2007 fiscal year CDM/JI Business Survey
Business survey of the biomass use in the electric arc furnace for steel manufacture in Indonesia

Abstract

1. Outline of the survey

(1) Project outline

Steel companies in Indonesia mainly use electric arc furnaces for melting and refinement of the steel scrap by using the electric energy to manufacture steels for building. In this process, the coke originated from the fossil fuel is used in quantity of 2 - 3 % of the steel weight refined to prevent oxidation of scrap, control carbon content in steel, and supply auxiliary heat source. On the other hand, oil palm manufacturing industry is in very active in Indonesia and Malaysia. The volume of oil palm wastes generated from this industry is about 4 million ton in every year.
Although a part of oil palm wastes is used as fuel or activated carbon raw materials, the rate of abandonment and simple incineration being carried out is large.
The charcoal (PKS Charcoal) manufactured from Palm Kernel Shell (PKS) has the physical properties of high bulk density and high strength, compared with the charcoal of the woody origin, and very close to the coke used for steel manufacture. This project intends to reduce GHG (greenhouse gases) which generates from fossil fuels, based on the principle of Carbon Neutral, by replacing the coke with PKS charcoal.

(2) Survey framework

Entrusted company : **JP Steel Plantech Co.**
Design, manufacture, and installation of almost all steel-making equipment . Electric arc furnace is the main product and the biggest manufacturer in Japan.

Host company : **PT The Master Steel Mfg.**
Steel company in Indonesia which ranks second to a national Krakatau steel company. The Master Steel has 4 factories, and produces 1 million ton of steel by electric furnaces every year. In Kesa works, which is a factory for this project, yearly steel production is 360,000 ton.

Cooperation company 1 : **Pt. JFE Trade Indonesia**
The local company of the trading company of JFE group. They take charge of the company attendance of the visit to local offices and companies, arrange an interpreter, and collect local information.

Cooperation company 2 : **JFE Engineering (M) SDN. BHD**
The local company of JFE engineering in Malaysia. They take charge of the company attendance of the visit of to palm oil industry in Malaysia, arrange an interpreter, and collect local information.

Cooperation company 3 : **YBUL**
It is an NPO of Indonesia located in Jakarta and has wide experience especially in biomass related CDM field. The take charge in PDD making.

Cooperation company 4 : **KYOEI Steel Ltd.**
A Japanese leading electric arc furnace steel company. In collaboration

with JP Steel Plantech Co., they tested PKS charcoal use in their electric arc furnace. It takes charge also of the technical assistance to a host company.

2. Outline of a host country

(1) Outline of host country Indonesia

The Republic of Indonesia is the world's largest archipelagic state. Consisting of 17,508 islands, the full length of the entire coastline is 54,716 km. It is known as a world leading maritime country. Area is about 1,890,000 **km²**. Population is about 217 million. The Capital is Jakarta which is the center of politics and economics. Other main cities are port town Surabaya based on industrial area, Bandung in western Jawa, etc. The main industries are mining (oil, LNG, aluminum, tin), agriculture (rice, rubber, palm oil), and industry (wood products, cement, fertilizer).

Fig. 1 Country map of Indonesia

Although Indonesia is blessed with wide range of natural resources, large and rapidly increasing population are the hamper of its economical growth. Industrial production occupies about 40 % of GDP, but depends on the supply of various natural resources of own country, such as crude oil, natural gas and tin, metal, and coal. The investment from foreign countries has also led to the production increase and export increase in recent years. The export expansion by products other than oil has actually helped economic growth greatly.

(2) Situation about CDM of Host Country

In Indonesia, although Kyoto Protocol ratification had been stagnated, it went into effect at last on July 28, 2004. Organization is prepared now by making the Ministry of Environment into Designated National Authority (DNA), and projects have been recognized one after another.

(3) Steel industry of Indonesia

It roughly divides into two iron and steel making processes. One is the process in which iron ore is smelted into pig-iron by blast furnace, and this pig iron with LD converter to make steel. The other is the electric furnace (EAF; Electric Arc Furnace) process, which carries out melting, and refinement of the steel scrap. In Indonesia, almost all steel making process is electric arc furnace process which uses domestic or imported steel scrap.

