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Section 4

Project Justification

4.0 ANALYSIS OF PROJECT ALTERNATIVES

4.1 Description of the Technical Situation in the Smelter

Equipment in the smelter and sulfuric acid plants, for the most part, are about 40 years old. Line No. 1 for roasting and smelting was built and put into operation in 1961, during the first phase of construction. Later, it had been restored and modernized. Line No. 2 for roasting and smelting and sulfuric acid plant K2 were built during the second phase of the smelter construction and was operational in 1971. Only the sulfuric acid contact factory K3 was built in 1983.

Currently, the smelter is working at a reduced capacity due to lack of concentrates. Technological line No. 1 for roasting and smelting is operating, as well as part of the converter line and anode refining in the smelter and sulfuric acid contact factory K2.

Technological line No. 2 for roasting and smelting ceased operationin November 2001. Since then, the equipment bas been exposed to aggressive environmental and atmospheric conditions. In addition, some of the equipment has been dismantled and has become unstable due to neglect. The sulfuric acid plant K3, which hasn't been operational since January 1999 has missing parts, towers have eroded linings, electro filters are incomplete and the contact boilter and heat exchangers are eroded.

It is estimated that reconstruction of line No. 2 in the smelter and sulfuric acid plant K3 requiresan investment of 15 to 20 million USD and would take up to a year to complete.

All of these investments and efforts would be meaningless because the required ecological and economic results can not be achieved. Existing technology does not provide the required utilization of sulfur and does not meet environmental standards, does not provide sufficient recovery of metals, has high energy and maintenance costs.

Obsolete technology and old and amortized equipment does not provide the ability to achieve rather low (95%) projected technological recovery of copper.

Table 4.1. shows achieved technological recovery of copper for the period 1987- 1997, when the smelter worked at approximate projected capacity.

Table 4.1.1 Achieved Copper Recovery for The Period 1987 – 1997

Year	1987	1988	1989	1990	1991	1992
Recovery, %	93.03	94.00	93.50	92.13	91.35	92.23
Year	1993	1994	1995	1996	1997	
Recovery, %	91.00	91.55	90.86	92.54	91.26	

The total recovery of copper from concentrates to cathode, as the final product, for the last five years, when the smelter was working with reduced capacity (30 to 40%) is given in Table 4.1-2. Recovery efficiency also includes recovery efficiency of copper in smelter from concentrate to anode in technological stages: roasting, smelting, converting and anode refining and utilization of electrolytic refining.

Table 4.1.2 Recovery of Copper for the Period 2004-2008

Year	2004	2005	2006	2007	2008
Recovery of copper to cathode, %	92.40	92.44	91.83	92.77	93.87

The achieved recovery of copper was lower in real terms of about 1% to 3% for this standard technological scheme, but about 4% to 5% lower than those achieved by using new technologies.

Maintenance costs, ,which amounted to over 200 USD per tonne of cathode copper in the last five years, which is about 20% of the production cost. This is an unacceptable cost and it is a consequence of the old and depreciated equipment.

4.2 Environmental Aspects

It is not possible to achieve more than 60% sulfur utilization, which is put into the smelting process with the concentrate, by using existing technology. Achieved sulfur utilization for the period of operating with the designed concentrate processing capacity is very low and the average is 38.67% (Table 4.1-3). The utilization of sulfur means the sulfur as SO_2 gas refined to H_2SO_4 in relation to the total sulfur which entered with concentrate into the smelter for processing.

Table 4.2-1. shows that, from 1988 to 1997, 961600 tons of sulfur or 58.64% was emitted into the atmosphere, 32 798 tons of sulfur or 2% went to the slag and 11,415 tons or 0.69% went to waste acid. With the sulfur utilization of 38.67% it gives the sum of the total sulfur of 100%.

Table 4.2-2. shows the balance of sulfur from copper concentrate for the period 1988 - 1997. (Period of operating with the designed capacity) where it can be seen that 961 600 t or 58.64% of the input S quantities (point 2.4), of the total sulfur amount of 1,639,950 tons, which entered the smelter with the copper concentrates in that period, was emitted to the atmosphere as follows: about 9.5% S with the gasses of air furnace, about 2% S through the stacks of sulfuric acid factory, about 0.5% S with fugitive gas and about 46.6% through the 150-meter smelter stack.

Table 4.2.1 Utilization of Sulfur from Copper Concentrate for the Period 1988 to 1997.

No.	Year	INPUT OF SULFUR WITH CONCENTRATE			OUTPUT OF SULFUR (t / yr.)				Utilization	Emission
		Processing of concentrate (t/year)	% S	Sulfur (t / year)	Sulfur in H_2SO_4	Sulfur in waste water	Sulfur in waste slag	Sulfur emitted into the atmosphere	of sulfur (%)	of SO_2 to atmosphere (t / year)
1.	1988	571,837	33.29	190,344	100,938	1,817	3,807	83,782	52.20	167,564
2.	1989	605,837	33.00	199,800	107,892	1,942	3,996	85,970	54.00	171,940
3.	1990	616,561	33.02	203,565	115,218	2,074	4,071	82,202	56.60	164,404
4.	1991	619,646	33.02	204,614	98,624	1,775	4,092	100,123	48.20	200,246
5.	1992	505,518	33.00	166,650	70,493	1,269	3,333	91,555	42.30	183,110
6.	1993	302,442	31.74	95,997	18,777	338	1,920	74,962	19.56	149,924
7.	1994	409,172	31.70	129,695	5,094	92	2,594	121,915	3.93	243,830
8.	1995	390,380	31.52	123,050	21,423	386	2,461	98,780	17.41	197,560
9.	1996	518,342	31.52	163,367	56,378	1,015	3,267	102,707	34.51	204,414
10.	1997	511,581	31.84	162,868	39,300	707	3,257	119,604	24.13	239,208
11.	SUM	5,051,316	32.47	1,639,950	634,137	11,415	32,798	961,600	38.67	1,923,200

Table 4.2.2 Balance of Sulfur for the Period 1988 to 1997.

