Chapter 7. Development of Copper Industries in Mongolia

7.1 Copper Smelting

There are two types of copper smelting process, one is pyrometallurgical process and the other is hydrometallurgical process. There are two types of ores, one is sulfide ores and the other is oxides ores (see Chapter 2 and Chapter 5). Sulfide ores are processed by the pyrometallurgical process, and oxide ores are processed by the hydrometallurgical process. Production of copper by the pyrometallurgical process accounts for approximately 80% of the total copper production in whole world.

Pyrometallurgical process is applied to sulfide ores. The majority of copper ore is chalcopyrite ($CuFeS_2$). As it is understood from the chemical formula of copper sulfide ore, the chalcopyrite type copper ore is sulfide and many iron (Fe) components are included as impurities. Blister copper can also be produced by oxidizing the copper ore by the procedures that sulfur (S) in the copper ore is oxidized and converted into SO_2 gas and removed in the form of SO_2 gas and that iron (Fe) is converted into iron oxide substances by the oxidation and slag (complex oxides of iron and silica) is produced by adding silica (SiO_2) and removed in the form of slag after reduced copper oxide in the slag into metallic copper and separated from slag. However, the copper oxide has a tendency of moving into slag, and as the copper ore contains large quantities of Fe, a lot of slag is generated and copper losses in the slag will be increased accordingly. For the purpose of reducing the copper loss in the pyrometallurgical smelting of copper, it is the procedure employed that the matte (mixtures of Cu sulfide and Fe sulfide) is to be produced at an intermediate step in lieu of oxidizing impurities (Fe, S) completely and directly concentrating Cu, and the majority of Fe is to be removed in the form of slag (complex oxide of Fe and Si) then the matte is to be oxidized and metallic copper is produced.

Pyrometallurgical process consists of smelting process and electrolytic refining process. Smelting process consists of matte making from copper ores, converting process to produce blister copper from matte, and the process to produce anodes to be used for electrolytic refining after reducing sulfur and oxygen in blister copper. The advantages of this process, the recovery rate of copper and precious metals is high. More than 99.99% purity electrolytic copper (cathode) is produced by electrolytic refining.

Hydrometallurgical process is applied to the oxide ores. Copper leached into sulfuric acid solution and this copper contained in the solution is selectively recovered by SX-EW method which is recovering metallic copper by means of Electro Winning Method. Precious metals cannot be recovered by this process. Pressurization method and chloride method etc. are under development for recovering metallic copper from sulfide ores. Precious metals recovery process is also under development. Precious metals cannot be recovered. Pressurization method and chloride method etc. are under development from sulfide ores. Precious metals recovery process is also under development. The construction cost of hydrometallurgical process is smaller than that of pyrometallurgical process since the blister copper producing process can be omitted in the hydrometallurgical process, and the consumption of fuel, etc. is lower than the pyrometallurgical one as its advantages.

In the pyrometallurgical process, it is required to refine blister copper produced to the grade of cathode copper. And, it is necessary to recover metallic copper concentrated into the solvent solution in the hydrometallurgical process. The electrolysis is applied as the chemical processing in both processes. The refining from anode copper to cathode copper is carried out by electrolysis in which anode copper is installed at the positive terminal and pure copper plate or stainless plate is installed at the negative terminal. For the recovery of copper from solvent solution in which copper is concentrated, the electrolysis is to be carried out by installing insoluble electrode at the positive terminal and installing stainless plate at the negative terminal. The method for recovering copper by installing blister copper at the positive terminal is called the electrolytic refining, and that for recovering metals from electrolytic solution by installing insoluble anode at the positive terminal is called the electro-winning. In the electro-winning by means of sulfuric acid solution, oxygen gas is generating at the positive terminal. As the energy to generate oxygen gas is required, a higher voltage of electrolytic cell is required and unit consumption of electric power becomes higher accordingly.

7.1.1 Pyrometallurgical Process (method of matte production)

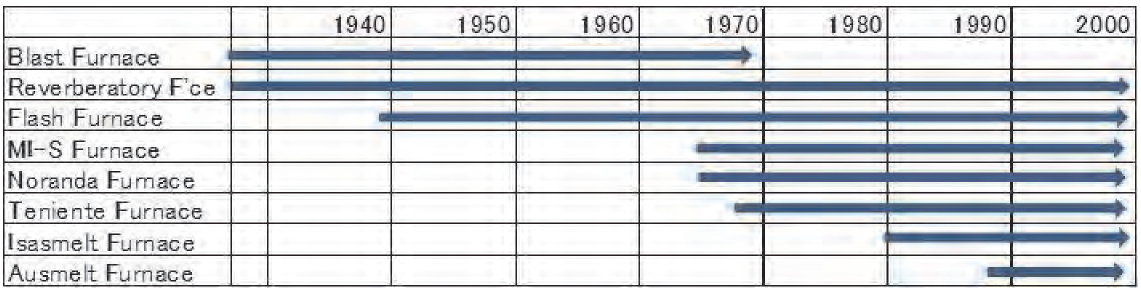
There are various types of pyrometallurgical process and the matte is to be produced in all of such types. Copper ores are melted, and matte and slag are produced to concentrate Cu into matte and Fe into slag and then slag is to be removed and matte is to be recovered after the separation of slag from matte according to the difference of their specific gravities.

Most of precious metals are migrated to the matte, and the recovery rate of precious metals is high as the characteristic feature accordingly. Heavy metals which are likely to be oxidized are fixed in the slag as the form of steady complex oxides. The sulfur is oxidized to sulfur dioxide (SO_2) transferred to the off gas line. High concentrations of SO_2 gas is used as a sulfuric acid production, low concentrations of SO_2 gas is recovered as gypsum. Most of the copper loss is due to mixing of matte into the slag.

As the constructions of larger smelters have been proceeded in order to save the cost of smelting, small scaled mountainside smelters which belong to mines have lost their cost competitiveness. Moreover, according to the development of floatation and to the increase of distance from the mine to the smelter, it became a basic concept to reduce the transportation cost by reducing the quantity for transportation. The ore flotation process is adopted for cost reduction technique by decreasing the ore traffic volume

At the initial stage of the pyrometallurgy, matte is produced by heating and melting lump ores, etc. by using blast furnace, reverberatory furnace, electric furnace, etc. In accordance with the development of floatation method, powdered copper concentrates are mainly being used in the smelter. Powdered copper concentrates have the characteristic that heat spread easily to the inter-granular part because their surface area is large and the mass is small. The ore melting process had been developed by utilizing such characteristics. Several different ore melting methods in which the heat of oxidation reaction of sulfur in sulfide ores is fully utilized by blowing ore and flux into the furnace center with oxygen enriched air ware developed, such as, the flash furnace, the MI furnace, the INCO furnace, the Teniente furnace, the Ausmelt furnace, and the Isasmelt furnace, etc.

The pyrometallurgical process can be classified into the process to produce matte, that to produce blister copper by oxidization of matte as well as removal of sulfur and iron, electrolytic refining process to produce cathode copper by reducing sulfur, iron and other impurities in blister copper. The MI furnace is a combination of furnaces finally producing blister copper, and other furnaces are to produce matte.
Blister copper is produced from matte. Blister copper is produced by removing iron and sulfur from matte by using PS converter (Peirce-Smith converter) or FC furnace (Flash Converter). The FC furnace had been developed and implemented by applying the technology of flash furnace so as to process matte in the stationary type furnace since PS converter had difficulty in preventing the contamination of environment. The first FC converting furnace had been commissioned in 1995 at Rio Tinto, Kennecott Utah Copper in Magna, UT, USA. Transition of smelting process (production of matte) is shown in figure 7.1.1.



(Source: Prepared by Survey Team)

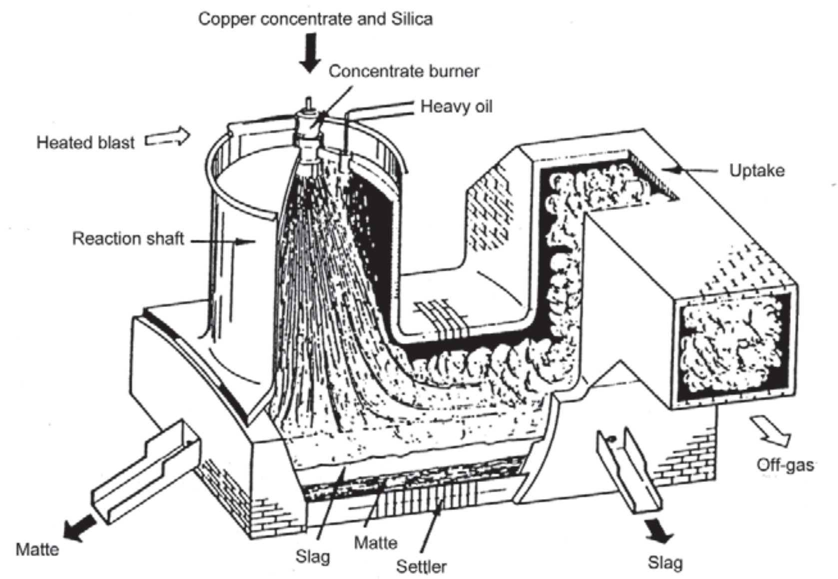
Figure 7.1.1 Transition of Smelting Process (matte production process)

The structure and the specific feature of pyrometallurgical processes are introduced as follows.

(1) Flash Smelting Furnace

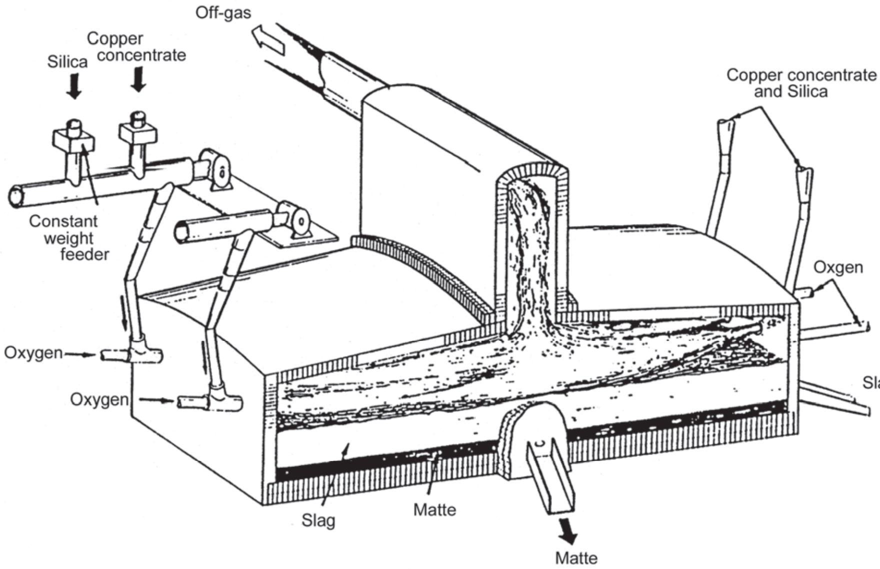
Flash smelting furnace had been developed and operated for practical use at first in the world as the furnace for processing powdered copper ores. This furnace had been constructed at the Harjavalta smelter of the Outokump Oy Co., Ltd. of Finland in 1949. There are two types of the flash smelting furnaces classified depending on differences of the blowing method. One is Outokump method and another is INCO method. In the Outokumpu method, the furnace has the structure that dry copper concentrates are blown in with the heated oxygen enriched air to the furnace form the top of the reaction shaft. On the other hand, in the INCO method, the furnace has the structure to blow in concentrates from both the right and the left ends of the furnace horizontally, and off-gas is exhausted from the center of the furnace.

Figure 7.1.2 and Figure 7.1.3 shows the conceptual diagram of the Outokumpu method and that of INCO method respectively.



(Source; Flash smelting furnace method, JOGMEC)

Figure 7.1.2 Flash Smelting Furnace of Outokumpu Method



(Source; Flash smelting furnace method, JOGMEC)

Figure 7.1.3 Flash Smelting Furnace of INCO Method

Among these two flush smelting furnaces, Outokumpu type smelting furnaces are major ones presently being used most popularly.

Oxidation of a copper sulfide is the exothermic reaction and a certain amount of heat generated from the reaction was utilized even in conventional blast furnace method, etc. as well. The flash furnace thoroughly utilizes this heat generated from the reaction, and the heat obtained by oxidizing the sulfide ore is utilized to melt the matte and slag. In order to achieve this, heated oxygen enriched air is used in the Outokumpu method, and pure oxygen is used in the INCO method as the oxidant by blowing into the furnace. As a result, the consumption of fuel to be supplied from outside is decreased, the generation of flue gas is suppressed, and the heat and the dust which are exhausted with flue gas are also decreased. Because the amount of the exhaust gas generated decreases, the concentration of sulfur dioxide in the exhaust gas becomes higher, and the scale of the sulfuric acid plant in which exhaust gas is processed can be reduced and the investment amount can be suppressed accordingly. In addition, the easy operation control and management of the sulfuric acid plant can be achieved since the deviation in concentration of SO_2 in exhaust gas is less, and the efficiency of the sulfuric acid production can be improved, as well as the recovery rate and the yield of sulfur are improved.

On the other hand, it can be expressed as a disadvantage of the flash smelting furnace that the amount of copper inclusion in slag can hardly be reduced. It is necessary to prolong the retention time of melts in furnace by flush smelting furnace with Soderberg type electrode or by installing slag holding (or cleaning) furnace in addition to the flush smelting furnace for separation of matte from slag. Moreover, PS converter is used to produce blister copper, and it is required to take measures for prevention of SO_2 gas leakage since the converter has many movable parts and the matte has to be moved and transferred. As the concentration of SO_2 gas in exhaust gas is largely deviating in case of PS converter, the operation of sulfuric acid plant is difficult and recovery rate as well as yield of sulfur may decrease.

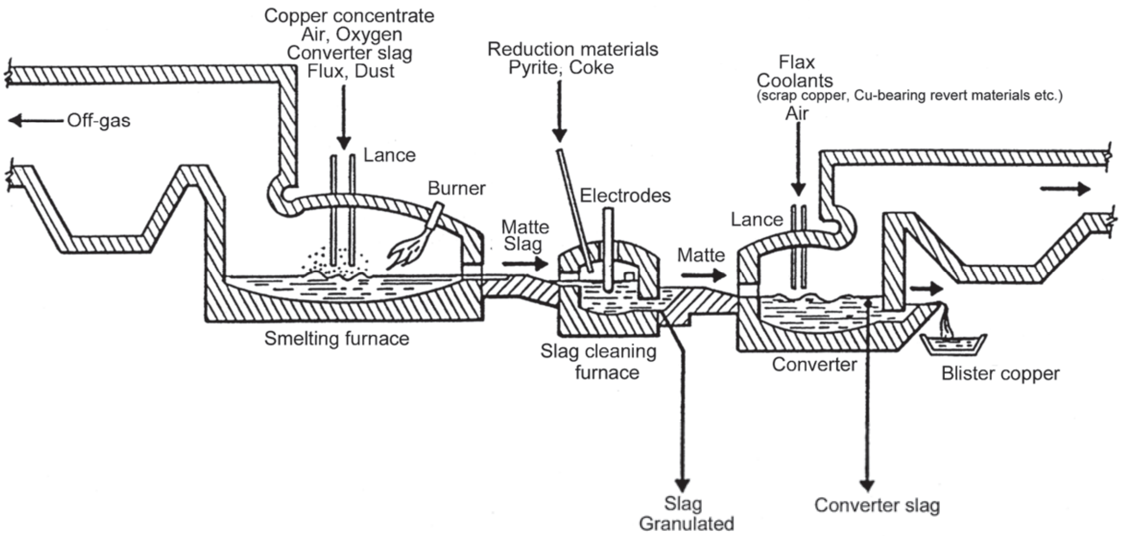
(2) The Mitsubishi Process

Although the high efficiency for matte production from copper ores had been realized by the flash smelting furnace, the copper converting process is separately required, and the converting furnace being used is tilting type furnace and thorough collection of exhaust gas cannot easily be achieved accordingly, and the issue on leakage of exhaust gas is existing since SO_2 gas is generated when the matte is transferred by ladle to blister copper producing process. Also, there is the issue that the operation of sulfuric acid plant is difficult because of very large variations in the concentration of SO_2 gas in exhaust gas from converter where matte is to be oxidized for producing blister copper.
In Mitsubishi Process, the blister copper production process is classified into three steps, from the ore melting to the blister copper production process, i.e. matte production, separation of matte from slag and blister copper producing process, and is carried out by three fixed types of furnaces. These fixed furnaces are connected by launders without movable parts for preventing from leakage of exhaust gas thoroughly for easy collection of exhaust gas and realized higher efficiency in the processing of ores as well. The first demonstration smelter had been constructed at the Naoshima smelter in 1974.

In Mitsubishi Process, dried copper concentrates and fluxes with the oxygen-enriched air are blown in from the top of smelting furnace (S-furnace), and melts of matte and slag are produced. The generated matte and slag are sent to slag cleaning furnace (CL-furnace) of electric heating type through launder, and matte and slag are separated by the difference of their specific gravities, then slag is to be discharged. The separated matte is to be sent to converting furnace (C-furnace) through siphon port and launder, and oxygen enriched air is blown to the C-furnace, and blister copper is produced. Mitsubishi Process is the only method that the whole process from ore to blister copper can continuously be performed.

MI furnace (i.e., furnaces to be used in Mitsubishi Process) thoroughly utilizes the reaction heat of copper ores as same as in the case of flash smelting furnace, and utilizes the heat obtained from the oxidation of sulfide ores to melt the matte and slag. As in the case of the flash furnace, the consumption of fuel to be charged from outside can be decreased, the generation of flue gas is suppressed, and the quantity of heat and dusts to be discharged with exhaust gas can also be decreased. As the amount of the exhaust gas generated is less, the concentration of sulfur dioxide in exhaust gas becomes higher, and the saving of investment for construction of sulfuric acid plant can be achieved since the amount of the exhaust gas generation decreases. The efficiency of the sulfuric acid production rises, and the recovery rate and the yield of sulfur also can be improved accordingly. Also, Mitsubishi Process has an advantage that the measures to prevent from gas leakage can surely and easily be performed since this copper production process uses fixed and stationary furnaces.

As the demerit, however, this process may have slightly large heat losses because the launder has water-cooling jackets.
Figure 7.1.4 shows the conceptual diagram of the MI method.



(Source; flash smelting furnace smelting method, 2013, and JOGMEC)

Figure 7.1.4 Mitsubishi Process

(3) Noranda Furnace and Teniente Furnace

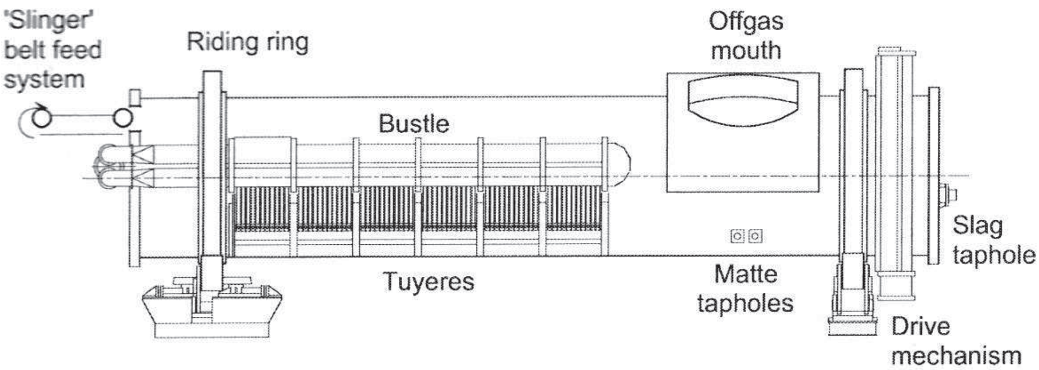
It has been carried out from a long time ago that oxidizing gas and powdered ores are blown into converter (i.e. revolving furnace) through the tuyere for oxidizing matte and producing blister copper and for increasing the quantity of ore treatment by utilizing the heat of matte oxidation. Noranda reactor and Teniente furnace are those developed from this principle, and the furnace has a structure of extending the dimension in a longer side direction and equipped with the tuyere for blowing dried ores, the tuyere for blowing oxidizing air to the layer of matte and with the equipment to charge materials repeatedly as well as a part of furnace for separating matte and slag by the difference of their specific gravities.

The first actually operated Noranda furnace had been constructed at the Noranda smelter of Canada in

1973. And that of Teniente furnace had been constructed at the Caletones smelter, Codelco of Chile in 1989.

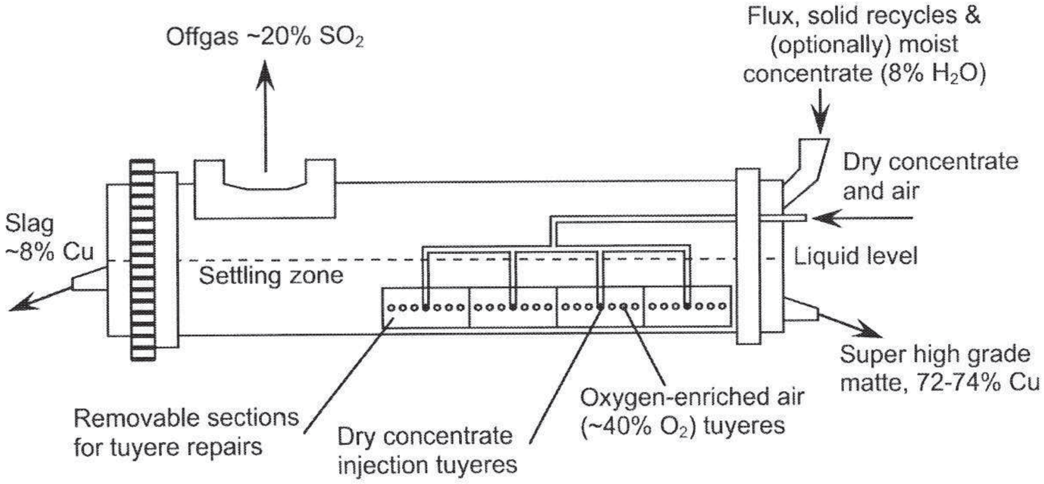
Both Noranda furnace and Teniente furnace are to be heated up to the melting temperature and matte is to be charged into the furnace and, after melting of matte, the operation for oxidation of matte is to be started. Dried ore is injected into matte phase, repeat materials and ore (around 8% moisture) are charged on the slag phase. Oxygen enrichment air is to be blown to matte phase, and ore and repeat materials are melted by the heat of oxidation reaction. High grade copper and low iron contained matte can be obtained.

Noranda furnace and Teniente furnace are to utilize the reaction heat of ores thoroughly as in the case of flash smelting furnace and MI furnace, and uses the reaction heat obtained from the oxidation of sulfide ore to melt the matte and slag. The settling zone is provided by extending dimensions in the transverse direction of furnace longer than that of PS converter in order to separate matte and slag.
It can be said as the disadvantage of this process that the recovery rate of SO_2 is lower.
Figure 7.1.5 shows the conceptual diagram of the Noranda furnace and Figure 7.1.6 shows the conceptual diagram of the Teniente furnace respectively.



(Source; Extractive Metallurgy of Copper fifth edition)

Figure 7.1.5 Conceptual Diagram of the Noranda Furnace



(Source; Extractive Metallurgy of Copper fifth edition)

Figure 7.1.6 Conceptual Diagram of the Teniente Furnace

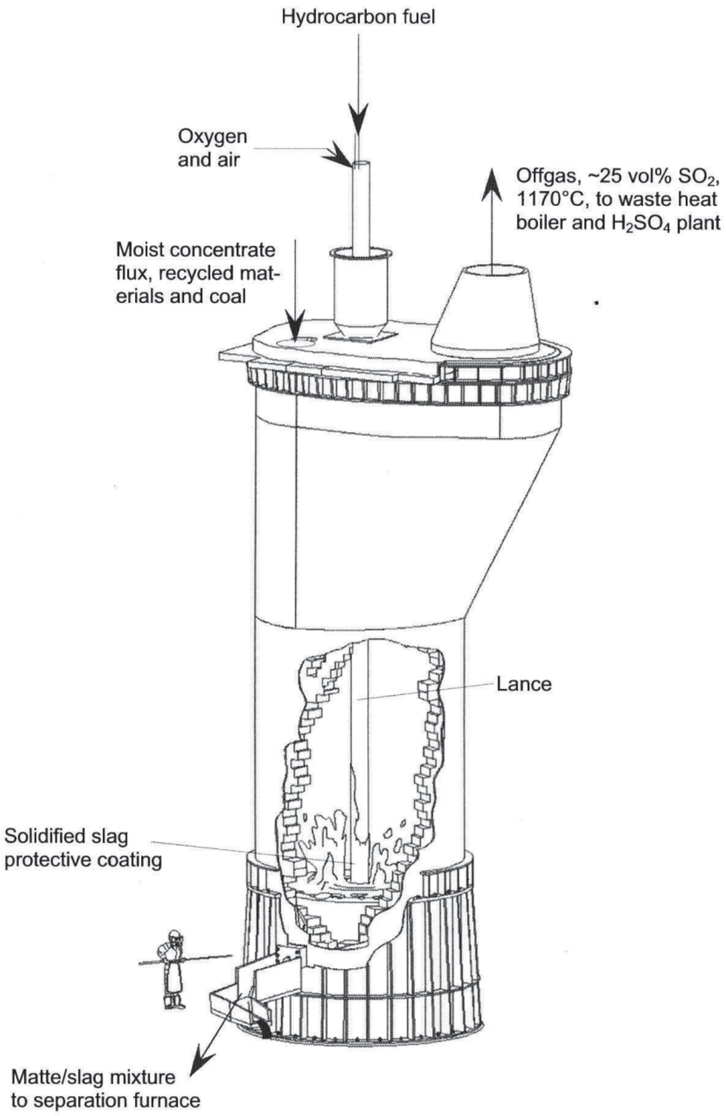
(4) Isasmelt Furnace and Ausmelt Furnace

The furnace had originally been developed by CSIRO (Commonwealth Scientific and Industrial Research Organization), and Isasmelt furnace had further been developed by Mount Isa Mines Limited (presently, Xstrata Holdings Pty. Ltd.) and Ausmelt furnace was developed by Ausmelt Limited both from the first technology as above stated.

Ausmelt furnace and Isasmelt furnace have a structure that fuel and oxygen enriched air is blown into slag phase through the lance which is installed from the top of cylindrical furnace so that the lower tip of lance may dip around the surface of slag phase. The tip of lance is protected by adhered and solidified slag. Ore raw materials are to be charged into furnace from the top of furnace. Drying of raw materials is not required since they are charged into melts. Even massive raw materials can be processed in this process. The products of the process are a mixture of matte and slag.

Both Isasmelt furnace and Ausmelt furnace are the fixed stationary furnace and the measures to prevent from leakage of exhaust gas may easily be taken, and however the furnace for separation of matte and slag is additionally required. As massive raw materials can be processed, treatment of massive wastes can also be achieved. On the other hand, there is a knowhow for the method of protecting lance and the operation of furnace is rather difficult. As PS converter is to be used for producing blister copper from matte, the measures to prevent from leakage of exhaust gas can hardly be taken.

Figure 7.1.7 shows the conceptual diagram of the Isasmelt furnace for representing both Isasmelt furnace and Ausmelt furnace.



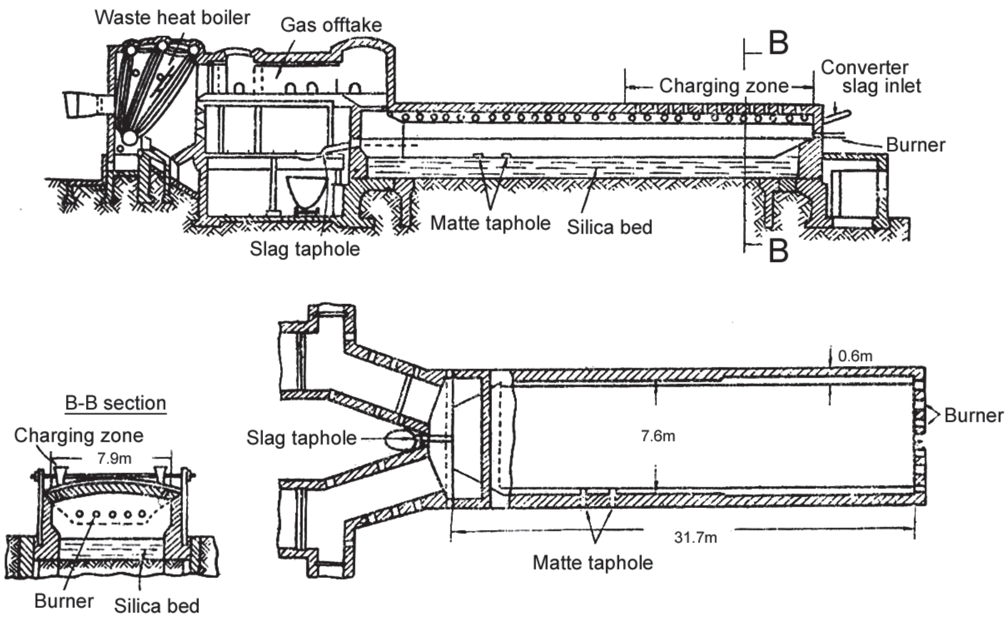
(Source; Extractive Metallurgy of Copper Fifth Edition)

Figure 7.1.7 Isasmelt Furnace

(5) Reverberatory Furnace

Old smelting furnace of lump ores, capable of heating and smelting copper ore is blast furnace, reverberatory furnace, electric furnace.

There are blast furnace, reverberatory furnace and electric furnace as the pyrometallurgical copper smelting furnace which is able to heat and melt lump ores, etc. These furnaces are also the type of process for melting ores to produce matte and slag and for recovering copper by concentrating copper into matte. As the concentration of SO_2 in exhaust gas is lower than that (approximately 2%) required for the production of sulfuric acid and a large amount exhaust gas is generated, the consumption of energy increases and almost of these furnaces are not used at this stage. In Japan, reverberatory furnace is used only at the smelter plant of Onahama Smelting and refining Co., Ltd. Figure 7.1.8 shows the conceptual diagram of the reverberatory furnace.



(Source; Non-ferrous metal Pyrometallurgy, Japan Institute of Metals and Materials)

Figure 7.1.8 Conceptual Diagram of the Reverberatory furnace

7.1.2 Pyrometallurgical Process (converting)

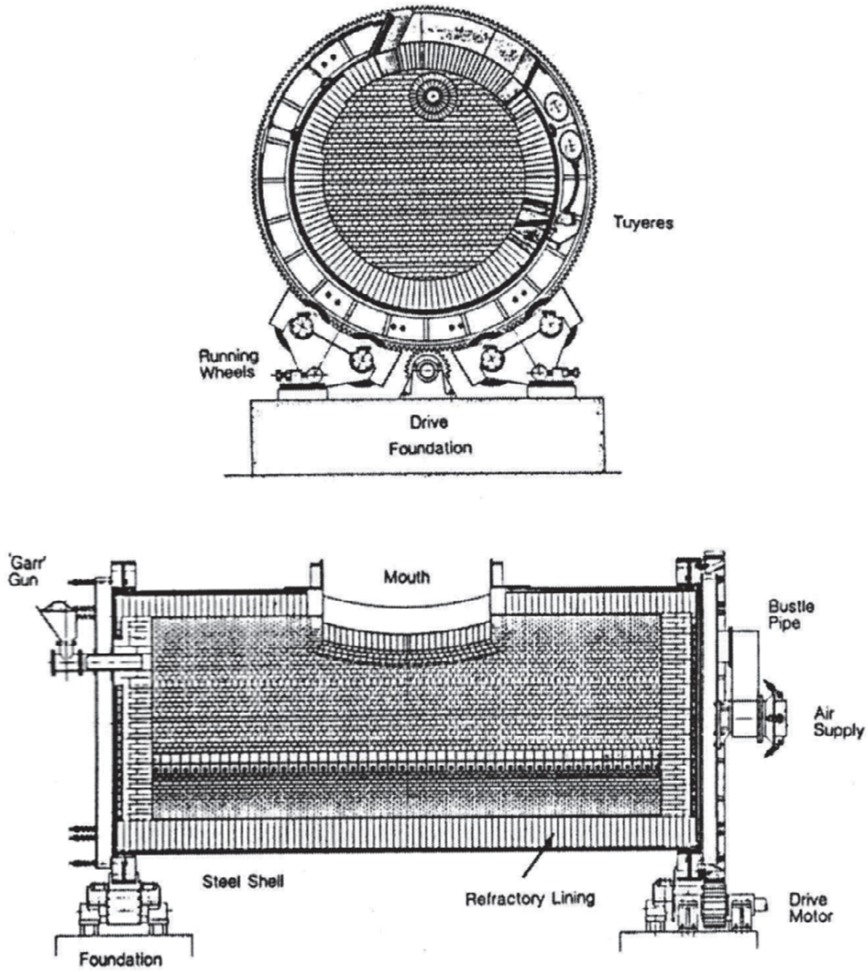
Produced matte is the sulfide of copper and iron recovered from copper concentrates charged into pyrometallurgical smelting furnace, and blister copper is produced by blowing air or oxygen enriched air into matte for removing iron and sulfur. This process is called the copper smelting process, and the converter has been used for this purpose from a long time ago. SO_2 gas generated from the converter is transferred to sulfuric acid plant and sulfuric acid is produced. SO_2 generated from converter can be almost completely collected after a hood is installed above the converter, However, the hood has to be removed at the period of receiving matte and SiO_2 and at discharging slag and blister copper for revolving the converter. Although the blowing air, etc. is stopped at this stage, gas leaks from the converter.

Also, as the concentration of SO_2 gas changed widely during the process for removing iron and sulfur by oxidation of them, the operation of sulfuric acid plant becomes difficult and the recovery rate of sulfur may be decreased. In recent years, the method which copper smelting process is carried out by the fixed and stationary furnace has been developed. One of such process is Mitsubishi process (MI furnace) and another is Flash Converting Process.

(1) PS Converter (Peirce-Smith Converter)

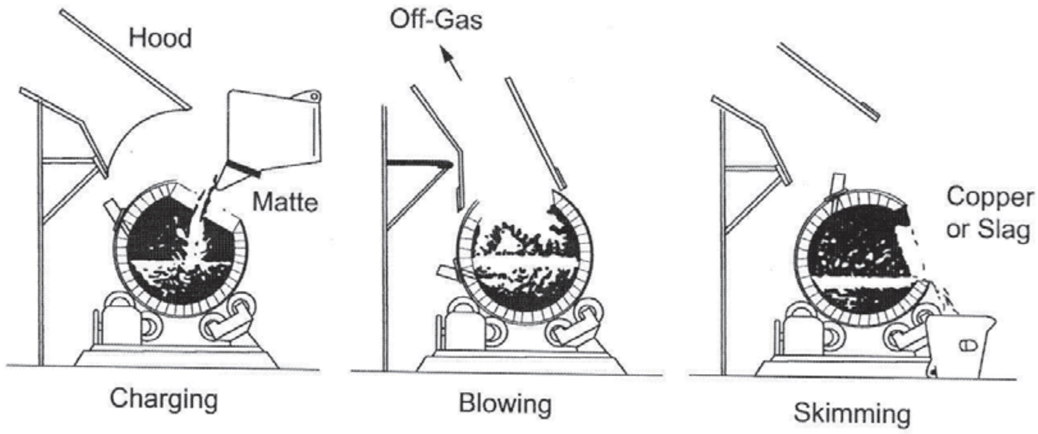
PS converter is to produce blister copper. In this converter, SiO_2 is added to matte as a flux and blowing air into bath in order to oxidize sulfur and iron contained in matte, and sulfur and iron are to be removed in such a manner that sulfur is oxidized to sulfur dioxide (SO_2) gas exhausted to flue and iron is oxidized and combined with SiO_2 forming FeO-SiO_2 series slag and discharged. This furnace has a structure enable to revolve so that the tuyere may be positioned above the upper surface of melts at the time of matte charging and generated slag may be discharged from the furnace.

Figure 7.1.9 shows the conceptual diagram of the Peirce-Smith Converter. Figure 7.1.10 shows position of a Peirce-Smith Converter for charging, blowing, and skimming.



(Source; Extractive Metallurgy of Copper Fifth Edition)

Figure 7.1.9 Conceptual Diagram of the Peirce-Smith Converter



(Source; Extractive Metallurgy of Copper Fifth Edition)

Figure 7.1.10 Position of a Peirce-Smith Converter for Charging, Blowing, and Skimming

At the production of blister copper by oxidizing matte, the priority order of oxidation reaction differs depend on its components, oxidation of FeS takes priority over others. As the melting point of FeO and Fe_3O_4 is higher than that of Cu_2S, complex oxide slag of FeO-Fe_3O_4-SiO_2 series having a low melting point is to be produced by adding SiO_2. As it is required to remove generated slag, slag is discharged by revolving (tilting) the converter after stopping blowing oxidizing air. From this reason, the concentration of SO_2 in exhaust gas widely varies. Also, there are issues as an example that complete collection of exhaust gas at the time of slag discharging, etc. For utilizing the heat of oxidation reaction, scrap copper is processed in the converter, and there are similar issues since the blowing of oxidation air is to be stopped when charging scrap copper.

(2) Flash Converting Furnace

After the production of matte in flash smelting furnace, the matte is to be granulated by water granulation and the granulated matte is to be oxidized to produce blister copper by a separate flash converting furnace in this process. This process has been realized by Tongling Non-Ferrous Metals Group Co. Ltd. in 2011. This process is still newly developed technology since it has been pasted only for over two (2) years from the commencement of initial operation.

As the production of matte and the oxidation of matte (i.e. production of blister copper) are performed by the fixed and stationary furnace, it has an advantage that measures to protect leakage of exhaust gas can thoroughly be taken. On the other hand, it has an issue as the disadvantage that it has a large heat loss since the molten matte has to be once granulated by water granulation.

The structures of flash converting furnace are same as those of flash smelting furnace.

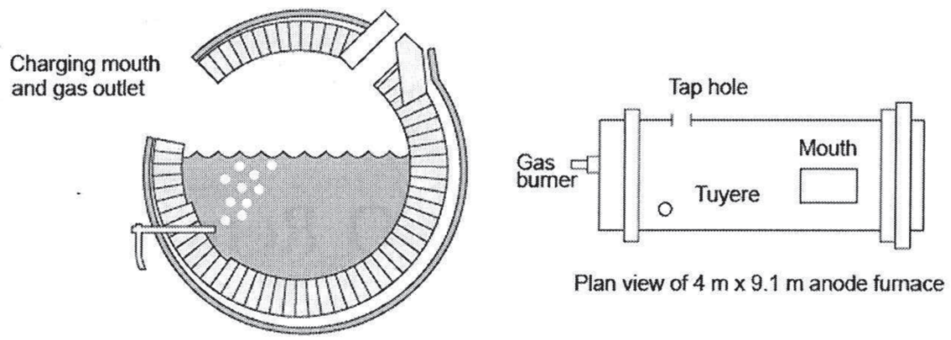
(3) MI Furnace (MI-C Furnace)

The explanation of MI furnace is omitted since it is described in the foregoing item 7.1.1-(2) on the production of matte.

7.1.3 Pyrometallurgical Process (Production of Anode)

Blister copper produced in blister production process includes sulfur and oxygen, and SO_2 gas is generated and forms bubbles in the anode casted. Also, as oxygen may cause trouble(s) in the electrolysis process, anodes to be used in the electrolysis process are casted after decreasing these substances.

In order to remove sulfur and oxygen from matte, the revolving type anode furnace is used.
Figure 7.1.11 shows the conceptual diagram of the anode furnace.



(Source; Extractive Metallurgy of Copper Fifth Edition)

Figure 7.1.11 Conceptual Diagram of the Anode Furnace

Anode furnace has similar structures with those of PS converter and however it has only two (2) or three (3) tuyeres. Firstly, air is blown to remove sulfur by oxidation. Secondly, butane gas or natural gas is blown to remove oxygen contained in blister copper. After the completion of refining of blister copper, the blister copper is to be casted to the shape of anode.

7.1.4 Pyrometallurgical Process (Electrolytic Refining)

Anode casted after its oxygen content is reduced to equal or less than 0.2% in anode furnace is sent to the electrolytic refining process, and electrolytic copper is produced by electrolyzing in copper sulfate solution for the period of around twelve (12) days setting anode at the positive terminal and stripping sheet made of pure copper at the negative terminal. The stripping sheet is made by electrolyzing in copper sulfate solution for one (1) day setting blister copper at the positive terminal and stainless steel plate at the negative terminal and deposited pure copper film on the surface of stainless plate is peeled off from the plate and used as the stripping sheet.

Instead of stripping sheet made of stainless steel plate, the method to use titanium plate at the negative terminal as the permanent cathode has also been realized. Although the permanent cathode method can neglect for carrying out the production process of stripping sheet, the cathode copper generated is to be peeled off from both surfaces of the permanent cathode separately and the weight of cathode copper becomes a half of that made by the conventional method of stripping sheet. It is pointed out as its issues that the capacity of transportation in the plant to produce copper products from electrolytic copper is decreased and that the melting capacity of shaft furnace for melting cathode copper is decreased (the unit consumption of fuel is also decreased).

For the purpose of improving the working efficiency of electrolytic refinery plant, it is being discussed to increase the current density. In case of increasing electrical current density, copper deposited on cathode tend to form needle-like shape and likely to be rough surfaces. In some plants, the reverse current (i.e. periodic reverse current electrolysis – PR electrolysis) is employed in order to prevent such needle shaped copper deposited, the current density is increased by approximately 50%. Electrolytic refinery plant may also have differences in some details, and however, there may not be large differences as a whole.

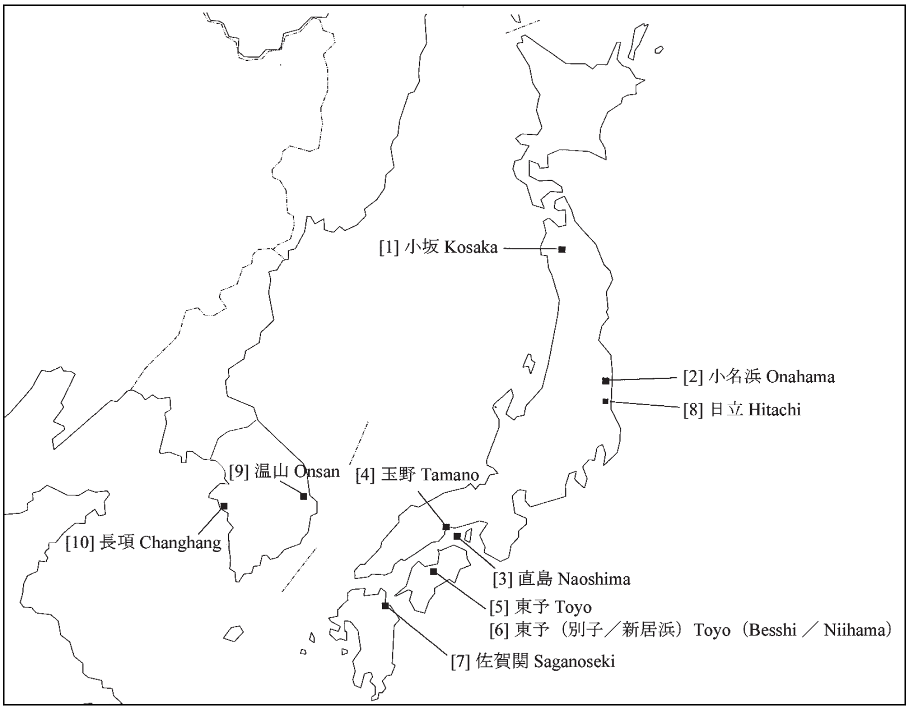
In the copper electrolytic refining process, electrolysis is carried out by setting casted anode at the positive terminal and pure copper sheet (starter sheet) or stainless steel sheet or titanium plate at the negative terminal dipped into copper sulfate solution of sulfuric acid electrolyte. Copper and other metals contained in the anode and having a larger ionization tendency than that of copper are dissolved into the electrolyte by the passage of electric current and noble metals having a smaller ionization tendency than that of cupper such as gold, silver, etc. are not dissolved into electrolyte and deposited underneath the anode as anode slime. Among metals dissolved in electrolyte, metals having a larger ionization tendency than that of copper do not deposit to the cathode and are remained in electrolyte, and only copper is deposited on the surface of cathode.

7.1.5 Pyrometallurgical Copper Smelter in the World

Major copper smelters in the world are shown in Figure 7.1.1 to Figure 7.1.14, and Table 7.1.1 to 7.1.5.

Abbreviations on the method of smelting used in these figures are as follows:

FS: Flash Smelting, MI: Mitsubishi process, MI-S: Mitsubishi -S Furnace, RF: Reverberatory Furnace, AUS: Ausmelt Furnace, ISA: Isasmelt Furnace, EF: Electric Furnace, BF: Blast Furnace, NOR: Noranda Furnace, ET: Teniente Furnace, Van: Vanyukov Furnace



(Source: Metal Economics Research Institute, Japan, 2014)

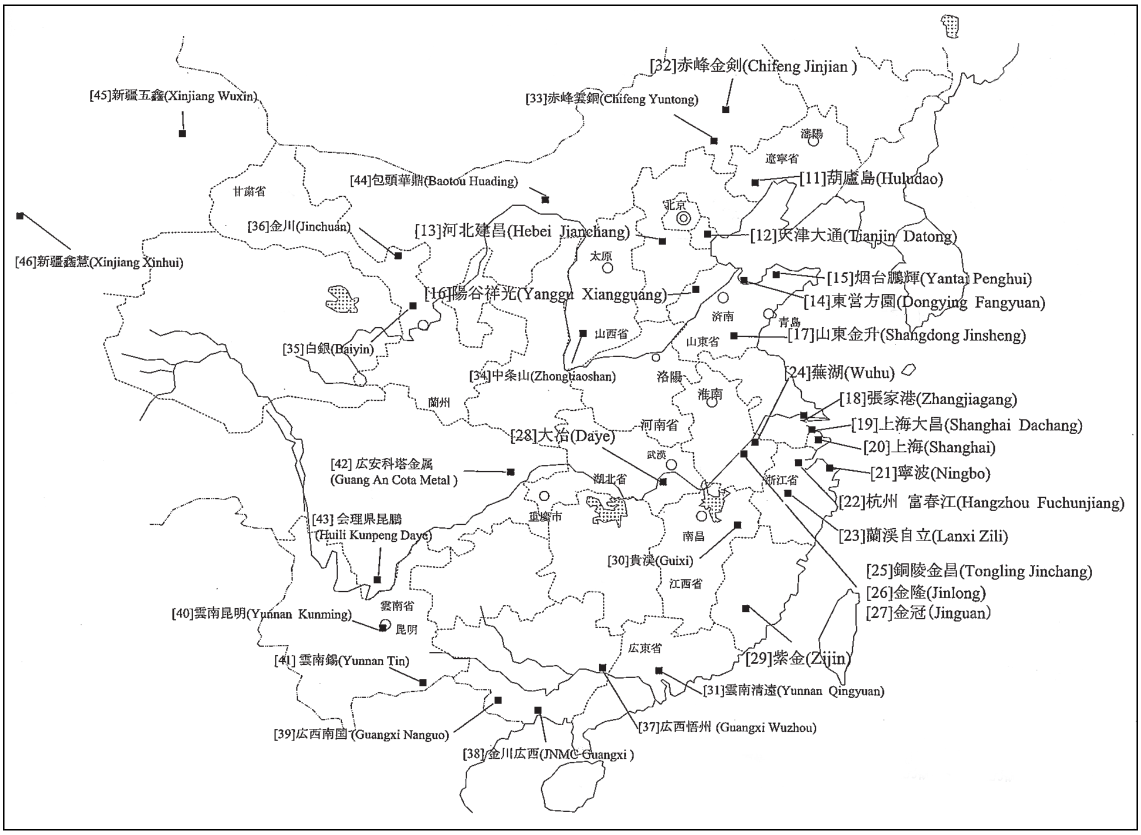
Figure 7.1.12 Copper Smelter in Japan and Korea

Table 7.1.1 List of Copper Smelter in Japan and Korea

(Unit: 1000 t/year)

Country / Name	Location	Process	Capacity	Production (2013)
Japan				
Kosaka	Kosaka, Akita	AUS		12
Onahama	Iwaki, Fukushima	RF, MI-S	320	354
Naoshima	Naoshima, Kagawa	MI	342	342
Tamano	Tamano, Okayama	FS	260	260
Toyo	Saijo, Ehime	FS	450	450
Saganoseki	Oita, Oita	FS	450	450
Korea				
Onsan	Onsan, Ulsan	FS, MI	520	532 (2012)

(Source: Metal Economics Research Institute, Japan, 2014)



(Source: Metal Economics Research Institute, Japan, 2014)

Figure 7.1.13 Copper Smelter in China

Table 7.1.2 List of Copper Smelter in China

(Unit: 1000 t/year)

Country / Name	Location	Process	Capacity	Production (2013)
China				
Guixi	Guixi, Jiangxi	FS, BF	900	900
Jinlong	Tónglíng, Anhui	FS	350	350
Daye	Huangshi, Hubei	Nor, RF	300	300
Jinchuan	Jinchuan, Gansu	EF, FS	800	410
Yunnan	Kunming, Yunnan	ISA, EF	350	350
Yanggu Xiangguang	Yanggu, Shantung	FS	400	400
Chifeng Jinjian	Inner Mongolia	AUS	100	100
Chifeng Yuntong	Inner Mongolia	FS	100	100

(Source: Metal Economics Research Institute, Japan, 2014)

Table 7.1.3 List of Copper Smelter in Europe and Africa

(Unit: 1000 t/year)

Country / Name	Location	Process	Capacity	Production (2013)
Germany				
Hamburg	Hamburg	FS, EF	450	450
Luenen	Luenen	ISA	180	180
Spain				
Huelva	Huelva	FS	320	320
Sweden				
Ronnskar	Ronnskar	TBRC	250	204
Finland				
Harjavalta	Harjavalta	FS	210	210
Poland				
Glogow	Glogow	BF, FS	540	530
Serbia and Montenegro				
Bor	Bor, Serbia	RF	80	170
Bulgaria				
Pirdop	Pirdop, Sofia	FS	330	330
Zambia				
Nkana	Kitwe, Copperbelt	FS	310	310
Mufulira	Mufulira, Copperbelt	EF	230	230
Chambishi	Copperbelt	ISA	250	250

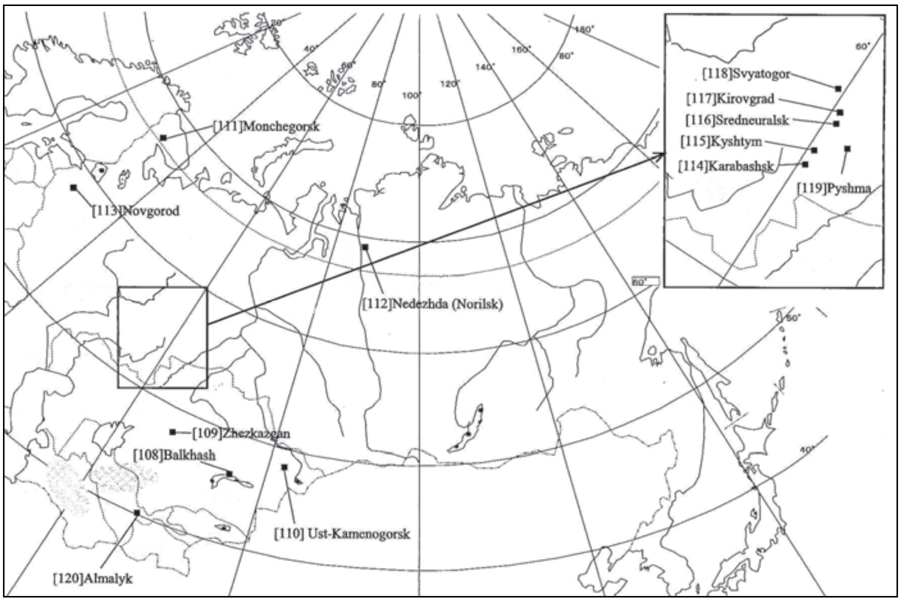
(Source: Metal Economics Research Institute, Japan, 2014)

Table 7.1.4 List of Copper Smelter in Asia and America

(Unit: 1000 t/year)

Country / Name	Location	Process	Capacity	Production (2013)
Indonesia				
Gresik	Gresik, Java	MI	300	300
Philippine				
Leyte	Isabel, Leyte	FS	250	250
India				
Dahej	Gujarat	MI, FS, AUS	500	500
Tuticorin	Tamil Nadu	ISA	400	400
Iran				
Sar-Cheshmeh	Sar Cheshmeh, Kerman	RF, FS	225	225
Australia				
Mount Isa	Queensland	ISA	300	208
Olimpic Dam	South Australia	FS	250	250
Canada				
Sudbury	Ontario	FS	135	135
Horne	Qubec	MOR	205	205
United State				
Grafield	Utah	FS	320	192
Hayden	Arizona	INCO	210	210
Miami	Arizona	ISA, EF	180	180
Mexico				
La Caridad	Nacozari, Sonora	FS, ET	300	300
Brazil				
Camacari	Camacari, Bahia	FS	280	280
Peru				
Ilo	Ilo, Moquegua	ISA	360	360
Chile				
Altonrte	Antofagasta	NOR	350	350
El Teniente	O'Higgins	RF, ET	400	400
Chagres	Catemu	FS	184	145
Chuquicamata	Antofagasta	FS, ET	450	450
Hernan Videla	Atacama	RF, ET	94	94
Ventanas	Valparasio	ET	130	130
Salvador	Atacama	ET	190	190

(Source: Metal Economics Research Institute, Japan, 2014)



(Source: Metal Economics Research Institute, Japan, 2014)

Figure 7.1.14 Copper Smelter in CIS Countries

Table 7.1.5 List of Copper Smelter in CIS Countries

(Unit: 1000 t/year)

Country / Name	Location	Process	Capacity	Production（2013）
Kazakhstan				
Balkhash	Balkhash	Van, RF	220	220
Zhezkazgan	Zhezkazgan	EF, RF	215	215
Russia				
Monchegorsk	Monchegorsk, Kola	FS	100	100
Norilsk	Norilsk, Siberia	RF, EF	400	400
Sredneuralsk	Sredneuralsk, Sverdlovsk, Urals	Van, RF	160	160

(Source: Metal Economics Research Institute, Japan, 2014)

7.1.6 Comparison with Respective Pyrometallurgical Processes

There are many pyrometallurgical copper smelting processes. The comparison on characteristics of respective pyrometallurgical processes, such as construction costs, operating costs, difficulty of operation, production and measures for environmental protection etc. of respective processes is made in the following.

(1) Construction cost

From Extractive Metallurgy of Copper, Isasmelt furnace and Ausmelt furnace are inexpensive. But compare with ancillary facilities such as electric furnace, furnace structure, size, matte and slag separation, construction cost is equal to flash smelting furnace and MI-S+SC furnace.

Although the detailed construction cost has to be estimated by carrying out the feasibility study (F/S), it may be considered that Noranda furnace and Teniente furnace are the lowest in the construction cost since they have simple structures from the view point of scale, structures, auxiliary facilities, etc. According to the report of Extractive Metallurgy of Copper, there is the information that Isasmelt furnace and Ausmelt furnace is the lowest, and however, it is considered that the construction cost of the said furnaces would be same level in comparison with that of MI furnace (Smelting furnace + Slag cleaning furnace), Flash smelting furnace, etc. taking into consideration of the cost for auxiliary facilities such as electric furnace for separation of matte an slag.

The construction cost for copper smelters using Outotec Oyj's Flash smelter and Flash Converter is disclosed. According to this informaton, construction cost of copper smelter which has the annual production of 200 Kt would be approximately 1 billion US $.

