CCEI

Cleaner and more cost effective industry in Macedonia

Bitola District Heating with Thermal Energy from TPP Bitola

Developed under the project “MAK-09/006 Cleaner and more cost effective industry in Macedonia“ funded by the Norwegian Government and implemented by Norsk Energi and Centre for Climate Change

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The Norwegian Ministry of Foreign Affairs is funding the program MAK-06/009 Cleaner and more cost effective industry in Macedonia (CCEI), implemented by Norsk Energi and Centre for Climate Change. For more information about the program see www.ccei.org.mk. This pre-feasibility study is developed under the framework of the program in order to support the transition to a low carbon society in Macedonia.

REK Bitola is the largest coal fired power plant in Macedonia. The owner of the plant is the state utility company ELEM . Installed capacity is 675 MW. Average annual electricity production is 4,34 TWh. The power plant has three blocks of 225 MW, each with boiler, turbine and cooling tower.

Bitola is the second largest city in Macedonia, with 86000 inhabitants. This report analyses feasibility of supply of heat from REK Bitola coal fired power plant to Bitola city and the villages Novaci and Moglia. The report concludes that the investment will be about 40 mill EUR and the internal rate of return about 11%. Heat supply from the power plant to Bitola, Novaci and Moglia will reduce the electricity output from the power plant by 0.18 MW per 1 MW heat supplied.

This report has been developed by a team consisting of Prof. Risto Filkoski, Prof Ilja Petrovski, Consultant Mr Igor Mischevski, with active involvement from Mr Jani Radivchev at REK Bitola and Ms Daniela Mladenovska at ELEM AD and Mr. Goran Nedelkov representing the Municipality of Bitola

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1. Executive brief

“Cleaner and More Cost Effective Industry in Macedonia” is a three year programme funded by Norwegian Ministry of Foreign Affairs. The project is implemented by Norsk Energi and Center for Climate Change, with technical support from the Faculty of Mechanical Engineering, University “Ss Cyril and Methodius” in Skopje. The main aim of the programme is reduction of harmful emissions, including emissions of greenhouse gases and more cost efficient energy intensive industry in Republic of Macedonia. The programme is providing technical support to the industry sector in identifying energy efficiency measures and developing pre-feasibility studies, where, except identified measures, there are also included other environmentally sound technical solutions, recommendations, conclusions, etc., which can contribute towards better performance of the company.

This pre-feasibility study for the project “Bitola district heating with thermal energy from TPP Bitola” is part of this programme. Some of the considered issues were: the main influencing factors of installation of district heating system, present and expected future heat demand for Bitola space heating and for agriculture production in greenhouses, technical potential of TPP“Bitola for operation in combined heat and power mode, some technical aspects of the project etc. Environmental impact, economic, financial, social and other aspects are also considered, emphasizing multiple benefits of the implementation of such project.

This study is focusing on analysis of possibilities for district heating of Bitola and the neighbouring municipalities Novaci and Mogila, by use of thermal energy from the Thermal Power Plant Bitola, as well as on analysis of effects and benefits that would be achieved by implementation of such project.

Main findings:

1. From the engineering standpoint, TPP Bitola possesses a well-grounded potential to serve as a source of thermal energy for distant heating of the town of Bitola and for agriculture production in greenhouses. This conclusion is based on the technical characteristics of the energy equipment installed in the plant and on the experiences with similar power plant units.
2. Regulated extraction of steam from the turbine system for heating purposes, regardless of whether it will be conducted from the intermediate and/or low-pressure turbine stages, or from the cross-over steam pipelines, will result with certain decrease of the plant’s electric power. According to the theory and practical experiences, the decrease of the installed electric power capacity is expected to be about 0.18 MW per 1 MW obtained thermal power.
3. Production selling price of 1 kWh thermal energy is calculated in the range of 0,4 – 0,74 MKD with end user price of kWh thermal energy 2 – 3 MKD
4. The investment of the project will be in the range of 40 mill EUR, which includes both sides production and supply
5. The financial income of realization of the project will give an internal rate of return about 11%

6. Regarding this project, the Municipality of Bitola has an opportunity to use the Cross Border component of IPA instrument in the following two years
7. Apart from the technical aspects, the project implementation is dependent on other issues and aspects, such as: decision regarding the type of entity that is going to manage the heating system (public enterprise, public-private partnership, etc.); sources for project development financing; the interest of the potential consumers - households, commercial sector, public sector, hospitals, industry, etc., for connection to a district heating system.
8. Finally, it has to be emphasised that the possibility to use thermal energy from TPP Bitola for district heating of Bitola is one of the opportunities, which has some obvious advantages, but also, some shortages compared to other solutions, such as construction of heating plants in the town. The focus of this study does not implicate that one of the options has advantages over the other. For correct decision it is necessary to conduct a comprehensive comparative analysis of all possible solutions.

2. Introduction

REK Bitola is located in the southern part of Macedonia, in Pelagonia plain. It has been built on the basis of the finds of coal-lignite, at around 12 km eastwards from the City of Bitola.

The conception of development and exploitation of the thermal power plant Bitola was initiated in the early 80-ties. In parallel with the start up operation of unit 1 in 1984, unit 2 was put into operation, and unit 3 in 1988, constructed in the manner that can be adapted for joint operation with another unit - unit 4 that remained undeveloped. Today REK Bitola with its three completed units of individual capacity of 225 MW or total installed capacity of 675 MW provides an average annual generation of 4,34 million MWh electricity. REK Bitola operates as a Plant of the Public Company ELEM (Elektrani na Makedonija; Power Plants of Macedonia).

Bitola is the center of the Bitola Municipality, covering area of 792 km2, with the town of Bitola and over 65 villages. The attitude of the terrain is between 590 and 710 m; average 650 m above the sea level. The total population is over 95,000 in about 28950 households. The total number of residential units (flats in collective residential buildings, houses etc.) is 37,225. The town itself has a population of about 86,000 inhabitants.

The Municipality of Mogila is located in Pelagonia, north-east of the city of Bitola. According to the last National census from 2002 this municipality has 6,710 inhabitants. The Municipality of Novaci is located in the southeastern part of Pelagonija plain and the central part along Crna Reka River, Bitola part of Mariovo region towards the border with Greece. According to the last National census from 2002 this municipality has 3,549 inhabitants. Both municipalities, Mogila and Novaci are rural municipalities, with agricultural production capacities and potential for greenhouses.

Initially, in the time of the construction of TPP Bitola, it was decided not to invest in a system for district heating of Bitola, although such a possibility was considered and analyzed.

On the other side, space heating residential, public, commercial and other sectors in the town is based on individual systems, using different energy sources: electricity, fire-wood and oil, with all the negative energy and environmental consequences. Central heating in an urban area has obvious advantages over individual systems: optimization of energy consumption, reduction of number of flue gas chimneys, reduction of consumption of electricity for heating, reduction of fire-wood cut, general improvement of air quality etc.

3. Technical report

3.1. Introduction and objective

The Thermal Power Plant Bitola is located on a distance of approximately 12 km from the town of Bitola. It is designed as condensation type thermal power plant and it consists of three units, with total electric power output of 675 MW (3x225 MW). The main technical parameters of the power plant are given bellow:

- Three boiler units, Ramzine type, Pp-670-140/ P-65, each one with capacity for production of 194.4 kg/s and average gross efficiency of about 85 %, designed for production of superheated steam, t=545oC, p=135 bar.
- Three turbines, type K-210-130-3, produced by LMZ, Russia, reconstructed in the 90-ies, the unit capacity was increased from 210 to 225 MWe.
- Fuel – low calorific lignite, with calorific value 7,000 – 7,500 kJ/kg and with high moisture content.
- Usually, on average annual basis, over 70 % of the total electricity in Macedonia is generated in TPP Bitola.
- Annual electricity generation in TPP Bitola in the last few years is 4.34 mill. MWh/year.

Initially, in the time of the construction of TPP Bitola, it was decided not to invest in a system for district heating of Bitola, although such a possibility was considered and analysed.

On the other side, space heating residential, public, commercial and other sectors in the town is based on individual systems, using different energy sources: electricity, fire-wood and oil, with all the negative energy and environmental consequences. Central heating in an urban area has obvious advantages over individual systems: optimisation of energy consumption, reduction of number of flue gas chimneys, reduction of consumption of electricity for heating, reduction of fire-wood cut, general improvement of air quality etc.

The present study is focusing on analysis of possibilities for district heating of Bitola and for heating of agriculture facilities (greenhouses) in the village of Novaci, by use of thermal energy from the Thermal Power Plant Bitola, as well as on analysis of effects and benefits that would be achieved by implementation of such project. This issue was a subject of analysis several times during the previous 30 years, starting from the initial phase of the power plant construction.

Some of the questions that should be answered or initiated:

- What is for the actual present and expected future thermal energy demand for heating purposes in Bitola?
- Is there any significant interest for agriculture production in greenhouses (which will need space heating) in the villages on the way from the TPP Bitola to the town of Bitola?

- Will there be any unacceptable negative consequences concerning the electricity generation in TPP Bitola, due to the extraction of certain amount of the overall steam flow for the heating system?
- How will the realisation of the project affect the electrical energy consumption in the town of Bitola? It is well known that most of the households use fire-wood and significant number use electricity for space heating. In actual circumstances in the country, it is not an easy task to make a reliable assessment of the amount of energy that will be replaced with thermal energy from TPP Bitola for space heating (what is going to be expected is relatively significant reduction of electricity and fuel oil consumption; certain reduction of fire-wood consumption; etc.).
- What will be the environmental benefits? Will there be any negative environmental impacts?
- What will be the role and responsibilities of ELEM, or REK Bitola in an eventual new company/consortium/ enterprise that would be responsible for heat supply of the consumers
- Also, there is a list of very important financial, economic and social issues to consider:
- How big investment will be required on the production side, in other words in TPP Bitola?
- How big investments will be required on the supply-side, meaning investment for the transmission pipeline from TPP Bitola to the town of Bitola, for heating sub-stations and for the in-town pipeline network?
- What will be the total simple pay-back period of the investment?
- How to determine the price of the heat energy: What would be the “production” price? What would be the lowest margin of the price that is acceptable for ELEM as a compensation for reduced production and sale of electricity? What would be the price derived according to a methodology used by the State Energy Regulatory Commission for the district heating system in Skopje? Is that methodology, with certain modifications, applicable in this case? What would be the price level that is bearable for the most of the customers?
- Will the expected price of the heat obtained from TPP Bitola be able to compete with other sources of energy used for heating: fire-wood, electrical energy, fuel oil, etc.?
- How many new employees need to be recruited to be directly and indirectly involved in the heat production and distribution?
- What other social effects will occur? How large share of the population will have opportunity to use the benefits of the heating system.

3.2. Previous studies and projects for district heating of Bitola

The technical possibilities of TPP Bitola to serve as a source of thermal energy for district heating of Bitola are envisaged from the beginning of the power plant construction works. In the period of design works on the TPP unit 3, in the year 1981, when the units 1 and 2 were under construction, one of the tasks in the frame of the scope of work for the designers was to propose a technical solution for installation of additional equipment in the power plant, aimed for distant heating purposes. However, the unit 3 is also ordered and delivered as a thermal power plant unit of condensing type, the same as the units 1 and 2. The only thing done is that the machine hall is designed with enough space for placement of a part of the eventual distant heating equipment. For the rest of the necessary equipment additional building should be erected between the boiler units 2 and 3. A listing of previous work done assessing the possibilities of district heating from REK Bitola can be found in Annex 8.1.

Comments to the previous studies

From the parts of the previous studies, analyses and opinions that were available, which relate to the possibilities of using thermal energy from TPP Bitola for heating the town of Bitola and to supply greenhouses on the way TPP Bitola – town of Bitola with thermal energy, several key conclusions can be drawn:

- Previous studies and analyses are carried out correctly and they are very good base point for further analysis.
- However, they were done in the period 1980-1986. As it is well known, in the meantime, the overall internal and external circumstances and conditions have changed significantly.
- Despite the general natural tendency for improvement of the life quality and living conditions, we have to keep in mind the fact that today's economic circumstances in the country, including the Bitola region, are not better than in the middle 80-ties. Moreover, in many segments, such as the population employment and financial conditions, they are even worse.
- From an engineering-technical perspective, significant changes have occurred in the meantime: some of the boiler plants that have been planned to serve as heating sub-stations in the town outskirts or in the urban are don't exist anymore. There are large changes in the urban structure of the town – newly built commercial-trade centres, new residential buildings etc., but the total number of residents has not changed significantly.
- It has to be emphasised that the possibility to use thermal energy from TPP Bitola for distant heating is one of the opportunities, which has some obvious advantages, but also, some shortages compared to other solutions, such as building of heating plants in the town.

3.3. The main influential factors of district heating

District heating is a system for distributing heat generated in a centralised location for residential and commercial requirements, such as space heating and water heating. A typical district heating system comprises a number of objects, facilities and installations that connect one or more heat sources with pipelines for transportation and distribution of heating medium to individual consumers. The main parts of the district heating system are:

1) Heat source. The core element of a district heating system is as a minimum a heat-only boiler station or a cogeneration plant (also called combined heat and power, CHP), with auxiliary equipment and facilities for: fuel storage and handling, water treatment, flue gases treatment etc. In the present case, TPP Bitola is going to be used as a heat source.

2) Heat transportation and distribution. The heat is distributed to the customers via a network of insulated pipes. District heating systems consist of feed and return lines. Usually the pipes are installed underground but there are also systems with overground pipes and systems with both underground and overground pipes. Within the system, heat storages may be installed to even out peak load demands. Hot water or steam is distributed via the pipeline network, then, in a system of heat sub-stations, heat is transferred to another media and distributed to final consumers. Additional part in the case of Bitola heating system will be the main transportation pipeline from the thermal power plant to the town, with approximate length of 12.5 km.
3) Local distribution network. At customers level the heat network is usually connected to the central heating of the dwellings by heat exchangers (in heat substations). The water (or, sometimes, the steam) used in the district heating system is not mixed with the water of the central heating system of the dwelling.