No.		Period of 1898-1997.	
		t	%
1.0.	Input of sulfur with concentrate	1,639,950	100.00
2.0.	Output of sulfur		
2.1.	Sulfur in H_2SO_4	634,137	38.67
2.2.	Sulfur in the slag	32,798	2.00
2.3.	Sulfur in waste water from H_2SO_4 factories	11,415	0.70
2.4.	Emission of sulfur into the atmosphere	961,600	58.64
2.4.1.	Gasses from air furnace	155,795	9.50
2.4.2.	Fugitive convertor gasses	8,200	0.50
2.4.3.	Gasses through the stacks of H_2SO_4 factories	33,376	2.04
2.4.4.	Gasses through the 150-meter smelter stack	764,229	46.60

In the period 2004 -2008 when the smelter was operating with reduce capacity, the sulfur utilization ranged from 34.32% to 55.28%, and emitted from 12,892 t to 43,927 t of sulfur into the environment. Balance and distribution of sulfur for this period is given in Table 4.2.3.

Table 4.2.3 Distribution and Utilization of Sulfur for the Period 2004 – 2008.

Utilization Values	2004.	2005.	2006.	2007.	2008.
Input of sulfur with the batch, t	30361	58089	69074	58851	65463
The output of sulfur with the monohydrate, t	16784	30774	23707	21712	23133
The output of sulfur with the slag from air furnace, t	685	1218	1440	1321	1405
Recovery of sulfur, %	55.28	52.98	34.32	36.89	35.34
Emission of sulfur into environment, t	12892	26097	43927	35818	40925

The most important reasons for unsatisfactory levels of sulfur transformation from raw materials in sulfuric acid are as follows:

- Applied melting technology in the reverb furnace;
- Gasses from the reverb furnace, which contain about 1 ÷ 1.5% of SO2, are not suitable for processing in the existing sulfuric acid factories.As a result, these gases in the total amount are emitted into the atmosphere and along with them about 10% of the sulfur that enters the batch process;
- Capacity of sulfuric acid factory is consistent with the total amount of emissions from smelters (including reactors and converter). Therefore, the excess gasses are emitted from the converter line to the atmosphere;
- Instabilities in smelter work further increase sulfur dioxide emissions into the atmosphere. After the unplanned downtime and start of the smelter work, time will be needed while sulfuric acid plants reaches “technological readiness” to accept the gas. During this time the entire amount of gasses from smelter is emitted in the atmosphere;
- Applied technology in sulfuric acid plant; single way direct catalysis- single way direct absorption (even if it would work in optimum conditions) emits waste gas in concentration of SO2 and SO3 that are higher than the maximum permitted by regulations;
- The results analysis of sulfur dioxide and smoke point their frequent presence. The pollutants are transported by wind, so, areas with increased pollution occur usually in wind direction. The most frequent winds are from western and eastern quadrants so that the measuring points with the exceeded sulfur dioxide content are usually in these wind directions (“Stari centar grada” and “Elektroistok”). Content of sulfur dioxide and the time overrun was significantly higher in the period when the production was higher (period since 1989 to 1991);
- The values of the smoke concentration are moving in the acceptable limits;
- Content of heavy metals in suspended (floating) particles is increased at the measuring points that are on the most frequent wind directions and close to industrial zone;
- Analysis of the spatial distribution calculation results shows that the largest accumulation of pollutants are in northwest and southeast areas from industrial zone in Bor. Long range sulfur dioxide pollution to the level of

emission limit values in these directions are 15 km and for floating particles 2-3 km. The areas with higher pollution levels are those at greater height;

4.3 The "No Project Implementation" or Do Nothing Option

Existing melting technology in the reverb furnaces is a generation out of date. It has been in use for more than 200 years, with various modifications over time. Production of copper in the world, using this technology, has drastically dropped from 60% in 1950 to about 25%-30% in 1995 and today accounts for only 6-8%. The last air furnace was built in the 1980's.

The main disadvantages of this melting technology in the reverb furnaces are: small specific melting capacity, low energy efficiency, i.e. high fuel consumption and utilization of sulfur (50% to 60%), which is the main reason for their replacement and introduction of autogenic technology.

The results in the previous period in the Bor smelter, using melting technology in the reverb furnaces, indicate that further production using this technology is economically unjustified and environmentally unacceptable. Low technological recovery of copper, a specific utilization of energy, high maintenance costs and costs of production as a whole, as well as emissions of hazardous substances into the environment make it inefficient.