(2) Operating Costs

As to the operation cost of present smelting process specifically processing copper concentrates, especially the energy cost, the operation cost of Noranda furnace and Teniente furnace is deemed to be higher in comparison with other furnaces, and however the operation cost for other furnaces has principally not much differences. It is considered that differences in statistic data may be due to differences in operational technologies.

(3) Operation

(a) Operation of Smelting Furnace (matte production process)

As for the operation of smelting furnace, the operation of blast furnace and electric furnace is simple, and the melting is possible by merely charging raw materials into the furnace and also most of every raw materials from powdered copper concentrates, massive copper ores, copper scraps, etc. can be processed by these furnaces.

Other furnaces which are developed for processing powdered concentrates as their priority order have the disadvantage that processing of massive raw materials is difficult though they are suitable for processing powdered copper concentrates.

Isasmelt furnace, Ausmelt furnace was developed on how fuel and heating air for oxidation and ore from the same Lance charged into the furnace without the Lance blockage problem. For this

problem, ore charge is divided by fuel and oxygen enrichment air. Fuel and oxygen enrichment air pipe will be bond or coagulation of slag. This way is very difficult operations.
Although Isasmelt furnace and Ausmelt furnace had been developed so as to charge fuel, oxidizing air, copper ores through the same lance, their design was improved by changing to the separate charging of raw materials since the issue on blockade of lance could not be solved. From the reason that the charging of raw materials was separated from fuel and oxidizing air, the restriction of raw material shape capable to charge into furnace was decreased. In this process, the cylindrical pipe is equipped with outside of lance for the purpose of protecting lance and the pipe with lance is protected by adhering and solidifying molten slag in the furnace. This is an essence of knowhow in these furnaces and the operation is difficult.

In Kosaka Smelter of DOWA Metal Mines Co., Ltd. in Japan, copper smelting and refining as well as waste copper treatment are being carried out, and the smelter renewed its furnace from flash smelting furnace to Asmelt furnace which is easy to process the waste copper. After this renewal, it took approximately three (3) years until the furnace became in the state of steady operation. It would be a thoughtless way to employ Asmelt furnace in Mongolia since even DOWA Metal Mines Co., Ltd. who has a plenty of experience in operation of the pyrometallurgical smelting process, such as blast furnace, reverberatory furnace and Flash smelter and has accumulation of technologies encountered difficulties for operation of this process.

(b) Operation of Converting Furnace (Blister Copper Production)
PS converter has been used for the converting process to remove the sulfur and iron from matte. As PS converter has movable parts, it is difficult to perform complete collection of off gas which includes detrimental sulfur dioxide gas (SO_2 gas) of higher concentration.
From the difference in affinity between Fe and Cu, process reaction is divided into three processes as described in the following.

(i) Slag Blow

FeS contained in matte is to be oxidized and generates FeO and Fe_3O_4 as well as SO_2 gas, and SO_2 gas generated is to be transferred to sulfuric acid plant as the raw materials, and slag is produced by the chemical reaction of FeO and Fe_3O_4 with silica (SiO_2) added.

(ii) Slag Discharging

Slag generated is poured out from the converter by tilting.

(iii) Copper Blow

Cu_2S concentrated in matte is oxidized and blister copper (Cu) is produced.

Cu_2S enriched matte is oxidized, in order to producing copper (Cu). During the period between Slag Blow and Copper Blow, generated slag has to be poured out by stopping the oxidizing air blowing at

certain time(s). At this time, SO_2 gas concentration in the off gas becomes almost zero.
Oxidizing reaction of matte is a large exothermic one. In order to use this heat, scraps containing valuable materials such as copper, gold, silver and their alloys are charged into the furnace and melt them by utilizing the heat of reaction effectively. At this time too, SO_2 concentration in off gas becomes close to zero because blowing of air to oxidize the matte is stopped. From the reason that the blowing of oxidizing matte is stopped interruptedly at many times in PS comverter, the content of SO_2 gas in off-gas fluctuates widely, the operation of sulfuric acid plant becomes very difficult.

There are almost no fluctuation of off gas SO_2 concentrations for MI furnaces and FC furnace (Flash Converting furnace). Reactions of Slag blow, slag skimming and copper blow are to be performed in one furnace, and slag discharge is to be achieved continuously by utilizing difference of specific gravities between slag and blister copper, and the operation of sulfuric acid plant becomes easy accordingly.

(c) Environmental protection
Detrimental or poisonous substances generating from copper smelting process are sulfur dioxide and heavy metals. It is necessary to remove both of them for decreasing the environmental impact. Regarding to measures for collection of sulfur dioxide and heavy metals, it is understood that heavy metals can also be collected simultaneously when the measures to collect sulfur dioxide gas are carried out though there is a difference in the state of sulfur dioxide gas and heavy metals, i.e. gaseous state and solid state respectively.

(i) Sulfur dioxide (SO_2)
In the pyrometallurgical smelting process, the prevention against dispersion and/or diffusion of SO_2 gas and heavy metals will mostly be possible if SO_2 gas generated can be collected and send to sulfuric acid plant. Heavy metals can be removed in the sulfuric acid plant at and before gas cleaning process.

The suction of exhaust gas from fixed and stationary furnace is easier than that from revolving (tilting type) furnace. For example in Japan, the gas leaked from the pyrometallurgical smelting furnace is firstly collected at the furnace as measures to prevent from leakage of smoke, and secondly whole of equipment and facilities are covered by building and kept at a negative pressure in the building to prevent from leakage and dispersion of smoke and gas to environment.

If leakage of gas and smoke from smelting furnace, the quantity of air suction from building has to increase as well and the working environment for workers in the building also becomes worse. It is desired to prevent from leakage of gas and smoke as much as possible even though the entire smelting furnace is covered with building accordingly.

In case of PS converter, it is difficult to prevent completely from leakage of sulfur dioxide gas generating from converting furnace. For the construction of pyrometallurgical smelter plant in Mongolia, it would be recommended to employ the process without using PS converter.
In the flue gas of a sulfuric acid plant, SO_2 gas of about 2,000 ppm is included, and generally SO_2 gas is to be absorbed by the desulfurization equipment using hydrated lime and recovered in the form of plaster. There are large fluctuations of SO_2 concentration in the flue gas from PS converter is large, and it is difficult to manage and to control the operation of the sulfuric acid plant. As SO_2 gas concentration in exhaust gas fluctuates, it is difficult to manage and control the operation of desulfurization equipment, and also plaster production is increased.

(ii) Heavy metals
Heavy metals are included in exhaust gas from pyrometallurgical smelting furnace and transported to the sulfuric acid plant. After removal of dusts by electrostatic precipitators in sulfuric acid plant, heavy metals are completely removed by the gas cleaning equipment. Heavy metals lower the capacity of SO_2 oxidizing catalyst in transforming equipment. Heavy metal migrated to the dust in the part is used as raw materials for lead-zinc smelter and another part is repeatedly returned to copper smelting furnace.

Heavy metals dissolved in the water are removed at the cleaning process in waste water treatment facility. The smelter of 200 Kt/year in scale generates waste water of approximately 50 m^3/day. Construction of the waste water treatment plant for processing this waste water is required. The quantity of waste water generated is determined depend on the amount of exhaust gas sent to the sulfuric acid plant without any relationship to the heavy metal content. For the design of waste water treatment facility, heavy metal content in the ore will be required.

7.1.7 Hydrometallurgical Copper Extraction

The pyrometallurgical copper smelting process is a method of copper smelting to concentrate copper and to remove impurities into slag, and oxide ore of a certain rate can be processed as well. The smelting of copper ores which mainly include oxides could not be achieved. The direct electro-winning, which recovers deposited copper from copper oxide ore by leaching the ore in sulfuric acid solution and chemically substituted by iron for copper, had been carried out, and however only low grade copper could be obtained. In 1960s, the solvent suitable for copper extraction solvent (LIX) had been developed and put to practical use. From this development of solvent, copper sulfate solution including smaller amount of impurities, and consequently, a higher grade metallic copper could be produced. Currently, the hydrometallurgical copper smelting is being carried out mainly for oxide ores and becomes to produce approximately 20% of the world's copper production.

The copper ores which is possible to be processed by hydrometallurgical smelting are oxidized ore, chalcocite (Cu_2S), covellite (CuS), and the research of hydrometallurgical process for copper ores which is not leached to sulfuric acid solution such as chalcopyrite ($CuFeS_2$), etc. is also being carried out and some of them reached to the step of demonstration test.

As there is no hydrometallurgical process directly applicable to sulfide copper ores, descriptions and discussions on the same are omitted herein. Hydrometallurgical process requires less initial investment and the expansion of facilities can comparatively be carried out even though it has some issued on building(s), transportation equipment, etc.

In addition, the methods for smelting without generating sulfuric acid as well as the process in which gold and silver can be recovered are experimenting. However, it is considered that the advantage to produce sulfur in comparison of that for sulfuric acid is only the possibility of easy storage since the production of sulfur is in a trend of over demand of world wide scale.

Sulfuric acid should be stored in containers. As the storage volume of sulfuric acid is limited, damage could be restricted within a certain scope when an accident occurred. However, sulfur can be stored by piling-up and the storage of sulfur to several ten Kt can be performed by piling up as in the case of Vancouver in Canada. There is a concern that further large damage may be occurred in case that fire accident happened in storage areas having a smaller amount of water as in Mongolia. Table 7.1.15 indicates sulfur production, consumption and retention in the world.

Table 7.1.15 Sulfur Production, Consumption and Retention in the World

Unit: 10,000 t

	2013	2014	2015	2016	2017
consumption	86,925	89,381	91,598	93,514	95,655
production	87,735	92,659	96,970	100,591	103,421
retention	810	3,278	5,372	7,077	7,766
retention total					

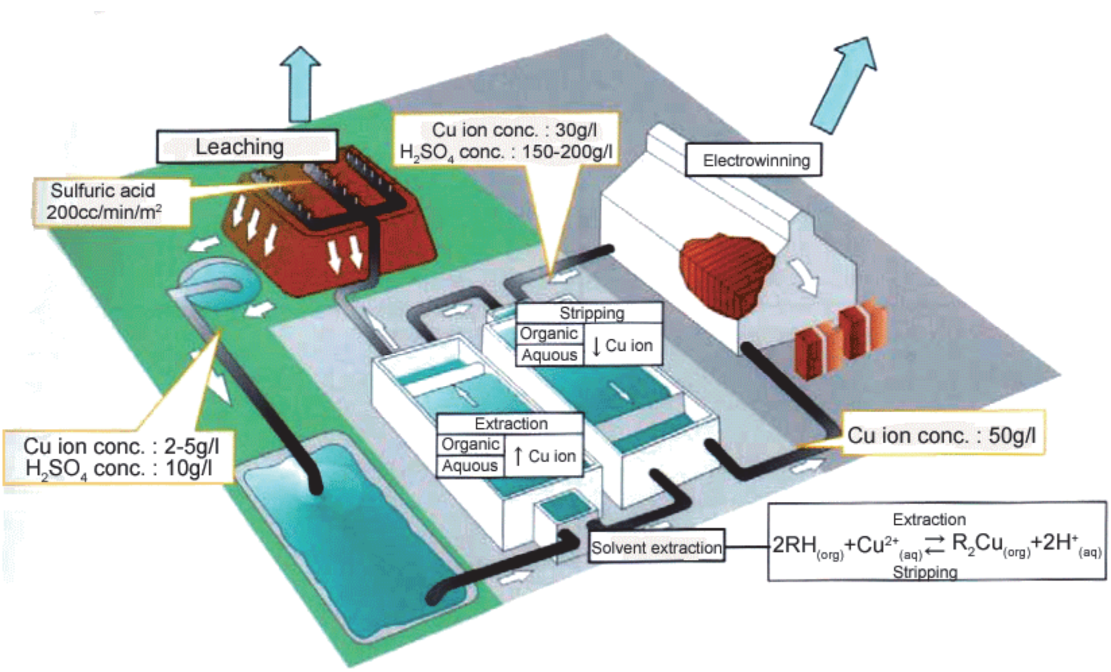
(Source: 81th IFA Annual Conference, Chicago(USA), 2013)

From the worldwide view point, both supply and demand of sulfur are around 100,000 Kt/year respectively. Supply exceeds the demand by approximately 5 Mt. Most of the sulfur demand is for production of sulfuric acid. Sulfur produced will eventually be used for the production of sulfuric acid.

(1) Hydrometallurgical Copper extraction of Oxides Ore

The copper ore are divided into two major groups, i.e. sulfide ore and oxide ores, and sulfide ores are processed by pyrometallurgical process (SX-EW) and oxide ores are processed by hydrometallurgical process. The hydrometallurgical process is to recover high grade copper from copper concentrated solution by the electro-winning after dissolving copper oxide ore into sulfuric acid solution and concentrating copper in the solution by solvent extraction.

Figure 7.1.16 shows the conceptual diagram of the SX-EW.



(Source: JIGMEC, 2013)

Figure 7.1.16 Conceptual Diagram of the SX-EW

The following conditions are required to adopt the SX-EW method at this stage:

1) Type of ore: copper oxide (chalcocite, covelline, etc.)
2) Type of gangue: low acid consumption
3) Terrain: ravines and lowlands. Not an aquifer.
4) Weather conditions: dry and mild temperature. Evaporation > precipitation
5) Transportation distance to the sedimentary yard: short
6) Natural water drainage patterns: small water loss
7) To have sufficient land

In South America, Chile and Peru that meet such conditions, SX-EW method for oxide ore is established. Hydrometallurgical process of the oxide ore (SE-EW method) is consisting of following processes:

1) Leaching
2) Solvent extraction and separation
3) Electro-winning

(2) Leaching

There are five methods employed for the leaching of copper minerals as follows:

1) Agitation leaching

The high grade oxide ore is crushed and ground to a state of slurry by adding leachate in the tank and leaching is carried out during agitation by mixer.

2) Vat leaching

The oxide ore is charged and deposited in the large container after crushed, and leached in the sulfuric acid solution.

3) Heap leaching

The oxide ore is crushed and deposited on the impermeable base (including sheets), and leached by pouring leachate.

4) Dump leaching

Low-grade crude ore and debris are deposited and leaching is carried out by pouring leachate on the deposit.

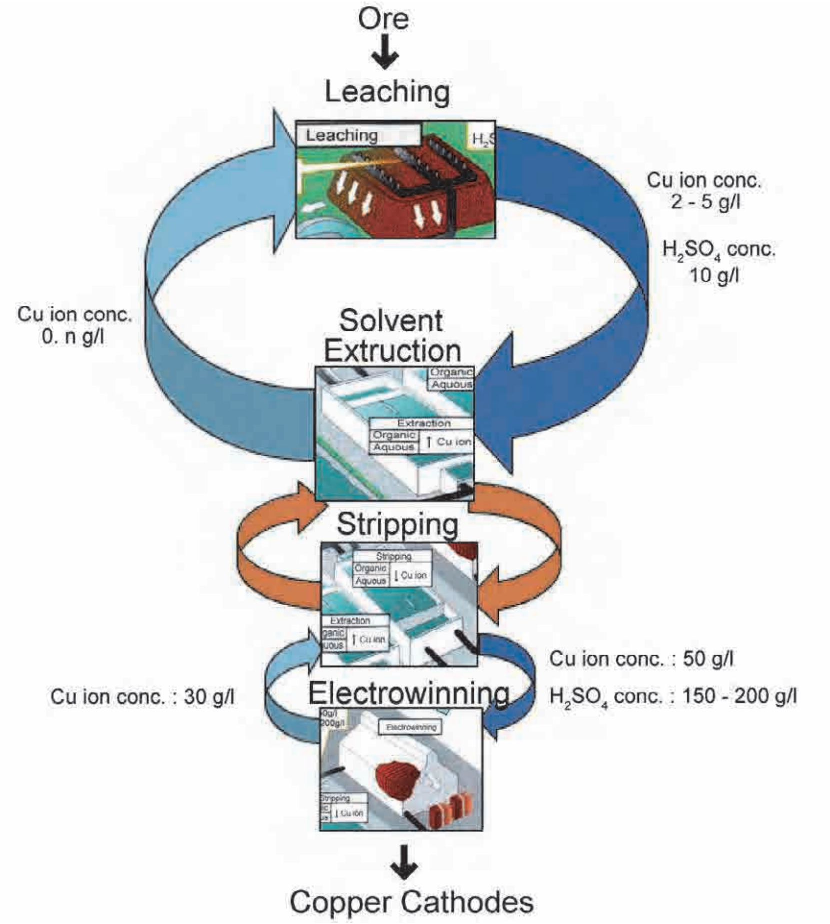
5) In-situ leaching

Cracks on ores are made in situ at the mine prior to mining, and then leaching is carried out by pouring leachate on cracked ores.

Although in-situ leaching is the lowest cost method, copper oxide ore in the mine is mined for the purpose of mining sulfide ore. The sulfide ore cannot be leach by the sulfuric acid solution. There are a few examples of in-situ leaching in the world. The leaching of oxide ore currently being carried out are mostly heap leaching or dump leaching.

(3) SX-EW

The concept of leaching, SX (solvent extraction), EW (electro-winning) represents the form that two (2) aqueous circles (leaching and electrolysis) are linked with one (1) organic circle and copper ions are delivered through this link of circles.
Figure 7.1.17 illustrates the concept of leaching and SX (solvent extraction), EW (electro-winning).



(Source: JIGMEC, 2013)

Figure 7.1.17 Concept of Leaching and SX (solvent extraction), EW (electro-winning)

Copper dissolves as a form of copper ion from ore by leaching, the liquid solution PLS (Pregnant Leach Solution) in which copper concentration is reached to 2 - 5 g/l, is sent to solvent extraction process. In the solvent extraction process, PLS is mixed and agitated by the mixer with kerosene-based organic solvent, and copper components are separated in the settler by difference in specific gravity to remain in the organic phase. The solution not containing copper (Raffinate) is recycled to the leaching process for reuse repeatedly.

The solvent in which copper concentration reaches to a satisfactorily high level in the solvent extraction process is sent to the stripping process, and the solution is mixed with the liquid waste from electrolytic refinery and separated by the difference of specific gravity after mixed and agitated in the mixer-settler and then copper transferred into the liquid waste of electrolytic refinery and becomes electrolyte. The organic layer in which copper is separated is send to solvent extraction process for reuse. The electrolyte is sent to electro-winning process, starting sheet or stainless steel sheet, as insoluble anode and cathode, are used for deposition of copper by electro-winning. Liquid waste from electrolytic refinery is sent to the stripping process to reuse repeatedly.

7.2 Prerequisites for Construction of Copper Smelter

The price of copper cathode is determined between buyers and sellers based on the LME or COMEX designated values. However, the same price is not necessarily applied to all the trading, but the individual selling prices are all slightly different depending on the premium or the product quality certified by LME. Copper is one of the internationally traded commodities across the value chains and susceptible to the trends of the global economy, as finished products or parts produced from copper and copper-based alloys are used in a wide range of applications which contribute the industries including building/housing construction, electric and electronic equipment, railways, and motor vehicles. Consequently it is inevitable for the smelting companies to compete with the other smelting firms for securing not only the copper concentrates but the salable quality of cathodes, as the smelting business is intimately connected with the downstream copper semi/alloy and fabrication industries. It is required for the smelter management to have involvement in the market of copper semi/alloy business in addition to the upstream mining industry as suppliers of copper concentrates. Prerequisites necessary to construct and operate the copper smelter in Mongolia are given chiefly from technical and commercial viewpoints as follows.

7.2.1 Study Items for the Construction and Operation of Copper Smelter

The prerequisites discussed here include fundamental technical aspects with regard to the construction and operation of the smelter and the trading market of copper cathode. Sulfuric acid is discussed in another topic.

(1) Human Resources Development for Construction and Operation

It is mostly in the Southeast Asian region that the copper smelters have newly been constructed recently, except for the facility expansion for production capacity. The rush for construction and capacity expansion of the smelters continued in China in the past decade, and in particular brand new smelters have commissioned almost every year for the last several years. In Vietnam, the state-owned corporation constructed the first refinery in the country in 2005 with technical supports from the Chinese smelting company, and it is reportedly planning to double the annual production capacity up to 20,000 t from 10,000 t. Further, according to an economic newspaper as of December 2010, the same state-owned corporation in Vietnam reached a joint venture agreement with a Russian enterprise on the copper smelter construction plan of 50,000 t. However, no follow-up press release has been seen since then. Construction of smelter needs technical staffs who have experiences in the same type of projects and backgrounds of engineering and other technical services as in the case of mine construction. However, in comparison with the mine construction there are few available companies which can provide such engineers and related technical services.

It is necessary for the engineering stage of smelter construction in Mongolia to outsource engineering services including design, procurement and construction management after the selection of smelting method and feasibility study. However, Mongolian technical staffs should also be involved in the work in order to gain experience in the field of construction work under the supervision and instruction of the expatriate engineers. Mongolian engineers thus trained during the construction stage will be surely of great help even in the operation stage, in particular for maintenance and repair work. They will play an active role in case of a potential expansion of the facility in the future.

Operation stage of the smelter needs staffs of other technical disciplines including pyrometallurgical process engineers. Experienced expatriate engineers in this field also play the leading role at the initial phase of operation, but they have to be gradually replaced with Mongolian staffs in stages with the progress of time. A localization plan should be designed and implemented with cooperation and understanding of the expatriate staffs, learning from similar cases in Mongolia including Erdenet Mine or in other countries. The government also should develop the institutional system. This includes the new establishment of the professional metallurgy course in university or modification/expansion of the existing courses of similar specialty such as applied chemistry and preparation of an opportunity to learn in foreign countries.

Copper smelting technology in Japanese smelting companies is still among the most advanced level as they have been developing it over the century since started mining and smelting companies. They advanced to the overseas copper smelting projects during the period 1980s to 1990s by joint ventures with the local smelting companies and license on the contract basis as well. Copper matte smelting facilities based on their technology and experiences have been built in China, Korea, Philippines, India, Australia, Canada and Indonesia. However, the projects on the contract basis did not bring profits to the companies as originally planned, because they could not win such number of contracts that allowed them to employ regular engineers exclusively allocated for the projects. Consequently they had to withdraw from those overseas projects. As a result, the number of experienced engineers available to such a construction project gradually tapered off.

It is a Chinese smelting company that Mongolia has to rely on technically and cost wise too with regard to the copper smelter construction project. It would be most cost effective and advantageous to Mongolia to proceed with the project together with the Chinese company whichever by a joint venture or on a contract basis, because China is the most probable export partner country of cathode and sulfuric acid when the smelter starts production.

Both of major smelters and refineries are listed respectively in Table 7.2.1 and Table 7.2.2. SX-EW facilities are also included in the refineries. The listed facilities have all large capacity; above 320

Kt/year for smelters and above 350 Kt/year for refineries. It is prominent that a number of Chinese smelters and refineries are listed in the tables. There is a significant percentage of the Outokumpu flash method for smelters.

Table 7.2.1 Top 20 Copper Smelters by Capacity, 2012

Rank	Smelter	Country	Operator/Owner	Process	Capacity
1	Guixi	China	Jiangxi Copper Corp.	Outokumpu Flash	900
2	Birla	India	Birla Group	Outokumpu Flash, Ausmelt, Mitsubishi	500
3	Codelco Norte	Chile	Codelco	Outokumpu/Teniente Converter	450
3	Hamburg	Germany	Aurubis	Outokumpu Flash, Contimelt, Electirc	450
3	Besshi/Toyo	Japan	Sumitomo Metal Mining	Outokumpu Flash	450
3	Saganoseki	Japan	Pan Pacific Copper	Outokumpu Flash	450
7	El Teniente	Chile	Codelco	Reverberatory/Tenient Conv.	400
7	Jinchuan	China	Jinchuan Nonferrous Metal	Reverberatory/Kaldo Conv.	400
7	Xiangguang Copper	China	Xiangguang Copper Co. Ltd	Outokumpu Flash	400
7	Norisk	Russia	Norisk G-M	Reverb, Electirc, Vanyukov	400
7	Sterlite	India	Vedanta	Isasmelt	400
12	Ilo	Peru	Southern Copper Corp.	Isasmelt	360
13	Onahama	Japan	Mitsubishi, Dowa, Furukawa	Reverberatory	354
14	Altonorte	Chile	GlencoreXtrata plc	Noranda Continuous	350
14	Jinlon	China	Tongling Nonferrous Metal, Sumitomo	Flash Smelter	350
14	Yunnan	China	Yunnan Copper Industry	Isasmelt	350
17	Naoshima	Japan	Mitsubishi Materials Corp	Mitsubishi Continuous	342
18	Pirdop	Bulgaria	Aurubis	Outokumpu Flash	330
19	Onsan Ⅱ	South Korea	LS-Nikko Co	Mitsubishi Continuous	320
20	Huelva	Spain	Attlantic Copper	Outokumpu Flash	320

(Source: ICGS Directory of Copper Mines and Plants, Feb 2013)

Table 7.2.2 Top 20 Copper Refineries by Capacity, 2012

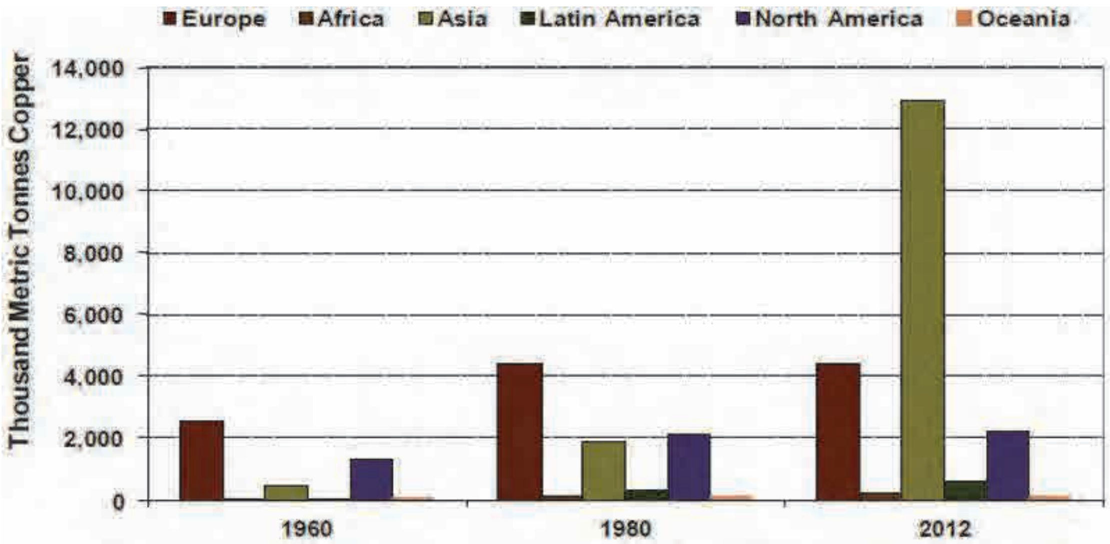
Rank	Refinery	Country	Owner(s)	Process	Capacity
1	Guixi	China	Jiangxi Copper Corp	Electrolytic	900
2	Jinchuan	China	Jiunchuan Non Ferrous Co.	Electrolytic	650
3	Chuquicamata	Chile	Codelco	Electrolytic	600
4	Yunan Copper	China	Yunnan Copper Industry	Electrolytic	500
4	Birda	India	Birda Group Hidalco	Electrolytic	500
6	Toyo/Niihama	Japan	Sumitomo Metal Mining	Electrolytic	450
6	Amarillo	USA	Group Mexico	Electrolytic	450
8	Codelco Norte(SX-EW)	Chile	Codelco	SX-EW	440
9	Pyshma	Russia	Uralelectromed	Electrolytic	420
10	El Paso	USA	Freeport-McMoRan	Electrolytic	415
11	Las Ventanas	Chile	Codelco	Electrolytic	400
11	Jinlong	China	Tonglin NonFerrous, Sumitomo etc	Electrolytic	400
11	Sterlite	India	Vedanta	Electrolytic	400
11	Daye/Hubei	China	Daye Non-Ferrous Metal	Electrolytic	400
11	Xiangguang Copper	China	Yanggu Xiangguang Copper Corp	Electrolytic	400
16	Hamburg	Germany	Aurubis	Electrolytic	395
17	CCR refinery	Canada	GlencoreXstrata	Electrolytic	370
18	Ilo Copper	Peru	Southern Copper Corp	Electrolytic	360
18	Onsan Ⅰ	South Korea	LS-Nikko Co	Electrolytic	360
20	Morenci(SX-EW)	USA	Freeport-McMoRan/Simitomo	SX-EW	350

(Source: ICGS Directory of Copper Mines and Plants, Feb 2013)

(2) Target Market for Sales of the Products

A remarkable growth rate of the copper consumption lies in Europe and Asia for the 20 years from 1960 to 1980 (Figure 7.2.1). Japan, which attained the considerable economic growth during the same period, significantly contributed to the increase of copper consumption in Asia. It is only in Asia that the copper consumption increased during the three decades from 1980 to 2012, and only China greatly contributed to the growth rate for the period. It is also apparent from the statistics for the past decade that China achieved the overwhelming growth rate and volume of copper consumption.

From the above statistic data, China can be a top priority as a potential major market for sales of the smelter products in Mongolia. The Chinese market is attractive and most advantageous to Mongolia in terms of availability of infrastructures including railways and roads and transportation costs. However, it may be a little risky to trade with only one country, which is the second largest size of economy in the world. It is safe and secure to export a certain proportion of the products to other countries than China; Korea, Japan, India, and the Southeast Asia including Vietnam and Thailand. It will be a tough challenge to develop the existing matured market in Japan and Korea, but still there is a chance to sell them because they have a number of downstream industries that use copper. India and the Southeast Asian region will become the most potential target other than China due to the economic growth rate in these years sustained by the large population in the region. It is essential to diversify the marketing targets other than China, regardless of a disadvantage in transportation costs.



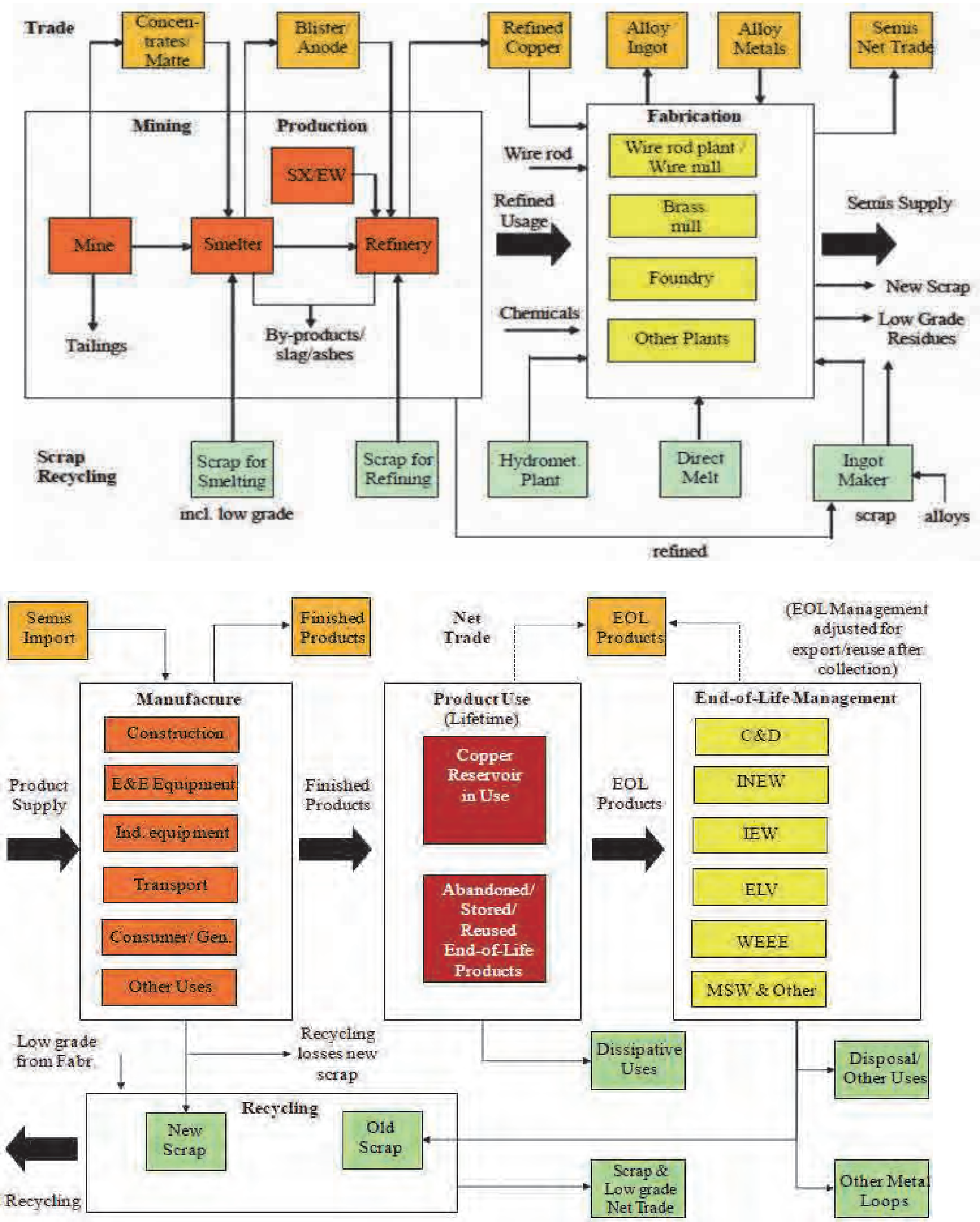
(Source: International Copper Study Group "The World Copper Factbook 2013")

Figure 7.2.1 Refined Copper Usage by Region, 1960, 1980 and 2012

(3) Understanding of Copper Business and Security of the Marketing Channel

Copper produced in the smelter is fabricated into the primary and secondary products in the downstream manufactures, followed by extensive final applications to building/housing construction, electric and electronic equipment, industrial machinery, railways, and motor vehicle. As a result, the quality of copper cathode as raw materials of the finished products for the downstream industries weighs heavily in particular among the electronic customers. As such it is important for the seller of copper and copper semis products to understand the entire supply chain to the final uses, especially if advancing to the downstream fabrication (Figure 7.2.2).

Consumption of copper quickly responds to the global economic trends because of the close link to a variety of industries. Thus, security of such a level of the sales volume towards the stable customers is essential even in the economically depressed situations that allow the smelting company to sustain the copper business by minimizing the impacts of uncontrollable external factors as least as possible. Copper trading based on the agreements or concord with the bigger major smelting firms may be one of the options for a small-scale newcomer in the business.



(Source: International Copper Study Group "The World Copper Factbook 2013")

Figure 7.2.2 Copper Flow from Mines to Final Users

It is challenging to develop the copper business under the Japanese major smelting companies or trading giants including Mitsubishi or Mitsui Corporations. They have continued the non-ferrous metal business through their own supply chains across the countries almost closed within the individual groups. It is more difficult for an independent smelting company to establish its own supply chain against those global players, which requires much more time and efforts in addition to the better product quality. Thus the copper business will be tough unlike gold that can be rather easily sold at the global markets. It is necessary and appropriate for a newcomer to learn in advance the mechanism and structure of the copper business.

(4) Preparation of Infrastructures

(a) Security and Preparation of the Transportation Route

A connection with railways or roads is required to transport the products to customers. The port facility for cargo loading should be taken into account if the products are exported to other markets than China.

(b) Power and Fuel

As already discussed in section 5-3-1, for example a smelter with a production capacity of 200 Kt/year copper needs power capacity and electricity consumptions as follows. Smelters use much more electricity than refining, and differ in the consumption rates by smelting methods.

- Power facility capacity: 72 - 100 MW
- Annual electricity consumption: 442,000 - 610,000 MWh

In addition to the above electricity required energy consumption from fossil fuel for smelting is equivalent to 12,000 to 34,000 t of thermal coal using a calorific value of 25MJ/kg of standard thermal coal. There is no concern about the supply of the thermal coal used for power generation and smelting in Mongolia.

(c) Industrial Water

A massive amount of water is used for rapid cooling and granulating the molten slag, separated from copper containing matte during the smelting process. An average water volume, excluding potable water, used for the seaside-located copper smelter in Japan that has a production capacity 200 K t/year is given below.

- Seawater: 300,000 t/day
- Fresh industrial water: 28,000 t/day

Seawater pumped up is all returned to the sea after used for slag cooling and granulation. It will be possible to some extent for the inland smelter to recycle fresh industrial water used for these purposes via a storage pond. The storage pond will help reduce the water intake rate from the streams or underground reservoir. A significant volume of evaporation and underground penetration of water is anticipated in an arid region like Mongolia especially in the summer season.

Metrological data collection and analysis on the historical and ongoing measurements including precipitation and evaporation are definitely required to assess the water balance in the selected region.

(5) Environmental Response

(a) Waste Water Treatment

Waste water generated from a copper smelter is sourced chiefly from effluents of gas-cleaning and slag granulation in the smelting process and those of the electrolytic circuit. Gas-cleaning could bring about arsenic and mercury dissolved from the copper concentrates into waste water, and these hazardous substances must be treated properly below the control levels before draining into rivers. Waste water recycled for slag granulation could result in a pH decrease. The repeatedly recycled water needs to be replaced with fresh industrial water and be neutralized at the treatment facility before draining.

(b) Slag

Molten slag is recovered as granulated coarse sandy substances generated by rapid cooling in the granulation circuit. Slag contains copper and other minor metal constituents in concentrates in addition to a significant amount of iron. They are all insoluble even in the wet conditions as they are physically confined in the vitrified grits due to rapid cooling down in the water. However, it has to be appropriately managed by selling as materials for road and building construction and blasting medium for removing rust and paint, as it is generated in a quantity as three times large as copper cathode.

(c) Flue Dust

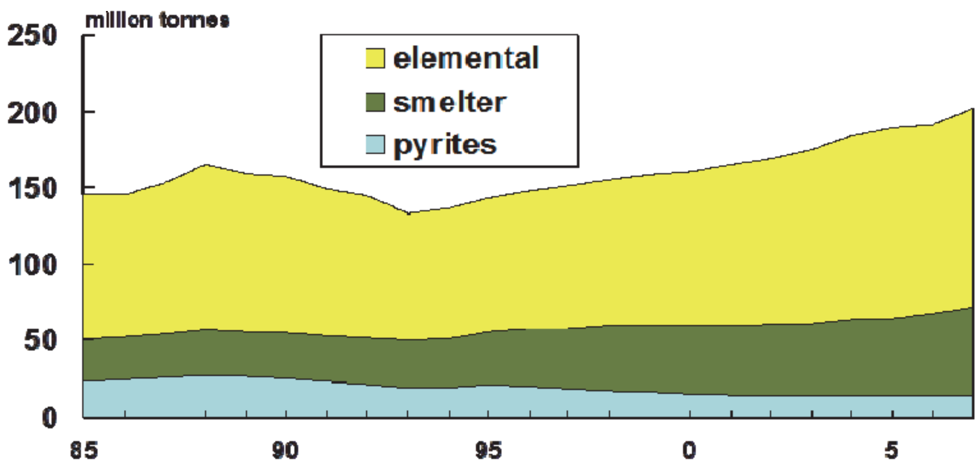
Flue dusts, which are generated in the converter circuit to enhance copper grade in the matte, are recovered into the dust collectors, preventing diffusion into the air. They contain a significant amount of valuable metals, including copper, lead, zinc and bismuth. During the process stage to recover those metals in the same circuit, some of them are gradually concentrated in the process circuits to such a level that may deteriorate the quality of products. Recently hydrometallurgical treatments of the flue dusts have been employed to cope with this issue outside the smelter processing circuits.

7.2.2 Basic Study Items for Sulfuric Acid

Handling of sulfuric acid produced in a copper smelter needs to be studied well in advance, because it is quite different from copper cathode including its market, price settlement system, and physical/chemical natures.

(1) Sulfuric Acid Produced from Copper Smelting

In copper smelters across the world sulfur dioxide used to be released into the atmosphere without being treated when it attracted people's attention as serious environmental issues several decades ago. It was not until late 1960s that all of sulfur dioxide began to be recovered to produce sulfuric acid in copper smelters with tightening of regulations on gas emission from industrial facilities. It was slightly before this timing that sulfur mines operating in Japan to yield elemental sulfur for sulfuric acid production were closed and replaced by plants attached to copper smelters. However, two thirds of sulfuric acid is still produced by burning of elemental sulfur in the world (Figure 7.2.3). The elemental sulfur is mostly generated during the stage of desulfurization process of oil and gas.



(Source: Sulfuric Acid Market by PentaSul (Feb 2008))

Figure 7.2.3 World Acid Supply Trends by Source

(2) Basic Features of Sulfuric Acid

Sulfuric acid produced as a byproduct of copper smelting has unique characteristics as follows.

- The prime objective of sulfuric acid production is to capture sulfur dioxide generated in the smelting circuit with an actual recovery rate as high as 99.3 to 99.4% and to prevent it from being emitted into the atmosphere.
- Production output of sulfuric acid is nearly as three times much as copper cathode. About 580,000 t of sulfuric acid is produced along with copper cathode outputs of 200,000 t/year, given that the concentrates comprise chalcopyrite with 26% of both copper and sulfur and a recovery rate of sulfur dioxide is 99%.

  $$(200{,}000 \div 26\%) \times 25\% \times (98/32) \times 99\% = 583{,}000$$

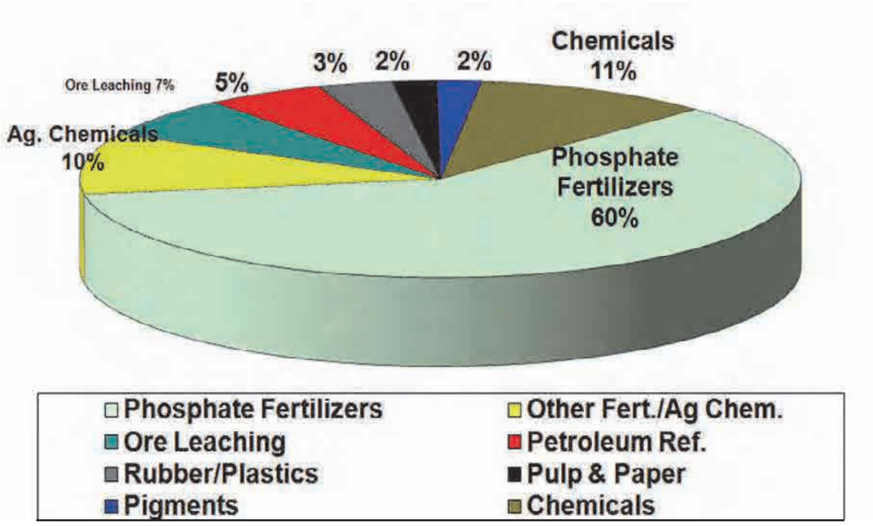
- Sulfuric acid storage tanks are required for exclusive use as it is a poisonous and liquid chemical.
- Sulfuric acid is most intensely used in the fertilizer industry, and its application to acid

solvents for oxidized copper ore has increased recently in Chile, the USA and Peru.

- Sulfuric acid was traded in the low price range around 100 US$ /t in the market in the past decade.
- A change in the market price is so intense that smelters are occasionally compelled to sell the excessive sulfuric acid beyond an onsite storage capacity at the risk of a deficit while it contributes to the revenue of the smelters for some period.

(3) Applications, Demand and Supply of Sulfuric Acid

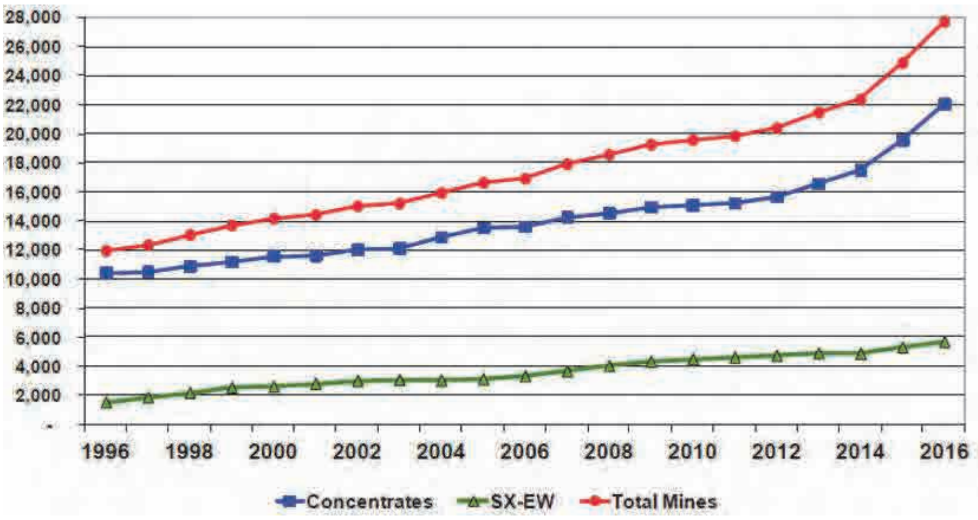
Sulfuric acid is produced 200 Mt annually from sulfur gas of pyrometallurgial smelting, sulfur as byproducts of oil and gas refining, and pyrite concentrates. It is used most intensively for raw materials of phosphate fertilizer, reaching 60% of the products, followed by agricultural chemicals and solvents for oxide ore leaching as shown in Figure 7.2.4. It is expected as a potential market because an annual growth rate of 5 to 6% in the demand is currently anticipated chiefly due to a serious deficiency of food resulting from the surge of the global population in many developing countries (home page of Sumitomo Corporation).



(Source: Sulfuric Acid Market by PentaSul (Feb 2008))

Figure 7.2.4 Sulfuric Acid End Uses

Sulfuric acid consumption as solvents for leaching of oxidized ore recently increased to reach 14 Mt annually. Its application to copper oxide ore is the largest. SX-EW cathode using sulfuric acid accounts for 4 Mt, about 20% of the total cathode production in the world. Chile is the world most intensive user of sulfuric acid for ore leaching, 7.9 Mt of consumption in 2010. About 5.3 Mt of sulfuric acid supplied by Chilean smelters, with the balance of 2.6 Mt imported. To make one ton of copper cathode by SX-EW, 1 to 12 tons of sulfuric acid is necessary depending on the oxide ore grade. An average consumption ranged 2.86 t per ton of copper cathode production in 2004, and rose to 3.65 t in 2010 due to the degradation of oxide ore grade. The total production of SX-EW copper cathode is expected to reach 6 Mt in 2016. This is supposed to consume nearly 20 Mt of sulfuric acid (Figure 7.25).



(Source: ICGS "The World Copper Factbook 2013")

Figure 7.2.5 Historical Trends of Copper Cathode Production

(4) Market Trends of Sulfuric Acid Price

A couple of features are given below a little bit more in detail with regard to the trading of sulfuric acid.

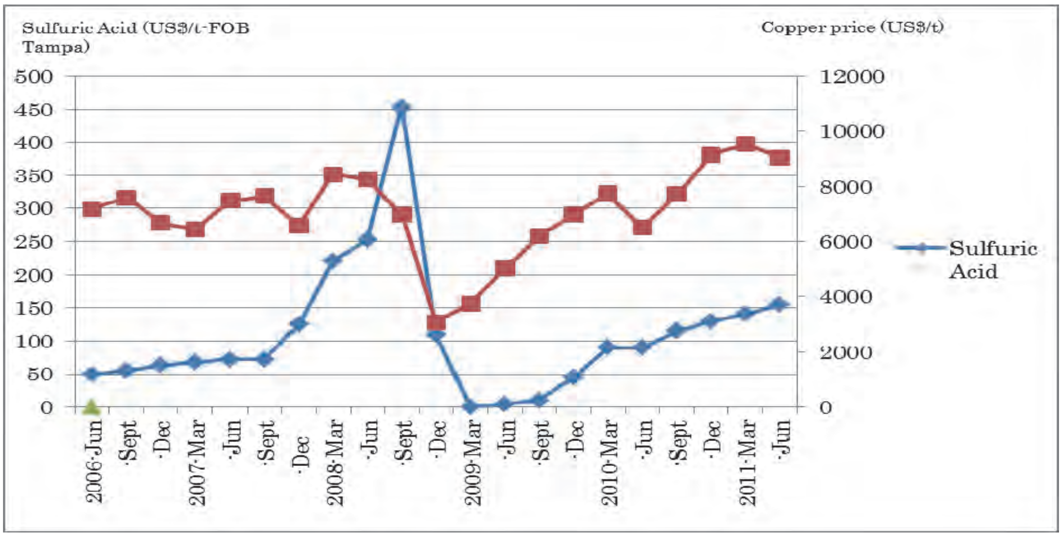
(a) Characteristics on Handling and Storage

Sulfuric acid requires a careful handling for transportation, storage tanks for exclusive use and consequently more costs than solid commodities such as coal and iron ore. Except for the trading giants, it is costwise difficult for the copper smelters to have extra buffer storage tanks, extending timing of sales to wait the price hike through the short to medium term adjustments in the market. It is more cost effective for the smelter in Mongolia to sell sulfuric acid to adjacent China or Russia than to other countries, taking into consideration the costs of ocean freight, ship loading at port facilities and insurance.

(b) Remarkable Price Changes

Sulfuric acid is subject to a hectic price change in spite of a massive amount of production and a wide range of applications including fertilizer, leaching solvents, pulp and paper, pigments, rubber and plastic, supposedly in part due to the above mentioned features. The price change in the coal and iron ore markets, lying at the same range as sulfuric acid in their unit values, seems to be moderate compared to sulfuric acid. Sulfuric acid is susceptible and over responsive even to a slightly unbalanced supply-demand relation. This is supposed to be inevitable for the commodity which has to be traded in the market immediately after produced because of its difficulty as buffer stocks.

This can read from a trend of price changes between sulfuric acid and copper before and after the global financial crisis in late 2008. A quarterly trend on the average import prices of sulfuric acid to Chile are shown against that of copper prices for the same period in Figure 7.2.6. The prices, staying around the range of 50 to 70 US$/t from June 2006 to September 2007, rapidly surged to 450 US$, the historically highest peak immediately before the crisis and then sharply dropped to zero in half a year. Smelters, not having extra storage tanks, cannot help putting the products on the market at the risk of deficits because they had to continue copper production. During the same period Chilean demand for leaching ore was reduced to 6.9 Mt by only 3% from 7.1 Mt in 2008.

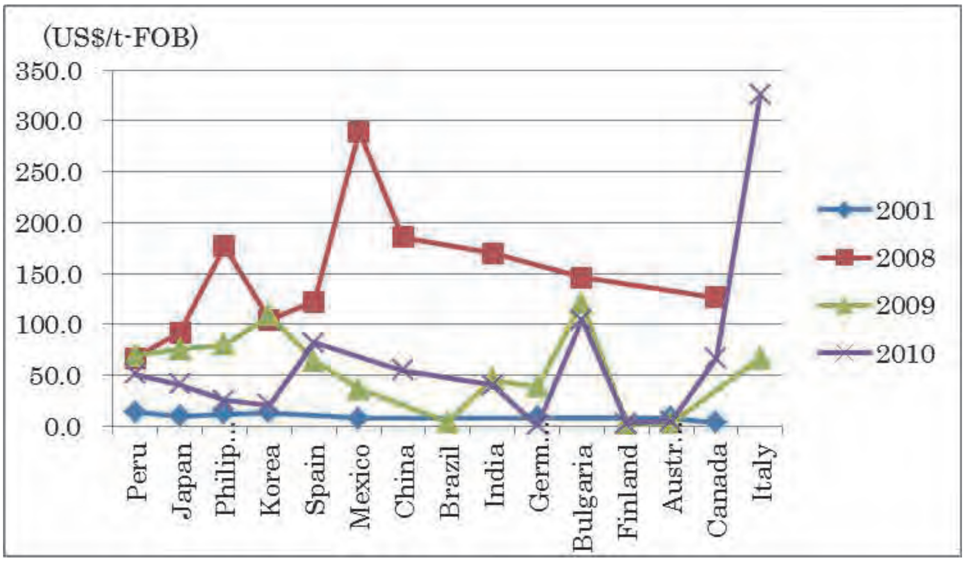


(Source: Sulfuric acid prices quoted from Chilean Copper Commission 05-2011)

Figure 7.2.6 Price Trends of Sulfuric Acid and Copper

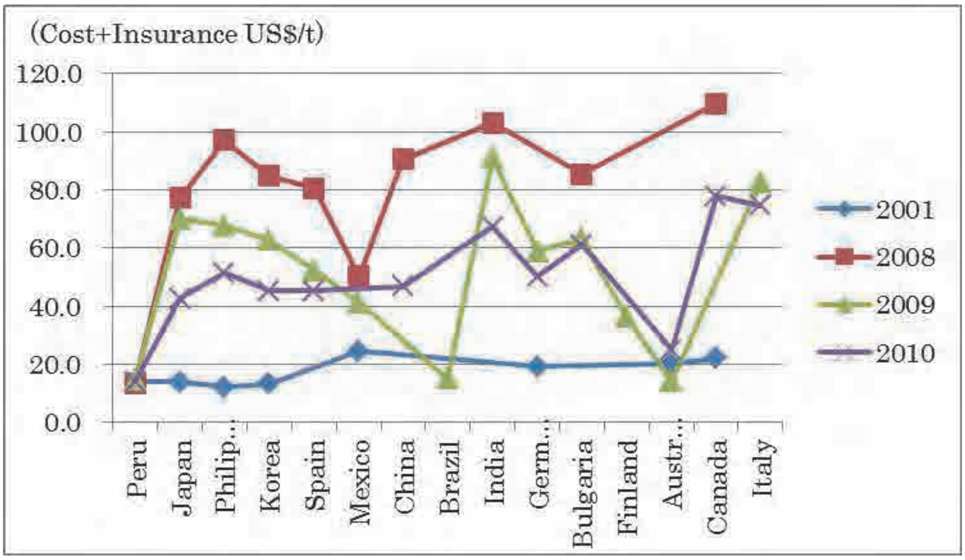
(c) Price Gaps by Region

Price gaps by region are also significantly wider than other commodities. The price gaps by region appeared getting remarkable since 2007, a year before the crisis. The prices demonstrated in the Figure 7.2.6 are the average values of the major products across the world, thus making it difficult to see the gaps among the regions. There seems to be a certain trend in the respective recent prices in the regions. Historical trends for the FOB prices of imported sulfuric acid to Chile from each region are graphed for the periods of 2001 and 2008 to 2010 before and after of the crisis from the statistics available (Figure 7.2.7).



(Source: Sulfuric acid prices quoted from Chilean Copper Commission 05-2011)

Figure 7.2.7 Historical Trends of FOB prices for Imported Sulfuric Acid to Chile from Each Region



(Source: Sulfuric acid prices quoted from Chilean Copper Commission 05-2011)

Figure 7.2.8 Historical Trends of Freight plus Insurance Costs for Imported Sulfuric Acid to Chile from Each Region

The average FOB prices in 2001 ranged at the highest 13.9 US$/t in Peru and the lowest 3.5 US$ in Canada, whereas a price differential rose in 2008 between the highest 289.8 US$ in Mexico and the lowest 49.1 US$ in Sweden. The price gap further widened in 2010 regardless of the price drops to the max 325.4 US$ in Italy and the min 1 US$ in Germany. The reasons for the price gaps are probably a degree of urgency to sell or buy the products in the commercial negotiations and the product quality including contents of impurities. The FOB prices for Peru, Japan and Korea, which are constantly exporting a fairy large amount to Chile every year, remained relatively stable to the other countries in respective periods of comparison.

Historical trends for the ocean freight plus insurance costs associated with imported sulfuric acid to Chile from each region are also graphed for the same periods (Figure 7.2.8). They are not necessarily in proportion to the ocean distance from each region to Chile. CIF prices can be estimated by adding FOB and costs of ocean freight plus insurance. The CIF prices thus calculated and inland freight from the Mongolian smelter to a ship loading port in China or Russia could be used as reference for the preliminary study.