Crude steel production in Indonesia was 3,680,000 ton/y and crude steel appearance consumption was 7,810,000 ton/y in 2005. Many companies are owned by China origin family, and they are in the tendency that runs to profits reservation shorter-term than technical development and new facility introduction. The energy consumption of unit crude steel is higher than Japan in 30 %. Governmental steel industry policy calls for the improvement in efficiency by technical development and equipment replacements. The intention to achieve improvement is required rather than anything else, and the technical assistance from an advanced nation is expected.

(4) Palm oil industry of Indonesia and palm oil shell

Palm oil (CPO: Crude Palm Oil) is made from the fruit of oil palm and Indonesia and Malaysia are the two leading countries of production in the world. It has been used as cooking oil, detergent, etc., and has been used as materials of bio-fuel recently, resulting in a price rising. The yearly production of CPO in Indonesia amounts to 17million, and its production is concentrated to the Kalimantan and Sumatra.

Oil palm is not a spontaneous plant in Southeast Asia, and it is raised in plantation area. FFB (Fresh Fruit Bunches) is formed in the root of a leaf. FFB is an armful about 20 kg. Tens of yellow fruits are born on FFB, which are a little smaller than chicken eggs. The outside of a fruit is the soft portion and contains oil. By separating this portion from shell (hard core) by using high temperature steam and taking off with a press, CPO can be obtained. Kernel is the center core of the shell and is extracted further to collect another kind of oil. The shell (PKS: Palm Kernel Shell) is hard and contains small amount of moisture, it becomes fuel itself. Carbonized PKS (PKS charcoal) is a raw material of activated carbon. Oil palm, FFB, and oil palm shell are shown in Photo 1.

Photo **1 Oil palm, FFB and oil palm shell**

This project replaces the coke with PKS charcoal to reduce greenhouse gases which are generated from fossil fuel combustion. Although PKS charcoal is produced in Malaysia commercially, it is not yet common in Indonesia. But the PKS charcoal manufacturing in Malaysia is the small-scale, matching to the activated carbon market scale.

If PKS is carbonized to reduce the volatile matter to below 10 %, which is the same level as coke, the yield of the charcoal from PKS is about 25 %. Namely, PKS charcoal obtained from 1ton of PKS is about 250 kg.

3. Explanation of the technology of a proposal project

(1) Electric Arc Furnace (EAF) process and its solid carbon use

Electric arc furnace (EAF) is used to melt and refine steel scraps to manufacture steels. Though its main energy source is electricity, auxiliary energies such as oxygen, liquid/gaseous fuel, and coke breeze are used to save electricity and to expedite melting and refining. Ratio of auxiliary energy to electrical one is roughly 50: 50 in modern EAFs. Most important auxiliary energy source is coke (lump and powder), which contains fixed-carbon as a main constituent. The use of coke at each stage of EAF process is described below. Unit consumption of coke is about 20 - 30kg/ton-steel.

(1) At the early stage of melting (Fig. 2 left) oxygen is blown into the EAF for smooth meltdown and scrap cutting. Some part of the scrap is oxidized by oxygen and melted. In order to retard excess scrap oxidation, lump coke is pre-mixed in scrap or coke powder injected at the hot point.

(2) At the end of melting and temperature rising stage (Fig. 2 center) high temperature open arc tends to radiate much energy and to injure wall lining. In order to avoid bad effect of this bare arc, oxygen and coke powder are injected into the slag to formulate “foaming slag”. Foaming slag is made by CO foam and encloses the arc to improve thermal efficiency and heat transfer to the molten bath.

(3) At the end of the refining stage (Fig. 2 right) only coke powder is injected into the slag and molten steel to reduce FeO to recover Fe and to control carbon percentage in the steel.