The "No Project Implementation" option would mean the end of the existing metallurgical operation in Bor as of March 2012 due to the current operating scenario and appropriate laws. The "Do Nothing" option would result in the following:

- Closure of other facilities related to the processing of copper,
- The collapse of mining production,
- Temporary (during construction phase) and permanent jobs will be lost,
- The loss of jobs with great social unrest,
- The migration of population from the Bor region,
- RTB would lose the opportunity to improve its environmental baseline through implementation of the Project within WB and GoS.

Assumption could be that without the implementation of this Project, the current smelter will shut down in 2012, due to the implementation of IPPC directive.

If the modernization of Metallurgy in Bor is not achieved, the existing smelter must stop production. As a result,the copper concentrates produced at mines RTB will have to be transported for processing abroad. This would increase the transport costs by $15 to $45

/ t of concentrate, depending on the country in which the concentrate would be processed resulting in anannual amount of $5.5 to $16 million . In addition, there would also be lower usage (recovery) of gold and silver, as well as selenium, platinum and palladium, whose annual total value is estimated at $6 million. There is also the possibility of production of rare metals from copper concentrate such as rhenium, germanium, tellurium, and others.

If the project is not executed, a majority of the problems related to the environmental legacy remain unresolved. Economic recovery is not feasible and Bor becomes a city without business opportunities.

The preservation of jobs and employment of domestic resources is most important for recovery and development of the economy and society as a whole.

Explanation of Selection of the Location for the Smelter Reconsruction and Construction of New Sulphuric Acid Plant (by RTB).

4.4 Explanation of Selection of the Location for the Smelter Reconstruction and Construction of New Sulphuric Acid Plant (by RTB)

4.4.1 Existing Setting

Bor Copper smelter has a tradition in the production of copper longer than a century. Building a smelter is performed in several stages and the current layout is from 1971 when it was, at the end of the second phase, inaugurated in the second technological line for processing copper concentrate at a capacity of 300,000 tons per year. In this way RTB came to a total processing capacity of 600,000 tons of concentrate per year and production of about 120,000 tons of copper anodes from raw materials.

The technological process of production of copper anode consists of roasting in FS batch reactors, smelting in the reverb furnaces, mate converting in standard PS converters, anode refining of blister copper to anode material and casting. Technological off gas that is generated in the process of roasting and converting is transported to the factory for the production of sulfuric acid. Other gases are emitted through the stack into the atmosphere. Such obsolete 'standard' procedures of obtaining copper are characterized by:

- low utilization of technological copper and other metals;
- high energy consumption;
- high operating costs;
- low use of sulfur; and

- non-compliance of environmental standards for emissions and ambient air quality.

Based on a proposal by the Serbian government, in March 2009, the company RTB Bor decided to change the outdated technology of melting to a autogenously Flash smelting system by Outotec and build a new factory for producing sulfuric acid by Fenco Company. This conversion will increase the technological utilization of copper and sulfur, lower operational costs, as well as reslove long standing environmental issues.

This project is based on feasibility studies conducted by the Canadian company SNC Lavalin. New facilities will include a reconstructed smelter located in the area of technology that takes existing roasting and smelting line no. 2 of the smelter. Location for the reconstruction of a smelter and construction of a new sulfuric acid plant was carried out based on the following indicators:

- Lower level of investment because it is the reconstruction of the smelter rather than building new one, and building a new sulfuric acid plant at the location of old one;
- Preserves parts of the existing smelter (leave preparation section, converter department with four PS converters, section of anode refining furnaces with, two casting machines, three 75 ton capacity crane and two small capacity 50 tons);
- All new/modernized facilities are going to be built on the site owned by the company RTB Bor;
- Possession of a license on the site according to the law on planning and building of the Republic of Serbia;
- Proximity to already built infrastructure (road trip and railway), and built transportation infrastructure: two railway tracks in the converter hall and refining;
- Proximity to the factory for the production of technical oxygen, which is owned by Messer that is required to provide technical oxygen for smelting;
- Proximity to compressor department for smelter low and high pressure air supply;
- Storage of metallurgical slag;
- The possibility of easy supply of new units with water, electricity, fluxes;

- There is infrastructure for technological water supply, electricity, telephone communications, computer networks for data exchange, tanks for liquid fuels;
- Storage tanks of sulfuric acid;
- Storage space for fluxes;
- Spare parts warehouses, workshops;
- Built facilities for standard employee bathroom, dressing room, hospital ambulance, etc; and
- Constructed physical facilities for technical protection.

based on the aforementioned, and interviews with experts from the company SNC-Lavalin in October 2009, RTB Bor believes that they have chosen the right location for the reconstruction of the smelter and the construction of a new sulfuric acid plant, which is defined as the ‘ Project’.

4.4.2 Production Costs

Concentrate processing in Bor smelter has a relatively high level of operational costs due to high consumption of fossil fuels and electricity, high costs of maintenance and labor costs.

4.4.3 Implementation of New Technologies

New autogenic technology of copper concentrate smelting were made in response to the demands of modern society in terms of environmental protection, energy saving, getting the required quality of metal, more complex utilization of raw materials and achieving high techno-economic indicators in the production of copper.

Autogenic processes have emerged in 1950’s. Since then, their importance has been increasingly growing, so they are now becoming dominant in pyrometallurgical production of copper. Their share in total production of smelter copper in the world, which was amounted at 10 to 11 million tons per year at the end of the twentieth century, was about 60%. In the world today, 85% of smelter copper is attained using this technology.