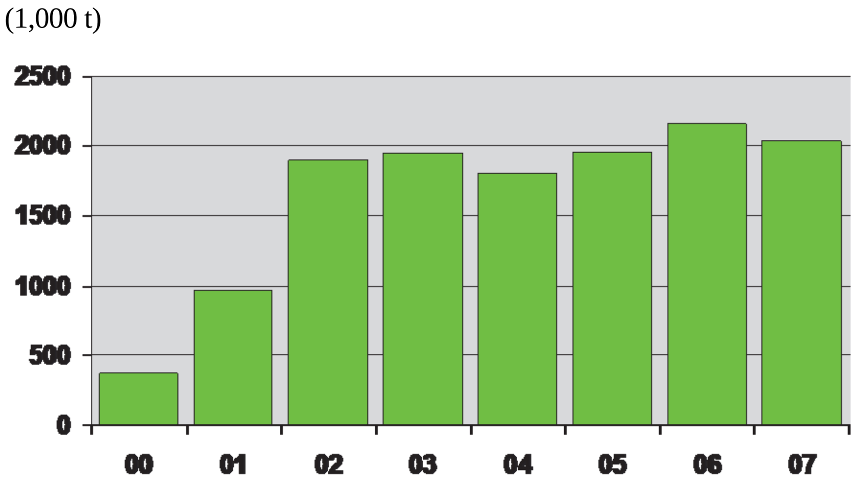
(5) Sales of Sulfuric Acid to Outside Mongolia

Sulfuric acid traded by the marine transportation is extremely small in a quantity at 10 Mt, 5% out of the total world production. Exports to Chile account for 26% out of the traded products by the ocean transportation. Chile studied the possible scenarios on its future demand-supply of sulfuric acid with an expected annual shortfall of 2.5 to 3 Mt through the mid-2010s, then easing to about 1 Mt by the end of 2010s. Thus the chance for sales to Chile is very slim due to the scenario and possibly expensive ocean freights from Mongolia.

Exporting to China and Russia is most cost effective without ocean shipping. However, Russia is exporting sulfuric acid. China exported 210,000 and 111,000 t of sulfuric acid in 2008 and 2010 respectively to Chile. However, China can be a potential target of exports because it is basically an importing country like Chile (Figure 7.29).

Exporting to Korea does not require the marine transportation either, but probably sales to Korea cannot be expected as it is exporting a significant amount to Chile every year (Table 7.2.3).

Chances of trading for the Mongolian smelter will increase if exporting via ocean is economically viable to the countries, such as the Southeast Asian region and the US. The USA relies on the imports of about 2.5 Mt out of 36 Mt of the domestic consumption. However the market study in detail is absolutely necessary on the individual countries.



(Source: Sulfuric Acid Market by PentaSul (Feb 2008))

Figure 7.2.9 Imports of Sulfuric Acid to China

Table 7.2.3 Exports of Sulfuric Acid to Chile

	Amount(t)	CIF price (1,000 US$)	Average Price (US$/t-CIF)	F+I (US$/t)
2004	21,988	1,583.1	72.0	43.5
2005	68,504	5,181.7	75.6	45.4
2006	96,389	6,290.9	65.3	44.6
2007	223,178	23,025.6	103.2	70.0
2008	391,376	73,994.2	189.1	84.7
2009	189,645	32,568.8	171.7	62.7
2010	669,413	44,184.1	66.0	45.2

(Source: extraction from Chilean Copper Commission 05-2011)

7.2.3 Basic Factors on the Economic Viability of Copper Smelter

The management staffs of copper smelter need to understand the mechanism of RC-RC settlement, and the differences of revenue and profit structures between the mine and smelter as well.

(1) Revenue Structure

The price of copper concentrate is usually determined based on the contents of copper and byproducts including gold and or silver if contained, using the mutually agreed purchasing conditions and the then LME official settlement prices. The smelters buy the copper concentrated at the price after subtraction of an agreed TC/RC and off-site expenses including transportation costs from the value thus calculated. The sales value to the smelter, that is revenue to the mine, is called

NSR (Net Smelter Return), and the amount of TC/RC is income to the smelter.

The smelter could penalize for impurities of hazardous elements or substances when contained in the concentrate, as they are obstacles for smelting. The mutually agreed concentrate purchasing conditions include the TC/RC, calculation formula for the definitions of metal contents traded and penalty.

The TC/RC is agreed through negotiations twice a year between the seller and buyer, taking into the LME copper price, demand and supply of copper and potential production capacities of both mines and smelters. The TC/RC will be reduced if the world copper concentrate production is anticipated to increase, and vice versa. Sulfuric acid as a byproduct contributes to the revenue and profit of the smelter when the demand is larger than the supply, and occasionally vice versa upon occurrence of the excessive supply. Earnings before taxes can be calculated by subtracting the expenses including on-site operating costs, royalty, depreciation, amortization, and financial costs from the revenue consisting of TC/RC.

A thorough feasibility study (FS) is required to make an appropriate assessment of economic viability of the smelter, taking into account the various conditions peculiar to Mongolia discussed so far. A phased approach is recommendable that a preliminary FS should be conducted initially as it does not relatively require so much time and expenses and then the FS and or the bankable FS be done if the result of the preliminary FS turns out favorable.

(2) An Example of Profitability for the Mine and Smelter

The smelter revenue has been estimated taking up Oyu Tolgoi mine as a model that started production early 2013 in Mongolia. The basic data is sourced from the year 2 operating parameters and costs in the technical report of Turquoise Hill Resources which holds 66% interests in the mine as shown in Table 7.2.4. Other conditions than listed in the table are as follows.

- TC/RC: 92 US$/conc-t for TC and 9.2 USc/lb-copper as agreed for the 2014 contract term between Freeport-McMoran and Jiangxi Copper in China.
- Unit deduction of copper: copper concentrate grade 1%.
- Smelting charge for gold and silver: 1 g/t per ton equivalent for gold and 30 g/t for silver in concentrates.
- Sulfuric acid price: 70 US$/t (CFR)
- Copper price: 3.2 US$/lb
- On-site costs: 13 US$/t-ore modified from the original costs in the report because the mine will get into the red if the reported costs are used.
- Off-site costs: 2.3 US$/t-concentrate for transportation and 2.0 US$/t-concentrate for other

costs.

- Royalty: 5% of the copper concentrate value prior to deduction of TC/RC

Table 7.2.4 Production of Oyu Tolgoi for Year 2

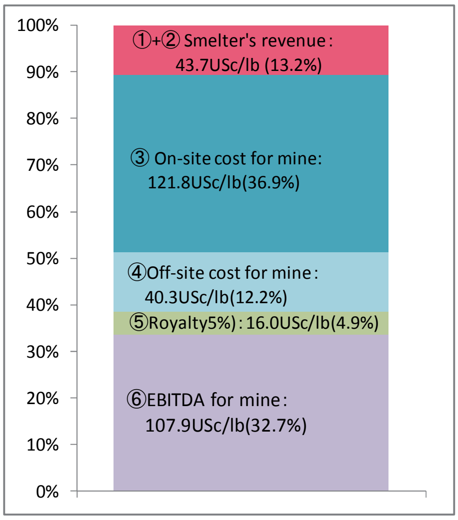
Prodcution Plan Y2	Grade	Weight
Waste tonnage		59,000,000 t
Ore tonnage		51,000,000 t
Cu(%)	0.55%	
Au (g/t)	0.59 g/t	
Ag (g/t)	1.43 g/t	
Cu conc tonnage		669,000 t
Cu in conc	25.5%	376 Mlb
Au in oonc	23.9 g/t	515,000 oz
Ag in conc	61.6 g/t	1,324,000 oz

(Source: Turquoise Hill Resources, Oyu Tolgoi Technical Report (2013))

The estimate result is illustrated as in Figure 7.2.10. Earnings for the mine before interest, taxes, depreciation and amortization, or EBITDA as a measure of an operating efficiency occupies 32.7% out of the copper price, while the smelter revenue is only 13.2%. In other word the smelter has to squeeze some profits from the revenue equivalent to 13.2% of the contained total copper tonnage in the concentrate multiplied by copper price after bearing on-site and depreciation, amortization, financial and other costs. The result implies that the smelting business is not so profitable although it is necessary for further accurate evaluation to make an economical assessment with a FS level.

Possible reasons why the copper smelters can still survive in Japan are as follows.

- Persistent efforts to reduce costs by power saving and automation
- Treatment of scrap metals
- Recovery of precious metals from copper electrolytic slime by wet processing method
- Treatment of industrial wastes on an inverse onerous contract basis



(USc/lb-Cu)

① TC-RC	**34.0**
② Credit of sufuric acid	**9.7**
③ On-site costs for mine(13US$/t-ore)	**121.8**
④ Off-site cost for mine(transportation & other costs)	**40.3**
⑤ Royalty : 5% of Gross Sales Value	**16.0**
⑥ EBITDA for mine (320-(①+③+④+⑤))	**107.9**
Total (Copper+sulfuric acid)	**329.7**
① TC/RC breakdowns	
Cu-TC: 92US$/DMT Cu-conc	92.0
Cu-RC: (25.5-1)% × 2204.62 × 9.2USc/lb/100	49.7
Au: (23.9-1)g/DMT ÷ 31.1035 × 10US$/oz	7.4
Ag: (61.6-30)g/DMT ÷ 31.1035 × 0.5US$/oz	0.5
Free Metal (US$/conc-DMT)	34.6
Cu: 25.5% × (98.0%-(25.5-1.0)/25.5) × 3.2 × 2204.62	
TC-RC Total (US$/conc-DMT)	184.1
② H2SO4 credit: S25%、S-rec 98% (US$/conc-DMT)	52.5
25% × (98/32) × 98% × 70US$/t	
③ Transportation: 2.3 US$/t-ore (USc/lb)	21.6
Other off-site costs: 2 US$/t-ore (US/lb)	18.7

(Source: Turquoise Hill Resources, Oyu Tolgoi Technical Report (2013))

Figure 7.2.10 Revenue and Profit Structure of the Mine and Smelter

(3) Procedures of the Preliminary Feasibility Study (FS)

The work of FS level is necessary to assess an economic viability of the smelter construction project. Procedures to be reviewed in the preliminary FS are as follows.

- Site selection of the smelter
- Review on the utility including power and industrial water
- Review on the basic infrastructures for transportation to the foreign territory outside Mongolia
- Study on the target countries for sales of copper and determination of the production scale
- Review and selection of the smelting method
- Estimate of mass balance on the entire processes from concentrate feed to the final products including cathode and sulfuric acid
- Comprehensive study of design, engineering and instrumentation on the entire process circuits and resultant cost estimates for the equipment, materials and manpower for construction
- Study on financing for the construction (equity, loan and its interest)
- Cost estimates for the operation (personnel, spare parts and expendables)
- Determination of revenue, operating expenses, financial costs, tax, royalty, TC/RC and financial analysis based on the cash flow model

7.2.4 Future Business Development

The study of the future downstream business development in view of the long term 20 to 30 years ahead is required for the smelter in Mongolia where no downstream industries of copper has been raised. Historical changes and the current situations of the copper smelters in Japan and the US are described as typical cases in the developed country. The copper smelters in Bulgaria and Oman are also taken up as cases in the countries which are similar to Mongolia in size of the population and economy. They could provide some suggestions when reviewing the future domestic copper business deployment in Mongolia and in the Southeast Asian region because it is closely associated with the global economic trends as international commodity and with the country's industrialization level as fabricated products.

(1) Historical Development of Copper Smelters in Japan and the US

(a) Case of the US

In the US the top three giants including Anaconda, Phelps Dodge and Kennecott were at their peaks in the 1920s by developing business from mines and smelter to downstream copper semi/ fabricated products. However business structures began to change in those companies in the 1990s. Copper mines/smelters and downstream fabrication businesses were each separately amalgamated to horizontally integrated groups from the vertical integration. In such a situation copper semi and fabrication industries were consolidated through merger and acquisition into major groups including GBC, Mueller, PMX, Wolverine (Netherlands), Kuvata (Austria), Kobelco (Japan), towards the oligopolization in the market, while Anaconda, Phelps Dodge and Kennecott which remained as mine and smelting industries were merged by other mining companies. The enhancement of nation's awareness of the environment and shifting of industrial structures from smokestack to IT and finance sectors are considered as the main background factors that pushed up these shifts. The shift of industrial structure in the US was paralleled by heading for a decline of once prosperous copper mining and smelting industry.

In the US there are still operating copper smelters or SX-EW plants that are attached to inland located copper mines. SX-EW copper cathodes are produced mostly in the oxide copper mines in Arizona and New Mexico, with annual production ranges 10,000 to 50,000 t each. Some smelters which processed copper concentrates have been shut down in the decades, and there are only three matte smelters and two refineries currently operating in the US (Table 7.2.5). A total of 1.1 to 1.2 million tones of cathodes is produced in the country from the refineries including the SX-EW facilities. This is quite small in quantity, only one quarter of Japan in a proportion of products to the population.

Table 7.2.5 Currently Operating Copper Matte Smelters and Refineries in the US

Smelter/Rifinery	Owner	Production	Concentrates/anodes supply
Hayden Smelter (Arizona)	ASARCO	anodes 300, 000 t/y	Ray Copper Mine
Miami Smelter (Arizona)	Freeport McMoran	anodes 200,000 t/y	Miam Copper Mine
Utah Copper Smelter (Utah)	Kennecot	anodes 300,000 t/y	Bingham Mine
Amarillo Refinery (Texas)	ASARCO	cathodes 450,000 t/y	Hayden and others
El Paso Refinery (Texas)	Freeport McMoran	cathodes 415,000 t/y	Miami and others

(Source: Prepared by Survey Team)

(b) Case of Japan

In Japan the top five companies including Mitsubishi, Sumitomo, Dowa, Nippon Mining and Furukawa were operating the copper mines and attached smelters around the turn of the century 1890s to early 1900s, contributing to the modernization and industrialization of Japan soon after the Meiji Restoration.

In 1971 the currency exchange control policy was drastically changed to the floating rate system from the fixed rate by so called the Nixon Shock, including unilateral cancel of the direct convertibility of the US dollar to gold, which triggered the collapse of the Bretton Woods system of international financial exchange. This was accompanied by yen appreciation that threw the domestic mines into the difficult situations in addition to exhausted ore reserves, eventually followed by their shutdowns (Table 7.2.6). Some of attached copper smelters to the mines located deep inland were also closed. The copper industries in Japan advanced to find their ways in the secondary to tertiary copper semi/alloy and fabrication sectors.

Table 7.2.6 Domestic Major Copper Mines and Attached Smelters in Japan

Smelter	Owner	Mine shutdown	Attached smelter
Osarizawa	Mitsubishi	1978	shutdown in 1966
Kosaka	Dowa	1990	in operation for metal recyle and scrap
Hitachi	JX Nikko Metal	1981	shutdown in 1976
			Electrolytic refinery continues to operate
Ashio	Furukawa	1973	shutdown in 1989
Besshi	Sumitomo	1973	shutdown in 1976 to be relocated

(Source: Prepared by Survey Team)

However, two inland copper smelters survived (Table 7.2.6). At Hitachi the matte smelter was closed but only the electrolytic refinery has been processing anode copper transported from the seaside located Saganoseki smelter. At Kosaka the copper smelter, which used to handle the complex Kuroko ore from a number of mines in the region already shutdown, still keeps processing scrap metals and waste electronic substrates/parts. It is a model copper smelter exclusively used as recycles in the economically matured developed country.

Since 1980s the seaside located copper smelters in Japan have all relied upon the concentrates purchased from overseas mines, and simultaneously began to put money into overseas copper mine projects more aggressively than ever in order to make a concentrate purchase negotiation advantageous and to secure the stable concentrate supply in long term contracts. Furthermore, they advanced to the overseas smelter projects (Table 7.2.7). Copper smelters in China and Korea were constructed and operated through the technology transfer from the Japanese smelters. The smelting technology was also provided to the projects in India and Canada on a licensing basis other than as investors.

Table 7.2.7 Overseas Copper Smelters Projects by Japanese Smelting Companies

Smelter/Country	Company	Operation started	Cuurent situation
Pasar/Philippines	Mitsui	1983	Sold, cathode 215,000 t/y
Jinlon/Sumitomo	Sumitomo	1995	Holding minor equity, cathode 400,000 t/y
Onsan/South Korea	Pan Pacific Copper	1979	Holding minor equity, cathode 360,000 t/y
Port Kembla/Australia	Furukawa	acquired in 1996	Shutdown in 2003 and demolished in 2010
Gresic/Indonesia	Mitsubishi	1999	Operator and majority share holder
			cathode 200,000 t/y

(Source: Prepared by Survey Team)

In late 1980s to 1990s the copper smelters in Japan were forced to face an uphill battle against further yen revaluation to the US dollar. Despite of these difficult situations, the copper smelters in Japan could survive to continue operations supported by the factors given below.

- Dividends from invested overseas copper mines.
- Processing of scrap metals, waste electronic substrates/parts, electrolytic slime rich in precious metals and industrial wastes.
- Persistent business deployment within the supply chain towards the secondary and tertiary copper semi/alloy and fabrication sectors.

(2) The copper smelters in Bulgaria and Oman

Two examples of the copper smelters operating in the countries that have a similar size of the population and economy to Mongolia are provided as follows.

One is the Pirdop smelter in Bulgaria (Table 7.2.8). It started as the government owned copper smelter under the socialist system, and was acquired by Aurubis of Germany in 1997 after Bulgaria changed its regime to capitalistic economy. Since then Aurubis expanded an annual production rate gradually from 160,000 t/year up to the current 330,000 t/year. Aurubis' business covers from smelting to the downstream copper semi and fabrication. It supposedly acquired Pirdop for raw material procurement to be used for the downstream secondary and tertiary fabrication. The concentrates for Pirdop was supplied from domestic mines before acquisition, however currently a significant portion of them is supposed to be purchased from outside the country. The Pirdop smelter lies inland 50km east of Sophia, the capital of the country, and 300 km to the Adriatic Sea.

The copper smelter's capacity operated by the state owned OMCO in Oman is small in its scale of production at 20,000 t/year (Table 7.2.8). The smelter was constructed in 1983 together with the development of copper mines as a part of the government's diversification policy in an effort to find ways out of the economy heavily reliant on oil resources. The smelter continued production on a toll basis, purchasing concentrates from domestic mines of the private company after the state owned mines were closed in 1994 due to the depletion of ore resources. The smelter located near the coast is exporting copper cathodes outside Oman to neighboring Gulf countries, India, Southeast Asian countries, China, Taiwan and so on. It is questionable why the smelter is able to keep production on such a small scale and in such a rather wealthy country that has a per capita GDP over triple as large as Bulgaria. However, the details are not known due to the insufficient information.

Table 7.2.8 Outlines of the Copper Smelters in Bulgaria and Oman

	Pirdop (Bulgaria)	OMCO (Oman)
Smelter Capacity	cathode 330,000 t/y	cathode 20,000 t/y
Concentrates Supply	Domestic and Toll	Toll
Start of Production	1958	1983
Owner / Operator	German Corp / Bulgarian	National Corp / Omani
Downstream Deploy	To EU market	−
Population (million)	7.5	2.6
GDP/per capita , 2012	53 bUS$/ 7,049 US$	76 bUS$/ 24,700 US$
Remarks	Originally owned by National Corp. and sold to Aurubis, German at 80 MUS$ in 1997.	OMCO Cu Mines closed in 1994, and the smelter continues to operate at toll basis.

(Source: Prepared by Survey Team)

(3) Business Development Direction for a Copper Smelter in Mongolia

The countries which have domestic copper smelters could be characterized and grouped into the several types in terms of the copper business development as follows.

- Chilean type: most smelters as attached facilities to the mines are inland located but not distant from the ports, which enabled the products to be exported outside the country.
- Japanese type: most smelters were constructed on the seaside to exclusively treat concentrates imported and waste electronic substrates/parts and electrolytic slime rich in precious metals as well as scrap metals, and sell products to downstream copper semi/alloy fabrication industries of the vertical supply chains mostly within the affiliated groups.

German smelters are also of the similar type.

- The US type: All the US smelters that had once been in the golden age through the vertical development to downstream fabrication industries declined gradually after having been split into mine/smelter sectors and fabrication sectors by merger and acquisition, and are currently in a low profile position as industry with only one quarter of Japan in a proportion of product to the population.
- Chinese type: most smelters, both of which initially started operation as attached facilities to the copper mines and newly constructed, have successively increased their production capacities in the decade mostly for concentrates purchased from outside China, and are in the midst of developing downstream semi/alloy industries.
- Bulgarian type: the smelter that has been in operation for a long period was shored up both in its production scale and product trading to further deploy its sphere of copper business to downstream sectors within the supply chain under the German smelting major firm.
- Oman type: the state owned small scale smelter that was constructed 30 years ago as attached facility to copper mines of the same company continues production, purchasing concentrates on a toll basis even after the shutdowns of state owned copper mines.

The geographical locations, historical backgrounds and current situations of the smelters in the above listed respective countries will be of great help when making an overall assessment and studying the directions of business development for the Mongolian smelter to pursue in the future. Of course none of the above listed countries are in the same conditions as Mongolia, and characteristics peculiar to it should be taken into account. To clearly understand an aptitude of the construction of copper smelter with those basic conditions simplified, the above listed six countries have been evaluated for their abundance of domestic copper resources, technological levels of smelting, and chances of downstream development and exports, and Mongolia has also been assessed with the same criteria (Table 7.2.9).

Table 7.2.9 Aptitude for Copper Smelters in the Six Countries Referred to and Mongolia

Type	Cu Resource	Smelter Technology	Downstream Deployment	Copper Export
Chile	◎	○	×～△	◎
Japan	×	◎	◎	○
US	○	○～◎	◎	×
China	○	○～◎	○	×
Burugaria	△	○～◎	◎	○
Oman	△	△	×	○
Mongolia	○～◎	×	×	○

notes) ◎: Excellent, ○: Good, △: Poor, ×: None

(Source: Prepared by Survey Team)

An overall assessment on Mongolia has been rated poor as it reads from the table, except for copper resources. The reason why it has been assessed good for copper exports is neighboring China. Nevertheless Bulgaria will be a suitable type for Mongolia to aim at if giving one. Namely Mongolia should seek for the joint venture partner that is able to provide not only smelting technology but hopefully financial supports to build the smelter. Some of copper cathodes should be fabricated to such an extent in the production facilities in Mongolian that can be traded in the markets through the sales routes of the partner. This is a sort of export type of business development based on the smelter and fabrication bases within Mongolia for the medium to long term. The most suitable partner for the business development will be a Chinese smelting company.

(3) Business Development Direction for a Copper Smelter in Mongolia

The countries which have domestic copper smelters could be characterized and grouped into the several types in terms of the copper business development as follows.

- Chilean type: most smelters as attached facilities to the mines are inland located but not distant from the ports, which enabled the products to be exported outside the country.
- Japanese type: most smelters were constructed on the seaside to exclusively treat concentrates imported and precious metals as well as scrap metals, and sell products to downstream copper semi/alloy fabrication industries of the vertical supply chains mostly within the affiliated groups. German smelters are also of the similar type.
- The US type: All the US smelters that had once been in the golden age by developing vertically to downstream fabrication industries declined gradually after having been split into mine/smelter sectors and fabrication sectors through merger and acquisition, and are currently in a low profile position as industry with only one quarter of Japan in a proportion of product to the population.
- Chinese type: most smelters, both of which initially started operation as attached facilities to the copper mines and newly constructed, have successively increased their production capacities in the decade mostly for concentrates purchased from outside China, and are in the midst of developing downstream semi/alloy industries.
- Bulgarian type: the smelter that has been in operation for a long period was shored up both in its production scale and product trading to further deploy its sphere of copper business to downstream sectors within the supply chain under the German smelting major.
- Oman type: the state owned small scale smelter that was constructed 30 years ago as attached facility to copper mines of the same company continues production, purchasing concentrates on a toll basis even after the shutdowns of state owned copper mines.

The geographical locations, historical backgrounds and current situations of the smelters in the above listed respective countries will be of great help when making an overall assessment and studying the directions of business development for the Mongolian smelter to pursue. Of course none of the above listed countries are in the same conditions as Mongolia, and characteristics peculiar to it should be taken into account. To more clearly understand an aptitude of the construction of copper smelter with those basic conditions simplified, the above listed six countries have been evaluated for their abundance of domestic copper resources, technological levels of smelting, and chances of downstream development and exports, and Mongolia has also been assessed with the same criteria (Table 7.2.9).

An overall assessment for Mongolia has been rated poor as it reads from the table, except for copper resources. The reason why it has been assessed good for copper exports is neighboring China. Nevertheless Bulgaria will be a suitable type for Mongolia to aim at if giving one. Namely Mongolia should seek for the joint venture partner that is able to provide not only smelting technology but hopefully financial supports to build the smelter. Some of copper cathodes should be fabricated to such an extent in the production facilities in Mongolian that can be traded in the markets through the sales routes of the partner. This is a sort of export type of business development based on the smelter and fabrication bases within Mongolia for the medium to long term. The most suitable partner for the business development will be a Chinese smelting company.

Table 7.2.1 Aptitude for Copper Smelters in the Six Countries Referred to and Mongolia

Type	Cu Resource	Smelter Technology	Downstream Deployment	Copper Export
Chile	◎	○	×～△	◎
Japan	×	◎	◎	○
US	○	○～◎	◎	×
China	○	○～◎	○	×
Burugaria	△	○～◎	◎	○
Oman	△	△	×	○
Mongolia	○～◎	×	×	○

notes) ◎: Excellent, ○: Good, △: Poor, ×: None

(Source: Prepared by Survey Team)

7.3 Copper Production Process Suitable for Mongolia

In case of investigating and determining the construction of copper smelter upon the conditions for construction were satisfied, the matter to be discussed first is whether the hydrometallurgical process or the pyrometallurgical process should be selected. Respective features of these processes are shown Table 7.3.1.

Table 7.3.1 Features of Hydrometallurgical Process and Pyrometallurgical Process

	Hydro-metallurgical process (SX-EW)	Pyro-metallurgical process
feature	small scale plant oxide ore	large scale plant sulfide ore
merit	low operation cost operator is existed small water consumption	high purity Copper is obtained high recovery of precious metals
de-merit	small ore treatment waste water treatment	large operation cost large water consumption waste water and waste gas treatment

(Source: Prepared by Survey Team)

The bases of selection on smelting and refining methods are as described in the following:

1) Hydrometallurgical process which is able to produce copper from sulfide ores has not reached to the level of commercial operation. However, since Mongolia has the experience in operation of SX-EW for processing oxide ores and since the processing of sulfide ores by hydrometallurgical process might be possible for practical use in the near future (after 5 ~ 10 years), it would be a better way to reconsider on the copper smelting after a sufficient accumulation of experience in practical operation from oxide ores and after confirmation of commercial operation of hydrometallurgical process from sulfide ore. However, from the Erdmin observation, improvement of process is necessary.
2) From climatic conditions in Mongolia, it is esteemed that vegetation is poor and week. Under these conditions, leakage and dispersion to atmosphere of sulfur dioxide gas are deemed to provide a large impact to vegetation. In case of selecting a pyrometallurgical process, PS converter should not be selected since it has a large amount of gas leakage and has poor gas collection efficiency as well. From the view point of restricting exhaust gas leakage, the following two processes would be recommendable:
    (a) Mitsubishi Process (MI furnace)
    (b) Flash smelter + Flash converting (FC) Process
3) The maximum use of sulfuric acid is for producing fertilizer. Since there is the People's Republic of China, who is the biggest consumer of sulfuric acid in the World, existing at adjacent to Mongolia, it would be proposed to construct fertilizer plant(s) cooperating with Chinese enterprise(s).

Chapter 8. Transport Infrastructure

This chapter covers four categories, namely i) Transportation amounts at three main mines on current status and future estimation, ii) Ways of transportation such as roads, road and airway, iii) Electric power supply and iv) Other information regarding the transport infrastructure. Since the copper infrastructure should be related closely related with coal infrastructure, new information on this study would be added on the "JICA, 2013: Master Plan Study for Coal Developed and Utilization", in order to obtain maximum effectiveness and efficiency.

8.1 Transportation Amounts at Three Main Mines on Current Status and Future Estimation

Transportation amounts at three main mines in Mongolia, Erdenet copper mine, Oyu Tolgoi mine and Tsagaan Suvarga deposit were investigated on current status and future estimation.

8.1.1 Current Status

Transport amounts at three main mines on current status are shown in Table Table 8.1.1. According to this table, total annual amount of these mines reaches to 100 M ton on the copper concentrates.

Table 8.1.1 Transport Amounts at Three Main Mines on the Copper Concentrates, 2012

Name of mine	Daily	Monthly	Annually
Erdenet	1,610 t	48,300 t	580,000 t
Oyu Tolgoi	220 t	6.600 t	80,000 t
Tsagaan Suvarga	—	—	—

(Source: Prepared by JICA study team based on MRT data)

Concentrates produced by Erdenet mine are exported by a railway to China via Ulaanbaatar, Sainshand and Zamyn-Uud gate. As transportation capacity is 64 tons per a railroad car, 63 cars are necessary for dairy transportation. Concentrates produced by Oyu Tolgoi mine are exported by a road to China via Gashuunsuhayt gate.

Concentrates produced by Tsagaan Suvarga deposits will be exported by a railway to China via Sainshand. If the railway between Tsagaan Suvarga and Sainshand will not be completed in these three years, road is only the way to transport them. This railway construction has an impact to the moment of mine opening.

8.1.2 Future Estimation

The transport amounts of concentrates at three mines mention above are summarized in Table 8.1.2.

According to this table, transport amounts will reach to 1,764,000 t/year in 2016, 2,314,000 t/year in 2020 and 2,691,000 t/year in 2030. In particular, accumulation total shows that transport amounts by Oyu Tolgoi mine and Tsagaan Suvarga deposit reach almost 80 % to the overall of accumulation total. This implies that southern railway network plays an important role for concentrate transportation.

Table 8.1.2 Transport Amounts at Three Main Mines on the Copper Concentrates, Future

Mine name	2016	2020	2030	Accum. total
Erdenet	580,000 t	580,000 t	580,000 t	9,860,000 t
Oyu Tolgoi	864,000 t	1,414,000 t	1,791,000 t	29,175,000 t
Tsagaan Suvarga	320,000 t	320,000 t	320,000 t	5,120,000 t
Total	1,764,000 t	2,314,000 t	2,691,000 t	44,155,000 t

Note) Tsagaan Suvarga mine will be open in 2015, and will have been operated at full capacity after 2016.

(Source: Prepared by JICA study team based on MRT data and others)

It is considered that railway construction between Tavan Tolgoi and Sainshand is one of the most important factors for future transportation of copper concentrates. The railway construction plan is shown in Table 8.1.3. Although the plan which locates Phase I under three Phases remains the original scheme, railway construction is suspended by invalidity of previous concession contract owing to ‘Accelerating approach regarding railway transportation’ adopted by parliament.

Table 8.1.3 Railway Construction Plan between Tavan Tolgoi and Sainshand

Date	Contents
2012/3/27	‘Action regarding railway construction’ issued by Mongolian government
	‘Concession of foundation for railway construction’ adopted by parliament
2012/11/3	‘Accelerating approach regarding railway transportation’ adopted by parliament

(Source: Prepared by JICA study team based on MRT data)

8.2 Transportation by Railway, Road and Airway

8.2.1 Transportation by Railway

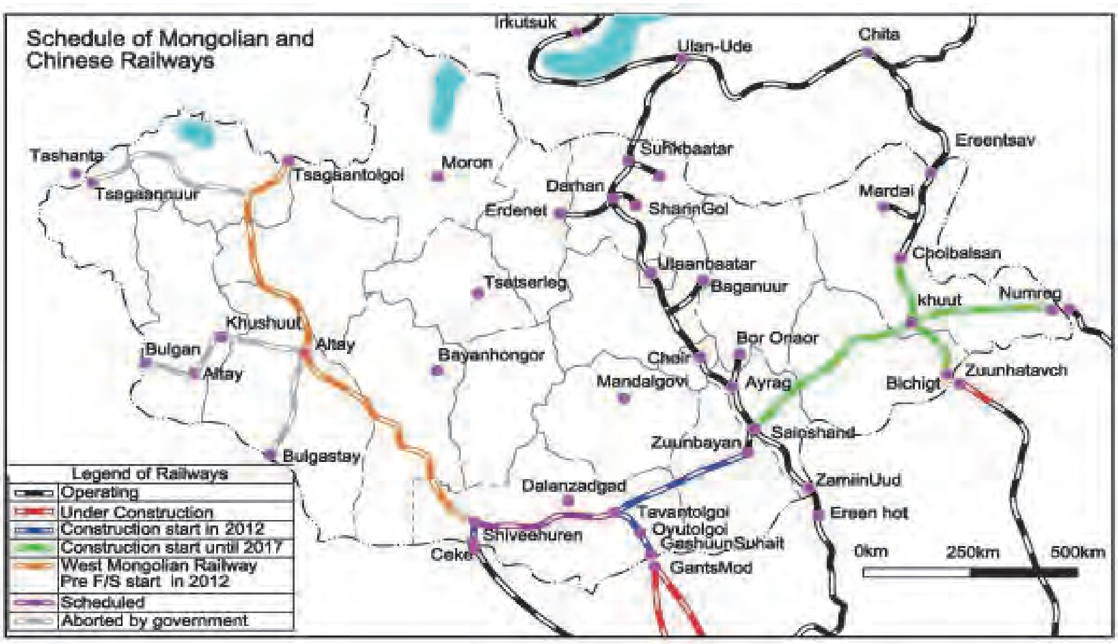
(1) Current status of railway

The country’s arterial railway is a north-south route of Sukhbaarar-Ulaanbaatar-Zamiin-Uud. Connecting to Russia, Ulan-Ude of the Siverian railway in the north line, while southern route, from Ereen to China. In the north-eastern, there is a route that goes between Choibalsan-Ereensave, connecting to the Siberian railway. Besides, these routes are also used for cargo shipments other than ore. The railway distance and annual transportation capacity is shown in Table 8.2.1. In addition, there exist branch lines that connect an arterial railway to a mine, another branch line to the Erdenet mine of Ulaanbaatar north, a branch line from Sharyngol coal mine, etc. The total extension of the railway is 1,810 km. These existing railways are shown in Figure 8.2.1.

Table 8.2.1 Transport Capacity of the Existing Railway

Railway section in domestic	Railway distance (km)	Annual transportation capacity (M tons)
Sukhbaatar-Ulaanbaatar-Zamyn-Uud	1,108	20
Choibalsan-Ereensav	238	6

(Source: JICA, 2013 (RAM))

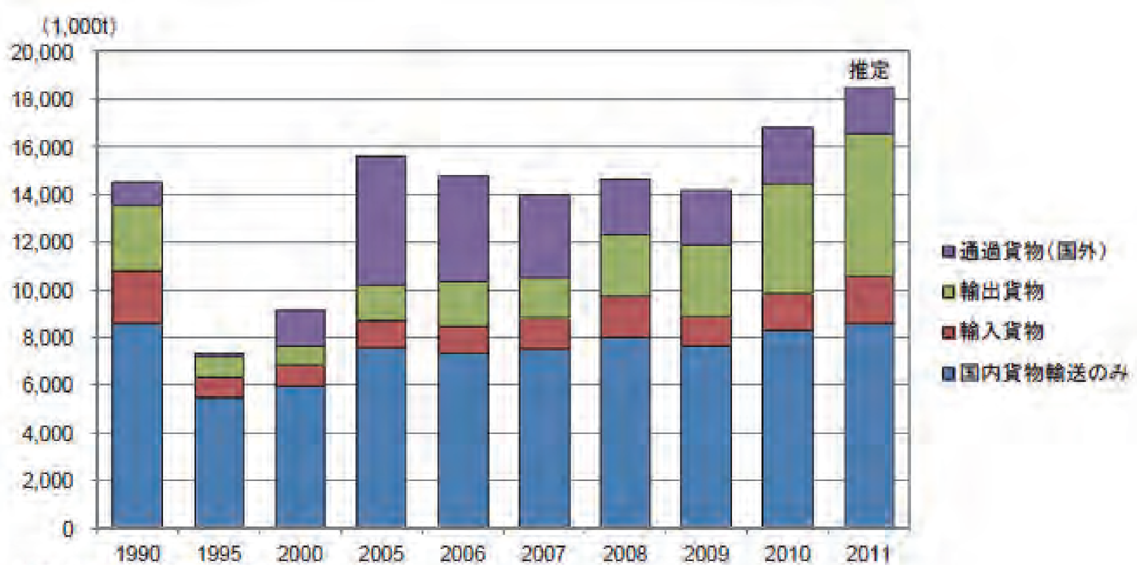


(Source: JICA, 2013 (RAM))

Figure 8.2.1 Schedule of Mongolian and Chinese Railways

The railway construction plan of 2010 is shown in Table 8.2.3. The following characteristics are listed according to the table.

- The transit commodities for Russia and China occupied many domestic cargos in 2005.
- The amount of domestic cargos changed at around 8 Mt, rising about 9 % in 2010.
- Transporting coal by railway from the Zamyn-Uud to China has been ceased since 2007 to the requirements from China, although iron ore can be exported to China at this stage.
- Total of concentrates produced by Erdenet mine is exported to China via Zamyn-Uud gate.



(Source: JICA, 2013 (Mongolian Statistical Yearbook, 2011))

Figure 8.2.2 Railway Transport Performance in 2010

Different rail gauge is adopted in China and Russia. The country has adopted the rail gauge of Russia standard. Rail gouges and axle load of China and Russia are specified in Table 8.2.2.

Table 8.2.2 Trajectory Comparison of Countries

Country	Gauge(mm)	Axle load (ton)
Russia and Mongolia	1,520	23.5
Chine	1,435	23.0

(Source: JICA, 2013 (NEDO, 2012))

(2) Railway Plan

On the basis of railway plan decided by the country parliament in June, 2010, State Owned Mongolian Railway Company (hereinafter called “MTZ”) divided railway network with total distance of 1,800 km into three phases, the stages of Phase I, Phase II and Phase III. Among these, railway planned in the Phase I and Phase II are of high importance and to be built by 2015. The new railway construction plans by Phase I and Phase II are shown in Table 8.2.3. According to the construction plan in Phase I and Phase II, it is supposed that the new and existing railway can convey about 51.8 Mt of copper concentrates per year by 2020.

Table 8.2.3 Mongolian Railway Construction Plan in 2010

Route		Distance (km)	Annual trans. amount (M tons)	Remarks
Phase I	TavanTolgoi-Sainshand	468	24.7	(1)
	Sainshand-Khuut	450	15.7	
	Khuut-Choibalsan	155	0.5	
Phase II	Khuut-Numrag	380	15.2	
	Sainshand-Zamyn-Uud		1.0	(2)
	Sainshand-Sukhbaatar		8.0	(3)
	TavanTolgoi-Gashuun Sukhait	267	18.1	(4)
	Nariinsukhait-Shiveekhuren	46	23.2	
Total		1,766	66.0	Trans. total (1-4)

(Source: JICA, 2013 (RAM))

On the other hand, regarding the financing required for it, railway construction funds are to be raised from the Mongolia Development Bank to MTZ, investment by cash from SPC (Special Purpose Company), and/or the investment from the country's mining contractors or an investors, etc. In fact, it was directed that the planning should be entrusted a third party company. The amount of capital investment concerning the railway construction of these series was estimated at about US$ 4-5 billion.

The result of Feasibility Study, concerning a new line building program, was received and modified in 2011. Mentioned below are the five points regarding the main changes from the plan of 2010.

- Carrying-out Phase I and Phase II, simultaneously, among the priorities of a railway construction plan.
- The fund procurement is to be the B.O.T. System (Build Operate Transfer).
- Conducting the construction to be started in 2012, in each route, is in three routes shown in Table 8.2.4.
- F/S of the route that connected China border to the inside, and west part of the country that was being made into Phase III to Russia.
- The west and south-west route would not be constructed, which passes China through the railways of Phase III on a national security level, instead railway would be converted into the road.

Table 8.2.4 Three Lines of the Start of Construction in 2012

Route	Distance (km)	Annual transportation Amount (M ton)	Const-Ruction Method	Const-Ruction Period
TavanTolgoi-Sainshand	468	Bold tumor eruu Gol (50%) Russian Railways (50%)	B.O.T.	2.5 years
TavanTolgoi-Gashuun Sukhait	267	ER (100 %)	B.O.T	
Nariinsukhait-Shiveekhuren	46	MAK (100 %)	B.O.T	
Total	781			

(Source: JICA, 2013 (RAM))

The construction or reinforcement of each line shown in Table 8.2.5, is likely to be made within this three route construction time.

Table 8.2.5 A Future Railway Construction Plan and Reinforcement Plan

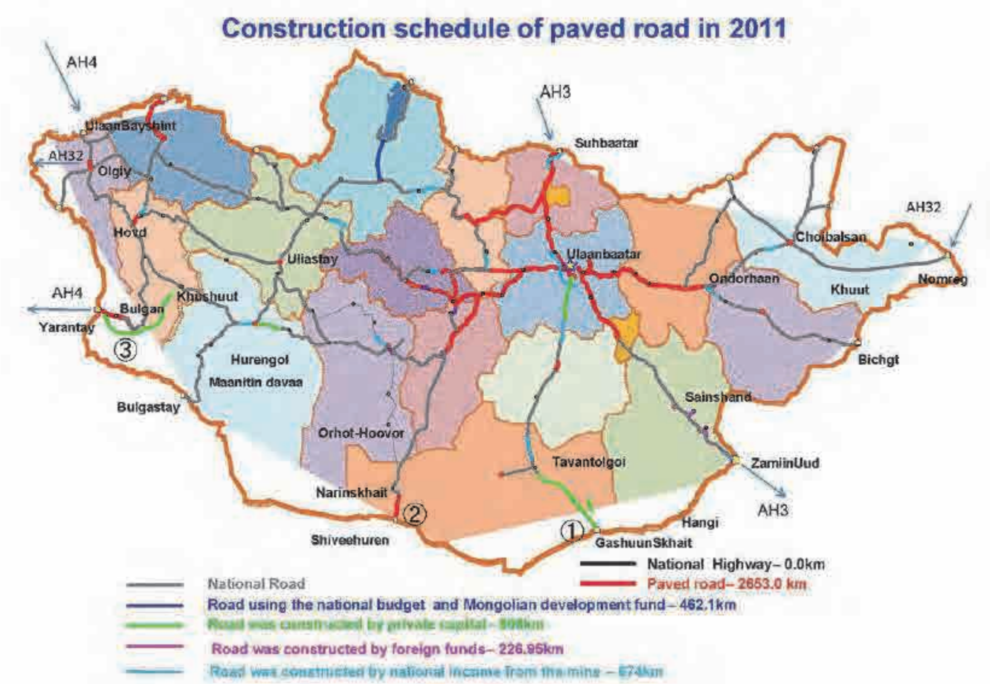
Route/Interval	Summary
Sainshand-Choibalsan	Contractors for construction are to be decided by the end of 2012. The construction span will be five years.
Zamyn-Uud-EreenHot	Although there exists a railway, Mongolian and China sides shall reinforce existing facilities for coal export and import.
Khuut-Bichigt	US$ 3.5 million was given for F/S expense from the World Bank. Investigation budget is likely to be one-by-one from now on. In 2012, it will bid for this F/S on the 31st in August. The plan is posted on the World Bank homepage.
Western part (TsagaanTolgoi-Altay-Shiveekhuren)	US$ 3.2 million was given as F/S expense from the World Bank. Pre-F/S is due to be carried out from 2013. The construction is scheduled five years later.

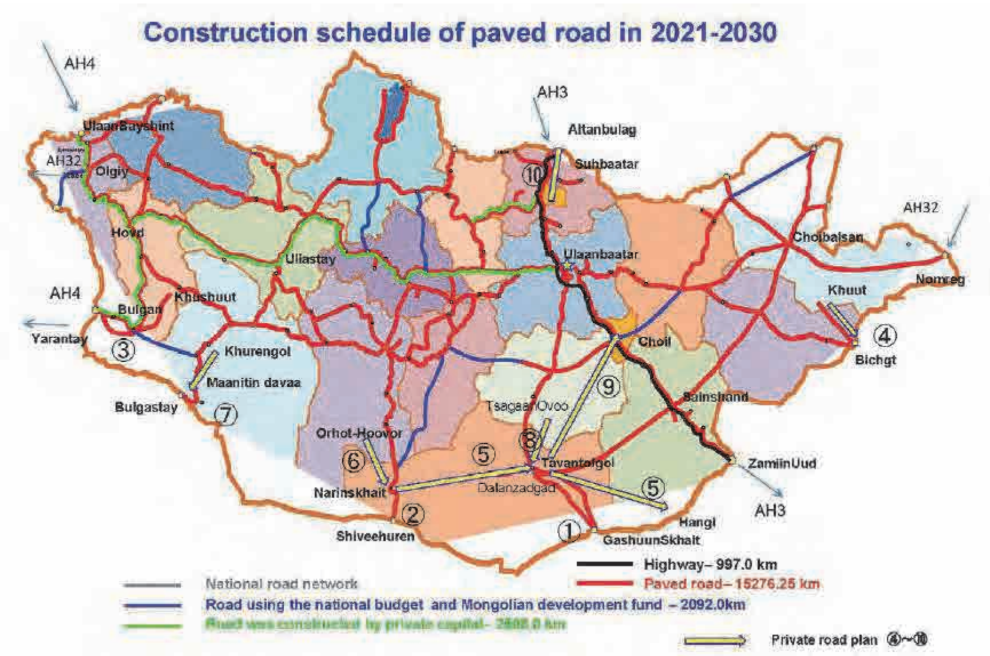
(Source: JICA, 2013 (RAM & World Bank HP))

8.2.2 Road

(1) Current Status of the Road

The road map made in 2011 by Department of Road, Ministry of Road, Transport and Tourism of Mongolia (hereinafter called DOR) and the road map planned in 2021-2030 is shown in Figure 8.2.3. The national road pavement distance shown in the upper of these figures is in red color, and it accounts for less than 10 % of the whole, about 2,600 km. The section currently paved is radiating from Ullaanbaatar, while most of the roads in rural areas are unpaved.





(Source: JICA, 2013 (DOR))

Figure 8.2.3 Construction Schedule of Paved Roads (Upper: 2011, Lower: 2021-2030)

MNS6872 is a new standard for transporting load efficiently and enabling mass transportation. The export road, under construction in 2011, is in compliance with the conventional standard MNS4598. The road to be in compliance with new standard, MNS6872 is likely to increase from now onwards.

(2) Road Plan

According to the jurisdictional road segmentation, roads in Mongolia are segmented into Asian Highway as an international road, national highway, local highway and private road. Among these, an international road and a national highway are managed by DOR. There are three international roads, AH3, AH4 and AH32 shown in the lower of these figures. The current status of those roads is outlined in Table 8.2.6.

Table 8.2.6 Progress of Asian Highway

Road name	Distance (km)	Distance completed (km)	Section to be completed by 2013	Section to be completed by 2017	Section suspending completion timing
AH3	1,000	700	300 km around Sainshand	Sainshand-Zamyn-Uud	
AH4	741	140		全区間	
AH32	2,500	1,200	(1) Ulaanbaatar-Choibalsan (2) Ulaanbaatar-Uliastay		(1) The east of Choibalsan (2) The west of Uliastay

(Source: JICA, 2013 (DOR))

According to DOR in 2013, the route of AH3 between Sainshand-Zamiin-Uud is scheduled to complete earliest among the three routes. The arterial road of Mongolia, running along the railway from Suhkbaatar through Ulaanbaatar to Zamiin-Uud, turns into all the paved roads, and its function as the arterial road is substantially improved.

Although many unpaved roads still exist as of 2011 (referring to the upper of the Figure 8.2.3), national highway is scheduled to be paved in entire interval by 2020, by DOR information. Comparing between the upper (2011) and the lower (2021-2030) of Figure 8.2.3, roads marked ‘1’ and ‘3’ in the figure being privately constructed in 2011 will become the national highways in 2021 and later. These were constructed by the B.O.T. system for coal transportation, and then they will be national highways after 10 years from the points of construction. From now on, road will be constructed on the premise of the B.O.T. system.

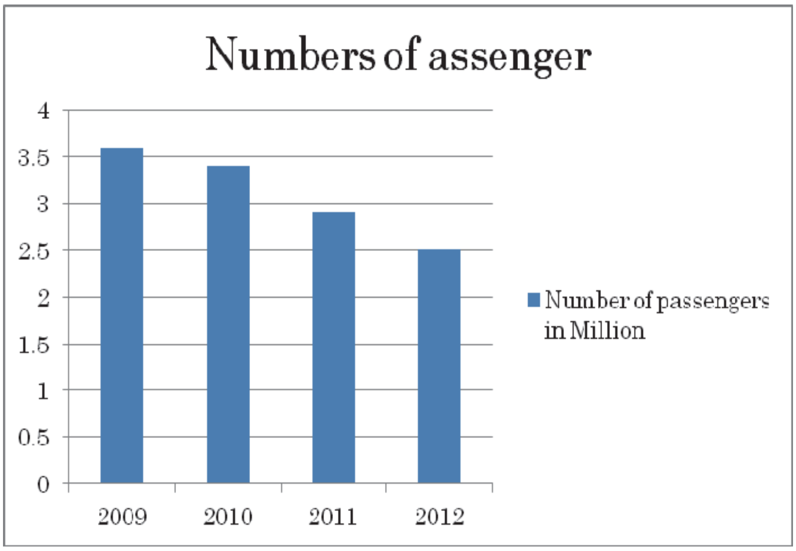
DOR is due to construct 42 ore-transportation roads by a B.O.T. system, of which 23 roads are exclusively for coal. Most of roads radiate outward the Tavan Tolgoi and Nariinsukhait.

8.2.3 Airway

An airway operated between Mongolia and Japan is focused in this section.

The airway contract between Mongolia and Japan was signed in 1993, and was come into effect in 1994. The direct flight between them has been operated twice a week by Mongolian an airway company. Unfortunately, no Japanese company has been participated since 1994, and no cargo has been recorded in the direct flight between Mongolia and Japan.

Annual average number of passengers recorded to approximately 30,000 in years 2009 to 2012, shown in Figure 8.2.4.



(Source: MLIT, 2013)

Figure 8.2.4 Annual Number of Passengers in 2009-2012

Airway company, Mongolian CAD, that is a contractor of Mongolian Central Bank will be established at the beginning of 2014, which may be possible new way of logistics. It takes about 4 to 5 hours by an aircraft A300 between Mongolia and Japan. It is possible that precious metal such as gold could be transported by using the air-cargo. The export of gold, however, is strictly controlled by Mongolian government.

8.3 Electric Power Supply

In MMRE 2011 report, the electric power supply and the demand by 2030 is discussed. Here, the outlined is the demand anticipation and the electric supply plan of Gobi region, which needs to correspond to the increase of electricity demand by the future mining development. New coal fired power plants and so forth are to be constructed in the southern Gobi region to meet the increased demand for electricity.

New coal fired power plant construction program over the country is shown in Table 8.3.1. And also the main electric power supply points from Tavan Tolgoi plant are shown in Table 8.3.2. Moreover, the electric power supply and the demand by 2025 of the south Gobi region are shown in Table 8.3.3. The locations of those plants are shown in Figure 8.3.1.

Plant construction corresponds to the increased demand of Ulaanbaatar and the electric power supply to the Sainshand industrial complex, aiming at supply in the mines of the south Gobi region. Referring to these tables, it can be assumed that about 600 MW of demand in 2025 is thought to be for Tavan Tolgoi plant. The supply status due to the increased demand by coal development in the south Gobi region is put in place.

Table 8.3.1 New Coal Fired Power Plant

Power plant name	Scale (MW)
Mogoin Gol CHP	60
Ulaanbaatar CHP	830
Shuren HPP	300
Ukhaa Khudag CHP	18
Oyu Tolgoi CHP	420
Tavan Tolgoi CHP	360
Shivee-Ovoo CHP	500
Total	2,488

(Source: JICA, 2013 (MMRE, 2011))

Table 8.3.2 Main Demands for the Power

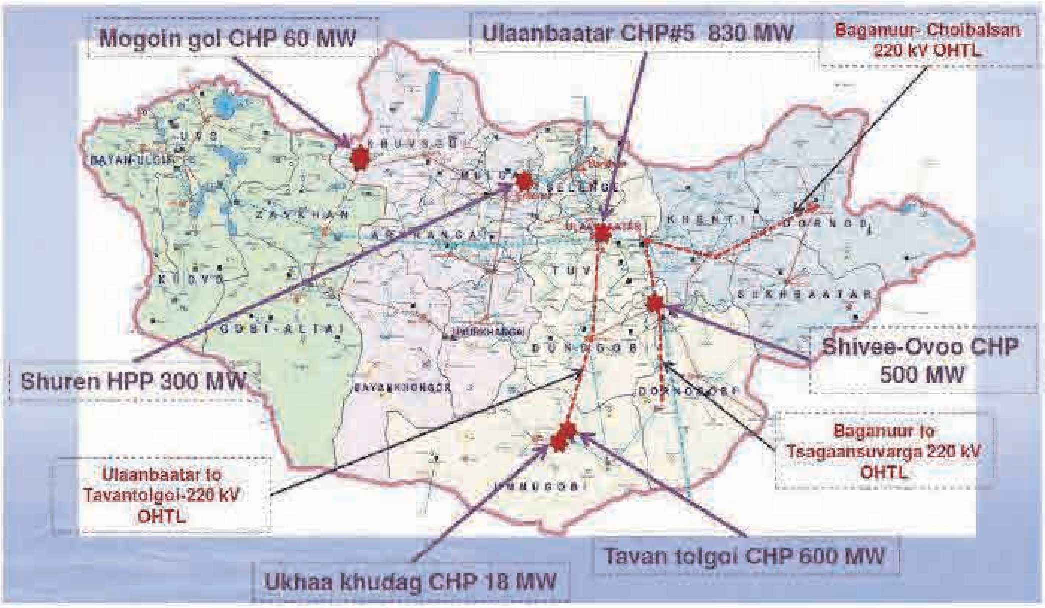
Tavan Tolgoi power plant		
Mine name	type	Scale (MW)
Oyu Tolgoi	Copper	200-310
Tavan Tolgoi	Coal	100-250
Tsagaan Suvarga	Copper	50
Total		350-610

(Source: JICA, 2013 (MMRE, 2011))

Table 8.3.3 Power Demand Estimate in the South Gobi Region

Year	2012	2015	2020	2025
Generation(MW)	48.5	260	498	607

(Source: JICA, 2013 (MRAM, 2012))



(Source: JICA, 2013 (MMRE, 2012))

Figure 8.3.1 Location Map of Planned Power Plants

8.4 Other Information Regarding Transport Infrastructure

There are two important aspects regarding the transport infrastructure, they are 'supply and demand of water resources' and 'possible areas for smelters and their logistics'.

(1) Supply and Demand of Water Resources

In Mongolia, the common water resources in the country are groundwater, river water, lake water and glacier water, of which only groundwater is available in the Gobi areas with little precipitation. The main water use in Mongolia is for drinking, livestock, irrigation, mines, industrial and power plant.

In the WB2009 report, the trial calculation is conducted, where the available groundwater supplies of Gobi area's three provinces (Dunggobi, Dornogobi and Umnogobi), and the amount of supply for the mine development are compared. According to the report, if the groundwater resource of Gobi area is estimated strictly, the amount of water resources confirmed at this stage will be exhausted by around 2020.

In order not to drain the water resources of Gobi, supplying water to the Gobi area through pipeline, from two rivers in the northern areas of Mongolia, is examined by the state. It is called Orhon-Gobi Pipeline Project (OGP) and Herlen-Gobi Pipeline Project (HGP), respectively. Each outline is shown in Table 8.4.1 and Figure 8.4.1.