The concept of the district heating system that is going to be selected depends on a number of influential factors: engineering-technical, environmental, economic-financial etc. Some of the most important factors are:

- maximum heat load demand,
- types of consumers,
- selection of fuel
- selection and location of heat sources and sub-stations, with regard to zoning and other requirements,
- financial-economy criteria,
- possibility of an eventual use of existing local heat sources (for sub-stations and/or for other purposes), etc.

It is not always possible to make selection of suitable technical solution for heat source of district heating system according to the criterion of achieving the highest energy efficiency. Sometimes, the dominant and deciding factors are the location of the primary sources of energy, urban development and the financial resources of investors.

In particular, for proper selection of district heating system concept, the following parameters should be analysed:

- Density of the heat load for the considered area
  - Heat load over unit of urban area (MW/km2)
  - Heat load along the pipeline length (MW/km)
  - Available heat energy at the heat source

- Structure of the area to be heated
  - Specific conditions of locations for sub-stations and local heat sources
  - Traffic intensity
  - Emission of harmful substances: SO2, particles etc.
  - Allowable emissions and concentrations of harmful substances in start-up mode,
  - Noise

- Choice of parameters in the heating system
  - Temperature of the working medium in the feed and return lines
  - Pressure and temperature at the heat source
  - Top heat load
  - Annual utilisation of the system (hours/year)

- Concept of setting up a pipeline network
  - Manner of conducting: in channel, without channel, soil properties etc.
  - Security of supply
  - Accessibility of the pipelines (city, open space)
  - Type of land (soil)

- Way of control of heating plant and district heating system
  - With or without remote control
  - On-shift work, etc.
  -

On the outskirts of the city there are usually suitable locations to build the heat source object or the main heat station of a distant heating system. For economical operation of district heating systems, a necessary requirement is adequate density heat load. Wide-spread practice has shown that justified heat load density for a new urban district heating system is 20-30 MW/km2. The highest heat densities are typically met in the urban centers, and the lowest heat load density has settlements with individual family houses.

3.4. Present and possible future heat demand

Basic meteorological/climate parameters

Bitola is the center of the Bitola Municipality, covering area of 792 km2, with the town of Bitola and over 65 villages. The attitude of the terrain is between 590 and 710 m; average 650 m above the sea level. The total population is over 95,000 in about 28950 households. The total number of residential units (flats in collective residential buildings, individual houses etc.) is 37,225. The town itself has a population of about 86,000 inhabitants. The average population density is about 788 persons per m2.

The main meteorological conditions for Bitola:

– general climate type – modest-continental	
– average annual temperature	11.1oC
– the coldest month is January, with an average temperature	0.6oC
– the lowest temperature	-30.4oC
– the hottest month is July, with an average temperature	22.2oC
– the highest temperature	41.2oC

Systems for central heating in Bitola

At present, the residential, public, commercial and industrial sectors are supplied with thermal energy in a decentralised manner. Most of the households use fire-wood, light oil (for households) and electrical energy for space heating. Just a small share of the residential sector units is equipped with appropriate installations (pipelines, radiators, etc.), and some of them are connected to a local heat generation source.

From the technical point of view, Bitola is an urban area with very good opportunities for implementation of district heating, due to the relatively large population density in some of the parts of the town. Therefore, in October 1999, a joint stock company was established by AD Toplifikacija – Skopje and Primatehna – Bitola, named Toplifikacija – Bitola. Seven boiler rooms, with total installed capacity of slightly above 26 MW, owned by the Bitola Municipality, were given under concession to Toplifikacija – Bitola. The district heating company is not in operation from the autumn 2008, because of the high cost of the fuel (heavy oil), resulting in high regulated final price for the consumers and because of the relatively small installed capacity (high costs per installed power). An overview and assessment of the situation concerning the heat demand in Bitola is presented in the following table. The heat demand of about 63.2 MW in the Bitola urban area can be expected in the first phase of the project development.

Table 1. Assessment of the heat demand in Bitola

Type of consumer	**Apartment Blocks**		**Commercial buildings**		**Total**
	m^2	kW	m^2	kW	kW
Connected to the local heating system	215,315	25,838	6,785	950	**26,788**
Not connected to the local heating system, but with internal heating installations, water based	105,950	12,714	3,050	427	**13,141**
Not connected to the local heating system, without internal installations	105,900	12,708	19,100	2,674	**15,382**
Existing consumers	427,165	51,260	28,935	4,051	**55,311**
Future (possible) consumers	54,600	6,552	9,400	1,316	**7,868**
Total	**481,765**	**57,812**	**38,335**	**5,367**	**63,179**

There are, also, other local systems installed for heating of one or several collective apartment buildings. These systems posses a boiler room, small heat distribution network and internal installations. The total installed capacity of this kind is assessed between 2 and 6 MW. Parts of these systems are not in function at the moment, due to the high heating price for the final consumers.

There is a list of boiler plants in industrial, public and commercial objects in Bitola, prepared about 20 years ago. Some of the boiler plants are just for space heating and others are aimed for steam generation used in technology and for heating. It is very likely that some of them don't exist anymore. Since, the existing boiler plants are serious candidates to be used as heating sub-stations, it is necessary to make an up-dating of the list.

Possible future heat demand

One of the most important tasks in the beginning of an analysis of feasibility of a project for district heating system is proper definition of the heat demand. In a present situation in Bitola (and the country as a whole!) this is not just a technical question, such as what is the total area in residential buildings (in m2), both individual and collective ones, in public buildings, in commercial objects etc. More than this, it is a socio-economic question, meaning whether there is a willingness and readiness to be connected in a district heating system and to bear all the financial consequences during the installation works and operation of the system.

According to certain assessments of the Bitola Municipality experts, more than 65 % of the households in the collective residential buildings would be ready to connect to central heating system on mid-term basis (5 years). About 10-15 % of households, living in individual buildings, are also willing to connect to a central heating system. Also, it is assumed that some public entities and significant number of commercial and industrial sector enterprises will be connected to the central heating system.

However, the previous assessments for the willingness of the households, public and commercial sector entities etc., to connect to the eventual district heating system, must be checked and confirmed with properly prepared and conducted survey on scientific basis. The survey must be prepared and provided according to the proven and accepted methodology. This is, probably, one of the most important issues related with implementation of the project.

An assessment of the possible future heat demand by different consumers is given in Table 2. In this case, according to the experiences concerning the types of buildings in the region, the normatives of specific consumption of heat may vary in large interval of 30-70 W/m3 or 70-170 W/m2.

Table 2. Assessment of the heat demand in Bitola (actual and possible future demand)

Description	Installed heat capacity	Presumed future development	Total
	MW	MW	MW
Collective residential objects with internal installations (pipelines, radiators etc.), connected to the existing heating boiler rooms	35	5	40
Collective residential objects with internal installations, not connected to the existing heating boiler rooms	5	-	5
Collective residential objects without internal installations, not connected to the existing heating boiler rooms	5	15	20
Individual residential buildings (houses)	10	10	20
Public buildings (schools, administrative buildings	20	2	22
Commercial buildings	5	5	10
Hospitals, health-care objects, etc.	10	2	12
Industry	15	20	35
Agriculture production (greenhouses)	5	30	35
Total	**110**	**90**	**200**

According to some of the previous assessments, in the first phase, a heat demand of approximately 135,000 MWh/year and in the second phase 270,000 MWh/year can be expected, which is, probably, a bit exaggerated.

During the preparatory stage of the project, a comprehensive analysis must be done with regards to the following issues: the density of the heat demand (in MW per km2 urban area), structure of the area that is going to be supplied with thermal energy (base- and top-mode heat load, the way of energy use, existing heat sources in the area that may be still used, etc.), selection of the technical parameters of the system (temperature, pressure), conceptual design of the pipeline system, necessary operational staff etc. As a general rule, the critical value of the heat demand density is 25 MW/km2. If the heat demand density in parts of the town is below this value, it would mean that the installation of central heating in these areas is not feasible.

Conclusion to this section

The possible heat demand (heat consume) should be defined precisely as more as possible, by structure (households, public buildings, schools, commercial buildings, small businesses, industrial facilities etc.), by distribution etc. This is necessary in order to enable better assessment of the financial feasibility of the project and to define important technical aspects of the project, such as the location of sub-stations and main network pipelines. At the same time, the survey can give some results, or, at least better assessment concerning the structure of energy sources used for heating purposes in the town: how much electricity, fire-wood, light oil for households, etc., is used for space heating. The survey should be accomplished in close cooperation with the local authorities.

3.5. Assessment of the technical potential of TPP Bitola for heat supply of Bitola and Novaci

The main technical parameters of the TPP "BITOLA" relevant for the recent project

The Thermal Power Plant Bitola is designed and built as condensation type thermal power plant. Some of the original design and actual operating parameters of the TPP Bitola units are given in Table 3. The power plant units were reconstructed in 1994, which has resulted in increasing of electrical power of 15 MW per unit, or 45 MW in total. A simplified schematic representation of the main equipment of one unit in TPP Bitola is given in Fig. 1.

Table 3. Original design parameters and actual operating parameters of TPP Bitola

Parameter	Unit	Initial design value	After the project for power increasing in 1994	Example: According to the balance for 2009
Nominal installed electrical power per TPP unit	MW	210	225	225
TPP own electricity consumption	%	7.82	8	8.182
Electric power (per TPP unit) on the threshold of the electricity network	MW	193.6	207.0	206.6
Number of hours in operation at nominal installed power capacity	h/an.	6500	6500	6782
Capacity factor (coefficient of utilisation of the installed nominal power capacity)	%	74.2	74.2	77.4
Electricity generation (per TPP unit) on the threshold of the electricity network	MWh/an.	1,258,205	1,345,500	1,401,092
Electricity generation on the threshold of the electricity network, total (three units)	MWh/an.	3,774,615	4,036,500	4,203,277

During the last 15 years, the average annual electricity generation in the TPP Bitola is about 7 % larger than the designed generation, following the permanent pressure for production over the designed nominal capacity. Having in mind the present conditions within the country's electricity market, where about 20 % of the electricity consumption on annual basis must be covered with import, that sort of pressure can be expected in the following years, too.

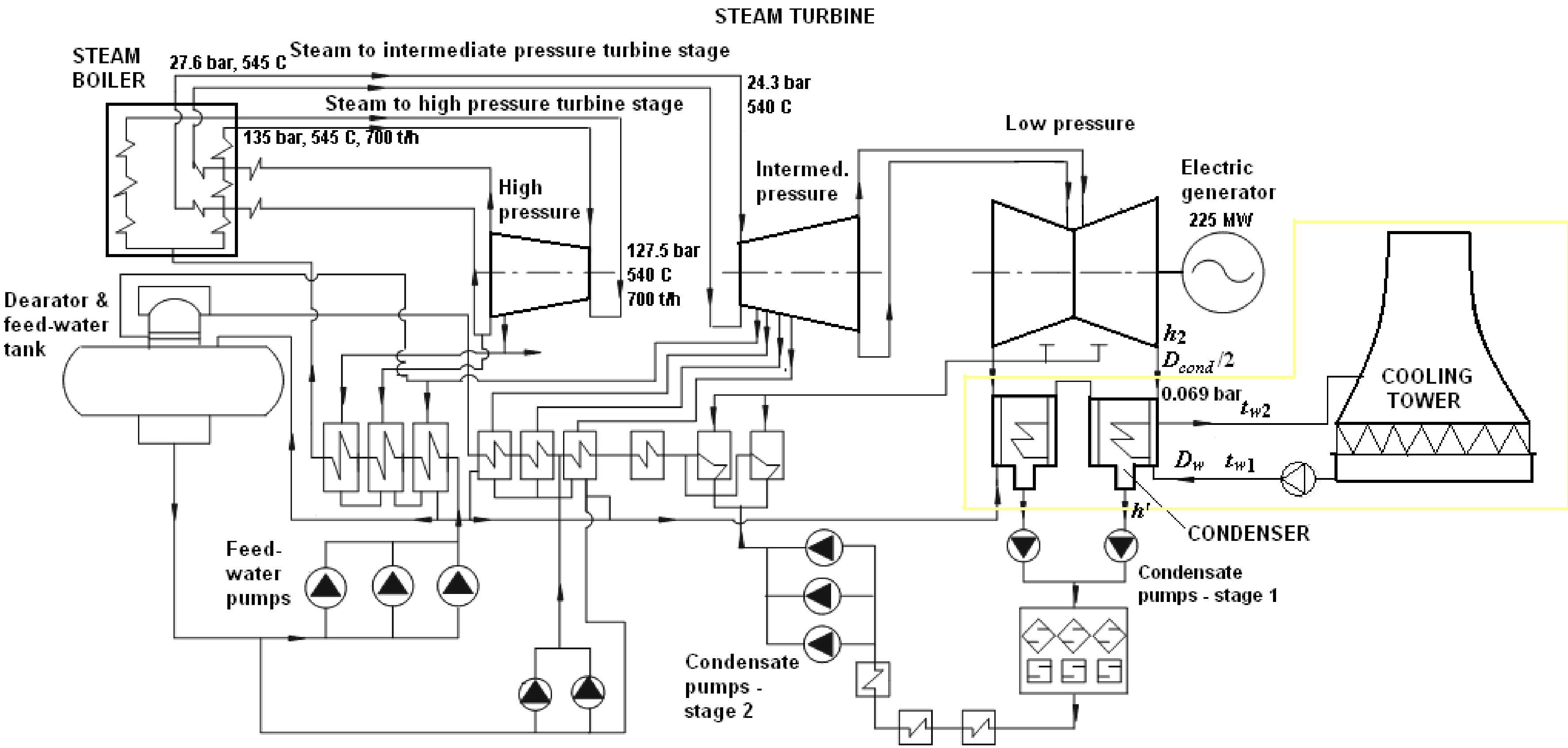


Figure 1. Schematic presentation of the main equipment of one unit of TPP Bitola

Possibilities for reconstruction of TPP 'BITOLA' for operation in combined mode

TPP Bitola is a potential efficient source of thermal energy for district heating of the town of Bitola. The turbines in two out of three units of the TPP Bitola can be reconstructed to work as combined plant for electricity and heat generation. For the purpose of heat generation can be used partly utilised steam, with low work capacity, which has already performed significant amount of mechanical work in the high and intermediate pressure turbine stages. Such steam has still enough high parameters, required to obtain heat for district heating system. According to the operational experiences related with power plants of the same or similar capacity and design characteristics, with reconstruction of two units of TPP Bitola it will be possible to obtain a thermal energy source for district heating with capacity of 2x200 MWt, which is more than enough for covering present and future demands of the town and of the agriculture producers in the near-by villages.