One of the main criteria for evaluating the success of the process in copper metallurgy is the possibility of utilization of sulfur and sulfur dioxide bonding asit affects the environment. Autogenic process of copper concentrate smelting allows sulfur binding of more than 95% of the batch for melting. In some smelters, achieved fixation of sulfur was over 99%.

4.4.4 Other Site Options

The existing infrastructure and support services within the RTB Bor complex provides favourable conditions for the modernization and reconstruction of the existing smelter and the development of a new acid plant. These conditions do not exist at the Kevelji and Cerovo Mine Production sites.

4.5 Concept of Copper Metallurgy Modernization in Bor

4.5.1 Concept Basis

The following factors are most relevant in the selection of a new copper smelting process:

Minimum energy required by using:

- Latent heat of exothermic reaction in the concentrate melting process,
- Enrichment of air for combustion with oxygen,
- Utilization of waste heat.
- Minimum volume of waste gases, causing minimal emissions, through: Enrichment of air for combustion with oxygen,
- The use of the minimum possible amount of fossil fuels.

Low-CO_2 gas emissions by increasing:

- Concentration of SO2 in the gas smelting,
- Share of rich SO2 gas,
- Conversion efficiency double adsorption/double catalysis of sulfuric acid.

Minimize consumption of fresh water by using:

- Internal recirculation and indirect cooling.

Minimum amount of solid waste generation through:

- Maximum fixation (valorization) of sulfur in acid and / or other– products.

The concept of reconstruction and modernization of metallurgical copper production in smelter in Bor is based on the processing of 400,000 tons of concentrate per year and producing of about 80,000 tons of copper per year from primary raw materials. This production should be realized by applying a contemporary autogenic smelting technology, which results in much better environmental and economic performances.

New autogenic smelting unit should ensure better efficiency regarding metal production. All the technological gases need to be processed in Sulfuric acid factory and there must not be the possibility of their emissions into the atmosphere through the stack. Fugitive gases that are generated in the process of smelting, converting and flame refining must be evacuated from the place of their generation, dedusted by appropriate treatment and cleaned by chemical routes and can be emited into the atmosphere through the stack only when purified this way. Stack can only be used for evacuation of purified fugitive gases, not technological.

The introduction of new modern technologies and processes in the metallurgical production in Bor copper smelter should provide:

- Technological recovery of metal up to 98%,
- Efficiency of sulfur binding from SO2 gas above maximum and fulfilling all environmental standards,
- Maximum technologically justified energy efficiency,
- Low operating costs,

Reconstruction and modernization includes the following:

- Replacement of existing technologies and equipment in roasting and smelting line by new contemporary line for autogenic smelting,
- Reconstruction of the line for the converter gas treatment,
- Reducing agent replacement and installation of gas treatment in flame refining,
- Construction of a new sulfuric acid plant for the processing of all the technological gases,
- Closing the cycle of waste water from the sulfuric acid factory, with neutralization of harmful substances from waste water prior to their deposit,
- Building of systems for capture and purification of fugitive gases,
- The construction of oxygen factory for the new autogenic unit needs:

- Reconstruction and construction of system in order to supply the new equipment with electricity and energy fluids,
- Construction of necessary facilities and infrastructure objects,
- Introduction of a system for process control and management.

In determining the concept of modernization, the following must be taken into consideration:

- The new equipment for autogenic smelting line and sulfuric acid factory is built in the existing smelter in such a way that existing infrastructure facilities, equipment and installation are used to the greatest possible extent,
- Smelter modernization project implementation should be carried out with minimum disruption of existing production,
- The whole modernization project is to be conducted with minimal capital expenditure and the greatest possible involvement of local and regional resources.

4.5.2 The Criteria for Technology and Equipment Selection

Bearing in mind the conditions of funding, a commitment to modernize the smelter will be made on the basis of specific competitive bids and supplier technology.

The new autogenic smelting line consists of the following basic units: batch preparation, furnace, and gas treatment system including utilization boiler and electrostatic filter and slag treatment system (slag flotation or electric furnace, depending on the technology choice).

The nominal capacity of the project line for melting is 400,000 tons of dry concentrate per year.

In the process of melting and possibly matte converting, technical oxygen is used. For the needs of new unit for melting, about 300 to 400 tons of oxygen per day is required. The current oxygen production capacity is not sufficient, and calculation is performed with an external supplier, on the basis of long-term contract for technical oxygen supply.

The processing of the total amount of concentrate from the mine RTB Bor, from 270 to 350 thousand tons per year, is provided by the program, with an average copper content of about 20% and about 34% of sulfur and additional quantities of imported concentrate, from 50 to 130 thousand tons per year, with copper content about 25% to 30% and about 32% of sulfur. Due to demands for reducing the production process costs and optimization of the whole process from mining to cathode copper production, increase of the concentrate quality by means of increasing copper content is expected.

By melting the concentrate, matte with copper content of about 62% is going to be obtained. Subsequent slag treatment from the melting furnace is to provide the technological recovery of copper up to 98%.

The new furnace will be located close to the existing converter hall, so that transfer of matte into the existing converters is going to be possible, using existing cranes. Melting gases after cooling and deducting will be transported to the mixing tower in front of sulfuric acid factory, where they will be mixed with the converter gas.