Table 8.4.1 Pipeline Project Overview

Project name	Water Quantity (l/sec)	Transportation distance (km)	Urban Transit	Current status
OGP	2,500	740	TavanTolgoi Oyu Tolgoi Mandarugobi Dalanzadgad	F/S underway
HGP	1,500	540		Investigation not stared

(Source: WB, 2009 and others)

(Source: WB, 2009)

Figure 8.4.1 Location of Orhon-Gobi Pipeline (OGP) and Herlen-Gobi Pipeline (HGP)

The demand of water in South Gobi area in 2020 is estimated to be around 518,000 m^3/ day (6,000 l/sec). It assumes to supply 4,000 l/sec, which amounts to about 66 % on the pipeline. The water supply plan in 2020 to be ready to run ready is shown in Table 8.4.2.

Table 8.4.2 The Water Electric Supply Plan in 2020

No.	Water user	Estimated demand source (l/sec)	Source demand (l/sec)	
			Surface	Underground
Energy and mining industry				
1	Shivee-Ovoo	616	467	149
2	Tsagaan Suvarga	604	300	304
3	Oyu Tolgoi	1,060	360	700
4	TavanTolgoi	951	486	465
Subtotal		3,231	1,613	1,618
Urban water supply				
5	Mandalgobi	50	50	0
6	Dalanzadgad	70	60	10
7	Choir	40	40	0
8	Sainshand	85	65	20
9	Zamyn-Uud	50	50	0
10	Soum center and rural	104	52	52
Subtotal		399	317	82
Agriculture and environment				
11	Livestock	200	100	100
12	Agriculture	1,750	1,750	0
13	Environment	300	100	200
Subtotal		2,250	1,950	300
Others				
14	Others	120	120	0
Total		6,000	4,000	2,000

(Source: WB, 2009)

It is believed that by carrying out this plan, the mining operation could be conducted while preventing the drainage of groundwater. The only problems are to realize the plan and its costs. In recent years, regarding the OGP plan, there are certain oppositions from the residents nearby the river, etc., although investigation is progressing with Japan’s cooperation. Whereas, regarding the HGP plan, it is unlikely that it is a stage to conduct investigation. Moreover, although the outline of a pipeline’s cost is not clear yet, it is however expected to be more expensive than the method of pumping up and purifying groundwater.

Although each mining company has secured underground water supplies, mines may find the difficulty in water use, that is, immediately shift from underground water to water through a pipeline in case that the cost difference is large. Especially, as the possibility of political restriction for the amount of underground water being used in South Gobi, aiming at the prospective underground water supplies preservation in South Gobi area is also considered, all interested parties and person concerned should consider a smooth transition.

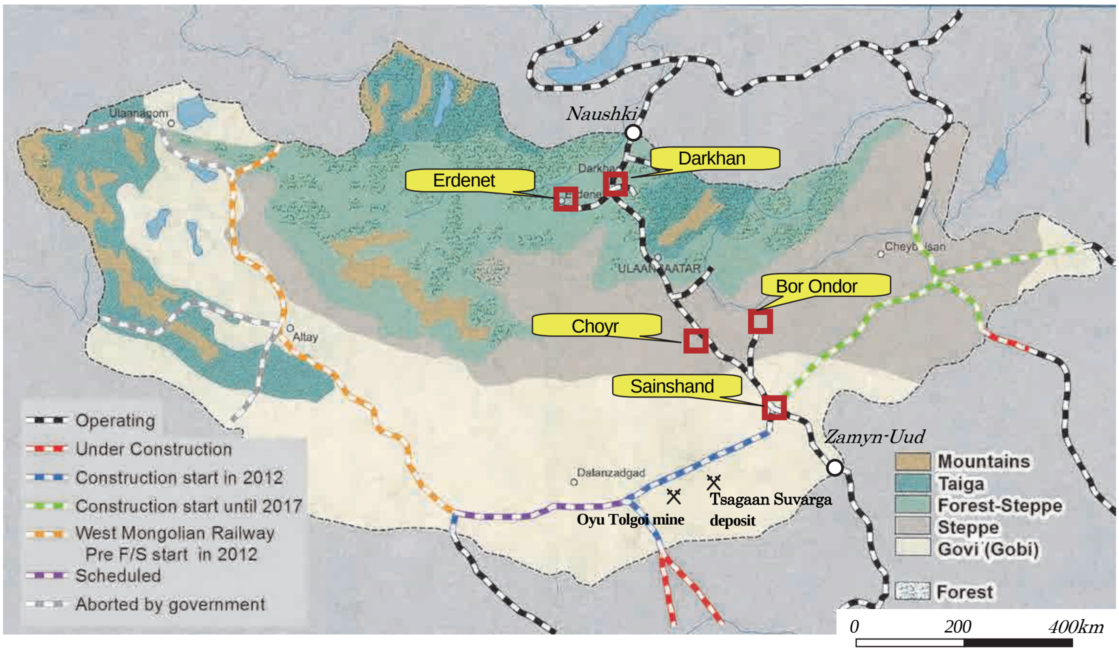
(2) Possible Areas for Smelters and their Logistics

Possible areas for smelters and their logistics at this moment are summarized in Table 8.4.3, and their locations are illustrated in Figure 8.4.2, on the map of the scheduled Mongolian and Chinese railways.

Table 8.4.3 Possible Areas for Smelters and their Logistics

No.	Area name	General location	Characteristics
1	Sainshand	Along main route 450 km apart from UB in southeastern direction	Close to Oyu Tolgoi copper mine
2	Choyr	Along main route 300 km apart from UB in southeastern direction	Almost center between Erdenet and Oyu Tolgoi
3	Bor Onaor	Along branch from main route 300 km apart from UB in southeastern direction	Close to Choyr town
4	Darkhan	Along main route 150 km apart from UB in northeastern direction	Close to Erdenet copper mine
5	Erdenet	Branch end 200 km apart from UB in west-northwestern direction	Erdenet copper mine located
6	Khovs-Gol	Remote area 550 km apart from UB in west –northwestern direction	No railway plan

(Source: Prepared by JICA study team based on MM data)



(Source: Prepared by JICA study team based on International Travel Map 'MONGOLIA')

Figure 8.4.2 Locations of Possible Areas for Smelters

The logistics mentioned above possible areas for smelters is shown in Table 8.4.4.

Table 8.4.4 The Logistics of Possible Areas for Smelters

Area name	Characteristics
1. Sainshand	Copper concentrates produced at Erdenet mine are transported to Sainshand by Trans-Mongolian railway. Oyu Tolgoi mine and Tsagaan Suvauga deposits are close to Sainshand. Access to Zamyn-Uud which is an international gate to China is very good in condition. However, water resources are one of the big obstacles because the area is discriminated in Gobi dry region.
2. Choyr	The area along Trans-Mongolian railway is almostly located between Erdenet mine and Oyu Tolgoi mine / Tsagaan Suvarga deposit. Regarding water resource, there is a plan to make a pipe-line from Kherlen Gol river, using its surplus water. There is no big industry developed at this moment in this area.
3. Bor Ondor	Branch at Ayrag from Trans-Mongolian railway is abarable to transport copper concentrates and products. Kherlen Gol river is also close to Bor Ondor, using its surplus water. As the big fluorite mine is located in this area.
4. Darkhan	This is an industrial city where Trans-Mongolian railway and AT3 international road have already been prepared. Access to Naushki which is an international gate to Rusia is very good in condition. Both of electric power and water resources use current plants which would be boosted in future, if necessary. In addition, Erdenet mine is very close to the area via railway.
5. Erdenet	Erdenet mine is located in this city. All of railway, road, electric power and water resource are very good in condition to build a smelter here. However, Oyu Tolgio mine and Tsagaan Suvarga deposits are remotely situated from the city. On the other hand, air pollution has been argued because of long-term mining activity.

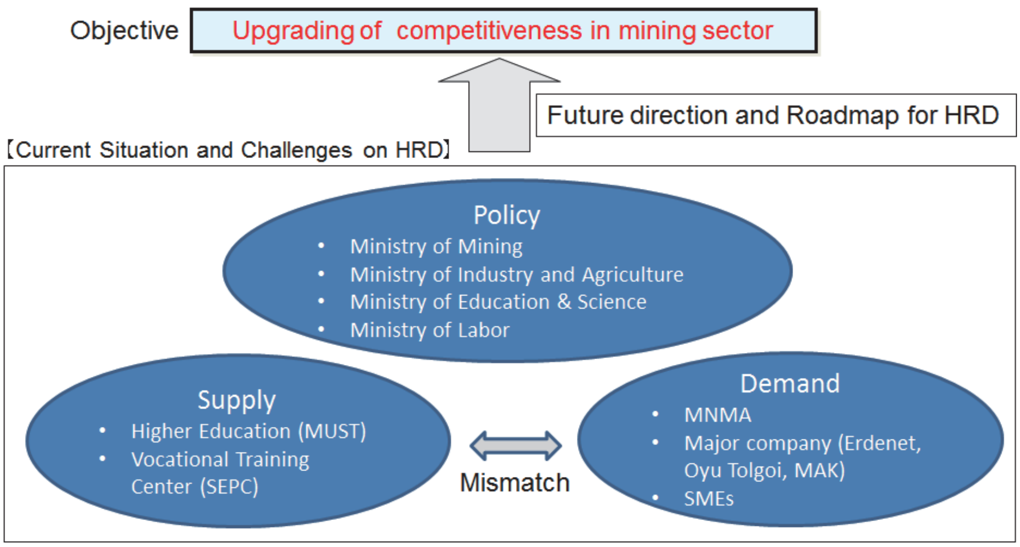
(Source: Prepared by JICA study team based on MM data)

Chapter 9. Industrial Human Resource Development

In this chapter, we confirm the current situations and challenges of industrial human resource development in the mining sector of Mongolia, based on the results of interviews conducted with the relevant local parties and the literature research, and propose a roadmap for promoting the realization of industrial human resource development with the aim of improving the international competitiveness of the mining sector of Mongolia in future.

9.1 Analytical Framework for Industrial Human Resource Development in Mining Sector

To understand the current situations and challenges of industrial human resource development in the mining sector of Mongolia, we have conducted the analytical work with the aspects of policy, supply and demand, as shown in the figure below (Figure 9.1.1).



(Source: Prepared by Survey Team)

Figure 9.1.1 Analytical Framework for Industrial Human Resource Development in Mining Sector

9.2 Current Situation on Industrial Human Resource Development in Mining Sector

The mining sector of Mongolia is an extremely significant industry in the country that accounts for about 20% of the gross domestic product and about 90% of the total exports. As of 2013, there are 620 mine-related companies, about 68,000 people are employed.

Employment of the mining sector in Mongolia is expected to continue expanding and the labor population in the sector will reach about 84,000 people (6.8% of the total labor population in

Mongolia) by 2020[2]. Also, the ratio that the mining sector occupies to the gross domestic product is expected to be 20.5% in 2020.

9.2.1 Aspect of Policy

(1) Background

There are three major mines (deposits) in Mongolia: Erdenet, Tsagaan Suvarga, and Oyu Tolgoi.
The Erdenet mine has been operated by the engineers who studied in Russia in the past. However, it recently employees the young engineers who graduated from domestic universities. The Tsagaan Suvarga deposit has been operated by the engineers who graduated from domestic educational institutes, as well as recruiting the highly-skilled engineers from domestic or overseas organizations through the head hunting. At the Oyu Tolgoi mine, both external talent from foreign countries and local talent will be employed, and its mine management will be done by the engineers who are developed through OJT at the workplace or other training institutes.

In this section, we analyze the current situation of the industrial human resource development in the mining sector of Mongolia with the aspects of policy, supply and demand.

(2) Key policies

The Ministry of Mining is responsible for mining development & planning, while the Ministry of Education & Technology is responsible for primary-/secondary-/tertiary-education, and the Ministry of Labor is responsible for vocational training.

The key policies in mining sector of Mongolia are the “National Policy on Mineral Resource Areas (2014-2025)” and “Copper Program (draft).” The government of Mongolia is aiming at developing these policies in order to strengthen the country’s mineral resource areas. Human resources development will be implemented according to the policy and the program.

(a) National Policy on Mineral Resource Areas (2014-2025)

The Ministry of Mining delivered the "National Policy on Mineral Resources Sector (2014-2025)" in January, 2014.

Currently, there are 15 mining development projects in Mongolia, and the government wants to support mining development on policy matters. However, there are many cases where the development plan does not proceed, because of the controversy over the project financing between

[2] According to the study conducted by the Ministry of Labor of Mongolia with the cooperation of the country’s Labor Research Center and the Ministry of Labor of South Korea

the government and a private company: The government usually requests the procurement of fund on hand, while a private company wants to raise fund through the project finance. There are also cases where the government is excessively involved in the project and places utmost priority on the national interest. Such cases can discourage the foreign investments and as a result, drag on the private sector.

The “Copper Program (draft),” in which the human resources development policy is stipulated, is a program implemented under the Minerals Policy.

(b) Copper Program (draft)

The objective of this Copper Program (draft) is stated as to develop the non-ferrous metal industry by using the copper ore resources for the long-term" and “to secure the implementation of the 57th Diet resolution that was adopted by the Mongolian copper program in 2010 and establish the method and the form of involvement for the relevant country to participates in a factory that purifies the refinement of the copper concentrate, gold, and silver.

This Program (draft) has a feature of emphasizing on the refinement of copper. The copper resources are currently exported in the form of copper concentrate, but the Program tries to raise the processing level and increase the export of the value-added products in the future. It will consequently contribute to improve the balance of international payments of Mongolia, and to provide the works for more people.

The objective of this Copper Program (draft) is stated as to develop the non-ferrous metal industry by using the copper ore resources for the long-term and to secure the implementation of the 57th Diet resolution that was adopted by the Mongolian copper program in 2010 and establish the method and the form of involvement for the relevant country to participates in a factory that purifies the refinement of the copper concentrate, gold, and silver.

This Program (draft) has a feature of emphasizing on the refinement of copper. The copper resources are currently exported in the form of copper concentrate, but the Program tries to raise the processing level and increase the export of the value-added products in the future. It will consequently contribute to improve the balance of international payments of Mongolia, and to provide the works for more people.

Specifically, the Copper Program (draft) contains the following.

- To establish an organization responsible for practical operations of the copper program.

- To make the strategic copper deposit as the government-owned asset.
- To limit the exports of concentrate through the tax policy, and to give preferential treatment to the processing industry.
- To improve the tax environment related to the copper concentrate.
- To construct the first factory (smelter) that uses copper concentrate mined from the Erdenet and the Tsagaan Suvarga deposits as raw material.
- To construct the second copper smelter in the Sainshand industrial park as part of the establishment of the copper and gold mine development project of the Oyu Tolgoi deposit.
- The Program specifies that the 1st smelter, which will refine the Erdenet and the Tsagaan Suvarga deposits by the TSL method with the annual refinement capacity of 200,000 t, will be constructed in the ourtskirts of the Erdenet deposit by 2016, the 2nd smelter which refine the Oyu Tolgoi deposit will be constructed in the Sainshand industrial park by 2020, and the precious metal recovery from the anode slime will be done by 2025.
- To support the sulfuric acid use of the accessory product (for the use of manufacturing coke, cryolite, uranium, gypsum, fluoric acid, phosphate, elemental sulfur, etc.), as well as to support these exports.
- To promote the development of high-skilled, well-trained engineers.
- The burden and the assistance work the national expenditure to the survey such as national support of the human resources development cost, the establishment of the assay office, and universities and the researches by the national expenditure.
- Projects of study, the research, the survey, and the demonstration, etc. are promoting promoted.
- The technical development for the production of copper by sulfuric acid leaching and the extraction of pure copper from the oxide ore and wastes are supported.
- The project that purifies gold and silver from the anode slime is conducted in stages.
- The sulfuric acid solvent technology is secured, and the base of the chemical industry development is made.

(c) Vocational Training Programs

The Ministry of Labor is starting to focus on vocational training programs: four programs (OJT, specialization and retraining, program to develop skilled workers, and vocational training centers) are implemented under the vocational training development policy, in cooperation with the government-managed or private training institutions (Table 9.2.1).

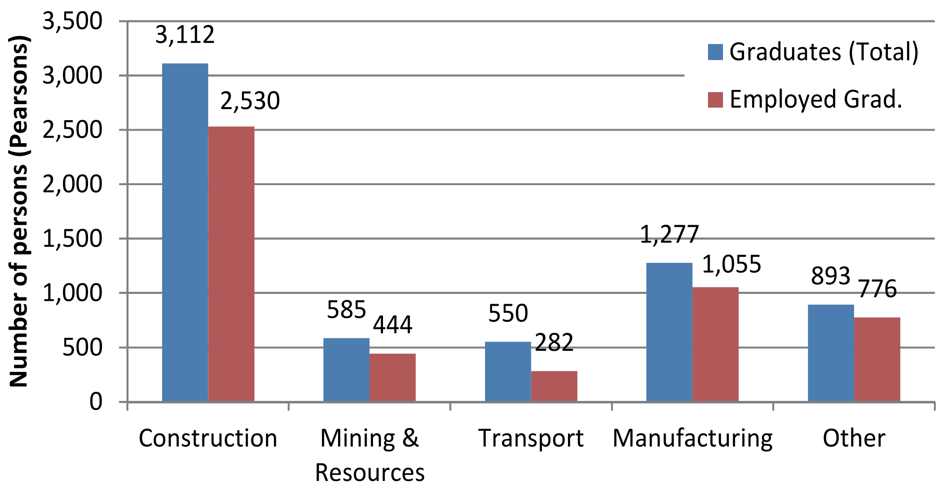
Table 9.2.1 Programs Implemented under Vocational Training Development Policy

	Term	Implementing body	Supporting body
OJT	Less than 2 months (on the request of companies)	Vocational training institution qualified as a vocational training center	Employment Support Fund
Specialization and Retraining	15 - 45 days	At UB City; by certification	Employment Support Fund
Program to develop skilled workers	5 months	Vocational training institution qualified as a vocational training center	Employment Support Fund
Vocational training centers	1 - 3 years	Vocational training institution qualified as a vocational training center	National: 53 schools Private: 26 schools

(Source: Ministry of Labor)

In Mongolia, the total of 6,417 highly-skilled Mongolians, including 585 persons specialized in mining sector, were developed during 2013 (Figure 9.2.1).

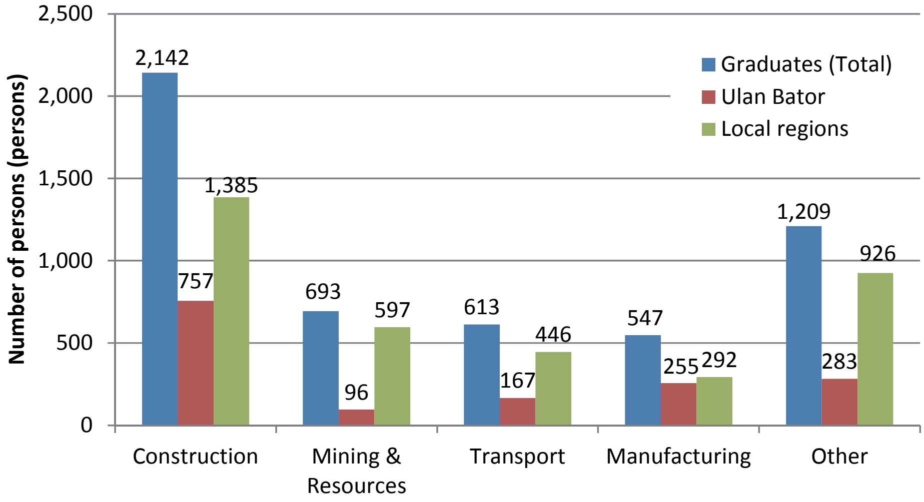
The Ministry of Labor is aiming to further develop 7,000 highly-skilled persons separately in two phases. As the first phase, the ministry is planning to develop and register the total of 5,204 highly-skilled persons, including 693 persons specialized in mining sector (96 within the city of Ulaanbaatar, and 597 in other provincial cities) in 2014 (Figure 9.2.2).



Item	Construction	Mining & Resources	Transport	Manufacturing	Other	Total
Graduates (Total)	3,112	585	550	1,277	893	6,417
Employed Grad.	2,530	444	282	1,055	776	5,087
Employment rate	81%	76%	51%	83%	87%	79%

(Source: Ministry of Labor)

Figure 9.2.1 Results in Highly-skilled Human Resource Development by Sector (2013)



(Source: Ministry of Mining)

Figure 9.2.2 Plan for Highly-skilled Human Resource Development by Sector (for 2014)

(3) Necessity of Interministerial Cooperation

As discussed earlier, the Ministry of Mining is responsible for mining development & planning, while the Ministry of Education & Science is responsible for primary-/secondary-/tertiary-education, and the Ministry of Labor for vocational training.

And thus a problem of "vertically divided administrative functions" can be pointed out in the human resource development in the industry in the Mongolia. For example, according to the Ministry of Mining, a department in charge of career development associated with the upgrade of copper industry (including smelting) does not exist within the ministry, but it is probably under the jurisdiction of the Ministry of Industry and Agriculture. For a new industry, Project Implementation Unit (PIU) will be established by relevant ministries.

9.2.2 Aspect of Supply

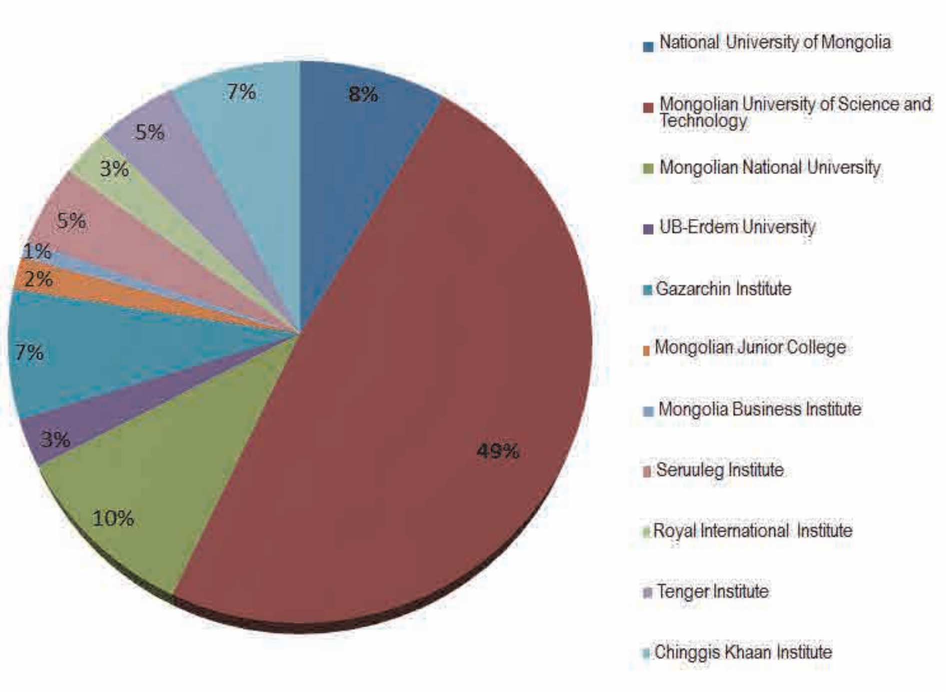
(1) Higher Education

Since 2000, the Mongolian Science and Technology University (MUST) and the National University of Mongolia have trained about 60% of the specialists in mining sector (Figure 9.2.3).

Besides those two universities, about 15 private universities have baccalaureate degree program associated with the mining industry, and most of them provide the courses related to mining technology and mining electrical machinery/equipment under their mine management programs (Figure 9.2.4). There is also a construction technical college in the city of Ulaanbaatar which provides the courses on construction machinery management.

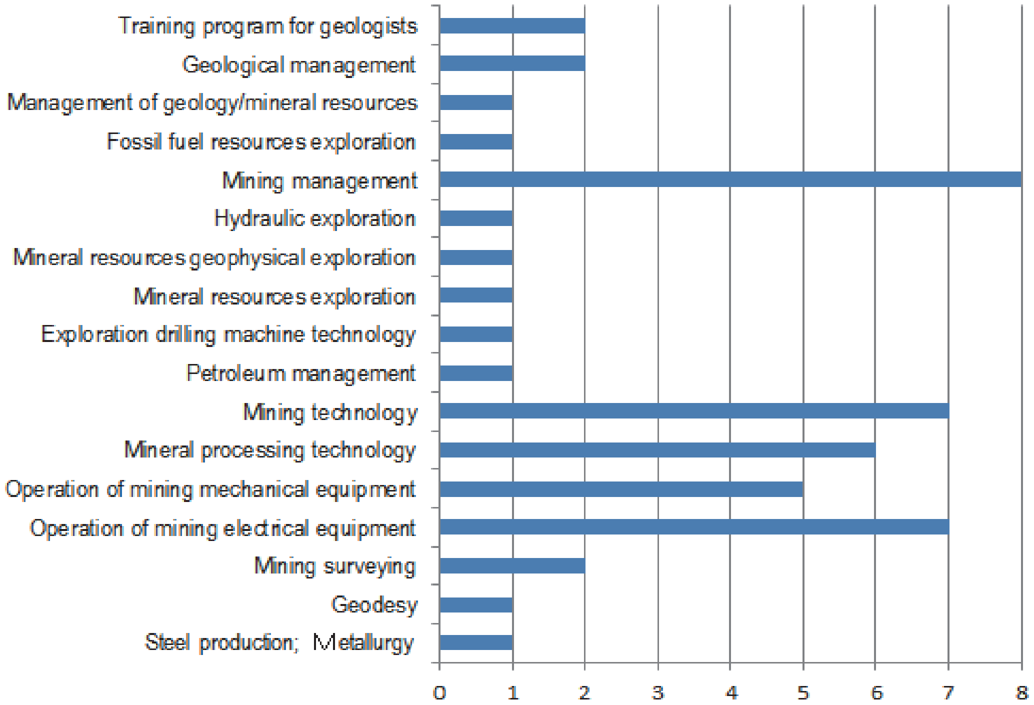
In the academic year of 2011-2012, total of 4,877 students are registered at the 6 major universities including the Mongolian Science and Technology University, and about 50% of these students are studying at the Mining Engineering School (MES) of the Mongolian Science and Technology University.

Ministry of Education and Science is currently conducting a review of the curriculum of the Mongolian Science and Technology University and the National University of Mongolia. For instance, the course “Principle of mining industry” has been added to the curriculum of electric department.



(Source: Ministry of Mining)

Figure 9.2.3 Universities Developing Specialists in Geology / Mining and Petroleum Sectors



(Source: Ministry of Education and Technology)

Figure 9.2.4 Mine-related Courses being Provided at Each University

(a) Mongolian University of Science and Technology

The Mongolian University of Science and Technology (MUST) is the first university that starts personnel trainings in the mining sector of Mongolia, and the major higher education institution that promotes the highly-skilled specialists. The main campus is located in the city of Ulaanbaatar (Photo 9.2.1) and a branch school in Darkhan. Since it produced the first 16 graduates in 1976, the university has steadily producing the talented specialists in the similar field for over 40 years.

The university provides courses associated with mineral resources at the departments of mining engineers, construction machinery/equipment, machine mechanics, etc (Table 9.2.2). At the Mining Engineering School (MES) of the Mongolian University of Science and Technology, about 450-500 students enter the school and about 200-250 students (bachelors) graduate every year. As of the academic year of 2013, 2,666 students are enrolled at 10 departments (2,323 students in baccalaureate program, 373 in master's program, and 6 in doctoral program). Most of the students at the Mining Engineering School (MES) of the Mongolian University of Science and Technology find their works at the mining companies within Mongolia after graduation.

The School of Technology of the Mongolian University of Science and Technology is running its activities as a complex program of "Training + Scientific + Industry," based on preparing mining related engineers, updating their majors and skills, and improving the techniques and technology to be utilized at the Erdenet Mining Corporation.

(Source: Prepared by Survey Team)

Photo 9.2.1 Facilities of MUST

Table 9.2.2 Overview and Academic Activities of MUST

	School of Technology
Overview	• School of Technology was founded as a training center and as a division of the Mongolian-Russian joint venture Erdenet Corporation in 1975. It has been a branch of MUST since 1996 and started training courses in mineral processing offering a bachelors degree. • It has 114 staffs which including 42 teaching personnel (30 with Ph.D. degree) • Approx. 1100 student are studying at 6 departments and 40% of its graduate are working for Erdenet
Academic Activities	• Under 6 departments, namely Dept. of Information Technology, Dept. of Mining Exploration and Processing, Dept. of Mechanical Engineering, Dept. Of Natural Science, Dept. of Power Engineering, Dept. of Humanity, 10 courses have been delivered. • Foreign relations and cooperation has been promoted to increase certain activities such as teacher and student exchange programs and joint research programs in the field of training. The School has partners university and research institution main in Russian, USA and Germany.
Challenges	• Shortage of teaching personnel, Insufficient academic background of teaching personnel, Lack of Laboratory and equipment, insufficient teaching material including shortage of reference textbook at library

(Source: Prepared by Survey Team)

(b) Mongolia-Germany Institute of Technology

Mongolia-Germany Institute of Technology was established in Nalaikh with the support of the Oyu Tolgoi LLC in 2014. There are currently about 40 students (including the Mongolian social members) are studying at the school. Also, the Ministry of Education and Science is constructing a similar school in Dalanzahgd (Name of the school has not been decided yet).

(2) Vocational Education & Training

Vocational education and training in Mongolia is provided by the Specialist Education and Production Centers (SERPs) and polytechnic colleges (Table 9.2.4).

Recently, universities and vocational training centers have been newly established or strengthened with the support of mining companies. For example, Erdenet Mining Corporation and Oyu Tolgoi LLC have established their own vocational training schools to provide education/training programs and to employee the trained specialists and improve their skills. For education and training in the field where they can not correspond by their own, they conduct the programs tied-up with other companies and the institutions with external specialists in the form of supplementing each other.

With regard to the location, most of the vocational schools for training the mine-related technicians have been established not in Ulaanbaatar City but in the provincial cities. For instance, they are established in the mine city of Erdenet in Orhon Aimag located in the northen part of Mongolia, Govisümber Aimag in the central part, and in the industrial city of Darkhan in Darkhan-Uul Aimag in the northern part.

Table 9.2.3 Number of Professional Education Training Institutions and Teachers

No.	Region (number of schools)	Newsbeat	No.	Object school name	Capital system	Number of teachers		
						ulsory edu	sional edu	Total
1	The Chubu region (10)	Selenge Prefecture	1	Selenge Prefecture SEPC	Government-run	9	11	20
2			2	Selenge Prefecture Zu-nhara- SEPC	Government-run	13	14	27
3			3	Selenge Prefecture "Shearing machine mull" SEPC	Government-run	8	14	22
4			4	Selenge Prefecture "SANT" SEPC	Government-run	8	17	25
5		Darhan wool prefecture	5	Darhan wool prefecture SEPC	Government-run	27	32	**59**
6			6	Darhan wool prefecture poly technique College	Government-run	16	13	29
7			7	Darhan wool prefecture mine and power poly technique College	Government-run	11	11	22
8		[Tobu] prefecture	8	[Tobu] prefecture SEPC	Government-run	10	15	25
9			9	[Tobu] prefecture Za-maru SEPC	Government-run	7	11	18
10			10	[Tobu] prefecture Erudene SEPC	Government-run	1	12	13
11	Hanger Juncus effusus var.decipiens region (11)	Bulgan Prefecture	1	Bulgan Prefecture SEPC	Government-run	11	28	**39**
12			2	Bulgan Prefecture is agricultural SEPC.	Government-run	8	4	12
13		Orhon Prefecture	3	Orhon Prefecture SEPC	Government-run	17	27	**44**
14			4	Orhon Prefecture is agricultural SEPC.	Government-run	11	12	23
15			5	Mechanics school in Orhon Prefecture MUST	Government-run	–	11	11
16		Hovsgol Prefecture	6	Hovsgol Prefecture SEPC	Government-run	12	26	**38**
17		Ovorhangay Prefecture	7	Ovorhangay Prefecture SEPC	Government-run	18	33	**51**
18		Niphon spinosus hanger Juncus effusus var.decipiens prefecture	8	Niphon spinosus hanger Juncus effusus var.decipiens prefecture SEPC	Government-run	15	31	**46**
19			9	Arxangaj prefecture "Bulgan" SEPC	Private organization	4	9	13
20			10	Arxangaj prefecture "In conspiracy Banta Corp. mill" SEPC	Private organization	n/a	n/a	n/a
21			11	Arxangaj prefecture Dedebutetsu SEPC	Private organization	n/a	n/a	n/a
22	[Gobi] region (6)	[Dondagobi] prefecture	1	[Dondagobi] prefecture SEPC	Government-run	13	28	**41**
23		[Gobisunberu] Prefecture	2	[Gobisunberu] Prefecture poly technique College	Government-run	16	16	**32**
24		Dornogovi Prefecture	3	Dornogovi Prefecture SEPC	Government-run	14	26	**40**
25			4	Dornogovi Prefecture railway SEPC	Private organization	–	10	10
26		[Umunugobi] prefecture	5	[Umunugobi] prefecture SEPC	Government-run	8	32	**40**
27		Quercus serrata Iha Ward	6	Quercus serrata Iha Ward SEPC	Government-run	17	32	**49**
28	Western district (9)	Dzavhan Prefecture	1	Dzavhan Prefecture SEPC	Government-run	18	29	**47**
29			2	Music and dance College of Dzavhan Prefecture culture and art university subsidiary	Government-run	9	18	27
30			3	SEPC of Dzavhan Prefecture [tosontsuengerusomu]	Government-run	n/a	n/a	n/a
31		Uvs prefecture	4	Uvs prefecture "Ulaangom" poly technique College	Government-run	27	45	**72**
32		Hovd Prefecture	5	Hovd Prefecture development poly technique College	Government-run	27	41	**68**
33		[Gobi] Ertai Prefecture	6	[Gobi] Ertai Prefecture SEPC	Government-run	17	37	**54**
34		[Bayan] Ur ghee prefecture	7	[Bayan] Ur ghee prefecture SEPC	Government-run	20	36	**56**
35		Bayan Hongor Prefecture	8	Bayan Hongor Prefecture SEPC	Government-run	21	35	**56**
36			9	Bayan Hongor Prefecture Uruji-to SEPC	Private organization	4	5	9
37	Eastern district (5)	Dornodo Prefecture	1	Dornodo Prefecture SEPC	Government-run	13	21	**34**
38			2	Dornodo Prefecture polytechnic College	Government-run	16	29	**45**
39		Staple fiber bar torr prefecture	3	[Sububa-toru] prefecture SEPC	Government-run	7	12	19
40		[Hentei] prefecture	4	[Hentei] prefecture SEPC	Government-run	7	30	**37**
41			5	[Hentei] prefecture "Boro Un dollar" SEPC	Government-run	5	7	12
42	Ulan Bator area (35)	–	1	Polytechnic College of production and public entertainments	Government-run	20	61	**81**
43			2	Mongolia South Korea poly technique College	Government-run	25	52	**77**
			3	[Bayanchandamani] SEPC	Government-run	14	22	**36**
44			4	Railway SEPC	Government-run	1	15	16
45			5	Transportation junior college	Government-run	n/a	n/a	n/a
46			6	Architectural polytechnic College	Government-run	30	41	**71**
47			7	SEPC of MUST commerce and production faculty	Government-run	–	8	8
48			8	Mechanician university of MUST	Government-run	8	9	17
49			9	Health service technical university of health service and science university	Government-run	n/a	n/a	n/a
50			10	Music and dance College	Government-run	–	84	**84**
51			11	Implementation "Amgalan of decree of litigation of bureau" SEPC	Government-run	n/a	n/a	n/a
52			12	Sergeant's School under the University Law Enforcement	Government-run	n/a	n/a	n/a
53			13	National plastic operation center of the social security Ministry of Labor direct control	Government-run	n/a	n/a	n/a
54			14	Construction and technological College	Private organization	n/a	n/a	n/a
55			15	"Amidrah uhaan (wisdom where it lives)" SEPC	Private organization	n/a	n/a	n/a
56			16	"Anima" SEPC	Private organization	n/a	n/a	n/a
57			17	"Baz school" SEPC	Private organization	n/a	n/a	n/a
58			18	"Don-Bosko" SEPC	Private organization	n/a	n/a	n/a
59			19	SEPC of "Ih zasag" university	Private organization	n/a	n/a	n/a
60			20	SEPC of Mongolian business junior college	Private organization	n/a	n/a	n/a
61			21	Mongorufua-ma- SEPC	Private organization	n/a	n/a	n/a
62			22	Machine and technological junior college	Private organization	30	24	**54**
63			23	"USI" SEPC	Private organization	–	6	6
64			24	SEPC of Hangai junior college	Private organization	–	11	11
65			25	"Hamag Mongol" SEPC	Private organization	7	10	17
66			26	Technological junior college (ＸＴＫ)	Private organization	41	49	**90**
67			27	SEPC of "New civilization" junior college	Private organization	n/a	n/a	n/a
68			28	"Transwest" SEPC	Private organization	n/a	n/a	n/a
69			29	"New age" SEPC	Private organization	n/a	n/a	n/a
70			30	"LEMUR" SEPC	Private organization	n/a	n/a	n/a
71			31	Ekomongoru SEPC	Private organization	n/a	n/a	n/a
72			32	"International, technical school" SEPC	Private organization	n/a	n/a	n/a
73			33	"Майнтех" MCYT	Private organization	n/a	n/a	n/a
74			34	Mongolian branch school of teacher and engineer College school in [uran-ude] city	Private organization	n/a	n/a	n/a
75			35	SEPC of Nomundarai junior college	Private organization	n/a	n/a	n/a

– 28,317 people per 76 school in total are on the register (The Oyu Tolgoi Co. amount is included).
・49 government-run schools (It is ..UB city.. 36 in 13 and the provinces).
・27 private schools (It is ..UB city.. 5 in 22 and the provinces).
– 21 schools (= light blue) in total,

*SEPC : Specialist Educatin and Production Center
(Source: Ministry of Labor)

(a) Orkhon SEPC

Orkhon SEPC (Specialist Education Production Center) has established by Erdenet Mining Corporation (EMC) in 2009 as a vocational training center for the Erdenet Mining Corporation (Picture 9.2.2). Since the establishment, the school has provided mine-related technicians not just for Erdenet Mining Corporation but also for other mining companies, such as Oyu Tolgoi LLC and MAK. It is also conducting vocational trainings for the trainees in Khangai Region as a regional vocational training hub.

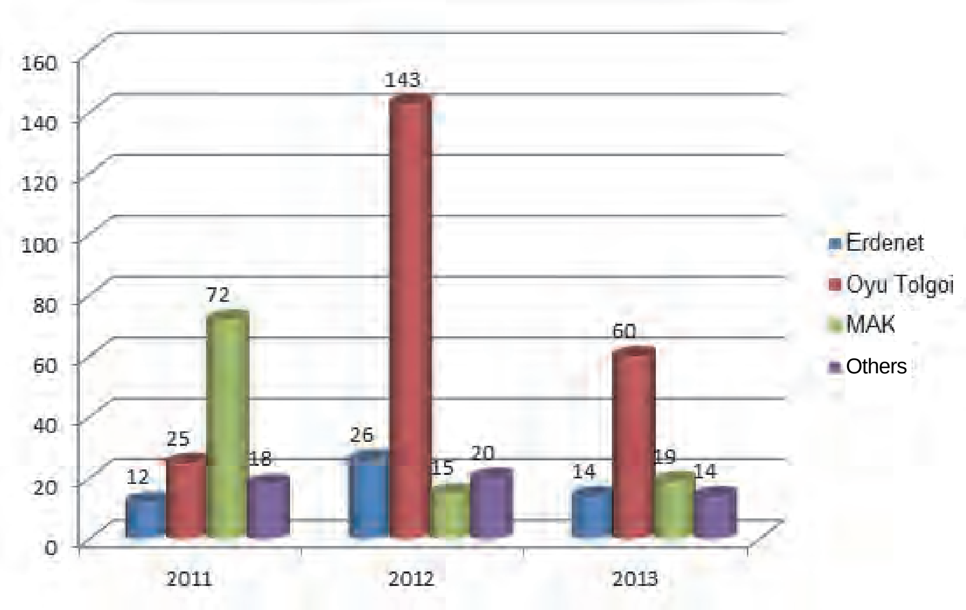
(Source: Prepared by Survey Team)

Photo 9.2.2 Facilities of Orkhon SEPC

Table 9.2.4 Overview and Academic Activities of Orkhon SEPC

	Orkhon SEPC
Overview	• Orkhon SEPC is located inside the campus of MUST Orkhon Branch the School of Technology and some laboratory are using with the School of Technology • 8 staffs are employed as 1 vice director, 2 teachers, 4 mangers and 1 laboratory staff. • Approx. 210 student at studying at three courses.
Training Program	• **3 month course**: provided for high school graduate. Currently 71 students are studying in 5 technical training courses • **5 month course**: this program is provided based on the request from private company and Ministry of Labor as the retraining program. Trainee will be paid 195,000 Tg monthly as an allowance for training. • **10 month program**: this program is certified by Ministry of Labor and currently 37 trainee is studying at maintenance of drilling machine, road maintenance of heavy machinery, mineral processer, electro-technique and lathe course. • **Training program for EMC**: train approx. 1000 technician annually as a designated training course for EMC as short term training (1.5 month, 2 month and 3 month)
Challenges	• Shortage of teaching personnel, Lack of Laboratory and equipment, insufficient practical training, lack of own building

(Source: Prepared by Survey Team)



(Source: Erdenet Mining Corporation)

Figure 9.2.5 Place of Employment after the Training Completion at Orkhon SEPC

(b) Mongolian-Korean Polytechnic College

Mongolian-Korean Polytechnic College (MKPC) is a leading national vocational training institution established in the city of Ulaanbaatar in 1966. After the democratization and the financial difficulties, it was reconstructed in 2001 with the support of Korea International Cooperation Agency (KOICA) using the grant aid of the government of South Korea.

The school provides various courses, such as professional education courses, machine operation courses, and training courses for adults. There is an institutional system like a short-term study abroad program for teacher and a scholarship study abroad program in South Korea. There is, however, no system favorable for the students graduated from the school to find employment at South Korean companies on a priority basis.

Mongolian-Korean Polytechnic College has received financial support for supplies of material/equipment, not just from mining companies, such as Oyu Tolgoi LLC, but also from the international donors, such as the South Korean government. The donations for purchasing machines are received in cooperation with the companies through the Social Partnership Program, and moreover, teachers are dispatched to the companies for the purpose of improving their knowledge and skills. It is currently planning to establish more classrooms aiming at opening new courses.

(Source: Prepared by Survey Team)

Photo 9.2.3 Facilities of Mongolian-Korean Polytechnic College (MKPC)

Table 9.2.5 Overview and Academic Activities of MKPC

	Mongolian-Korean Polytechnic College (MKPC)
Outline	• MKPC is an vocational training institution for light industrial sector established in 1966 by the Mongolian government. Currently, it has 150 faculty members and more than 1,800 trainees. • Breakdown of faculty members is: 100 teachers (about 60% masters, 40% bachelors, and 10 taking doctoral programs), and 50 staffs.
Programs provided	• **Professional education courses:** A 2.5-year education program of vocational training along with general classes is provided for junior high graduates. About 1,200 students are currently enrolled. Certificate is issued on successful completion. • **Machine operation education courses:** A 3-year education program is provided for high school graduates in 5 specialized courses: 1. automobile mechanic course; 2. graphic design course; 3. fashion design course; 4. Korean language interpreter course; and 5. computer technology course. About 340 students are currently enrolled. Diploma is issued on successful completion. • **Training courses for adults:** A vocational training program is provided for company employees on the request of a company. About 200 trainees are currently enrolled. There are 6 courses (1. maintenance/operation of mining machinery; 2. welding certified technician; 3. building electricity certified technician; 4. textile certified technician; 5. light industrial machinery repairer; and 6. automobile mechanic). • There is also a **specialized workers development program** for Mongolians, designed as the vocational training project commissioned by the Ministry of Labor, which provides a 5-month vocational trainings for 110 trainees in 8 specialized areas: repair and operation of mining machinery; welding certified technician; building electricity certified technician; textile certified technician; light industrial machinery repairer; automobile mechanic; wood processing; and sewing.
Challenges	• Aging of teaching materials and equipment; shortage of laboratory and classrooms; capacity building of faculty members

(Source: Prepared by Survey Team)

(i) Training Programs

For the training program for adults, six courses are provided in the form that corresponds to the needs of labor market and the needs of the companies. Upon the completion of the 1-year program, a student can acquire Certificate, but not receive Diploma qualification.

The curriculum of the same course has been revised for 2-3 years, based on the needs of the labor market, situation and request of company, and/or as a result of consultation with the Ministry of Labor.

Also, there is a specialized workers development program for Mongolians, designed as the vocational training project commissioned by the Ministry of Labor. Five-months training courses for adults in eight specialized areas which the Ministry of Labor specified as there are needs of job offer for the unemployed.

(ii) Current Challenges

According to the Mongolian-Korean Polytechnic College, there is no mismatching, because the school is providing the educational courses where the needs of labor market are high, such as the mechanics of mining machineries, as the mining is recently a boom in Mongolia.

It has not provided education course for the area of metallurgy, as the need for that area does not exist, but the school will soon respond and provide relevant courses, once the need becomes evident as a result of consultation with the Ministry of Labor.

The school, although it provides courses for operators and mechanics of mining machineries required for mining sector, wants to receive financial support to purchase teaching equipment and materials for the heavy industry sector.

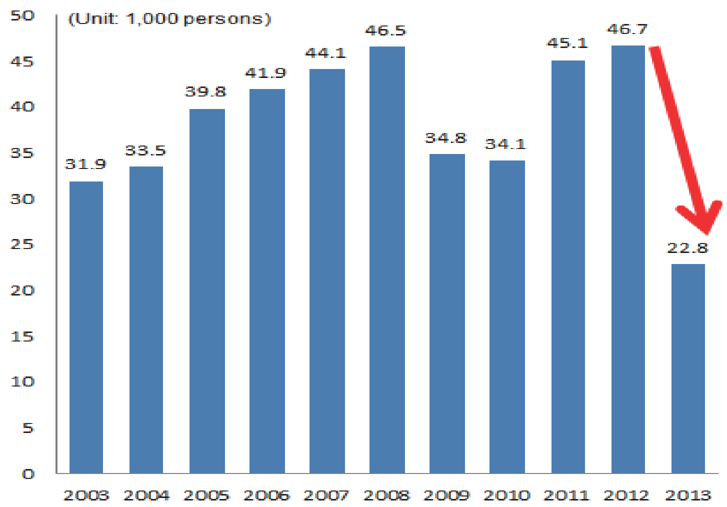
The shortage of the simulation facility / equipment has long been a problem. Even though the curriculum requires each student to complete eight hours of practice, it is not possible to train enough, since there are only two simulation machines. The arc welding simulator machine used at the school is made in France and is procured with the financial support from Oyu Tolgoi LLC.

There is a problem of obsolescence of teaching materials and decrepit facilities. For the establishment of new courses in the future, the Mongolian-Korean Polytechnic College is considering establishment of new classrooms and improvement of facilities.

9.2.3 Aspect of Demand

(1) Number of Employees in the Mining Sector

As of June 2013, labor population in mining sector in Mongolia is 22,800 persons, which is about 4% of the total labor population in the country and has been decreased by more than half since 2012. According to the study conducted by the Ministry of Mining, about 88% of the companies engaged in mining sector in Mongolia are SMEs, while about 84% of the workers are employed by large companies.



(Source: Ministry of Mining)

Figure 9.2.6 Number of Employees in Mining Sector in Mongolia

Table 9.2.6 Size of Business and Number of Employee in Mining Sector

Scale of mining companies (No. of workers)	No. of companies participated in the study	No. of workers
Large (more than 300)	12 (11.3%)	15,933 (84.0%)
Medium (50 – 299)	20 (18.8%)	1,851 (9.7%)
Small (less than 50)	74 (69.8%)	1,179 (6.2%)
Total	106	18,963
* Of those responded to the study (124 out of 620), 106 companies actually reported on human resources. Remaining 18 companies answered that they were temporarily closed down and not able to report on human resources.		
The number of workers in the companies participated in the study accounts for 83.1% of the labor population in mining sector. For this reason, result of the study can be described that those numbers of workers in mining sector match with the current situation.		

(Source: Ministry of Mining)

(2) Measures Taken by the Mining Industry Group

Mongolian National Mining Association (MNMA) was established in 1994 so as to best safeguard the lawful interests and legitimate benefits of its members by seeking to reflect their voices and concerns in the state policies, provide the member and general public with the most up-to-date and comprehensive information and knowledge on mining industry, and help build lasting and effective cooperation and partnerships for the industry. Since the association does not consider the form of investment as membership requirements, MNMA has the present members of 170 companies, including the foreign companies (30-40%) and NGOs.

The association does not only tell the requests of private organizations to the government as an industry group, but also participates in the policy making and provides advises to the government. For instance, MNMA has sent its members to the working group to revise the mineral resources law and appeal to the government, aiming at positive invitation of the foreign investors over the development of the Tsagaan Suvarga deposit where the consideration of the plan has just been started since 2012. Also, MNMA implements the short-term personnel-management training programs for the member companies.

(3) Measures Taken by Individual Enterprises

(a) Erdenet Mining Corporation

Erdenet Mining Corporation (EMC)[3] was established in 1978 as a joint venture between the governments of Mongolia and Russian (former Soviet Union). It has conducted various types of training programs for its employees within Mongolia and overseas as one of its management focusing topics. Also, the company has established the cooperative relationships with the worldwide companies and expertise in the mining sector, such as Phelps Dodge (United States), Outokumpu Oyj (Finland), Bateman Engineering (Australia), Pacific Ore Technology (Australia), Brook Hunt & Associates (Great Britain), KD Engineering (United States), Samsung (South Korea), etc.

The company's Institute of Technology is the same facility as the campus of the School of Technology of the Mongolian University of Science and Technology at Erdenet, where the educational activities as a compound program of "Training + science + industry," based on preparing mining related engineers is provided. The vocational training courses are provided in the way that corresponds to the requests of Oyu Tolgoi LLC and MAK, as well as the request of Erdenet Mining Corporation.

[3] http://erdenetmc.mn/en/social_responsibility/education/

Table 9.2.7 Overview and Vocational Training Programs of Erdenet Mining Corp.(EMC)

	Erdenet Mining Corporation (EMC)
Overview	• Total number of employees is 5993 and 7.5% (451) is Russian employees. • Spends approx. 3 billion Tg for industrial Human Resource Development annually.
Major training program	• **Oversea higher educational training program**: approx. 150 employees have been sent to study at overseas university (e.g. 108 for undergraduate, 45 for master course and 3 for Ph.D course in year 2013-2014) and Russian is account for 48.7% (76) of total number. • **Domestics higher educational training program**: approx. 90 employees have been sent to domestic University and approx. 59.3% (51) are studying at MUST. • **Managerial training course**: Approx. 100 managerial staff have been sent for 2-3 days short term training courses focusing on human resource development, effectiveness improvement, innovation subjects conducted by Mongolian Productivity Organization • **Vocational training program**: Approx. 1100 employees have been trained at vocational training center such at Orkhon SEPC annually for enhancing technical skill. Orkhon SEPC is funded and operated by Erdenet. • **Special training program**: Some special short term training program are conducted in collaboration with foreign company for installation of new equipment and/or machine at overseas.
Challenges	• How to endure the technology transfer from senior employees to young engineers who are going to retire in coming years.
Future Plan	• HRD Working Group is formed to strengthen HRD initiative which is headed by DGD of Development

(Source: Prepared by Survey Team)

Table 9.2.8 External Training of EMC (Academic year of 2013-2014)

• Agreement with the overseas

No.	Name of country/school	Enhancement of Education	Courses			No. of people
			Bachelor	Master	Doctor	
1	Russia		41	32	3	76
2	The United States		28	9		37
3	China		15			15
4	Turkey		9			9
5	South Korea		4	1		5
6	Britain		2	1		3
7	Singapore		3			3
8	Japan		2			2
9	Germany			1		1
10	Canada			1		1
11	Australia		1			1
12	Portugal		1			1
13	Ukraine		1			1
14	Malaysia		1			1
Subtotal			**108**	**45**	**3**	**156**

• Agreement with domestic schools

No.	Name of country/school	Enhancement of Education	Bachelor	Master	Doctor	No. of people
1	Mongolian University of Science and Technology	3	6	33	9	51
2	National University of Mongolia	1	4	10	3	18
3	Government finance economic university		3	1		4
4	-		3			3
5	-				2	2
6	Shiki khutag law university	2				2
7	Mongolian national teacher university				1	1
8	College of agriculture		1			1
9	Orhon university	1				1
10	-	1				1
11	Mongolian junior college					1
12	TSETSEE Gun Management junior college					1
Subtotal		**8**	**19**	**44**	**15**	**86**
Total		**8**	**127**	**89**	**18**	**242**

(Source: Erdenet Mining Corporation)

(b) Oyu Tolgoi LLC

Oyu Tolgoi LLC is the largest mining company in Mongolia established along with the development project of the Oyu Tolgoi mine which is located in the southern part of Mongolia and is said to be the world's largest mine. It was established upon the conclusion of the project agreement in 2009 between the Mongolian government (34%) and the Rio Tinto Group[4] (66%).

The development plan, however, has been delayed due to the delays in the approval of fund raising.

Table 9.2.9 Overview and Vocational Training Programs of Oyu Tolgoi LLC

	Oyu Tolgoi LLC
Overview	• The largest Mongolian mining company established with the development project of the Oyu Tolgoi mine located in southern Mongolia. • As of December 2013, total of 7,079 Mongolians are employed at Oyu Tolgoi project (including employees of related companies). 2,619 (about 95% of the total) are employed by Oyu Tolgoi LLC (91% are Mongolians). Most of those employees are newly graduated, so the company provides necessary trainings prior to their practical works (especially for the newest technology and handling of new machines used at the company) to improve the employees' skills. • Since 2011, it started to provide training activities aiming at improving the health and environmental activities, productivity, provision of fundamental mine-related information to new employees, knowledge and skills of expert staffs, etc.
Major training program	• The company provides the technical training program for the 7 specialized field (Condenser operator, electrical engineer, mechanical engineer, commercial trade, welding, heavy machinery operator, heavy machinery mechanic), with the cooperation with other domestic vocational training institutions and with the Australian company. • There are 3 curriculums (Labor, Safety, and Health) provided for each trainee. Using the actual machines and simulation facilities, appropriate training programs, OJT, and testing of skills are conducted. • Invest about 110 billion MNT (US$85 million) in training and education over the next 5 years. This total includes a commitment to invest 78 billion MNT (US$58 million) as agreed in a MoU signed between Oyu Tolgoi and the Ministry of Education and Science in June 2010. ➢ Establishment of training facilities at the Oyu Tolgoi site and a training center in Khanbogd soum. (US$30 million) ➢ Construct 2 universities equipped to international standards in Nalaikh and Dalanzadgad ➢ Upgrading of 5 educational centres and colleges in Ulaanbaatar, Erdenet, Dalanzadgad, Darkhan, and Choir (US$8 million) ➢ Establishment of 2 mining-focused professional training centers near the cities of Dalanzadgad and Nalaikh (up to US$11.5 million) ➢ Scholarship program for 200 students studying at Mongolian universities and 30 students studying overseas in mining-related fields (US$10 million) ➢ Full financial support for 3,300 Mongolians being trained in 18 different industrial sectors at 42 Technical and Vocational Education and Training schools ➢ Supplying of education and training equipment (worth 3.5 billion MNT) to schools across Mongolia. As part of this commitment, 30 welding simulators (worth 1 billion MNT) have already been delivered to 25 Technical and Vocational Education and Training schools ➢ Additional 25 schools will be equipped with training equipment, modern technology, electronic libraries, textbooks and other training materials.
Future Plan	• Deliver the Mongolian workforce a solid base of highly skilled professionals and tradespersons in the areas of HME Mechanic, Operation of heavy equipment, Human resources & training, Fixed plant mechanic, Health & safety, Mining, Environmental studies, Metallurgy, Accounting and economics, Geology, Warehousing, IT, Asset management.