From a technical aspect, in order to be capable to deliver thermal energy for heating purposes, it is necessary to undertake the following main steps in the frame of the TPP Bitola:

- To provide reconstruction of the steam turbines low pressure stages on the Units 2 and 3 and to install the necessary equipment in order to be technically capable for regulated steam withdrawal. They will serve as baseline heat sources. The steam that will be used should be low pressure, of the order 1.3÷1.5 bar and 180-200oC (note: higher steam pressure for this purpose results with bigger losses!).
- To give a technical solution for covering the thermal energy needs in a top operating mode (the coldest period), either by another regulated steam withdrawal at slightly higher pressure (2.3÷2.5 bar) or by installation of a top boiler plant. In this process, condensation of steam is taking place in heat exchangers, where thermal energy is transferred to heating water. The power plant units (2 and 3) should be connected in a system for steam supply of the heat exchanging & pump station (HEPS) with a pipeline and appropriate equipment, including a pressure reduction station. In this way reliable operation of the heating system is ensured in terms of unplanned stoppages.
- To install the necessary base-mode equipment for distant heating in the heat exchanging & pump station (HEPS): baseline heat exchangers, circulating pumps, collectors, pipeline connections, regulation & control equipment, etc. The HEPS should be located in the premises of TPP Bitola. In steam- water heat exchangers of the HEPS, water will be heated and then used for heat supply of the users. The role of the circulating pumps is to provide an adequate flow of water to the users, depending on external conditions. In the case of TPP Bitola, despite the phase approach to the project development, the HEPS has to be completely installed in the first phase.
- Central regulation - The water heating and its circulation should be conducted under the rules of qualitative and quantitative central regulation. Its role is to adapt the heating power of the source to the real needs of the system. The consumers needs are changing due to the changes of the ambient temperature.

Therefore, it is necessary to adjust the flow and the parameters of the heating medium according to the needs of consumers. The operating mode of the distant heating system depends on many factors, but the most influencing are the characteristics of the heat load (type, concentration and total amount of heat demand - consumers that are connected to the system: households, commercial buildings, etc.), type of heating sub-stations that are installed in the system and the type of connection of the local installations to the heating network.

– To provide connection to the hot-water pipeline.

A schematic representation of a thermal power plant unit of condensing type reconstructed to work in combined heat-and-power mode, that means, to be also used for heat supply with regulated steam extraction, in a case such as in TPP Bitola, is given in Figure 2. It must be noted that points of steam extraction should be selected after further analysis. The scheme in Fig. 2 doesn't prejudice the technical solution, since in this turbine type there are already implemented different solutions, including combinations of extraction from: last stages of intermediate pressure turbine part, low pressure turbine stages and cross-over pipes between the intermediate and low pressure turbine stages.

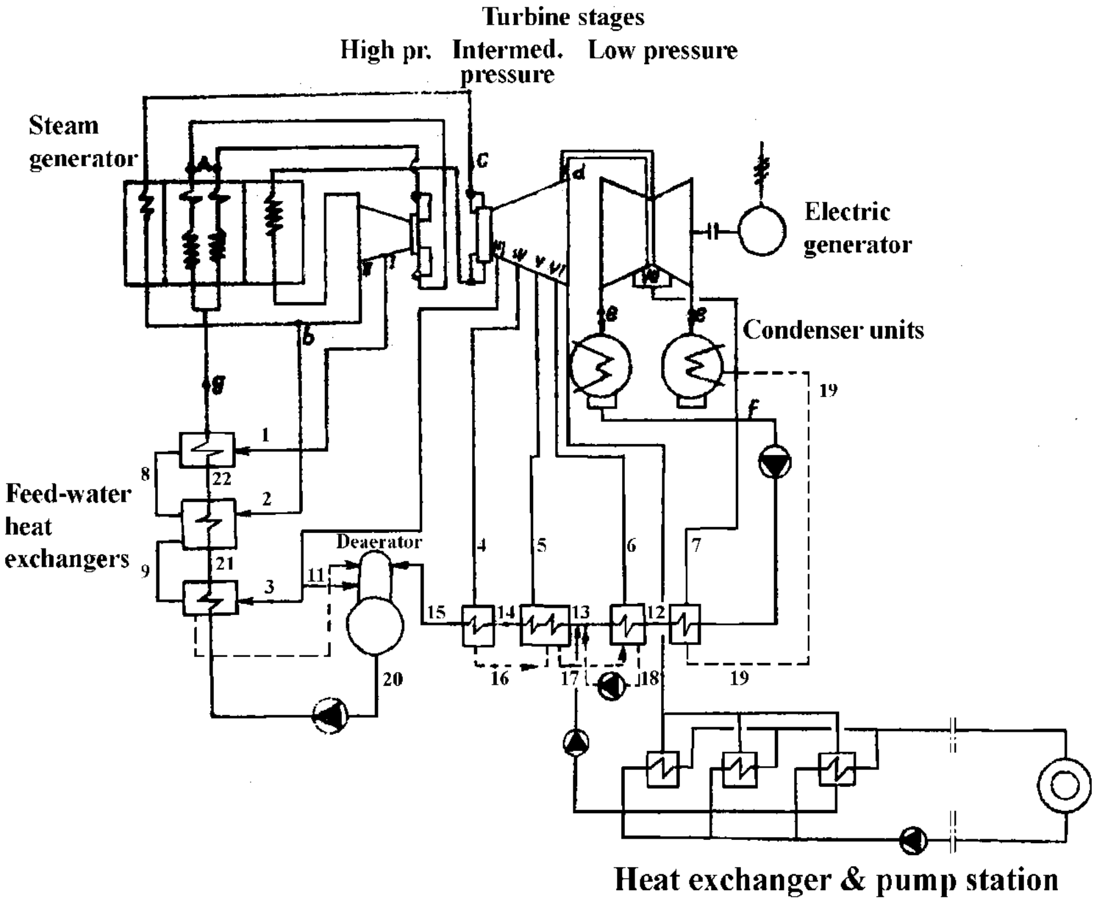


Figure 2. Schematic representation of thermal power plant unit of condensing type reconstructed to be also used for heating

A concept of the heat exchanger and pump station in TPP BITOLA

A schematic presentation of the heat exchanger and pump station, which should be installed in the TPP Bitola premises, is given in Fig. 3. Regulated steam withdrawal (extraction, take-off) from the units 2 and 3 should be used for heat supply. In a case of immediate shut-down of one, or even both units, a supply with fresh steam at higher pressure should be overseen. In that way, the facility will provide a more reliable heat energy supply to consumers in extraordinary circumstances. Additional capacity of fresh steam can serve for that purpose, which, as appropriate, may be used to heat water in the HEPS. In this case, the term "fresh steam" doesn't mean steam directly brought from the steam boilers, but steam with various parameters that doesn't fulfilled completely its work in the turbine. Usually, in similar power plant facilities, for the previously mentioned purpose is used superheated steam, taken (extracted) after a pressure reduction station designated for plant's own needs (at pressure ~20-25 bar or 4-5 bar).

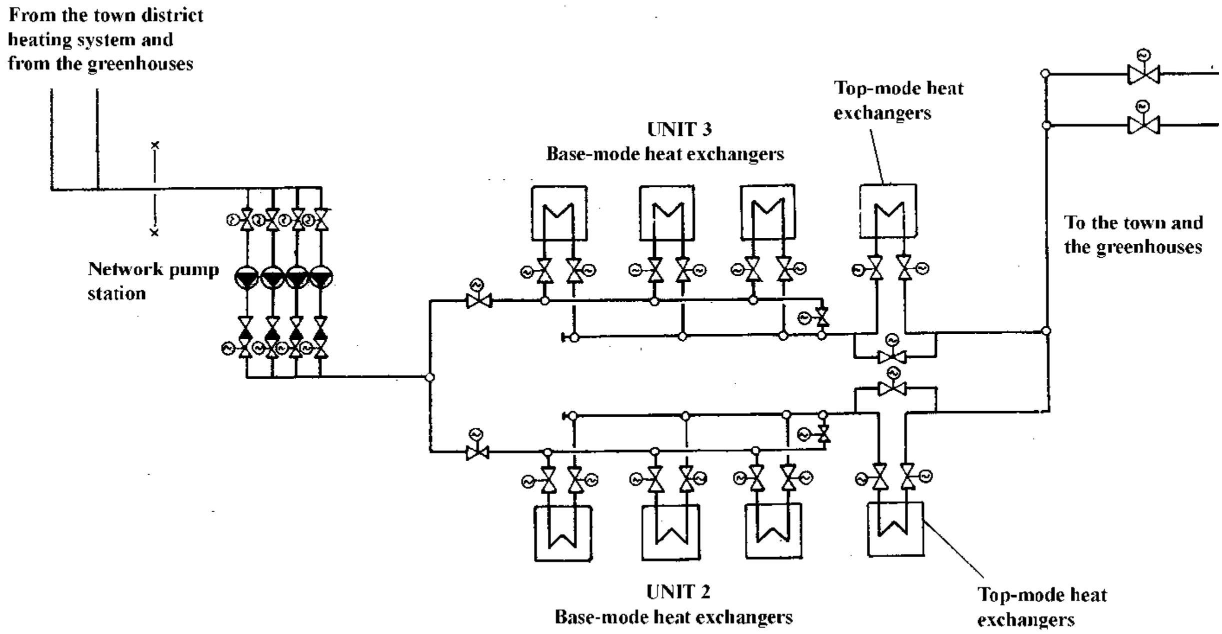


Figure 3. Schematic representation of the heat exchanger & pump station (HEPS)

Heat carrier

Choice of heat carrier

The common medium used for heat distribution is hot water, but, also, steam is used in some systems. One of the basic questions is whether steam or hot water at certain values of pressure, temperature and velocity are able to transfer more heat energy for the same time through the same pipe diameter? In general, hot water at temperature up to 150oC has certain advantages against steam as a heat carrier for distant consumers. This means, that larger amount of heat can be transported through a pipeline of a given size by hot water flow at ordinary velocity (1.0-2.0 m/s), than by saturated steam (at velocity 30-60 m/s). Some of the main disadvantages of hot water are:

- the need for larger electricity consumption for system operation (pumps etc.);
- the necessity to maintain constant static pressure higher enough than the evaporation pressure at working temperature.

Steam has advantages as a medium for temperature processes above 150oC and for higher pressures. Another advantage of steam is that, in addition to heating purposes, it can be used in industrial processes due to its higher temperature. One of the disadvantages of steam as a long-distant heat carrier is a higher heat loss due to the high temperature in the pipeline network. Also, there is no possibility for central regulation of the system, the installation and maintenance of the pipeline system is more expensive and the lifetime is shorter. One of the most important disadvantages of steam is the fact that the thermal efficiency of cogeneration plants is significantly lower if the heating medium is high temperature steam, causing smaller electric power generation.

General conclusion regarding the choice of heat carrier in the Bitola case is that hot water is better distant heat carrier than saturated steam, mostly because of the following:

- Less heat losses during transportation.
- Possibility of central regulation, better system flexibility towards ambient temperature.
- Simpler layout of pipelines, lower financial investment.
- Longer technical life of the system.
- Easier operation and lower operational costs.
- Operation experiences of different distant heating systems show that optimum transport velocity of hot water is in the range 1.0 – 3.0 m/s. The lower values concern to pipelines with smaller diameter.
- Proper design of pipelines network is very important and will result with: better operational security, reduction of operational costs, reduction of pressure drop, lower electricity consumption for pumps etc.

Temperature regime

According to the experiences and comparative analysis, when using hot water as distant heat carrier, optimum temperature regime is bellow 150oC. In recent years, systems with temperature up to 130oC are mostly in use, due to certain advantages, including lower energy losses during transport and possibility to use standard technical solutions, such as pre-insulated pipes.

For the Bitola distant heating case, the optimum solution for a primary heat carrier would be to use hot water, in two-pipelines system, with a temperature regime (130-135)oC/(70-75)oC. Secondary network would have temperature parameters 90oC/70oC. The opportunity to use standard polyurethane foam (PUR) pre-insulated pipes for a part of the network would lower the pipeline installation works and insulation cost and would add to the financial attractiveness of the project. Hot-water pipelines insulated in this manner have found extensive use in municipal heat distribution piping systems. One of the principal advantages of this technical solution is the possibility of extremely rapid laying of the pipes, without a need for classic concrete ditches or supporting and suspension aids. This insulation system is also very resistant and characterised by a minimum loss of heat.

Hot-water transportation from TPP Bitola to the town of Bitola

Initial data for definition of the hot-water flow and the appropriate pipeline system properties are: defined heat energy source (in this case, TPP Bitola has enough capacity, but the whole necessary reconstruction works and installation of equipment have to be done in the first phase); demand (capacity) of the district heating system by phases and total capacity of the system, heat carrier parameters, system operational mode (regime), auxiliary equipment, including automatics etc.

Maximum load of the distant heating system, that means, the capacity at which the main hot-water transportation pipeline should be designed, including a perspective for heating demand development in Bitola and demand for thermal energy for agriculture production is assessed at about 200 MW.

Several main objectives that must be achieved when deciding about the manner of transportation of heat carrier must be security of energy supply, minimisation of heat losses and economic-financial feasibility. In order to satisfy these objectives, while designing the system, attention should be paid on simple and energy effective technical solutions.

Conclusion to this section

As a conclusion of the previous analysis, it may be noted that TPP Bitola possesses a well-grounded potential to serve as a thermal energy source for distant heating of Bitola and for agriculture production in greenhouses. Apart from the technical aspects, the project implementation is even much more dependent on other issues, such as: finding sources for financing of the project; the interest of the potential consumers - households, commercial sector, public sector, hospitals, industry, etc., for connection to a district heating system. Obviously, the second issue is closely related with the financial circumstances and the expected necessary cost for connection to the system. A properly prepared comprehensive survey should be accomplished, in order to obtain relevant parameters on this issue.