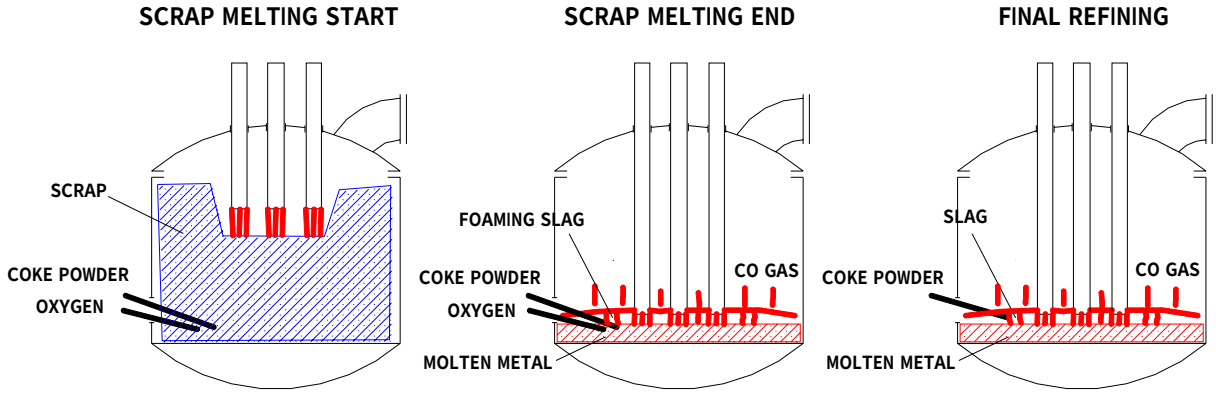

Fig. 2 EAF process to use coke

(2) Use of the palm kernel shell (PKS) charcoal in EAF

This project is the simple process of replacing the coke with the PKS charcoal that is a biomass fuel. It is necessary to investigate the possible troubles of PKS charcoal use in an electric arc furnace to verify its stable use.

In the course of this project planning, SPCO imported PKS charcoal from Malaysia in to use it in an 80 ton EAF of Kyoei Steel, Osaka, Japan. After a peeping test in April 2007, the test run was executed again on December 2nd 2007, to collect required data. The result was satisfactory, and the coke alternative use of PKS was verified. Experimental outline are explained below.

Coarse coke (lump coke) had been mixed into the scrap, and fine coke (coke breeze) had been injected into a furnace after meltdown. In test operation, therefore, large size charcoal (grain PKS charcoal) was mixed into the scrap, and small size charcoal (fine PKS charcoal) was blown into the furnace by pneumatic transport system. Other operational conditions were the same as those of the coke operation. Tests of coke use and the tests of charcoal use were done 3 times each one after the other.

Exhaust gas temperature after the combustion chamber, and cooling water temperature of elbow section were recorded. Slag samples were analyzed.

Exhaust gas temperature is a guide of the effective use of the fuel energy, and the ferrous oxide in slag and the analysis for metallic Fe are the guides of the efficiency of the PKS charcoal as a reducing agent. It was proved that the performance of the PKS charcoal operation can be evaluated as about the same as coke operation. The analytical value of PKS charcoal and coke are shown in Table 1. As shown in Table 1, PKS charcoal contains less ash and sulfur and shows higher heating value than those of coke which mean that it has a good fuel quality.

Table 1. Analysis of PKS charcoal and coke

Items	Unit	PKS charcoal (Envirocarbon) 5)			Coke (Kyoei Steel) 6)	
		Large	Medium	Fine	Lump	Breeze
		3.3 - 8.0 mm	2.0 - 3.3 mm	0.1 - 2.0 mm	1.0 -15 mm	0 - 1.0 mm
Moisture 1)	wt %	7.5	5.9	5.2	13.0	0.7
Ash	dry wt %	3.2	3.6	13.3	12.1	11.7
Volatile	dry wt %	8.5	8.8	10.9	1.1	1.1
DHV 2)	kcal/kg	7,840	—	6,940	6,650	6,950
(Dried Heating Value)	kJ/kg	32,810	—	29,070	27,820	29,080
HHV 3)	wet kcal/kg	7,250	—	6,580	5,780	6,900
(High Heating Value)	wet kJ/kg	30,350	—	27,560	24,210	28,880
LHV 4)	wet kcal/kg	7,100	—	6,450	5,700	6,880
(Low Heating Value)	wet kJ/kg	29,710	—	27,000	23,880	28,790
C	dry wt %	89.1	—	—	83.0	85.8
H	dry wt %	2.2	—	2.0	< 0.1	0.3
N	dry wt %	0.6	—	—	0.5	0.6
S	dry wt %	< 0.1	—	—	0.6	0.5
Cl	dry wt %	< 0.1	—	—	< 0.1	< 0.1
Fe	dry wt %	0.09	—	2.56	0.14	0.33
Ca	dry wt %	0.31	—	0.94	0.21	0.38
Si	dry wt %	0.85	—	2.37	3.49	2.78
Al	dry wt %	0.03	—	0.49	2.34	1.57
Na	dry wt %	< 0.01	—	—	—	0.04
K	dry wt %	0.18	—	—	—	0.08
P	dry wt %	0.02	—	—	0.03	0.04
Mg	dry wt %	0.04	—	0.10	0.04	0.14