(Source: Prepared by Survey Team)

[4] World's second largest resource major company (listed on UK and Australia)

(c) Mongolian Alt Corporation

Mongolian Alt Corporation (MAK) is one of the largest private mine companies in Mongolia established in 1993. The Tsagaan Suvarga deposit that the company is developing is located about 530 kilometers south from the capital Ulaanbaatar and the eastern part of the Gobi regions. This deposited was discovered by local residents in 1964, and the former Soviet Union conducted the geological survey from 1965 to 1973.

In the Tsagaan Suvarga deposit development project, the Mongolian government and MAK have 50% of rights and interests respectively. Due to that the participation of the government is quite large, delay of the project is concerned.

Aiming at actively developing the specialized human resources and employing those in the future, MAK is focusing on making investment for developing the specialized human resources in domestic and foreign educational institutions. As of 2008, the company is providing the scholarship program for 20 students (10 studying in domestic educational institutions, and 10 studying in Russia, China, the United States, and Japan. The company has also selected 7 students who graduated from the high school near the copper mine of its own management, sent to the Saint Petersburg State Mining Institute and Technical University in Russia, and employee at the company upon the completion of the baccalaureate degree program and return to Mongolia.

9.3 Challenges on Industrial Human Resource Development in Mining Sector

In this chapter, the challenge on the policy side, the supply side, and the demand side is extracted through analyses of present state of the industrial human resource development in the mining industry sector of Mongolia, and the analysis for the strategy consideration is done.

When the main challenge item is organized before it goes into the detail, it is as follows.

First of all, major challenges on the policy side are the following four items: (1) The system of human resources development became non-functional, because it was left to the private sector after the democratization; (2) Policy collaboration among ministries is insufficient, because there are two or more presiding ministries exist; (3) The enrollment limit of industrial human resources allocated by the government does not match with the actual needs of the market; and (4) The supporting policies for promoting the industry-academics cooperation are not enough.

Next, major challenges on the supply side are the following four items: (1) There are mismatches between the demand and supply of human resources (for example, there is not refinery-related course as needed by the industry) ; (2) There are shortages of teaching staffs and laboratories due to the financial difficulties; (3) The curriculum tends to be obsolete; and (4) There are few opportunities for the students of mine major to have relevant practical trainings.

Finally, major challenges on the demand side are the following three items: (1) There are shortages of the high-skilled Mongolian engineers and managers; (2) Many of the small and medium-sized mine-related companies are not able to conduct in-house trainings, due to the financial reasons; and (3) Many of the mine-related companies are experiencing the shortages of know-how and facility for conducting in-house R&D.

9.3.1 Aspect of Policy

(1) Non-functional of the System of human Resources Development

The multiparty system was introduced in Mongolia in 1990 and socialism was practically abandoned. However, the operation of the Erdenet mine got on the right track in around 1978 under the planned economy, the period when the National Development Plan was developed along the five-year plan. Therefore, the factory establishment plan and associated issues, such as engineers, industrial needs for the development of human resources, relevant systems, etc. were clear and foreseeable.

Under such situation, human resources development was implemented by sending necessary personnel to the Union of Soviet Socialist Republics (former Soviet Union) , a country which Mongolia had a cooperative partnership with at that time.

However, the government changed the mineral resources policy with the democratization to promote the import which costs lower compared to the domestic production. Therefore, because it politically decreased the development measure of engineers (technical engineers and specialists) etc., the machining process of the mining industry sector was declined especially,.

Moreover, the problem on the organization institutional system can be pointed out. That is, the industrial human resource development under the jurisdiction of the Ministry of Education and Science, and this ministry also has a jurisdiction over the human resources development of the mining industry sector. Therefore, the Ministry of Mining cannot grip the needs of the industrial human resource development, and the human resources development institutions such as universities individually develop and conduct their human resource development plans based on their own prediction.

Under such situation and reflecting the prosperous mining industry in recent years, the vocational training centers have been established since 2-3 years ago, and the signs of improvement of the situation can be seen.

(2) Insufficient Policy Collaboration among Ministries

Under the human resource development system in Mongolia, the Ministry of Education and Science has a jurisdiction over the primary-, middle-, and higher education, while the Ministry of Labor has a jurisdiction over the technical colleges. Moreover, each ministry agencies such as the Ministry of Mining and the Ministry of Construction and Urban Planning give the professional licenses accordingly. With regard to the measures associated with the employment, the Ministry of Education and Science has a jurisdiction over the development of advanced-skilled engineers and managers, while the Ministry of Labor has a jurisdiction over the employment of common workers.

The report of the interagency exists, and however, it is insufficient and so-called the problem of the vertical administrative structure exists. For instance, because a mechanism the ministries horizontal doesn't exist, a related policy is hardly adjusted though the mining engineer's promotion, security, and the problem of the environmental response etc. are challenges with which it should grapple the ministries horizontal.

For instance, a smelter, which belongs to a facility of heavy industry and also of mining industry, is managed by both the Ministry of Mining and the Ministry of Industry and Agriculture but not managed cooperatively, leading to the so-called double administration. For that reason, construction plan of a smelter has been considered individually by a government-owned mine company, as well as by relevant working groups established by each ministry, without the interministerial collaboration.

Similar examples can be seen and to solve this problem, a new legal framework must be established to promote the plan in a horizontal manner.

(3) Capacity Quotas that do not match to the Actual Needs of the Market

The Mongolia government is working out the plan to create novel employment of 150,000 people for the period of 2012 - 2016. According to the result in 2013, about 52,000 people were newly employed. The construction sector created the greatest portion of the new employment: 23% (about 12,000 people), and the mining industry sector created 4.3% (2,256 people).

The kind and the number of necessary personnel are done to the human resources development based on the list that the government appropriates every year (quota system). The list includes 39 occupational categories that needs to develop the specialists, but does not include the specialists of copper smelter and does not match the actual needs of the market.

(4) Shortage of Supporting Policies to the Industry-academics Cooperation Promotion

The human resources development of the refinement and processing sector is indispensable to achieve the upgrade of the mining industry sector of Mongolia. However, the craftsman on the site such as the beneficiation and the smelting engineers invites because the education according to such industry needs is not done in the higher education institution and the shortfall invites the situation of working.

As a background of such situation of the industry-academics cooperation, there is a problem of the vertical administrative structure. For instance, the Ministry of Education and Science is responsible for the curriculum of national universities, and that is causing some problem in promptly reflecting the industrial needs of human resources.

Another example is the lack of smoothness in promoting the industry-university joint project, because the financial independence of national universities is not approved. For instance, a research expense sponsored and paid by the private company is collected not by the university conducted the research but by the country.

The development of the legal environment such as drastic improvement of the educational curriculum for the industry development and revision of the mining education act is necessary for improving such situation.

Additionally, as an example of the industry-academics cooperation, there are some cases where private companies are developing internal human resources through OJT, and where local government manages and operates the vocational training school near the mine to develop high-skilled engineers, .

9.3.2 Supply Side

(1) Mismatching of Talent Supply and Demand

The mismatching is caused in the industrial area of Mongolia between the needs of the human resources whom the mine companies are requesting and the human resources developed at the universities. In this situation, the industry is voluntarily conducting the additional educational trainings for the skills needed in the industry.

There are also additional education and training program implemented by the industry: (1) education and practical training (OJT) at the company sites; (2) in-house training program; and (3) in-house educational training program provided by university teachers for the employees to develop necessary skills.

For instance, as an example of (1) and (3), lectures are offered by teachers of the Mongolian University of Science and Technology (MUST) who visit to the mine, and as an example of (2), 3-week re-education program for mine engineers and technicians to teach and certify the qualifications for professional engineers and consultant engineers .

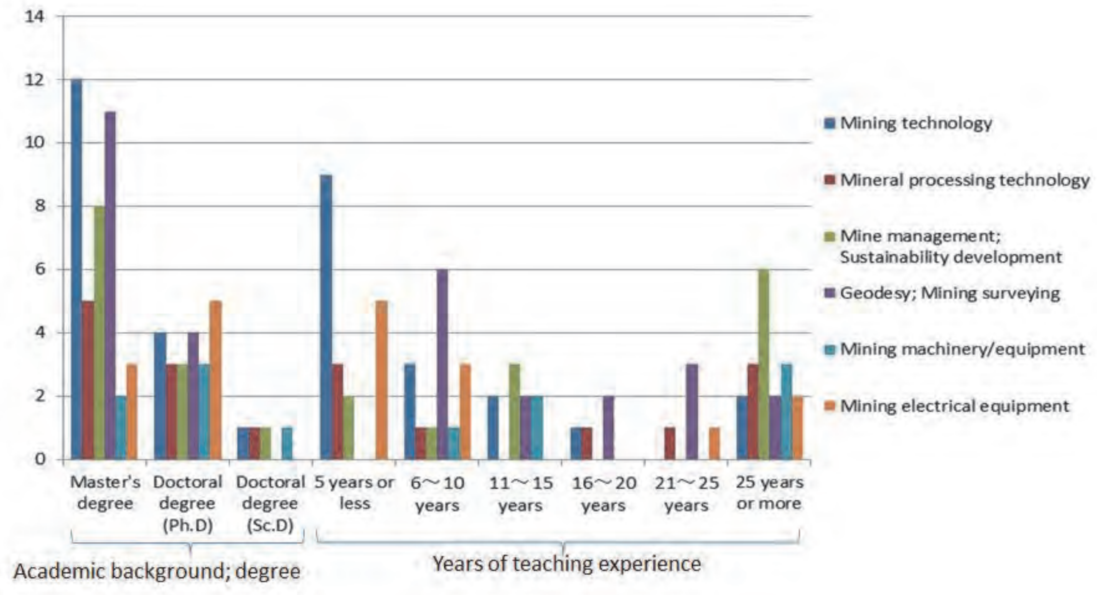
However, in Mongolia, there are currently no teachers, teaching materials, nor practice sites necessary for developing the human resources, because neither coal preparation nor copper refining are implemented in the country, even though there are growing needs for those technicians and experts.

Therefore, in order to enable the high-skilled human resources development within the country, the country must firstly dispatch the excellent students to be educated and trained at the foreign smelters or universities, then hire those graduates as the teachers of domestic universities.

(2) Shortage of Teachers and Laboratories due to Financial Difficulties

MUST is a university that starts the mineral resources sector for the first time in Mongolia, and other universities are established referring to the curriculum of MUST. Therefore, the level of the entire mineral resources sector in Mongolia might decrease if no do reinforcement of the teacher talent of MUST.

Looking at the situation of MUST, 42.5% of the teachers have the Master's degrees or higher, and there seem to be no problem in this respect. However, 80% of the operating costs of this university (including the faculty's salaries) are covered by tuition fees collected from students, which are not managed by the university but the country. For that reason, the university has difficulty in procuring the fund for strengthening its original teaching material.



(Source: Mongolian University of Science & Technology)

Figure 9.3.1 Teachers of the Mining Engineering School (MES), Mongolian University of Science and Technology (MUST)

(a) Shortage of the Facilities such as Universities

The building of MUST is a national property, and not the university but the government is bearing the maintenance expense and light and fuel expenses. However, it is not appropriate as a structure for providing lectures and conducting experiments, because the building of the university was built in the socialist age and was not originally designed as a school. Moreover, the facility has not been improved in accordance with an increase of the number of students in recent years. It was 4,000-5,000 students in the 1990's and has been increased by 8 times to 36,000 students. Therefore, the number of classrooms to offer lectures has been seriously deficient.

As a correspondence to such situation, the Mongolian government has decided to construct a new campus at the location of 120km from Ulaanbaatar. The industry park will be also constructed around the scheduled site.

It is assumed that a modern educational program can be provided if a new campus is constructed. The mine department of the university is preparing a plan for the teaching materials, classrooms, laboratories, etc. that will be necessary for offering the better, more appropriate programs.

(b) Shortage of the Facility at the Vocational Training Centers

In addition to the aging of classrooms and buildings of the vocational training centers constructed in

1960-70's, there is also a problem with inappropriate or out-of-date contents of the teaching material. Moreover, the environment for developing highly-skilled experts and engineers is not sufficient, due to the lack of capacities and expertise of teachers.

(3) Trend of the Curriculum to become Obsolete

Each university makes its curriculum every five years. However, once the curriculum is created, it will not be reviewed or changed easily for the next five years. For that reason, it is in fact very difficult to provide the curriculum that promptly corresponds to the industry's needs of the human resources.

(4) Lack of Opportunities for the Mine Major to have Mine-related Practical Rrainings

Most of the mines are managed by the private companies in Mongolia, and are not active in accepting interns from the universities. Therefore, there are only few places for the students to practice.

The reasons that the private companies are not active in accepting the student apprentices (interns) include (1) the employees must take care of the interns and as a result the productivity of a company will be decreased, and (2) the intern may produces a loss for a company in case where injury or incident is occurred, because the intern has no certification required for an actual practice.

Moreover, there is also a reason that a company is negative about accepting the interns, because most of the students will be concentrated to work as interns at the private companies during the period from June to August, when they have no academic classes (academic classes are held during the period from September till June next year).

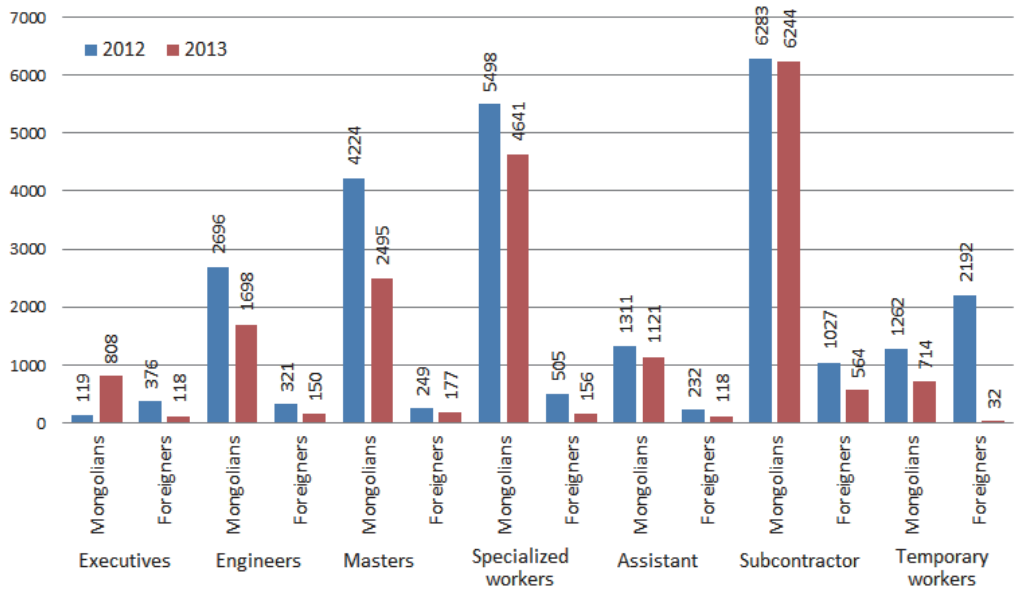
Under a socialist system before, students were allowed by the Ministry of Mining to have field trainings at any of the mine companies in Mongolia. However, because the private companies are negative about conducting, the field trainings, as stated above they currently conduct the field trainings only slightly as part of their CSR activities. Under the present situation, though the students of MUST voluntarily find the companies to work as interns and the university also tries to request the companies, there are still very few opportunities for students to have the field training.

9.3.3 Aspect of Demand

(1) Shortage of High-skilled Mongolian Engineers and Managers

Looking at the break-downs of the Mongolians and foreigners at the mining companies in Mongolia, most of the key posts such as executives and engineers are still occupied by foreigners, although the ratio of foreigners has been decreased in recent years (Figure 9.3.2).

The mine-related companies themselves, as the demand-side, are responding to the issue of shortage of industrial human resources. However, they are also facing the issues, such as for small and medium-sized mine-related companies are often difficult to conduct in-house trainings, for a financial reason and shortage of know-how or facility to provide R&D.



(Source: Ministry of Mining)

Figure 9.3.2 Workplace Classification in Mining Sector in Mongolia

9.4 Future Directions on Industrial Human Resource Development in Mining Sector

In this chapter, the consequence of the challenge analysis on the industrialist material promotion in the mining industry field in Mongolia is assumed to be a base, do the study of the polarity of the countermeasure on the policy side, the supply side, and the demand side, and this is specifically presented as a road map.

9.4.1 Aspect of Policy

As a basic direction in terms of policy side, the following four items can be proposed.

(1) Enhancement of the cooperation between policies by the task forces established in relevant ministries
(2) Enhancement of the policy making capacity building of the persons in relevant ministries
(3) Introduction of support policy for promoting industry-academics cooperation in mine field

(4) Introduction of subsidy system for a joint research with overseas universities and laboratories.

With regard to (3) of the above-stated four items, the Mongolian government has already provided the supports for the mining sector as a priority field through the scholarships and tuition assistances ,. Having confirmed the importance of those supports from this sturdy, we propose the provision of further supports.

For (4), two cases are important: The case of cooperation between the Mongolian University of Science and Technology (MUST) and the overseas universities and the case of program implemented by Japan International Cooperation Agency.

Regarding the former case, MUST is conducting joint curriculums with the United States (University of Arizona and University of Alaska), Germany (Barbara University), and China (Shandong University of Science and Technology). To develop the specialists in a short period of time, cooperation with overseas universities will be one of the most effective procedures..

Regarding the latter case, as part of "Industrial higher-education program" by Japan International Cooperation Agency (JICA)[5], the twinning program[6] at the universities in Japan, the study abroad programs at the technical colleges in Japan, and the teacher's Ph.D. certificate acquisition courses for are currently implemented. For instance, a student can spend two years for basic studies at an university in Mongolia, and then spend another two years remained for studying in the particular field at an university in Japan.

Additionally, another typical example is JICA's human resource development program for the mining sector (commonly called "Natural Resources Kizuna Program"), aimed at the assistance of sustainable mining resources development in the developing countries through ODA. Under this program, various activities are implemented for the practical officials of mining administration (including administrator, engineer, investigative agent, employee of the public corporation, etc.), faculty and researchers in the developing countries which have high production potential of important mineral resources, to improve academic and practical capabilities, to exchange and form personal relationships with the industrial and academic stakeholders in the Japanese mining sector, and to conduct overseas field studies. From 2015, new acceptance of 20~30 people are planned every year, with a goal of having more than 200 people in 10 years.

---

[5] ODA loan with the total amount of 7.5 million USD; signed on March 11, 2014; project implementation period from 2014 through 2023; plan to provide exchanges of the total of 1,000 persons

[6] Program that enables a student to study at two or more universities in different countries (Japan and Mongolia) and complete the courses necessary for a degree in 4 years

MUST is now proposing JICA with the plan for conducting the joint curriculum related to the smelting with Akita University's Faculty of Engineering and Resource Science, and the joint curriculum related to the underground mining with Kyushu University.

9.4.2 Supply Side

As a basic direction in terms of supply side, the following three items can be proposed.

(1) Improvement of the quality level of teachers through the cooperation with higher- education institutions in Japan
(2) Re-edition of curriculums through the periodic conversations with mine-related industry
(3) Improvement of the vocational training institutions through the use of former high-skill employees of mine companies in Japan.

With regard to (1) of the above, the use of "Higher Engineering Education Development Project," in which the Ministry of Education and Science of Mongolia and JICA concluded the ODA loan agreement (L/A) (signed March 11, 2014), is hoped as the scheme of developing advanced human resources to be promoted for the mining industry field.

Although this program has been currently limited to two schools (Mongolian University of Science and Technology (MUST) and National University of Mongolia (NUM)), development of mining engineers and also development and capacity improvement of instructors and teachers necessary in developing high-skilled specialists is strongly expected through the exchange of students in mining sector to the universities in Japan.

The Mongolia Ministry of Labor chooses the professional human resources in the mining industry field from the 7,000 engineers with the advanced knowledge among those 23,000 attendees of the vocational training program on which it has implemented so far and provides them appropriate trainings in Japan. It should be noted that the needs of Mongolia and the assistance being provided by our country has been matched very well.

9.4.3 Demand Side

As a basic direction in terms of demand side, the following three items can be proposed.

(1) Appeal for the introduction of incentive system for developing human resources for the Mongolian government
(2) Development of in-house/external training system at mine-related companies

(3) Improvement of the industry's coordinating ability through the capacity building program implemented for the industry group.

Among the above items, (1) is the one which private sector appeals for the government to establish the Human Resources Development Fund (HRDF).

The above (2) is to enable the provision of education that promptly and appropriately reflects the industrial needs for developing high-skilled industrial human resources by strengthening the in-house/external training system, instead of outsourcing with the use of educational training institutions, such as SEPCs.

(3) is aiming at improving the capacities of industry groups such as MNMA to summarize the requests and coordinate opinions of member companies, to create a draft, to propose for and coordinate with the government, in order to strengthening the cooperation between the policy sectors and actual operating companies.

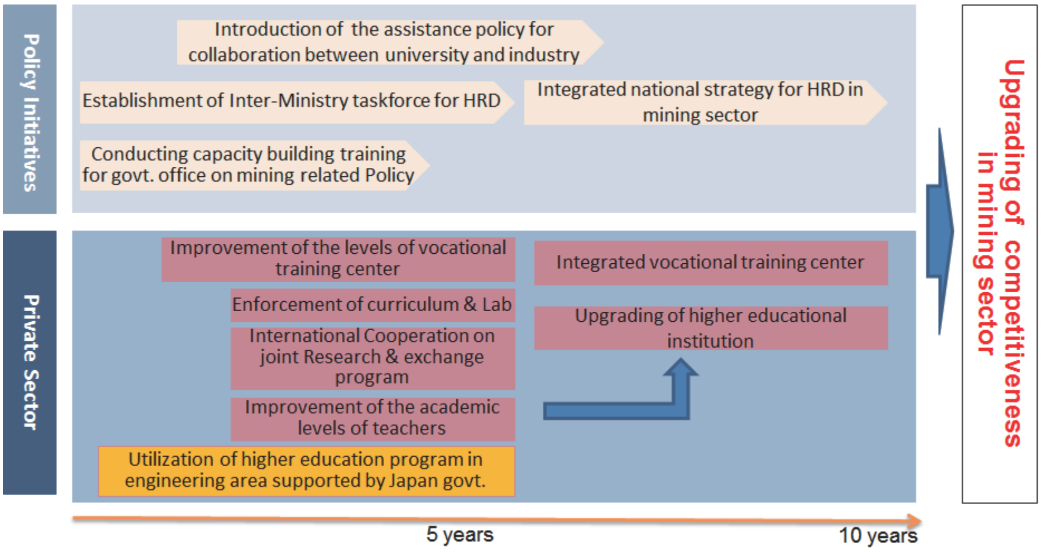
9.4.4 Road map of industrialist material promotion upgrade in mining industry field

It is necessary to conduct the development of industrial human resources under the positive cooperation between the government and private sectors in a way that is integrated and gradual method.

For example, the development of the curriculum can be more effective with the mutual collaboration among relevant ministries (Ministry of Mining, Ministry of Industry and Agriculture, Ministry of Education and Science, Ministry of Labor, etc.), educational institutions (MUST, NUM, SEPT, etc.), mining-related companies (Erdenet Mining Company, Oyu Tolgoi Co., MAK Co., SMEs, MNMA, etc.), compared to each of the above tries to individually implement.

This can be the same in other cases. For instance, in the case of developing hard infrastructure (such as classrooms and facilities) or soft infrastructure (such as teachers), mutual and cross-sectional collaboration in promoting the project with a view of industrial value chain as a whole, instead of each player promotes the project individually, will be preferred required.

From the intent mentioned above, the following roadmap shows the development of industrial engineers and related human resources in mining industry, including copper industry in Mongolia.



(Source: Prepared by Survey Team)

Figure 9.4.1 Roadmap for Upgrading of Industrial Human Resource Development in Mining Sector

For the first five years of this road map, the private and policy sectors stay in step with one another. The private sector tries to improve the level of vocational training centers, while the policy sector introduces an assistant measure aiming at the industry-academia partnership.

Through the utilization of higher education program in engineering area supported by the Japanese government, the private sector will strengthen the curriculum and laboratories, promote the international cooperation such as cooperative studies and exchange programs, and improve the level of vocational training centers.

On the other hand, the policy sector will conduct training of policymaking capacity building for the government officers and will realize the effective and efficient human resource development administration, as well as establishing the interagency taskforce for the human resource development and developing the foundation of cross-sectional approach.

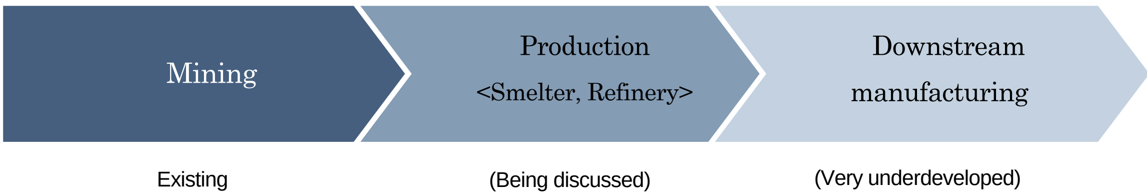
Under such environmental arrangement, introduction of an assistant measure for the cooperation between universities and industries should be promoted.
Also, for the following 5 year, the private sector will promote the advancement of higher educational institutes, establish new integrated development center for the human resources, looking at the whole mining industry value-chain.

The policy sector will also establish an integrated national strategy for developing human resources in the mining industry and realize the sustainable development of the mining industry in Mongolia.

Chapter 10. Promotion of Investment in Mongolian Mining Sector

10.1 Introduction

The figure below shows a simple flow of the mining industry. Basically, the minerals are and mined, concentrated, then they are smelted and refined. The resulting products are then used in industries downstream. However, in Mongolia, copper related industries almost cover only the mining part. Full-scale refining of copper has not been carried out. In addition, downstream manufacturing industries have been seriously underdeveloped.



(Source: Prepared by Survey Team)

Figure 10.1.1 Simplified Flow of the Mining Industry

In this chapter, current situation and issues of the investment climate in Mongolia's mining sector are analyzed from the viewpoint of soft and hard infrastructure.

- Soft infrastructure
  - Mining-related laws and regulations
  - Investment laws and tax systems
- Hard infrastructures (transport network, electricity, water etc.)

Next, inherent issues of the copper industry in Mongolia, including hurdles in constructing a copper smelter, are analyzed.

Finally, recommendations to promote investment in Mongolia's mining sector are presented. Recommendations for the copper sector are also presented with consideration to the downstream manufacture industry.

10.2 Current Situation and Issues of the Investment Climate in Mongolia's Mining Sector

10.2.1 Soft Infrastructure

Governing agencies, laws and regulations etc. related to the Mongolia mining sector are summarized in the table below.

Table 10.2.1 Basic Information Regarding Mongolia's Mining Sector

Governing Agencies	Ministry of Mining, Ministry of Industry and Agriculture, Ministry of Economic Development, Foreign Investment Agency
Mining-related regulations	Mining Resources Law
Royalties	Foreign export: 5% of export value + additional royalty depending on international market price and the level of processing Domestic sales: 2.5% of sales value for fuel carbon and general coal, 5% for other minerals
Foreign Investment Law	Foreign Investment Law Foreign Investment Regulation (regulation to facilitate foreign investment by companies engaging in strategic areas) (enacted on 2012/5/17, revised on 2013/4/19)
Mining companies (state-owned)	Erdenes MGL, Erdenes Oyu Tolgoi, Erdenes Tavan Tolgoi, Erdenet (Mongolia 51%, Russia 49%), Mongol Rosstsevtment (Mongolia 51%, Russia 49%)
Operating private mining companies	Ivanhoe (Canadian), Rio Tinto (English), Areva (French)
Recent mining-related issues	Revision of Mining Resources Law (the President Office of Mongolia drafted and publicized the law revision on December 2012, and the revised law was approved by the National Assembly on July 1st, 2014). Infrastructures such as railway, electricity and water are undeveloped Issues regarding the development of Oyu Tolgoi Copper Mine (increase of Mongolian government's interests, introduction of progressive royalty, etc.) Trouble with the bidding for the Tavan Tolgoi mine development (the democratic government elected in June 2016 didn't accept the bidding result of previous government)

(Source: World mining industry 2013 (Monglia) (by JOGMEC))

(1) Mining Resources Law-related Issues

Regarding the mining resource law, a proposal for with changes was presented in December 2012. The revised draft been discussed at the National Assembly, and was approved on July 1st, 2014. In this revised law, there are a number of adverse changes for investors which may affect their decisions to expand or newly invest in the future.

The revisions in question are as follows.

- Condition to acquire mining rights becomes stricter. For example, the percentage held by of Mongolian nationality is raised.
- Regarding strategic mine deposits, investors used to be able to sign “stable contract” with the Mongolian government. However, the Mongolian government will not sign “stable contracts” anymore.
- Mine owners have to sign “cooperative agreement” with the government before actually mining. The initial period of this cooperative agreement is the same with return period of initial investment. However, after this cooperative agreement ends, the Mongolian government can renegotiate better condition for their side. In addition, in case Mongolia’s regulations are revised, the content of the cooperative agreement can also be revised. This revision will add more risk on the investors.
- More commitments are now being required from investors to contribute to the domestic development. For example, when mining, investors have to put priority to buy local companies’ products and services, or set up mineral resources exchanges to sell mined resources under market price.

(2) Investment Law and Taxing System-related Issues

The current royalty for export of copper are high and does not take into account non-production-related costs, such as transportation, insurance. In addition, Mongolia’s royalty is adjusted based on the international price, which can be volatile. This approach puts more risk in the investor side. Specifically, royalty for concentrate copper export is 5% base plus additional tax based on international copper price and the level of refinery (13-15%).

As shown in Figure 10.2.1, more and more countries are adopting the profit-based tax regime. The differences with a production-based one are that, in the profit-based tax regime, the state and the extractive corporation share the risk more evenly than in a production-based one and having better economic allocative efficiency (meaning the mining activity is less affected by change in unit tax).

Source: Mineral royalties and other mining-specific taxes (by International Mining for Development Centre, Australia)

(Source: "Mineral royalties and other mining-specific taxes" (International Mining for Development Center, Australia))

Figure 10.2.1 Qualitative Assessment of the Performance of Various Royalties/taxation Types with Regard for the Government's Fiscal Objectives

10.2.2 Hard Infrastructure

(1) Underdeveloped Transportation Network

As a landlocked country, Mongolia has to rely mostly on land transport to carry its mineral products. However, it lacks an efficient transport network to export large volume of goods to neighboring countries. The result is that a large portion of the sales has to cover for the high transport cost, reducing the profit for mining companies as well as tax revenue for Mongolia. According to a study, Mongolia currently spends a high 15% of its export sales on transport services, while its neighbors spend on average less than 6% in transit.

With the additional mining output to China, the existing single track railway linking Russia to China through Ulaanbaatar has become insufficient to transport all the available freight, which led to the rapid increase of road transport. As shown in the following table, while rail transport only increased less than 30% in 4 years (2007-2011), road transport increase 180%, mostly due to the increased transport of minerals.

Table 10.2.2 Transportation Statistics for Mongolia

	2007	2008	2009	2010	2011
Freight (Thousand tones)	23,281.6	23,904.4	24,729.7	29,415.9	43,956.6
By Rail	14,072.6	14,646.9	14,164.5	16,753.2	18,327.4
By Road	9,207.1	9,255.7	10,563.8	12,610.2	25,635.3
By Air	1,887.2	1,847.0	1,369.3	1,641.6	2,930.9

(Source: National Statistical Yearbook 2011, Mongolia)

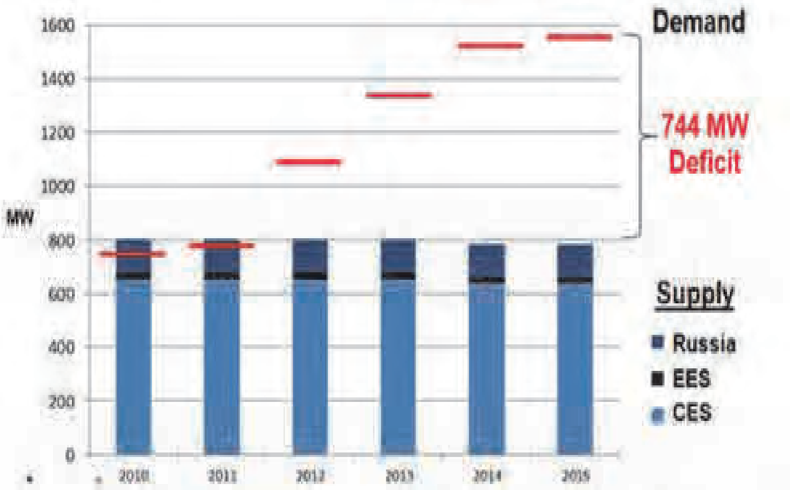
However, the increase of road transport has resulted in the degradation of road condition. This issue reduces the efficiency of road transport.

(Source: Pictures taken by Investigation Team)

Photo 10.2.1 Pictures of Road Condition between Ulaanbaatar and Darkhan.

(2) Insufficient Electricity and Water Supply

Power supply is insufficient in mining areas in Mongolia. According to a report in 2012, a 744MW electricity deficit will occur by 2015 if a powerful new source of electricity production is not developed (see figure below). To address this problem, mining companies have to invest a lot of capita to secure necessary power for production. The same goes for the planned copper smelter as it is being planned in an area without sufficient power supply.



Note: International Corporation, Prophecy Coal Corp (TSX: PCY)

(Source: CES－Central Energy System, EES-Eastern Energy System)

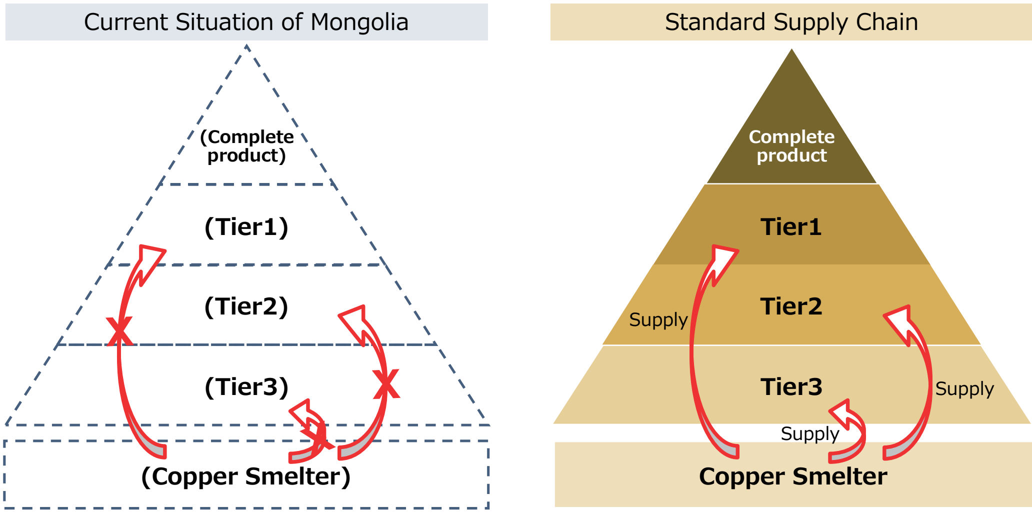
Figure 10.2.2 Prediction of Power Supply and Demand in Mongolia

In addition, water supply is also insufficient in mining areas in Mongolia, causing problem for mining companies which have to invest more to secure necessary power for production. The same goes for the planned copper smelter as it is being planned in an area without sufficient water supply.

10.3 Inherent Issues of the Copper Industry in Mongolia

(1) Inherent Issues Regarding the Copper Industry in Mongolia

Generally, investment in copper smelters makes business sense when the refined copper can be supplied to downstream suppliers in a standard supply chain. However, as such a complete supply chain doesn’t exist in Mongolia, there is not a significant domestic market for the copper produced by the smelters. This in turn leads to the need to rely on the international market which tends to be very competitive and volatile.



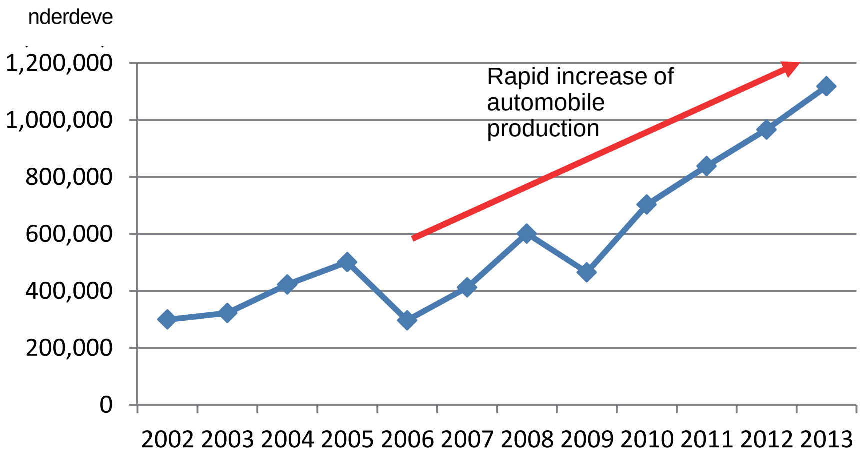
(Source: Prepared by Survey Team)

Figure 10.3.1 Comparison between a Standard Supply Chain and the Current Situation in Mongolia

(2) Case Study of Other Countries and Indications for Mongolia

(a) Indonesia

Indonesia Copper Smelting Co., (or PTS) operates the largest copper smelter among Southeast Asian countries. The PTS copper smelters started operation in 1999 and enjoyed success due to the booming needs for copper products from local manufactures, especially in the automobile and motor bikes segments. In order to tap into the local needs, many foreign companies, including Japanese ones, not only the assemblers but also the part suppliers, set up their factories in Indonesia and formed a more and more complete supply chain. This supply chain provides a stable domestic market for the PTS copper smelter, and justifies the initial investment in the development of this copper smelter.



(Source: Marklines)

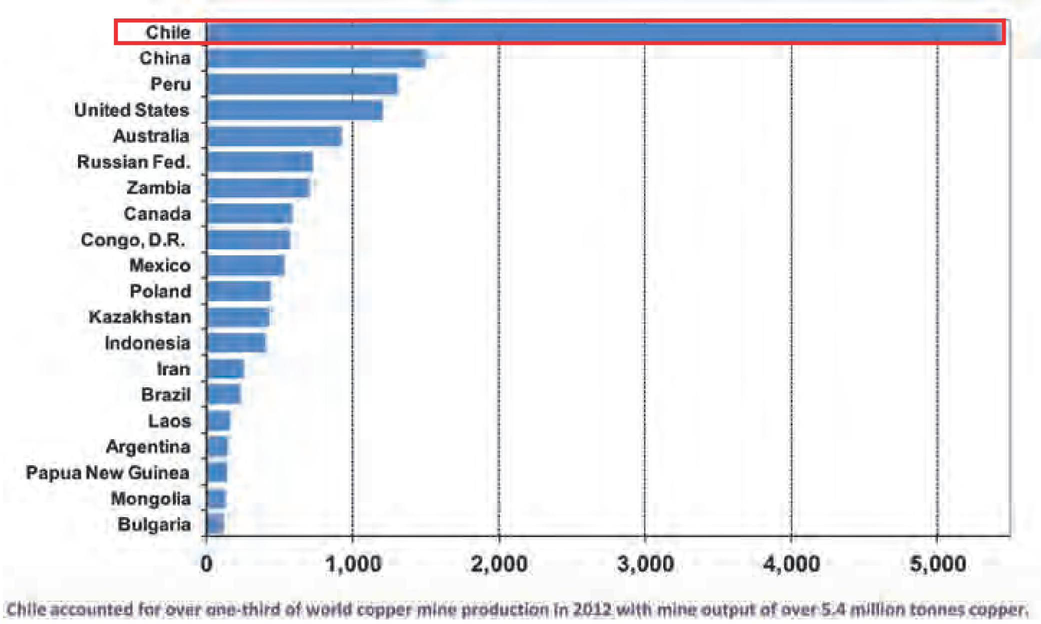
Figure 10.3.2 Trend of Production of Automobile in Indonesia

However, the population of Indonesia is 240 million people, roughly 100 times of Mongolia. Their domestic market is a big attraction to foreign investors to manufacture in Indonesia. On the other hand, Mongolia might find it difficult to attract the same type of companies due to its relatively small market.

(b) Chile

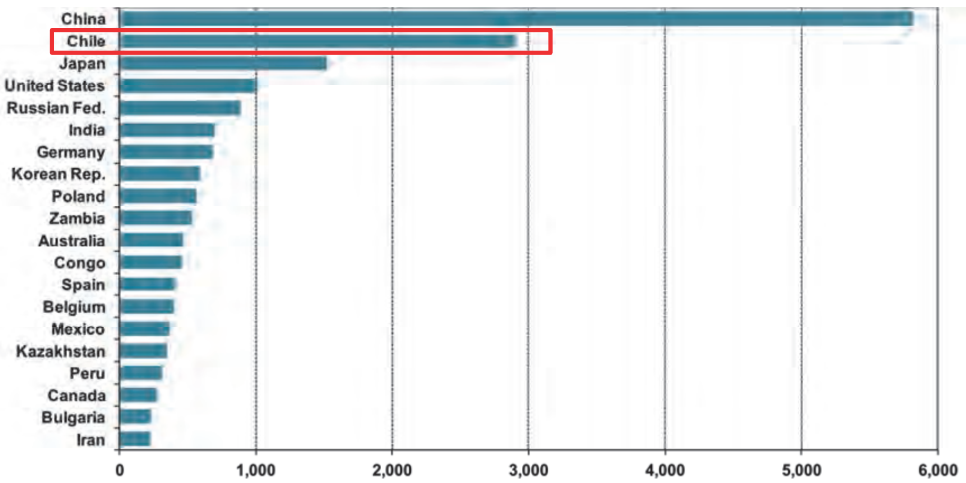
Chile is the world's largest copper producer. It has approximately 24% of the world's known copper reserves (see figure below). It also has copper smelters operating domestically, producing 11% of the world's copper metal. However, unlike Indonesia, a large portion of its refined copper are exported to countries such as China, Japan etc. due to its convenience access of sea transport (see figure below).

On the other hand, Mongolia, as a landlocked country, wouldn't find it easy to transport its refined copper to other countries. It might have to depend only on China, which can be a risky strategy.



(Source: The World Copper Factbook 2013)

Figure 10.3.3 Copper Mine Production by Country in 2012 (unit: 1000 t)



(Source: The World Copper Factbook 2013)

Figure 10.3.4 Refined Copper Production by Country in 2012 (unit: 1000 t)

10.4 Recommendations to Promote Investment in Mongolia's Mining Sector

10.4.1 Soft Infrastructure

(1) Recommendation to Address Mining Resources Law-related Issues

Recommendations for the improvement of the mining-related investment climate of Mongolia are summarized below.

- **Relax strict condition to obtain mining rights**
  Relax the requirement of interest ratio of Mongolian nationality so that it is easier for foreign company to enter the Mongolian market.
- **Revive the Cooperative Agreement system**
  Revive the cooperative agreement system for especially important strategic deposits so that the investors can have more confidence in the project.
  Ensure that the agreements between investors and the government are not revised due to change of legislation changes or government.
- **Keep a right balance between condition for contribution to local market and investors' operation**
  The importance of mining investors contributing to the local market is acknowledged. However, in order not to have negative effect on investors' business, a right balance between condition for contribution to local market and investors' operation should be considered.

(2) Recommendation to address investment law and taxing system-related issues

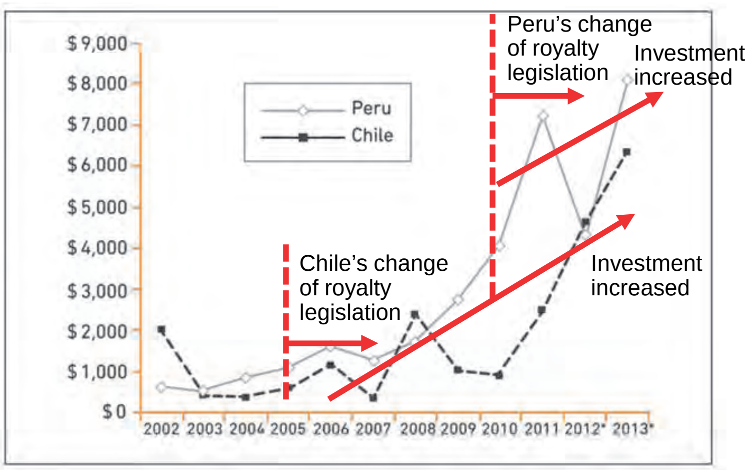
To address the dissatisfaction from investors about the royalty for export, Mongolia can consider the following approaches to attract more investors into the mining sector:

- Make use of actual volumes and values rather than deemed prices
- Net Smelter Return approach that allows an adjustment in the value basis for certain non-production-related expenses such as transportation, handling, and insurance.
- Use profit or income-based royalty.
- Forgoing the royalty and adjust the income tax.

The case studies of Chile and Peru will be presented here to support the recommendation of employing the profit-based royalty method.

Chile has increased its profit-based royalties and income tax from 17% to 20% as well as. Peru has followed this trend by increasing its profit-based royalties. Investors have accepted the overall increase in tax burden in exchange for a fiscal stability agreement offered by the two governments. The benefit of this approach is that in a profit-based tax regime, the state and the extractive corporation both share the risk more evenly than in a production-based one.

Profit-based tax regimes do not appear to discourage, but rather encourage, mining investment. A clear indicator comes from the performance of Chile and Peru: increases in profit-based taxes and the shift from production-based to profit-based royalties through legislation introduced in Chile in 2005 and Peru in 2010 has had no impact yet on private investment flows in these countries (see figure below).



(Source: Profit-based versus production-based tax regimes: Latin America's experience)

Figure 10.4.1 Private Mining Investment in Chile and Peru (unit: million US$)

10.4.2 Recommendation to Address Infrastructure-related Issues

(1) Recommendation for Transportation Network Issues

As a landlocked country, one option for Mongolia to efficiently increase its capacity of exporting mineral products is to expand its freight railway network (see Figure 10.4.2) and road network.

(Source: Enhancing Northeast Asia and Mongolia Economic Cooperation through Transport Network Development, 2013)

Figure 10.4.2 Railway Network Development Plan of Mongolia

One example for Mongolia to consider is the case of South Africa. One of the reasons that South Africa, which also possesses vast land like Mongolia, can be a major exporter in the world is because they have built an expansive freight network connecting to domestic ports as well as to neighboring countries.

(2) Recommendations for Electricity and Water Supply-related Issues

Mongolia should invest more to strengthen its electricity supply capacity if it aims to promote the mining sector. Water supply is especially important for the operation of copper smelter. However, as it is inefficient to carry water over a long distance, Mongolia needs to choose the location for its planned smelter carefully.

(3) Other Recommendations

In order for Mongolia to develop its copper industry, one of the options is to develop a downstream manufacturing industry, which provides a stable domestic market for the planned copper smelters. As Mongolia doesn't have strong local manufacturing companies, it is important at this stage to first attract foreign assemblers and part suppliers to set up factories and manufacture in Mongolia. Possible candidates are suppliers in the power sector (which has large demand for copper electrical wires) and construction machinery. Although the automobile industry is a great user of copper, it is possible that suppliers for automobile will hesitate to invest in Mongolia due to the country's relatively small population.

Actions need to be taken to attract these companies to Mongolia can include the followings,

- Tax incentives
- Development of industrial parks (Note: see planned projects in figure on the right)
- Support of necessary infrastructure (road, electricity, water etc.)
- Development of mining sector human resources

(Source: Matsumoto, Foreign Investment and Foreign Trade Agency of Mongolia, 2012)

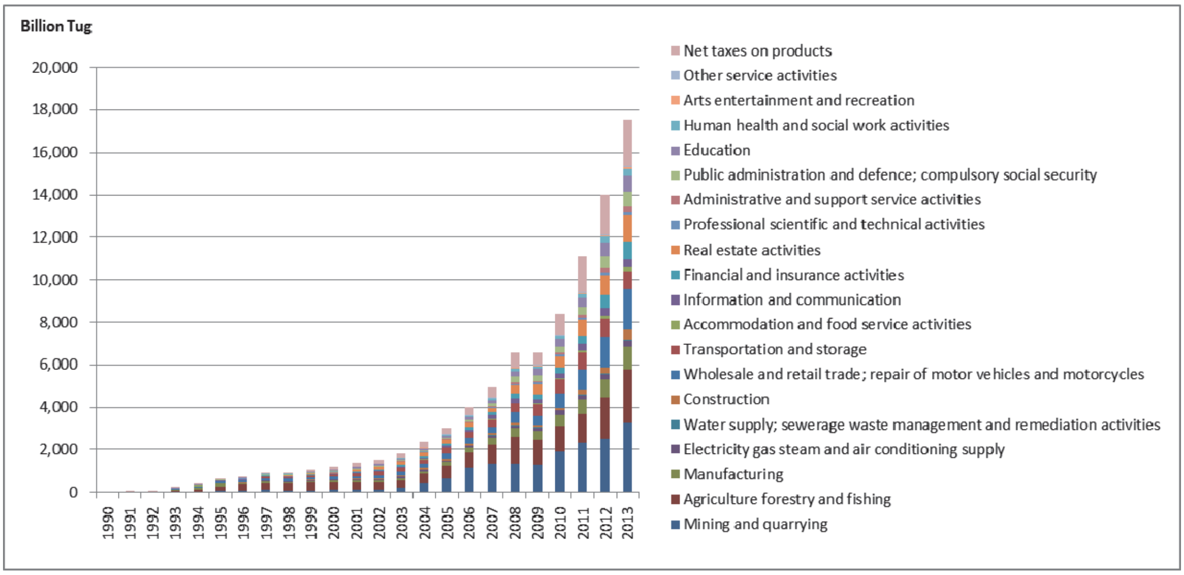
Figure 10.4.3 Planned Industrial Parks and their Core Activities

Chapter 11. Economic Analysis

11.1 The Economic Significance of the Mining Sector in Mongolia

11.1.1 The Economic Growth of Mongolia and the Growth of its Mining Sector

The mining sector is economically important in Mongolia. The sector has led the economic growth in Mongolia. The sector has been the driver of economic growth of the country. Due to development of mines and the increase in metal prices, the added value of the mining sector has been rapidly increasing in recent years.

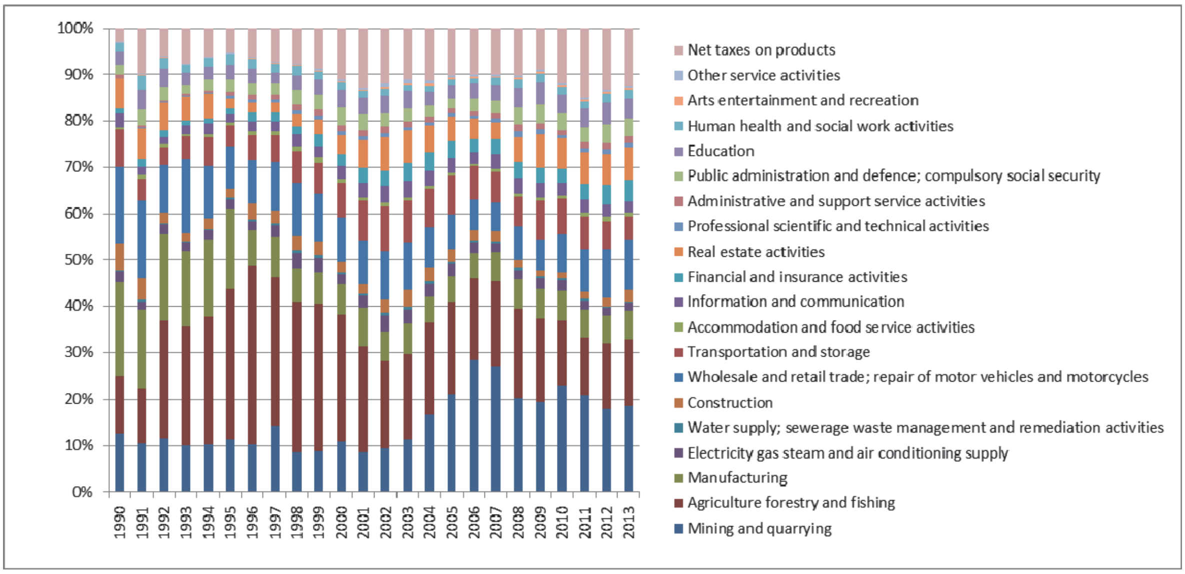


(Source: Prepared by Survey Team from the Website of the Department of Statistics)

Figure 11.1.1 Change in Nominal GDP

Taking a look at its proportion in GDP, the proportion of the mining sector increased after 2003, up to 30% in 2006; however, it is on the decline afterwards, currently down to 20%. In the other major copper-producing countries, value-added of the mining sector at the GDP ratio is 11.1% in Chile (2013: statistics of Central Bank of Chile), 7.8% in Peru (2013: Central Reserve Bank of Peru), 2.7% in the United States (2013: United States Bureau of Economic Analysis), 5.8% in China (2011: China statistical Yearbook 2013), 5.3% in Indonesia (2013 Indonesia Bureau of Statistics).It can also be said that the 20% proportion of the mining sector in Mongolia is higher than the other countries' number. It shows how other industries have not developed very much.

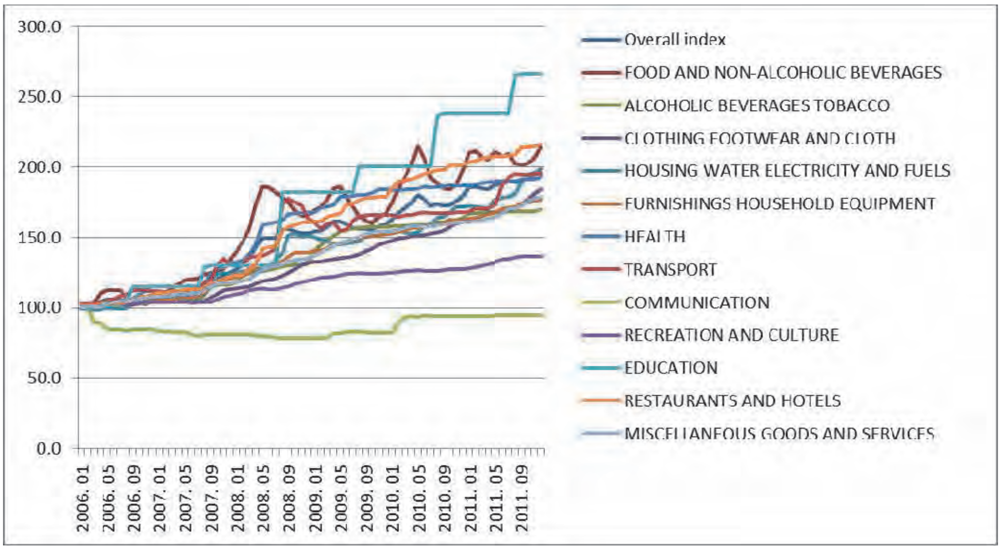
However, the added value of agriculture and pasturage is assumed to be low in the rural areas, since some of self-consumptions are not counted in calculation of GDP. Logically, self-consumption of agricultural products should consider in National Accounts, but it is very difficult to cover whole of these activities.. Therefore, the production activities of agriculture and pasturage sectors are likely to be larger than the value shown in GDP.



