The project shall compensate the possible power shortage assumed in 2004 winter peak in Macedonia.

Utilization of large quantities of natural gas is favorable for the entire economy of the country where at present the usage of the gas pipeline is very small and insufficient.

The project shall be located in the existing "ENERGETIKA"-Skopje power plant, and it could share the heat and steam supply system becoming energy saving co-generation plant.

The project is also a renovation plant, utilizing the existing equipment to maximum extent.

The project is located in the capital of Macedonia, Skopje the area of most consumption of electric power and shall contribute to the Macedonian policy of the acceleration of natural gas conversion from coal and oil by consuming large amount of gas.

The project shall contribute to the stabilization of the Macedonian transmission system and also the reduction of the total transmission losses.

Natural gas conversion from oil and the adoption of an energy saving co-generation plant shall contribute to the reduction of global warming gas CO<sub>2</sub> and also acid rain gases SO<sub>x</sub> and NO<sub>x</sub>.

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