There are two possible locations of the new melting furnace, depending on the choice of technology. One is the area of the existing line No.2, which would be dismantled, and the free space between lines No.1 and No.2. Another possible location is at the head of the converter hall, on the south east side.

Furnace and converter slag are going to be treated subsequently in order to achieve additional copper recovery. A slag treatment choice is going to follow after the smelting technology selection.

The following two methods are most commonly used : slag decopperisation by additional liquid slag treatment in the electric furnace, or flotation in plants constructed especially for those purposes.

On the existing converter line, a new system for capturing, transporting, cooling and purification of converter process gases, as well as system for fugitive gases removal and treatment, is being built.

The existing equipment for receiving and storing raw materials and auxiliary materials and equipment for the preparation of batch remains in use after construction of a new line for melting. These systems meet new demands by means of capacity and only some small-scale interventions are needed.

On the flame refining and anode casting section, it is necessary to substitute beech trees as reducing agent by another reducing agent. Also, system for the capture and treatment of gases from the anode furnaces needs to be installed. On the system for casting of anodes No.2, general repair and restoration of the system for the anode weight measuring and automatic casting needs to be conducted. All of this would be carried out independently of the modernization program, and would be financed with funds from the current production.

For the processing of process gases, a new sulfuric acid factory needs to be built. It should be designed so that it can receive all the technological gases from the furnace for melting and PS converter and to convert the sulfur dioxide into sulfuric acid. The factory has dual-catalysis and double absorption, and the degree of conversion is 99.8%. The factory also has a plant for wastewater treatment.

Location of the new sulfuric acid plant would be in the free space between the existing factories K2 and K3, closer to the factory K2.

Existing systems for cooling water, power supply and all systems of energy fluids, which will remain after changing the melting technology, will undergo a general revitalization by the replacement of dilapidated and unreliable elements.

For process control and management, a system will be built in order to enable efficient process control and management at the level of the entire smelter and sulfuric acid plant.

During the metallurgy modernization project in Bor, production will be conducted normally.

Electrolytic refining of copper would be conducted in an existing electrolysis. It has sufficient (and larger) capacity requirement. The state of technology and equipment is such that production achieves acceptable parameters. In this phase, its reconstruction and modernization is not planned, but it is planned for the period after the smelter modernization.

Resolving the treatment of waste water from electrolytic refining issues is not included in the smelter modernization project, but the problem must be solved immediately and funding must be provided from the current production.

4.5.3. Selection of the Best Available Technologies (BAT)

By the comprehensive analysis of the different processes of autogenic smelting of concentrates, which are applied in the industrial practice of copper production in the world, and considering the goals of modernization of metallurgy in Bor listed in the concept, there are three possible technologies.

Smelting Alternatives Considered

In evaluating the various smelting alternatives the following three points were kept in focus:

(a) Increasing power costs in Serbia and recent global developments and applications of more efficient high intensity smelting technology;

(b) Potential increase in concentrate availability above the 400,000 tpa level from RTB mine developments; and

(c) The legislation requirement for sulphur fixation at the Bor Smelter and Serbian implementation of IPPC directive.

Several studies were undertaken to evaluate different primary smelting technologies. The different technologies evaluated, and alternatives were predominantly high intensity oxygen smelting technologies, namely;

- Outokumpu Flash Furnace Technology; and
- ISA/Ausmelt Top Submerged Lance (TSL) Technology.

Their brief description is given below.

OUTOKUMPU flash technology

The concept of applying this melting technology in Bor smelter is:

Clean environment

Outokumpu developed the Flash Smelting process half a century ago. It was first applied in 1949 in Harjavalta, Finland.

Today, this process produces 50% of the world's primary copper and 30% of the world's nickel. Flash Smelting has been continuously improved. This state-of-the-art technology offers environmentally sound techniques for copper, nickel and lead production with low investment and operating costs.

Minimal unit operating cost

Flash Smelting technology is very flexible. An existing plant can be renovated to yield a threefold amount of copper or nickel with minimal new capital expenditure while simultaneously achieving a decrease in unit operating costs.

Continous development

The Flash Smelting process is continuously developed to meet the needs of the industry, in collaboration with customers and Outokumpu's own research centre.

More profitable business options

Special features, such as flexibility, low energy consumption and eliminated sulphur emissions as well as economy of scale, have given Outokumpu Flash Smelting Technology a leading position in the copper production business. Outokumpu Flash Technology has become a benchmark for the copper and nickel industry. Now Outokumpu Flash Technology has an even more important role – in addition to its technical and economical benefits, the process contributes to new, more profitable business options (e.g. Production Network) by maximizing the benefits of de-coupling smelting and converting and Direct Blister/Flash Converting Technologies.

Advantages of Flash Smelting

- Offers new business options for metal;
- Reliable and proven process and equipment;
- Low investment and operating costs;
- Capability to treat different qualities with variable feed rates;
- High recovery of valuable metals;
- Meets the strictest environmental requirements;
- The cleanest smelting method available; and
- Safe and easy working conditions

Top Submerged Lance (TSL) Technology

Top Submerged Lance (TSL) technology was considered to be a viable alternative to reverb smelting based on preliminary data and marketing-level information provided by two technology suppliers (Xstrata Technology marketing the Isasmelt furnace and Ausmelt Technology marketing the Ausmelt furnace).