Phases/activities of project implementation:

- Survey for detection of real interest and willingness of potential consumers for connection to district heating system, and mapping of what is an acceptable price of heat of an average consumer.
- Initiation to make an agreement with the interested stakeholders.
- Establishing a consortium or company with the main task to supply the town of Bitola and agriculture producers (greenhouses) with thermal energy for heating.
- Preparation of tariff rule-book with methodology for definition of thermal energy price.
- Achievement of long-term agreement for thermal energy supply.

- Research/investigation works, studies, design works, design documentation (development of design documentation for turbines modernisation; projects on pipelines tracing, location of existing objects, location of new objects, etc.).
- Reconstruction works in the TPP: modification of turbines (in two units), regulation and control system,
- Construction of the main hot-water pipeline.
- In-town pipeline network and heating sub-stations.
- Local installations (consumers)
- Testing
- Commissioning

3.6. Technical aspects of the project

Energy Efficiency

Advantages of combined mode centralised system for heat supply

With combined heat and power generation it is possible to achieve much higher efficiency of the power plant unit than with purely condensing power plant unit. In this case, the steam produced in the boiler, is transported to the steam turbine, from where, according to the consumers' needs, steam is taken off at appropriate temperature level.

- Energy efficiency facts:
  - According to the thermal engineering theory and experiences, installation of a system for steam extraction for heat supply in this type of power plant units means loss of minimum power of 0.18 MW for electricity generation per 1 MW power for thermal energy production.
  - If the heat demand of the potential consume is equal to 60 MW thermal power, as it is assessed for the first phase of the Bitola district heating project implementation, that would result in about 11 MW lower electric power generation capacity of the power plant.
  - However, the overall utilisation of energy in a combined heat and power plant is higher than in condensing plant, which is depicted through the Sankey diagrams of energy flow, given in Figures 4 and 6. Principal schematic presentation of combined heat and power plant unit of 225 MWe installed capacity is presented in Figure 5.
  - It is very important to note that the decrease of electricity generation will be partly compensated by the expected electricity consumption for heating purposes in the areas covered with the district heating system.

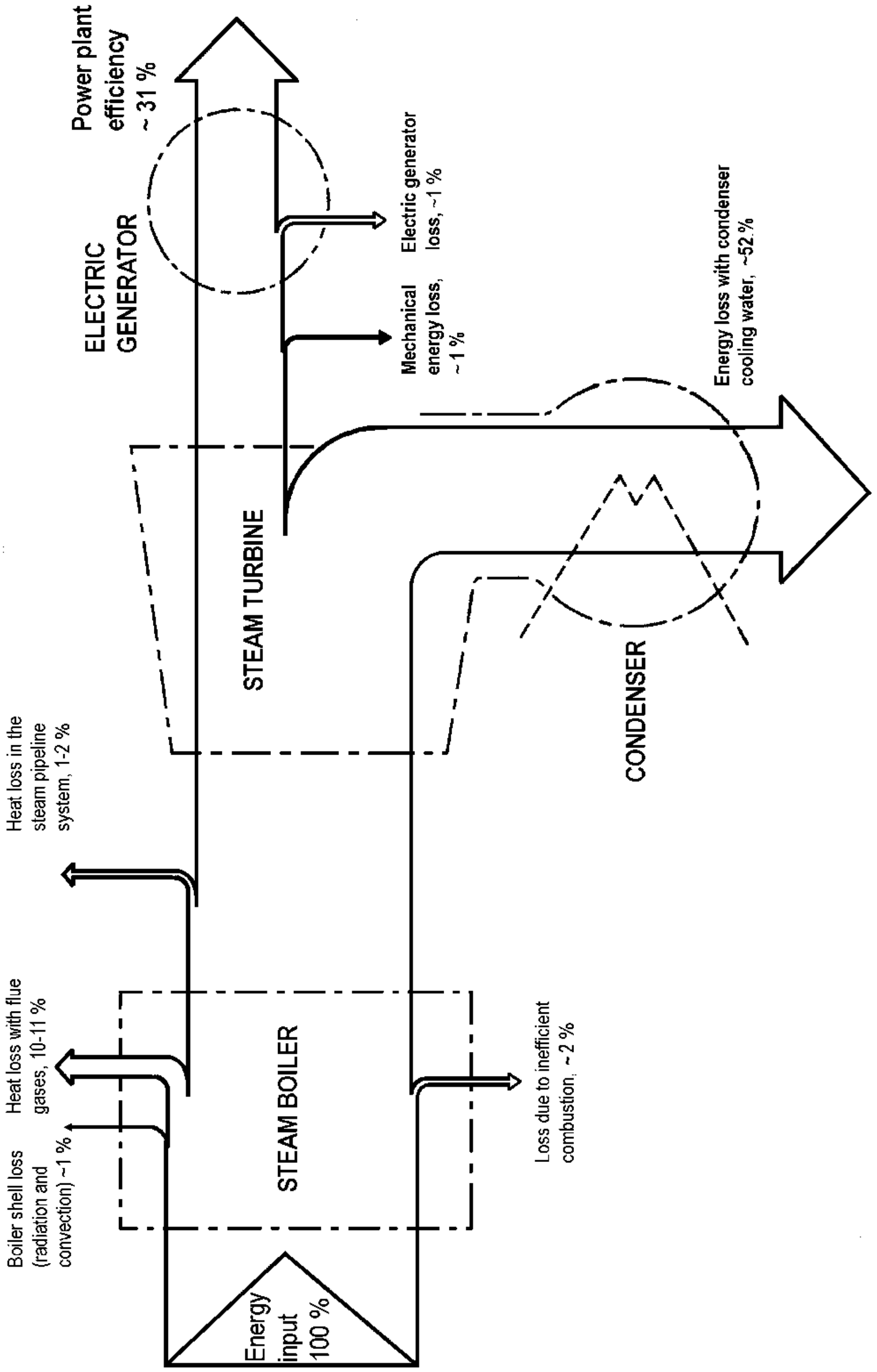


Figure 4. Sankey diagram of energy flow – condensing TPP

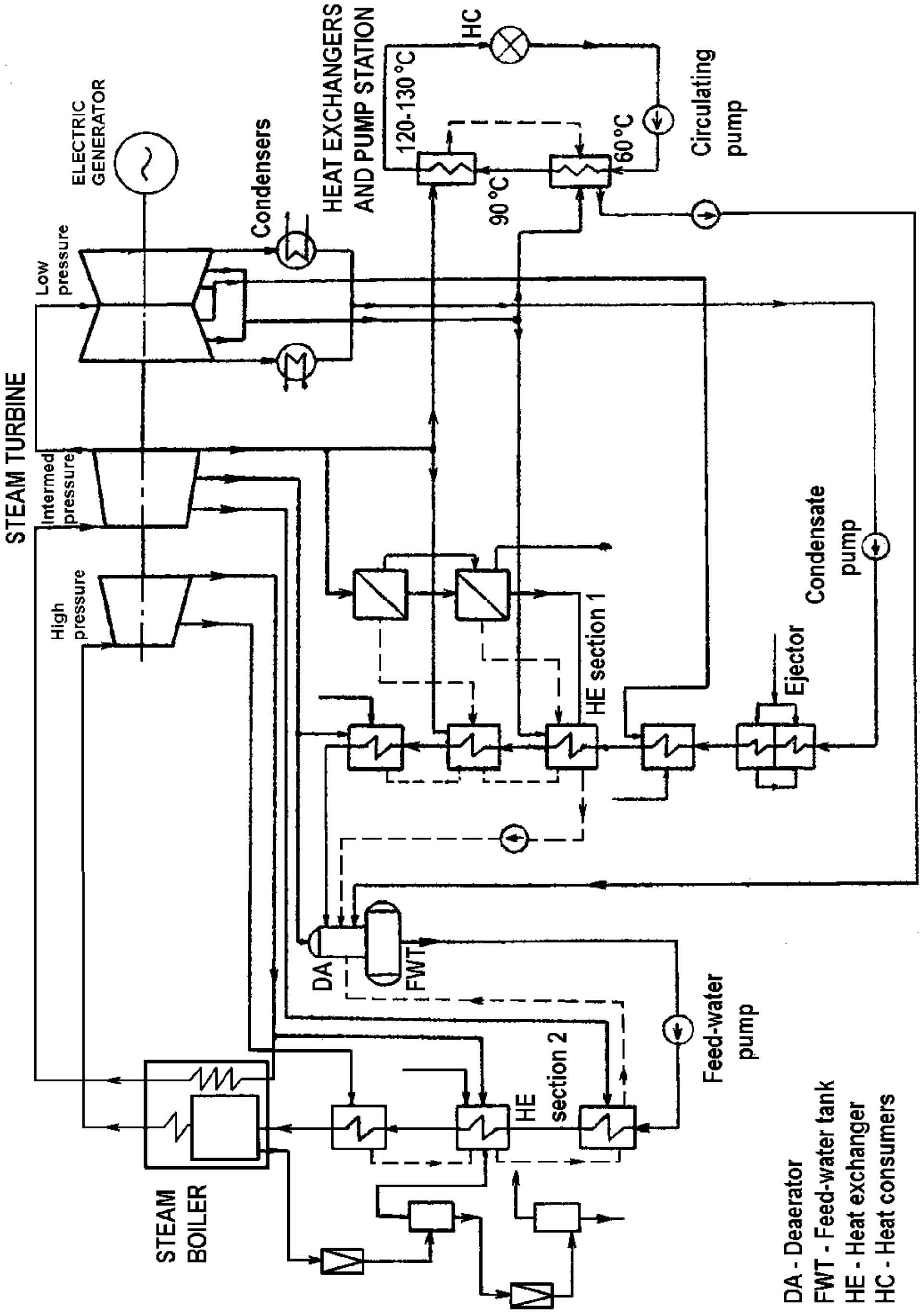


Figure 5. Schematic presentation of combined heat and power TPP unit

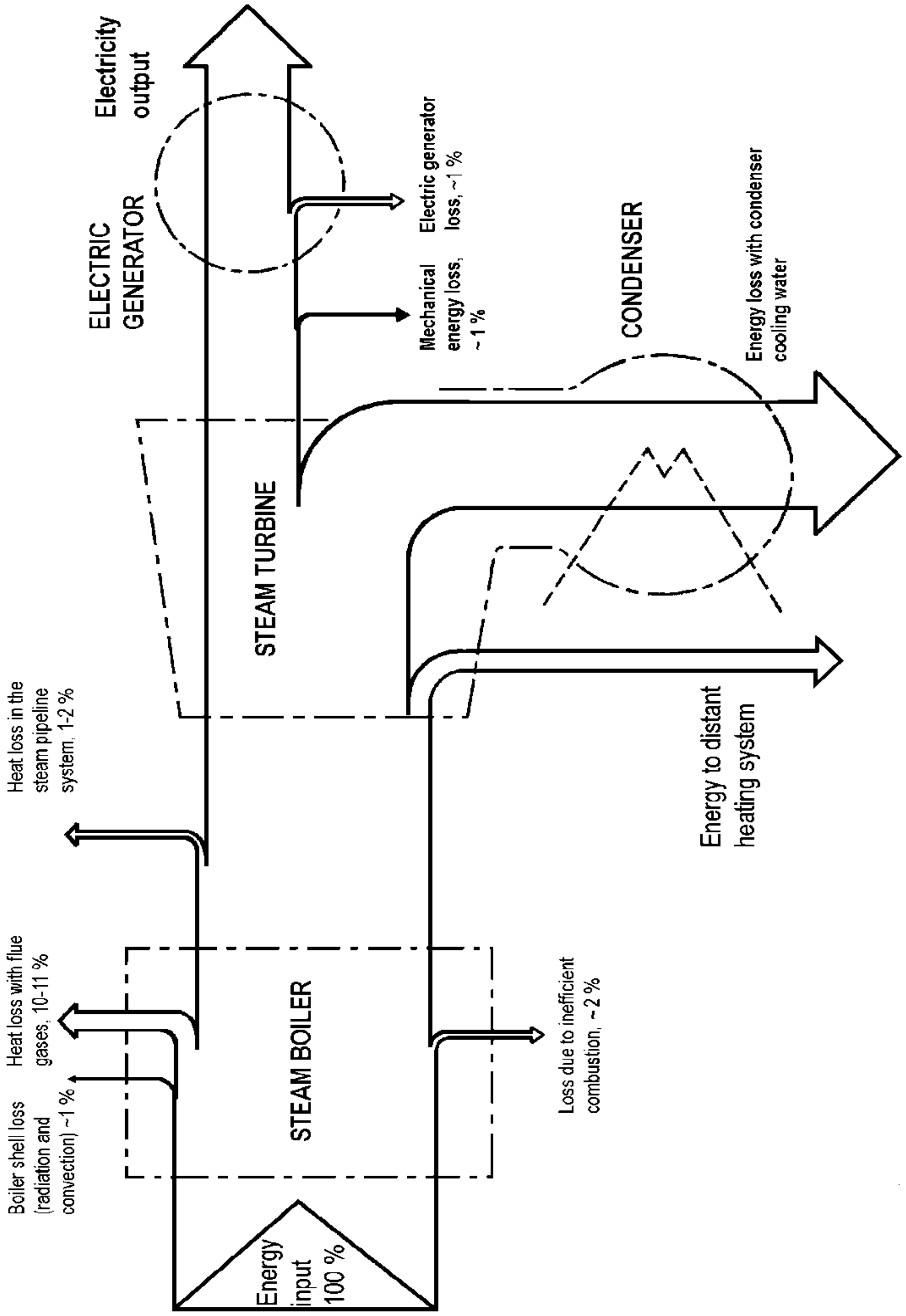


Figure 6. Sankey diagram of energy flow – combined heat and power TPP

Necessary technical steps to achieve better energy efficiency in a case of combined heat-and-power generation

It is a fact that TPP Bitola possesses a capacity to play an important role of efficient thermal energy source for heating purposes of Bitola and other near-by municipalities. Complex ways to increase the efficiency of steam turbine plant that operates in combined heat and power mode are the following:

- Lowering the temperature level at which steam withdrawal from turbine is performed; that is usually achieved by two-stage heating of water;
- Decreasing of steam pressure reduction after the take-off from turbine;

- Reduction of pressure drop in the steam pipelines;
- During the design phase: Optimal steam turbine design, taking into consideration the conditions of mutual operation of the turbine and hot water network, aerodynamics of the turbine flow space etc.;
- Maximum use of heating operation mode, when the heat loses in the condenser are lower;
- Providing high reliability in operation, with as less as possible interruptions;
- Increasing the degree of automation (automatic regulation) of the steam turbine (plant) operation.