1) Moisture is the weight loss when dried at 105 degC two hours.
2) DHV means the measured heating value at the dried condition after dried at 105 degC two hours.
3) HHV = DHV x (100 - Moisture %) / 100
4) LHV = HHV - 6 x (9 x Hydrogen (wet base) + Moisture) kcal/kg
Hydrogen (wet base) = Hydrogen (dry base) x (100 - Moisture %) / 100
5) PKS charcoal is the charcoal made from palm kernel shell in Malaysia by Envirocarbon Sdn Bhd.
6) This coke is used at the electric arc furnace of Kyoei Steel in Osaka, Japan.

4. Formation of CDM Project

(1) Contents of the CDM project

The Host Company is PT. The Master Steel Mfg at Kesa works in Jakarta, Indonesia Jakarta, which is melting and refining steel scrap as follows. Some part of this coke will be replaced with the PKS charcoal to reduce the GHG emission.

Electric arc furnace capacity : **80 ton**
Annual steel production : **360,000 ton/y**
Coke unit consumption : **25 kg-coke/ton-steel**
Annual coke consumption : 360,000 ton/y x 25 kg coke/ton-stee
= 9,000 ton/y
Carbon content of the coke : **85 %**
Annual GHG emission from the coke : 9,000 ton/y x 0.85 x 44/12
= 28,050 ton-CO_2/y

(2) Project boundary, Baseline, Economical analysis, and Additionality

Indonesia and Malaysia are the two leading countries of palm oil production in the world now. Although a large amount of PKS are generated in these countries there are no PKS charcoal factories which satisfy the use in steel mills. It is at the stage of explanation to palm oil

companies to increase its production. Our PDD is made by assuming that the PKS charcoal will be supplied from a liquid timber factory in Sumatra, where the charcoal is a by-product (or waste). The project boundary is limited to the inside of the steel mill of the Host Company. At first the GHG emission rate from a unit ton of steel by the present fossil fuel use should be defined. In the Baseline scenario, the GHG emission volume shall be calculated by multiplying the unit emission with the annual steel production. In the Project scenario, the GHG emission volume shall be calculated by the actual fossil fuel volume used in the plant and its carbon content. As for the Additionality, the PKS charcoal price is more expensive than a fossil fuel price now, so financial barrier is considered to be cleared. As there is no example of the PKS charcoal use in a commercial scale, Technical barrier condition can also be cleared.

(3) GHG emission reduction of Project Scenario and leakage

The amount of GHG emission reduction shall be assumed that the replacing rate by biomass is 40 %, by considering realistic charcoal supply at the moment, namely 11,220 ton CO2/y (28,050 x 40 %). This value be easily extended if the production scale of PKS charcoal will be expanded. AS the Boundary is restricted to a steelworks, leakage shall be calculated by the comparison of GHG generated by PKS charcoal manufacture and GHG generated by the coke manufacture. Most of the coke currently used in the steel mill in Indonesia is imported from China. Coke production from coal requires 8 % of the fossil fuel. If this energy and the transportation from a remote place China are considered, reduction the GHG emission reduction becomes still larger, but we did not included these value for the conservative case.

(4) Monitoring

The amount of GHG emission is greatly influenced by the steel production. Therefore, it is necessary to decide the amount of GHG emission per unit steel quantity to set a Baseline. For this purpose, the following **UWB_CO_2** data shall be fixed before the PKS charcoal use

Annual production of crude steel : WB_steel (ton/y)
Annual purchase of solid fossil fuel : WB_coke (ton/y)
Carbon content of solid fossil fuel : RCB_coke (%)
GHG emission rate from unit steel volume
: UWB_CO_2 = (WB_coke x RCB_coke/100 x 44/12) / WB_steel

Next, the following data after the Project practice shall be monitored.