The TSL smelting process was first commercialized in Australia in the late 1980's and has recently been gaining increasing acceptance in a wide range of applications in such diverse countries as USA, Belgium, Germany, India, China, South Korea, Peru, Malaysia, South Africa, Zimbabwe and Namibia. The TSL smelting process relies on a vertical lance inside a vertical cylindrical smelting vessel. The tip of the lance is submerged in the molten furnace charge, and air, oxygen and/or fuel are injected via the lance, causing extremely rapid smelting reactions.

The most definitive study on the subject that was supplied for review was performed by SNC-Lavalin (2010). The criteria used to evaluate the different technologies in this study were:

1. Metallurgical applicability;
2. Industry acceptance;
3. Previous/current scale of proven operational production experience;

4. Easear incorporation within the production scenario proposed at Bor Smelter;

5. Economic factors (i.e., indicative capital and operating costs); and

6. Environmental considerations.

4.6 Effects of Modernization

The most significant physical effects of the implementation of the Modernization program in the Bor smelter:

- Increasing copper production from copper concentrates by the higher recovery of copper in comparison to existing technology;
- Reduction of energents consumption, investment and maintenance and other material costs;
- Increasing the use of sulfur and sulfuric acid production compared to the current situation;
- Increased production of gold, silver, selenium, platinum and palladium on the basis of higher technological efficiency;
- Reduction of sulfur dioxide emissions into the atmosphere and waste acid solution into the recipient until reaching statutory values; and
- All of these physical effects resulting in significant improvement in the economic parameters of the program.

4.6.1 Increased Production of Copper from Copper Concentrate Due to the Increased Utilization of Technology in Relation to the Current Situation

Due to the increased technological efficiency in the copper smelter from the existing 93% to 97.5%, volume of copper produced from the same amounts of concentrates is increased.

Differences in the quantities of copper cathodes produced by the increase in efficiency, for ten years, are given below in Table 4.6-1.

Table 4.6.1 The difference in the production of cathodes based on increased efficiency

Year	Difference, tons/year	Year	Difference, tons/year
I	3.958	VI	3.897
II	3.855	VII	3.925
III	3.880	VIII	3.992
IV	3.807	IX	3.898
V	3.812	X	4.094

Ten-year average is: 3912 tons / year.

4.6.2 Increase in Sulphuric Acid Production

With the existing sulfuric acid factory (K2), which is operationally active, it can produce about 151,000 tons of sulfuric acid annually. Its towing capacity and outdated technology solutions are limiting factors. By that, 38% of the sulfur would be used. The rest of 62% would be emitted into environment in different ways.

By applying new technologies (for the annual processing 400 000 t of concentrate) the production of about 415,000 tons of sulfuric acid per year would be achieved, with the use of sulfur of 96.85%.

The difference in the production of sulfuric acid for the same processing capacity of concentrate is: Δ = 415.00 0 – 151.000 = 264.000 t of sulfuric acid annually.

4.6.3 The Difference in Consumption of Normative Material

Differences in consumption of electric power and normative material for existing and new autogenic smelting technology are present in the smelter and sulfuric acid plant. For electrolytic refining these differences do not exist because it does not change anything in the technological process.

Table 4.6-2 gives an overview on energy and other fuels and materials consumption in the smelter without the electrolytic refining, the existing technology, and two variants autogenic technology.

Table 4.6.2 Overview of Energy and Materials Consumption

Material	Normative Unit	Existing	Flash technology	ISA/AUS tech.
Smelting				
Power	Kwh/t conc.	Tot. 200	60	55
Oxygen	t/t conc.		0.24	0.27
Coal	t/t conc.	0.07		0.008
Fuel oil	t/t conc.		0.0035	0.007
Electric furnace				
Power	Kwh/t conc.			100
Coke	t/t conc.			0.01375
Slag flotation				
Power	Kwh/t conc.		40	
Balls and bars	kg/t conc.		2.0	
Lime	kg/t conc.		2.0	
Converters				
Power	Kwh/t conc.		70	70
Oil	t/t conc.		0.0068	0.0068

Regarding sulfuric acid factory, the comparative overview of normative materials and energy is as follows:

Table 4.6.3 Normative Materials and Energy Use

Normative material	Normative Unit	Existing technology Achieved in average	New technology	Difference
Power	kWh/t MH	150	90	-60
Fuel oil	Lit/t MH	2	0.3	- 1.7
Cooling water	m^3/t MH	4		
Catalyst	Lit/t MH	0.65	0.2	- 0.45
Hydrated lime	kg/t MH	1	1	0

4.6.4. Ecological Indicators – Environmental Benefits of Modernization

Sulfur emissions in the existing technology with the gas phase

50 000 to 100 000 tons per year.

Sulfur emissions from the gas phase after the modernization:

941 tons of fugitive gases + 196 t through the stack H_2SO_4 = 1137 tons per year

Reduction of emission from the gas phase:

Δ = (50 000 ÷ 100 000) – 1137 = 48 863 ÷ 98 863 tons per year

Emission of sulfur from the waste water after the modernization:

404 tons per year

Reduction of emission from the liquid phase:

Δ = (1 000 ÷ 2 000) – 404 = 596 ÷ 1 596 tons per year

Emissions of heavy metals and toxic elements through the gas phase, suspended particles and liquid phase will be reduced below the allowable emission and ambient air limit values. Selected technologies are the best available technical solutions in copper pyrometallurgy according to the law on integrated pollution control and prevention.