(Source: Prepared by Survey Team from the Website of the Department of Statistics)

Figure 11.1.2 Change in Nominal GDP by Sector Ratio

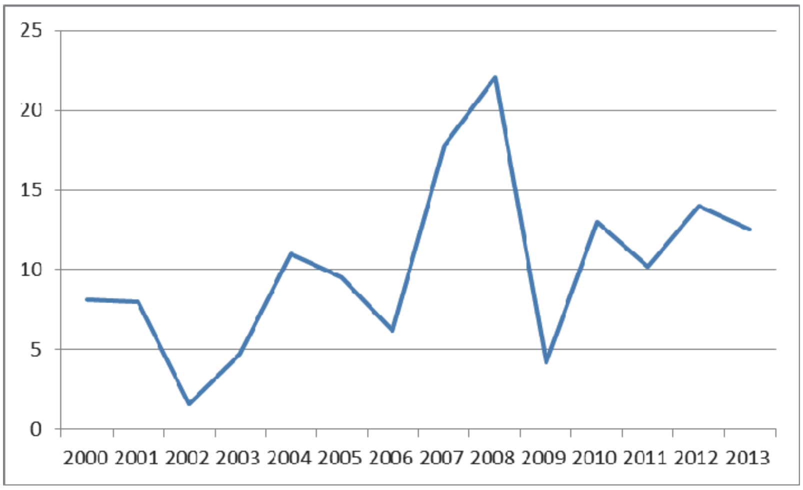
Prices are rapidly on the rise in Mongolia. Setting the price in December 2005 as a standard of 100, food and non-alcoholic beverages is 214.1, alcoholic beverages and tobacco is 169.5, clothing, footwear and cloth is 183.8, housing water, electricity and fuels is 196, furnishings household equipment is 176.6, health is 193.5, transport is 195.2, communication is 94.6, recreation and culture is 136.8, education is 266.5, restaurants and hotels is 215.8, and others is 178,6; as a whole, the price is 198.1, nearly doubling in six years.



(Source: Prepared by Survey Team from the Website of the Department of Statistics)

Figure 11.1.3 Change in Consumer Price Index

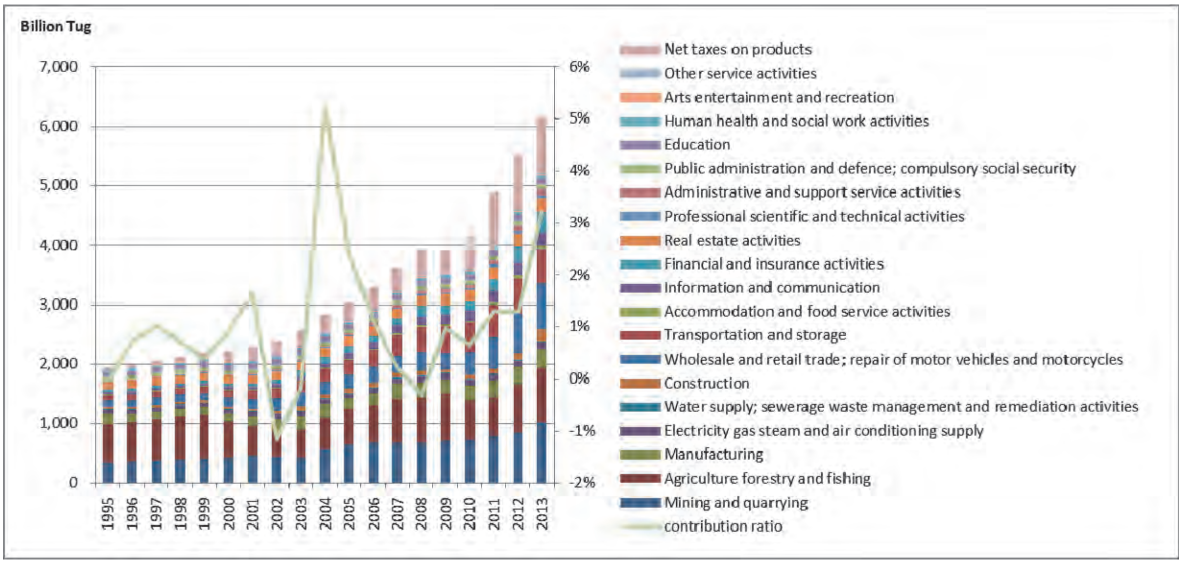
Additionally, the inflation rate is quite high, around 10%.



(Source: Prepared by Survey Team from the Website of the Department of Statistics)

Figure 11.1.4 Change in Inflation Rate

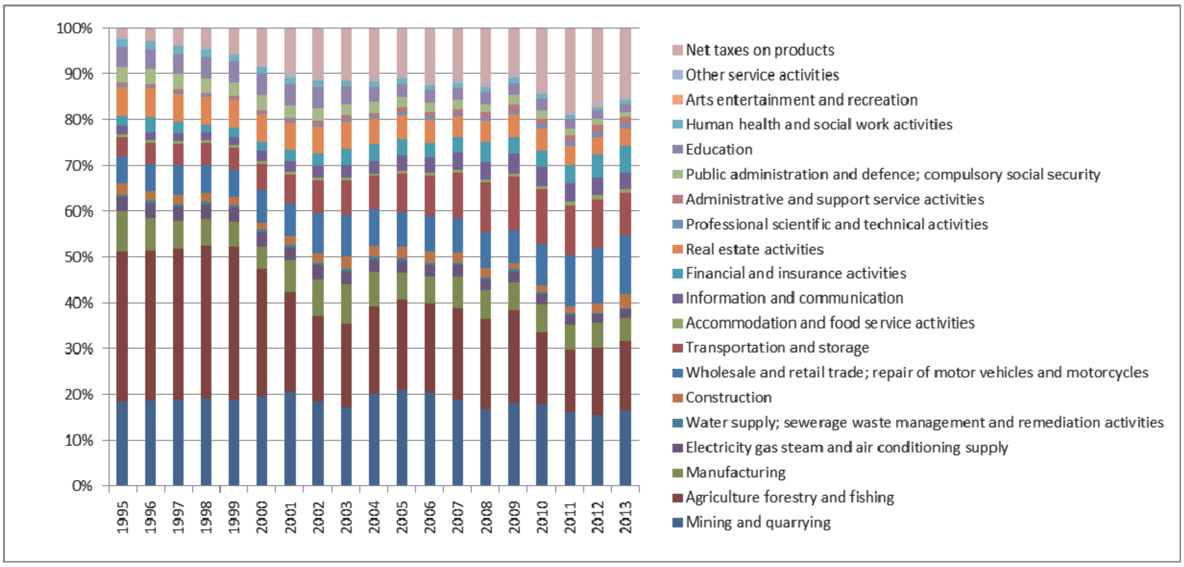
Considering the increase in prices, the amount of GDP evaluated at constant 2005 U.S. dollars has not increased much, compared to the overall increase in GDP itself. The contribution rate of mining sector to GDP growth has largely shifted after 1996 between -1.2~5.2, but the difference between 2004 and 2005 is noticeable. During most of the periods after 1996, the value has been positive; the sector has steadily contributed towards the overall increase in GDP.



(Source: Prepared by Survey Team from the Website of the Department of Statistics)

Figure 11.1.5 Change in Nominal GDP (constant 2005 U.S. dollars)

Comparing the proportions of value-added of mining sector in GDP in constant 2005 U.S. dollars, they are changing at around 20%. The price increase influenced the increase in added value of the mining sector.

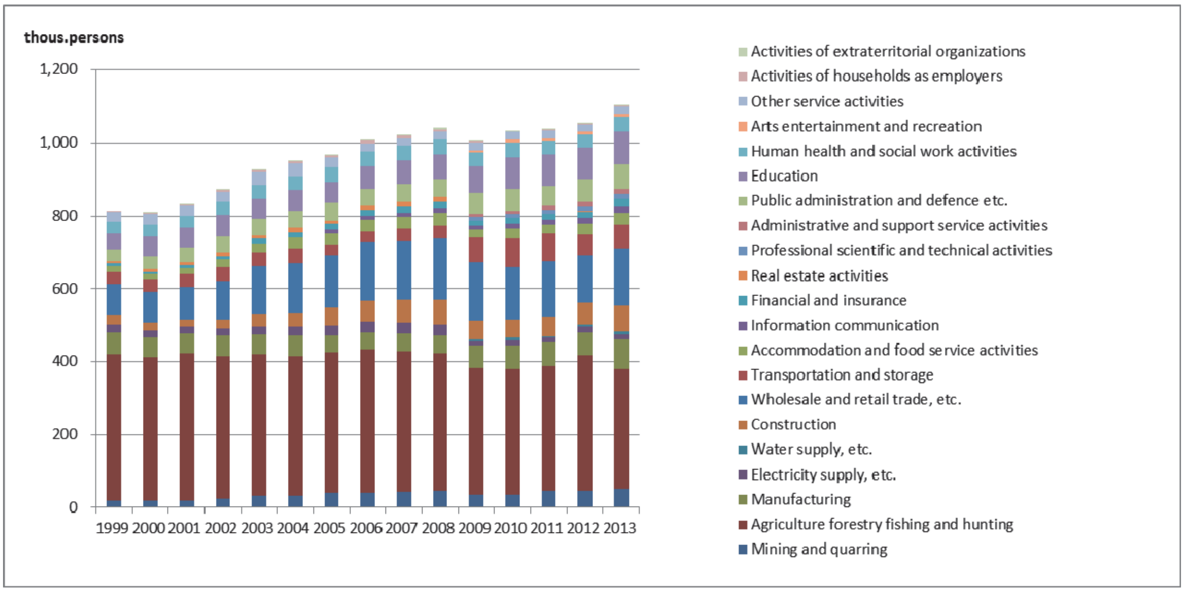


(Source: Prepared by Survey Team from the Website of the Department of Statistics)

Figure 11.1.6 Change in Nominal GDP Ratio (standard year 2005)

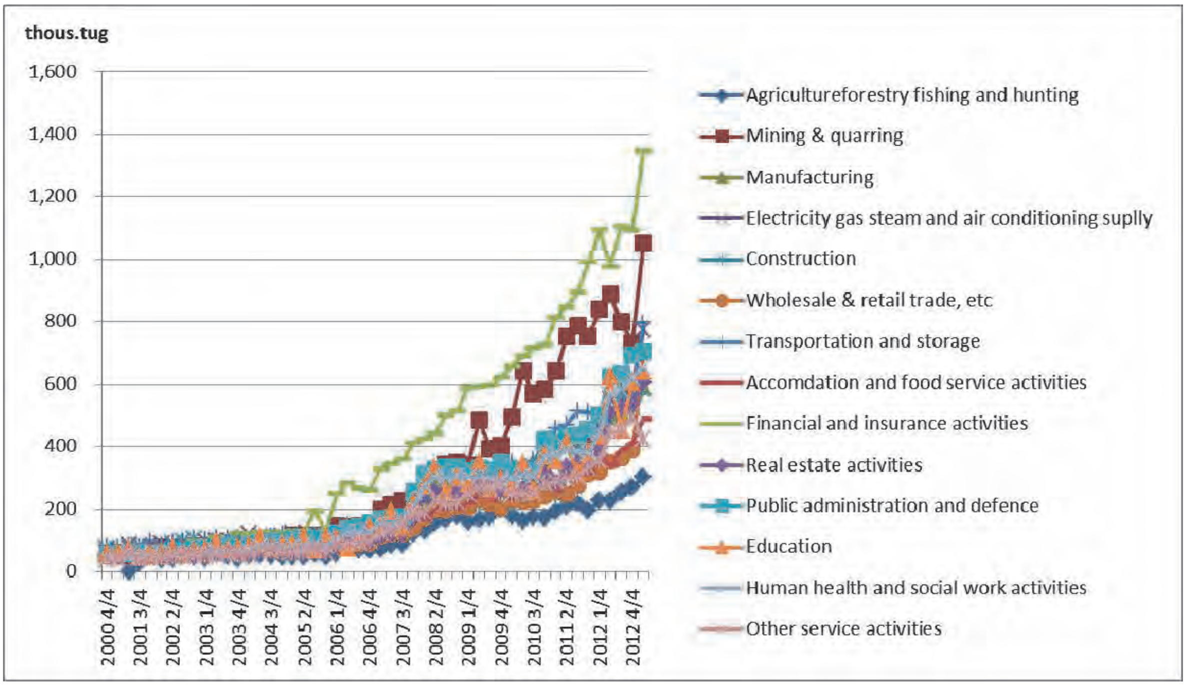
11.1.2 Trends in Employment and Wages

Contrary to that value-added of mining has large share in GDP such as 20%, the proportion of workers in the mining sector in labor population is only less than 5%.



(Source: Prepared by Survey Team from the Website of the Department of Statistics)

Figure 11.1.7 Ratio of Workers by the Industry



(Source: Prepared by Survey Team from the Website of the Department of Statistics)

Figure 11.1.8 Average wage by the Industry

According to JETRO, because of the scarcity of labor force in mining sector, the wages of the mining sector has become higher than the other sectors. It is also the reason for small proportion of workers in mining sector in total labor population. If wage difference between mining sector and the other sector is expanded, the distribution of profit gained in mining to the poorer parts of the country will be a topic of discussion in the future as N. Batnasan mentioned in his paper "Mongolia's Mining-Based Development and Trade Policy".

11.2 Reviews on existing studies of economic analysis

11.2.1 The Results of the Analysis of Existing Studies

The research results of the existing studies that have conducted an economic analysis of Mongolian mining will be shown next.

Amrita Batchuluun, et al. organized the macro data (i.e. GDP) and mining data and showed their significance in the Mongolian economy. At the same time, they state that the economy will be unstable if the development of sectors other than mining is not promoted.

Shagdar Enkhbayar, et al. created a social accounting matrix in 2008 and analyzed the economic effects of the main 26 projects under consideration in Mongolia with CGE analysis. In specific, they categorized the 26 projects into mining, energy, agriculture and food (AgFood), infrastructure (Infra), and technology and education (Ted) and created and analyzed the effects of five scenarios, each assuming an investment will be done into each area.

The results are shown as below. GDP will increase by 28% with investment into the mining sector, 11% into the energy sector, 28% into the AgFood, 48% with Infra, and 85% into Ted.

Ch.Altannar, et al. conducted a periodic analysis such as ADF (Augmented Dickey-Fuller) test and analyzed the trends often referred to as resource curse and Dutch disease. As a result of the periodic analysis, it concluded that investment in mining sector provide a positive influence on increase of GDP and export in the short term, whoever the impact is limited, and there is a possibility of Dutch disease in the long term because it provide negative impact on exchange rate.

N. Batnasan used the Computable General Equilibrium (CGE) models analysis and analyzed the effects of investment of Oyu Tolgoi and Tavan Tolgoi mine developments. CGE models analysis is the method to analyze the effect of the change of parameters by assuming that industry, consumer, and government behave optimally. The analysis results of N. Batnasan concluded that due to investments by Oyu Tolgoi and Tavan Tolgoi mines, GDP will be seven times as much compared to 2011.

Table 11.2.1 Examples of Existing Studies with Economic Analysis on the Mongolian Mining Sector

	Paper	Points
1	Amrita Batchuluun, et. al. "An analysis of mining sector economics in Mongolia", global journal of business research, volume 4, number 4, 2010	● Brief the economic growth and mining sector's contribution to it. ● This paper emphasizes how to maintain the sustainability of Mongolian economic growth while identifying and analyzing the main difficulties, challenges and strategic efforts in the mining sector and determining appropriate solutions based on international experience and practices. However, the analysis remains limited to brief on copper mines in Mongolia and illustrate production size of them.
2	SHAGDAR ENKHBAYAR, et. Al. "MONGOLIA'S INVESTMENT PRIORITIES. FROM A NATIONAL DEVELOPMENT. PERSPECTIVE." SEPTEMBER 2010	● Use the new, 2008 Social Accounting Matrix for the country, this economy-wide decision support tool to assess 26 of the country's highest priority development projects. ● Categorized 26 investment projects into 5 scenarios Mining (Primary mining and mineral resource development), Energy sector development, AgroFood development, Infrastructure development, Technology and education investment and analyzed the effect of the investments according to the scenarios. ● The results suggest that each of these can make an important contribution to the national development agenda, but they differ in important ways in both the scope and timing of their impacts. Mining, Energy sector development, and AgroFood development contribute to GDP growth in short term (up to 2020). Infrastructure development, Technology and education investment don't contribute to GDP growth not so much but it contribute very much in long term (up to 2030). ● The mining scenario is consist of Oyu Tolgoi, Tavan Tolgoi, Copper Smelting Plant, Steel & Metallurgical Complex projects. The paper assumed that the investments of the scenarios contribute 5% per annum to target sector total factor productivity. However, how each project contributes to increase of total factor productivity is not analyzed in detail.
3	Ch.Altannar,Sh.Bolormaa, .Enkhbat,T.Ouyngerel,D.Bayanjargal, Tsolmon, "Impact of mining industry on other sectors",Mission report of consulting service Ulaanbaatar city, December 21, 2011	● Indicated the generation of Ditch Disease in Mongolia by econometrics analysis. ● The increase of export of mineral resources is not estimated based on increase of production of the concrete mine but total trend of export.
4	N. Batnasan, "Mongolia's Mining-Based Development and Trade Policy", ERIA REPORT No. 109 2013 JANUARY	● Analyzed the impact of investment of Oyu Tolgoi and Tavan Tolgoi by Computable general equilibrium (CGE) analysis. ● It analyzed impact of increase of production of Oyu Tolgoi (annual 1.8 million ton concentrate production from 2013 and Tavan Tolgoi (two scenarios are set: annual 20 t coal production or 40 t) by considering the price increase of commodities. It analyze the impact by setting 6 scenarios. ● The simulation result shows that the two large investment projects will significantly increase Mongolian GDP, up to 7.56 times. ● The simulation results also indicate that mining-based growth will lead to a significant increase in Mongolia's export and improvement of the trade balance. ● The paper identified the negative effect from Dutch disease. The appropriate policy measures are required to recover it with promoting liberalization of trade.

(Source: Prepared by Survey Team)

Table 7: Macroeconomic Results
(Cumulative percent change in real 2010 PPP values, 2010-2030)

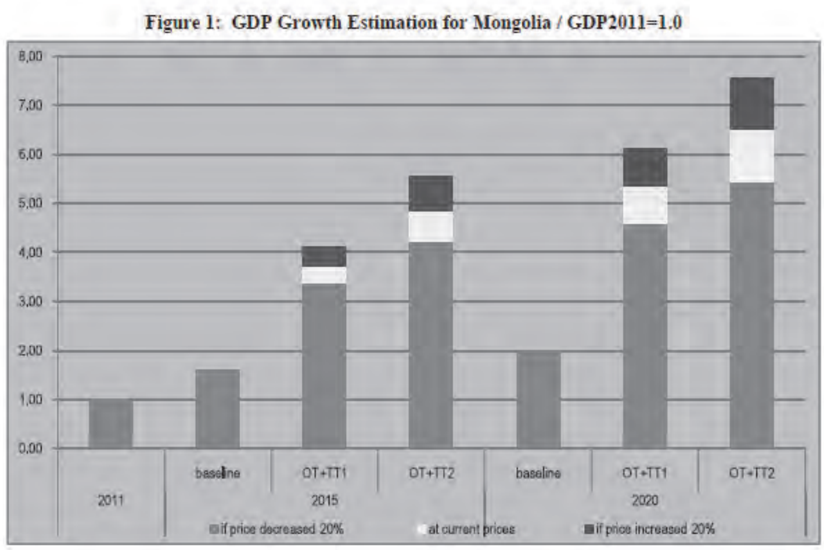
	Mining	Energy	AgFood	Infra	Ted
Output	38%	11%	33%	43%	80%
GDP	38%	11%	28%	48%	85%
HH Income	14%	8%	21%	33%	43%
Consumption	18%	12%	19%	36%	59%
Exports	41%	8%	43%	51%	96%
Imports	22%	6%	23%	35%	54%
CPI	-1%	-3%	4%	-4%	-10%
Wage	8%	0%	13%	11%	5%
Rental	-10%	4%	4%	6%	8%

(Source: Batnasan, "Mongolia's Mining-Based Development and Trade Policy", ERIA REPORT No. 109 2013)

Figure 11.2.1 Economic Effects by the Scenario

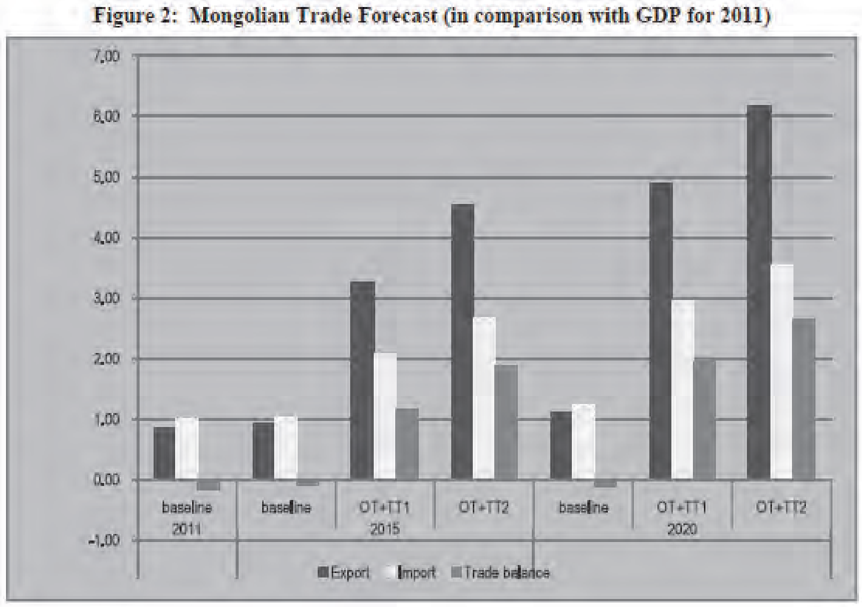
In addition, investment into Oyu Tolgoi and Tavan Tolgoi mines will contribute to an increase in export of Mongolia, but it also has a possibility of causing problems such as Dutch disease. To avoid Dutch disease, the paper suggests that appropriate policy measures are required such as investment policy for non-mining sector in addition to liberalization of trade.

All the papers shown in Table 11.2.1 are macro-economic analyses about mining sector. N. Batnasan analyzed the effect of specified mines but the other papers analyzed without specifying the mines for analysis.



(Source: N. Batnasan, "Mongolia's Mining-Based Development and Trade Policy", ERIA REPORT No. 109 2013)

Figure 11.2.2 Effects of Investment into Oyu Tolgoi and Tavan Tolgoi (in terms of GDP)



(Source: N.. Batnasan, "Mongolia's Mining-Based Development and Trade Policy", ERIA REPORT No. 109 2013)

Figure 11.2.3 Effects of Investment into Oyu Tolgoi and Tavan Tolgoi (in terms of export)

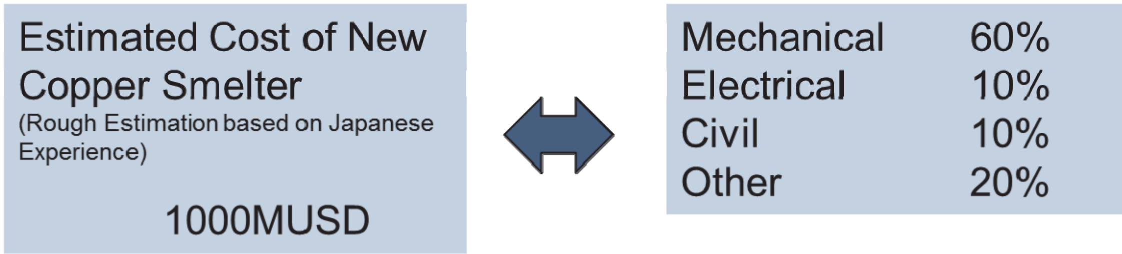
11.3 The Predicted Economic Effects of Constructing Smelter (provisional)

11.3.1 Analysis Method and Hypothesis

The existing studies shown in section 11.2 are studies on the mining sector, analyzing the economic effects of investment into exploiting and processing. The current interest of Mongolia is on the construction of smelters, but there were no existing studies found on the economic analysis on the construction of smelters. Therefore, in this research, an economic analysis of smelter (pyrometallurgy) construction by the input-output analysis was conducted.

The newest input-output table of Mongolia was created based on data from 2010. The 32 vertical sectors and 32 horizontal sectors, opened to the public by the department of statistics, were included in the analysis. The National Statistical Office of Mongolia provided 55 by 55 sector input-output table to study team. However, some data are missing (Some cells in Excel sheet are blank). It was very difficult to cover this missing value by estimation because of limitation of related data, therefore the study team used 32 by 32 sector matrix.

On calculating, hypothesis on income from CAPEX and trade were placed as a precondition. CAPEX can be assumed as about 1 billion USD, with a production capability of 200 Kt/year. Also, the economic effects were calculated with a precondition that 100% of metal copper is exported, and that 100% of sulfuric acid, its byproducts are consumed domestically at a certain price. This analysis assumed that whole metal copper is exported therefore processed products are not considered. Slug is also not considered in this analysis.



(Source: Prepared by Survey Team)

Figure 11.3.1 Precondition on CAPEX

Table 11.3.1 Outlet Conditions of Product and Byproducts

Product/Byproduct	Purpose	Assumed clients
Cupper (200,000 t/year)	Material for products	Can be used domestically or exported to China. Assumption for this study: 100% are exported to China (7,000 US$/t)
Sulfuric acid (588,480 t/year)	Fertilizer or solvent	Can be used domestically or exported to China. Assumption for this study: 100% are used domestically (70 US$/t)
Processed products (Wire, etc.)	Used for construction or material for automobile	Can be used domestically or exported to China. Assumption for this study: Not considered (Not utilized)
Slug	Material for cement production	Can be used domestically or exported to China. Assumption for this study: Not considered (Not utilized)

(Source: Prepared by Survey Team)

11.3.2 Provisional Results

Firstly, as for the construction of a smelter, domestic production will increase by 1.33 trillion Tg with an investment of 1.79 trillion Tg. (The timing is not clear because of characteristic of Input-output analysis. It will be in the early years). The primary ripple effect was calculated in this result.

Sectors		Investment (million tog)	Value Added (million tog)	Value Added (million USD)
1	Crop production, related service activities	0	269	0
2	Animal production, hunting	0	1,626	1
3	Forestry and fishing	0	722	0
4	Mining of coal and crude petrolium	0	45,610	26
5	Mining of metal ores	0	-16,455	-9
6	Other mining and quarrying	0	-924	-1
7	Mining support service activities	0	7,207	4
8	Manufacture of food products	0	943	1
9	Manufacture of beverages and tobacco	0	96	0
10	Manufacture of textiles; wearing apparel; leather and related products	0	3,057	2
11	Manufacture of wood, paper and related products; printing and reproduction of recorded media	0	13,470	8
12	Manufacture of coke and refined petroleum products; chemicals and chemical products	0	2,442	1
13	Manufacture of other non-metallic mineral products and metal products	0	22,702	13
14	Manufacture of machinery and equipment	1,251,250	650,554	364
15	Other manufacturing	357,500	258,118	144
16	Electricity, gas, steam and air conditioning supply	0	27,580	15
17	Water supply; sewerage, waste management and remediation activities	0	4,090	2
18	Construction	178,750	134,516	75
19	Wholesale and retail trade, repair of motor vehicles and motorcycles	0	72,897	41
20	Transportation and storage	0	18,859	11
21	Accommodation and food service activities	0	2,247	1
22	Information and communication	0	18,079	10
23	Financial and insurance activities	0	11,817	7
24	Real estate activities	0	18,638	10
25	Professional, scientific and technical activities	0	16,220	9
26	Administrative and support service activities	0	5,014	3
27	Public administration and defence, compulsory social security	0	5,861	3
28	Education	0	2,299	1
29	Human health and social work activities	0	723	0
30	Arts, entertainment and recreation	0	214	0
31	Other service activities	0	1,538	1
32	Other activities	0	0	0
		1,787,500	1,330,031	744

(Source: Prepared by Survey Team)

Figure 11.3.2 Investment Effects (production value)

The reason the domestic ripple effect (1.33 trillion Tg) decreases from smelter construction (1.79 trillion Tg) is due to the high import ratio of the machine manufacturing industry and construction industry. Materials needed for construction of a mining industry cannot be procured domestically, therefore depending on import, resulting in some of the investment effects leaking overseas.

Table 11.3.2 Import Ratio of the Raw Materials

Industrial Sector	Ratio of the raw materials
Manufacture of machinery and equipment	47%
Other manufacturing	28%
Construction	31%

(Source: Prepared by Survey Team from the Website of the Department of Statistics)

	Sectors	Investment (million tog)	Value Added (million tog)	Value Added (million USD)
1	Crop production, related service activities	0	112	0
2	Animal production, hunting	0	1,173	1
3	Forestry and fishing	0	335	0
4	Mining of coal and crude petrolium	0	25,105	14
5	Mining of metal ores	0	-10,073	-6
6	Other mining and quarrying	0	-377	-0
7	Mining support service activities	0	2,465	1
8	Manufacture of food products	0	230	0
9	Manufacture of beverages and tobacco	0	46	0
10	Manufacture of textiles; wearing apparel; leather and related products	0	558	0
11	Manufacture of wood, paper and related products; printing and reproduction of recorded media	0	4,714	3
12	Manufacture of coke and refined petroleum products; chemicals and chemical products	0	643	0
13	Manufacture of other non-metallic mineral products and metal products	0	8,676	5
14	Manufacture of machinery and equipment	1,251,250	156,054	87
15	Other manufacturing	357,500	95,475	53
16	Electricity, gas, steam and air conditioning supply	0	8,239	5
17	Water supply; sewerage, waste management and remediation activities	0	1,190	1
18	Construction	178,750	25,519	14
19	Wholesale and retail trade; repair of motor vehicles and motorcycles	0	43,580	24
20	Transportation and storage	0	8,714	5
21	Accommodation and food service activities	0	502	0
22	Information and communication	0	9,532	5
23	Financial and insurance activities	0	7,647	4
24	Real estate activities	0	14,157	8
25	Professional, scientific and technical activities	0	6,467	4
26	Administrative and support service activities	0	2,298	1
27	Public administration and defence; compulsory social security	0	3,486	2
28	Education	0	1,547	1
29	Human health and social work activities	0	394	0
30	Arts, entertainment and recreation	0	117	0
31	Other service activities	0	787	0
32	Other activities	0	0	0
		1,787,500	419,310	235

(Source: Prepared by Survey Team)

Figure 11.3.3 Investment Effects (added value)

Furthermore, calculating with the assumption that export of metal copper increases and that export of concentrate decreases, the result showed that the added value increases by 231 billion Tg annually.

	Change of Export [illegible]	Change of Value Added [illegible]
1Crop production, related service activities	0	135.6
2Animal production, hunting	0	3 033.5
3Forestry and fishing	0	5 338.6
4Mining of coal and crude petrolium	0	24 162.8
5Mining of metal ores	-1 487 557.5	- 970 100.6
6Other mining and quarrying	0	- 3 555.3
7Mining support service activities	0	- 1 387.5
8Manufacture of food products	0	1 587.6
9Manufacture of beverages and tobacco	0	76.9
10Manufacture of textiles; wearing apparel; leather and related products	0	706.6
11Manufacture of wood, paper and related products; printing and reproduction of recorded media	0	2 618.4
12Manufacture of coke and refined petroleum products; chemicals and chemical products	0	3 010.8
13Manufacture of other non-metallic mineral products and metal products	2 502 500.0	1 032 218.3
14Manufacture of machinery and equipment	0	202.7
15Other manufacturing	0	1 610.0
16Electricity, gas, steam and air conditioning supply	0	7 414.8
17Water supply; sewerage, waste management and remediation activities	0	1 696.1
18Construction	0	4 135.8
19Wholesale and retail trade; repair of motor vehicles and motorcycles	0	71 976.4
20Transportation and storage	0	- 1 590.1
21Accommodation and food service activities	0	- 45.4
22Information and communication	0	6 287.6
23Financial and insurance activities	0	12 932.4
24Real estate activities	0	19 703.1
25Professional, scientific and technical activities	0	1 742.5
26Administrative and support service activities	0	2 681.6
27Public administration and defence; compulsory social security	0	5 532.9
28Education	0	- 990.9
29Human health and social work activities	0	- 632.6
30Arts, entertainment and recreation	0	- 914.0
31Other service activities	0	1 448.6
32Other activities	0	0.0
		231 263.3

(Source: Prepared by Survey Team)

Figure 11.3.4 Effects of the Changes in Export/import Amount (added value)

However, there is a problem in this calculation. Originally, decrease in export of concentrate is supposed to avoid decrease in added value because metal copper export should increase. However, the current input-output table is based on the current production structure of Mongolia without the mining industry. Therefore, in the calculation, sectors related to metal products barely utilize the output from the mining industry, leading to a decreased added value in the mining industry sector. In addition, the sector’s import ratio is high; the production increase in the metal production sector of the downstream will lead to increase in import, making the increase in added value of the mining sector difficult to realize. Therefore, the result drawn here is underestimating the economic effects that would actually be realized by the construction of the smelters.

In addition, calculating with the assumption that all of the sulfuric acid will be consumed domestically at 70 US$/t, there was an impact of 28 billion Tg.

	[illegible]	[illegible]
1Crop production, related service activities	0	10,993
2Animal production, hunting	0	73.4
3Forestry and fishing	0	2.9
4Mining of coal and crude petrolium	0	1 282.8
5Mining of metal ores	0	- 282.9
6Other mining and quarrying	0	- 6.6
7Mining support service activities	0	363.2
8Manufacture of food products	0	42.7
9Manufacture of beverages and tobacco	0	23.3
10Manufacture of textiles; wearing apparel; leather and related products	0	13.2
11Manufacture of wood, paper and related products; printing and reproduction of recorded media	0	59.7
12Manufacture of coke and refined petroleum products; chemicals and chemical products	0	19 308.1
13Manufacture of other non-metallic mineral products and metal products	2 502 500 0	106.5
14Manufacture of machinery and equipment	0	5.8
15Other manufacturing	0	21.0
16Electricity, gas, steam and air conditioning supply	0	348.4
17Water supply; sewerage, waste management and remediation activities	0	39.9
18Construction	0	58.2
19Wholesale and retail trade; repair of motor vehicles and motorcycles	0	2 594.6
20Transportation and storage	0	1 192.9
21Accommodation and food service activities	0	31.5
22Information and communication	0	294.0
23Financial and insurance activities	0	323.6
24Real estate activities	0	397.2
25Professional, scientific and technical activities	0	196.7
26Administrative and support service activities	0	160.2
27Public administration and defence; compulsory social security	0	779.5
28Education	0	57.8
29Human health and social work activities	0	17.2
30Arts, entertainment and recreation	0	26.6
31Other service activities	0	17.0
32Other activities	0	0.0
		27 957.3

(Source: Prepared by Survey Team)

Figure 11.3.5 Effects by the Sales of Sulfuric Acid (added value)

Furthermore, the secondary ripple effect by the increase in workers' income was calculated. The increase in workers' income due to investment was about 142 billion Tg, 147 billion due to change in export, and 8 billion due to increase in the consumption of sulfuric acid. The consumption trend, or how much of the income will lead to consumption, will be set at 0.60 for now, as related data could not be acquired.

From the above information, it was calculated that 478 billion Tg from investment, 304 billion Tg from export increase, and 31 billion Tg from the production of sulfuric acid would be raised.

To compare the result with the investment of 1,788 billion Tg, the accumulated effect of 20 years was calculated, with the project period of 20 years and the discount rate of 9.63%. As a result, effect from the investment of 1,788 billion Tg was calculated as 3,684 billion Tg. The effect of investment exceeds the investment amount; it can be seen that the construction of smelters is economically effective.

	Impact of Investment (million tog)	Impact of change of export of copper (million tog / year)	Increase of domestic consumption of H2SO4 (million tog / year)	Total
Direct impact Indirect impact	419,310	231,263	27,957	678,530
Induced impact	59,005	72,303	3,336	118,009
Total	478,315	303,566	31,293	813,174

*Current GDP 1,413 billion tog（2012年）

Accumulated for 20 years

Discount rate is 9.63%

Impact of Investment (million tog)	Impact of change of export of copper (million tog)	Increase of domestic consumption of H2SO4 (million tog)	Total (million tog)
478,315	2,906,361	299,601	3,684,277

(Source: Prepared by Survey Team)

Figure 11.3.6 Effect of the New Construction of Smelter (20 year accumulation)

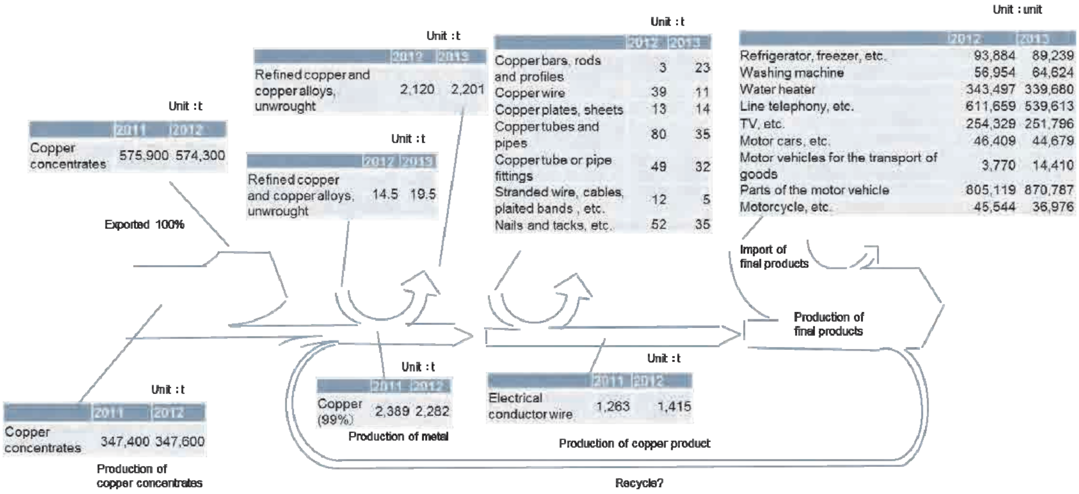
To avoid the decrease in the calculated added value due to the fact that the current input-output table is based on the Mongolian production structure without the mining industry, only the increase in the added value from the processing of copper was calculated, with the precondition that there is no change in the added value of the mines whether the concentrate is exported or domestically consumed. The export value of copper is 2.5 trillion Tg, and the added value rate of the industry which includes the mining industry, or “Manufacture of other non-metallic mineral products and metal products,” is 0.382. Therefore, increase in the added value is 956 billion Tg. In addition, increase due to increase in workers’ income is as small as 446 million Tg. The total is 956 billion Tg.

Evaluating this result in 20 years, the total is 9.2 trillion Tg, and 9.9 trillion Tg with the investment effect and the sulfuric acid effect in total. If everything goes well, it can be seen that the economic effect of constructing smelters is quite large. However, this depends on the price of coppers. If the price of the copper was half, the economic effect would be 5.4 trillion Tg, decreasing by a quite large amount.

11.3.3 The Appropriateness of the Location of the Mining Industry and its Dwonstream Industries

Since the economic effect due to the sales of byproducts is quite small, the key in the end will be whether a sales contact of coppers can be acquired or not. Currently, it is assumed that all of it will be exported to China, but the risk as a country will be high, and its economic effect will be limited. In addition, if the price of coppers decreases, there is a large impact on the economic effect.

In addition, just because the concentrate changes into copper does not mean that the Dutch disease problem can be resolved. The current flow of the copper related products in Mongolia is as shown below. There is barely any production between mining and the final product; its economic structure depends on import for the final products. In this situation, even if the mining industry is created, its economic effect will be small. Furthermore, as the actual project executor, there is no stable sales contact, increasing the risk of the mining project. Whether the mining project goes well in Mongolia or not depends on how much the downstream industry can be developed.



(Source: Prepared by Survey Team from the Website of the Department of Statistics)

Figure 11.3.7 The Flow of the Copper Related Products in Mongolia

11.3.4 Challenges and tasks to complete in the future

The calculation above has many points to be improved.

For example, decrease in the added value due to the decrease in the amount of concentrate export should be able to be covered by increase in export of metal copper, so the values in the input-output table need to be revised exogenously. Increase in the added value simply from copper processing was calculated, but this does not appropriately take the ripple effect into account. In some parts, the data are not consistent. The consumption trend needs to be reviewed, since it may not correspond to the actual situation in Mongolia.

In addition, the investment of the mining sector has negative value in the input-output table, but this is probably because the stocks are brought down to sales. This needs to be confirmed as well.

Investment amount, copper price, copper's export feasibility, and sulfuric acid's domestic demand

and its export feasibility need to be confirmed as well, but that would require a detailed feasibility study.

To analyze a more precise economic effect, there should be an analysis with the CGE model. Professor BATNASAN of the National University of Mongolia states that to conduct an analysis with the CGE model in Mongolia, there are various challenges, such as creating SAM. If there is to be a CGE analysis on the effect of the construction of smelters in the future, Professor BATNASAN can cooperate; however, he predicts that 2~3 years will be required to acquire the result. Considering that the project is important for Mongolia, a long-term analysis project, with the cooperation of the National University of Mongolia, will be necessary as well.

11.4 Scenarios for Copper Business Development and their Economic Ripple Effects

In addition to the above-mentioned discussion from macroeconomic viewpoints in Chapter 11.3, three scenarios could be anticipated from microeconomic perspective on the future potential copper business development in Mongolia as given below. Each case is quantitatively assessed for its economic ripple effects to the domestic economy in terms of royalty and tax revenues to the government, export values, and domestic turnover in addition to creation of new jobs, in particular in comparison with the present situation without the copper smelter and its associated downstream industries of economic significance.

The size of market for each scenario was estimated under the prerequisites as follows.

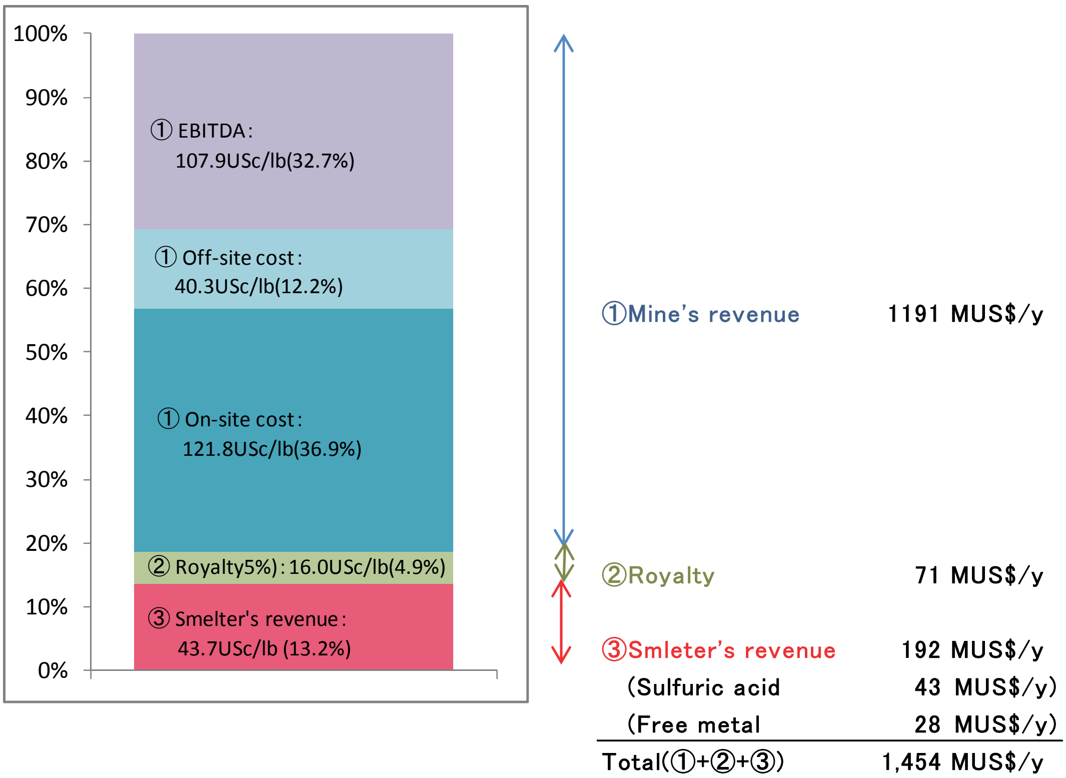
- The sales volume in each scenario is based on equivalent production of the copper cathode of 200,000 t/year and sulfuric acid of 583,000 t/year for both of copper mine and smelter.
- Twenty percent of the products of copper cathode (40,000 t/year) and sulfuric acid (117,000 t/year) are used to yield value added fabrication and sulfuric acid chemical products which are all exported. The remaining eighty percent, 160,000 t/year of copper cathode and 466,000 t/year of sulfuric acid, is exported outside Mongolia.
- The market potential is quantitatively assessed only based on the sales volume of products in each scenario without taking into account the individual profitability of mining, smelting, fabrication and sulfuric acid chemical industries. Preconditions used for the estimate of the sales values are exactly the same as those for the discussion on the economic viability of the copper smelter (Chapter 7.2.3), including 3.2 US$/lb for copper price and 70 US$/ton for CFR sulfuric acid price.
- Sales values of copper fabrication and sulfuric acid chemical products can be inversely estimated as given below using 32% as a ratio of the direct material cost to the gross cost (Small and Medium Enterprise Agency of Japan, 2009 “General Situations on Heisei 20 Survey”), 5% as a profit margin on sales and the prices of copper and sulfuric acid as direct material costs.

Sales value = (direct material cost / 32%) × 1.05

The ratio of material costs including direct material, purchased parts and subcontract expenses reportedly amounts to more than 50% or 80% of the gross costs in the manufacturing industries in Japan. However, 32% was taken from the reliable data source of Small and Medium Enterprise Agency of Japan on the Japanese small and medium sized enterprises with employees less than 300 and capitals less than 300 million yen.

(1) Scenario 1

This scenario is based on copper mining only, the same business model as the current situation. Products of 200,000 t/year copper cathode and 583,000 t/year sulfuric acid are equivalent to the total sales volume of 1,454 million US$ under the preconditions described (Figure 11.4.1). The 1,192 million US$ sale volume or 81.9% of the total sales is proceeds to the mine, whereas the 192 million US$ or 13.2% is virtually an income to the smelter and the remaining 71 million US$ or 4.9% is due to the government as royalty. Consequently 1,261 million US$ is obtained as net proceeds including 71 million US$ of royalty by exporting the copper concentrates in the scenario 1 without the copper smelter (Table 11.4.1). The government revenue in the scenario comprises taxes from mining in addition to 71 million US$ of royalty, excluding dividends from state-owned shares.



(Source: Prepared by Survey Team)

Figure 11.4.1 Revenue Structure for the Mine and Smelter (modified from Figure 7.2.10)

Table 11.4.1 Scenarios for Copper Business Development in Mongolia

(million US$/y)

Business Models	Total Revenue	Exports Value	Royalty+ tax	Industrys' Profitability	Employment
(1) Only Copper Mines					
Copper mine industry	1,191	1,261	α1(*1)	AAA	AA
Royalty	71	–	71	–	–
Entire Mongolia	**1,261**	**1,261**	71+α1	AAA	AA
(2) Copper mines＋Smelter					
Copper mine industry	1,191	0	α1	+AAA(*2)	AA
Smelter	192	1,454	α2(*1)	–A～0(*3)	A
Royalty	71	–	71	–	–
Entire Mongolia	**1,454**	**1,454**	71+α1+α2	AAA～–AAA	AAA
(3) Copper mines+Smelter+Fabrication					
Copper mine industry	1,191	0	α1	+AAA	AA
Smelter(*1)	192	1,163	α2	–A～0	A
Fabrication+Chemical(*1,*5)	954	954	α3(*1)	A	A
Royalty	71	–	71	–	–
Entire Mongolia	**2,408**	**2,117**	71+α1+α2+α3(*4)	+AAA	AAAA

*1 : α1 to α3 represent taxes from mining, smelting and downstream industries.

*2 : Rating +AAA is because of significant cost reduction of concentrate transportation for the mine compared to the scenario 1.

*3 : The bottom line profits of smelting business is fixed at 0, not negative.

*4 : It is not necessarily the case that α1＜α1+α2 and α1＜α1+α2+α3 is always maintained.

(Source: Prepared by Survey Team)

(2) Scenario 2

In this scenario which includes a copper smelter to process concentrates produced in the mine, copper cathode and sulfuric acid are all exported outside the country. Domestic sales values and exports brought about by the scenario increase by 192 million US$ to 1,454 million US$ annually compared to the scenario 1. This amount is only 1.15 times of the scenario 1. It obviously takes a long period of time for the newly constructed smelter to recoup the invested money from profits as an annual smelter's sales value at 192 million US$ is rather small against a huge amount of invested money, which is supposed to approximately range 0.8 to 1 billion US$ for the 200,000 t/year capacity copper smelter. Or it may be impossible to collect all the expenditures. On the other hand, it is more beneficial for the government as its income can be increased from the smelting business in addition to royalty and tax from mining, and new jobs will be created (Table 11.4.1).

(3) Scenario 3

This scenario includes the development by copper fabrication and sulfuric acid chemical industries in addition to smelting and mining business. Twenty percent of the copper cathode (40,000 t/year) and sulfuric acid (117,000 t/year) produced is used to downstream industries to generate value added products to be exported outside the country together with the remaining 160,000 t/year of copper cathode and 466,000 t/year of sulfuric acid. Assuming 32% for the ratio of the direct material cost to the gross cost for the copper fabrication and sulfuric acid chemical products, the downstream sector gives the annual sales volume of 954 MUS$, that is also equal to exports. Consequently a total annual domestic sales volume, including the remaining 80% of concentrates and smelter products, amounts to 2,408 MUS$, and associated exports to 2,117 MUS$, 1.9 times and 1.7 times respectively of the scenario 1. The government income including taxes and royalty also significantly rises and the domestic employment opportunity increases further (Table 11.4.1).

(4) Summary

Quantitative appraisal on the economic ripple effects and qualitative assessment on the government tax revenue and employment have been developed on three simplified scenarios under some preconditions. Economic viabilities of individual projects including copper mining, smelting, copper-semi fabrication and sulfuric acid chemical industries are not considered in the assessment on their economic ripple effects. Further, it is quite difficult to predict which scenario will be most probably realized in the future Mongolia because it is deeply affected by unforeseeable global political and economic factors in addition to domestic situations. On the other hand, it is possible to make some comments relating to the future development scenario of copper industry with some degree of certainty as follows.

- The economic ripple effects caused by the domestic copper smelter are not so large in the short term, ranging about 1.15 times of the mining only scenario. However, it will be slightly more advantageous to the domestic copper mining industry as freight costs will be lessened depending upon location of the smelter.
- In scenario 3 where copper-semi and sulfuric acid chemical industries will be deployed in addition to the copper smelter, its economic ripple effects will be raised more than scenario 2, up to nearly 2 times of the scenario 1 only if 20% of the smelter products are converted for use as raw materials to the downstream sectors. Furthermore, it is likely cost effective in terms of initial capitals required to start the copper-semi and sulfuric chemical industries compared to the copper smelter, although quantitative appraisal is not performed on the downstream business in this study.
- Various downstream industries are anticipated to develop under the scenario 3 as in the case with other countries such as Japan. They will contribute to enhancement of the entire domestic economy in the long run, because they include electrical and mechanical maintenance, components and parts-supply, machine and equipment manufacturer, housing and construction, and distribution and trade.

- Consequently if the copper smelter is constructed in Mongolia, it is most desirable to grow the copper-semi and sulfuric acid chemical industries using a part of the smelter products so as to reinforce the basic structure of domestic industry, to enhance the entire technology standard and to contribute to job creation. It is important to start the projects in reasonable scales and steadily grow them from a long-range point of view, making use of foreign capital and technology.

It is desirable for Mongolian authorities concerned to minimize state intervention in the individual projects and primarily focus on government's roles including general planning and direction of the copper business, simplification of paper work procedures of permits and licenses and establishment of fairness and justice in the taxation system so as to secure accessibility for foreign capitals. Nevertheless, it may be necessary for the government to take favorable treatment towards the foreign capitals in the taxation system of smelting business, as it is not so attractive for them due to its extremely low profitability unlike mining business. For the projects by foreign capitals, it is also the government's role to determine the localization program that enables promotion of the technology transfer by replacing expatriate employers in stages with Mongolian staffs after a certain period of time when the operation is stabilized.

Chapter 12. Environmental and Social Considerations

12.1 Laws and Regulations relating to Environment

12.1.1 "Environmental Protection Law" as the Basic Environment Law

The Environmental Protection Law of Mongolia, 1995 is established for the purpose of regulating the relation between the country, citizens, enterprises and organizations so as to secure the human right for living people under healthy and safety environment, the development of social economy harmonized with nature, the protection of present and future generations, appropriate utilization of natural resources and the recovery of utilizable resources. In order to realize the above purpose, the government is to follow the rule as stated below:

1) To prepare the comfortable conditions of natural environment for human life, labor work and leisure time.
2) To secure sustainable balance between the economical development and the natural environment for ecological system.
3) To fulfill appropriate conditions for utilization of natural resources under the scientifical basis.
4) To improve in transparency for decision on the policy of business activities to the enterprise who utilizing natural resources so as to protect natural environment.

This law is to protect the following resources as its subject from the view point of activities possibe to provide the harmful influence to natural environment.

1) Lands and Soils
2) Underground Resources and Minerals
3) Water
4) Plants
5) Animals
6) Atmospheric Air

In case that every nations who suffered any harmful influence from resource(s) shall have the right to present the case to court to request the compensation for loss(es) and damage(s) and to bear cost(s) and expense(s) for recovery.

On the one hand, in case of violating the Environmental Protection Law, punishment and/or administrative disposition shall be inflicted to the violator, and the following compensation shall be paid by the violator in case that he is not subject to such punishment. And the amount of such compensation will differ from the kind of subject suffered by contamination and from the area where such contamination occurred.

- Enterprise(s) and/or Organization(s)：50,000 -100,000 Tg
- Misappropriation of Budget for Environmental Protection by Governmental Staff(s) : 10,000 - 20,000 Tg
- Misappropriation of Budget for Environmental Protection by Enterprise(s) and/or Organization(s)：75,000 - 150,000 Tg
- In case that any of citizens refused against the request specified under the relevant law : 10,000 - 20,000 Tg
- In case that any of enterprise(s) and/or organization(s) refused against the request specified under the relevant law：150,000 - 200,000 Tg

12.1.2 Law on Environmental Impact Assessment

The Law on Environmental Impact Assessment, 1998 is established for the purpose of stipulating the environmental protection, the protection of ecological system, the utilization of natural resources, the environmental impact assessment and the decision making on commencement of project, and matters requested, screening, carrying out of environmental impact assessment and procedures of reviewal are specified in the law.

As to the Environmental Impact Assessment (EIA), as specified in this law, it ia stipulated that the person to carry out the new and/or expansion project, such as mining industries, which will affect to the natural environment shall have the obligation to submit the application for assessment. EIA is broadly composed of two (2) steps, i.e. the General Environmental Impact Assessment (GEIA) and the Detail Environmental Impact Assessment (DEIA), and the procedures for application and obtaining the approval are as follows:

1) The Screening of General Environmental Impact Assessment (hereinafter expressed as GEIA).
2) Carrying out the Detail Environmental Impact Assessment (hereinafter expressed as DEIA) (to be carried out only when required).
3) Obtaining the Approval for Environmental Protection Plan (EPP) and Environmental Protection Plan (EPM).

In addition, it is required, in the field of mining industries, to obtain the approval on GEIA at the time of obtaining the right for exploration and to have the approval for DEIA prior to obtaining the right for mining. Also, in case that the existing mining area is located at around the mining area which is obtaining the exploration right and the mining right, the Cumulative Environmental Impact Assessment (CEIA) for the areas including such existing mining area(s) may be required in some cases.