What is necessary to be done in TPP Bitola

- Development of design documentation.
- Reconstruction of the intermediate- and low-pressure steam turbines stages of the Units 2 and 3 (pressure level 1.0-2.5 bar) or cross-over pipes between IP and LP stages and installation of the necessary equipment in order to be technically capable for regulated steam extraction. Reconstruction of two units is necessary, in order to provide secure supply with thermal energy. Also, supply with fresh steam at higher pressure should be technically overseen in a case of immediate shut-down of one, or even both units.
- Installation of the necessary equipment for two-stage water heating: base-mode (base heat exchangers for water heating up to 120oC, pumps, pipelines, regulation & control equipment, etc.) and top mode. The heat exchanger and pump station (HEPS) has to be located in the power plant.
- Implementation of a technical solution for top-mode heating of water up to 130-135oC (for instance, by non-regulated steam extraction from the steam collector for the plant own needs) or to the temperature level that will be decided during the design works.
- Central regulation. Central regulation of the distant heating system has a specific and very important task to adjust the thermal power of the heat source to the exact actual needs of the heating system. These needs are constantly changed, according to the ambient temperature. That is why the water flow rate and the water temperature should be changed, following the parameters of the heat consume (heat demand). The mode of the central regulation of the distant heating system depends on a number of factors, but the most important are the type of the heat load and the way of the connection of households installations to the district heating network.
- To provide connection to the hot-water pipeline

Pipeline system from TPP Bitola to the town of Bitola

One of the most complicated problems that should be resolved may be the project for construction of a transmission pipeline system from the thresholds of the TPP Bitola to the heating stations in the town and in the greenhouses.

About 12.5 km distance from the TPP Bitola to the town of Bitola has to be connected with two pipelines. The pipelines will be used for transmission of hot water (temperature 130-135oC, or as decided; pressure 16 bar), from the heat exchanger and pump station (HEPS), located in the premises of TPP Bitola, to the primary town heating network of Bitola and for transportation of water (70oC) back to the heating source, thermal power plant. The pipeline should be designed taking into consideration presumed future energy demand for space heating and for greenhouses. The total heat demand and, accordingly, the hot water flow rate, should be decided, having in mind the two-phase implementation of the project. Approximate maximum hot water flow rate is going to be about 1 m3/s. Assuming that the diameter of the main hot water pipeline is going to be 700-800 mm, (Unit cost, 900 – 950 €/m) at maximum flow rate, the total pressure drop is expected to be 10-11 bar.

The logical trace of the pipeline TPP Bitola to Bitola town will pass through high-quality soil for agricultural production, it is very important to examine the possibility to use part of the hot-water flow for heating of greenhouses for agricultural production. Thus, there have to be connection(s) on the pipeline for the municipality of Novaci, for greenhouses and, possibly, for heating of some households. Due to the expected capacity of this part of the system (for heating of greenhouses), which is about 60 MW, there has to be a heat and pump station in Novaci (about 2 km from the power plant) with all the necessary equipment and installations.

Pipeline design peculiarities: Installation of pipelines: due to the high level of underground water, the pipeline has to be laid mostly over-ground. Proper attention should be paid to the compensation of thermal expansion (dilatations) of the hot-water pipeline, which can be secured by axial compensators, “U” compensators and by self-compensation. Appropriate insulation of pipelines is necessary for efficient operation of the system. Further there must be a sectioning of the main pipeline, in order to secure the system from great losses of water in a case of accident or pipeline water discharge during ordinary maintenance activities.

Pump station for pressure maintenance (pressure holding-on), distribution system, sub-stations, local boiler rooms etc.

The purpose of installation of a pump station for maintaining or raising the pressure level is:

- to maintain or to increase the hot water pressure to two main in-town pipeline networks: northern and southern;
- to push water back to the heating source (TPP Bitola).

The location of the pump station will be in the outskirts of the town, about 12 km from the heat source. Some existing (industrial or other) object may be used for this purpose. There must be two series of pumps in the pump station, one on the feed line and one on the return line of the main hot-water pipeline. It has to cover total pressure losses of the in-town pipeline network.

Primary town network

The primary town pipeline and heating sub-stations network is going to be built according to several-phase implementation plan: (1) Connection of buildings that already possess internal heating installations; (2) Connection of buildings that don't have internal installations, but are located close to the sub-stations; (3) Connection of other buildings. Inclusion of the near-by Bitola suburbs should be examined.

The primary town network comprises: pipeline from the end of the main hot-water pipeline at the town entrance, up to the heating sub-stations. The length is approximately 35 km for the initial phase. Due to the specific disposition of the urban concentration regions of Bitola, there have to be two main lines, laid underground, one leading to the northern and one to the central-southern part of the town. For the northern part, the Dragor river trace may be used. The static pressure and fluid expansion in the town network is going to be achieved by pressure-maintaining ("dictir") pumps and appropriate auxiliary equipment. Eventual passing over the permitted pressure may be prevented by installation of security valves in the sub-stations. There should be installed steel pre-insulated pipes, with a system for detection of water leaking.

The secondary town network consists of heating sub-stations, distribution pipelines from local sub-stations to the local space heating systems of the objects and internal installations: pipelines, radiators, etc. In this case, heat carrier is hot water with parameters 90/70oC, PN 5-6 bar and it is transported to separate buildings by circulating pumps that must compensate pressure loss in the system up to the final consumers.

Infrastructure through the city that will enable heat supply to the customers will be developed in two main phases. In the first phase a pipeline network with approximate length of 15 km will be installed; and in the second phase up to about 35 km. According to certain previous data, there are about 25 boiler rooms with steam and hot-water boilers in the industry sector and over 60 boiler rooms in the public and commercial sectors in the town. Some of them should be examined from the point of view to be used as heating sub-stations. In general, for this case, a three-stages scheme distant heating system is assessed as the most appropriate, Figure 7.

Technology of heat sub-stations operation

Heat energy is transported to the heating substations in different objects by the primary network, with hot water parameters of 130/70÷75oC and PN=16 bar. Heat energy is transferred to the secondary system indirectly, via the heat exchangers water-water. The parameters of the secondary system are 90/70oC and PN 6 bar. The heat transferred is distributed to the consumers by the secondary local pipeline system. In order to achieve the necessary parameters, the heat sub-station is equipped with proper auxiliary and regulatory equipment. Temperature of the heating fluid in the primary system slides according to the sliding diagram in the heating plant, and the additional regulation of the desired temperature of the heating medium in the secondary system is achieved by changing the flow rate in the primary part of the sub-station.

In order to achieve as highest as possible energy efficiency, the whole process must be regulated and automated. Also, a system of remote control of different parameters from the dispatcher centre has to be anticipated, which will enable remote monitoring and managing of the entire heating system and the performances of heat sub-stations are fully automatic.

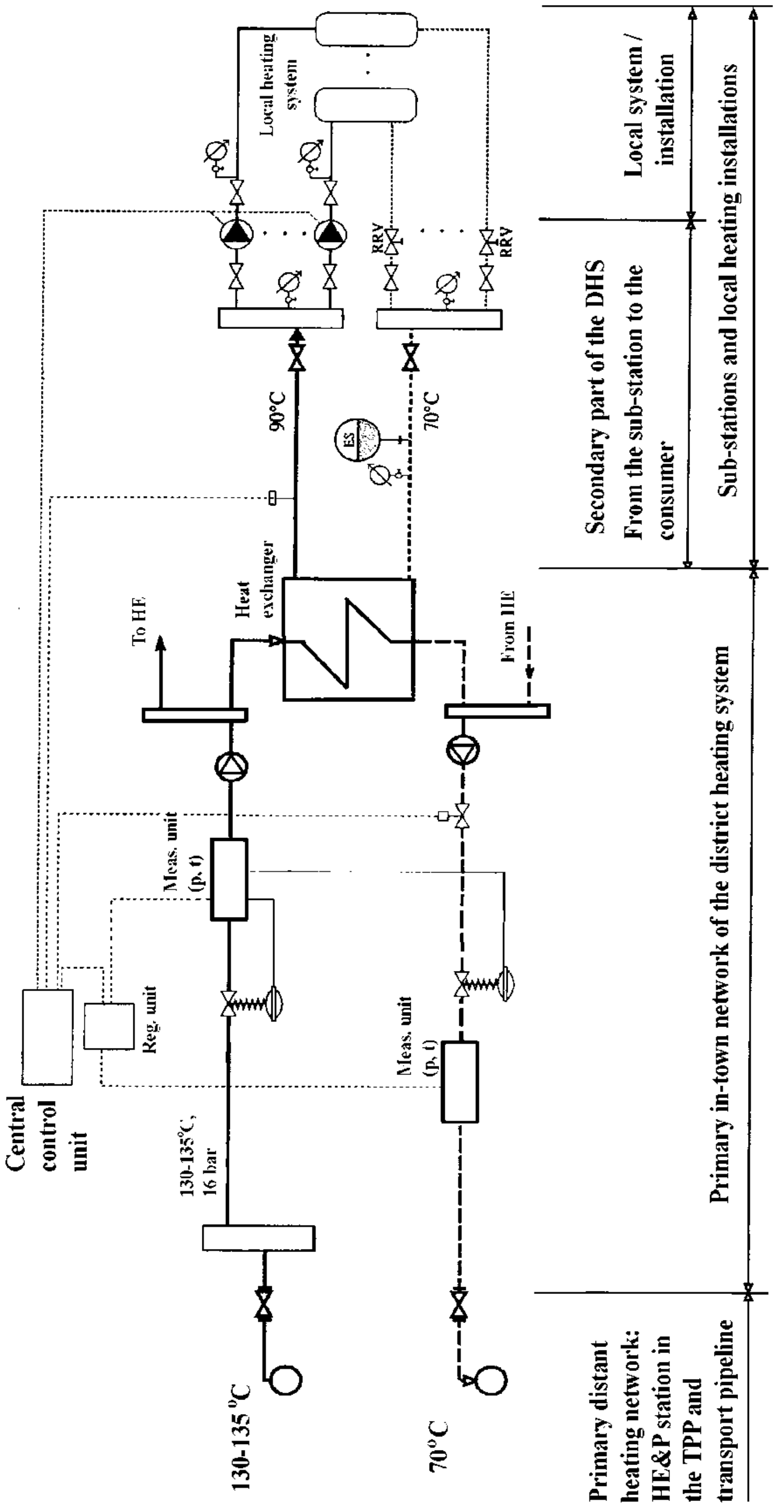


Figure 7. Schematic representation of a three-stage heating system

Trace of the pipeline system

Transmission of the heat carrier is usually a specific problem that depends on many influencing factors. One of the main factors is the type of the transmission system, which, in this case, is two-pipe, indirect, closed system. The maximum design hot-water flow rate of 1400 litres per second demands a transmission pipeline of approximately 800 mm diameter, with a maximum water flow velocity of 2.82 m/s and total pressure drop of about 13-15 bar.

The length of the main pipeline trace is going to be about 12500 m. Optimal technical solution of the pipeline trace must include:

- precisely defined trace of the pipeline;
- decided system of pipeline layout;
- type of pipeline insulation;
- compensation (expansion) of the pipelines.

In general, the trace of the pipeline leads throughout a plane terrain (Figure 8). The soil is high quality fertile, with high level of underground water. There are also two rivers to pass, one over the Crna river and another over the Dragor river. Along the pipeline trace, there are two settlements, the villages of Novaci and Logovardi. There are several local roads to be crossed. On the city entering there is a railroad that also needs to be crossed.

In order to cut the expropriation costs and for better access, the pipeline should follow the line of the local way Makovo-Bitola. Due to the high level of underground water, canal underground running of the pipeline seems inappropriate. Another requirement that has to be met is that pipeline must not prevent communication crossings (roads, streets in the villages, common points of agricultural machinery, goods, etc.). Also, the land that will be affected by the pipeline should be as narrow as possible, since it is a high quality arable land.

There are several basic ways of pipeline tracing: low above-ground, in canal, with pre-insulated pipes without channel etc. Low, above-ground tracing seems the most appropriate solution for the largest part of the transmission pipeline in this case, due to its advantages:

- there is not a large amount of construction work – just excavation of land, setting foundations and supports;
- simple and easy installation;
- pipeline is not exposed to particular mechanical stresses;
- easy detection of defects and damages;
- simpler project documentation and lower investment costs etc.

There are several disadvantages of the above-ground pipeline tracing: larger energy losses, the system is unprotected from deliberate damages, unsuitable for use in urban areas because of aesthetic reasons etc. In the Bitola case, the problem of the pipeline tracing via the villages may be solved in two ways: (1) by aboveground pipeline that will bypass the villages and (2) by underground tracing through the villages, following the road to Bitola.

Given the relatively large length of the pipeline, from techno-economic aspect, choosing a proper insulation is very important segment of the project. This is even more important if the transmission pipeline is to be led mostly above ground.