4.7 Economic Analysis

- *Basic Assumptions for Calculation of Economic Effects*

- In addition to technical and technological analysis that undoubtedly suggests a real need and justification for the reconstruction and modernization of the plant, it is necessary to analyze the economic feasibility and the necessary investments. The aim of the analysis of economic indicators is to show, by comparative analysis of existing economic indicators with economic indicators the planned production, advantages of use this new procedure from the point of the relevant economic criteria.

- *Indicators of economic justification of investments are calculated on the basis of elements of investment and resulting elements that can be achieved in the projected production after complete process reconstruction and modernization. As resulting elements indicators of overall revenue, profit and net profit were analyzed. As basic elements of investment, all costs were analyzed.*

- *The costs amount of the projected production is calculated based on energy consumption standards, standards of consumption of basic input raw-material (for the technologies that were evaluated as the best and that are on short list), while the amount of other costs is assessed on the basis of previous experience and on the available data on the previous cost changes.*

- *Total income as an indicator of the value of production in a specific period of time, is calculated on the basis of the planned cost of raw materials processing. Price level of concentrate processing, is estimated on the basis of estimate long-term trend in the concentrates market.*

- *Price of inputs is determined based on the level at which they were given at the time of development of study. The exception is the price of electric energy which has increased by 56% compared to the current value and is $ 0.07 / KWh. This step has been made in order to prevent negative consequences of a probable increase of price of electric energy and to achieve that estimated economic efficiency indicators were realistic.*

- *During the analysis of indicators of economic efficiency of the process it is very important to point out that the price of concentrate processing (smelting and refining) have a pronounced tendency to oscillate in the global market (as is the case with the prices of copper cathodes). However, given oscillations most often are independent in relation to the movement of prices of final products. The average movement of processing cost expressed in price of copper is between 19% and 20%.*

4.8 Project Justification

4.8.1 Key Underlying Conclusions

- *The following are the key conclusions drawn from the consideration of site conditions and available technologies:*

- *Modernization of the copper metallurgy in Bor is required because it represents the unique way to solve problems of pollution of air, water and soil with sulfur dioxide and other toxic elements in accordance with the highest environmental standards. So, first of all, this study is environmental project, although it should emphasize its economic feasibility. Namely, the implementation of the project would significantly reduce production costs and significantly increased the use of basic metals from copper alloy.*

- *Modernization includes replacement of existing technologies in copper concentrate smelting using reverb furnaces by installing modern autogenic technology of smelting with appropriate equipment and building sulfuric acid plant, with maximum use of existing capacity (converter line, flame and electrolytic refining) and infrastructure facilities.*

- *Results achieved in previous period in the Bor smelter, using technology of melting in reverb furnaces shows that the further use of this technology is environmentally unacceptable and economically unjustified.*

- *The main disadvantages of technology of smelting in the reverb furnaces are: low-sulfur utilization (50 to 60%) and excessive emissions of other hazard substances, low specific melting capacity, low energy efficiency, i.e. high fuel consumption and significantly lower recovery of metals, which are the main reasons for their replacement and the installation of autogenic technology.*

- *World copper production, using technology of melting in the reverb furnaces has drastically dropped from 60% in 1950 to about 25-30% in 1995 and today accounts for only 6-8% of the world copper production. The last reverb furnace was built during 80's.*

- *Rigorous environmental laws have imposed a new modern and rational solutions based on the principles of autogenic melting using heat from the concentrates themselves. Sources of heat for autogenic processes of copper concentrates smelting are exothermic reactions of sulfide oxidation that are in them.*

- *Autogenic smelting process of copper concentrate appeared during 50's of the 20th century. Since then, their importance increase, so they are now becoming* *dominant in pyromellarugical production of copper. By using these processes is obtained over 85% of copper in the world related to the total pyrometallurgy.*

4.8.2 Advantage of Autogenic Smelting

Compared to the conventional smelting process, autogenic systems are characterized by:

- Higher energy efficiency;
- The process is faster and unit capacity of melting furnaces is higher
- Far greater degree of bonding of sulfur from the concentrate, and thus better protection of the environment
- Improved working conditions
- Reduced unit investment, operating and total production costs
- Higher degree of mechanization and automation of process
- Reducing the engagement of the workforce, higher productivity etc.

4.8.3 Production Capacity

Capacity of new line for autogenic smelting is defined to 400,000 tons of concentrate per year. Part of that amount is calculated on the concentrate from local mines, which amount ranges from 288 thousand tons to 352 thousand tons per year. As a supplement to nominal capacity, import of the required amount of concentrate is planned. Imports of concentrate are technologically necessary and have positive effect on overall indicators of the procedure efficiency.

Capacity of 400,000 tons of concentrate per year is defined on the basis of projections of mining production. Prospectively speaking, it should be count with an increase in mining production by improving the quality of concentrate (higher copper content), which would eventually decrease the need for imported concentrate. Autogenic melting line has adequate flexibility and change of regime, oxygen enrichment of air may be respond to those requests.

4.8.4 Technology Selection Criteria

The main criteria for selection of melting technology are as follows:

- Technological exploiting of metals,

- Exploiting (bonding) of sulfur from melting gases and decreasing emissions of other hazard in accordance with ecological standards,
- Amount of the required capital investment,
- Operating costs,
- Reliability of applied technology,
- Matching the proposed facilities with the exisitng in-situ infrastructure and support services,

On the basis of known data and information received from potential suppliers of technology and equipment, it was concluded that, regarding the conditions in Bor smelter, the best technological solutions were autogenic flash smelting technology.