1) Screening

The screening is to be commenced from presenting GEIA Report to the Ministry of Natural Environment and Green Development as well as that of local government prior to obtaining respective kinds of license such as the right for exploration, etc. by the person who carries out the project. The Ministry of Natural Environment and Green Development and the local government are to determine their judgment of the following four (4) kinds on the report within twelve (12) working days from the receipt of GEIA Report:

- To approve the commencement of project without carrying out DEIA.
- To approve the commencement of project under fixed condition(s) without carrying out DEIA.
- To request for carrying out DEIA.
- Rejection or to request for resubmitting the report revised.

2) DEIA

In case of the judgment that DEIA is required at the screening, the person who carries out the project is to investigate the following matters and submit the result to the Ministry of Natural Environment and Green Development as well as to the local government:

- Baseline and Index relating to Environment at the Subject Area
- Technical Alternative Proposal(s) for Plan
- Mitigation and/or Solution on Environmental Impact
- Simulation on the Scale and Scope of Environmental Impact
- Risk Assessment
- Environmental Protection Plan (EPP)
- Environmental Monitoring Plan (EPM)
- Opinions from Inhabitants of the Subject Area and from Representative(s) of Council in the Local Government
- Protection of Cultural Asset(s) being located at the Subject Area
- Plan for Environmental Recovery by the Project

The Evaluation Committee established in the Ministry of Natural Environment and Green Development is to deliberate on the submitted DEIA Report, and comment(s) and/or instruction(s) for improvement will be provided from the ministry, or the additional investigation may be instructed if required. After the execution of these instruction(s) for improvement, etc. by the person who carries out the project, the Ministry of Natural Environment and Green Development will provide the approval.

3) Approval on Environmental Protection Plan (EPP) and Environmental Monitoring Plan (EMP)

For the purpose of carrying out matters investigated and planned by GEIA and DEIA as well as continuous monitoring, it is requested that the person who carries out the project shall submit the Environmental Protection Plan (EPP) and the the Environmental Monitoring Plan (EMP) annually to the Ministry of Natural Environment and Green Development and the local government during carrying out the work.

In the Environmental Protection Plan (EPP), the environmental impact to be suffered by the project and measures, cost(s) as well as the period of execution for mitigation of the impact are to be described. And in the meantime, methods, procedures, method of analysis and costs as well as the period of executing for the environmental monitoring are to be described in the report of Environmental Monitoring Plan (EMP).

After the submission of the Environmental Protection Plan (EPP) and the Environmental Monitoring Plan (EMP), the person who carries out the project shall report on the matters to be carried out for environmental protection and on the result of environmental monitoring to the Ministry of Natural Environment and Green Development and to the local government in February of every year. Upon the receipt of this report, the Ministry of Natural Environment and Green Development is to carry out the inspection on the same, and it is attempted to carry out the environmental protection measures and the monitoring sustainably by the method that the result of inspection with the matters to be instructed are reflected to the Environmental Protection Plan (EPP) and to the Environmental Monitoring Plan (EMP) in next year.

And, it is stipulated that the person who carries out the project in the field other than mining industries shall pay the amount more than fifty percent (50%) of the cost required for carrying out the environmental protection plan, as a security deposit, annually. On the other hand, although the said stipulation is not applicable to the mining industries, it is stipulated by the Law of Mineral Resources, as the legal action, that the person who carries out the project in the field of mining industries shall deposit the amount equivalent to fifty percent (50%) of the cost required for the environmental conservation to the special bank account designated.

4) Strategic Environmental Assessment (SEA)

The Strategic Environmental Assessment (hereinafter expressed as SEA) is one of EIA which is to be carried out by the person who carries out the project by himself in lieu of the policy, program and plan which are planned by the governmental bureau and/or department. SEA is the item newly established by the legal reform in 2012. The report of SEA submitted is to be deliberated by the Evaluation Committee and submitted to the government upon its approval.

12.1.3 Other Law(s) relating to Environment

Laws relating to environmental affairs in Mongolian Peoples' Republic are composed of the Environmental Protection Law of Mongolia, 1995 as previously described as a fundamental law, several related laws, acts and regulations for protection of animals and plants and, in addition, the areas where valuable animals and plants are lived and propagated are protected by designated as "Protection Zone (Preserve Area)" under the Law of Special Protection Zone. Also, there are laws relating to atmospheric air, water quality and land, and their related acts and regulations are prepared and maintained. Laws relating to environment in the Mongolian Peoples' Republic are shown in Table 12.1.1.

Table 12.1.1 Laws relating to Environment in Mongolian Peoples' Republic

	Documents	Year
General	Law on Environmental Protection	1995
	Decree on Environmental Audit	2013
	Law on Environmental Impact Assessment	2012
	Regulation of EIA	2012
Protected Area	Law on Special Protected Areas	1994
	Law Buffer Zone	1997
Ecology	Law on Forests	2012
	Law on Hunting.	2012
	Law on regulation of export and import of endangered species of flora and fauna	2002
	Law on Natural Plants	2012
	Law on Natural Plant Use Fees	2012
	Law on Plant Protection	2006
	Law on Subsoil	1998
Others	Law on Water	2012
	Law on Water and Mineral Water Use Fees	2001
	Law of land	2002
	Law on Air	2012
	Law on Air Pollution Fee	2010
	Law on Sanitation	2012
	Law on Solid Waste	2010

(Source: Prepared by Survey Team)

1) Laws, Acts and Regulations relating to Closing Mine(s)

In the field of mining industries, management of mine(s) and environmental protection after closing of mine(s) are very important matters. The closing mines stipulated by "The Regulation on Temporary and/or Permanent Closing Mine(s) (2003)", and the National General Bureau for Specialty was in charge of regulating the procedures and the documentation management of closing mine(s) until 2012.

However, these matters as above stated were transferred from the National General Bureau for Specialty to the Ministry of Natural Environment and Green Development due to the change in the Mining Law as well as laws and regulations relating to environment. Also, the closing mine became to be regulated due to the change in the Law on Environmental Impact Assessment in 2012 as well. According to the above legal revision, it is stipulated as the obligation that the person who holds the mining right shall have to submit the plan for closing mine(s) to the Ministry of Mining until two (2) years before the mine closing. The submitted closing mine plan is to be sent from the Ministry of Mining to the Ministry of Natural Environment and Green Development, and instruction(s) and Comment(s) on the plan will be provided to the person who holds the mining right from the said ministry. However, the regulation and rules on detailed provisions in regard to the mine closing scheduled to be prepared and maintained in accordance with the revised Law on Environmental Impact Assessment.

2) Water Resources Law and Revision of Rules on Charges for Water Utilization

As to the legal regulation relating to water resources in Mongolian Peoples' Republic, the management and maintenance of river basins and the protection of water resources as well as appropriate utilization are being carried out in accordance with provisions of the Water Resources Law (1995). And, the industrial water to be utilized for mine development, etc. is regulated by the Law on Damage(s) due to the Utilization of Water Resources or Mineral Water (1995) and by Amended Rule of Charges for Utilization of Water, and respective mines shall have to renew the contract for utilization of water in every year.

12.1.4 Environmental Standards

As environmental standards in the field of mining industries, the allowable exhausting quantity of SOx, NOx and PM which are the cause of atmospheric contamination, the recovery of destroyed area(s) due to mining work, the allowable quantity of contaminants to underground water, etc. are defined by the Mongolian National Standards (MNS), etc. The environmental standards in regard to the field of mining industries are as shown in Table 12.1.2.

1) Environmental Standards on General Contaminants in Atmosphere

As to contaminants of atmospheric pollution, heavy machinery to carry out mining work and other vehicles discharge atmospheric contaminants such as SOx, NOx, PM, etc., and also the contaminants as above stated are discharged due to combustion of fuel in case that the power generator is equipped in the mine. In Mongolian Peoples' Republic, allowable concentrations of general contaminants in atmospheric air are prescribed by Mongolian National Standards (MNS4585:2007) (refer to Table 12.1.3). In case that these allowable standard values are compared with those of WHO Guideline, it can be said that values of SOx, NOx and O_3 are almost equivalent to those of WHO Guideline and however those of PM10 and PM25 are approximately twice of the same.

2) Environmental Standards in regard to Contaminants in Waste Water

The waste water discharged from mines is composed of industrial waste water from ore concentration process, domestic sewage from office, accommodation, etc. and rainwater as well as surface water which are flowing into mine area(s). Generally, acidic waste water may be generated due to chemical reaction between sulfide ores and rain water, etc. In copper mine(s), appropriate treatment of waste water may be required prior to discharge since heavy metals and acidic waste water may have the possibility to provide harmful influence to the environment around the mine.

In Mongolian Peoples' Republic, allowable standard value of contaminants in waste water are prescribed by Mongolian National Standards (MNS4943:2011) (refer to Table 12.1.4 and Table 12.1.5). In case that these allowable standard values are compared with those of IFC Guideline, it can be said that they are approximately in the level equivalent to the value of IFC Guideline. Also, although the allowable standard value for twenty (20) items in waste water are prescribed in IFC Guideline, Mongolian National Standards (MNS4943:2011) prescribes the standard allowable value in waste water for forty-three (43) items in further detail.

Table 12.1.2 Standards relating to Environment in Mongolian Peoples' Republic

MNS No.	Documents	Year
MNS 0900	Environment, health protection, safety, drinking water. Hygienically requirements, assessment of the quality and safety	2005
MNS 2570	To determine freshness of water	1979
MNS 2573	Surface water - To determine concentration of phenol compound	1978
MNS 3342	Surface water - To protect groundwater from pollution	1983
MNS 3532	Surface water - To determine the concentration of lead	1986
MNS 3597	Surface water - To protect ground and surface water	1983
MNS 0017-1-1-14	Surface water - Types of water use	1979
MNS 3934	Drinking and industrial water - To conduct chemical analysis, store, transport and take samples	1988
MNS 3936	Drinking and industrial water- To analyse	1986
MNS 4047	Surface water - Water quality analysis	1992
MNS 4236	Water supply - Requirements on Central Waste Water Plant and Water Supply	2003
MNS 4288	General requirements for selecting a site for wastewater treatment plants and treatment technologies and effectiveness	1995
MNS 4341	Industrial water - To determine concentration of manganese	1996
MNS 4345	Industrial water - The approach for preparing water for chemical analysis	1996
MNS 4348	Industrial water - To determine concentration of copper	1996
MNS 4431	Industrial water - To determine concentration of nitrate compound	1996
MNS 4585	Environmental standards on air quality	2007
MNS 4586	Water - environmental quality	1999
MNS (ISO) 4867	Water quality - Taking a sample. The approach of storing and transporting the sample.	2000
MNS (ISO) 4889	Drinking water - To determine the electroconductive characteristics of water	1999
MNS 4943	Water quality - Waste water standard	2001
MNS 4943	Effluent treated wastewater. General requirements	2011
MNS 494300	Standard on water quality, wastewater and general technical requirements	1982
MNS 5032	Water quality - To determine the concentration of heavy metal by X-ray and flourescence analysis	2001
MNS (ISO) 566-1300	Standard on Water Quality: Guidelines for Taking Water Samples and Samples from Sludge in Wastewater Treatment Plants	1980
MNS (ISO) 5667-1	Water quality - To install the program of taking sample	2002
MNS (ISO) 5667-10	Water quality - Taking samples of waste water	2001
MNS (ISO) 5667-2	Water quality - Taking samples from natural and artificial lake	2001
MNS 5885	Tolerance range of concentration of air pollutants - Technical Requirements	2008
MNS 5915	Classification of land disturbed by mining activities	2008
MNS 5916	Requirements for determining fertile soil removal and Its temporary storage during earth excavation	2008
MNS 5917	Reclamation of land disturbed by mining activities - General technical requirements	2008
MNS 5918	Re-vegetation of disturbed Land - Technical requirements	2008
MNS 6063	Air quality - Tolerable concentration of air pollutants in public areas	2010
MNS 6148	Water quality, maximum limits of substance contaminating the groundwater	2010
MNS0017-1-1-10	Water use and protection – methods	1980
MNS (ISO) 11083	Water quality - To determine chromium concentration by spectrometry with 1.5 diphenylcarbazide	2001
MNS (ISO) 11923	Water quality - To determine the amount of solid substances in water by filtering	2001

(Source: Prepared by Survey Team)

Table 12.1.3 Environmental Standards on General Contaminants in Atmosphere

	Measurement average duration / time	Mongolin standard MNS4585:2007	WHO ambient air quality guidelines	Unit
		Allowable contents and allowable levels	Guideline value	
Sulfur dioxide (SO_2)	10 minutes	500	500	μg/m3
	20 minutes	450	-	
	24 hours	-	20	
	1 year	10	-	
Carbon monoxide (CO)	30 minutes	60,000	-	μg/m3
	1 hour	30,000	-	
	8 hours	10,000	-	
Nitrogen dioxide (NO_2)	20 minutes	85	-	μg/m3
	24 hours	40	-	
	1 hour	-	200	
	1 year	30	40	
Ozone (O_3)	8 hours	100	100	μg/m3
Soot and dust (total substance weight)	30 minutes	50	-	μg/m3
	24 hours	150	-	
	1 year	100	-	
PM_{10}	24 hours	100	50	μg/m3
	1 year	50	20	
$PM_{2.5}$	24 hours	50	25	μg/m3
	1 year	25	10	
Lead (Pb)	24 hours	1	-	μg/m3
	1 year	0.5	-	
Benzopyrene ($C_{20}H_{12}$)	24 hours	0.001	-	μg/m3

（Source: MNS4585:2000、WHO）

Table 12.1.4 Environmental Standards on Contaminants in Waste water (1)

	Mongolin standard MNS4943:2011	IFC guidelines	Unit
	Range / Mazimum allowance	Guideline value	
Water temperature	20	<3 degree differential	°C
Odour	no odour	-	Sense
pH index	6-9	6-9	mg/l
Biochemical Oxygen Demand	20	30, 50	mg/l
Chemical Oxygen Demand	50	125, 150	mg/l
Permanganate oxidation	20	-	mg/l
Suspended Solids	50	50	mg/l
Dissolved salt	1,000	-	mg/l
Cyanide	0.2	1 (free cyanide 0.1)	mg/l
Mineral oil	1	-	mg/l
Fat oil	5	10 (Oil & Grease)	mg/l
Sulphide	0.5	-	mg/l
Cu	0.3	0.3	mg/l
Cd	0.03	0.05	mg/l
Mg	0.5	-	mg/l
Hg	0.001	0.002	mg/l
As	0.01	0.1	mg/l
Ni	0.2	0.5	mg/l
Se	0.02	-	mg/l
Be	0.001	-	mg/l
Co	0.02	-	mg/l
Ba	1.5	-	mg/l
Sr	2	-	mg/l
V	0.1	-	mg/l
U	0.05	-	mg/l
Fe	1	2	mg/l
Pb	0.2	0.2	mg/l
Total Cr	0.3	-	mg/l
Cr (VI)	0.1	0.1	mg/l
Zn	0.5	0.5	mg/l

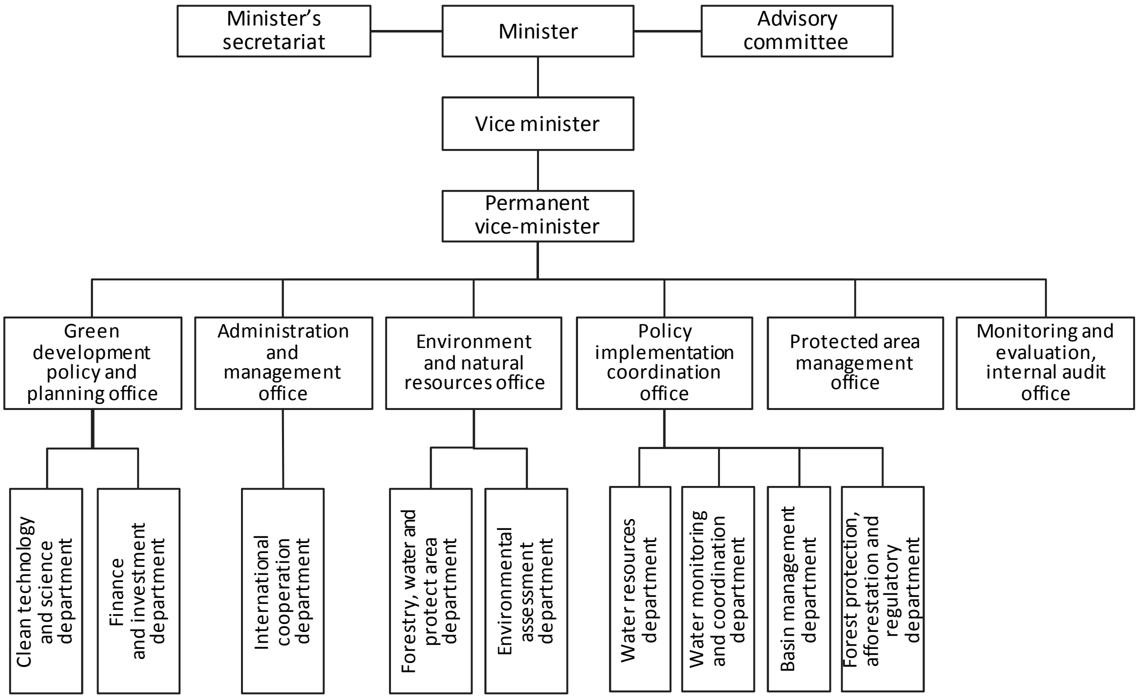
Table 12.1.5 Environmental Standards on Contaminants in Waste water (2)

	Mongolin standard MNS4943:2011	IFC guidelines	Unit
	Range / Mazimum allowance	Guideline value	
NH4+	6	-	mg N/l
Al	0.5	-	mg/l
Sb	0.05	-	mg/l
Mo	0.5	-	mg/l
B	0.3	-	mg/l
Total N	30	10	mg/l
Total P	1.5	2	mg/l
Organic P	0.2	-	mg/l
Phenols	0.05	0.5	mg/l
Trichloroethylene	0.1	-	mg/l
Tetrachlorethylene	1	-	mg/l
Remaining chlorine	0.1	-	mg/l
Pathogens and other irregular bacteria	not detectable in 1 mg/l	400	

（Source: MNS4943:2011, IFC）

12.2 Administrative Organization in regard to Environment

The administration relating to environment is under jurisdiction of Ministry of Natural Environment and Green Development in Mongolian Peoples' Republic. This ministry is carrying out the preservation and maintenance of natural environment in Mongolia, the planning and execution of policies, management and control of Special Protection Zone, the evaluation and approval on EIA. The organization chart of Ministry of Natural Environment and Green Development is shown in Figure. 12.2.1.



(Source: Ministry of Natural Environment and Green Development)

Figure 12.2.1 Organization of Ministry of Natural Environment and Green Development

12.3 Activities for Environmental Conservation in Mine

In Mongolia, the enterprise in charge of management on mine operation is obligated to perform planning and carrying out of the environmental protection plan (EPP) and the environment monitoring program (EMP), and Oyu Tolgoi Mine discloses to the public in the form of EMP Annual Report through Web site. Activities for environmental conservation being carried out in Oyu Tolgoi Mine are described in the following.

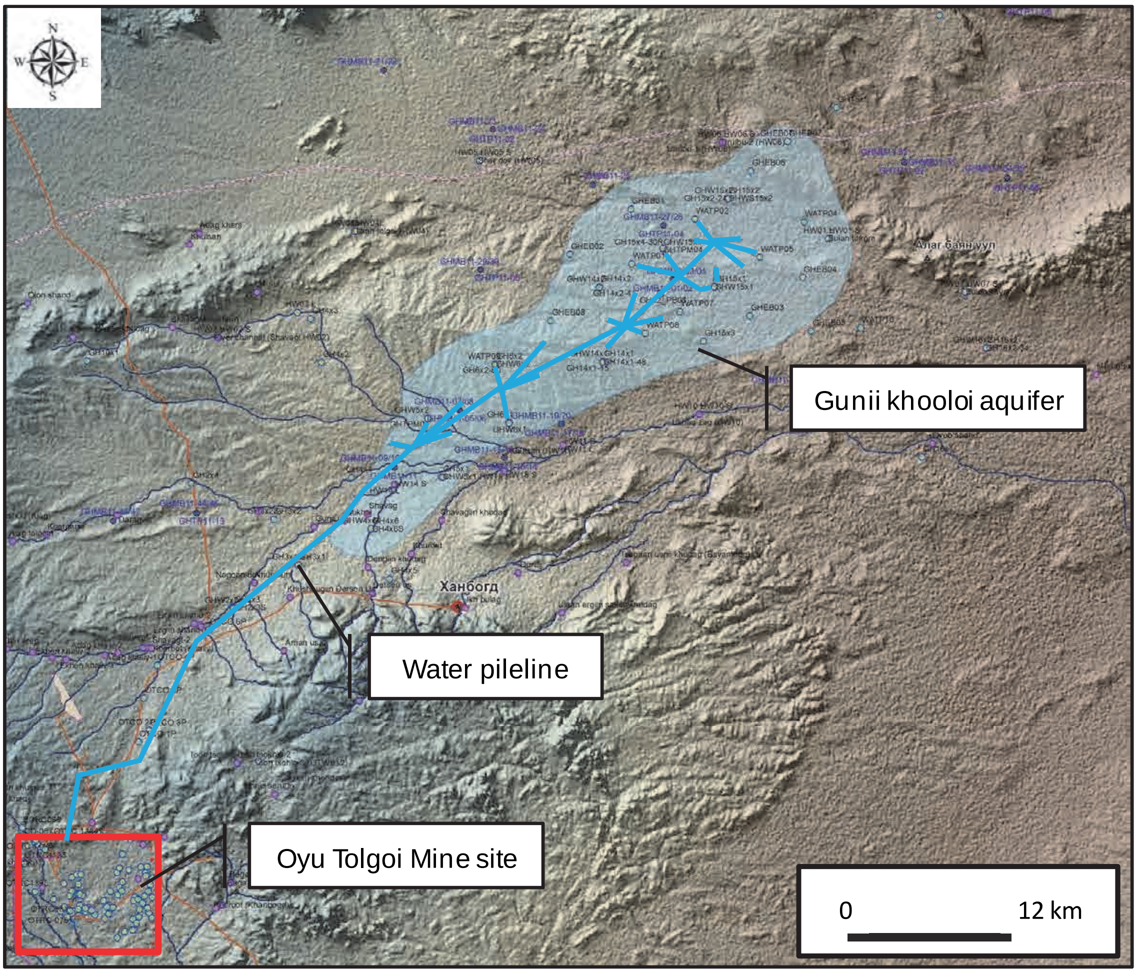
12.3.1 Water Resources

Ground water from Gunii Khooloi Aquifer locating mainly at 82 km north-east from the mine is being supplied and utilized for industrial water and domestic water as well in Oyu Tolgoi Mine (Figure 12.3.1). It is confirmed by the investigation carried out during the period from 2003 to 2007 that this Gunii Khpploi Aquifer has the abundance of 6.8 billion cubicmeter (i.e. 6,800,000,000 m^3), and Oyu Tolgoi Mine obtained the permit for utilization of approximately 20% of the said abundance from the Ministry of Natural Environment and Development of Green, etc.

Industrial water and domestic water being used in the mine are pumped up from the aquifer from twenty eight (28) wells and transmitted to the reserve pond (max. reservable volume; 200,000 m^3) through a pipeline (max. conveying capacity; 900 litter/sec.) by five (5) sets of convey pumps

(Photo-12.3.1).

In order to minimize the pumping up quantity from this aquifer, Oyu Tolgoi Mine has a plan to save water consumption by recycling 80% of water being used and 83% of this plan has been achieved in 2013. Also, monitoring facilities of not less than 500 places are installed in Oyu Tolgoi Mine and the area of Gunii Khooloi Aquifer, and periodic measurements on water level and water quality are carried out.



(Source: Oyu Tolgoi, 2013)

Figure 12.3.1 Gunii khooloi Aquifer and Water pipeline

(Water is reserved underneath black colored sheets for vaporization prevention.)

（Source： Photo taken by Survey Team）

Photo 12.3.1 Water Reserve Pond around Oyu Tolgoi Mine

(1) Water Consumption

The water consumption of Oyu Tolgoi Mine in 2013 was 64,622,000 m^3. 53,925,000 m^3 of the above amount are reused by recycling (recycling rate; 83.45%), and the net water consumption, i.e. the value corresponding to amount of water pumping up from the aquifer, or in other words the value resulted by subtracting the amount of water recycled from the amount of water used, is 11,392,000 m^3/year (Table 12.3.1). As to the consumption for respective purposes of use, both the amount of water used and the net water consumption in ore dressing process is the largest and is 92% of the total amount. The domestic water after used treated by four (4) sets of waste water treatment facilities equipped in the mine and recycled and reused as spray water, etc. for prevention of dusting from mine roads.

Table 12.3.1 Amount of Water used and Consumption in Oyu Tolgoi (2013)

Prudunction	Water production (m^3)	(As of 2013)
Amount of water pumped from Gunii khooloi aquuifer	11,192,210	
Recycle	Recycle (m^3)	Recycle (%)
Cocentration	53,452,530	83.58%
Household (Waste water treatment facility)	473,069	80.50%
Sub total	53,925,599	83.45%
Production and Recycle Ttotal	65,117,809	
Water use and consumption	Water use (m^3)	Consumption (m^3)
Concentrator plant	63,955,443	10,502,913
Undergroud mine	11,714	452,676 (prodction w ithout concentrator)
Concrete batch	6973	
Oyu Tolgoi-Gashuun Sukhait roads	43,017	43,017
Household	587,670	375,597
Tree nursery irrigation	13,004	13,004
Water pumped from the open pit	5,003	5,003
Total	64,622,824	11,392,210

(Source: Oyu Tolgoi, 2013)

(2) Monitoring

In order to grasp the environmental impact to pumping up water from the aquifer, etc. due to development of Oyu Tolgoi Mine, monitoring facilities at five hundred and thirteen (513) places are installed at areas around Oyu Tolgoi Mine, and periodic measurements and observations are carried out. Among these monitoring places, measurements and observations are being carried out at observation holes of two hundred eighty seven (287) places in Gunii Khooloi Aquifer and at those of four (4) places at the water gushing out area are being carried out as well.

From the result of monitoring, it is observed that top surface levels of ground water at considerable numbers of wells are lowered down by several meters during six (6) months since April. 2013 due to the increase of pumping up water amount according to the commencement of normal operation of concentrator. It is desired in future too to carry out the appropriate management and control on the water pumping up amount of ground water from the aquifer and on the top surface level of ground water.

12.3.2 Atmosphere

As to the monitoring on matters relating to atmosphere, measurement and observation on four (4) items, i.e. weather observation, contaminant(s) of atmospheric air, noise and vibration, are presently being carried out.

As to the weather observation, measurement and observation are being carried out by means of automatic observation equipment installed at the northern part of the mine throughout the year. Items to be observed are atmospheric temperature, atmospheric pressure, humidity, wind direction, wind velocity and precipitation and they are automatically measured at hourly intervals.
And, as for the monitoring on atmospheric contamination, three (3) items, i.e. particulates such as $PM_{2.5}$, etc., CO_2, etc. and noise, are being observed and measured.

Three (3) items of particulate matters suspended in atmospheric air, i.e. $PM_{2.5}$, PM_{10} and TSP, are measured at twenty (20) observation points in total installed at the mine, air port, etc. and however the result of measurement at numbers of observation points exceeded the limit stipulated in the environmental standards of Mongolia (MNS4585-2007). From this result, the mine is considering the relocation of these observation points.

Regarding to the concentration of atmospheric contamination, CO, CO_2, CH_4, O_2 and NH_3 in addition to NO_2 and SO_2 are measured at thirty six (36) points in the mine. Although most of results of measurements on the above items are below the limit value stipulated in the environmental standards, the results of measurement on NO_2 in some months are exceeding the said limit at the most of measuring points, and accordingly the reconsideration on this matter including method of measurement may be required.

The measurement of noise is being carried out by mobile type sound level meter at eleven (11) points during day time and night time. Noise levels during day time are mostly 35 ~ 45 dB and is below the limit of 60 dB stipulated in the environmental standards. On the other hand, those during night time are exceeding the limit of 45 dB, and it should be noted that these levels during night time include the influence due to strong winds.

Vibrations are being measured by means of vibration meter at eight (8) points of 5 km - 20 km apart from open pit as a center point and the result of measurement shows that the vibration is controlled within the basic limit of the standard.

12.3.3 Soil

Two (2) kinds of analysis and observation on chemical compositions, chemical properties and physical properties as well as inspection of bacteria and microbes are being carried out. Descriptions on the above are made in the following.

(1) Chemical Compositions, Chemical Properties and Physical Properties

The analysis and measurement on chemical compositions, chemical properties and physical properties at sixteen (16) points in the area around the mine and Gunii Khooloi Aquifer are being carried out. The respective samples of soil collected are divided into two (2) sections depend on its depth, i.e. 0 - 5 cm section and 5 - 20 cm one, and the measurement is carried out for investigating the difference depend on depth and items to be measured are pH, EC, main components, heavy metals and particle size of soil.

According to the report on carrying out EIA by Oyu Tolgoi Mine, the concentration of As in all sample soils collected for measurement at the area around Oyu Tolgoi Mine are exceeding the upper limit of 6 mg/kg stipulated in the environmental standards, and the mine stated that these measured values are those of soil originally existing at areas around the mine.

Table 12.3.2 Concentration of Heavy Metal Components in Soil

Location	F	As	Se	Co	Cr	Cu	Mo	Ni	Pb	Zn	Sn	Sr	Hg	Cd
	mg/kg												%	
QrBP	<0.05	11	<5	5	23	64	<5	19	17	51	<20	357	<0.05	<3
EP01	<0.05	14	<5	7	45	26	<5	21	21	68	<20	255	<0.05	<3
EP02	<0.05	14	<5	7	32	17	<5	21	18	64	<20	255	<0.05	<3
LaFi0l	<0.05	17	<5	14	40	34	<5	20	14	56	<20	284	<0.05	<3
LaFi02	<0.05	17	<5	10	42	85	<5	24	105	65	<20	245	<0.05	<3
Main	<0.05	18	<5	13	48	41	<5	19	110	186	<20	303	<0.05	<3
WaHo	0.05	15	<5	16	43	93	5	28	19	85	<20	311	<0.05	<3
CHP	<0.05	13	<5	5	40	27	<5	20	15	53	<20	280	<0.05	<3
WWTP	<0.05	19	<5	6	40	141	5	23	16	67	<20	374	<0.05	<3
PDS01	<0.05	15	<5	14	37	63	<5	19	18	67	<20	408	<0.05	<3
PDS02	0.08	14	<5	6	39	50	<5	20	17	54	<20	320	<0.05	<3
PDS03	<0.05	20	<5	10	34	108	<5	23	7	60	<20	421	<0.05	<3
PDS04	<0.05	18	<5	12	42	273	<5	24	18	68	<20	336	<0.05	<3
DS01	<0.05	17	<5	7	31	59	<5	20	31	63	<20	317	<0.05	<3
DS02	<0.05	17	<5	6	23	100	<5	14	19	68	<20	326	<0.05	<3
DS09	<0.05	54	<5	33	44	804	30	24	<5	77	<20	411	<0.05	<3
PAP02	<0.05	11	15	49	27	<5	27	14	55	<20	244	95	<5	
SH01	<0.05	17	<5	9	28	42	<5	18	17	72	<20	251	<0.05	<3
TSF01	<0.05	14	<5	11	53	27	<5	24	13	51	<20	258	<0.05	<3
TSF02	<0.05	11	<5	<5	38	22	<5	23	22	80	<20	227	<0.05	<3
TSF03	<0.05	9	<5	6	23	25	<5	15	12	43	<20	261	<0.05	<3
UnRi01	<0.05	13		<5	31	18	<5	22	17	46	<20	287	68	<3
UnRi02	<0.05	14		11	66	36	<5	30	18	66	<20	305	90	<3
UnRi03	<0.05	17		14	51	37	<5	24	13	56	<20	305	100	<3
MNS5850:2008 Maximum permissible level	200	6	10	50	150	100	5	150	100	300	50	800	2	3

(Source: Oyu Tolgoi, 2013)

(2) Inspection of Bacteria and Microbes

In Oyu Tolgoi Mine, the existence of bacteria and microbes in the soil sampled from twenty two (22) observation points at the mine area, the area around pipeline from Gunii Khooloi Aqifer and the road between Oyu Tolgoi and Gashn Sukhait are being inspected. Items to be inspected are colon bacillus, enteric bacteria, heat resistant bacteria and Welch bacillus. Three times of the monitorings on these items were carried out in summer season, i.e. June, July and September, 2013 were carried out, and no evident change was found in soil samples from any of these observation points.

12.3.4 Wild Fauna and Flora

Kinds and numbers of the wild fauna inhabiting and flora naturally growing are periodically monitored and the influence due to the development work of mine are investigated.

As for the flora, plants naturally growing at thirty two (32) places of the area around the mine and those at four (4) places of the area around the remain of mining restored were monitored and kinds of plants, dominant species, density, height of trees, temperature of soil and humidity are observed and measured in 2013. These monitoring are to be carried out at the interval of once a year for around five (5) years and then the monitoring is to be carried out at the interval of once per 5 - 8 years for utilizing to observe the change in flora due to the development of mine.

On the one hand, numbers (i.e. population) of wild faunas inhabiting at the area around the mine are being observed from the ground surface and from the air-plain. Two times of the above observation have been carried out for eleven (11) kinds of wild faunas in total, and such observation has been carried out at six (6) points in the mine and two (2) points around Gunii Hhooloi Aquifer in 2013. Also, the range of behavior of wild donkeys inhabiting around the mine is to be observed by fitting GPS receiver on the body of wild donkey(s) and activities to reflect the above range of behavior for the construction of road, etc. so as to minimize the influence and/or impact to wild faunas are being carried out as well.

12.3.5 Restoration of Remains of Mining

For the purpose of restoring biological species and plants lost due to the development of mine, the surface soil generated by mining work at open pit mine and construction work of plant such as concentrator, etc. is kept as it is at the storing area, and planting and covering with the surface soil stored as above mentioned in some area where mining work were completed for restoration.

In Oyu Tolgoi Mine, surface soils of approximately 6,491,000 m^3 were peeled up and removed for various construction works, and approximately 5,462,000 m^3 of such surface soil among them are being stored for the restoration of remains of mining. These removed surface soils are piled up at ten (10) areas in total around open pit mining yard and tailing dam, etc., and such soils are managed and controlled by carrying out of chemical analysis, etc.

Planting and soil covering were carried out at thirty five (35) areas at and around the mine and at the area where land change was performed in 2013. Major areas where such planting and soil covering ware carried out are seven (7) places at the site of boring exploration, eleven (11) places at the site of boring for ground water exploration and six (6) places at the site collecting aggregates for construction of paved road, and such work was carried out for the area of 83 ha in total. As to planting, the greening ground by spraying method using seeds previously collected from naturally grown plants around the mine is carried out, and the plantation of some trees is performed by the procedures that nursery trees from collected seeds are grown then such young trees are planted with soil covering.

Chapter 13. Issues and Recommendations for Development of Copper Industries

As described in previous chapters, Mongolia has not reached to such a stage that the copper resources may not be able to utilize effectively due to inadequate infrastructures, undevelopment of downstream industries, lack of domestic demands, etc., although a higher potential of copper resources is existing in the country at present. For the purpose of economical development in Mongolia, the utilization of plentiful copper resources will be indispensable. From this reason, issues required for the development of copper industries and the measures to solve this matter are described in the following.

13.1 On The Development of Copper Industries

As the issue required for the development of copper industries in future, nine (9) items as shown in Table 13.1.1 can be listed up. As to these items, descriptions are made in the followings.

Table 13.1.1 Issues required for Development of Copper Industries

1) Preparation of Infrastructures for Transportation (Railways & Roads)	2) Ensuring the Route for Inland Transportation to Countries Outside of Mongolia	3) Development of Downstream Industries (Dressing & Processing)
4) Ensuring of Water Resources and Effective Utilization	5) Nurturing of Engineers and Technicians	6) Market Research and Improvement of International Competitiveness
7) Promotion of Technical Development relating to Mining and Manufacturing Industries by The Governmental Leading	8) Carrying-out of Fundamental Investigation and Survey for Development of Mineral Resources by The Governmental Leading	9) Preparation of Laws, Regulations and Organizations for Environmental Conservation

(Source: Prepared by Survey Team)

1) Preparation of Infrastructures for Transportation

The preparation of railways and roads is required and particularly the preparation of railways is indispensable for long distance transportations. The existing railway line which had already been constructed in Mongolia at this stage is the north-south line between Suhhbaatar and Zamyn-Uud and the line between Choibalsan and Ereentsav as the principal railway line with several branch lines which are connecting from the said principal line to Erdenet Mine and coal mines only. Therefore, the transportation from mines in South Gobi where no railway is constructed is to be only by road. From this reason, the destination for export will be limited to Republic of China having a short transportation distance and adequate infrastructures as the destination for export.

From the present state, the mine where copper concentrates can be exported to the country other than China and will become a subject for the development of copper industries by utilizing copper concentrates is only Erdenet Mine. For the development of copper industries by utilizing mines in South Gobi Area, either the construction of railway line connecting to the railway in China side at the border or the construction of east-west railway connecting to Sainshand is the absolute condition required.

2) Ensuring the Route for Inland Transportation to Countries Outside of Mongolia

At present, the inland transportation route of products from Mongolia to the international market has only through three (3) gates, i.e. Sukhbaatar at north, Zamyn-Uud at south and Ereentsev at north-east, and there is no alternative but 1) to be carried out and transported from Sukhbaatar or Ereentsav either to the port at Japan Sea side or to the Central Russian Upland at west side as well as to the area of former Soviet Union by Russian railway line, or 2) to be carried out and transported from Zamyn-Uud to Tianjin City in China by Chinese railway line. In consideration of wider country areas and inadequate preparation of domestic infrastructures in Mongolia, it is requested to increase the international gate for the advance of exportation into international market. Also, for the purpose of attempting to develop copper industries in South Gobi area, the construction of railway line through Gashuun Sukhait and the establishment of additional international gate(s) are required as a matter of the highest priority.

As for transportation through the border line between countries (i.e., cross-border transportation), it will be required not only to deliberate between Mongolia and China or Russia in which the cargo is passing through the country but also it may be required to deliberate with the adjacent relating country for the cooperation in order to improve the distribution system and to mitigate relating regulation(s).

3) Development of Downstream Industries

Due to decrease of TC/RC (Treatment Charge / Refining Charge) caused by the superior situation of supplier side of concentrate, it is the present state that ensuring the profit only by smelting work has become difficult. From this reason, the development of downstream industries in which the copper after smelting is to be processed is requested in order to achieve the promotion of copper industries for the enterprise as well as for the government. Presently, there is only the copper wire manufacturing and processing plant in Erdenet, it is urgent matters to develop downstream industries for producing and selling the products suitable for the domestic market as well as for markets in neighboring countries.

Also, it is desirable to promote an industrial policy focusing the investment climate in order to foster internationally, of course domestically as well, competitive downstream industries by active introduction of foreign capitals and technologies.

4) Ensuring of Water Resources and Effective Utilization

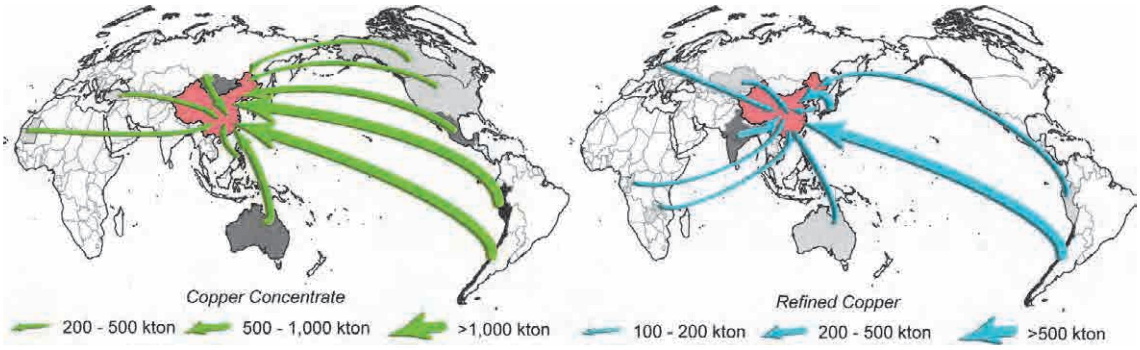
For the development of industries, it will be an extremely important issue to ensure water resources. Especially, from the reason that Mongolia has less precipitation, the development of industries which require a large amount of water will be difficult. Also, although water consumption of respective plants is less, the industrial estate as a whole consumes very much quantities of water. From this fact, it is required that the location of plant which consumes a large amount of water has carefully to be determined. In addition, it is important that the pump up discharge has to be determined upon sufficiently knowing the groundwater storage potential and the groundwater recharge for respective areas, and that the valuable water resources have to be efficiently utilized by increasing the recycling rate.

5) Nurturing of Engineers and Technicians

Numbers of employees relating to mining industries in Mongolia is approximately fifty thousand (50,000) persons as a whole, and numbers of skilled technicians are very limited. The nurturing of skilled technicians will be very urgent requirements for the expansion of mines and the development of new mine(s) in the future. And, as numbers of employees engaged in manufacturing industries are only approximately eighty one thousand (81,000) persons and mechanical and electrical engineers/technicians extremely less, the nurturing of these engineers and technicians is a large issue for the development of processing of copper ores.

6) Market Research and Improvement of International Competitiveness

In order to carry out the business expansion of copper ores and copper products into international market, it is required to make sure what sort of products can be sold and what is demanded by carrying out the sufficient market research. The products having a higher processing rate can not always be sold in the market. For example, as Japan is a country of exporting copper ingots, Japan has no demand of copper ingots though copper concentrates are needed. As shown in Figure 13.1.1, China is importing all of copper concentrates, copper ingots and sulfuric acid and is the country consuming large amount of these materials and accordingly it is evident that China is to be considered as the first marketable target for Mongolia. However, it has large risks to make biased business with a specific country and accordingly it is necessary to make efforts for widening the market, and the preparation of items **1)** and **2)** as above stated is required for this purpose.



(Source: Prepared by Survey Team)

Figure 13.1.1 Importation State of Copper Concentrates and Copper Ingots in China

In order to carry out the business of copper ores and copper products into international market, it is required to ensure the quality satisfactory to purpose of use, steady supply and to ensure the competitiveness in price. Taking an example of the quality, the quality of copper ingots is requested to be satisfactory to that stipulated in LME Grade-A (Table 13.1.2) as well as COMEX Grade-I (Table 13.1.3). In addition, it is required to be superior to other countries in the price competitiveness including transportation cost.

And it is considered that the establishment of organization such as a think tank which is capable to carry out the collection and analysis of information on the international market and to provide its advice(s) and proposal(s) for the policy on resources to the government is required as well in order to improve the international competitiveness.

Table 13.1.2 Upper Limit of Impurities including in Copper of LME Grade-A

Se	≦0.00020%	Te	≦0.00020%
Bi	≦0.00020%	Sb	≦0.0004%
As	≦0.0005%	Pb	≦0.0005%
Fe	≦0.0010%	S	≦0.0015%
Ag	≦0.0025%		
Total Quantity of Impurities including above element(s)			≦0.0065%
Se+Te+Bi			≦0.0003%
As+Sb+Cr+Mn+Cd+P			≦0.0015%
Fe+Si+Sn+Ni+Zn+Co			≦0.0020%

(Source: Prepared by Survey Team)

Table 13.1.3 Upper Limit of Impurities including in Copper of COMEX Grade-1A

Se	≦0.0002%	Te	≦0.0002%
Bi	≦0.00010%	Sb	≦0.0004%
As	≦0.0005%	Pb	≦0.0005%
Fe	≦0.0010%	Ni	≦0.0010%
Sn	≦0.0005%	S	≦0.0015%
Ag	≦0.0025%		
Total Quantity of Impurities including above element(s)			≦0.0065%
Se+Te+Bi			≦0.0003%

(Source: Prepared by Survey Team)

7) Promotion of Technical Development relating to Mining and Manufacturing Industries by The Governmental Leading

In order to carry-out mine development, treatment and processing of ores continuously, it is required to develop further effective methods and procedures by carrying out the technical development on technologies of exploration, treatment and processing at all times. Particularly, as Mongolia has less water resources, it is an extremely important matter to develop the water saving technologies in treatment and processing of ores. Also, from the reason that the pyrometallurgy produces a large amount of sulfuric acid and the treatment of such acid is an issue to be solved, it is important for Mongolia to develop the hydrometallurgy (i.e. wet copper smelting) of sulfide ores which does not produce sulfuric acid as well. These technical developments are to be carried out by the leadership of government and it would be proposed that the research organization and research institute are to be established under the initiative of the Ministry of Mining. In Japan, the Agency of Industrial Science & Technology (AIST) had been organized under the Ministry of Industrial Trade and Industry (MITI) [Presently called “the Ministry of Economy, Trade and Industry (METI)”], and the research and development carried out therein have largely been contributed to the development of mining and manufacturing industries in Japan.

By organizing the governmental agency, the cooperation and/or the support with/from overseas organization(s) as a form of joint research can easily be received and the carrying out of efficient technical development can be performed.

8) Carrying-out of Fundamental Investigation and Survey for Development of Resources by The Governmental Leading

For the purpose of achieving sustainable development in mining industries, it is vitally important to grasp details of known deposit(s) and to discover the new deposit by carrying out the fundamental investigation continuously. Results of these fundamental investigations and data accumulated by the exploration of deposits carried out are to be arranged as the data base and are to be disclosed to the public for the promotion of participation to mine development(s) by the enterprise, and the efficient exploration is possibly be performed by the enterprise.

In addition, the geological map of 1/200,000 in scale, as the basic information, has been completed for covering approximately eighty percent (80%) of whole country areas, and however that of 1/ 50,000 in scale has been prepared only around thirty percent (30%) so far. Almost of these data are kept as digital data and available at the Geological Information Center of the Mineral Resources Agency of Mongolia (MRAM), and however detailed reports and maps on the past exploration of mineral deposits, etc. have not been prepared as electronic files.

9) Preparation of Laws, Regulations and Organizations for Environmental Conservation

Copper smelting industries require a large amount of electric power as well as industrial water and on the other hand generate waste water as well as flue dusts during the course of the smelting process. And accordingly, concentrative cares should necessarily be taken not only to the energy saving and water saving but also to the measures for environmental conservation such as consummation of facilities for waste water treatment and those for flue dust treatment.

In Mongolia, the environmental conservation is an extremely important issue since there is less water resources and are numbers of nomadic people living by stock farming in grassy plains as their life occupation, and sufficient cares shall necessarily be taken to this matter at the development of mine(s) and the operation of smelter. Accordingly, it is very important issues to prepare laws and regulations for environmental conservation and to establish the organization for supervision on the same.

13.2 Economic Effect due to Development of Copper Industries

13.2.1 Macroeconomic Effect

The amount of copper materials exported became 2.5 billion Tg. from the computation carried out taking into consideration of only the increased amount of value added on the assumption that the value added in mines does not change either in case of exportation or domestic consumption. The value added rate of “Manufacture of Other Non-metallic Mineral Products and Metal Products” which includes smelting industry is 0.382, and the increased amount of value added is nine hundred and fifty six billion (956,000,000,000) Tg. And, this vale becomes nine hundred and fifty six billion and four hundred million (956,400,000,000) Tg. in case of adding the amount increased due to the income increase of laborers to the above. This value becomes nine trillion and two hundred billion (9,200,000,000,000) Tg. evaluating as the accumulated value for twenty (20) years, and becomes ten trillion and four hundred billion (10,400,000,000,000)) Tg. in case of taking into account of the effect of investment and that from profit of sulfuric acid. It was indicated that the construction of smelting industry has a large effect to the economy in case of all going satisfactorily. However, this is largely depending upon the price of copper, and the economic effect will become five trillion and eight hundred billion (5,800,000,000,000) Tg. if the price of copper becomes a half of present one and the economic effect will largely be decreased accordingly.

As the economic ripple effect from the sales of by-products in copper industries is extremely small, whether the purchaser of copper products can be ensured or not will become a key, as the result. Although it is assumed at this stage that all of copper products are to be exported to China, this will not only have a higher national risk but also have a smaller economic ripple effect as well. Also, as downstream industries for the copper industry have not been developed yet at present in Mongolia, the economic ripple effect would become lower even though the production of smelting industry would be commenced.

13.2.2 Development Scenario of Copper Industries and Economic Ripple Effect

Regarding to the future of copper industries in Mongolia, three (3) cases of business development were assumed as described below. Discussions and considerations are made on the range of increase on economic ripple effect in Mongolia in respective cases, comparing with the present state that copper smelting and processing have not been developed yet, on the basis of the amount of royalties and taxes to be the revenue of government, the amount of exportation to countries outside of Mongolia and sales amount of domestic industries, etc.

- Scenario 1 ： Development of only mining industry
- Scenario 2 ： Development of copper smelting in addition to mining
- Scenario 3 : Development of copper mining, copper smelting, copper processing industries as well as chemical industry to produce sulfuric acid

Summary on the result of above is shown in Table 13.2.1.

Table 13.2.1 Development Scenario of Copper Industries in Mongolia

(million US$)

Business Models	Total Revenue	Exports Value	Royalty+ tax	Industrys' Profitability	Employment
(1) Only Copper Mines					
Copper mine industry	1,191	1,261	α1(*1)	AAA	AA
Royalty	71	—	—	—	—
Entire Mongolia	**1,261**	**1,261**	71+α1	AAA	AA
(2) Copper mines＋Smelter					
Copper mine industry	1,191	0	α1	+AAA(*2)	AA
Smelter	192	1,454	α2(*1)	-A～0(*3)	A
Royalty	71	—	—	—	—
Entire Mongolia	**1,454**	**1,454**	71+α1+α2	AAA～-AAA	AAA
(3) Copper mines+Smelter+Fabrication					
Copper mine industry	1,191	0	α1	+AAA	AA
Smelter(*1)	192	1,163	α2	-A～0	A
Fabrication+Chemical(*1,*5)	954	954	α3(*1)	A	A
Royalty	71	—	71	—	—
Entire Mongolia	**2,408**	**2,117**	71+α1+α2+α3(*4)	+AAA	AAAA

Notes: The meaning of marks and abbreviations in the above table is as follows:

*1: α1～α3 are corporation tax and income tax to the enterprise (mine, smelting and/or processing)

*2: ＋AAA means that no transportation is required since concentrates are being consumed at its own smelter.

*3: The minimum profitability is assumed to be 0, though it may have a possibly to be minus value.

*4: $\alpha 1 < \alpha 1 + \alpha 2$ or $\alpha 1 < \alpha 1 + \alpha 2 + \alpha 3$ is not always correct.

- Scenario 1 is only the development of mine as same as present state. Royalty of mine and taxes are to be the revenue of the government.
- Scenario 2 is to produce copper ingots and sulfuric acid by newly constructed smelter(s), and whole of copper ingots and sulfuric acid produced by processing therein are to be exported.
  - ⇒In comparison with the case of Scenario 1, increase in the amount of domestic production and that of export revenue was only 1.15 times respectively.
  - ⇒The revenue of government will be increased since the tax revenue from smelter in addition to the royalty of mine as well as tax revenue from mine can be collected by the government, also the employment will be increased.
- Scenario 3 is the case that the quantity corresponding to 20% of total production of copper ingots and sulfuric acid are to be domestically processed in Mongolia, and products from the said processing as well as remaining 80% of copper ingots and sulfuric acid are whole to be exported to countries outside of Mongolia.
  - ⇒In comparison with the case of Scenario 1, the amount of production in Mongolia

will become 2.3 times, and the amount of exportation will be approximately 2.1 times.

⇒Further increase of the revenue of government as well as that of employment will be expectable since tax revenue from copper smelting, copper processing and sulfuric acid production from chemical plant in addition to the royalty and tax revenue from mine can be collected by the government as well as the increase of employment in comparison with Scenario 1 and 2 above.

In case that the smelter plant is constructed, it is desirable to develop the copper processing and sulfuric acid chemical industries by using a part of products from smelter for the purpose of creating industrial infrastructure, improvement of technical level in whole of nation as well as generation of employment. Also, it is important to advance the scheme in no hurry by utilizing foreign capitals and technologies from the long term viewpoint.

13.3 On Construction of Smelter

The method of copper smelting can be classified into two (2) types, i.e. the hydrometallurgy (i.e. wet copper smelting) to be used for oxide ores and the pyrometallurgy (i.e. dry copper smelting) to be used for sulfide ores. Proposals on the construction of smelter for respective methods in Mongolia are described in the followings.

13.3.1 Hydrometallurgy (i.e. Wet Smelting)

At Erdenet, the SX-EW (Solvent Extraction / Electrowinning) smelter which constructed by Erdmin Co. and commenced its production of 2,500 t/year cathode copper from 1997 and the smelter of Achit Ikht Co. which commenced its production from July, 2014 and has its production capacity of 10,000 t/year cathode copper are in existence. Both of these smelters are producing copper recovered by leaching the waste rocks (oxide ores) in Erdenet Mine into sulfuric acid solution. According to the extension of mining pits toward the area around the extended pit in Erdenet Mine, a certain quantity of oxide copper ores will be exploited in future too and it is considered that the supply of ores will be made without any issue accordingly. As sulfuric acid is not domestically produced, it is imported from foreign countries.

From the reason that the small scale SX-EW, in which producing copper metal from oxide ores, having production capacity of even around 10,000 t/year can be economically operatable, it is considered that Mongolia has to carry out the production of copper by the hydrometallurgic smelter at first as the matter of priority for the accumulation of technologies and the development of downstream industries. It is considered that the sufficient operation of SX-EW will possibly be carried out depend on the size of ore reserve from the fact that plenty of oxide copper ores can be observed in the surface layer even in Tsagaan Suvarga Mine where the peeling off of the surface soil is being carried out in addition to that of Erdenet Mine. It is important to grasp the possible duration for operation of SX-EW smelting by carrying out the calculation on the oxide ore reserve in respective mines.

13.3.2 Pyrometallurgy (i.e. Dry Smelting)

There is no pyrometallurgic smelter existing in Mongolia at present stage. As for the construction of pyrometallurgic smelter, numerous investigation and discussions have been made in Mongolia so far. In this section, result of discussions on site for construction, type of smelting and treatment of sulfuric acid, which are important issues, are described in the following.

In case of pyrometallurgic smelting, it is generally required that the scale of smelter of which the economical operation is expectable should be not less than 100,000 t/year. From this fact, the pyrometallurgic smelting requires a larger scale in comparison with that of hydrometallurgic smelting and the cost for construction and operation becomes far large as well.

(1) Site Prospected for Construction of Smelter

As the geographical and social conditions of a location for constriction of smelter, the existence of infrastructures for transportation prepared, the existence of sufficient water resources utilizable, the possibility for ensuring skilled technicians, possibility to keep sufficient laborers, the existence of engineering companies required for maintenance work of smelter as well as material supplier(s) for procurement of parts and materials for maintenance at the area around the smelter can be listed up as important points. Among these issues, as the skilled technician cannot be found in Mongolia at present, skilled technicians for major processes are required to be invited from countries outside of Mongolia for the time being. As the result of discussions and comparisons made on the conditions of location with the exception of these matters as mentioned above, Erdenet, Darkhan, Bor Ondor, Choyr and Sainshand were selected, in the order of priority, as the site prospected for construction of smelter. The result of relative comparisons made on respective sites prospected for construction of smelter is shown in Table 13.3.1.