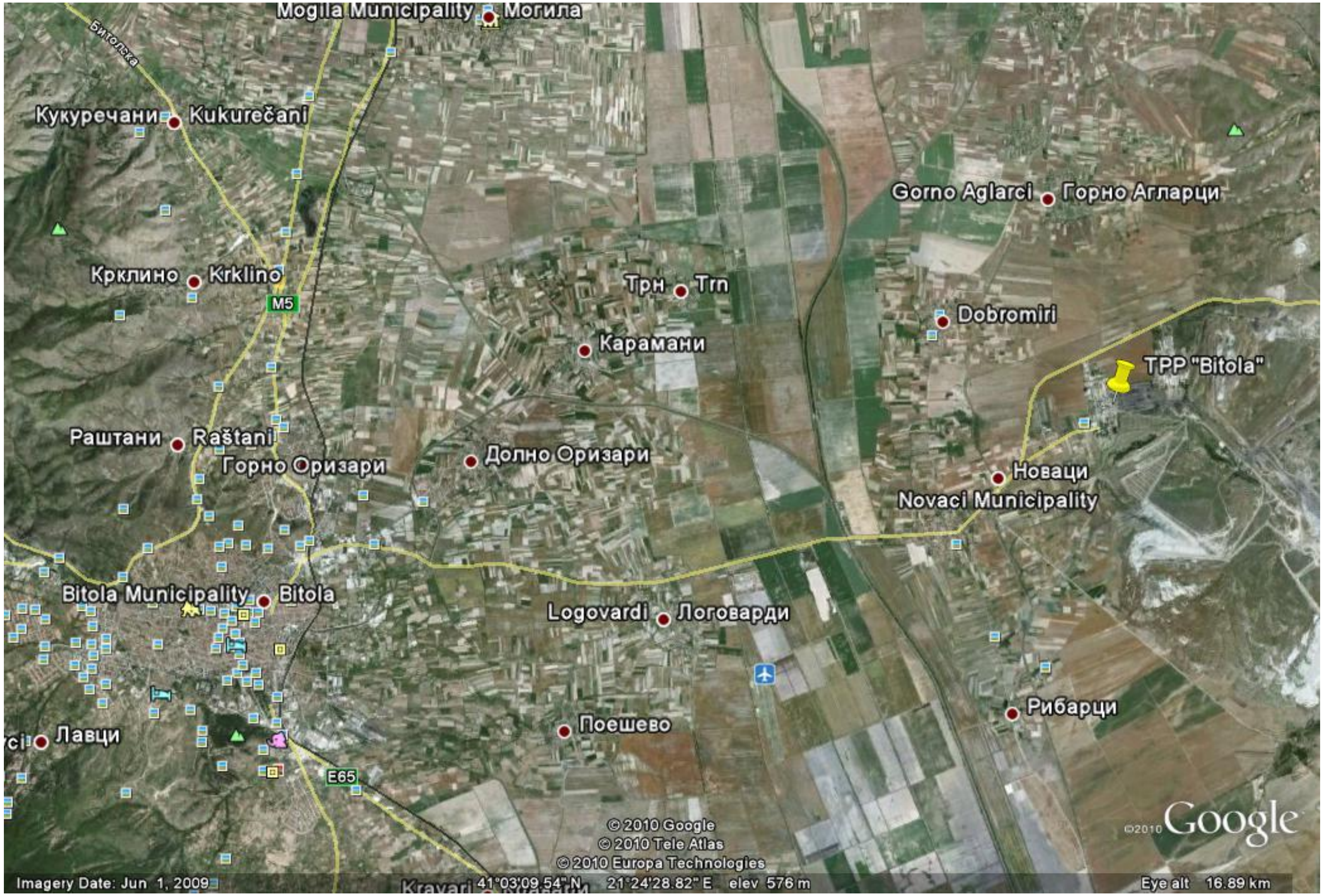


Figure 8. Aerial view of the terrain

3.7. Recommendations

TPP Bitola possesses a capacity to play a role of thermal energy source for heating purposes of Bitola and other near-by municipalities. However, at the moment, the assessments of the heat demand are very weak.

What should be done (the necessary steps)?

Necessary steps towards the implementation of the project – district heating of Bitola with thermal energy from REK Bitola:

- To exactly define the present and possible future heating demand by location and category: residential buildings (collective and individual), commercial buildings, public buildings, etc. The methods of comprehensive survey, in cooperation with local authorities (and NGOs) should be applied.
- For the Novaci and Mogila municipalities, the thermal energy demand for the heating of greenhouses should be defined, depending on the types of vegetables/fruits that will be grown. Again, the basis should be proper comprehensive survey with support of the local authorities and NGOs.
- Comprehensive feasibility study, which will comprise a number of different aspects: technical, social, economic, financial, environmental, etc., should be provided, including comparative analysis of two substantially different approaches: (1) District heating system with thermal energy from TPP Bitola and (2) District heating system with hot-water boiler plants located in the town.
- A project for the necessary internal reconstruction that will make possible regulated steam take-off from the turbine stages of units 2 and 3 at pressure range 1.5-2.5 bar. Following the decision to go ahead with the project, to undertake the necessary steps for reconstruction of the steam turbines of the TPP units 2 and 3, 1,0-2,5 bar pressure stages, in order to be prepared for regulated steam take-off. The process of water heating from 70oC up to 120-122oC would be driven by use of regulated steam take-off in base-mode heat exchangers. Additional heating of the water, up to 130oC, would be accomplished in top-mode heat exchangers with non-regulated steam take-off.
- A project for heat exchanging and pump station (heat exchangers “steam/water”) in the frame of the TPP Bitola.
- To undertake further steps in coordination with the other members of the consortium (or company), such as: project for transmission pipeline system and connection points; project for the secondary pipeline network; project for the pump stations; project for the sub-stations network; etc.
- Construction of transport pipeline from TPP Bitola to a pump station at the town entrance, distance ~12.5 km, together with all necessary equipment.
- Construction of distribution pipelines network in the town (approximate length in the first phase 15 km, second phase up to 35 km).
- Examine the possibility to use existing objects and facilities, like the location and capacity of sub-stations. ….
- Taking into account the characteristics of the region (close-border), it is necessary to consider the possibilities for financing part of the project through the IPARD, Cross-Border-Cooperation or other programmes for technical assistance or as potential financing sources of project implementation.

- Make rough assessment of the size of investment, at least, in two variations (concrete underground channels and pipelines with standards thermal and hydro insulation; pre-insulated pipelines).

3.8. Important considerations

In order to get the project implemented the following considerations should be made:
How to get the majority of the citizens and enterprises to approve of the project?

- How gain interest in the project from economic entities, public institutions and others stakeholders?
- How many households needs to be connected to the system in order to make the project technical, economical and environmental viable?
- What type of agreement should be made between the central actorsELEM, REK Bitola, Municipality of Bitola, Municipality of Novaci, consumers andindustrial entities? What would be an acceptable price for thermal energy for both producer, distributor and final user? The assessment should take into account the expected future electricity price. What financing modell would be suitable for the project, and where to source the funds from?
- For how much longer will TPP Bitola have access to lignite? When the reserves are exhausted, will fuel be imported or will REK Bitola close down?

4. Environmental impact and social aspects

Multiple benefits and effects can be expected from the realisation of the Bitola distant heating project. Some of them are: reduction of air pollution, substitution of other resources (fuels, fire-wood, electricity etc.), direct and indirect increase of employment, improved living conditions, better opportunities for certain businesses (such as greenhouses agriculture production) etc.

4.1. Air pollution reduction

Energy transformation using fossil fuels will always have a certain environmental impact.. However, it iseasier to control one or two large sources of air pollution, in this case – TPP Bitola units, than thousands of individual chimneys and a number of smaller heating facilities. A centralized thermal power plant gives opportunity for cost-effective application of adequate equipment for flue gas treatment and air pollution control. In that sense, one immediate results of the project for Bitola district heating would be improved air quality, with lower concentration of smoke, SO_2, CO, particulate matter as well as reduced greenhouse gas emissions. Also, small local heating sources, stoves and small capacity boiler plants are usually characterized with low combustion efficiency.
As an example, here are some data regarding the Kozani district heating system in northern Greece, which has many similarities with the case in Bitola, and its influence to the local and global environment protection:

- The district heating system has a significant contribution to the reduction of gas emissions during the winter period.
- Smoke concentration in winter has dropped from 50-60 μg/m3 before, to a level bellow 20 μg/m3 after the district heating system installation.
- SO_2 concentration has dropped from 160-180 μg/m3 before, to 10-15 μg/m3 after the district heating system installation.
- Reduction of CO_2 emission is estimated at about 54000 t/year.
-

4.2. Substitution of other fuels used for heating

Very important positive effect of the project implementation would be substitution of other energy resources: fire-wood, liquid fuels, electricity etc.

Substitution of fuel oil

Decrease of the consumption of heavy and light oil, from environmental point of view, means lower pollution during fuel handling, lower SO_2 emissions, lower particulates emission, etc. Annual consumption of fuel oil in Bitola is approximately 20,000 tonnes, while annual consumption of light oil is approx. 1,500-2,000 t. As a rough assessment, an average annual fuel oil consumption of about 130 l is necessary per kW installed thermal power.

Experiences from the Kozani district heating system in northern Greece show that the operation of the system substitutes more than 20000 tonnes of oil equivalent per year.

Substitution of fire-wood

Decrease of the use of fire-wood for heating, and reduced wood cutting is another result of the project. It is not an easy task to give exact quantity of wood used for heating in Bitola. Indirectly, the annual consumption can be assessed taking into account the annual felled fuel wood in Pelagonia region. The gross felled timber in Pelagonia region in 2009 was 153056 m3 and 120470 m3 of that amount was fuel wood, while the rest was technical wood and normative waste. In particular, important indicator is felled wood in several branches of the Public enterprise "Macedonian woods", presented in Table 4. According to the previous data, the annual fire wood consumption in Bitola can be assessed at about 60000-70000 m3.

Table 4. Gross wood production in 2008 in several branches of PE "Macedonian woods"

No.	Branch Office of PE "Macedonian woods"	Max. annual felling, m^3	Planned annual felling, m^3	Wood production in 2008				
				Techn. wood, m^3	Fire-wood, m^3	Total wood vol., m^3	Waste wood, m^3	Waste wood, %
1	Kajmakcalan, Bitola	65393	43815	19369	20092	39461	4354	9.9
2	Bigla, Demir Hisar	47408	43123	2032	36779	38811	4312	10.0
3	Lipa, Krushevo	11686	15555	80	13920	14000	1555	10.0
4	Prespadrvo, Resen	34545	28593	1800	23933	25733	2860	10.0

Substitution of electricity used for heating

Decrease of the use of electricity for heating. In the country in total, 20 to 25 % of the households use electricity for space heating and sanitary water preparation. Statistical data for the electricity consumption in the Bitola municipality show trend-line that indirectly proves the previous fact. Electricity consumption during the heating season (October-March) is at least 20 to 30 % larger than in the period April-September. By construction of district heating system, it is expected that the electricity consumption for heating purposes will significantly decrease.

4.3. Other environmental impacts

The construction of the pipelines from REK Bitola to the town of Bitola could become a non-positive environmental impact. The pipeline will affect high-quality land today used for agricultural purposes, and potentially also have a negative visual effect. The pipeline route should be carefully determined and measures should be made in order to reduce any negative consequences.

4.4. Social and public interest

There following social and public benefits are expected as a result of the project implementation:

- Increase of employment – The implementation of the project is expected to result in about 60-90 direct new work places.
- Potentially additional 1000 employments due to the cheaper energy for greenhouses agriculture production, lower energy costs for industrial companies, companies in the business of heating systems installation works, etc.
- Overall improvement comfort level of life quality of the population.
- Reduced problem of illegal wood-cut.

5. Financial aspects of the project

Systems for central heating in Bitola

At present, the residential, public, commercial and industrial sectors are supplied with thermal energy in a decentralized manner. Most of the households use fire-wood and light oil (for households) for space heating. Just a small share of the residential sector units is equipped with appropriate installations (pipelines, radiators, etc.), and some of them are connected to a local heat generation source and they are operated on bulding level (or several buildings).

From the technical point of view, Bitola is an urban area with very good opportunities for implementation of district heating, due to the relatively large population density in the parts of the town. Therefore, in October 1999, a joint stock company was established by AD Toplifikacija – Skopje and Primatehna – Bitola, named Toplifikacija – Bitola. Seven boiler rooms, with total installed capacity slightly above 26 MW, owned by the Bitola Municipality, were given under concession to Toplifikacija – Bitola. The district heating company is not in operation from the autumn 2008, because of the high cost of the fuel (heavy oil), resulting in high regulated final price for the consumers and because of the relatively small installed capacity (high costs per installed power).

5.1. Scope of work for the project

Because the whole project is complex, regarding the production and distribution of the heat energy are two (in this case) different parts, since ELEM/TPP REK declared that ELEM has not interest in distribution of heating energy. Three municipalities have the interest of distribution and using of the heat energy (especially Bitola city) and therefore they can be responsible for the distribution system for heating.

ELEM as a producer, and three municipalities as potential users (the citizens of the municipalities, public sector and businesses) have different interest, ELEM to sell energy for higher price, and municipalities to secure cheap heating energy for its inhabitants. Therefore, the whole project should be divided in two parts: production side and demand side. The boundary of production side with the demand side is same with the physical boundary of the TPP REK Bitola. This means that ELEM will take care only for production, but new formed entity should take over the heated steam and distribute to the end users.

Figure 9. Production side of the project (boundary of production side is same with the physical boundary of the TPP REK Bitola)

5.2. Production price (price at threshold TPP Bitola)

Production price
Method A is based on an assessment of the basic financial parameters, and is the lowest acceptable income for ELEM. This method of calculation resulted in a heat price of 0,4 MKD/kWh

Method B - Calculation of the price of 1 kWh of thermal energy is based on methodology derived from the one used in the case of Skopje district heating system. This method of calculation resulted in a heat price of 0,4 MKD/kWh

5.3. End user prices

In the following table the following assumptions are made

- 5% annual increase in the heating prices charged in Skopje
- 10% annual increase in production costs per kWh energy

–

Table 5. Time table of prices of heating energy

MKD/kWh	2007	2009	2010	4Q 2010	2011	2012	2013	2014
Production cost of 1 kWh heating energy (cost for lost electrical energy production)					0,40	0,44	0,49	0,53
Production cost Methodology B					0,74	0,81	0,89	0,98
Price of heating energy in denars per kWh (Bitola 2007)	2,30							
Price of heating energy in denars per kWh (Toplifikacija Skopje)		2,09	3,66	4,07	4,27	4,49	4,71	4,95

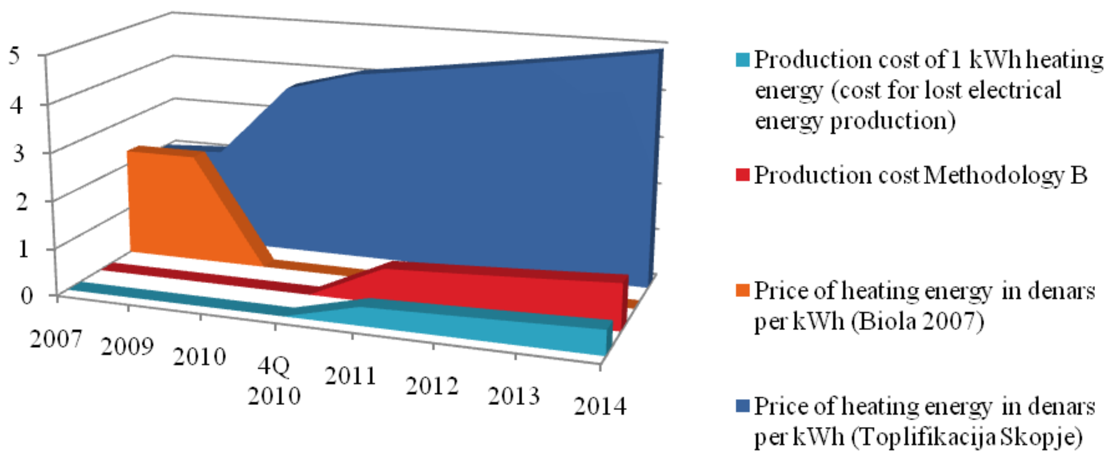


Figure 10

The diagram in Fig. 10 shows that even with 10% increasing of the production price of electrical energy in TPP Bitola will be 5-10 times lower than market price for thermal energy in Skopje (households). This leaves enough space to built the investment and operational costs in the price, and still the heating energy produced from TPP Bitola will be cheaper than Skopje (with included distribution costs).