Annual production of crude steel : WP_steel (ton/y)
Annual purchase of solid fossil fuel : WP_coke (ton/y)
Carbon content of solid fossil fuel : RCP_coke (%)

GHG emission amount of the Project practice shall be calculated as follows;

GHG emission of Project scenario
: **WP_CO_2** = **WP_coke x RCP_coke/100 x 44/12**
GHG emission reduction : WRP_CO_2 = WP_steel x UWB_CO_2 - WP_CO_2

(5) Environmental influence and others

Expansion of the palm oil plantations is criticized as it will reduce the primeval forest. But our

case will not intend to expand the plantations but aims at the effective use of the waste. The air pollution, which are worried in a PKS charcoal manufacturing, shall be avoided to meet the emission standards of the host country. The PKS charcoal manufacturing process is planned to be the simple labor concentration type from local technology. It can contribute to the local employment with the cheap equipment cost.

(6) Stake holder's comment

In the 1st field survey of early Oct. 2007, we visited the Ministry of Environment, Ministry of Industry, and Ministry of Agriculture which are the administration concerned of Indonesia, and explanation of a project proposal and an opinion interview were carried out. Next, in the 2nd field survey of Oct. to early Nov., we visited the west Kalimantan state and south Sumatra state which are the main production fields of palm oil, and visited the local office of the Ministry of Agriculture and a palm oil plantation. Although palm oil industry is developed in Indonesia, PKS charcoal manufacturing is not common. Some portion of PKS is used as a fuel in the oil mills, and the rest is sold to buyers at a low spot price. All attendants showed interest in our idea to use PKS charcoal for steel making. The outline of an opinion at a visiting place is described below.

1) Oct. 4 2007, Ministry of Environment, Indonesia (DNA of CDM)

(a) Type of Methodology was questioned. As we answered that New Methodology is being made, the comments was that the registration will take so long time.

(b) Selection of Validator is also important. There is no Validator's main office in Indonesia. Validators in Malaysia or Singapore are recommended. Japanese will be better.

(C) At the stage of Governmental recognition, the verification of the possibility and continuity of the project is important. The supply contract between a PKS charcoal supplier and Master Steel should be submitted

(d) If possible, the PKS charcoal supplier should be in Indonesia. If imported from Malaysia, Governmental recognition may not be easy.

2) Oct. 4, 2007, Ministry of Industry, Indonesia (controlling steel industry)

(a) Our plan to use domestic biomass fuel instead of imported fossil fuel was welcomed..

(b) There was a request to explain to the other steel companies to spread this technology.

(c) By the recent price up of natural gas and oil, the use of coal is recommended to the steel company, especially for reheating furnaces. We explained the possibility that wood powder can be used instead of coal.

3) October 4, 2007, Ministry of Agriculture, Indonesia (controlling palm oil industry)

(a) Possibility of the commercial size charcoal plant was discussed. There is no such big plant to match the needs of steel industry because the charcoal is only used for activated carbon now, but the resource is plenty and the expansion of charcoal plant is easy.

(b) Since the expansion of PKS plantation is blamed for its primeval forest felling, the project like this is welcomed to ease the criticism. They showed the intention to assist.

(c) Now that the most of the PKS is sold to Malaysia, the PKS charcoal industry can be a significant business, and it will contribute to the reduction in coke import and increase in employment.

(d) The headquarters of a palm oil manufacturers association GAPKI is located in Medan and

the Jakarta branch, about 200 companies are the members. They recommended to have a presentation to them.

(e) The area of oil palm plantation area is 3.8 million ha, and the 75 % is in Sumatra, and 20 % is in Kalimantan island. The local branches of Ministry of Agriculture are located in Sumatra and Kalimantan. They recommended to visit there.

4) Oct. 30, 2007 Plantation Forestry Commission in Sanggau, West Kalimantan State

(a) There was an explanation about the usage situation of PKS in some oil mills. Some CPO mill boiler consumes almost all the PKS by their boilers. Difference of boiler efficiency is very large at every boiler.

5) Oct. 30, 2007, CNIS (Citra Nusa Inti Sawit) in West Kalimantan State (state owned compnay)

(a) 35,099 ton/y of PKS ought to be generated and it cannot be used up by boilers, where has it gone ? They do not recognize the value of PKS.

(b) The fuel ratio in their boilers are 75 % from fiber and 25 % from PKS.

(c) They have a plan to manufacture activated carbon from PKS, but if the use in steel mill is promising, there can change the plan.