Table 13.3.1 Result of Comparison with Respective Sites prospected for Construction of Pyrometallurgic Smelter

Order of Priority	Name of Area	State of Preparation Infrastructures	Existence of Water Resources utilizable	Preparation of Power Source and Supply	Possibility to keep Sufficient Laborers	Possibility of existing Maintenance Company
1	**Erdenet**	Good (Railways constructed)	Sufficient (Riverwater & Groundwater utilizable)	Power plant for copper mine existing but requires additional plant(s)	High (Population: 83,000 persons)	Highly possible (Existence of Erdenet Copper Mine)
2	**Darkhan**	Good (Railways constructed)	Sufficient (Riverwater & Groundwater utilizable)	Power plant existing for iron making works but require additional plant(s)	High (Population: 74,000 persons)	Slightly high (Existence of iron works)
3	**Bor Ondor**	Good (Railways constructed)	Slightly sufficient(Distance to river is over 100km	Power plant for fluorite mine existing but requires additional plant(s)	Low (Population: 9,000 persons)	Slightly high (Existence of Bor Ondor Flourite Mine
4	**Choyr**	Good (Railways constructed)	Slightly sufficient(Distance to river is over 100km	Additional power plant(s) is required	Low (Population: 9,000 persons)	Low (No mining & industrial base at neighboring areas)
5	**Sainshand**	Good (Railways constructed)	Less sufficient (Only groundwater can be utilized)	Additional power plant(s) is required	Slightly high (Population: 20,000 persons)	Low (No mining & industrial base at neighboring areas)

(Source: Prepared by Survey Team)

(2) Type of Smelting Process

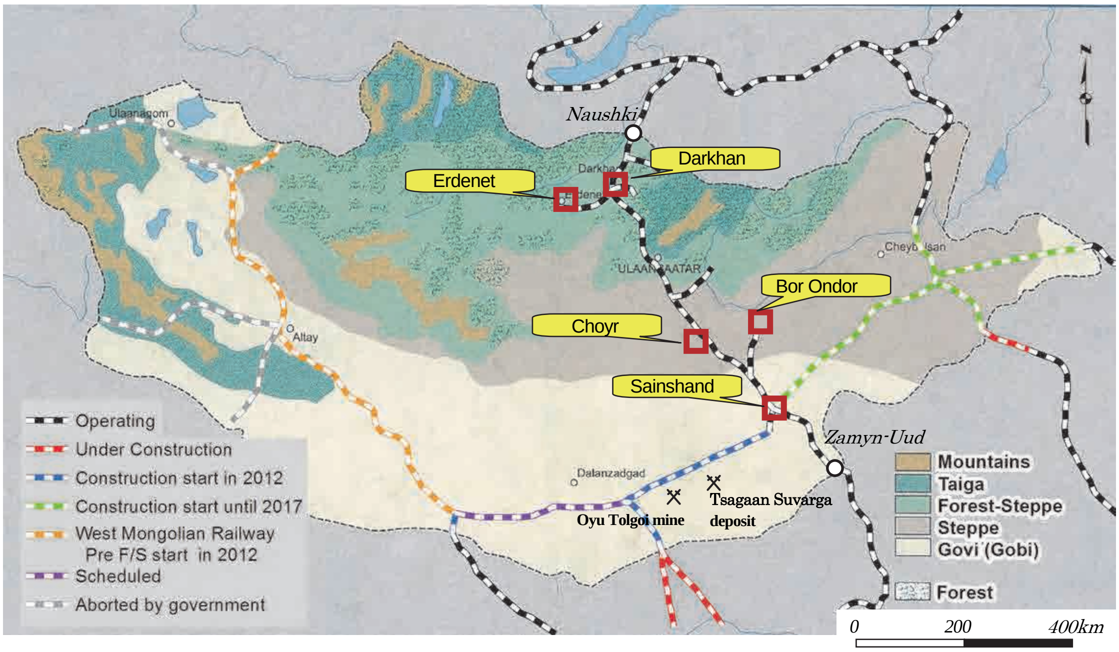
Although copper ores had previously been processed in the form of massive rocks, the type of smelting process suitable to powdered concentrates was developed since powdered concentrates became main materials to be processed in smelting in accordance with the development and progress of floatation dressing. In consideration of construction cost, operation cost and degree of operational easiness, the following two (2) processes would be recommended from the view point of restricting the exhaust gas (SO_2 gas) leakage to atmosphere as the most important issue.

1) MI Process (Mitsubishi process)

2) Flash Smelter + FC (Flash Converting) Process

(3) On Treatment of Sulfuric Acid

As sulfur dioxide gas generates during processing of sulfide ores, sulfuric acid is produced by



(Source: Prepared by Survey Team)

Figure 13.3.1 Location Map of Respective Sites prospected for Construction of Pyrometallurgic Smelter

collecting and processing the said gas for the purpose of environmental conservation. In order to produce one (1) ton of copper ingot, approximately three (3) times in weight of sulfuric acid will be produced. As to the usage of the said sulfuric acid produced, formidably large amount, i.e. sixty percent (60%), of total sulfuric acid produced is used for the manufacture of fertilizer and others such as leaching agent for oxide ores, materials to be used for synthetic fiber, paper manufacturing and building materials. At the present state that the scarcity of food has become more serious from the background of worldwide increase in population, further increase of demand to sulfuric acid for the manufacture of fertilizer would be expected. Although Mongolia has a promising hope for the production of fertilizer since it has phosphorous resources therein, the country is not in a situation to be able for utilizing these resources at this stage from the reasons of insufficiency of transportation infrastructures, etc. Therefore, it would be considered there might be no alternative but to export the surplus amount of sulfuric acid, after some of those are used domestically, to China which is an importing country of sulfuric acid for the time being.

13.4 Action Program for Development of Copper Industries

In case that the country having sufficient resources is attempting to promote the economy of the country itself by utilizing its resources, there are two (2) cases, i.e. one is to supply resources to other countries as raw materials, in other words the case of “Resource-supplying Countries”, and another case is to industrialize the country by utilizing own resources and to produce final products, that is to say the case of “Industrial Countries”. The former case is represented by African countries and the Republic of Peru and the latter is represented in cases of the Peoples’ Republic of China and the Federative Republic of Brazil. The Commonwealth of Australia, the Republic of Chile, the Republic of Indonesia, etc. are situated at the middle between the former case and the latter one.

Mongolia has numerous issues for the development of copper industries as aforementioned, and it requires considerable time to solve these issues. Accordingly, it would be proposed that Mongolia should firstly establish its situation as “Resource-supplying Countries” by supplying its resources to other countries at “the First Stage” and should carry out the preparation and improvement of domestic conditions by the profit obtained from supplying resources, and at the same time should carry out the nurturing of engineers and technicians, and then proceed with the partial industrialization as in cases of Chile and Indonesia.

For copper smelting, as mentioned above, it is considered that Mongolia has to carry out the production of copper by the hydrometallurgic smelter at first as the matter of priority for the accumulation of technologies and the development of downstream industries.

Items of action to be taken for the development of copper industries and schedule for carrying out are as shown in Table 13.4.1.

Table 13.4.1 Major Items of Action to be taken for Development of Copper Industries and Its Carrying-out Schedule

Action to be taken	1st Stage (2015－2025)		2nd Stage (2025－)	
1. Preparation of Infrastructures for Transportation				
1) Construction of Railway for Gashuum Sukhait Route	━━			
2) Construction of Railway between South Gobi and Sainshand		━━		
2. Ensuring Inland Transportation Route to Countries outside of Mongolia				
1) Establishment of Additional International Gate	━━	━━		
2) Improvement of Transportation System through the Border	━━	━━		
3. Development of Downstream Industries	━━	━━	━━	━━
4. Ensuring of Water Resources & Effective Utilization				
1) Execution of Survey for Water Resources	━━	━━		
2) Preparation of Water Resource Map (Grasping of Quantity Utilizable)		━━	━━	
5. Nurturing of Engineers and Technicians				
1) Nurturing of Mining Engineers and Technicians	━━	━━	━━	━━
2) Introduction of support measures for the industrial-academic cooperation	━━			
3) Planning the comprehensive national strategy for development of human resources		━━		
6. Market Research & Improvement of International Competitiveness				
1) Market research	━━			
2) Improvement of Quality, Supply and price competitiveness	━━	━━	━━	━━
7. Research & Development on Technologies of Mining and Manufacturing Industries				
1) Establishment of Organization, Institute and/or Agency for Research & Development	━━	━━		
2) Carrying-out of Research & Development		━━	━━	━━
8. Carrying-out of Basic Investigation on Resource Development				
1) Preparation of Detailed Geological Map & Resource Map	━━	━━	━━	━━
2) Preparation of Resource Data Base	━━	━━	━━	━━
9. Preparation of Laws & Regulations and Organization for Environmental Conservation				
1) Improvement of Laws & Regulations and Establishment of Supervisory Organization	━━	━━		
2) Nurturing Engineers & Technicians for Environmental Monitoring	━━	━━	━━	━━
10. Construction and operation of smelter				
1) Construction and expansion of SX-EW smelter	━━	━━	━━	━━
2) Construction and operation of pyrometallurgic smelter			━━	━━

note: ━━ implementation

(Source: Prepared by Survey Team)

13.5 Proposals on Direction of Support from Foreign Countries in Future

It will be proposed that the subject of the cooperation support request in future for the development of copper industries is the development of human resources, the preparation of mineral resource database, the establishment of think tank and the environmental conservation measures from this study.

13.5.1 Support for Development of Human Resources

The development of human resources for industries has to be carried out by comprehensive and step-by-step method under the positive public-private partnership. Preparation of hardware infrastructures such as class rooms, facilities, etc., and that of software infrastructures such as planning of curriculum, teachers, etc. are requested to be carried out the project by integrated and cross organizational activities with due consideration of whole value chain for industries without carrying out their own projects separately by the government authorities concerned (the Ministry of Mining, the Ministry of Industry and Agriculture, the Ministry of Education and Science, and the Ministry of Labor, etc.), educational organizations (MUST, NUM, SEPC, etc.), enterprises, etc.(Erdenet, Oyu Tolgoi, MAK, MNMA and other small and medium sized enterprises) respectively.

In this study, the following recommendations as the road map for the development of human resources would be made.

1) First five (5) years : Realization of raising the level of job training center, introduction of support measures for the industrial-academic cooperation, and planning the comprehensive national strategy for development of human resources.
2) Next five (5) years continued from **1)** : Establishment of the comprehensive job training center together with promotion of the advance for institution of higher education as well as planning the comprehensive national strategy for development of human resources continuingly from **1)**.

In order to realize these matters, JICA is carrying out "Capacity Building on the Natural Resource and Mining Sector in Mongolia", "Training Program for Human Resources Development in the Mining Sector" and "Higher Engineering Education Development Project". It is important to carry out the development of human resources continuingly by means of support from foreign countries as above described.

13.5.2 Support for Preparation of Mineral Resource Database

According to the amendment of the Minerals Law of Mongolia in July, 2014, it was newly decided to establish the Bureau of Geological Survey. The Bureau of Geological Survey is to carry out the geological surveys and the evaluation of mineral deposits, and the arranged information regarding to the geology and the mineral deposit is to be provided to investors as its important duty. It is an aim of the government to promote the investment to the field of mining industries from domestic and foreign enterprises.

Even though it is not clear what kinds of organization is the Bureau of Geological Survey for us, the Geological Investigation Center (a state-owned enterprise) in which the geological and resource analysis have already been carried out by means of satellite data as an organization as well as the Geological Information Center of Mineral Resources Agency of Mongolia are existing. As it is considered that these are the basic organization of the Bureau of Geological Survey,

From the reason that these organizations as above mentioned are considered to be the basis of Bureau of Geological Survey, it would consequently be for the improvement of organizations in the Bureau of Geological Survey to improve technologies of these organizations and to accumulate a higher accurate information therein.

In order to improve the database of mineral resources in Mongolia, it would be proposed to promote the cooperation support of the technical guidance and the technology transfer from developed countries in mining industry as follows:

1) Technology of digital processing and analysis for extracting geological and resource information from ASTER Data.
2) Technology of image interpretation for extraction of geological and resource information from ASTER Processing Image.
3) Technology for geomorphologic analysis by means of ASTER DEM (Digital Elevation Model).
4) Technology for compilation of GIS Database on geological and resource information.
5) Technology on construction of the website for disclosure of information to the public.

13.5.3 Support for Establishment of Think Tank

It is important for the development of mining industrial sectors of Mongolia in future to establish the think-tank which is an organization capable to carry out the collection and analysis of information on overseas markets and to provide proposal(s) on the policy for resources and advice(s) on the business strategy by consignment from the government and/or private enterprise(s) as well as to strengthening its function.

13.5.4 Support for Mine Environmental Conservation Measures

For the purpose of performing the comprehensive development of copper industries including development of mines, the environmental conservation is important as previously stated. Issues from the view point of environment in Mongolia are as shown below.

1) Grasping of Actual State on Mining Environment for Operating, Suspended and Abandoned Mines
2) Preparation of Environmental Management System
3) Monitoring of Environment
4) Carrying-out of Survey on Actual States after the Environmental Impact Assessment (EIA)
5) Investigation and Discussions on Measures for Environmental Conservation of Mines including Closed Mine(s)

In order to solve these issues, the improvement of laws and regulations as well as the preparation of organization for execution are required. It would be recommended to request developed countries in mining industry for providing their technical cooperation and/or support in these fields as above mentioned.

Appendixes

APPENDIX 1: Input - Output Table (32 by 32)

САЛБАР ХООРОНДЫН ТЭНЦЭЛ, 2010, сая төг
INPUT-OUTPUT TABLE, 2010, mln.tog

	Industries / Industries	Crop production, related service activities	Animal production, hunting	Forestry and fishing	Mining of coal and crude petrolium	Mining of metal ores	Other mining and quarrying	Mining support service activities	Manufacture of food products	Manufacture of beverages and tobacco	Manufacture of textiles; wearing apparel; leather and related products	Manufacture of wood, paper and related products; printing and reproduction of recorded media	Manufacture of coke and refined petroleum products; chemicals and chemical products	Manufacture of other non-metallic mineral products and metal products	Manufacture of machinery and equipment	Other manufacturing	Electricity, gas, steam and air conditioning supply
A	C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Crop production, related service activities	36 922.8	109 558.6	1 811.9	83.8	742.7	31.7	4.6	43 826.9	9 359.1	4.6	0.8	6.8	6.7	0.0	1.4	350.1
2	Animal production, hunting	436.8	35 026.4	21.4	4.4	9.8	5.8	0.1	449 228.0	186.8	170 805.3	0.0	0.1	0.5	0.0	2.1	69.9
3	Forestry and fishing	285.1	845.9	17 224.6	78.7	825.1	5.4	0.0	470.1	72.7	280.3	1 388.5	0.5	1 090.0	0.3	34.0	121.4
4	Mining of coal and crude petrolium	21.1	30.6	2.7	79.9	200.2	13.4	42.4	85.8	44.5	34.0	16.0	32.4	53.2	2.3	3.6	56 731.5
5	Mining of metal ores	124.3	181.9	5.3	764.4	6 592.9	3 238.7	261.9	248.3	253.2	124.8	35.0	112.2	3 686.9	6.3	511.8	4 309.3
6	Other mining and quarrying	24.2	42.2	0.8	48.5	1 835.7	4 856.5	44.7	797.3	523.3	16.2	268.6	53.9	3 607.0	33.8	36.6	34.8
7	Mining support service activities	3 173.2	7 880.2	149.9	2 914.4	8 773.0	284.0	139 235.6	4 034.4	1 473.1	269.0	126.0	1 229.5	214.4	31.0	298.9	588.4
8	Manufacture of food products	32.3	6 685.3	3.4	732.8	1 654.4	223.1	258.5	66 935.2	4 193.2	71.7	24.8	147.0	919.2	2.8	21.8	118.5
9	Manufacture of beverages and tobacco	4.2	72.8	0.5	101.6	28.8	9.5	59.5	1 723.7	10 385.3	29.8	2.3	61.4	23.7	0.3	1.1	28.3
10	Manufacture of textiles; wearing apparel; leather and related products	245.5	16.5	0.6	71.7	47.0	38.7	129.1	89.8	289.5	68 205.1	586.2	43.3	345.6	0.9	243.7	28.1
11	Manufacture of wood, paper and related products; printing and reproduction of recorded media	39.0	115.8	60.2	352.2	818.7	257.1	519.7	453.5	1 790.2	378.5	9 384.3	199.5	1 111.3	209.5	941.3	357.3
12	Manufacture of coke and refined petroleum products; chemicals and chemical products	546.2	795.1	2.7	9 223.1	3 403.0	319.2	3 885.0	483.3	4 366.0	227.6	77.9	4 658.5	3 098.8	84.2	67.2	190.1
13	Manufacture of other non-metallic mineral products and metal products	45.2	88.6	326.8	24 094.2	4 215.9	2 018.0	10 822.0	501.2	2 544.6	261.5	1 013.9	258.0	34 535.9	205.0	439.9	4 349.7
14	Manufacture of machinery and equipment	40.2	40.7	2.7	9 092.0	1 227.0	108.0	5 020.7	94.1	118.3	85.8	73.6	8.7	241.2	233.5	210.8	628.8
15	Other manufacturing	85.9	370.2	8.4	2 849.6	1 176.7	158.3	2 438.3	289.2	179.0	189.4	1 355.7	49.9	867.4	52.3	476.5	723.4
16	Electricity, gas, steam and air conditioning supply	35.6	71.9	24.3	8 186.1	60 932.8	718.9	1 664.5	5 315.7	12 951.2	2 661.7	1 421.9	598.0	8 078.7	192.4	823.0	273 572.0
17	Water supply; sewerage, waste management and remediation activities	331.6	43.7	1.6	2 328.5	6 358.0	136.4	313.5	398.0	1 060.4	206.8	99.3	52.9	1 109.7	14.0	114.1	20 106.3
18	Construction	431.4	971.9	67.3	3 757.6	3 861.8	285.0	255 158.5	2 699.2	903.7	1 362.2	489.9	149.7	3 908.1	91.4	473.7	1 976.9
19	Wholesale and retail trade; repair of motor vehicles and motorcycles	17 104.5	38 881.8	2 923.7	45 093.5	54 506.1	6 505.0	24 354.4	94 800.6	15 557.7	42 744.2	6 635.5	5 992.7	21 359.2	1 267.2	1 868.4	22 737.6
20	Transportation and storage	23 758.8	7 748.9	1 083.8	46 559.0	50 338.0	2 002.5	4 366.0	4 381.1	1 887.2	3 718.8	2 000.3	3 253.9	2 782.6	203.9	553.5	6 634.5
21	Accommodation and food service activities	143.4	241.4	18.4	5 512.9	8 714.6	136.5	20 941.7	675.6	229.6	424.6	216.9	188.4	723.7	39.8	130.5	331.0
22	Information and communication	826.5	3 804.5	2.9	3 855.1	8 056.7	291.1	6 422.1	2 868.4	1 040.9	957.6	1 299.7	369.1	1 819.2	133.1	1 265.7	481.0
23	Financial and insurance activities	12 069.0	15 234.5	200.4	3 920.4	12 690.0	220.9	64 517.1	2 878.0	4 448.9	3 752.7	3 657.4	263.0	3 364.2	45.3	669.4	441.3
24	Real estate activities	1 060.8	763.3	89.9	1 713.6	2 404.0	1 087.8	4 814.2	618.2	617.2	1 877.7	1 816.4	383.2	2 783.8	218.4	675.5	136.4
25	Professional, scientific and technical activities	117.0	14 235.6	13.7	6 821.9	6 356.1	223.8	21 798.1	654.6	1 558.0	470.7	193.5	495.7	910.6	109.0	1 892.7	308.0
26	Administrative and support service activities	4 840.4	8 136.6	12.6	6 863.8	5 019.1	410.5	2 382.9	1 003.6	1 716.7	839.9	124.1	291.3	1 087.2	37.2	265.0	213.6
27	Public administration and defence; compulsory social security	560.6	33.5	36.7	7 658.7	4 250.9	69.8	1 616.4	799.0	213.9	161.9	254.3	1 600.5	1 492.4	23.9	10.8	663.0
28	Education	128.1	31.2	0.3	1 259.1	3 163.2	6.2	3 542.6	49.7	27.5	31.0	4.3	54.8	68.8	0.6	237.6	444.7
29	Human health and social work activities	76.7	101.6	6.2	374.4	2 189.4	10.6	2 332.5	114.8	1 241.3	50.4	10.9	16.0	41.5	1.7	12.1	118.5
30	Arts, entertainment and recreation	6.9	17.6	1.2	117.4	2 493.4	6.3	359.6	79.0	12.0	20.8	4.3	48.5	35.9	0.8	1.8	233.4
31	Other service activities	36.6	104.6	2.2	1 255.5	901.8	29.5	607.0	383.7	37.9	312.0	80.4	22.1	468.4	21.6	83.7	228.7
32	Other activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	Domestic intermediate consumption	103 553.8	252 173.6	24 107.2	195 768.6	263 786.8	23 708.3	577 913.3	686 980.0	79 283.0	300 576.7	32 662.6	20 641.2	99 835.5	3 262.6	12 368.1	397 256.8
34	Imports	92 786.4	115 635.8	3 696.9	257 483.3	339 804.5	29 767.0	208 562.0	66 822.7	66 921.4	23 415.9	27 328.9	34 057.6	83 429.1	7 276.1	10 756.9	71 880.2
35	Total consumption at basic prices	196 340.3	367 809.4	27 804.1	453 251.9	603 591.3	53 475.3	786 475.2	753 802.8	146 204.4	323 992.6	59 991.5	54 698.7	183 264.7	10 538.7	23 125.0	469 136.9
36	Taxes less subsidies on products	- 1 023.9	10 075.2	690.4	39 430.0	53 824.8	6 286.3	21 619.6	12 400.1	19 646.1	3 857.2	4 048.1	5 500.4	12 665.9	1 292.4	1 276.0	- 22 589.1
37	TOTAL CONSUMPTION at purch.prices	195 316.3	377 884.6	28 494.6	492 681.9	657 416.0	59 761.6	808 094.8	766 202.9	165 850.5	327 849.9	64 039.7	60 199.1	195 930.6	11 831.1	24 401.1	446 547.8
38	C.i.f./f.o.b. adjustments on exports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	Direct purchases abroad by residents	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	Direct purchases in domestic markets by non-residents	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	TOTAL	195 316.3	377 884.6	28 494.6	492 681.9	657 416.0	59 761.6	808 094.8	766 202.9	165 850.5	327 849.9	64 039.7	60 199.1	195 930.6	11 831.1	24 401.1	446 547.8
42	Compensation of employees	25 809.2	13 623.3	5 796.9	49 408.8	142 808.7	18 276.8	49 635.5	24 307.4	19 991.3	27 289.9	10 593.8	6 308.7	31 702.1	1 494.4	4 794.3	86 102.1
43	Other net taxes on production	130.9	40.5	12.9	524.0	2 653.9	102.1	376.0	342.0	445.8	390.4	81.6	85.7	344.4	17.9	38.4	1 480.0
44	Consumption of fixed capital	5 963.3	499.0	895.0	36 626.0	82 599.5	4 066.9	9 048.9	6 586.2	6 563.8	4 461.8	2 132.6	1 734.7	10 497.0	453.1	805.6	62 357.2
45	Operating surplus/ mixed income, net	108 203.5	965 827.1	17 896.3	516 661.0	809 480.4	18 811.5	361 078.0	215 408.8	122 640.8	41 134.5	21 666.1	13 404.1	78 644.2	1 768.2	8 685.5	40 272.3
46	**GROSS VALUE ADDED at basic prices**	**140 106.9**	**979 989.9**	**24 601.1**	**603 219.8**	**1 037 542.4**	**41 257.3**	**420 138.4**	**246 644.5**	**149 641.7**	**73 276.6**	**34 474.1**	**21 533.2**	**121 187.8**	**3 733.6**	**14 323.8**	**190 211.6**
47	**TOTAL OUTPUT at basic prices**	**335 423.2**	**1 357 874.5**	**53 095.7**	**1 095 901.7**	**1 694 958.4**	**101 018.9**	**1 228 233.3**	**1 012 847.4**	**315 492.1**	**401 126.5**	**98 513.8**	**81 732.3**	**317 118.4**	**15 564.7**	**38 724.9**	**636 759.4**

	Industries / Industries	Water supply; sewerage, waste management and remediation activities	Construction	Wholesale and retail trade; repair of motor vehicles and motorcycles	Transportation and storage	Accommodation and food service activities	Information and communication	Financial and insurance activities	Real estate activities	Professional, scientific and technical activities	Administrative and support service activities	Public administration and defence; compulsory social security	Education	Human health and social work activities	Arts, entertainment and recreation	Other service activities	Other activities
A	C	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	Crop production, related service activities	212.1	18.5	0.0	120.1	7 633.9	0.7	0.0	26.6	6.5	17.2	1 914.1	3 730.2	1 747.1	51.0	149.8	0.0
2	Animal production, hunting	5.7	0.3	0.0	3.4	773.3	1.2	0.0	0.3	0.1	2.6	22.6	2 171.9	24.4	2.7	31.0	0.0
3	Forestry and fishing	12.0	211.2	28.3	69.8	71.5	102.1	0.0	0.2	2.4	14.8	14.8	51.2	13.9	1.4	21.5	0.0
4	Mining of coal and crude petrolium	458.6	102.5	291.7	160.7	36.0	30.6	9.5	28.7	25.6	32.4	55.0	171.2	53.3	19.2	11.8	0.0
5	Mining of metal ores	1 715.9	713.8	1 255.2	498.3	289.7	188.6	114.7	219.3	180.6	232.3	429.4	659.2	397.2	144.6	82.5	0.0
6	Other mining and quarrying	111.5	11 179.5	372.9	168.3	17.6	31.1	23.4	57.8	24.1	44.5	32.6	26.8	8.2	5.5	37.9	0.0
7	Mining support service activities	320.4	34 876.1	6 909.0	1 261.1	2 295.4	3 774.9	2 160.4	10 372.9	2 504.4	554.4	1 590.9	1 556.8	655.0	57.9	184.1	0.0
8	Manufacture of food products	34.6	366.8	2 540.2	287.6	28 164.2	130.4	38.4	198.9	153.3	1 710.3	6 213.0	12 395.6	5 106.8	44.7	315.2	0.0
9	Manufacture of beverages and tobacco	1.5	57.6	55.3	239.7	7 508.3	12.1	4.8	51.3	28.2	32.4	70.2	123.8	76.9	43.4	59.0	0.0
10	Manufacture of textiles; wearing apparel; leather and related products	32.5	5 422.9	4 486.1	569.5	558.1	209.7	1 338.6	6 694.7	1 279.3	675.2	72.3	11 364.7	2 407.3	1 437.6	1 106.0	0.0
11	Manufacture of wood, paper and related products; printing and reproduction of recorded media	119.2	21 390.5	8 724.1	1 737.8	171.1	1 894.2	899.3	471.2	2 630.9	788.9	2 297.0	1 003.7	182.9	101.0	746.7	0.0
12	Manufacture of coke and refined petroleum products; chemicals and chemical products	77.8	3 241.5	3 490.8	205.5	97.6	148.1	14.0	23.4	583.1	158.7	949.2	121.7	2 309.3	3.8	31.5	0.0
13	Manufacture of other non-metallic mineral products and metal products	920.3	171 839.9	6 480.4	2 317.6	434.6	776.8	673.7	4 636.0	7 614.1	1 479.3	507.2	993.7	564.3	174.4	521.5	0.0
14	Manufacture of machinery and equipment	56.7	5 133.2	1 439.5	1 585.9	63.6	3 036.8	30.4	1 730.8	506.4	274.0	117.8	170.6	197.2	60.8	363.1	0.0
15	Other manufacturing	268.4	5 271.0	2 686.8	4 454.4	320.1	1 412.6	19.3	548.2	1 191.6	406.9	493.0	799.6	872.5	111.2	206.4	0.0
16	Electricity, gas, steam and air conditioning supply	11 257.1	11 337.4	56 911.5	4 673.7	9 380.2	6 265.1	63.5	8 798.7	5 892.7	6 373.8	18 270.1	40 701.1	19 904.4	7 953.2	3 749.8	0.0
17	Water supply; sewerage, waste management and remediation activities	31 881.0	7 139.4	4 625.9	1 145.4	2 300.3	850.0	633.4	673.3	541.5	507.2	2 183.3	2 932.5	3 072.3	609.9	293.2	0.0
18	Construction	623.2	80 510.6	10 856.9	2 368.1	3 629.8	2 313.7	868.8	18 787.4	3 657.9	689.9	1 976.8	2 535.7	1 262.4	69.7	289.8	0.0
19	Wholesale and retail trade; repair of motor vehicles and motorcycles	2 173.8	105 132.7	37 966.5	56 026.9	15 760.1	12 302.7	4 869.3	10 627.5	12 644.7	6 075.2	15 260.5	11 841.7	10 458.1	1 476.5	2 682.9	0.0
20	Transportation and storage	745.9	23 134.7	227 713.0	149 841.7	3 858.5	9 190.7	3 062.6	1 628.7	10 681.7	20 340.1	6 837.0	1 432.5	1 214.2	332.9	1 831.2	0.0
21	Accommodation and food service activities	104.2	3 585.6	15 221.9	3 553.6	1 047.1	2 399.7	2 482.6	631.6	2 183.9	2 775.7	5 613.3	421.7	1 572.0	636.1	515.1	0.0
22	Information and communication	529.3	19 787.9	38 300.0	11 316.2	2 959.0	43 932.6	14 483.6	15 404.2	11 102.4	3 996.4	47 625.5	10 268.6	6 788.5	645.2	2 045.9	0.0
23	Financial and insurance activities	7 032.5	14 322.4	55 267.6	22 916.7	1 235.2	2 518.7	13 982.7	5 697.7	18 307.9	1 359.8	1 121.6	300.6	1 998.4	1 081.9	495.4	0.0
24	Real estate activities	238.9	7 029.0	21 159.5	3 177.7	8 385.0	28 705.8	16 232.6	71 153.5	7 659.8	3 150.9	2 138.4	3 539.5	5 757.0	1 533.9	3 343.8	0.0
25	Professional, scientific and technical activities	1 253.5	11 242.4	19 687.7	3 714.9	4 167.4	9 440.5	19 132.0	7 017.8	12 220.9	1 574.0	27 713.3	9 837.9	2 587.1	647.4	1 406.5	0.0
26	Administrative and support service activities	209.4	4 175.8	18 284.6	20 910.1	2 417.9	3 198.6	4 502.7	3 395.7	3 325.4	7 747.3	6 624.7	714.1	518.7	1 151.3	1 257.4	0.0
27	Public administration and defence; compulsory social security	728.2	39 461.8	7 671.5	9 704.5	5 774.6	5 247.0	927.7	2 750.2	6 536.6	4 272.7	5 357.2	5 867.5	9 123.5	36.0	241.2	0.0
28	Education	74.0	2 560.8	2 524.5	750.0	1 032.3	3 999.9	1 679.9	3 505.9	1 369.2	471.7	9 048.7	917.8	1 180.4	867.7	1 731.0	0.0
29	Human health and social work activities	7.7	4 366.9	2 051.5	4 378.5	278.8	829.6	177.7	88.5	1 095.4	60.4	1 925.3	24.2	26.3	10.0	542.4	0.0
30	Arts, entertainment and recreation	26.5	183.5	660.7	75.6	85.1	221.2	23.5	423.3	1 850.8	802.8	1 900.4	162.1	26.3	236.1	149.9	0.0
31	Other service activities	127.1	856.3	1 272.7	4 834.9	141.4	719.0	541.0	222.3	159.4	173.2	621.1	361.7	253.4	83.1	1 245.6	0.0
32	Other activities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	Domestic intermediate consumption	61 359.4	594 652.5	558 936.1	313 068.1	110 887.6	143 884.5	88 990.2	175 866.9	115 961.0	66 794.7	168 996.4	127 200.0	80 359.3	19 630.1	25 689.3	0.0
34	Imports	12 884.4	413 619.4	219 146.8	419 524.5	61 430.5	76 525.4	38 359.3	36 627.3	74 886.7	25 530.1	107 974.8	49 786.4	52 011.2	6 092.6	14 804.0	0.0
35	Total consumption at basic prices	74 243.8	1 008 271.9	778 082.8	732 592.6	172 318.1	220 410.0	127 349.4	212 494.2	190 847.7	92 324.8	276 971.2	176 986.4	132 370.5	25 722.7	40 493.4	0.0
36	Taxes less subsidies on products	1 828.4	60 535.8	28 525.8	56 702.2	10 500.6	8 863.5	3 319.9	5 181.6	8 737.0	3 590.2	12 779.8	7 523.1	6 822.0	888.9	1 857.4	0.0
37	TOTAL CONSUMPTION at purch.prices	76 072.3	1 068 807.7	806 608.6	789 294.8	182 818.7	229 273.4	130 669.3	217 675.8	199 584.7	95 915.0	289 751.0	184 509.5	139 192.5	26 611.6	42 350.8	0.0
38	C.i.f./f.o.b. adjustments on exports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	Direct purchases abroad by residents	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	Direct purchases in domestic markets by non-residents	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	TOTAL	76 072.3	1 068 807.7	806 608.6	789 294.8	182 818.7	229 273.4	130 669.3	217 675.8	199 584.7	95 915.0	289 751.0	184 509.5	139 192.5	26 611.6	42 350.8	0.0
42	Compensation of employees	20 892.8	103 221.4	256 856.3	145 868.3	30 539.0	67 861.1	91 878.6	13 823.2	98 412.3	40 930.8	307 008.5	321 082.8	134 904.3	25 030.1	22 948.0	0.0
43	Other net taxes on production	224.0	870.9	3 686.2	1 255.9	953.6	228.9	776.4	1 364.0	519.3	279.5	859.4	320.5	150.0	83.9	319.1	0.0
44	Consumption of fixed capital	11 037.1	24 997.9	93 663.7	44 069.5	7 999.3	24 767.6	23 642.2	4 606.8	7 731.0	7 835.4	117 482.4	51 397.0	27 437.6	2 254.8	1 878.7	0.0
45	Operating surplus/ mixed income, net	- 943.2	121 140.6	844 801.1	486 712.4	13 139.1	162 833.6	123 310.0	667 903.6	25 664.7	32 085.7	0.0	7 045.0	4 736.0	4 668.3	19 193.2	103.8
46	**GROSS VALUE ADDED at basic prices**	**31 210.6**	**250 230.7**	**1 199 007.2**	**677 906.2**	**52 631.0**	**255 691.2**	**239 607.2**	**687 697.6**	**132 327.3**	**81 131.4**	**425 350.3**	**379 845.3**	**167 227.9**	**32 037.1**	**44 338.9**	**103.8**
47	**TOTAL OUTPUT at basic prices**	**107 282.9**	**1 319 038.5**	**2 005 615.9**	**1 467 200.9**	**235 449.7**	**484 964.7**	**370 276.5**	**905 373.4**	**331 911.9**	**177 046.4**	**715 101.3**	**564 354.8**	**306 420.4**	**58 648.7**	**86 689.7**	**103.8**

	Industries / Industries	INTERMEDIATE CONSUMPTION	Final use: Final consumption expenditure	Final use: Gross capital formation	Final use: Exports	FINAL USE	TOTAL USE
A	C	33	34	35	36	37	38
1	Crop production, related service activities	218 340.5	87 713.7	24 857.1	4 511.9	117 082.7	335 423.2
2	Animal production, hunting	658 836.8	262 817.4	294 506.4	141 714.0	699 037.8	1 357 874.5
3	Forestry and fishing	23 337.6	19 208.9	10 497.6	51.5	29 758.0	53 095.7
4	Mining of coal and crude petrolium	58 880.3	12 358.8	- 87 016.2	1 111 678.9	1 037 021.4	1 095 901.7
5	Mining of metal ores	27 578.5	2 550.5	40 372.3	1 624 457.1	1 667 379.9	1 694 958.4
6	Other mining and quarrying	24 366.1	653.3	- 2 152.1	78 151.6	76 652.8	101 018.9
7	Mining support service activities	239 748.9	33 647.3	944 162.7	10 674.4	988 484.4	1 228 233.3
8	Manufacture of food products	139 723.7	704 396.7	93 674.6	75 052.3	873 123.7	1 012 847.4
9	Manufacture of beverages and tobacco	20 897.5	233 801.8	54 862.2	5 930.6	294 594.7	315 492.1
10	Manufacture of textiles; wearing apparel; leather and related products	108 035.9	73 057.4	70 620.0	149 413.1	293 090.6	401 126.5
11	Manufacture of wood, paper and related products; printing and reproduction of recorded media	60 146.7	24 262.8	6 595.9	7 508.4	38 367.1	98 513.8
12	Manufacture of coke and refined petroleum products; chemicals and chemical products	42 883.9	14 152.6	6 750.1	17 945.6	38 848.4	81 732.3
13	Manufacture of other non-metallic mineral products and metal products	285 654.2	9 986.2	- 40 487.5	61 965.4	31 464.1	317 118.4
14	Manufacture of machinery and equipment	31 993.0	434.8	- 17 431.2	568.1	- 16 428.2	15 564.7
15	Other manufacturing	30 332.1	3 282.1	3 337.0	1 773.6	8 392.8	38 724.9
16	Electricity, gas, steam and air conditioning supply	588 781.0	43 759.8	2 974.7	1 243.9	47 978.4	636 759.4
17	Water supply; sewerage, waste management and remediation activities	92 063.5	15 165.0	- 449.6	504.0	15 219.4	107 282.9
18	Construction	407 028.9	19 722.6	874 167.5	18 119.4	912 009.5	1 319 038.5
19	Wholesale and retail trade; repair of motor vehicles and motorcycles	707 631.4	533 596.2	206 840.3	557 547.9	1 297 984.5	2 005 615.9
20	Transportation and storage	623 118.2	572 379.6	12 037.4	259 665.7	844 082.8	1 467 200.9
21	Accommodation and food service activities	81 413.1	45 631.4	1 176.8	107 228.5	154 036.6	235 449.7
22	Information and communication	262 678.9	188 788.4	13 990.0	19 507.4	222 285.8	484 964.7
23	Financial and insurance activities	276 011.9	75 183.8	0.0	19 080.8	94 264.6	370 276.5
24	Real estate activities	204 265.6	699 442.4	652.6	1 012.7	701 107.8	905 373.4
25	Professional, scientific and technical activities	187 801.9	28 457.5	80 012.0	35 640.5	144 110.0	331 911.9
26	Administrative and support service activities	111 678.1	59 330.5	150.2	5 887.5	65 368.3	177 046.4
27	Public administration and defence; compulsory social security	123 146.4	591 954.9	0.0	0.0	591 954.9	715 101.3
28	Education	40 763.3	518 071.3	4.2	5 516.0	523 591.6	564 354.8
29	Human health and social work activities	22 561.9	279 524.1	3 011.4	1 323.0	283 858.5	306 420.4
30	Arts, entertainment and recreation	10 266.8	47 876.8	85.8	419.3	48 381.9	58 648.7
31	Other service activities	16 187.8	69 920.7	76.7	504.6	70 502.0	86 689.7
32	Other activities	0.0	103.8	0.0	0.0	103.8	103.8
33	Domestic intermediate consumption	5 726 154.2	5 271 233.2	2 597 879.4	4 324 597.8	12 193 710.4	17 919 864.7
34	Imports	3 048 828.1	975 772.5	1 283 940.6	6 022.7	2 265 735.8	5 314 564.0
35	Total consumption at basic prices	8 774 982.3	6 247 005.8	3 881 820.0	4 330 620.5	14 459 446.3	23 234 428.6
36	Taxes less subsidies on products	386 655.9	387 085.5	224 430.9	189.7	611 706.1	998 362.0
37	TOTAL CONSUMPTION at purch.prices	9 161 638.2	6 634 091.2	4 106 250.9	4 330 810.3	15 071 152.4	24 232 790.6
38	C.i.f./f.o.b. adjustments on exports	0.0	0.0	0.0	0.0	0.0	0.0
39	Direct purchases abroad by residents	0.0	214 597.1	0.0	0.0	214 597.1	214 597.1
40	Direct purchases in domestic markets by non-residents	0.0	- 223 466.0	0.0	223 466.0	0.0	0.0
41	TOTAL	9 161 638.2	6 625 222.4	4 106 250.9	4 554 276.2	15 285 749.5	24 447 387.7
42	Compensation of employees	2 199 200.4					
43	Other net taxes on production	18 957.9					
44	Consumption of fixed capital	686 091.9					
45	Operating surplus/ mixed income, net	5 853 976.2					
46	**GROSS VALUE ADDED at basic prices**	**8 758 226.5**					
47	**TOTAL OUTPUT at basic prices**	**17 919 864.7**					

APPENDIX 2: Seminar

Монгол Улс
Зэсийн аж үйлдвэрийн салбарын мэдээлэл цуглуулах судалгаа

Data Collection Survey on Copper Industry Sector in Mongolia

"Монгол улсын зэсийн аж үйлдвэрийн салбарын хөгжил" сэдэвт семинар

SEMINAR ON DEVELOPMENT OF COPPER INDUSTRY SECTOR IN MONGOLIA

Өдөр, цаг : 2014 оны 9 сарын 9
Хаана : Blue sky Hotel & Tower
3-р давхарт TOPAZ танхим

Японы Олон Улсын Хамтын Ажиллагааны Байгууллага(JICA)

Монгол Улсын Уул Уурхайн Яам(УУЯ)

Судалгааны баг:

"Мицүбиши Материал Технологи"ХХК
"Мицүбиши Ресорч институт"ХХК
"Сүмико Минерал Ресоурс Эксплорэйшн энд Девеломент " ХХК

Agenda

SEMINAR ON DEVELOPMENT OF COPPER INDUSTRY SECTOR IN MONGOLIA

Blue Sky Hotel, 9 September 2014

Time	Title	Speakers
9:00-9:10	Opening remarks	Mr. Hiroo Tanaka, Group director, Industrial development and public policy department, JICA Mr. Rentsendoo Jigjid, State secretary, Ministry of Mining
9:10-9:20	Outline of the study	Mr. Yoshiaki Shibata, JICA Study team
9:20-9:45	①Copper mine and copper resource potential in Mongolia	Mr. Tadashi Yamakawa, JICA Study team
9:45-10:10	②Copper supply, demand and market analysis in Mongolia	Mr. Hirohisa Kobayashi, JICA Study team
10:10-10:35	③Copper supply and demand in the world	Mr. Ken Nakayama, JICA Study team
10:35-10:50	Questions and Answers	
10:50-11:10	Coffee break	
11:10-11:35	④Copper smelting pants in Japan and in the world	Mr. Hideaki Shindo, JICA Study team
11:35-12:00	⑤Applications and demand of sulfuric acid in Mongolia	Ms. Uurtsaih Dagvatseren, Working group member
12:00-12:25	⑥Recommendation on policy for copper industries in Mongolia	Mr. Youichi Mizuochi, JICA Study team
12:25-12:40	Questions and Answers	
12:40-14:00	Lunch	
14:00-14:25	⑦Copper industry development plan in Mongolia	Mr. Zuunnast Tegshee, Working group member
14:25-14:50	⑧Investment promotion for copper industry development	Dr. Dinh minh hung
14:50-15:15	⑨Economic analysis	Mr. Shigefumi Okumura, JICA Study team
15:15-15:40	⑩Economic effects of constructing smelter	Mr. Yoshio Akiyama, JICA Study team
15:40-16:00	Questions and Answers	
16:00-16:25	⑪Conclusion and Recommendation	Mr. Yoshiaki Shibata, JICA Study team
16:25-16:45	Closing remarks	Mr. Otgochuluu Chuluuntseren, Head of Dept. of Strategic Policy and Planning, Ministry of Mining

Attendance List (1)

No.	Organization	Title	Name
1	Ministry of Mining	State Secretary	JIGJID. R
2	Ministry of Mining	Director of Strategic policy and planning dept.	OTGOCHULUU. CH
3	Ministry of Mining	Head of Mining Policy division	NERGUI. B
4	Ministry of Mining	Mining Policy division, Officer	ZUUNNAST. T
5	Ministry of Mining	Cooperation Division, Officer	ZOLBOO. G
6	“ERDENET” JVC	Advisor of General Director	Dr. VLADIMIR
7	“ERDENET” JVC	Engineer	BATTSENGEL
8	“ERDENET” JVC	Senior specialist	ERDENEBAATAR
9	Mineral Resource Authority of Mongolia	Officer	MAGVANJAV
10	Mineral Resource Authority of Mongolia	Officer	NARANTUYA
11	Mining Design Association	Director	BAT-OCHIR. B
12	Ministry of Industry &Agriculture of Mongolia	Deputy Minister	TSOGTGEREL. B
13	Ministry of Industry &Agriculture of Mongolia	Senior officer	BOLD. I
14	Mongolian Chemistry, Chemist &Engineer Association	Executive Director	D. UURTSAIKH
15	Mongolian Chemistry, Chemist &Engineer Association		BUDRAGCHAA
16	Mongolian Chemistry, Chemist &Engineer Association	Secretary	KHATANTUUL
17	Mongolian ALT Corporation	Vice President	G.DAVAATSEREN
18	Mongolian ALT Corporation	Engineer	KHATANBAATAR
19	Mongolian University of Science & Technology – Geology & Mining School	Director	B.CHINZORIG
20	Mongolian University of Science & Technology – Geology & Mining School	Professor	B.ALTANTUYA
21	Mongolian University of Science & Technology –Geology &Petroleum Engineering	Professor	S.JARGALAN
22	Mongolian State University, Economic School	Professor	H.TSEVELMAA
23	“ERDENES OYU TOLGOI” Co. Ltd	Vice president	D.DAVAADORJ
24	“ERDENES OYU TOLGOI” Co. Ltd	Head of Mining Technology	L.UNURBAATAR
25	“ERDENES MONGOL” Co.ltd	Infrastructure &department of technology president	DAMJIN
26	“ERDENES MONGOL” Co.ltd	Expert	OYUBAT
27	“ERDENES MONGOL” Co.ltd	Officer	SARANGOO
28	Mineral exploration, promotion &information center	Executive Director	B.MYAGMARJAV
29	Mineral exploration, promotion &information center	Secretary	JAVZAN

Attendance List (2)

No.	Organization	Title	Name
30	JICA	Industrial development & Public policy department, Group director	田中　啓生 TANAKA
31	JICA	Guest Expert	細井　義孝 HOSOI
32	JICA	Industrial development & Public policy department, Officer	飯崎　尭 HANSAKI
33	JICA UB Office	Officer	阿部　将典 ABE
34	JICA UB office	Officer	ANKHTSETSEG
35	Study Team	Team leader	柴田　芳彰 SHIBATA
36	Study Team	Deputy team leader	山川　正 YAMAKAWA
37	Study Team	member	奥村　重史 OKUMURA
38	Study Team	member	水落　洋一 MIZUOCHI
39	Study Team	member	秋山　義夫 AKIYAMA
40	Study Team	member	小林　浩久 KOBAYASHI
41	Study Team	member	中山　健 NAKAYAMA
42	Study Team	member	進藤　秀明 SHINDO
43	Study Team	member	ﾃﾞｨﾝ･ﾐﾝ･ﾌﾝ DEIN MIN HUN
44	Study Team	Interpreter	N.TSERENDORJ
45	Study Team	Interpreter	B.AMARJARGAL
46	Study Team	Interpreter	L.MUNGUNTSETSEG
47	Study Team	Interpreter	J.OYUNTSETSEG

Photos

APPENDIX 3: Working Group Meeting

DATA COLLECTION SURVEY ON COPPER INDUSTORY SECTOR IN MONGOLIA

Subject for Working Group Meeting

	Date	Time	Main Subject	Theme and person in charge of a presentation (20～30 min/person)
1	28-May	AM PM	･Outline of the study ･Copper mine development in Mongolia ･Copper supply and demand in the world ･Copper smelting and refining (part 1)	1. Outline of the study and working group (Mr.Shibata) 2. Copper mine and copper resource potential in Mongolia（Mr.Bold） 3. Future mining development plan in mongolia（Mr.Tamir） 4. Copper mine in the world and recent activity of major mining company（Mr. Yamakawa） 5. Copper supply and demand in the world（Mr. Nakayama） 6. Beneficiation of copper ore（Mr. Mizuochi） 7. Introduction of copper smelting method（Mr. Shindo） 8. Copper smelting and refining（by Video） 9. Copper smelting plant construction Plan in Mongolia（Mr. Davaatseren）
2	30-May	PM	･Copper smelting and refining (part 2) ･Mining policy of Mongolia ･Copper supply and demand and market analysis ･Economic analysis	1. Copper smelting plants in Japan and in the world（Mr. Shindo） 2. Conditions required for copper smelting plant construction and operation（Mr. Akiyama） 3. Mining policy of Mongolia（Mr. Zuunnast） 4. Works being executed whithin the framework of copper programs（Ms. Uurtsaikh） 5. Export-and-import situation of mining products in Mongolia（Mr. Kobayashi）
3	3-Jun	PM	･Economic analysis ･Environmental and social considerations	1. Interim report of economic analysis（Mr. Okumura） 2. Mining income situation（Ms. Altanzule） 3. Environmental issues related to mining activities（Mr. Miyaike）
4	6-Jun	PM	･Industrial Human Resources ･Investment promotion	1. Industrial Human Resources Development（Dr. Lim） 2. Investment promotion for copper industry development（Dr. Dinh）
5	16-Jun	PM	･Copper mine development ･Infrastructures	1. Field Investigation of Oyu Tolgoi Mine（Mr. Yamakawa） 2. Field Investigation of Tsagaan Suvraga Mine（Mr. Kobayashi） 3. Field Investigation of Sainshand are（Mr. Shindo） 4. Infrastructures development（Mr. Yamakawa）
6	18-Jun	PM	･Copper industry development ･Copper smelting and refining	1. Copper industry development（Mr. Yamakawa） 2. Copper industry development plan（Mr. Zuunnast） 3. Copper smelting and refining in Mongolia（Mr. Shindo）
7	23-Jun	PM	･Comprehensive discussion	1. Comprehensive discussion
8	5-Sep	PM	･Comprehensive discussion	1. Comprehensive discussion
9	8-Sep	PM	･Comprehensive discussion	1. Comprehensive discussion

APPENDIX 4: Reference

Reference

Chapter.2

1) Kavalieris I, Wainwright A (2005): Wholerock geochemistry of Late Devonian island arc intrusive suites from Oyu Tolgoi, Mongolia. 8th Biennial SGA meeting, Beijing. August, 2005, field excursion notes.
2) Khashgerel B, Rye R, Hedenquist JW, Kavalieris I (2006): Geology and reconaissance isotope study of the Oyu Tolgoi porphyry Cu-Au system, South Gobi, Mongolia. Econ Geol 101: 503-522.
3) Oyu Tolgoi Technical report (March 2007): Geological Information Center, Open file Report № 5730.
4) Oyu Tolgoi Technical report (2013)
5) VIST Group: http://eng.vistgroup.ru/mof/
6) Independent Mongolian Metals & Mining Research: http://uclalum.blogspot.com/2010/03/according-to-leading-mongolian-news.html

Chapter.3

1) Berry, G. (2013): Capex cannibalization pushes copper-further towards a mid-decade deficit. ICSG 2013 Meeting.
2) Cochilco (2013): Copper market trend report.25p.
3) ICSG (2011): Directory of copper mines and plants 2009 to 2014. 118p.
4) ICSG (2013): World Copper Fact Book 2013. 57p.
5) ICSG (2014): Copper Bulletin. March 2014. 53p.
6) IMF (2014): World Economic Outlook—Recovery Strengthens, Remains Uneven.p.216.
7) JOGMEC (2013) Report on the trend analysis of mineral departments of major companies.239p.
8) Metals Economics Group (2011): Corporate exploration strategies. 470p.
9) Metal Economics Research Institute, Japan (2010) : Current situation of Copper industries in China. No.164, 93p.
10) U.S. Geological Survey (2014): Mineral Commodity Summaries 2014.
11) World Bureau of Metal Statistics (1994～2014): World Metal Statistics Yearbook.
12) IWC C: http://www.coppercouncil.org/genstat1.aspx

Chapter.4

1) ICSG (2013): World Copper Fact Book 2013
2) ICSG (2014): Copper Bulletin. March 2014.
3) Mongolian Customs Data Base: Http://www. customs.gov.mn/statistics/
4) IMF Web Page : http://www.imf.org/external/np/res/commod/index.aspx
5) Erdenet Mining Company: Brochure
6) World Bureau of Metal Statistics (2014): World Bureau Metal Statistics

7) JOGMEC (2012): Copper Production in the World.
8) Turquoise Hill (2013): 2013 Oyu Tolgoi Technical Report.
9) Turquoise Hill (2013): Second Quarter Report.
10) Turquoise Hill (2013): Third Quarter Report.
11) Turquoise Hill (2013): Annual Report to Shareholders.
12) Wan Ling (2012): Chinese Copper Market and Mongolia.

Chapter.5
1) CODELCO (2014): CODELCO investor presentation
2) International Copper Study Group (2013): The World Copper Factbook 2013
3) Pascal Coursol et al (June 7th 2010): Energy Consumption in Copper Sulfide Smelting, Copper 2010 Conference in Hamburg, Germany
4) Teck Modeling Workshop (March 13, 2012)
5) U.S. Geological Survey (2010): USGS Mineral Yearbook
6) World Bureau of Metal Statistics(1994～2014) World Metal Statistics Yearbook.

Chapter.6
1) JICA (2013): Master plan study for coal development and utilization.

Chapter.7
1) ICSG (2013): Directory of Copper Mines and Plants (Feb/2013)
2) ICSG (2013): World Copper Fact Book 2013
3) Sulfuric Acid Market by PentaSul (Feb 2008)
4) Chilean Copper Commission (05-2011)
5) Turquoise Hill Resources LTD. (2013): 2013 Oyu Tolgoi Technical report

Chapter.8
1) JICA (2013): Master plan study for coal development and utilization.
2) World Bank (2011): Southern Mongolian infrastructure Strategy.
3) Mongolian Railway (2010): New railway infrastructure project.
4) Ministry of mineral resources and energy (2012): Current and future prospects of the electricity sector of Mongolia.
5) MMER (2011): Strategies and future development of energy and current status of nuclear energy program in Mongolia, Tudev TSERENPUREV.
6) World Bank (2009): Groundwater assessment in the Gobi region, Final draft report.

Chapter.10
1) The World Bank (2006): Mineral Royalties and other Mining-specific Taxes

2) National Statistical Office of Mongolia (2012): National Statistical Yearbook 2011, Mongolia
3) Energy International Corporation, Prophecy Coal Cor
4) ICSG (2013): World Copper Fact Book 2013
5) ELLA Area: Economic Development (2012): Profit-Based versus Production-based Tax Regimes: Latin America's Experience
6) NEA Economic Cooperation, Dr. Gotov Dugerjav (2013): Enhancing Northeast Asia and Mongolia Economic Cooperation through Transport Network Development

Chapter.11

1) Amrita Batchuluun, Asia University, Joung Yol Lin, Asia University (2010): An Analysis of Mining Sector Economics In Mongolia
2) N.Batnasan School of Economic Studies, National University of Mongolia (2013):Mongolia`s Mining-Based Development and Trade Policy
3) Owen Barder(2006):A Policymakers' Guide to Dutch Disease
4) U.S. Government (2013): Hearing before the Subcommittee on Africa, Global Health, Global Human Rights, and International Organizations of the Committee on Foreign Affairs House of Representatives One Hundred Thirteenth Congress
5) National Development and Innovation Committee (2011): Impact of mining industry on other sectors
6) Shagdar Enkhbayar, David Roland-Holst, Guntur Sugiyarto(2010): Mongolia's Investment Priorities from a National Development Perspective

Chapter.12

1) IFC (2007): IFC Environmental, Health and Safety Guidelines for Mining
2) IFC (2007): IFC General EHS Guidelines
3) Oyu Tolgoi LCC (2003): Implementation of the Environmental Protection Plan and Environmental Monitoring Program by 6709A License holder at Oyu Tolgoi Deposit