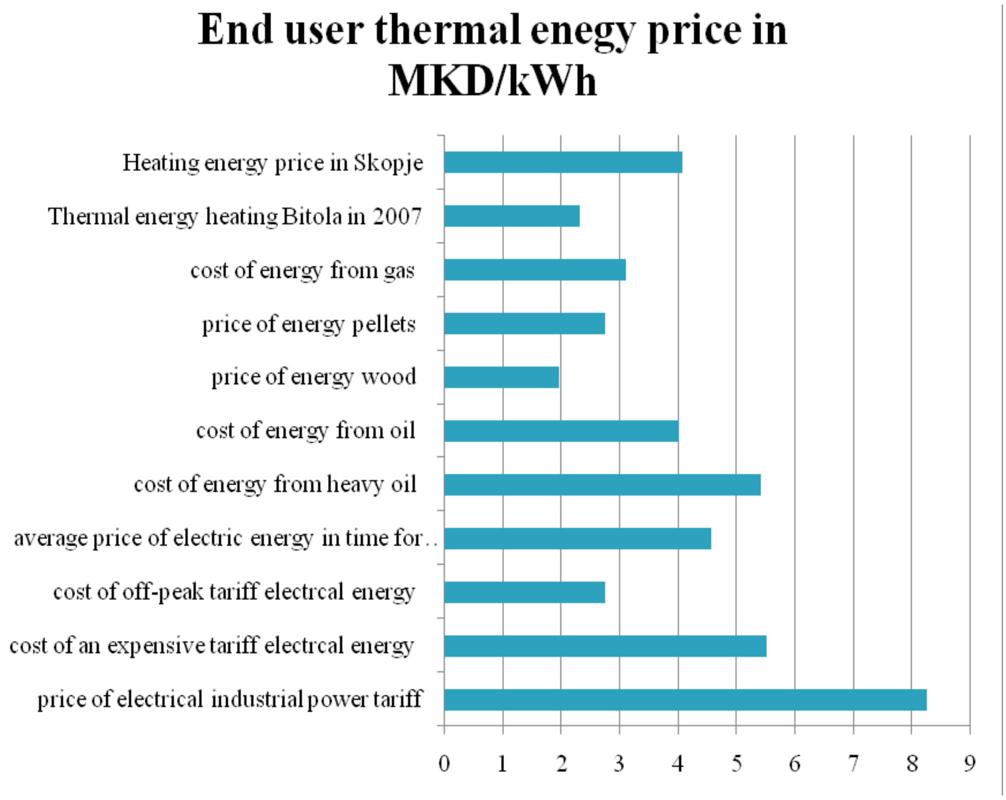
Still additional calculations are needed to establish the production price (selling price on the exit from TPP REK Bitola). The market price to the end user should be built on this price, with included distributional costs and investment made. In that manner, the TPP REK Bitola should decide the frame of production price, but three municipalities in the frame of the subject responsible for distribution should calculate the profitable heat energy price that will cover the investment in the frame of technical life of the project.

Heating energy end user prices from different fuels

Considering the prices of heating from comparing fuels, the cost of heat produced in REK Bitola can be quite competitive.

Table 6. Comparation of prices of heating energy from different sources

	MKD/kWh
price of electrical industrial power tariff	8,25
cost of an expensive tariff electrcal energy	5,5
cost of off-peak tariff electrcal energy	2,75
average price of electric energy in time for heting season for apartments	4,55
cost of energy from heavy oil	5,4
cost of energy from oil	4
price of energy wood	1,95
price of energy pellets	2,75
cost of energy from gas	3,1
Thermal energy heating Bitola in 2007	**2,3**
Heating energy price in Skopje	**4,07**



Experience from the region

In the region (Balkans) there are some practices of District Heating systems based on TPP. Some of it are with similar conditions (Power of the TPP, distance to the town) like

Pozarevac in Serbia and Kozani in Greece. We can use those prices like a comparison, because of the similar economical conditions in those neighboring countries.

1) **Pozarevac (Serbia)**: Apart of the obvious energy and environmental benefits, the price for the final consumers of the district heating in Pozarevac is significantly lower (in average, 30-35 %) compared to other energy sources for space heating.

2) **Kozani (Greece)**: Average cost of domestic heating in Greece in the year 2000

Fuel type	Cost in €/MWh
District heating	29.85
Briquettes	13.22 *
Firewood	15.34 *
Diesel	32.83
LPG	35.28
Natural gas	45.06

*) Heating area is not declared

5.3.3. Establishing the end user price

If we look at the Heating energy end user prices from different fuels, and the accessibility of those fuels in Bitola (and the using of it) we propose following end user prices

- **price of thermal energy for apartment 32,00 eur / MWh or 1,97 MKD / kWh**
- **price of thermal energy for businesses 49,00 eur / MWh or 3,01 MKD / kWh**

Those prices are in the price range that is acceptable by citizens and businesses and in same time stimulates investment in internal infrastructure (heating equipment). Still those prices should be propsed by the new founded public company or private-public partnership in front of the State Energy Regulatory Commission, taking in consideration investment (depreciation) costs.

5.4. Investment Cost

According to certain assessments of the municipality officials, the range of the investment is 35-40 mill. Euro. The annual financial effect is roughly assessed as saving of 3.3 mill. Euro after the realisation of the first phase, and 6.3 mill. Euro after the completion of the second phase, due to less imported fuels and other savings. However, much more detailed analysis on all the financial aspects of the project is necessary. The price of the heat energy for the final consumers will be a subject of regulation by the State Energy Regulatory Commission, derived on a basis of adopted calculation methodology.

In order to attract as more as possible consumers, the model for financing the project implementation should be of the kind that would create final price which will be lower than other energy sources for heating.

Rough assessment of the investment cost for realization of the first phase (60-70 MW for Bitola district heating and 50-60 MW for agriculture production), according to experiences from other, more or less, similar projects, is presented in Table 7. The estimated purchase and installation costs are based on the cost elements listed in the tables in annex 8.4.

Table 7. Rough assessment of investment cost

No.	Activity, equipment	Production Mil. €	Supply Mil. €	Total Mil. €
1	Investigation / research works, studies, basic design works	0.5	0.5	1.0
2	Buying land for pipeline tracing		1.0	1.0
3	Construction works, incl. terrain preparation	1.0	4.0 – 5.0	5.0 – 6.0
4	Energy equipment, facilities – procurement and installation (including design of reconstruction works in TPP Bitola)			25.0 – 27.0
4.1	- Reconstruction of turbines	2.0		
4.2	- Heat exchanger & pump station	4.0 - 5.0		
4.3	- Hot-water pipeline (from TPP to the town and part of the town network)		15.0 - 17.0	
4.4	- Pump station for maintaining pressure level		2.0 - 3.0	
5	Electrical equipment	1.0	1.0	2.0
6	Other	1.0	2.0	3.0
	Total	**10.5 – 11.5**	**24.5 – 28.5**	**35.0 - 40.0**

5.5. Total investment and payback period

Investment in TPP REK Bitola(4.1+4.2+4.4): 10-11 Milion Euros
Investment in Distribution system: 25-29 Million Euros
Assumed year thermal production 355,200 MWh/year

Total Investment: 40 Mil Euros

If we assume that 50% of the users are commercial or public buildings, average end user price will be **41,00 eur/MWh**

If we assume that the production price (threshold TPP REK Bitola) is calculated regarding the method B **0.7375 mkd/KWh = 12 Eur/MWh** (with 8% gross margin for TPP REK Bitola)

	MWh/year	Eur/MWh	
Total Sales	355200	41	14563200
Thermal losses (12% of total sales)	42624	41	1747584
Production costs	355200	12	4262400
Gross profit			8553216

550.000 yearly Fixed running costs for District heating company (O&M)

With this calculation it is clear that Gross profit can provide enough financial source for operational costs, depreciation, financial and other costs for new-formed District hating company.

Economic lifetime = **20 years**
Real interest rate = **4,5 %**

The analysis is based on 4.5% discount rate. It is the real interest rate and is calculated as the interest rate on state bonds (5,5%) minus the rate of inflation (National Bank of Republic of Macedonia predicted rate of inflation to be 1% in 2011).

According the assumed cash flow (Calculated in Annex 8.3) following values for feasibility of the project are calculated

NPV **34.645.019**
IRR **11,03%**

5.6. Sources of financing

Regarding the risk factors of investment, and the benefit of the project, the project owner (on the both sides, production and supply) can be financed trough loan.

Three municipalities are benefactors of the special environment fund from REK Bitola (400.000 Eur/year) that can be used for this project. There are also other state funds for regional development that can be provided through Ministry for Local Gouverment and Bureau for Regional Development (http://www.brr.gov.mk/)

Macedonian Bank for Development Promotion ad Skopje has crediting line that covers energy efficiency Projects, but with total project amount up to 500.000 Euros (http://www.mbdp.com.mk/en/mbdp.php?page=krediti_energija)

The same bank has Credit Line from The European Investment Bank which includes Product 3 with following characteristic:

PRODUCT No. 3
Product name: Priority project credits
Single credit amount intended to final beneficiaries: up to 12,500,000 EUR
Repayment period: up to 15 years
Grace period included: up to 3 years
Interest rate to final beneficiary (FB): 5.5% p.a.
MBDP partaking in the credit support: Maximum 50%

Purpose:
To provide support in the area of energy, ecology, industry, health, education, services and tourism.

http://www.mbdp.com.mk/en/mbdp.php?page=EIB_kredit

6. Policy and ownership

6.1. Ownership and stakeholders

ELEM is state owned company, and their project mainly depends from the management of the company, but in some cases where the investment is bigger, there is a need of decisions in the frame of Government of the R. Macedonia.

Three municipalities have history of inter municipality cooperation (common public companies, common projects), but this project requires mobilization of additional resources (financial and human), and therefore clear commitment should be made about future activities of the project. Those three municipalities are benefactors of the special environment fund from REK Bitola (400.000 Eur/year) that can be used for this project.

It is recommended that all parts should negotiate their roles, and the amount of contribution for the start of the projects. Even the project is pre-feasibility stage, the decisions should be taken and Memorandum of Understanding should be signed to keep the commitment for the project.

Production side

Production side ownership is in the frame of ELEM/REK Bitola. In that context, the following activities should be undertaken by ELEM:

- Reconstruction/modification of the Units 2 and 3 in the segment of intermediate and low pressure steam turbines' stages (pressure 1.0-2.5 bar) and/or cross-over steam pipes and installation of the necessary equipment in order to be technically capable for regulated steam take-off.
- Reconstruction of two units is necessary, in order to provide secure supply with thermal energy.
- Installation of the necessary equipment for two-stage water heating: base-mode and top mode (base heat exchangers for water heating up to 120oC, pumps, pipelines for district heating steam extraction, regulation & control equipment, etc.).
- Implementation of a technical solution for top-mode heating of water up to 130oC (for instance, by non-regulated steam take-off from the steam collector for the plant own needs).
- Central regulation, control and safety. Modification of the turbines control system. Central regulation of the distant heating system has a specific and very important task to adjust the thermal power of the heat source to the exact actual needs of the heating system. These needs are permanently changed, according to the ambient temperature. That is why the water flow rate and the water temperature should be changed, following the parameters of the heat consume (heat demand). The mode of the central regulation of the distant heating system depends on a number of factors, but the most important are the type of the heat load and the way of the connection of households installations to the district heating network.

- To provide connection to the hot-water pipeline

6.1.2. Demand side

The demand side of this project is consisted of distribution company (public company or private-public partnership) and end users (public buildings, households and businesses). The ownership of the demand side in this phase is in the three Municipalities – Bitola, Novaci and Mogila. From the demand side, the following activities should be taken:

- Management activities: initiation to make an agreement with the interested stakeholders, establishing a consortium or companies (or other form, as decided), with the main task to supply the town of Bitola and agriculture producers (greenhouses) with thermal energy for heating.

- Analysis for the heat demand and the current situation
  - For the need of this project, comprehensive in-depth analysis of the heat demand should be made
- Pipeline system from TPP Bitola to the town of Bitola
  - About 12.5 km distance from the TPP Bitola to the town of Bitola has to be connected with two pipelines. The pipeline will be used for transportation of hot water (130/70oC, or as decided), from the heat exchanger and pump station, located in the premises of TPP Bitola, to the primary town heating network of Bitola.
  - There have to be connection spots for Novaci and Mogila demand, particularily greenhouses.
  - The total heat demand and, accordingly, the hot water flow rate, should be decided, having in mind the two-phase implementation of the project.
- Distribution system, sub-stations, local boiler rooms etc.
  - Approximately 35 km long, underground, in-town pipeline system, with two main lines: one for the northern and one for the southern part of the town. For the northern part, the Dragor river trace may be used.
  - Several-phase implementation of the plan: (1) Buildings that already posses internal heating installations; (2) Buildings that don't have internal installations, but are located close to the sub-stations; (3) Other buildings.
  - Inclusion of the near-by Bitola suburbs should be examined.
  - The logical trace of the pipeline will pass through high-quality soil for agricultural production, it is very important to examine the possibility to use part of the hot-water flow for heating of greenhouses for agricultural production.