4.8.5 Environmental Benefits

By modernization of the smelter at Bor, emissions of sulfur dioxide, dust, arsenic, lead and other pollutants in waste smelter gas streams are drastically reduced and brought under the law set emission limit values (ELV). Therefore, emissions of SO_2 gas at different measuring points in the city is going to be below ELV (permitted average daily concentration is: 125 μg/m^3). Now the number of days with daily average concentration exceeded in the individual measuring points goes up to 189 days a year. Selected technologies are the best available technical solutions in copper pyrometallurgy according to the law on integrated pollution control and prevention.

Waste water from sulfuric acid plants send sulfuric acid and copper, arsenic, antimony, lead, selenium, and other substances in concentrations that exceed the allowable into environment water streams. Treatment of waste water in this project will provide quality that matches the class IV water with concentrations of these elements below the allowable limit. In parallel with the implementation of this project, project for treatment of waste water from electrolytic refining will also be implemented.

4.8.6 Economic and Financial Considerations

Key economic considerations supporting the project are summarized below:

- *With the implementation of the smelter modernization, significant economic effects are going to be achieved by increasing the technological recovery of copper in smelter from the current 93% to ≥98 %. In this way, the production of copper cathodes from the same amount of concentrate is going to be significantly increased. The average annual amount of copper that is obtained on this basis,* *taking into account the possible losses, amounts to 3500 tons, or about $14 million U.S. annually. Production of sulfuric acid, which is worth about $ 9 million U.S. per year, will be increased by about 260 thousand tons per year. Increasing the utilization of technology will provide additional quantities of gold, silver, selenium, platinum and palladium.*

- ***T**he implementation of the planned project would lead to substantial changes to the structure of energy consumption. Consumption of electric energy, including production and consumption of oxygen will be higher, because consumption of coal and fuel oil will be much less than the current consumption. It is important to note that the total cost of energents will be reduced by 3 to 5 million per year, or an average of about 26%, depending on the choice of melting technology.*

- *After modernization of the Bor smelter production (cash) costs will be lower than the $114 to $158 USD / t of copper cathodes, depending on the applied technology, that is, 9.7 to 13.4 million per year in comparison to existing technology, and the level of costs will be at the level of modern smelter in world.*

- *If the modernization project in Bor isnot implemented, the existing smelter wouldstop production due to environmental reasons. Copper concentrates, which would be produced in the RTB mines would have to be processed abroad. This would increase the cost from $15 to $45 U.S. / t of concentrate, in the name of the transport, depending on the country where the concentrate would be processed. This would amount to $5.5 to $16 million U.S.annually. The mining industry would be placed in a very difficult position. The effects that would be achieved by lowering the utilization of gold and silver production, also the effects of processing of selenium, platinum and palladium, whose total annual value is about 6 million USD, speak in support of the project. Also, it should noted the possibility of obtaining other rare metals from the copper concentrate, such as rhenium, germanium, tellurium and others.*

- *RTB Bor would have remained without a final product, and the state would be left without its own production of cathode copper by cessation of smelter This means that the processors would be forced to import this raw material, which would reflect negatively on the country's balance of payments.*

- *The failure of modernization would cause, in addition to the smelter, stopping the production in electrolytic refining, sulfuric acid factory, the factory of copper wires. As a necessary consequence, many workers would remain out of work and livelihood, which would aggravate rather complex and adverse social conditions in Bor and the economy as a whole. For all these reasons this option should not be thought about.*

- *Evaluation of investment for the modernization of metallurgy in Bor was made on the basis of volume and structure of the necessary procedures and collected investment costs of equipment, construction works and others. Preliminary rough estimates from the potential supplier of technology and equipment are obtained.*

- *Projection of the total investment was estimated that the possible variations of investment could be ± 10%. The final amount of investment required will be determined after the completion of negotiations with potential suppliers of technology and equipment, and after making basic engineering, technological and ideological project.*

- *Based on the information of potential suppliers of technology and equipment as well as the experience in implementing similar projects in the world, it is estimated that the project could be implemented within 40 months. The largest investment would be in the second and third year (approximately 50 million USD per year).*

- *During the smelter reconstruction and installation of new technology, the processing of concentrate and thus the production of cathode copper will be operating continually, because the new smelter will be located on the site of one of the existing line of melting, so that the second line will be in work. Concentrate processing capacity in this case is about 300 thousand tons per year, which is sufficient for the processing of its own concentrates. Also, one sulfuric acid factory will be in function.*

- *The projected financial results show that the project can properly return the obligations (interest and principal) of loans which would be used to finance the planned investments, as well as for the regular equipment replacement. Additional funds to maintain current liquidity would not be needed.*

- *The positive effects of the project of modernization of the smelter in Bor are completely real and expected. The reason for this is the fact that these are investments in the reconstruction that are generally much less than investing in completely new metallurgical facilities. These investments amount to about 1.800 USD per tone of annual copper production capacity and investment in new facilities today range from 4000-4500 USD per tone of cathode copper, or about 42% of investment in new capacity, which is approximately at the level of investment in world.*