6) Nov. 1, 2007, Forest Plantation Office of South Sumatra State

(a) SAMPURNA PLANTATION Company owns the plantation of 60,000 ha, and four factories in the South Sumatra State OKI prefecture. The amount of wasted FFB is 300 ton/h, and CPO production is 150,000 ton/y. 40 % PKS is used by own boilers, and 60 % (30,000-40,000 ton/y) is sold to outside companies. The Executive showed interest for our idea.

7) Nov. 1, 2007, PT Global Diorap Industry (pyroligneous acid manufacturing company)

(a) This is the family company of Rubber Company, PT BADIA BARU. PKS charcoal is manufactured and used to deodorization in rubber manufacturing process and timber vinegar is manufactured with the pyrolysis furnace. The amount of PKS treatment is 20 ton/d.

(b) PKS charcoal is a residual material of timber vinegar manufacture and piled up in the factory. They showed a big interest to the project of our proposal. Namely, if the charcoal of pyroligneous acid industrial waste can be used in steel mills, it is welcomed.

(7) CDM Project framework

As JP Steel Plantech Co. is a plant engineering company, there is no plan of a capital tie-up to PKS charcoal manufacture, and the participation to the CDM project is considered only. CDM Project Participants are a host company Master Steel and Steel Plantech now. Japanese trading company, an overseas Chinese local capital, and the PKS charcoal manufacturer of Malaysia can be Project Participants depending on the progress of the plan.

(8) Prospect and issues for CDM business scheme.

About the economical situation, the coke price is continuing to rise for the past several months, and also PKS charcoal price is rising alike. With the increasing oil price of these days, coke price and PKS price are very fluctuating. Followings are the economical estimation to make PDD based on the recent prices.

Electric arc furnace capacity : 80 ton
Annual crude steel production : 360,000 ton/y
Coke unit consumption at EAF : 25 kg coke/ton-steel
Annual coke consumption : 360,000 ton/y x 25 kg coke/ton-steel = 9,000 ton/y
Replacement ratio of coke to PKS charcoal : 40 %
Carbon content in coke : 85 %
Replacement amount of coke to PKS charcoal: 9,000 ton/y x 0.40 = 3,600 ton/y

Coke price : 200 US$/ton
PKS charcoal price : 250 US$/ton
Amount of annual coke buying-expenses reduction
: 3,600 ton/y x 200 US$/ton = 720,000 US$/y
Annual PKS charcoal buying expenses : 3,600 ton/y x 250 US$/ton = 900,000 US$/y
Amount of a cost up by change to PKS charcoal : 900,000 – 720,000 = 180,000 US$/y

Amount of annual GHG discharge reduction : 3,600 ton cokes/y x 0.85 x 44/12 =
11,220 ton CO_2 /y
CER credit
10 US$/ton CO_2 : 11,220 ton CO_2/y x 10 US$/ton CO_2 = 112,200 US$/y
15 US$/ton CO_2 : 11,220 ton CO_2 /y x 15 US$/ton CO_2 = 168,300 US$/y
20 US$/ton CO_2 : 11,220 ton CO_2 /y x 20 US$/ton CO_2 = 224,400 US$/y

When CER credit is 20 US$/ton CO_2, the income from CDM becomes 44,400 US$/y.
(=224,400 US$/y - 180,000 US$/y)

The prices of imported coke, anthracite and the petroleum coke are rising at present and it is advantageous to the Project practice. However, since the PKS charcoal price is also rising, a setup of the price is difficult. Since PKS supply capacity is enough, if the steel industry's concern over a price-up of coke becomes critical, PKS charcoal production will be drastically expanded. The PDD draft was made on the basis of New Methodology which is now on pre-validation stage. Since it is expected that recognition of New Methodology and correction of PDD may tale six months, CER is expected to be effective from January 2009.

5. Validation

The consultant and preliminary examination of New Methodology were entrusted to TUV Nord India, which is the Indian affiliated company of TUV Nord of Germany. The submission to the U.N. New Methodology Panel will be done by TUV Nord India.

6 Conclusion

It is estimated that 11,220 ton CO_2 /y reduction by the practice of this CDM Project will be realized. When CER credit is 20 US$/ton CO_2, the income by CDM will be expected as 44,400 US$/y. Moreover, if PKS charcoal supply system is fixed, steel industry and PKS charcoal manufacture both will be positive to the wide range use. When this situation comes, reduction of greenhouse gas can be achieved with economical efficiency.