The team recognized Agency for Regional Development Pelagonija PREDA as one of the potential facilitators in intermuniciplity cooperation for establishing of intermunicipality public company for heating and distribution through preparation of feasibility study and technical documentations.

Pelagonija – PREDA from Prilep prepared project document for CBC IPA and the project proposal was applied trough Municipality of Bitola. This project proposal contains cross-border activities Greece- Macedonia with transfer of expertise and know-how from the thermal power plant and district heating system from Kozani/Florina. The results from the call for application will be known in one year period.

Since the ownership of the project prepared for CBC IPA is on Municipality of Bitola and the bigger part of the district heating in the frame of this project will be focused in the town of Bitola, our suggestion is that the main partner for the further development and activities should be Municipality of Bitola, instead of finding ways to coordinate and run activities on regional level.

7. Recomendations

The whole project of distant heating of Bitola, with possibility for heat supply of greenhouses for agriculture production, by use of thermal energy from TPP Bitola is quite complex. Therefore, it is logic to make distinction between the production and distribution of the heat energy. In this case, the enterprise Power Plants of Macedonia (ELEM, REK Bitola) has interest of providing thermal energy, that will largely compensate the winter demand peak for electrical energy for heating in the Bitola region.

Because the Bitola city will be the main user and benefactor of this project, the Municipality of Bitola (having into consideration the previous experiences with the district heating) should be the carrier of the most of the activities on the demand side in the future. Municipalities of Novaci and Mogila should be included in potential development, especially in the part of the thermal energy utilisation for agriculture production in greenhouses.

The production price (or selling price) of thermal energy is calculated (on the threshold of TPP Bitola) with two methods that define the production price (with gross profit) in the range 0.40 – 0,74 MKD/kWh.

The municipalities, public company, or private-public partnership company, in connection of their needs should make calculation for the investment of distribution system and they should decide the economical price of the heat energy toward end users. The proposed end user price should be between 1,97 and 3,01 MKD/kWh. The differences between the prices for the household sector, public buildings and businesses should be further analysed and decided by the stakeholders.

Both price ranges, the production and end-user prices, are estimated based on available data, but we propose that deeper analyze should be made.

Since this is a complex project, and it affects higher interests, some substantial decisions in ELEM and in three Municipalities should be made for its implementation. This can be started in the form of signing a Memorandum of understanding, to keep the commitment for the project.

The whole process showed that this is feasible and profitable project, and should be implemented in the next few years. The Municipality of Bitola has an opportunity to prepare a part of the project documentation trough Cross Border component of IPA instrument in the following two years, regarding the one year application process. We recommend that additional activities that will involve both parties (ELEM and Municiality/ies) should be undertaken during the year 2011 and that should be included in the Memorandum. The next phases should be development of the feasibility study and project document for the project and seeking for financing modalities, investors and financiers.

8. Annexes

8.1. Previous works

Some of the previous works on this issue are the following:

- T. Trombev, I. Mijakovski, J. Pejchinovski, V. Volkanovski, Information on perceptions concerning the possibilities for district heating of the town of Bitola, 1981

- Technical proposal for a heating plant for Bitola, Teploelektroproekt, Kiev department, 1981 – partly available!

- Study by the Kharkov's filliale of the CKB Glavenenergoremont, Minenergo, 1984 – not available!

- District heating of Bitola town – previous studies, SOZT MZT – Skopje, RO "Goce Radosavljevic", Design sector, Bitola, 1985

- Investment technical documentation for district heating of Bitola, SOZT "Meatlaski zavod Tito" – Skopje, RO "Goce Radosavljevic" – Bitola, Bitola, 1986

- Assessment of the potentials for distant heating – Feasibility study for the town of Bitola, PHARE Programme "Investment possibilities in the energy sector", Exergia S.A., 2002

8.2. Production prices

The production price was calculated on two different methods, first one based on lowest acceptable income for ELEM as a result of loss of energy, and the second one based on the methodology similar to the methodology used in the case of Skopje district heating system (with gross margin 8%). We can say that the production price is in this range of calculated prices.

Assessment of the basic financial aspects – the lowest acceptable income for ELEM (Production price A)

Regulated extraction of steam from the turbine system for heating needs, regardless of whether it will be conducted from the intermediate or low-pressure turbine stages, or from the cross-over steam pipelines, will result with decrease of the electric power. According to the theory and practical experiences, the decrease of the installed electric power capacity is expected to be about 0.18 MW per 1 MW obtained thermal power.

This calculation is performed under the following assumptions:

- The present electricity price (ELEM to MEPSO/EVN) is about 35 €/MWh and it is expected to rise at annual rate of 5 % in the coming years.
- Engagement of the power plant for obtaining 120 MW thermal power will result with 20-22 MW electric power drop.
- Anticipated annual period in operation (heating system): 2960 hours/year.
- In the first phase of the project implementation, the demand will be 60 MWth for district heating and another 60 MWth for agriculture production – total demand: 120 MWth.
- Over a period of non-heating season, the thermal power plant will generate electricity in condensing mode.
- The actual price of electricity for ELEM is about 35 €/MWh and it is expected to rise at annual rate of 5-10 % until 2015.

Under the previous assumptions, for a heating demand of 120 MWth, 60 MW for Bitola district heating and 60 MW for greenhouses, the following results can be obtained:

- Annual reduction of electricity generation will be
  (22 MW)·(2,960 hours/year) = 65120 MWh/year, which is about 1.5 % of the total electricity generation;

- Drop of financial income due to decreased production of electricity
  (65120 MWh/year)·(35 €/MWh) = 2,279,200 €/year

- Thermal energy generation (22 MWel → 120 MWth)
  (120 MWt)·(2,960 hours/year) = 355,200 MWh/year

With assumed constant operating costs, and at minimal financial gain of 1,036,000 €/year, the lowest acceptable thermal energy price for ELEM on the threshold of TPP Bitola, according to this basis, will be

(2,279,200 €/year)/(355,200 MWh/year) = 6.42 €/MWh = 0.40 MKDen./kWh

In addition to this cost, depending on the way of financing the project, there must be added the specific costs for: reconstruction of turbines in two out of three units in TPP Bitola, installation of auxiliary equipment, installation of the equipment for HEPS in the framework of the plant, the cost for personnel, losses in the system, energy used for plant own needs and other costs.

Calculation of the price of 1 kWh of thermal energy on the threshold of transmission and distribution network Production price B)

This calculation of the price of 1 kWh of thermal energy is based on methodology derived from the one used in the case of Skopje district heating system.

Main assumptions:

- The calculation is performed for a concept of withdrawal of steam at temperature of 200oC and pressure 8 bar (enthalpy 2430 kJ/kg).
- Boiler efficiency 85 %
- Average lower calorific value of lignite in 2009 was 7290 kJ/kg

Based on the previous data, about 0.579 kg of lignite is needed to produce 1 kWh thermal energy. According to the methodology for calculation of the price of thermal energy for heating, a part of the operational costs for fuel, the following costs have to be taken into account:

1. Normalised costs
   - 1.1. Materials, energy, spare parts, auxiliary
   - 1.2. Maintenance, repair works, services
   - 1.3. Insurance of buildings and equipment
   - 1.4. Gross salaries
   - 1.5. Other services
   - 1.6. Other and extraordinary expenses
   - 1.7. Taxes and other charges that do not depend on operation
2. Depreciation (amortisation)
   Total operative costs (1 + 2)
3. Revenue of capital (margin)

In this case, the lack of such an approach is no data available for consumption side and forecast for delivered energy, as well as no model for internal cost allocation in REK Bitola for each activity (under the obligation of separate accounting arising from the license for regulated activity).

If the price of 1 t coal is 10 €, the specific costs are as follows:

1.	Normalised costs	0.4449	Den./kWh
	1.1. Fuel (lignite)	0.3578	Den./kWh
2.	Depreciation (amortisation)	0.2380	Den./kWh
	Total operative costs (1 + 2)	**0.6829**	**Den./kWh**
3.	Revenue of capital (margin)	8	%
	TOTAL	**0.7375**	**Den./kWh**

8.3. Assumed cashflow

The assumed cashflow is given in the following tables.

Activity	**Investment in Euros**
Project preparation and project management	1.000.000
Equipment and installation costs	29.000.000
Construction works	6.000.000

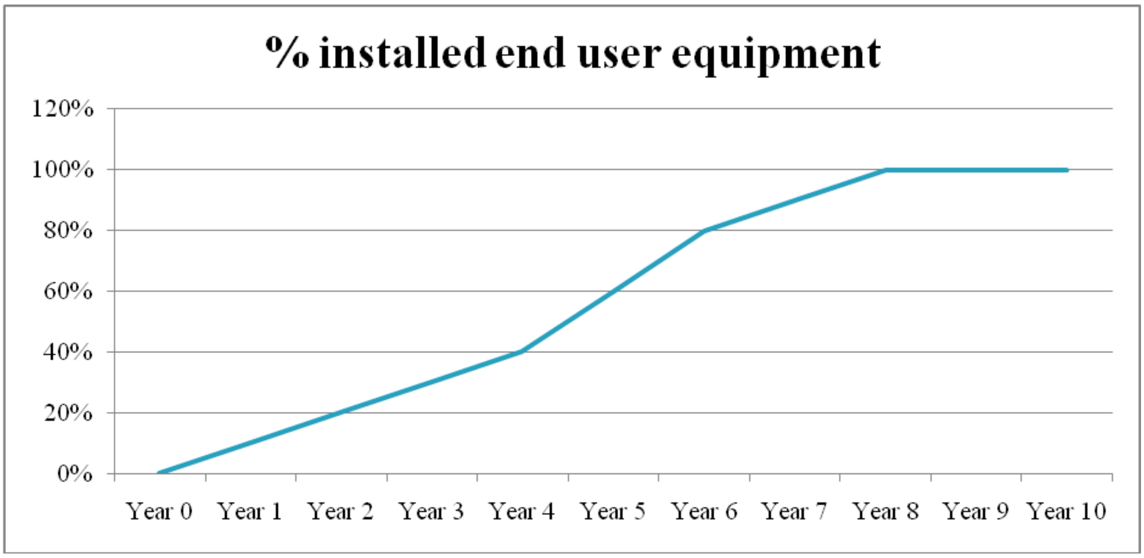
Buying land	1.000.000
Contingency	3.000.000
Total investment	**40.000.000**

Financial effect from income	8550000	EUR/year
O&M Expences	550000	EUR/year
Financial effect from income	**8000000**	EUR

O&M Expences are expences for operation of District Heating Company (Public Company or Public-private Partnership).

Because income of the project is directly connected with the utilization of the installed equipment we are assuming that installation of end user equipment will be increased from 0 to 100% in period of 8 years.

The analysis is based on 4.5% discount rate. It is the real interest rate and is calculated as the interest rate on state bonds (5,5%) minus the rate of inflation (National Bank of Republic of Macedonia predicted rate of inflation to be 1% in 2011).



	% instaled end user equpment	Cashflow	Cumulative cashflow
Real rate		4,50%	
Year 0	0%	-40000000	-40.000.000
Year 1	10%	305000	-39.695.000
Year 2	20%	1160000	-38.535.000
Year 3	30%	2015000	-36.520.000
Year 4	40%	2870000	-33.650.000
Year 5	60%	4580000	-29.070.000

Year 6	80%	6290000	-22.780.000
Year 7	90%	7145000	-15.635.000
Year 8	100%	8000000	-7.635.000
Year 9	100%	8000000	365.000
Year 10	100%	8000000	8.365.000
Year 11	100%	8000000	16.365.000
Year 12	100%	8000000	24.365.000
Year 13	100%	8000000	32.365.000
Year 14	100%	8000000	40.365.000
Year 15	100%	8000000	48.365.000
Year 16	100%	8000000	56.365.000
Year 17	100%	8000000	64.365.000
Year 18	100%	8000000	72.365.000
Year 19	100%	8000000	80.365.000
Year 20	100%	8000000	88.365.000
NPV		**34.645.019**	
IRR		**11,03%**	

8.4. Unit costs

A rough assessment of unit cost of delivery, transport and installation of standard pre-insulated pipes, with included fittings, connections, reduction elements, vales, system for remote control etc., is given in Table 8.

Table 8. Unit cost of delivery, transport and installation of standard pre-insulated pipes

Pipeline nominal diameter	d x δ, mm x mm	Unit cost, €/m
DN800	812.8 x 8	900 – 950
DN600 (2x)		600 – 650
DN500 (2x)		450 – 500
DN350 (2x)	355.6 x 5.6	350 – 400
DN300 (2x)	323.9 x 5.6	300 – 350
DN250 (2x)	273.0 x 5.0	250
DN200 (2x)	219.1 x 4.5	200 – 220
DN150 (2x)	168.3 x 4.0	150
DN125 (2x)	139.7 x 3.6	120
DN100 (2x)	114.3 x 3.6	100
DN80 (2x)	88.9 x 3.2	80-100
DN65 (2x)	76.1 x 2.9	50-60
DN50 (2x)	60.3 x 2.9	40-50

Projected unit costs of delivery, transport and installation of standard heat sub-stations, 130/70°C-90/70°C, of different heat capacity, is given in Table 9.

Table 9. Unit cost of delivery, transport and installation of standard heat sub-stations

Nominal power of heat sub-station, kW	With closed expansion, €	With “dictir” expansion, €/m
50	3500 - 4000	10000 - 11000
100	8000 – 8500	13000 – 14000
150	9000 – 9500	14000 – 15000
200	10000 – 10500	16000 – 17000
250	11000 – 11500	17000
300	11500 – 12000	17500
350	12000 – 12500	18500
400	13000	20000
450	14000	21000
600	17000 – 18000	24000
1000	25000	35000
3200	70000	90000